

LG1US54-12-1
Book 1 of 2

C-5 PROGRAM
INERTIA LOADS REPORT
FOR THE FIRST C-5A AIR VEHICLE
LG1US54-12-1
20 NOVEMBER 1968
CONTRACT AF 33(657)-15053
US-54-21.0-2 (ASD)

LOCKHEED-GEORGIA COMPANY

A DIVISION OF LOCKHEED CORPORATION

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LOCKHEED-GEORGIA COMPANY

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

MARIETTA



GEORGIA

TITLE

C-5 PROGRAM
INERTIA LOADS REPORT
FOR THE FIRST C-5A AIR VEHICLE
LG1US54-12-1
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SUBMITTED UNDER

MODEL <u>C-5A</u>	REFERENCE <u>US-54-21.0-2 (ASD)</u>
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FOREWORD

This Inertia Loads Report is presented as one of the data items required by TSAF US-54-21.0-2 (ASD), Form 9, under contract number AF 33(657)-15053. Data in this report are in agreement with the "Actual Weight Report For The First C-5A Air Vehicle", LG1US54-5-1, dated 20 November 1968, and LG1US54-2-68, "C-5A Weight, Balance and Inertia Status Report No. 68", dated 1 November 1968, and satisfies the requirements of paragraph thirteen (13) of the Form 9.

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SUMMARY

This report presents mass data based upon the actual weight of the first C-5A air vehicle, Air Force Serial 66-8303 (GELAC serial 0001). The actual weight empty is 327,000 pounds. A comparison of structural design criteria and actual weight conditions is presented followed by an AN 9103-D (Modified) Group Weight Statement. The Group Weight Statement contains a manufacturing variation of +1,079 pounds included in the fuselage basic structure to adjust the predicted weight to the actual weight.

Mass data are given by major component distributions for the Operating Weight Condition with a separate list of items to be removed to obtain Weight Empty.

Fuel center of gravity and inertia data are presented graphically for one wing only in the normal fuel usage sequence. Opposite wing is similar. Data are presented for air vehicle pitch attitudes of 29 and 12 degrees nose down, level, and 8 and 25 degrees nose up.

Sample calculations for cargo mass data are presented based upon a uniformly distributed cargo density.

Unit inertia loads are presented utilizing the mass distributions of the major air vehicle components. Data are presented for the wing with various fuel quantities and air vehicle pitch attitudes. Also shown is a single cargo case combined with the fuselage.

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SYMBOLS AND ABBREVIATIONS

<u>SYMBOL</u>	<u>DEFINITION</u>
Avg.	Average.
B.L.	Buttock Line - distance along air vehicle (Y) axis from the air vehicle (XL) reference plane.
C.G.	Center of Gravity.
F_X	Inertial force component parallel to the (X) air vehicle axis.
F_Y	Inertial force component parallel to the (Y) air vehicle axis.
F_Z	Inertial force component parallel to the (Z) air vehicle axis.
F.S.	Fuselage Station - distance along the (X) axis from the air vehicle (YZ) reference plane.
g	Acceleration due to gravity = 32.2 ft./sec. ²
I_{X_0}	Moment of inertia of a mass about its centroidal (X) axis.
$I_{X'_0}$	Moment of inertia of a mass about its centroidal (X') axis.
I_{Y_0}	Moment of inertia of a mass about its centroidal (Y) axis.
$I_{Y'_0}$	Moment of inertia of a mass about its centroidal (Y') axis.
I_{Z_0}	Moment of inertia of a mass about its centroidal (Z) axis.

SYMBOLS AND ABBREVIATIONS (CONT'D)

<u>SYMBOL</u>	<u>DEFINITION</u>
$I_{Z'_0}$	Moment of inertia of a mass about its centroidal (Z') axis.
I_{XY_0}	Product of inertia of a mass about its centroidal (XY) planes.
$I_{X'Y'_0}$	Product of inertia of a mass about its centroidal (X'Y') planes.
I_{XZ_0}	Product of inertia of a mass about its centroidal (XZ) planes.
$I_{X'Z'_0}$	Product of inertia of a mass about its centroidal (X'Z') planes.
I_{YZ_0}	Product of inertia of a mass about its centroidal (YZ) planes.
$I_{Y'Z'_0}$	Product of inertia of a mass about its centroidal (Y'Z') planes.
M.A.C.	Mean Aerodynamic Chord.
M_X	Moment about a component's (X) axis.
M_Y	Moment about a component's (Y) axis.
M_Z	Moment about a component's (Z) axis.
S_X	Shear force parallel to the (X) axis.
S_Y	Shear force parallel to the (Y) axis.
S_Z	Shear force parallel to the (Z) axis.
W	Weight.
W_i	Weight of a given panel, "i", in a component's weight distribution.

SYMBOLS AND ABBREVIATIONS (CONT'D)

<u>SYMBOL</u>	<u>DEFINITION</u>
W.L.	Water Line - distance along the (Z) axis from the air vehicle (XY) reference plane.
W.R.P.	Wing Reference Plane.
W.S.	Wing Station - distance along the W.R.P. from the air vehicle (XZ) reference plane.
X	Location of a point on the (X) air vehicle axis in F.S.
$\bar{X}$	Longitudinal location of a C.G.
$\bar{X}'$	Location of C.G. on a (X') axis in inches from its origin.
$\bar{X}_i$	Longitudinal location of the C.G. of the i th panel.
X_{LA}	Origin of the component's load axis on the (X) air vehicle axis in F.S.
X_j	Location of F.S. "j".
X_{PA}	Location of assumed rotational axis on (X) axis in F.S.
Y	Location of a point on the (Y) air vehicle axis in B.L.
$\bar{Y}$	Lateral location of C.G.
$\bar{Y}'$	Location of a C.G. on a (Y') axis in inches from its origin.

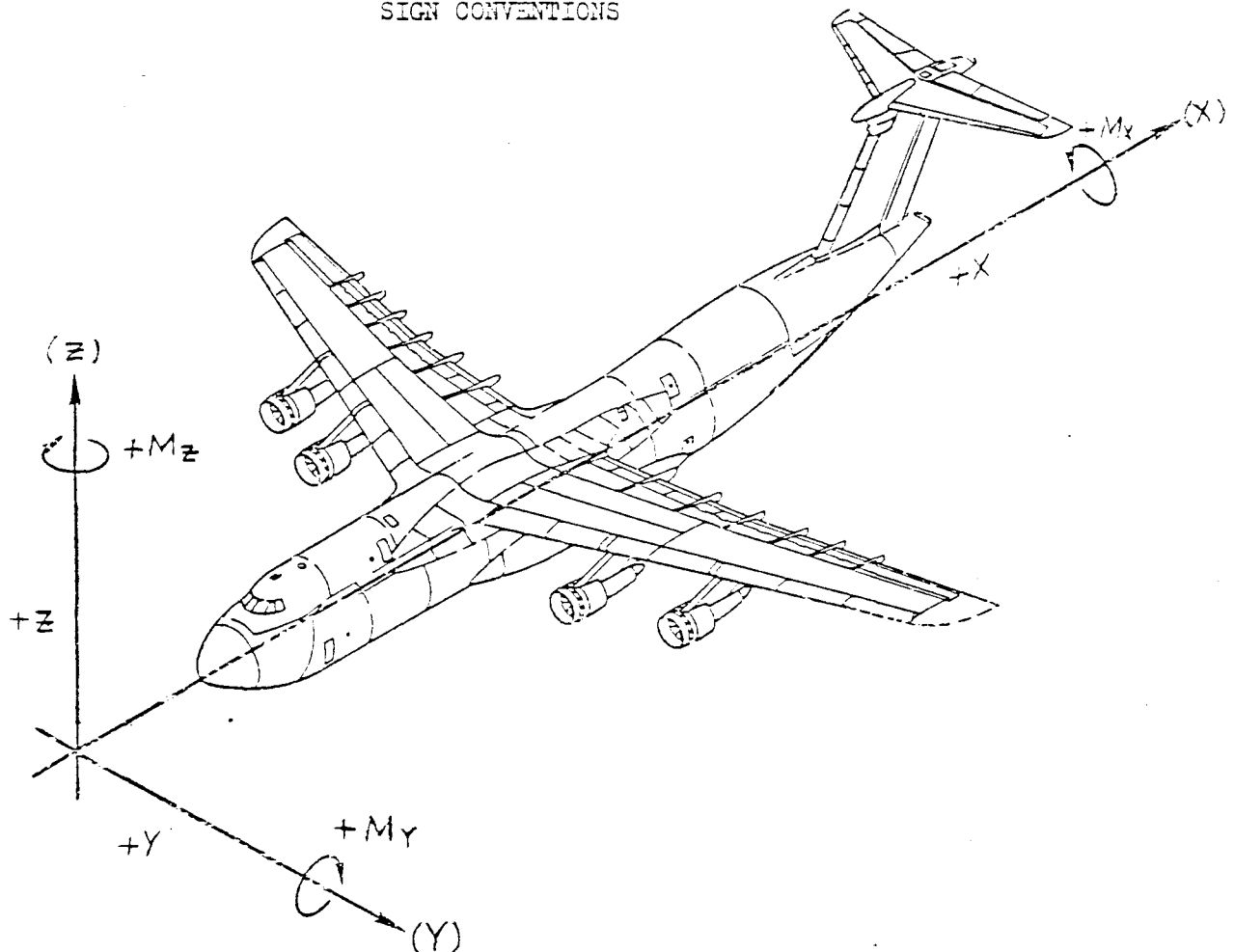
SYMBOLS AND ABBREVIATIONS (CONT'D)

<u>SYMBOL</u>	<u>DEFINITION</u>
$\bar{Y}_i$	Lateral location of the C.G. of the i^{th} panel.
Y_{LA}	Origin of the component's load axis on the (Y) air vehicle axis in B.L.
Y_j	Location of B.L. "j".
Y_{RA}	Location of assumed rotational axis in B.L.
Z	Location of a point on the (Z) air vehicle axis in W.L.
$\bar{Z}$	Vertical location of C.G.
$\bar{Z}'$	Location of a C.G. on a (Z') axis in inches from its origin.
$\bar{Z}_i$	Vertical location of the C.G. of the i^{th} panel.
Z_{LA}	Origin of a component's load axis on the (Z) air vehicle axis in W.L.
Z_j	Location of W.L. "j".
Z_{RA}	Location of assumed rotational axis in W.L.
ϕ	Angle between prime axis and air vehicle axis.
η_X	Denotes a unit "g" positive translational acceleration along the (X) axis (dimensionless).
η_Y	Denotes a unit "g" positive translational acceleration along the (Y) axis (dimensionless).

SYMBOLS AND ABBREVIATIONS (CONT'D)

<u>SYMBOL</u>	<u>DEFINITION</u>
η_z	Denotes a unit "g" positive translational acceleration along the (Z) axis (dimensionless).
$\dot{p}$	Denotes a unit positive rolling acceleration about the (X) rotational axis (rad./sec. ²).
$\dot{\theta}$	Denotes a unit positive pitching acceleration about the (Y) rotational axis (rad./sec. ²).
$\dot{\psi}$	Denotes a unit positive yawing acceleration about the (Z) rotational axis (Rad./Sec. ²).
p^2	Denotes the square of the angular velocity due to a rolling acceleration (rad./sec. ²).
$\dot{\theta}^2$	Denotes the square of the angular velocity due to a pitching acceleration (rad./sec. ²).
$\dot{\psi}^2$	Denotes the square of the angular velocity due to a yawing acceleration (rad./sec. ²).
pq	Denotes the product of the roll and pitch angular velocities (rad./sec. ²).
qr	Denotes the product of the pitch and yaw angular velocities (rad./sec. ²).
rp	Denotes the product of the yaw and roll angular velocities (rad./sec. ²).
a_x	Denotes a linear acceleration along the (X) axis.
a_y	Denotes a linear acceleration along the (Y) axis.
a_z	Denotes a linear acceleration along the (Z) axis.

SIGN CONVENTIONS



The sign conventions reflected in this report are described by the above sketch. Positive (X) air vehicle axis is aft, the positive (Y) axis is outboard on the left wing, and the positive (Z) axis is up. All length measurements, forces, and translational accelerations are positive in the direction of the positive axes. The sign of shear forces is positive in the direction of the positive air vehicle axes. The sign of the moments and rotational accelerations follows the left hand rule (i.e., when the left thumb is pointed in the direction of the positive axis, the curl of the remaining left fingers indicates the direction of the positive moment and rotational acceleration). In all of the unit inertia calculations a positive unit acceleration is assumed (Note, acceleration produces an opposite inertia force).

REFERENCES

1. LG1US54-5-1, "Actual Weight Report For The First C-5A Air Vehicle", dated 20 November 1968.
2. ASZZ Exhibit 66-1, "Contractor Data Requirements List For C-5A Airframe", dated 14 June 1967.
3. LG1-US54-2-68: "C-5A Weight, Balance and Inertia Status Report" No. 68, dated 1 November 1968.
4. MIL-STD-254 (ASG) - Military Standard - "Weight and Balance Data Reporting Forms For Aircraft", dated 26 August 1954.

1 INTRODUCTION

This report presents the mass data required to substantiate load and aerodynamic analysis of the C-5A air vehicle. These data are based upon the first C-5A air vehicle actual weight presented in Reference 1 and satisfy the inertia loads requirement of US-54-21.0-2 (ASD) Form 9 of Reference 2.

2 WEIGHT DISTRIBUTION AND INERTIA DATA

This section presents the moment of inertia and weight distribution data for the air vehicle components. Each sub-section describes the mass data for a major component. This description includes a sketch of the component geometry, a graphical presentation of the component weight distribution, a tabulation showing the distribution of the mass properties, and miscellaneous mass data considered necessary for use in load analysis.

2.1 AIR VEHICLE COMPLETE

2.1.1 General Data. The following figures and tables present weight, balance, inertia and structural data for the complete air vehicle. Basic air vehicle dimensions and reference point locations are shown by Figure 2.1-1. Figure 2.1-2 presents the structural design center of gravity envelope. Figure 2.1-3 illustrates the cargo loading envelope based upon the structural design center of gravity envelope, the air vehicle operating weight and center of gravity presented herein, and the standard fuel usage sequence considering fuel shift due to change in air vehicle attitude. It should be recognized that any change to these conditions will result in a change to the cargo loading envelope. Figure 2.1-4 presents the design cargo loading limitations provided the center of gravity limits of the air vehicle are not exceeded. The vertical center of gravity envelope presented by Figure 2.1-5 is derived by combining the operating weight with a maximum cargo load at a vertical center of gravity five inches above the cargo floor then adding fuel in the normal sequence. This defines the lower limits of the envelope. The upper limits are defined by adding a full complement of personnel in the upper deck forward and aft compartments and the removable troop kit in the aft compartment to Operating Weight. Then fuel is loaded in the normal sequence to maximum volume followed by cargo at the middle of the cargo compartment.

Figures 2.1-6, 2.1-7, and 2.1-8 present the roll, pitch, and yaw moment of inertia envelopes respectively with the product of inertia envelope presented by Figure 2.1-9. Extreme inertia data are derived by maintaining the air vehicle center of gravity limits (Figure 2.1-2) and adding varying fuel and cargo combinations. Fuel is added in the normal sequence. Cargo is loaded to the floor limitations (Figure 2.1-4) either in the extremes of the compartment or concentrated about the gross weight centroid to yield the maximum and minimum values respectively.

Figure 2.1-10 presents the cargo weight versus fuel weight limitations for structural design.

BASIC DATA	WING	VERTICAL	HORIZONTAL
AREA, SQ FT	6200 *	961.067	965.824
ASPECT RATIO	7.75 *	1.24	4.74
TAPER RATIO	0.371 *	0.800	0.370
SWEEP AT 25% CHORD	25° •	34°56'	24°35'
ROOT CHORD, IN.	545.303	371.197	250.160
CHORD PLANK BREAK	336.366		
TIP CHORD, IN.	184.036	296.958	92.559
MAC IN. (PROJECTED)	370.523 ♦	335.452	183.438
AERODYNAMIC SPAN, IN.	2630.437	414.256	811.620
ANHEDRAL	5° 5' 32" **		5° 0'
INCIDENCE	3° 30' ***		+4° TO -12°

- ♦ (TRUE MAC = 371.209) (REF)
- SWEEP OF OUTER WING IN ROOT CHORD PLANE
- * IN AERODYNAMIC PLANE
- ** IN AIRPLANE FRONT VIEW, 3° 30' 0" AROUND ROOT CHORD
- *** ROOT CHORD

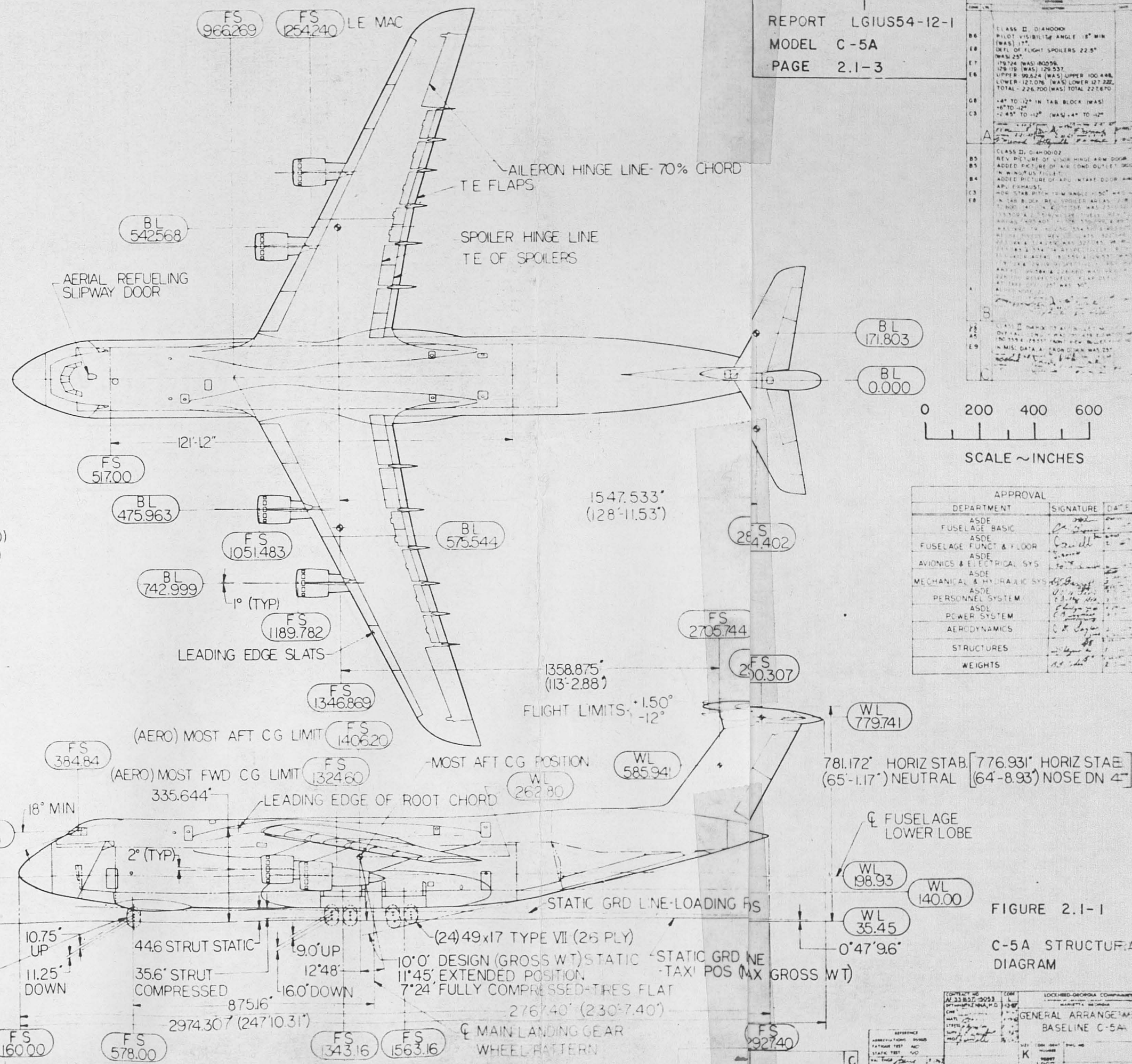
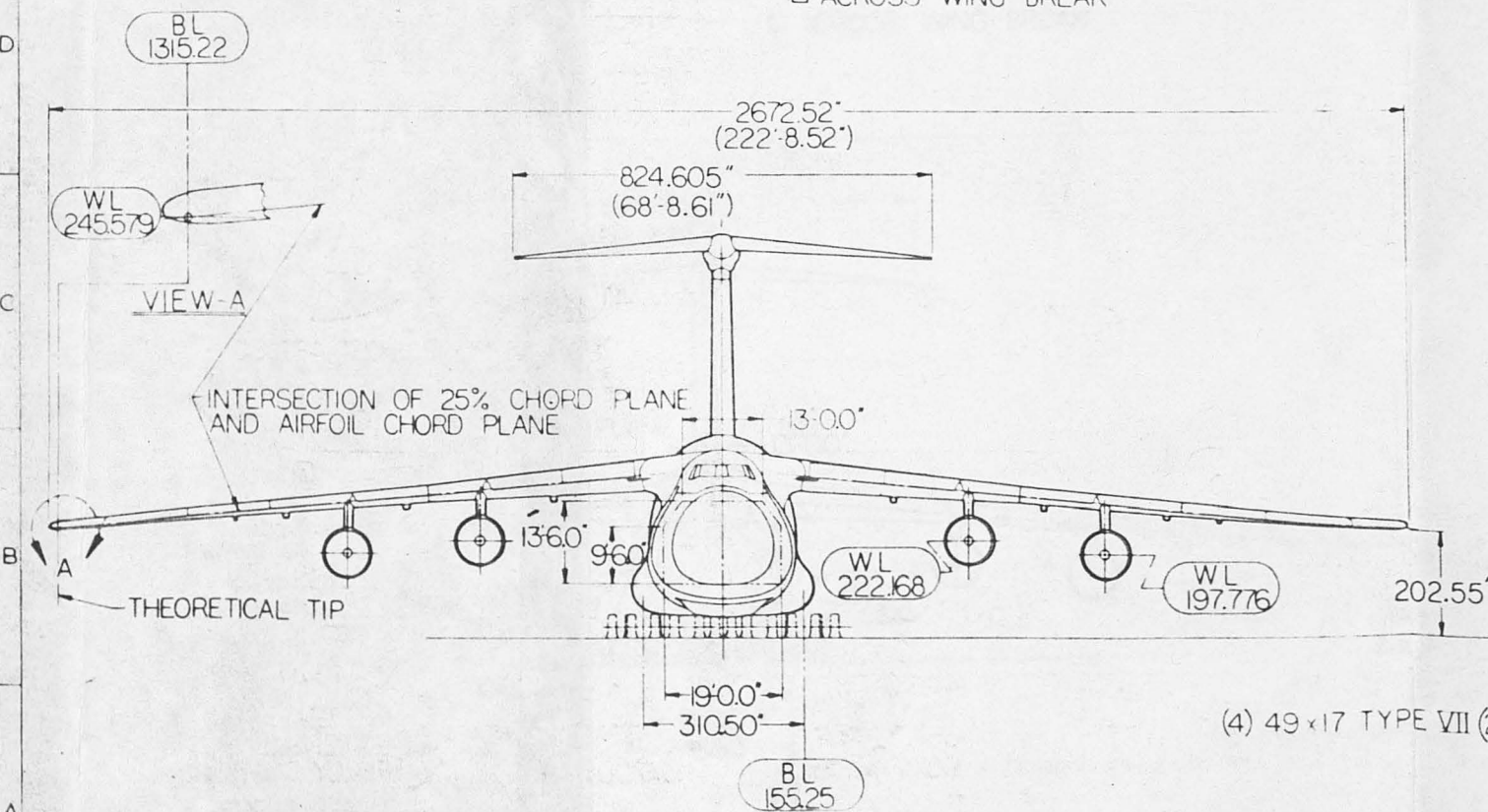
(4) TF39 ENGINES

MISCELLANEOUS DATA	AILERON	SPOILERS	TRAILING EDGE FLAPS	LEADING EDGE SLATS	ELEVATOR	RUDDER
AREA SQ FT	INBOARD	218.128	493.407	322.348	180.159	UPPER 99.584
	MIDDLE	72600 Δ	161.576 □	99.147		
	OUTBOARD	252.792	140.004 Δ	227.044	78.515	LOWER 127.076
	TOTAL/SIDE	126.396	215.366 ◊	324.269	129.33	TOTAL 226.660
DEFLECTION	UP 25°	GRD 60°	TAKE-OFF 25°	SEALED 21.5°	UP 25°	+35°
	DOWN 15°	FLT 22.5°	LANDING 40°	SLOTTED 22°	DOWN 15°	

- Δ ACROSS WING BREAK (LATERAL CONTROL)
- Δ OUTBOARD WING (LATERAL CONTROL)
- ◊ ALL SPOILERS (GROUND OPERATION)
- ACROSS WING BREAK
- INBOARD WING (SEALED)
- WING BREAK TO OUTBOARD ENGINE (SEALED)
- OUTBOARD ENGINE TO WING TIP (SLOTTED)

WEIGHT •	
CONDITION	LB
EMPTY	318.469
DESIGN FLIGHT GROSS (2.5g)	728.000
USEFUL LOAD-DESIGN FLIGHT	409.531
MAXIMUM DESIGN-GROSS	769.000
USEFUL LOAD-MAXIMUM DESIGN	450.531

• GUARANTEE FIGURES (ORIGINAL)



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PAGE 2.1-3

0 200 400 600
SCALE ~ INCHES

DEPARTMENT	SIGNATURE	DATE
ASDE		
FUSELAGE BASIC		
FUSELAGE FLOOR		
AVIONICS & ELECTRICAL SYS		
MECHANICAL & HYDRAULIC SYS		
PERSONNEL SYSTEM		
POWER SYSTEM		
AERODYNAMICS		
STRUCTURES		
WEIGHTS		

FIGURE 2.1-1

C-5A STRUCTURAL DIAGRAM

GENERAL ARRANGEMENT
BASELINE C-5A

PREPARED BY J. A. BAY
DATE 20 Nov 1968
CHECKED BY D. H. MARTIN

LOCKHEED-GEORGIA COMPANY
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NOTE:

MEAN AERODYNAMIC CHORD LENGTH = 370.52

LEADING EDGE M.A.C. = 1254.74

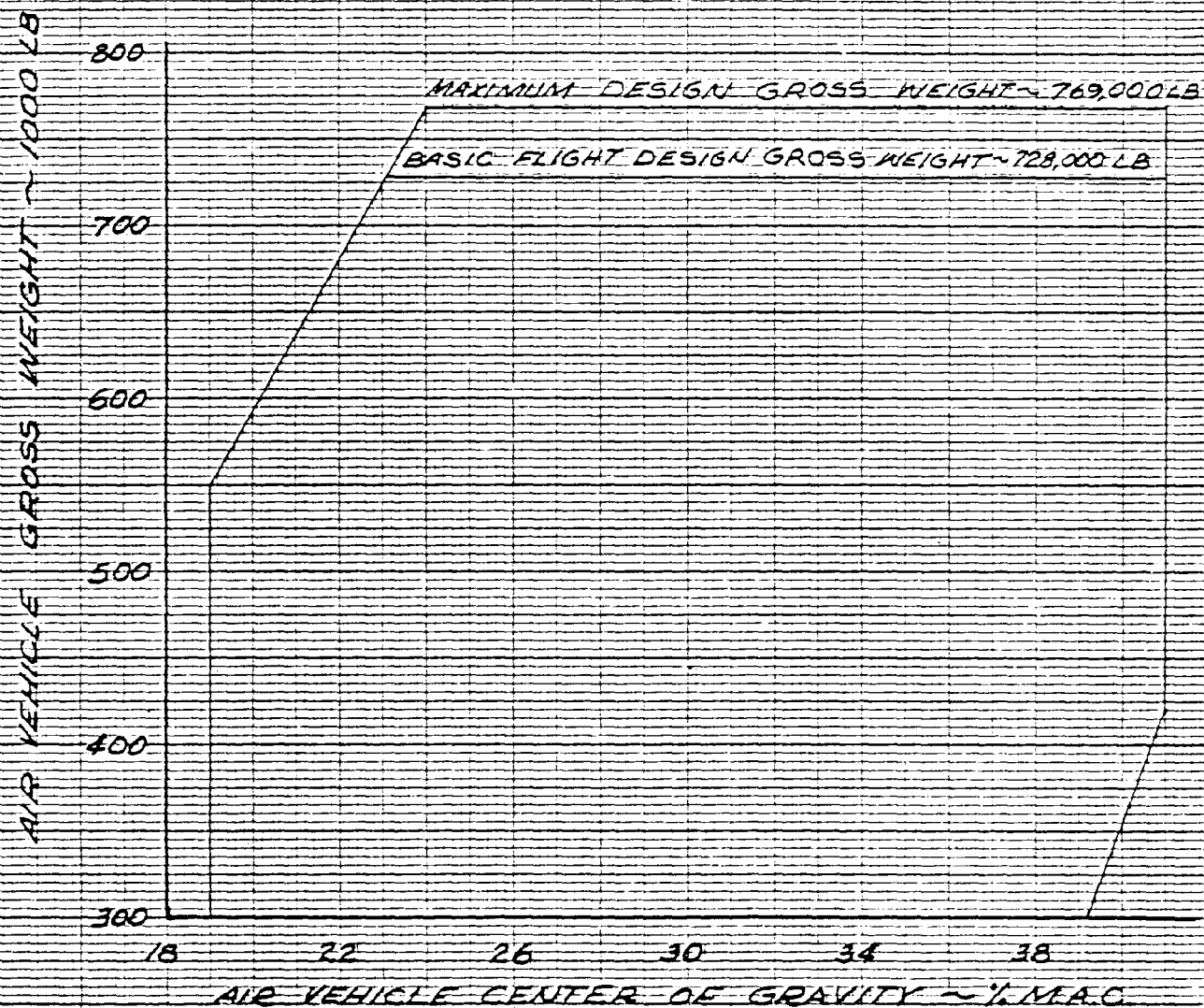


FIGURE 2-1-2

C-5A CENTER OF GRAVITY ENVELOPE

CARGO WEIGHT ~ 1000 LB

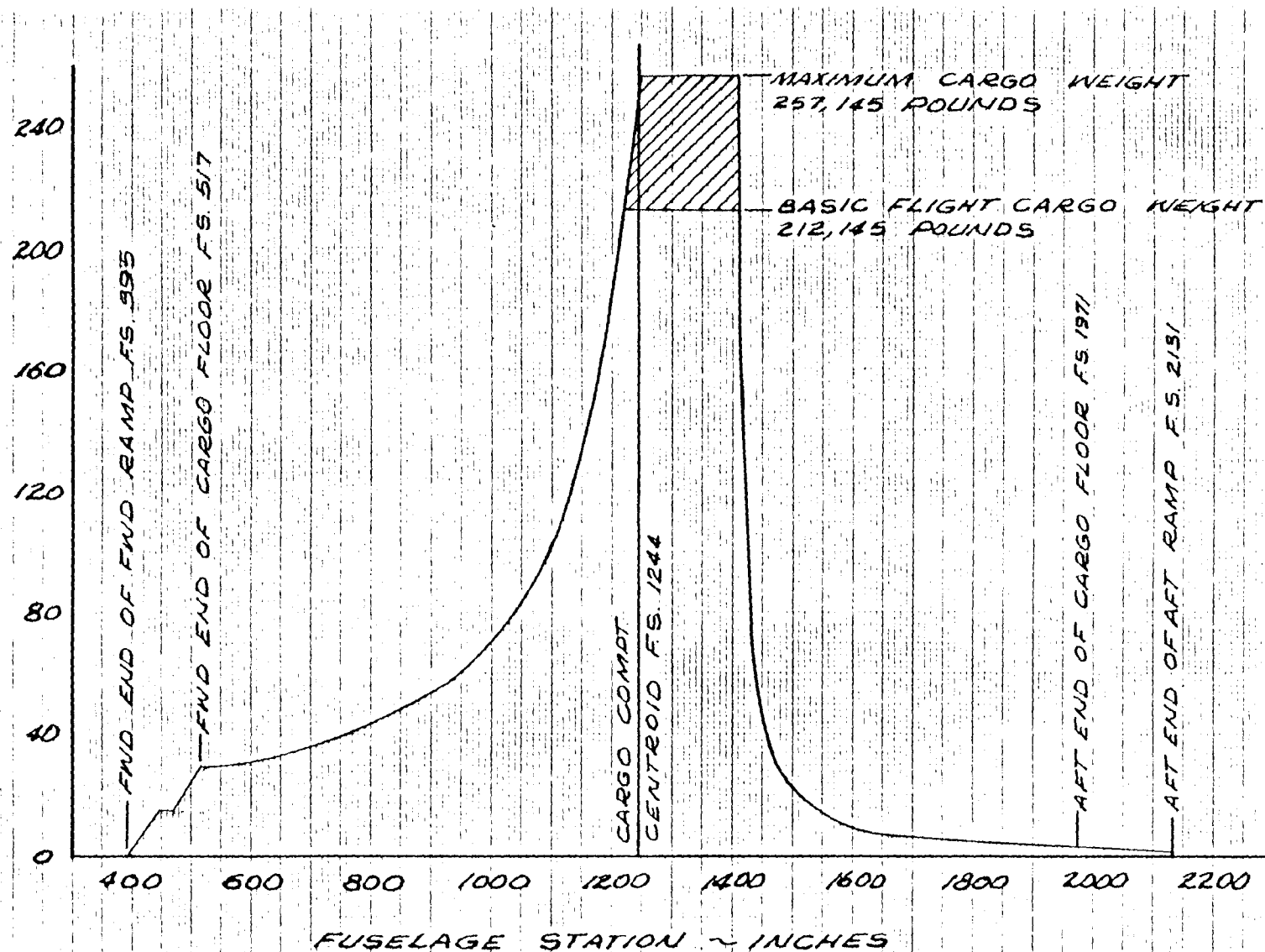
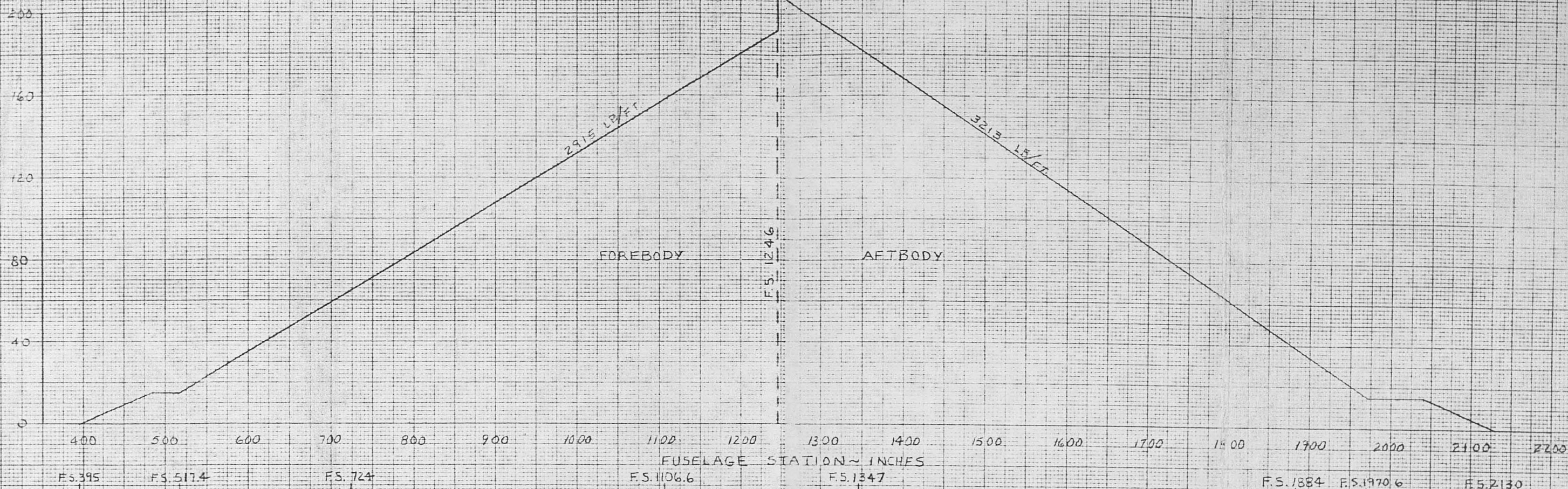


FIGURE 2.1-3
CARGO LOADING ENVELOPE

U.S. AIR FORCE
20 NOV 1968
J.E. DeLoraine

LG/US54-12-1
2-5A
2-1-5

MAXIMUM CARGO WEIGHT ~ 1,000 LB.



FORWARD
RAMP
TWO (2)
7,500 LB.
PALLET

ZONE A
15,000 LB. SINGLE
AXLE OR TWO (2)
10,000 LB. AXLES
SIDE BY SIDE

ZONE B
25,000 LB. SINGLE AXLE OR TWO (2) 18,000 LB. AXLES
SIDE BY SIDE

ZONE A
SAME AS
FOREBODY
ZONE A

AFT RAMP
TWO (2) 7,500
LB. PALLET

300 POUNDS PER SQUARE FOOT EXCEPT AS
LIMITED BY THE MAXIMUM CARGO WEIGHT
CURVE

400 POUNDS PER
SQUARE FOOT EXCEPT
AS LIMITED BY THE
MAXIMUM CARGO
WEIGHT CURVE

300 POUNDS PER SQUARE FOOT EXCEPT AS
LIMITED BY THE MAXIMUM CARGO WEIGHT
CURVE

LIMITATIONS DURING CARGO LOADING

ZONE A
ZONE B
FORWARD RAMP
AFT RAMP

THE AIR VEHICLE SHALL BE CAPABLE
OF SUPPORTING THE WEIGHT OF
VEHICLES, MISSILES, BULK, OR
PALLETIZED CARGO SUBJECTED TO
A LOAD FACTOR OF 1.33 g

NOTE: THE MAXIMUM CARGO WEIGHT CURVES DEFINE
THE MAXIMUM CARGO THAT CAN BE LOADED
FORWARD OF ANY FUSELAGE STATION IN THE
FOREBODY OR THAT CAN BE LOADED AFT OF
ANY FUSELAGE STATION IN THE AFTBODY
PROVIDED THE CENTER OF GRAVITY LIMITS
OF THE AIR VEHICLE ARE NOT EXCEEDED.

FIGURE 2.1-4

CARGO LOADING LIMITATIONS

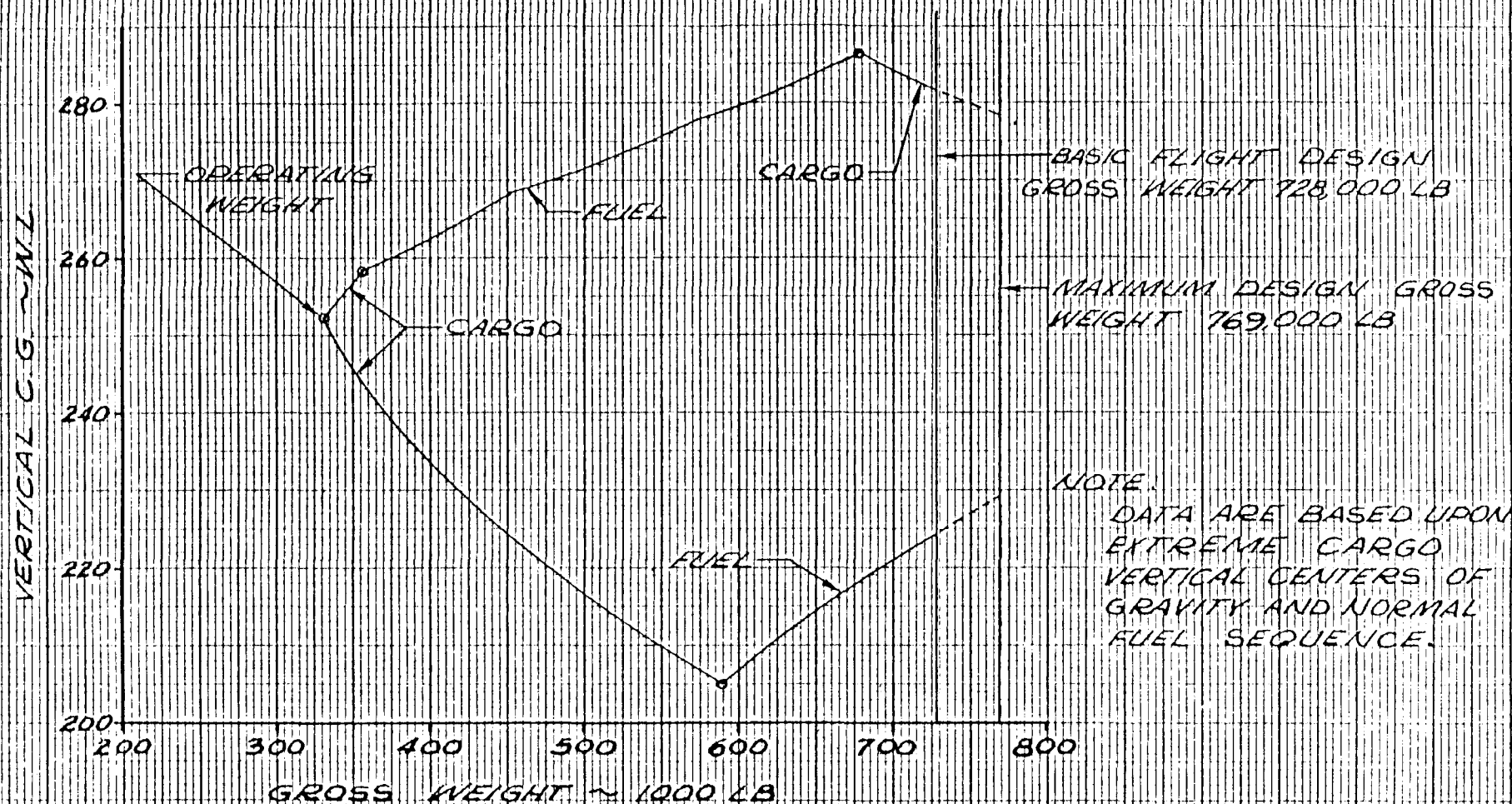


FIGURE 2.1-5
 VERTICAL CENTER OF GRAVITY ENVELOPE

NOTE

THIS ENVELOPE REPRESENTS THE COMBINED EFFECT OF NORMAL FUEL SEQUENCING AND "MOST ADVERSE" CARGO LOAD CONFIGURATIONS WITHIN THE ESTABLISHED G.G. LIMITS FOR THE AIR VEHICLE

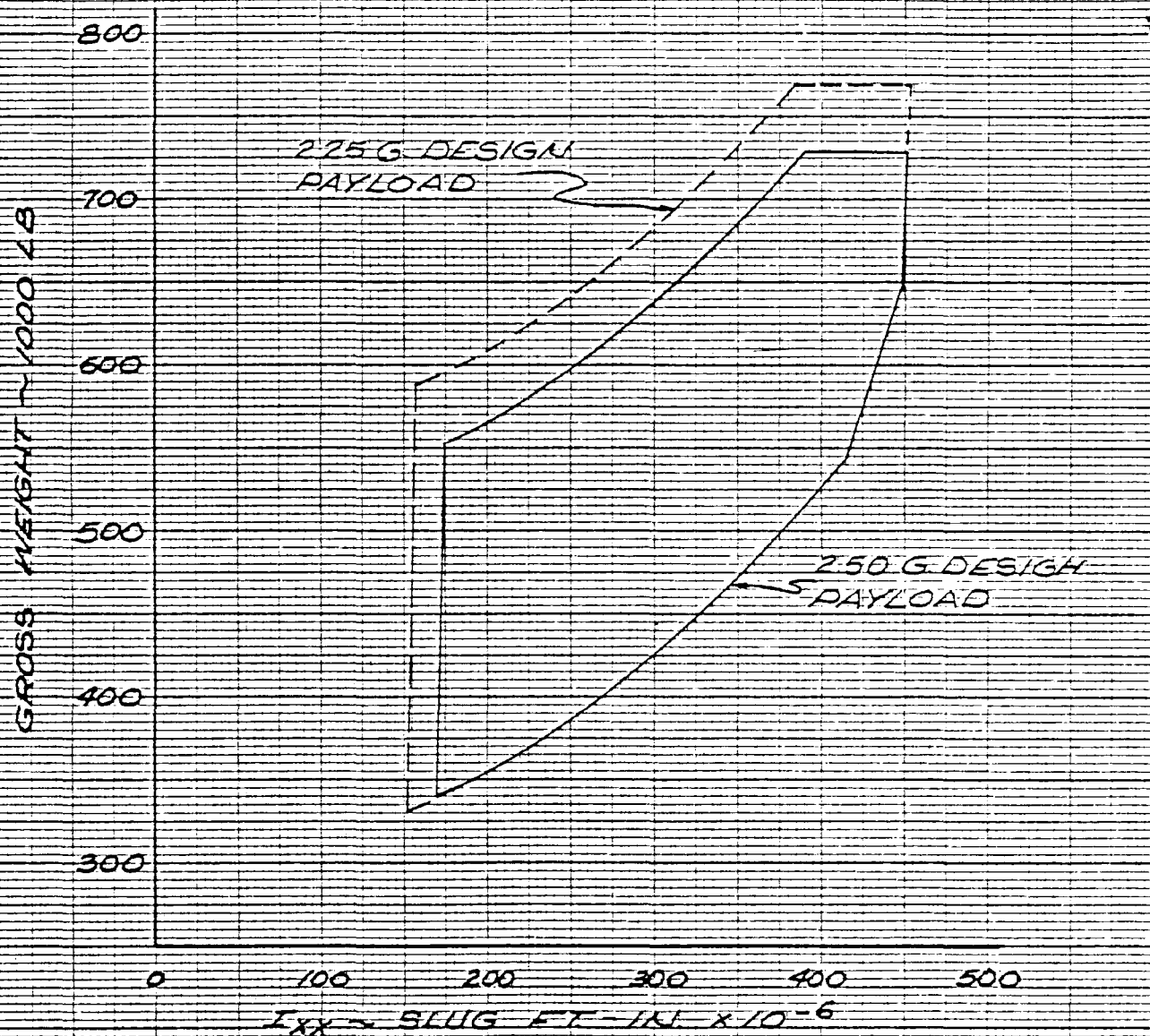


FIGURE 21-6

MAXIMUM ROLL MOMENT OF INERTIA

PREPARED BY J.A. BAY
DATE 20 NOV 1968
CHECKED BY D.H. MARTIN

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NOTE:

THIS ENVELOPE REPRESENTS THE COMBINED EFFECT OF NORMAL FUEL SEQUENCING AND "MOST ADVERSE" CARGO LOAD CONFIGURATIONS WITHIN THE ESTABLISHED C.G. LIMITS FOR THE AIR VEHICLE.

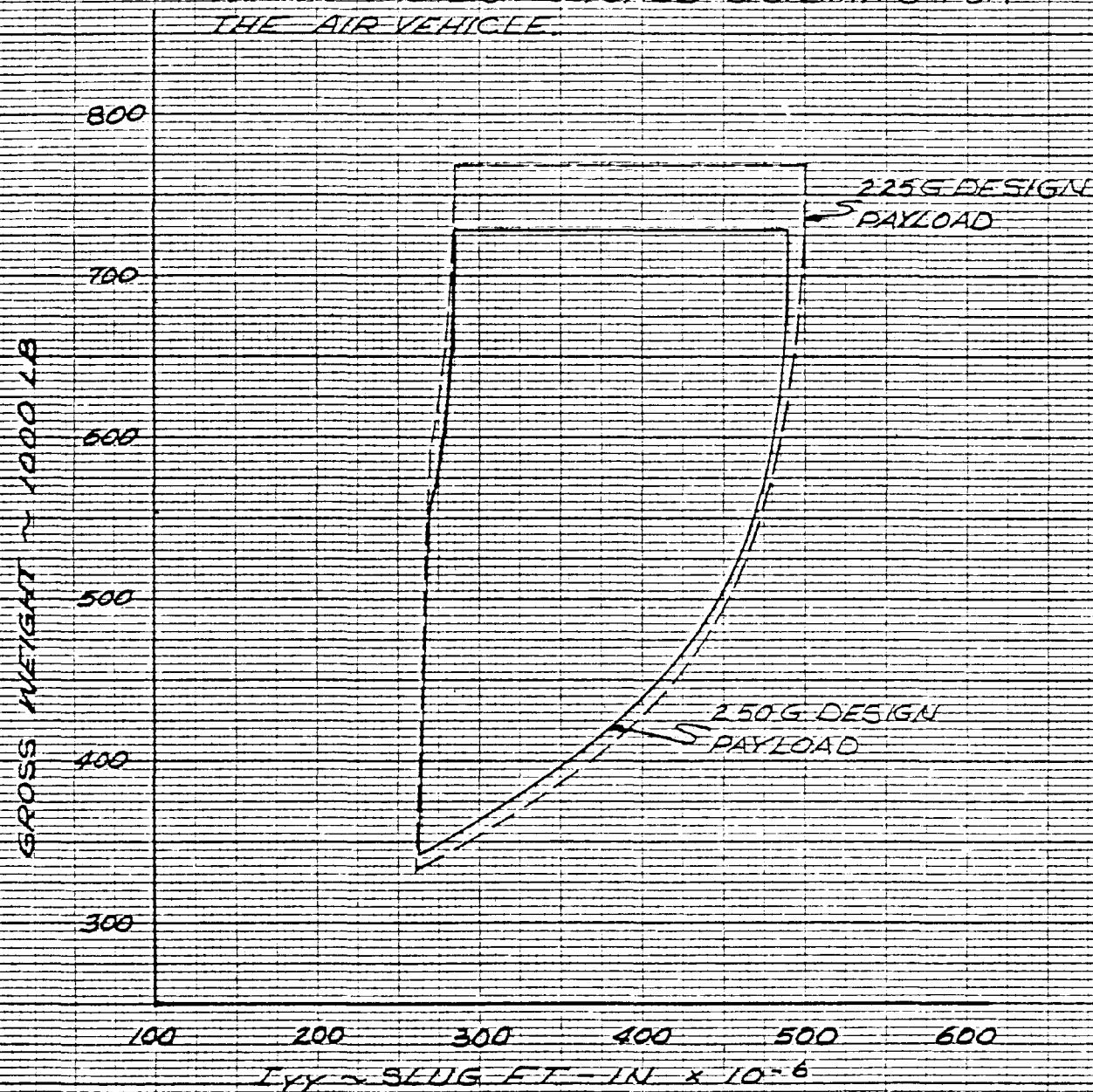


FIGURE 2.1-7

MAXIMUM PITCH MOMENT OF INERTIA

NOTE:

THIS ENVELOPE REPRESENTS THE COMBINED EFFECT OF NORMAL FUEL SEQUENCING AND "MOST ADVERSE" CARGO LOAD CONFIGURATIONS WITHIN THE ESTABLISHED C.G. LIMITS FOR THE AIR VEHICLE.

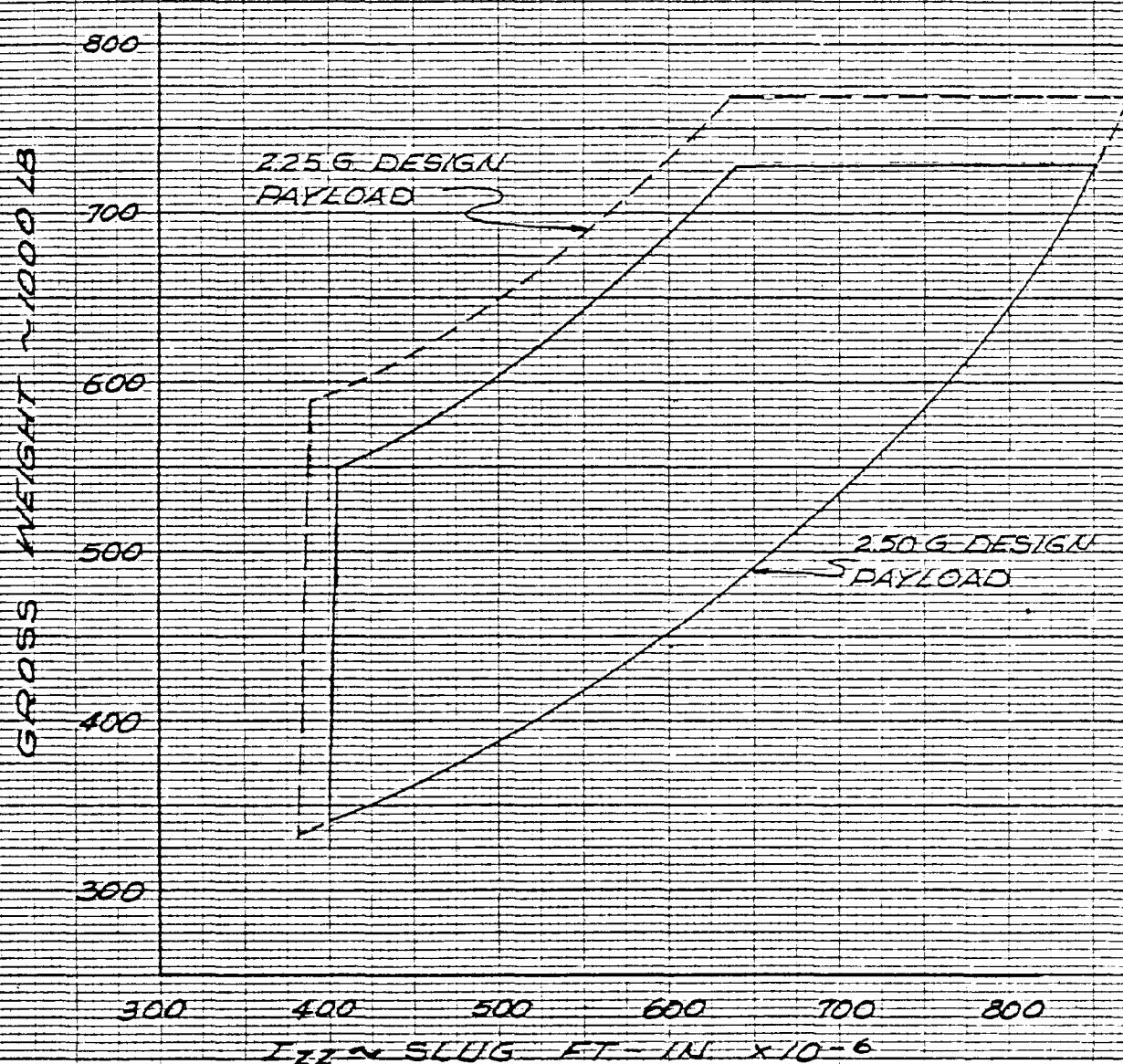


FIGURE 2.1-8

MAXIMUM YAW MOMENT OF INERTIA

NOTE

THIS ENVELOPE REPRESENTS THE COMBINED EFFECT OF NORMAL FUEL SEQUENCING AND "MOST ADVERSE" CARGO LOAD CONFIGURATIONS WITHIN THE ESTABLISHED C.G. LIMITS FOR THE AIR VEHICLE.



FIGURE 21-9

PRODUCT OF INERTIA

PREPARED BY J.R. Delbridge
DATE 20 Nov 1968
CHECKED BY J.A. Bay

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

REPORT NO LG/US54-12-1
MODEL C-5A
PAGE 2.1-12

OPERATING WEIGHT = 323,700 LB.

LANDING FUEL = 159,250 LB.

CAPACITY FUEL = 318,500 LB.

□ MANEUVER LOAD FACTOR OF 2.50

▨ MANEUVER LOAD FACTOR OF 2.25

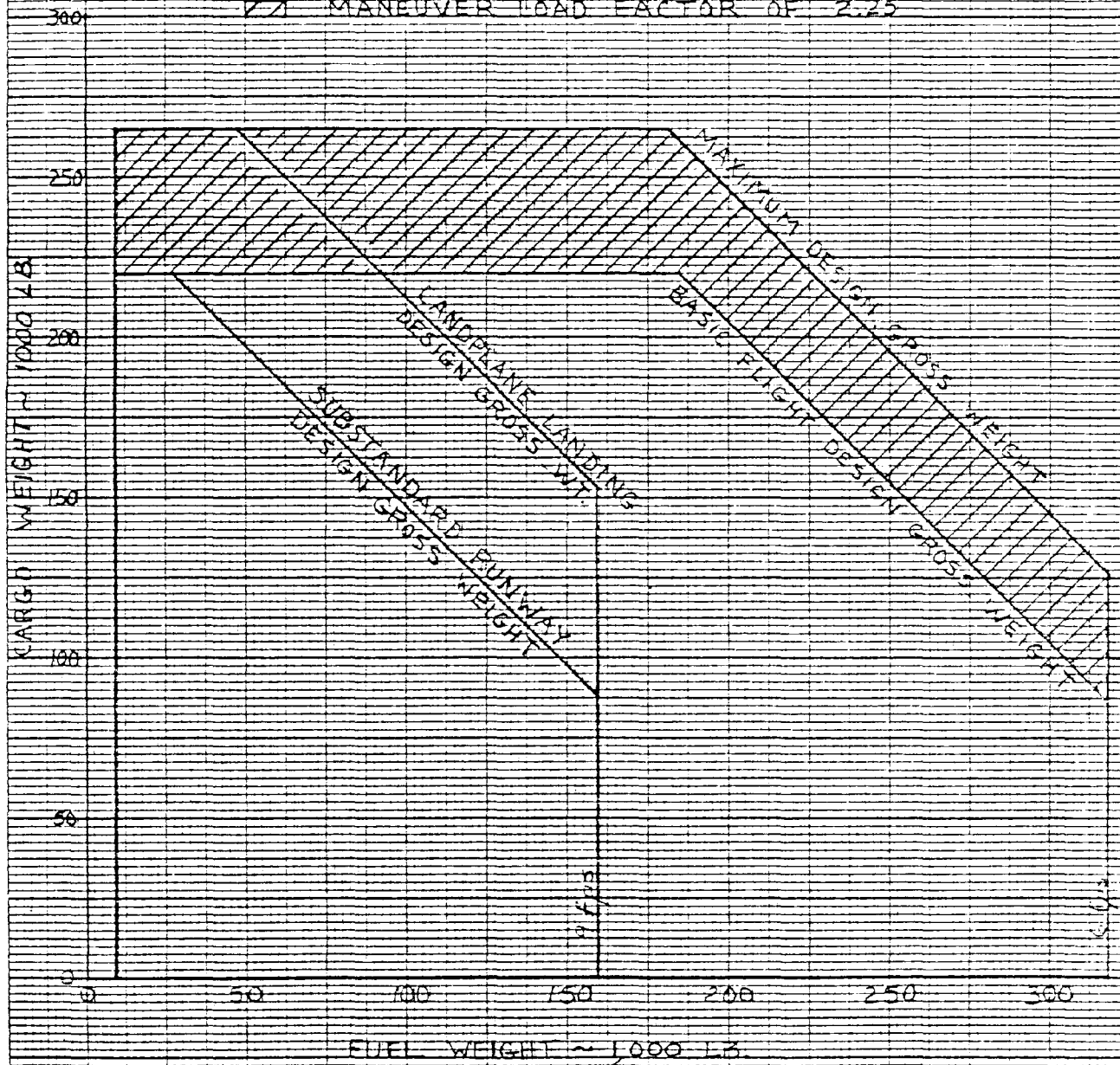


FIGURE 2.1-10

WEIGHT LIMITATIONS FOR STRUCTURAL DESIGN

2.1.2 Structurally Significant Weights. The Structural Design Weights shown in Table 2.1-I were used for load and aerodynamic analysis in the design of the C-5A air vehicle. They are presented here for comparison with the Structural Weights of Table 2.1-II. Derivations of the following conditions are presented in these two tables.

a. Weight Empty

The weight empty is the basis for the derivation of all other structural weights.

b. Operating Weight

The zero fuel weights are derived by adding cargo weight to the operating weight. The 100% operating capability of the air vehicle is based on this operating weight.

c. Minimum Flying Gross Weight

This weight is the minimum weight at which the air vehicle can be subjected to flight loads. The gust load factors are a maximum at this weight, and all fixed equipment attachments are designed for at least the load factors associated with this gross weight.

d. Zero Fuel Gross Weights

The zero fuel weights provide an index to the maximum wing loads attainable in flight.

e. Minimum Fuel Gross Weights

These weights are structurally significant since the associated cargo-fuel combinations yield the minimum inertia relief for the wing in combination with high aerodynamic loads on the wing.

f. Landplane Landing Design Gross Weight

This weight is the maximum gross weight permissible for landing the air vehicle at the maximum sink rate of 9 feet per second on a standard runway.

g. Maximum Landing Design Gross Weight

This is the maximum gross weight permissible for landing the air vehicle at a sinking speed of 6 feet per second.

h. Basic Flight Design Gross Weight

The basic flight design gross weight is the lift-off weight for the basic mission of the C-5A air vehicle. It is also the maximum weight at which the air vehicle may be submitted to a maneuver load factor of 2.5.

2.1.2 (Continued)

i. Maximum Design Gross Weight

This is the maximum gross weight the air vehicle is allowed to attain under any cargo/fuel combination. The maximum maneuver load factor for this configuration is 2.25.

j. Substandard Runway Design Gross Weight

This is the maximum design weight for operation on substandard runways. Its design sink rate is 9 feet per second.

Table 2.1-III presents a summary of the inertia data associated with various structural weights. Operating Weight inertia data are tabulated showing the major air vehicle components for the landing gear up and down in Tables 2.1-IV and 2.1-V respectively. Table 2.1-VI presents a sample inertia calculation for the Basic Flight Design Gross Weight.

TABLE 2.1-I
STRUCTURAL DESIGN WEIGHTS

WEIGHT CONDITION	WEIGHT POUNDS	REMARKS	
Weight Empty	318,469*	This weight includes all structure, power plant installations, and fixed equipment	
Crew, Equipment and Miscellaneous	5,435	Crew (6)	1,290
		Unusable Fuel	1,730
		Oil-Trapped	36
		-Engine	288
		Life Rafts and Survival Kits	180
		Food and Water	120
		Emergency Transmitter	41
		Tie-down Devices	1,750
			5,435
Operating Weight	323,904		
Deletion Potential	2,736	Crew (3)	645
		Life Rafts & Survival Kits	180
		Emergency Transmitter	41
		Food and Water	120
		Cargo Tie-down Devices	1,750
			2,736
Minimum Reserve Fuel	9,300	Fuel for 45 minutes at 10,000 feet altitude at speed for maximum range	
Minimum Flying Gross Weight	330,468	Operating Weight minus deletion potential plus reserve fuel	
Zero Fuel Gross Weight		Operating Weight Plus Cargo	
100,000 lb. Cargo	423,904	Maneuver Load Factor of 2.50	
220,000 lb. Cargo	543,904	Maneuver Load Factor of 2.50	
265,000 lb. Cargo	588,904	Maneuver Load Factor of 2.25	

*ECP No. 260 "Redesign of Empennage Bullet Fairing" which was approved per CCN No. 649 increased the Guaranteed Weight Empty by 1,340 pounds, the Structural Design Weights were not revised.

TABLE 2.1-I (CONTINUED)
STRUCTURAL DESIGN WEIGHTS (CONTINUED)

WEIGHT CONDITION	WEIGHT POUNDS	REMARKS
Minimum Fuel Gross Weight		Zero Fuel Weight plus Minimum Reserve Fuel
100,000 lb. Cargo	433,204	Maneuver Load Factor of 2.50
220,000 lb. Cargo	553,204	Maneuver Load Factor of 2.50
265,000 lb. Cargo	598,204	Maneuver Load Factor of 2.25
Landplane Landing Design Gross Weight	635,850	9 Feet Per Second Sink Rate
Maximum Landing Design Gross Weight	769,000	6 Feet Per Second Sink Rate
Basic Flight Design Gross Weight		
100,000 lb. Cargo	728,000	Maneuver Load Factor of 2.50
220,000 lb. Cargo	728,000	Maneuver Load Factor of 2.50
Maximum Design Gross Weight		
265,000 lb. Cargo	769,000	Maneuver Load Factor of 2.25
Substandard Runway Design Gross Weight	571,000	9 Feet Per Second Sink Rate
Capacity Fuel	318,500	49,000 Gallons at 6.5 lb. per gallon

TABLE 2.1-II
STRUCTURAL WEIGHTS

<u>WEIGHT CONDITION</u>	<u>WEIGHT POUNDS</u>	<u>REMARKS</u>
Weight Empty (Actual)	327,000	This weight includes all structure, power plant installations, and fixed equipment
Crew, Equipment and Miscellaneous	4,759	Crew (6) 1,290 Unusable Fuel 1,130 Oil - Trapped 58 - Engine 206 Life Rafts (Incl. Equipment) 202 Food (Crew) 17 Water (Crew) 43 Tie-Down Devices 1,750 Liquid Oxygen (Crew - 25 Liters) 63 4,759
Operating Weight	331,759	
Deletion Potential	2,720	Crew (3) 645 Life Rafts (Incl. Equipment) 202 Food (Crew) 17 Water (Crew) 43 Tie-Down Devices 1,750 Liquid Oxygen (Crew - 25 Liters) 63 2,720
Minimum Reserve Fuel	9,300	Fuel for 45 minutes at 10,000 feet altitude at speed for maximum range
Minimum Flying Gross Weight	338,339	Operating Weight minus deletion potential plus reserve fuel

TABLE 2.1-II (CONTINUED)
STRUCTURAL WEIGHTS (CONTINUED)

<u>WEIGHT CONDITION</u>	<u>WEIGHT POUNDS</u>	<u>REMARKS</u>
Zero Fuel Gross Weight*		Operating Weight plus cargo
92,145 lb. Cargo	423,904	Maneuver Load Factor of 2.50
212,145 lb. Cargo	543,904	Maneuver Load Factor of 2.50
257,145 lb. Cargo	588,904	Maneuver Load Factor of 2.25
Minimum Fuel Gross Weight*		Zero Fuel Weight Plus Minimum Reserve Fuel
92,145 lb. Cargo	433,204	Maneuver Load Factor of 2.50
212,145 lb. Cargo	553,204	Maneuver Load Factor of 2.50
257,145 lb. Cargo	598,204	Maneuver Load Factor of 2.25
Landplane Landing Design Gross Weight	635,850	9 Feet Per Second Sink Rate
Maximum Landing Design Gross Weight	769,000	6 Feet Per Second Sink Rate
Basic Flight Design Gross Weight		
92,145 lb. Cargo	728,000	Maneuver Load Factor of 2.50
212,145 lb. Cargo	728,000	Maneuver Load Factor of 2.50
Maximum Design Gross Weight		
257,145 lb. Cargo	769,000	Maneuver Load Factor of 2.25
Substandard Runway Design Gross Weight	571,000	9 Feet Per Second Sink Rate
Capacity Fuel	318,500	49,000 Gallons at 6.5 lb. per gallon

*These are Structural Design Zero Fuel weights and therefore do not reflect any affect of CCN 649.

TABLE 2.1-III

STRUCTURAL WEIGHT ~ MOMENT OF INERTIA

CONDITION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XZ_0}	ϕ^*
					LB-IN ² x 10 ⁻⁶				
WEIGHT EMPTY (ACTUAL)									
L.G. UP	327,000	1399.3	0.7	255.4	56,570.7	98,815.9	143,788.8	10,573.3	6.81
L.G. DOWN	327,000	1399.1	0.7	252.2	57,366.0	99,317.2	144,356.8	10,609.2	6.85
OPERATING WEIGHT									
L.G. UP	331,759	1394.7	0.7	255.2	57,586.0	100,423.7	146,348.0	10,498.7	6.65
L.G. DOWN	331,759	1394.5	0.7	252.1	58,380.9	100,923.7	146,915.1	10,529.6	6.69
MINIMUM FLYING GROSS WEIGHT									
L.G. UP	338,339	1398.9	0.7	256.8	64,124.2	99,896.9	152,354.8	10,476.9	6.67
L.G. DOWN	338,339	1398.7	0.7	253.6	64,922.4	100,401.0	152,922.7	10,512.4	6.72
ZERO FUEL GROSS WEIGHT									
92,145 LB CARGO									
L.G. UP	423,904	1361.9	0.5	247.8	58,271.6	118,572.4	164,609.7	10,872.5	5.77
L.G. DOWN	423,904	1361.7	0.5	245.3	59,051.4	119,053.0	165,172.4	10,868.0	5.79
212,145 LB CARGO									
L.G. UP	543,904	1335.8	0.4	241.9	59,121.2	141,328.1	187,555.3	11,169.3	4.93
L.G. DOWN	543,904	1335.6	0.4	240.0	59,889.1	141,793.2	188,114.5	11,136.9	4.93
257,145 LB CARGO									
L.G. UP	588,904	1331.2	0.4	240.3	59,432.8	149,472.1	195,777.6	11,221.2	4.67
L.G. DOWN	588,904	1331.1	0.4	238.5	60,197.4	149,933.3	196,336.2	11,183.8	4.67

*Angle of inclination of the principal axis (nose down) with respect to the air vehicle "X" axis.

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TABLE 2.1-III (CONTD.)

STRUCTURAL WEIGHT ~ MOMENT OF INERTIA (CONTD.)

CONDITION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XZ_0}	Φ^*
					LB-IN ² x 10 ⁻⁶				
MINIMUM FUEL GROSS WEIGHT									
92,145 LB CARGO									
L.G. UP	433,204	1363.7	0.5	248.8	64,953.4	119,030.8	171,680.3	10,843.1	4.74
L.G. DOWN	433,204	1363.5	0.5	246.4	65,735.6	112,514.0	172,243.3	10,840.5	4.75
212,145 LB CARGO									
L.G. UP	553,204	1337.6	0.4	242.8	65,808.7	141,837.9	194,671.6	11,157.4	4.91
L.G. DOWN	553,204	1337.4	0.4	240.9	66,578.5	142,305.3	195,231.2	11,127.0	4.91
257,145 LB CARGO									
L.G. UP	598,204	1333.0	0.4	241.2	66,121.9	149,993.0	202,903.4	11,213.3	4.66
L.G. DOWN	598,204	1332.9	0.4	239.4	66,888.4	150,456.3	203,462.3	11,176.8	4.65
LANDPLANE LANDING DESIGN G.W.									
46,946 LB FUEL) L.G. UP	635,850	1338.2	0.4	244.6	90,165.3	152,405.0	228,753.6	11,078.1	4.54
257,145 LB CARGO) L.G. DOWN	635,850	1338.1	0.4	242.9	90,939.0	152,876.3	229,313.2	11,048.4	4.54
159,250 LB FUEL) L.G. UP	635,850	1362.9	0.4	260.3	139,658.6	134,542.5	260,619.1	10,635.5	4.99
144,841 LB CARGO) L.G. DOWN	635,850	1362.8	0.4	258.7	140,465.8	135,050.6	261,182.0	10,633.0	5.00
MAXIMUM LANDING DESIGN G.W.									
180,096 LB FUEL) L.G. UP	769,000	1347.9	0.3	256.1	148,274.5	156,041.0	289,892.2	11,084.6	4.45
257,145 LB CARGO) L.G. DOWN	769,000	1347.8	0.3	254.7	149,073.1	156,538.5	290,453.1	11,066.0	4.45
318,500 LB FUEL) L.G. UP	769,000	1366.8	0.3	275.8	170,589.4	130,969.9	286,790.2	10,309.7	5.03
118,741 LB CARGO) L.G. DOWN	769,000	1366.7	0.3	274.5	171,429.8	131,511.7	287,353.6	10,312.4	5.04

*Angle of inclination of the principal axis (nose down) with respect to the air vehicle "X" axis.

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TABLE 2.1-III (CONTD.)

STRUCTURAL WEIGHT ~ MOMENT OF INERTIA (CONTD.)

CONDITION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XZ_0}	Φ^*
					LB-IN ² x 10 ⁻⁶				
BASIC FLIGHT DESIGN GROSS WEIGHT									
304,096 LB FUEL } L.G. UP	728,000	1373.6	0.3	276.4	168,952.9	125,580.0	280,263.8	10,213.1	5.20
92,145 LB CARGO } L.G. DOWN	728,000	1373.5	0.3	274.9	169,794.5	126,124.0	280,828.2	10,223.1	5.22
184,096 LB FUEL } L.G. UP	728,000	1352.5	0.3	258.7	149,302.1	147,933.9	282,857.2	10,972.2	4.67
212,145 LB CARGO } L.G. DOWN	728,000	1352.4	0.3	257.2	150,106.0	148,437.3	283,418.7	10,958.7	4.67
318,500 LB FUEL } L.G. UP	728,000	1373.7	0.3	278.9	170,191.8	122,877.7	278,740.6	10,017.1	5.23
77,741 LB CARGO } L.G. DOWN	728,000	1373.6	0.3	277.5	171,038.7	123,426.9	279,304.6	10,027.4	5.25
MAXIMUM DESIGN GROSS WEIGHT	(Same as Maximum Landing Design Gross Weight)								
SUBSTANDARD RUNWAY DESIGN G.W.									
27,096 LB FUEL } L.G. UP	571,000	1340.5	0.4	244.4	77,884.4	143,060.8	207,709.6	11,125.5	4.86
212,145 LB CARGO } L.G. DOWN	571,000	1340.4	0.4	242.5	78,657.6	143,531.9	208,269.5	11,098.3	4.86
159,250 LB FUEL } L.G. UP	571,000	1376.4	0.4	264.8	139,124.1	121,849.4	247,898.6	10,296.7	5.36
79,991 LB CARGO } L.G. DOWN	571,000	1376.3	0.4	262.9	139,940.6	122,368.5	248,463.2	10,308.9	5.38

*Angle of inclination of the principal axis (nose down) with respect to the air vehicle "X" axis.

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TABLE 2.1-IV

OPERATING WEIGHT MOMENT OF INERTIA (LANDING GEAR UP)

ITEM	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XZ_0}
					(LB-IN ² x 10 ⁻⁶)			
WING - LEFT	39,232.5	1433.1	568.7	312.7	3,731.1	972.0	4,630.1	- 140.4
WING - RIGHT	39,232.5	1433.1	-568.7	312.7	3,731.1	972.0	4,630.1	- 140.4
FUSELAGE	149,927.4	1303.1	1.6	219.5	2,576.1	59,358.4	59,226.4	688.0
HORIZONTAL TAIL - LEFT	3,275.4	2921.3	140.1	787.5	41.0	11.5	51.5	- 1.3
HORIZONTAL TAIL -RIGHT	3,275.4	2921.3	-140.1	787.5	41.0	11.5	51.5	- 1.3
BULLET	769.4	2895.6	0.0	786.6	0.5	9.8	9.8	- 0.4
VERTICAL TAIL	6,151.0	2786.6	- 0.1	633.1	85.5	142.9	59.8	43.2
MAIN L.G. - LEFT	14,869.3	1452.9	101.9	114.5	34.4	194.4	224.8	0.0
MAIN L.G. - RIGHT	14,869.3	1452.9	-101.9	114.5	34.4	194.4	224.8	0.0
NOSE LANDING GEAR	3,672.1	597.1	0.0	109.8	2.3	4.5	5.7	- 0.3
NO. 1 POWER PLANT	10,947.5	1331.9	745.4	200.2	11.4	54.4	49.6	4.6
NO. 2 POWER PLANT	10,911.5	1193.4	478.3	223.6	10.7	52.7	48.7	3.9
NO. 3 POWER PLANT	10,911.5	1193.4	-478.3	223.6	10.7	52.7	48.7	3.9
NO. 4 POWER PLANT	10,947.5	1331.9	-745.4	200.2	11.4	54.4	49.6	4.6
WING STUB	12,766.6	1236.4	0.0	352.7	13.8	42.2	46.6	- 1.0
TOTALS	331,758.9	1394.7	0.7	255.2	*57,586.0	*100,423.7	*146,348.0	*10,498.7

*Centroidal mass data with respect to the total operating weight C.G.

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TABLE 2.1-V

OPERATING WEIGHT MOMENT OF INERTIA (LANDING GEAR DOWN)

ITEM	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XZ_0}	
								(LB-IN ² x 10 ⁻⁶)	
WING - LEFT	39,232.5	1433.1	568.7	312.7	3,731.1	972.0	4,630.1	-	140.4
WING - RIGHT	39,232.5	1433.1	-568.7	312.7	3,731.1	972.0	4,630.1	-	140.4
FUSELAGE	149,927.4	1303.1	1.6	219.5	2,576.1	59,358.4	59,226.4		688.0
HORIZONTAL TAIL - LEFT	3,275.4	2921.3	140.1	787.5	41.0	11.5	51.5	-	1.3
HORIZONTAL TAIL -RIGHT	3,275.4	2921.3	-140.1	787.5	41.0	11.5	51.5	-	1.3
BULLET	769.4	2895.6	0.0	786.6	0.5	9.8	9.8	-	0.4
VERTICAL TAIL	6,151.0	2786.6	- 0.1	633.1	85.5	142.9	59.8		43.2
MAIN L.G. - LEFT	14,869.3	1452.2	154.2	82.2	26.1	207.2	199.4		0.3
MAIN L.G. - RIGHT	14,869.3	1452.2	-154.2	82.2	26.1	207.2	199.4		0.3
NOSE LANDING GEAR	3,672.1	578.6	0.0	85.6	4.9	3.7	2.4	-	0.5
NO. 1 POWER PLANT	10,947.5	1331.9	745.4	200.2	11.4	54.4	49.6		4.6
NO. 2 POWER PLANT	10,911.5	1193.4	478.3	223.6	10.7	52.7	48.7		3.9
NO. 3 POWER PLANT	10,911.5	1193.4	-478.3	223.6	10.7	52.7	48.7		3.9
NO. 4 POWER PLANT	10,947.5	1331.9	-745.4	200.2	11.4	54.4	49.6		4.6
WING STUB	12,766.6	1236.4	0.0	352.7	13.8	42.2	46.6	-	1.0
TOTALS	331,758.9	1394.5	0.7	252.1	*58,380.9	*100,923.7	*146,915.1	*10,529.6	

*Centroidal mass data with respect to the total operating weight C.G.

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TABLE 2.1-VI
SAMPLE CALCULATION ~ MOMENT OF INERTIA

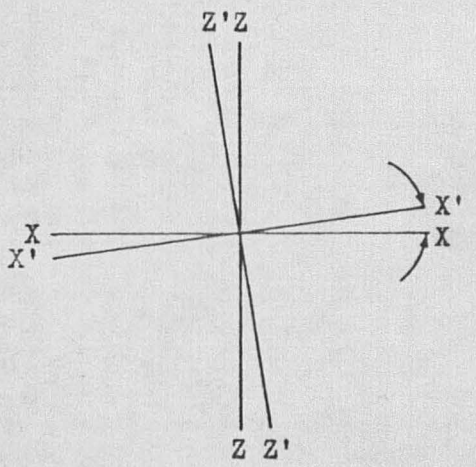
ITEM	W	$\bar{X}$	$\bar{Y}$	$\bar{Z}$	ΔX $\bar{X}_i - \bar{X}_t$	ΔY $\bar{Y}_i - \bar{Y}_t$	ΔZ $\bar{Z}_i - \bar{Z}_t$	$W(\Delta \bar{X})^2$	$W(\Delta \bar{Y})^2$	$W(\Delta \bar{Z})^2$	I_{X_0}	I_{Y_0}	I_{Z_0}	$W(\Delta \bar{X})(\Delta \bar{Z})$	I_{XZ_0}
UNITS	(LB)	(F.S.)	(B.L.)	(W.L.)	INCHES			(LB-IN ² x 10 ⁻⁶)							
OPERATING WEIGHT	331,759	1394.5	0.7	252.1	42.1	0.4	- 5.1	588.0	53.1	8.6	58,380.9	100,923.7	146,915.1	- 71.2	10,529.6
FUEL LEFT	92,048	1402.0	608.2	308.1	49.6	607.9	50.9	226.5	34,015.7	238.5	10,740.0	2,700.0	13,300.0	232.4	- 400.0
FUEL RIGHT	92,048	1402.0	- 608.2	308.1	49.6	-608.5	50.9	226.5	34,082.8	238.5	10,740.0	2,700.0	13,300.0	232.4	- 400.0
MAX CARGO + "2.5G"	212,145	1243.6	0.0	221.0	-108.8	- 0.3	- 36.2	2,511.2	0.0	278.0	1,382.9	37,797.8	38,252.8	835.5	0.0
BASIC FLIGHT DESIGN GROSS WEIGHT(L.G. DOWN)	Σ 728,000	Σ 1352.4	Σ 0.3	Σ 257.2				Σ 3,552.2	Σ 68,098.6	Σ 763.6	Σ 81,243.8	Σ 144,121.5	Σ 211,767.9	Σ 1,229.1	Σ 9,729.6

$\bar{X}_i - \bar{X}_t = \bar{X}$ ITEM - $\bar{X}$ TOTAL
 $\bar{Y}_i - \bar{Y}_t = \bar{Y}$ ITEM - $\bar{Y}$ TOTAL
 $\bar{Z}_i - \bar{Z}_t = \bar{Z}$ ITEM - $\bar{Z}$ TOTAL

$I_{X_{CG}} = \Sigma I_{X_0} + \Sigma W(\Delta \bar{Y})^2 + \Sigma W(\Delta \bar{Z})^2 = 150,106.0$
 $I_{Y_{CG}} = \Sigma I_{Y_0} + \Sigma W(\Delta \bar{X})^2 + \Sigma W(\Delta \bar{Z})^2 = 148,437.3$
 $I_{Z_{CG}} = \Sigma I_{Z_0} + \Sigma W(\Delta \bar{X})^2 + \Sigma W(\Delta \bar{Y})^2 = 283,418.7$
 $I_{XZ_{CG}} = \Sigma I_{XZ_0} + \Sigma W(\Delta \bar{X})(\Delta \bar{Z}) = 10,958.7$

PRINCIPAL AXIS CALCULATION:

$TAN 2 \theta = \frac{2 I_{XZ}}{I_{ZZ} - I_{XX}} = 0.164406$
 $2 \theta = 9.34^\circ$
 $\theta = 4.67^\circ$ NOSE DOWN
 $SIN^2 \theta = 0.006629, \cos^2 \theta = 0.993371, \sin 2 \theta = 0.162293$
 $I_{X'X'} = I_{XX} \cos^2 \theta + I_{ZZ} \sin^2 \theta + I_{XZ} \sin 2 \theta = 149,211.2$
 $I_{Y'Y'} = I_{YY} = 148,437.3$
 $I_{Z'Z'} = I_{XX} \sin^2 \theta + I_{ZZ} \cos^2 \theta + I_{XZ} \sin 2 \theta = 284,313.5$
CHECK: $I_{X_{CG}} + I_{Z_{CG}} = 433,524.7 = I_{X'X'} + I_{Z'Z'}$



XX & ZZ = AIR VEHICLE AXIS
X'X' & Z'Z' = PRINCIPAL AXIS

2.1.3 Group Weight Statement. The following Group Weight Statement information is presented in the AN 9103-D modified form which incorporates all the requirements of Part I of Reference 4. This form is modified to allow for efficient usage of the computerized weight record system. Body Group-Fuselage-Basic Structure (Page 2.1-27 , line 23) includes 1079 pounds of manufacturing variation. This variation consists of unaccounted for weight and was distributed throughout the fuselage basic structure to enable the computerized weight records to show the actual weight condition. Pages 2.1-29 through 2.1-31 summarize the air vehicle gross weight conditions. Table 2.1-VII presents a tabulation of functional versus major component weight breakdown.

AN 9100-B-MODIFIED

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MODEL C-5A

PAGE 2.1-26

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

FORM 941

GROUP WEIGHT STATEMENT

CONTRACT NO. AF 33(657)-15053

AIRPLANE GOVERNMENT NO. 66-8303

AIRPLANE CONTRACTOR NO. 0001

MANUFACTURED BY LOCKHEED - GEORGIA COMPANY

ENGINE

MANUFACTURED BY GENERAL ELECTRIC

MODEL TF-39 - FOUR REQUIRED

1				
2	PROPULSION GROUP			35072.4
3	ENGINE INSTALLATION		25809.2	
4	AFTERBURNERS (IF FURNISHED SEPARATELY)			
5	ACCESSORY GEAR BOXES AND DRIVES (CSD)			.0
6	SUPERCHARGERS (FOR TURBO TYPES)			.0
7	AIR INDUCTION SYSTEM			.0
8	EXHAUST SYSTEM		281.6	
9	COOLING SYSTEM		209.0	
10	LUBRICATION SYSTEM		10.4	
11	TANKS			
12	COOLING SYSTEM			
13	DUCTS, PLUMBING, ETC.			
14	FUEL SYSTEM		2411.9	
15	TANKS - WING	580.2		
16	- BODY			
17	PLUMBING, ETC.	1831.7		
18	WATER INJECTION SYSTEM		.0	
19	ENGINE CONTROLS		173.7	
20	STARTING SYSTEM		179.2	
21	THRUST REVERSERS		3932.4	
22				
23	AUXILIARY POWER PLANT GROUP			971.3
24				
25	INSTRUMENTS AND NAVIGATIONAL EQUIPMENT GROUP			959.3
26				
27	HYDRAULIC GROUP			3530.7
28				
29	ELECTRICAL GROUP			3594.8
30				
31	ELECTRONICS GROUP			3946.5
32	EQUIPMENT		2571.3	
33	INSTALLATION		1377.2	
34				
35	ARMAMENT GROUP			
36				
37	FURNISHINGS AND EQUIPMENT GROUP			6730.6
38	ACCOMMODATIONS FOR PERSONNEL		2109.3	
39	MISCELLANEOUS EQUIPMENT		911.5	
40	FURNISHINGS		3301.7	
41	EMERGENCY EQUIPMENT		458.1	
42				
43				
44				
45				
46	AIR CONDITIONING AND ANTI-ICING GROUP			4112.5
47	AIR CONDITIONING		3871.6	
48	ANTI-ICING		240.9	
49				
50	AUXILIARY GEAR GROUP			263.0
51	HANDLING GEAR		268.0	
52	ARRESTING GEAR		.0	
53	CATAPULTING GEAR		.0	
54				
55	MANUFACTURING VARIATION (INCLUDED IN BODY GROUP)			
56	TOTAL FROM PRECEDING PAGE			266761.7
57	WEIGHT EMPTY			326999.9

1			OPERAT	FLT DES	FLT DES	MAX DES
2	LOAD CONDITION		WEIGHT	MAX CAR	MAX FUEL	MAX CAR
3						
4	CREW (NO. 6) (INCLUDING BAGGAGE)		1290	1290	1290	1290
5						
6						
7	FUEL	TYPE	GAL.			
8	UNUSABLE	JP-4	174	1130	1130	1130
9	INTERNAL	JP-4	0	0		
10	INTERNAL	JP-4	28322	184096		
11	INTERNAL	JP-4	49000		318500	
12	INTERNAL	JP-4	27707			180096
13						
14						
15	OIL					
16	TRAPPED		58	58	58	58
17	ENGINE		206	206	206	206
18						
19						
20	BAGGAGE - CREW (INCLUDED IN CREW WEIGHT)					
21	TIEDOWN DEVICES		1750	1750	1750	1750
22						
23						
24	PAYLOAD		(0)	(212145)	(77741)	(257145)
25	DELIVERABLE CARGO					
26	AUXILIARY CREW					
27	BAGGAGE					
28	PASSENGERS/TROOPS					
29	PALLETS (300 LB EACH)			6600	2400	7800
30	PALLET NETS (75 LB-EACH)			1650	600	1950
31	PALLET LOAD			203215	74061	246715
32	VEHICLES					
33	CHAINS (IN EXCESS OF 1750 LB)					
34	ARM KIT			680	680	680
35	REMOVABLE TROOP PROVISIONS					
36	AFT TIE RAMP					
37						
38						
39						
40						
41						
42						
43	EQUIPMENT					
44	PYROTECHNICS					
45	PHOTOGRAPHIC					
46	LIFE RAFTS - CREW (INCL. EQUIPMENT)		202	202	202	202
47	OXYGEN (25 LITERS)		63	63	63	63
48	FOOD - CREW		17	17	17	17
49	WATER - CREW		43	43	43	43
50						
51						
52						
53						
54						
55	USEFUL LOAD		4759	401000	401000	442000
56	WEIGHT EMPTY		327000	327000	327000	327000
57	GROSS WEIGHT		331759	728000	728000	769000

1				MAY DES	FERRY	LOAD	PERSON
2	LOAD CONDITION			MAY FUEL	MISSION	LOADING	PAYLOAD
3							
4	CREW (NO. 6) (INCLUDING BAGGAGE)			1290	1290	1290	1290
5							
6							
7	FUEL	TYPE	GAL.				
8	UNUSABLE	JP-4	174	1130	1130	1130	1130
9	INTERNAL	JP-4	49,000	318500	318500		
10	INTERNAL	JP-4	7,222			46946	
11	INTERNAL	JP-4	28,322				184096
12	INTERNAL	JP-4					
13							
14							
15	OIL						
16	TRAPPED			58	58	58	58
17	ENGINE			206	206	206	206
18							
19							
20	BAGGAGE - CREW (INCLUDED IN CREW WEIGHT)						
21	TIEDOWN DEVICES			1750	1750	1750	1750
22							
23							
24	PAYLOAD			(118741)	(0)	(257145)	(212145)
25	DELIVERABLE CARGO						
26	AUXILIARY CREW						
27	BAGGAGE						3560
28	PASSENGERS/TROOPS (89 AND)						17800
29	PALLETS (300 LB EACH)			3600		7800	5700
30	PALLET NETS (75 LB EACH)			900		1950	1425
31	PALLET LOAD			113561		246715	175234
32	VEHICLES						
33	CHAINS (IN EXCESS OF 1750 LB)						
34	ARM KIT			680		680	
35	REMOVABLE TROOP PROVISIONS						7067
36	AFT TIE RAMPS						
37	OXYGEN KIT (75 LITERS)						187
38	PALLETIZED KIT - CARGO COMPARTMENT						
39	(INCLUDES OXYGEN KIT)						
40	FOOD AND WATER						1172
41							
42							
43	EQUIPMENT						
44	PYROTECHNICS						
45	PHOTOGRAPHIC						
46	LIFE RAFTS - CREW (INCL. EQUIPMENT)			202	202	202	202
47	OXYGEN (25 LITERS)			63	63	63	63
48	FOOD - CREW			17	17	17	17
49	WATER - CREW			43	43	43	43
50							
51							
52							
53							
54							
55	USEFUL LOAD			442000	323259	308850	401000
56	WEIGHT EMPTY			327000	327000	327000	327000
57	GROSS WEIGHT			769000	650259	635850	728000

AN 9103-D-MODIFIED

GROSS WEIGHT STATEMENT

REPORT LG1US54-12-1

GROSS WEIGHT

MODEL C-5A

DATE 20 NOV 68

PAGE 2.1-31

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

GA FORM 891J

1			TYPICAL	MAC
2	LOAD CONDITION		VEHICLE	PASSNGR
3				
4	CREW (NO. 6) (INCLUDING BAGGAGE)		1290	1290
5				
6				
7	FUEL	TYPE	GAL.	
8	UNUSABLE	JP-4	174	1130
9	INTERNAL	JP-4	28761	186949
10	INTERNAL	JP-4	41346	268751
11	INTERNAL	JP-4		
12	INTERNAL	JP-4		
13				
14				
15	OIL			
16	TRAPPED		58	58
17	ENGINE		206	206
18				
19				
20	BAGGAGE - CREW (INCLUDED IN CREW WEIGHT)			
21	TIEDOWN DEVICES		1750	1750
22				
23				
24	PAYLOAD		(209292)	(127490)
25	DELIVERABLE CARGO			
26	AUXILIARY CREW			
27	BAGGAGE			14360
28	PASSENGERS/TROOPS (359)			71800
29	PALLETS (LB EACH)			
30	PALLET NETS (LB EACH)			
31	PALLET LOAD			
32	VEHICLES		209292	
33	CHAINS (IN EXCESS OF LB)			
34	WRM KIT			
35	REMOVABLE TROOP PROVISIONS			7067
36	AFT TIE RAMPS			
37	OXYGEN KIT (75 LITERS)			187
38	PALLETIZED KIT - CARGO COMPARTMENT			30509
39	(INCLUDES OXYGEN KIT)			
40	FOOD AND WATER			3567
41				
42				
43	EQUIPMENT			
44	PYROTECHNICS			
45	PHOTOGRAPHIC			
46	LIFE RAFTS - CREW (INCL. EQUIPMENT)		202	202
47	OXYGEN (25 LITERS)		63	63
48	FOOD - CREW		17	17
49	WATER - CREW		43	43
50				
51				
52				
53				
54				
55	USEFUL LOAD		401000	401000
56	WEIGHT EMPTY		327000	327000
57	GROSS WEIGHT		728000	728000

1	1	LENGTH - OVERALL (FT)	247.80	HEIGHT - OVERALL (FT)	65.1
2	2	LOADABLE/CARGO/CABLE/CARGOABLE			
3	3	FWD CARGO			MACELLES /SIDE
4	4	RAMP RAMP	13.4	CONOT FUSE	INOC OUT30
5	5	LENGTH - MAX (FT)	9.8	121.1	144.8
6	6	DEPTH - MAX (FT)		13.5	26.9
7	7	WIDTH - MAX (FT)	19.0	19.0	23.8
8	8	WETTED AREA (SQ FT)			16645.7
9	9	FLAT SURF (SQ FT)	186.1	2300.9	2741.6
10	10	FUSE VOLUME (CU FT)		PRESSURIZED	65631.7
11	11			TOTAL	86610.1
12	12				
13	13			WING	H. TAIL V. TAIL
14	14	GROSS AREA (SQ. FT)		6200.0	965.8
15	15	EXPOSED PLATFORM AREA (SQ FT)		5077.5	875.8
16	16	SPAN (FT)		222.7	88.7
17	17	EXPOSED WETTED AREA (SQ FT)		10356.2	1843.6
18	18	STRUCTURAL BOX WIDTH AT BODY JUNCTION (IN)		240.4	117.4
19	19	SWEEPBACK AT 25 * CHORD (DEGREES) - C.L. TO BREAK		24.0	24.6
20	20			25.0	24.6
21	21	THEOR. ROOT CHORD (IN.) - INBD L.E. AND T.E. EXTD.		545.3	250.2
22	22	- MAX THICK (IN) EXTD TO CL		71.5	26.3
23	23	CHORD AT PLATFORM BREAK (IN.) - LENGTH		336.4	
24	24			37.3	
25	25	THEORETICAL TIP CHORD (IN.) - LENGTH		184.0	92.6
26	26			19.8	9.7
27	27	MEAN AERODYNAMIC CHORD (IN.) (PROJECTED)		370.5	163.4
28	28	L.E. OF M.A.C. (F.S.)		1254.2	2848.5
29	29	TAIL LENGTH - 25 * MAC WING TO 25 * MAC H. TAIL (FT)			129.0
30	30	- 25 * MAC WING TO 25 * MAC V. TAIL (FT)			113.2
31	31				
32	32	AREAS (SQ FT)	LE SLATS	649.6	SPOILERS
33	33		TE FLAPS	391.7	TAILPOONS
34	34				
35	35	ALIGNING GEAR			MAIN NOSE
36	36	LENGTH - OLEO EXTENDED - C.L. AXLE TO C.L. TRUNNION (IN)		80.8	55.1
37	37	OLEO TRAVEL - FULL EXTENDED TO FULL COLLAPSED (IN)		25.0	22.0
38	38	NUMBER OF WHEELS		24	+
39	39	NUMBER OF TIRES		24	+
40	40	NUMBER OF STRUTS		+	1
41	41	HYDRAULIC SYSTEM CAPACITY (GALLONS)		292.0	
42	42	FUEL AND LUBE SYSTEM			NO. TKS. GAL. DRPT
43	43	FUEL - INTERNAL		12	49000
44	44	OIL		+	43
45	45	HORIZONTAL REFERENCE DATUM TO F.S. ZERO (IN)		0	
46	46	VERTICAL REFERENCE DATUM TO M.L. ZERO (IN)		0	
47	47	STRUCTURAL DATA - CONDITION			FUEL WT STRESSOR WLT LE
48	48	FLIGHT		184096	728000
49	49	LANDING		46246	935850
50	50	MAXIMUM DESIGN GROSS WEIGHT		180096	769000
51	51	MAXIMUM GROSS WEIGHT WITH ZERO WING FUEL		0	586904
52	52	MINIMUM FLYING WEIGHT		9300	330468
53	53	LIMIT LANDING SLIKING SPEED (FT/SEC)		9	
54	54	WING LIFT ASSUMED FOR LANDING DESIGN CONDITION (PER CENT WT)			100
55	55	STALL SPEED - LANDING CONFIGURATION-POWER OFF (KNOTS)			102
56	56	CABLE AND CARGO COMPT. WLT. DESIGN PRESS. DIFFERENTIAL-ELF (PSI)			12.40
57	57	AIRFRAME WEIGHT (AS DEFINED IN AN-11) (LB.)			283,309.2

TABLE 2.1-VII

GROUP WEIGHT VERSUS COMPONENT WEIGHT

AN GROUP	WEIGHT DISTRIBUTION COMPONENTS										
	WING	FUSE.	HORIZ. TAIL	BULLET	VERT. TAIL	MAIN LANDING GEAR	NOSE LANDING GEAR	POWER PLANT	PYLON	WING STUB	TOTAL
WING	69256.0	2784.8								11137.9	83178.7
TAIL		538.2	5901.2	693.4	5068.5						12201.3
BODY		116763.1								1527.2	188290.3
ALIGNING GEAR		4452.4				29699.6	3639.2				37791.2
SURFACE CONTROLS	4129.0	1363.0	625.5		993.6					2.4	7113.5
NACELLE	566.0							3226.7	4394.1		8186.8
PROPULSION	2047.0	334.4						33420.4	181.3	89.3	36072.4
AUX. POWER PLANT	1.4	966.5								3.4	971.3
INSTRUMENTS	173.6	665.2	12.9		1.5	7.2		65.0	33.0	0.9	959.3
HYDRAULICS	527.6	2381.5						509.0	112.6		3530.7
ELECTRICAL	393.9	2353.6	4.6	5.3	25.7		6.7	740.9	64.1		3594.8
ELECTRONICS	78.1	3635.4	0.8	69.6	58.1	31.8	26.2	39.0	9.0	0.5	3948.5
FURNISHINGS AND EQUIPMENT	14.1	6665.4						7.0	94.1		6780.6
AIR CONDITIONING AND ANTI-ICING	213.7	3403.4						357.6	137.8		4112.5
AUXILIARY GEAR	2.0	255.5	5.8	1.1	3.6						268.0
TOTAL WEIGHT EMPTY	77402.4	146562.4	6550.8	769.4	6151.0	29738.6	3672.1	38365.6	5026.0	12761.6	326999.9

LOCKHEED - GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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2.2 FUSELAGE, LANDING GEAR, AND WING STUB

This section presents the mass data for the fuselage, landing gear, and wing stub. Wing stub mass data are also shown with the wing, since total loads must consider both its effect with fuselage mass and wing mass and also its effect when acting separately.

Figure 2.2-1 shows the fuselage, landing gear and wing stub geometry. Figure 2.2-2 shows graphically the weight distribution of the fuselage for conditions with and without the wing stub. Table 2.2-I presents the tabulated mass data for the fuselage, and Table 2.2-II presents the wing stub mass data distributed in a like manner to the fuselage. Table 2.2-III presents the items to be removed from the fuselage to obtain Weight Empty. Landing gear data, including individual data for the rolling stock portion, are given in Tables 2.2-IV and 2.2-V for the nose and main landing gears respectively.

LANDING GEAR ARRANGEMENT

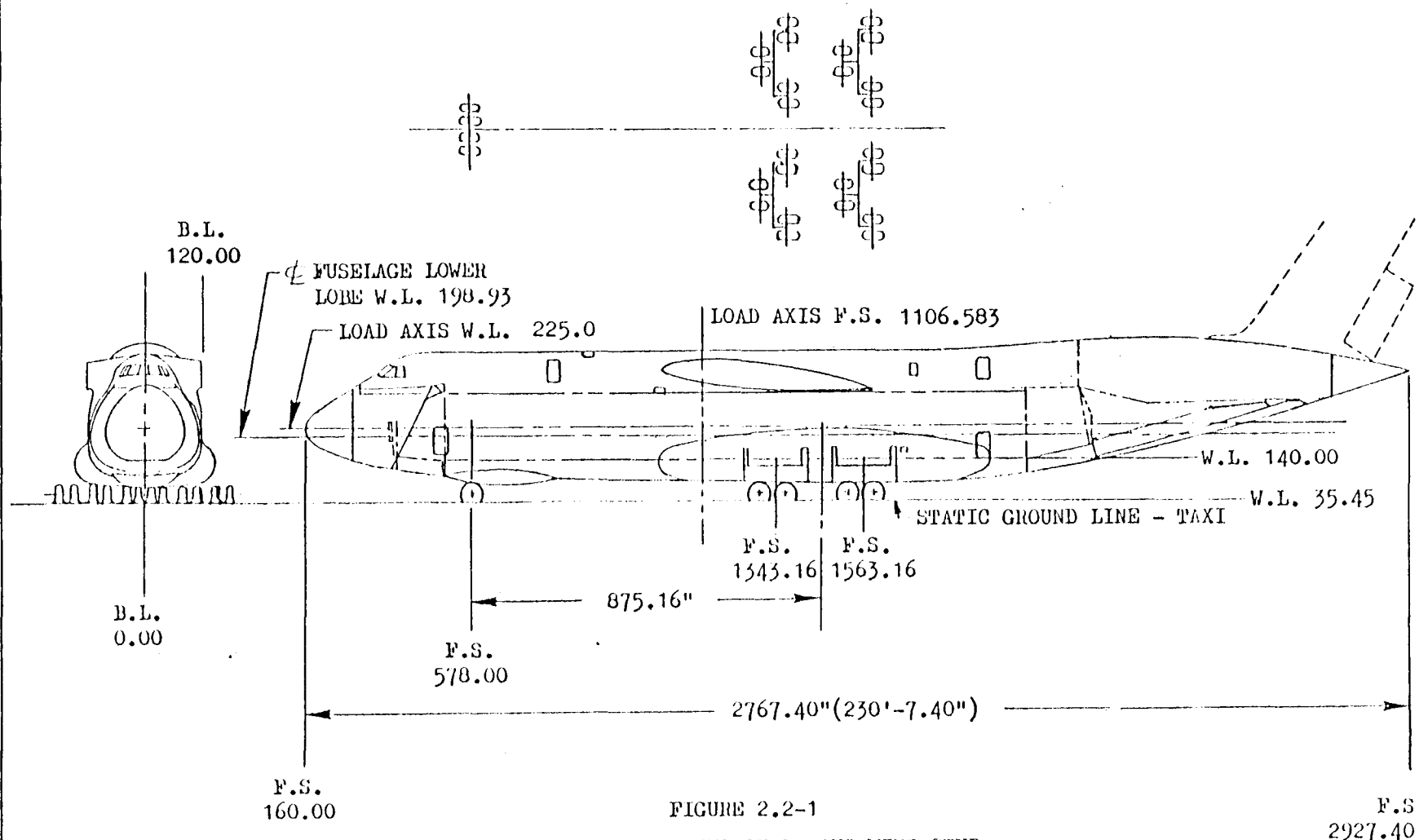


FIGURE 2.2-1
FUSELAGE, LANDING GEAR, AND WING STUB
GEOMETRY

PREPARED BY LA BAY
DATE 20 NOV 1968
CHECKED BY D.T. MILLER

LOCKHEED-GEORGIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

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MODEL 2-5A
PAGE 2-2-3

NOTE:

1. INCLUDES WING STUB AS INDICATED
2. DOES NOT INCLUDE LANDING GEAR OR CARGO
3. DATA REFLECT OPERATING WEIGHT DISTRIBUTION

WEIGHT DISTRIBUTION ~ LB/IN

160

120

80

40

0

0

400

800

1200

1600

2000

2400

2800

3200

FUSELAGE STATION ~ INCHES

INCLUDES WING STUB

FIGURE 2.2-2
FUSELAGE WEIGHT DISTRIBUTION

TABLE 2.2-I

FUSELAGE MASS DATA

- NOTE: 1. Data do not include landing gear, tail assembly, or wing stub.
 2. Data shown for "Operating Weight" condition.
 3. Data shown per air vehicle.

SECTION (F.S.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XZ_0}
					(LB-IN ² x 10 ⁻⁶)			
160.0 - 395.0	9,054.7	340.7	0.6	252.2	76.7	73.5	48.3	3.4
395.0 - 578.0	16,588.4	483.3	7.1	230.1	248.3	196.1	144.9	- 6.4
578.0 - 744.0	11,507.1	654.7	4.4	207.4	175.7	142.5	88.1	1.8
744.0 - 944.0	10,624.2	845.3	0.5	234.7	171.7	140.9	99.4	- 2.5
944.0 - 1106.6	10,742.6	1040.9	0.5	247.3	198.6	128.3	122.8	2.8
1106.6 - 1231.1	7,430.8	1173.3	1.6	189.9	124.1	59.8	84.5	- 1.4
1231.1 - 1343.2	10,237.7	1293.1	0.8	178.3	176.8	66.2	132.7	0.5
1343.2 - 1563.2	23,674.6	1449.4	0.0	189.5	444.7	302.7	381.6	- 14.3
1563.2 - 1675.3	9,998.7	1618.4	-0.5	181.5	171.3	75.1	116.8	- 0.9
1675.3 - 1804.0	6,865.3	1735.6	0.0	192.6	120.6	63.5	78.1	0.5
1804.0 - 1984.2	9,095.7	1900.3	2.9	203.0	152.8	96.5	106.2	- 1.1
1984.2 - 2167.0	11,372.2	2082.4	0.6	223.9	167.1	105.7	112.7	8.1
2167.0 - 2339.0	4,238.9	2260.0	0.3	285.1	60.3	33.8	47.3	0.7
2339.0 - 2472.0	2,927.4	2410.7	1.0	318.0	31.4	21.1	26.4	2.0
2472.0 - 2538.8	1,265.2	2514.5	0.3	323.9	10.9	5.0	7.2	0.2
2538.8 - 2927.4	4,303.9	2654.6	0.0	347.3	23.5	36.3	38.1	0.8
TOTALS	149,927.4	1303.1	1.6	219.5	*2,576.1	*59,358.4	*59,226.4	*688.0

*Centroidal mass data with respect to the total fuselage C.G.

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 PAGE 2.2-4

TABLE 2.2-II

WING STUB MASS DATA (FUSELAGE DISTRIBUTION)

- NOTE: 1. Data shown per air vehicle.
 2. See Table 2.6-III for distribution of this component in lateral direction.

SECTION (F.S.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}
					(LB-IN ² x 10 ⁻⁶)		
944.0 - 1106.6	591.1	1105.7	0.0	358.2	2.5	0.2	2.3
1106.6 - 1231.1	5,781.7	1182.8	0.0	355.3	41.1	17.8	49.8
1231.1 - 1343.2	5,890.5	1292.5	0.0	350.1	48.5	14.1	53.9
1343.2 - 1563.2	503.3	1349.5	0.0	347.3	2.7	0.6	2.7
TOTALS	12,766.6	1236.4	0.0	352.7	*94.9	*84.4	*160.4

*The inertia totals are taken about the total wing stub C.G.

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TABLE 2.2-III

ITEMS TO BE REMOVED FROM FUSELAGE TO OBTAIN "WEIGHT EMPTY"

NOTE:

1. Data are shown per air vehicle.
2. Centroidal moments and products of inertia are considered negligible.

ITEM	SECTION (F.S.)	WT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)
MILITARY CREW MEMBERS (2)	160.0 - 395.0	430.0	390.0	0.0	332.0
MILITARY CREW MEMBERS (3)	395.0 - 578.0	645.0	454.3	0.0	332.0
MILITARY CREW MEMBERS (1)	578.0 - 744.0	215.0	727.0	0.0	332.0
LIFE RAFTS - INCL. EQUIPMENT	744.0 - 944.0	202.0	858.0	33.0	334.0
LIQUID OXYGEN (CREW - 25 LITERS)	1343.2 - 1563.2	63.0	1453.0	135.0	140.0
FOOD - (CREW)	744.0 - 944.0	17.0	850.0	-25.0	335.0
WATER - (CREW)	744.0 - 944.0	43.0	811.0	-52.0	365.0
CARGO TIE DOWN EQUIPMENT	395.0 - 578.0	73.3	547.5	0.0	150.0
	578.0 - 744.0	193.9	658.3		
	744.0 - 944.0	256.6	845.7		
	944.0 - 1106.6	193.9	1032.2		
	1106.6 - 1231.1	157.3	1178.0		
	1231.1 - 1343.2	120.6	1293.9		
	1343.2 - 1563.2	256.6	1450.1		
	1563.2 - 1675.3	146.6	1617.9		
	1675.3 - 1804.0	157.3	1743.3		
CARGO TIE DOWN EQUIPMENT	1804.0 - 1984.2	193.9	1889.4	0.0	150.0

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TABLE 2.2-IV

NOSE LANDING GEAR MASS DATA

NOTE: Data shown per air vehicle.

RETRACTING COMPONENTS

POSITION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XY_0}	I_{XZ_0}	I_{YZ_0}
					(LB-IN ² x 10 ⁻⁶)					
UP	3,672.1	597.1	0.0	109.8	2.3	4.5	5.7	0	- 0.3	0
DOWN	3,672.1	578.6	0.0	85.6	4.9	3.7	2.4	0	- 0.5	0

ROLLING STOCK ONLY

NOTE: Data shown for one tire and wheel.

ITEM	WEIGHT (LB)	I_{Y_0} (LB-IN ² x 10 ⁻⁴)
WHEEL	92.1	6.27
TIRE AND AIR	155.4	5.39

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TABLE 2.2-V

MAIN LANDING GEAR MASS DATA

NOTE: Data shown for one half air vehicle.

POSITION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XY_0}	I_{XZ_0}	I_{YZ_0}
					(LB-IN ² x 10 ⁻⁶)					
UP (STRUT EXTENDED)	14,869.3	1452.9	101.9	114.5	34.4	194.4	224.8	0	0	3.8
DOWN (STRUT STATIC)	14,869.3	1452.2	154.2	82.2	26.1	207.2	199.4	0	0.3	- 0.7

ROLLING STOCK ONLY

- NOTE: 1. Data shown for one tire and wheel.
2. Rotating portion of brake included in wheel data.

ITEM	WEIGHT (LB)	I_{Y_0} (LB-IN ² x 10 ⁻⁴)
WHEEL AND BRAKE	226.9	7.26
TIRE AND AIR	153.9	5.34

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2.3 BULLET

This section presents the mass data for the bullet and its contents. Bullet geometry is shown in Figure 2.3-1 with mass distribution and mass data given in Figure 2.3-2 and Table 2.3-I respectively. Load and flutter analysis require the bullet data to be presented in a different manner than in Reference 3. Therefore, the bullet as a unit is presented in this section. The movable portion of the bullet (Sections 1 and 2 of Figure 2.3-1) are also combined with the horizontal tail in sub-section 2.4, and the fixed portion of the bullet (Sections 3 and 4 of Figure 2.3-1) are combined with the vertical tail in sub-section 2.5.

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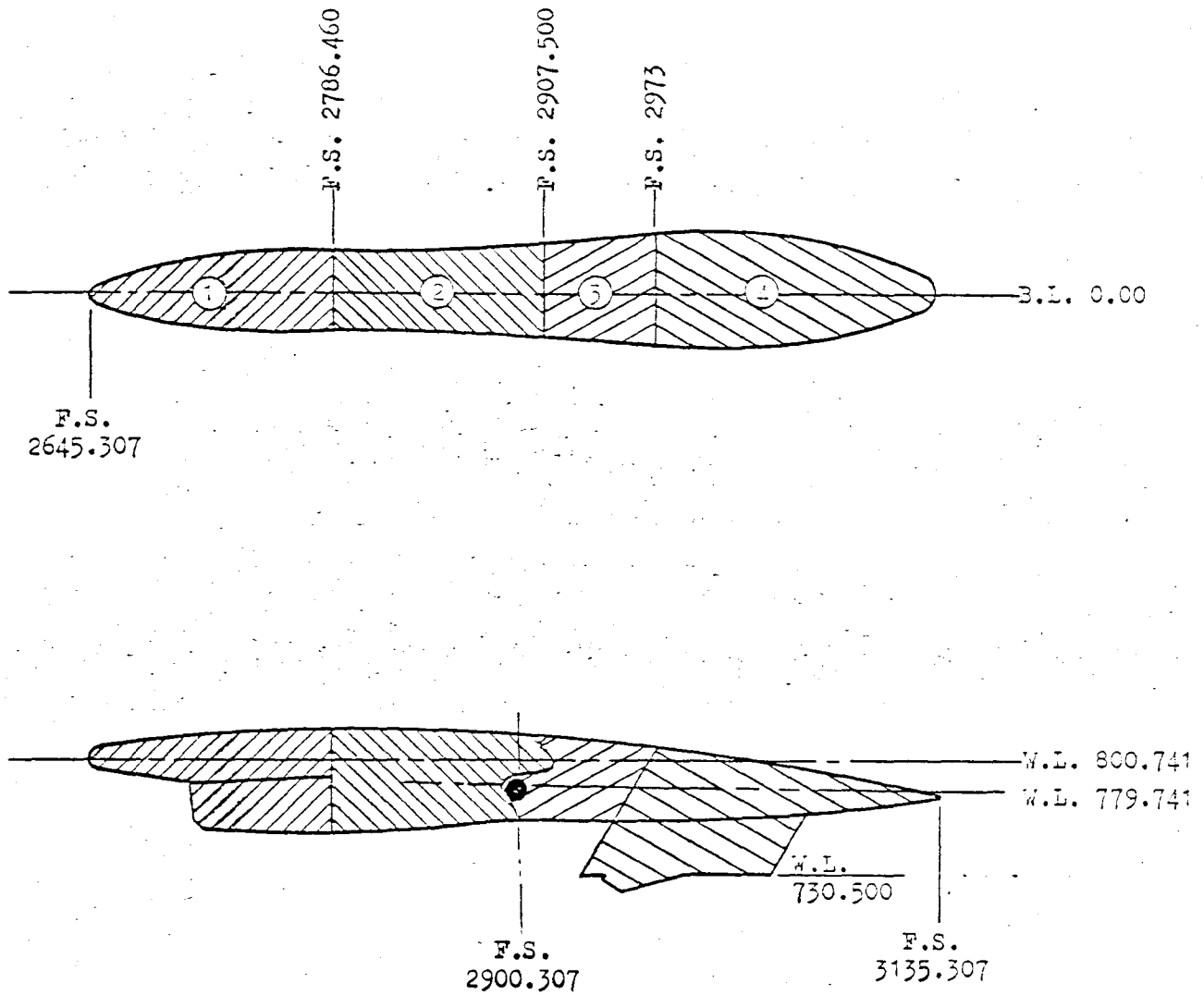


FIGURE 2.3-1

BULLET GEOMETRY

PREPARED BY J.A. BAY
DATE 20 NOV 1968
CHECKED BY D.T. MILLER

LOCKHEED-GEORGIA COMPANY
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NOTE

INCLUDES BULLET AND CONTENTS

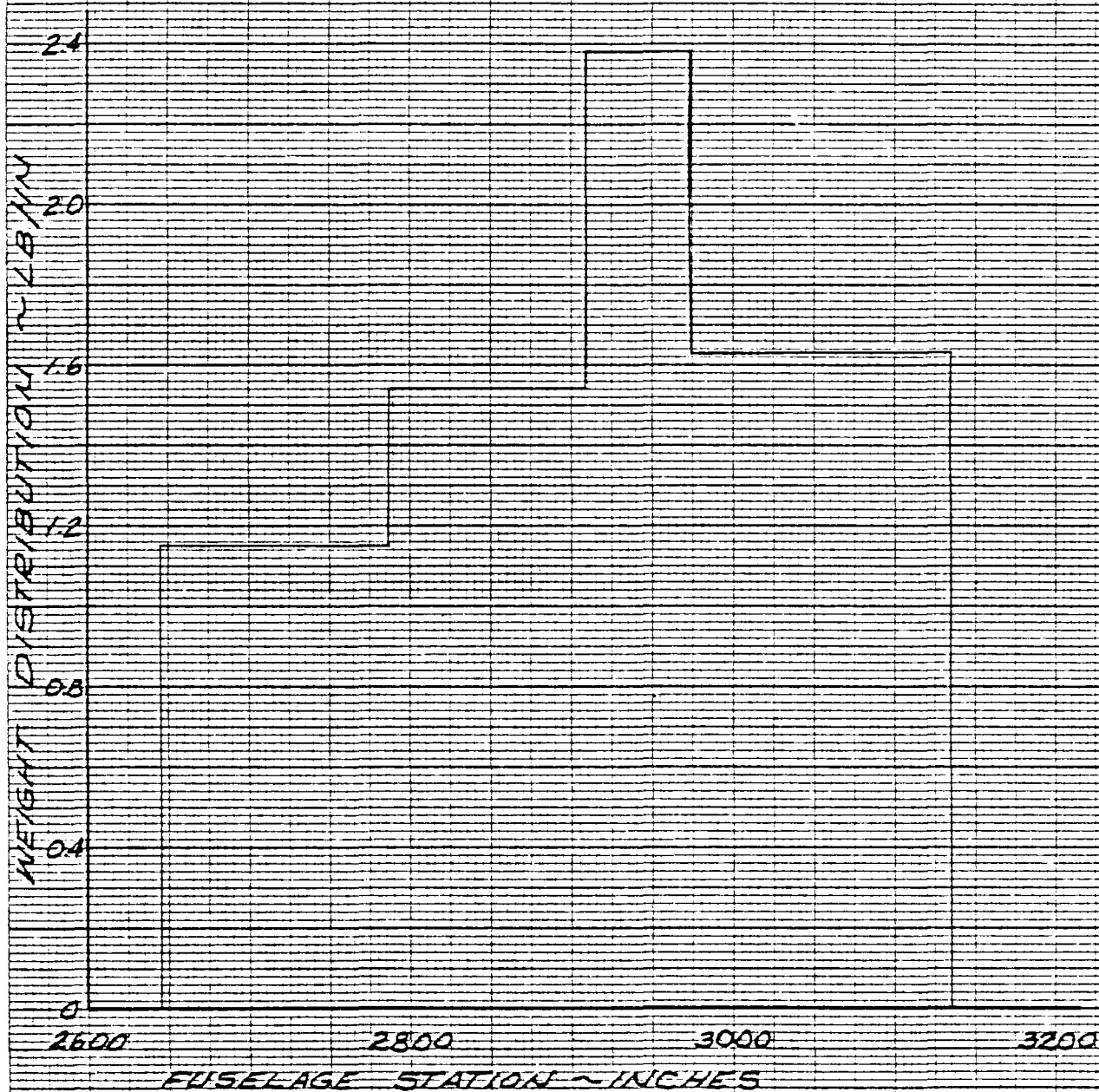


FIGURE 2.3-2
BULLET WEIGHT DISTRIBUTION

TABLE 2.3-I

BULLET AND CONTENTS MASS DATA

NOTE: Data shown per air vehicle.

SECTION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_g}	I_{Y_g}	I_{Z_g}	I_{XZ_g}
					(LB-IN ² x 10 ⁻⁶)			
1	162.2	2735.8	0.0	790.9	0.1	0.2	0.2	0
2	186.6	2837.6	0.0	790.0	0.1	0.4	0.4	0
3	156.2	2939.4	- 0.2	791.4	0.1	0.1	0.1	0
4	264.4	3008.6	0.0	778.8	0.2	0.6	0.6	0
TOTALS	769.4	2895.6	0.0	786.6	*0.5	*9.8	*9.8	* -0.4

*These totals are referenced to the bullet total C.G.

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2.4 HORIZONTAL TAIL

This section presents the mass data for the horizontal tail including elevator and balance weights. Data with the movable portion (Sections 1 and 2 of Figure 2.3-1) of the bullet are also given. Horizontal tail geometry is illustrated in Figure 2.4-1. Mass distribution is shown in Figure 2.4-2. The mass data for the horizontal tail are given in Table 2.4-I. These data reflect the theoretical tip of the horizontal tail to facilitate loads analysis. Structure beyond the theoretical tip is included in the outboard section.

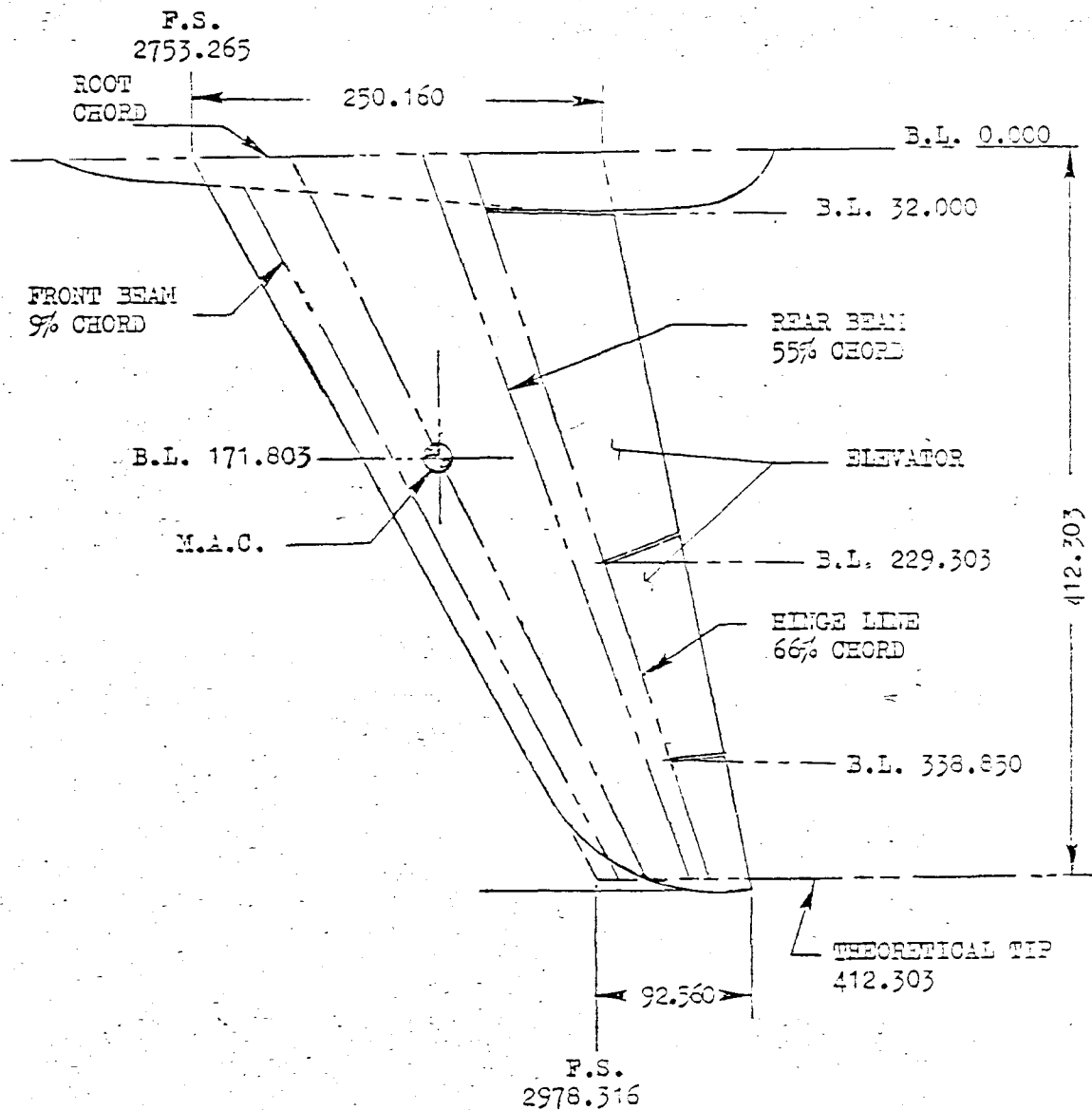


FIGURE 2.4-1
HORIZONTAL TAIL GEOMETRY

U.A. BAY
20 NOV 1968
D.T. MILLER

CG/US 54-12-1
C-5A
2.4-3

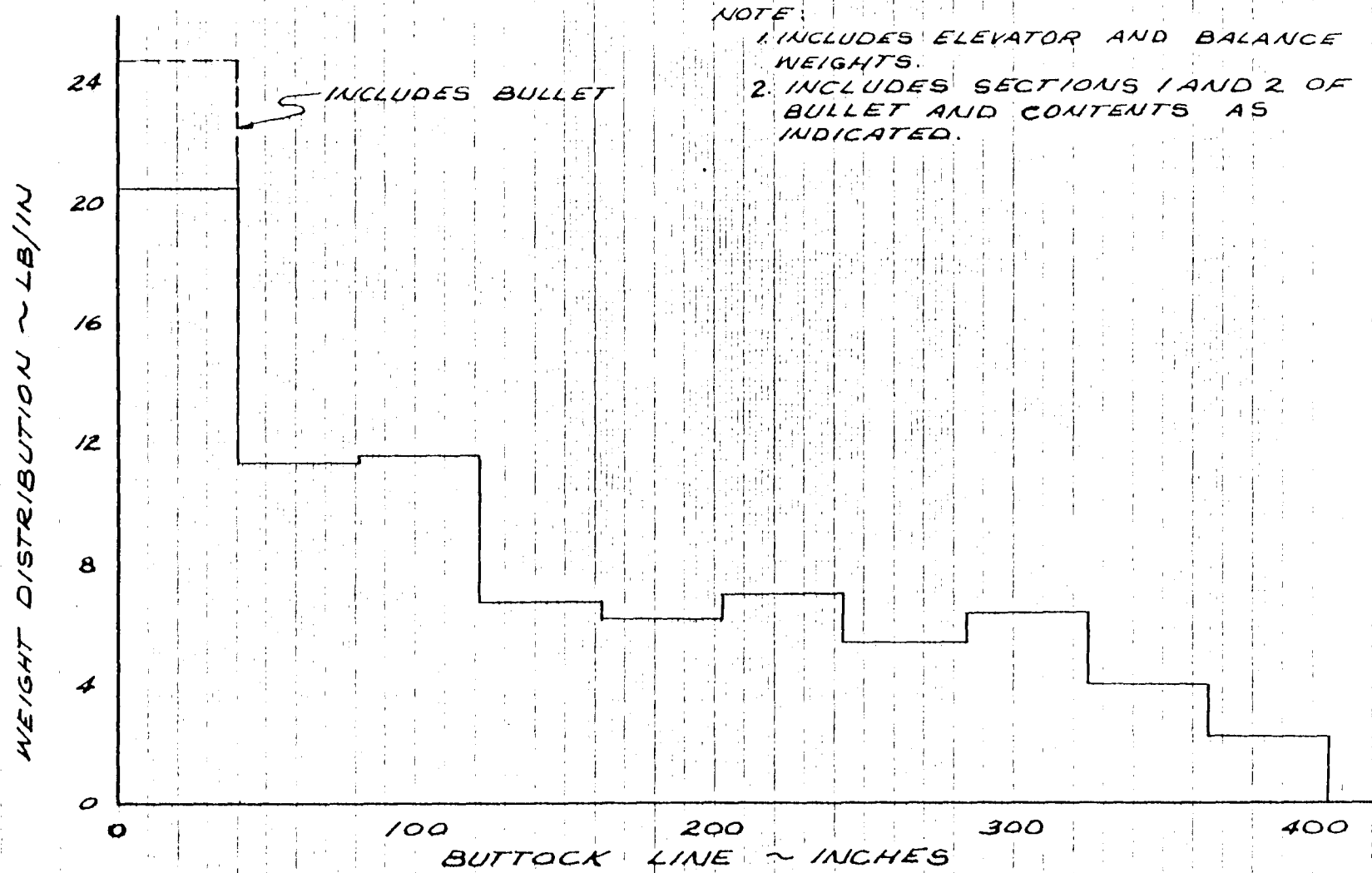


FIGURE 2.4-2
HORIZONTAL TAIL WEIGHT DISTRIBUTION

TABLE 2.4-I

HORIZONTAL STABILIZER AND CONTENTS MASS DATA

- Note: 1. Includes elevator and balance weights.
2. Data shown for one-half air vehicle.
3. Inertia totals are taken about the left horizontal stabilizer total C.G.***

SECTION (B.I.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{x_0}	I_{y_0}	I_{z_0}	I_{xy_0}	I_{xz_0}	I_{yz_0}
					(LB-IN ² x 10 ⁻⁶)					
0.0 - 40.5*	1,002.8	2858.7	18.2	794.1	0.2	3.1	3.1	0.1	0.0	0.0
0.0 - 40.5**	828.4	2873.1	18.6	794.9	0.2	1.4	1.4	0.1	-0.1	0.0
40.5 - 81.2	457.5	2891.4	60.1	795.6	0.1	1.1	1.2	0.0	0.0	0.0
81.2 - 121.7	468.0	2910.9	99.7	791.9	0.1	0.9	0.7	0.0	0.0	0.0
121.7 - 162.2	272.0	2917.7	140.3	788.6	0.0	0.5	0.6	0.0	0.0	0.0
162.2 - 202.9	248.3	2933.0	181.9	785.1	0.0	0.4	0.4	0.0	0.0	0.0
202.9 - 243.4	281.4	2957.8	223.1	781.3	0.0	0.4	0.4	0.0	0.0	0.0
243.4 - 284.1	217.6	2967.3	262.4	778.0	0.0	0.2	0.3	0.0	0.0	0.0
284.1 - 324.6	254.5	2985.6	305.3	774.3	0.0	0.2	0.2	0.0	0.0	0.0
324.6 - 365.2	159.2	2996.3	341.7	771.2	0.0	0.1	0.1	0.0	0.0	0.0
365.2 - 405.7	88.5	3011.7	384.0	767.7	0.0	0.1	0.1	0.0	0.0	0.0
TOTALS*	3,449.8	2914.7	133.8	787.7	***43.6	***15.1	***57.6	***18.3	***-1.3	***-3.1
TOTALS**	3,275.4	2921.3	140.1	787.5	***41.0	***11.5	***51.5	***15.6	***-1.3	***-3.1

*Includes sections 1 and 2 of bullet.

**Horizontal stabilizer without bullet.

2.5 VERTICAL TAIL

Mass data for the vertical tail including the upper and lower rudders are presented in this section. Data with the fixed portion of the bullet (Sections 3 and 4 of Figure 2.3-1) are also given. Vertical tail geometry and a graphical presentation of weight distribution are given in Figures 2.5-1 and 2.5-2 respectively. Mass data for the vertical tail are given in Table 2.5-I. These data reflect the theoretical tip of the vertical tail to facilitate loads analysis.

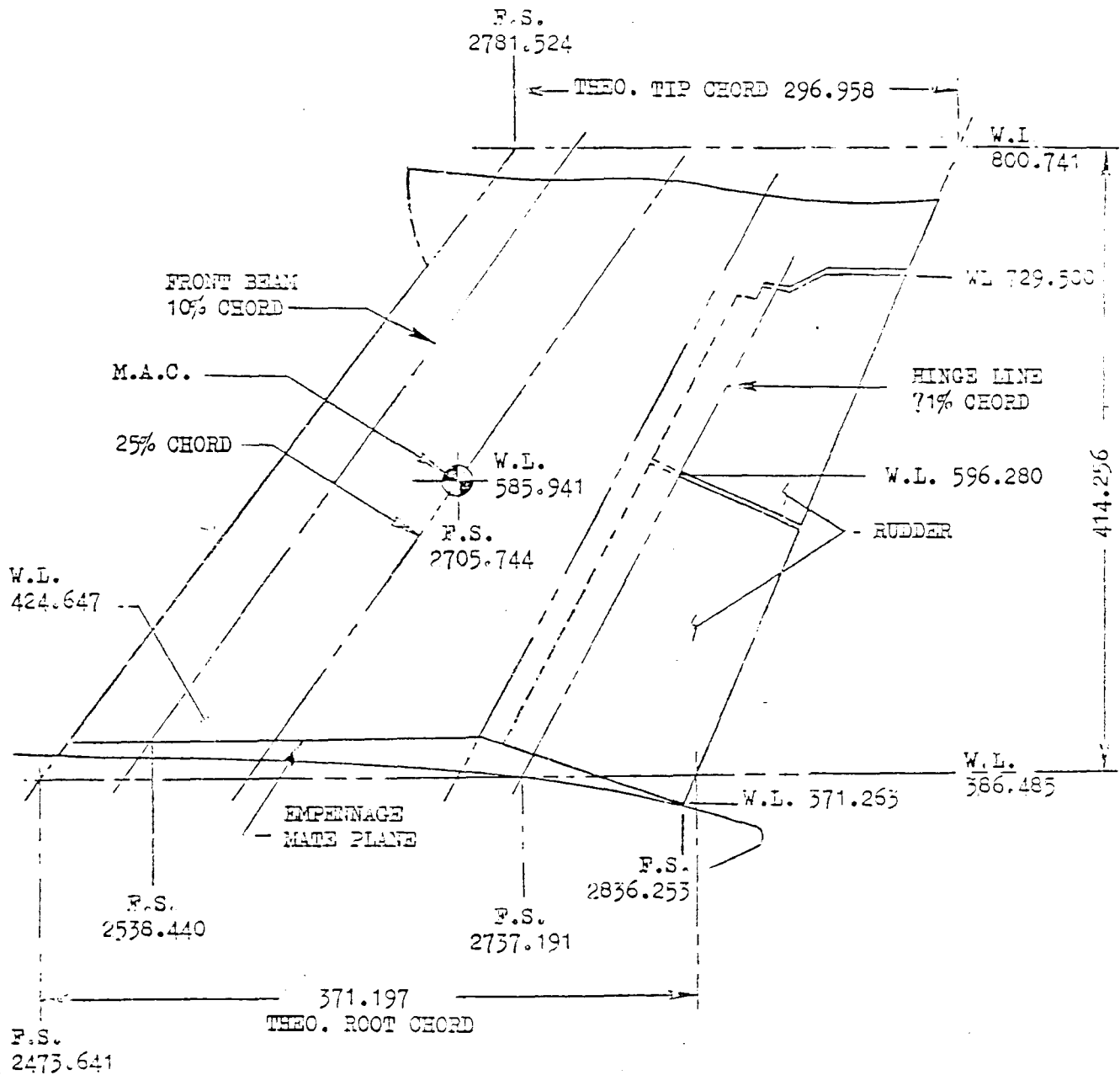


FIGURE 2.5-1
VERTICAL TAIL GEOMETRY

PREPARED BY CLAY
 DATE 20 NOV. 1968
 CHECKED BY D.T. MILLER

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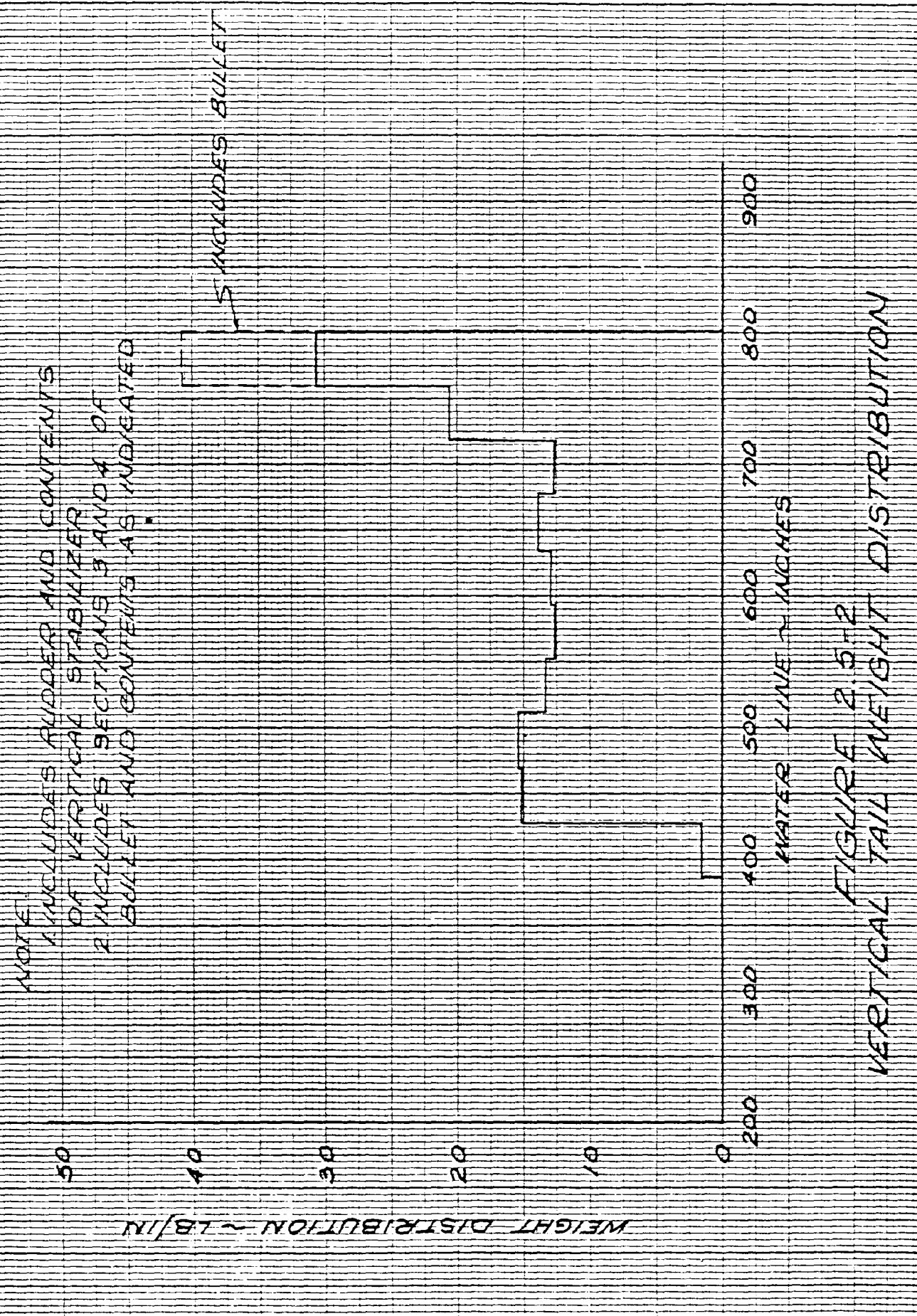


TABLE 2.5-I

VERTICAL TAIL AND CONTENTS MASS DATA

- Note: 1. Includes rudder
 2. Data shown per air vehicle
 3. Inertia totals are taken about the vertical tail total C.G.***

SECTION (W.L.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{x_o}	I_{y_o}	I_{z_o}	I_{xz_o}
					(LB-IN ² x 10 ⁻⁶)			
386.5 - 427.9	66.3	2751.8	-0.1	410.7	0.0	0.7	0.7	0.0
427.9 - 469.3	630.6	2662.9	0.0	448.2	0.2	4.9	5.0	0.1
469.3 - 510.8	634.9	2713.4	0.0	491.1	0.2	4.9	4.9	0.1
510.8 - 552.2	550.0	2730.0	0.0	529.6	0.2	3.6	3.6	0.0
552.2 - 593.6	518.7	2764.3	0.0	573.4	0.2	3.7	3.7	0.1
593.6 - 634.0	519.5	2790.5	0.0	614.4	0.2	3.1	3.1	0.0
634.0 - 676.5	590.8	2830.2	0.1	656.9	0.2	3.5	3.5	0.1
676.5 - 717.9	523.6	2841.3	0.0	698.6	0.2	2.8	2.8	0.0
717.9 - 759.3	853.0	2823.9	-0.3	739.0	0.2	3.7	3.7	0.0
759.3 - 800.7*	1,684.2	2883.7	-0.2	777.9	0.6	11.2	11.2	0.1
759.3 - 800.7**	1,263.6	2850.7	-0.2	776.0	0.3	4.4	4.5	-0.1
TOTALS*	6,571.6	2799.1	-0.1	642.8	***94.7	***168.2	***76.2	***54.7
TOTALS**	6,151.0	2786.6	-0.1	633.1	***85.5	***142.9	***59.8	***43.2

*Includes sections 3 and 4 of bullet.

**Vertical tail without bullet

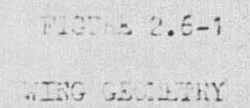
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2.6 WING AND WING STUB

This section presents the mass data for the wing and control surfaces. Wing stub mass data are included in this section and in Section 2.2 since total loads analysis must consider both its effect with the wing and with the fuselage and its effect when acting separately.

Basic wing dimensions and reference point locations are shown by Figure 2.6-1. Wing weight distribution is presented graphically in Figure 2.6-2. Table 2.6-I presents the mass data for the wing and contents. Table 2.6-II presents the unusable fuel to be removed from the wing to obtain Weight Empty. Table 2.6-III presents the wing stub mass data distributed in a like manner to the wing. Wing mass data reflect the theoretical wing tip to assist in loads analysis. Structure located beyond the theoretical tip is included in the outboard wing section.



PREPARED BY U.A. BAY
 DATE 20 NOV 1968
 CHECKED BY D.T. MILLER

LOCKHEED-GEORGIA COMPANY
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NOTE:
 1. INCLUDES WING AND CONTENTS
 2. DOES NOT INCLUDE POWER PLANT,
 PYLONS, OR FUEL (USABLE)
 3. DATA REFLECT OPERATING WEIGHT
 DISTRIBUTION.

WING WEIGHT DISTRIBUTION



FIGURE 2.6-2
 WING WEIGHT DISTRIBUTION

TABLE 2.6-I

WING AND CONTENTS MASS DATA

- NOTE: 1. Includes control surfaces.
 2. Data shown for one half air vehicle.
 3. Data shown for "Operating Weight" condition.

SECTION (B.L.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XY_0}	I_{XZ_0}	I_{YZ_0}
					(LB-IN ² x 10 ⁻⁶)					
120.0 - 197.3	3,950.6	1272.9	158.4	347.3	3.9	50.1	50.0	-1.2	-2.5	0.1
197.3 - 263.0	3,031.6	1283.8	230.2	342.6	2.4	32.6	32.4	0.6	-1.3	-0.1
263.0 - 328.8	4,069.9	1357.4	302.2	332.5	3.2	67.2	67.3	5.1	-4.3	-0.5
328.8 - 394.6	3,014.9	1344.6	357.1	331.6	2.0	34.4	34.8	-0.3	-1.4	0.0
394.6 - 479.9	3,632.5	1364.5	442.2	324.6	3.5	35.6	37.2	1.4	-1.0	-0.4
479.9 - 526.1	2,450.5	1419.3	497.9	317.0	1.0	28.0	27.9	-1.2	-1.5	0.1
526.1 - 575.6	2,051.2	1405.2	553.8	316.4	0.9	12.9	13.0	-0.1	-0.2	0.0
575.6 - 657.6	3,169.1	1457.9	616.3	309.3	2.0	26.8	2.8	0.9	-1.2	-0.1
657.6 - 746.7	2,844.7	1469.3	708.5	302.8	2.6	18.5	2.0	1.0	-0.4	-0.3
746.7 - 789.1	1,606.9	1517.9	763.4	295.8	0.5	11.4	11.4	-0.6	-0.5	0.0
789.1 - 854.9	1,552.1	1530.7	825.5	292.5	0.8	9.2	9.7	0.4	-0.3	-0.1
854.9 - 920.6	1,660.9	1571.7	881.3	285.3	0.8	9.2	9.7	-0.6	-0.4	0.0
920.6 - 986.4	1,481.7	1597.2	955.0	279.0	0.7	9.0	9.4	0.9	-0.4	-0.1

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TABLE 2.6-I (CONTD.)

WING AND CONTENTS MASS DATA (CONTD.)

SECTION (B.L.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0}	I_{Y_0}	I_{Z_0}	I_{XY_0}	I_{XZ_0}	I_{YZ_0}
					(LB-IN ² x 10 ⁻⁶)					
986.4 - 1052.1	1,005.8	1594.8	1018.5	274.6	0.4	3.8	4.1	0.1	-0.1	0.0
1052.1 - 1117.9	1,105.9	1635.5	1088.5	268.4	0.5	4.0	4.3	0.3	-0.1	0.0
1117.9 - 1150.8	514.3	1660.0	1135.1	263.3	0.1	1.5	1.5	0.0	0.0	0.0
1150.8 - 1183.7	415.5	1660.7	1167.5	260.6	0.1	1.2	1.2	0.0	0.0	0.0
1183.7 - 1216.5	467.9	1667.5	1199.5	257.3	0.1	1.3	1.4	0.1	0.0	0.0
1216.5 - 1249.4	874.4	1715.0	1236.0	254.3	0.1	1.4	1.4	0.1	0.0	0.0
1249.4 - 1282.3	170.2	1723.9	1263.4	252.5	0.0	0.4	0.4	0.0	0.0	0.0
1282.3 - 1315.2	161.9	1768.5	1305.5	248.4	0.0	0.3	0.3	0.0	0.0	0.0
TOTALS	39,232.5	1433.1	568.7	312.7	*3,731.1	*972.0	*4630.1	*1462.8	*-140.4	*-314.7

*The inertia totals are taken about the left wing total C.G.

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TABLE 2.6-II

UNUSABLE FUEL TO BE REMOVED FROM WING TO OBTAIN "WEIGHT EMPTY"

- NOTE: 1. Data shown for one half air vehicle.
2. Centroidal moments and products of inertia are considered negligible.

SECTION (B.L.)	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)
120.0 - 197.3	14.7	1254.6	165.5	332.1
197.3 - 263.0	47.7	1278.2	235.8	324.8
263.0 - 328.8	20.6	1326.3	283.4	323.5
328.8 - 394.6	7.6	1319.0	363.6	318.8
394.6 - 479.9	24.0	1339.1	447.0	311.7
479.9 - 526.1	37.4	1372.1	506.0	306.1
526.1 - 575.6	25.3	1396.5	537.9	302.0
575.6 - 657.6	7.7	1413.0	618.4	298.2
657.6 - 746.7	9.9	1457.3	706.1	291.6
746.7 - 789.1	7.8	1487.3	769.6	284.8
789.1 - 854.9	23.2	1513.4	826.2	279.0
854.9 - 920.6	30.3	1525.0	884.1	275.1
920.6 - 986.4	30.0	1532.6	954.3	272.6
986.4 - 1052.1	38.5	1572.2	1020.7	266.2
1052.1 - 1117.9	54.6	1608.6	1087.1	259.9
1117.9 - 1150.8	36.1	1633.7	1135.0	255.4
1150.8 - 1183.7	43.6	1650.8	1168.0	252.3
1183.7 - 1216.5	52.3	1668.2	1201.0	249.2
1216.5 - 1249.4	20.0	1684.8	1223.3	246.2
1249.4 - 1282.3	0.0	0.0	0.0	0.0
1282.3 - 1315.2	0.0	0.0	0.0	0.0
TOTALS	531.3	1505.7	819.8	280.5

TABLE 2.6-III

WING STUB MASS DATA (WING DISTRIBUTION)

NOTE: Data shown per air vehicle for Operating Weight condition.

SECTION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{X_0} (LB-IN ² x 10 ⁻⁶)	I_{Y_0}	I_{Z_0}
WING STUB - LEFT	6,383.3	1236.4	72.6	352.7	13.8	42.2	46.6
WING STUB - RIGHT	6,383.3	1236.4	-72.6	352.7	13.8	42.2	46.6
TOTALS	12,766.6	1236.4	0.0	352.7	*94.9	*84.5	*160.4

*The inertia totals are taken about the total wing stub C.G.

UNUSABLE FUEL TO BE REMOVED FROM WING STUB TO OBTAIN "WEIGHT EMPTY"

SECTION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)
WING STUB - LEFT	2.5	1550.0	103.0	289.0
WING STUB - RIGHT	2.5	1550.0	-103.0	289.0
TOTAL	5.0	1550.0	0.0	289.0

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MODEL C-5A
PAGE 2.0-7

2.7 POWER PLANT AND PYLON

This section presents the power plant and pylon mass data. Figures 2.7-1 and 2.7-2 show the plan and side elevation geometry of the power plant and pylon respectively. Table 2.7-I presents the power plant and pylon mass data and the data for total oil and trapped fuel to be removed from the Power Plant and pylon to obtain the Weight Empty condition.

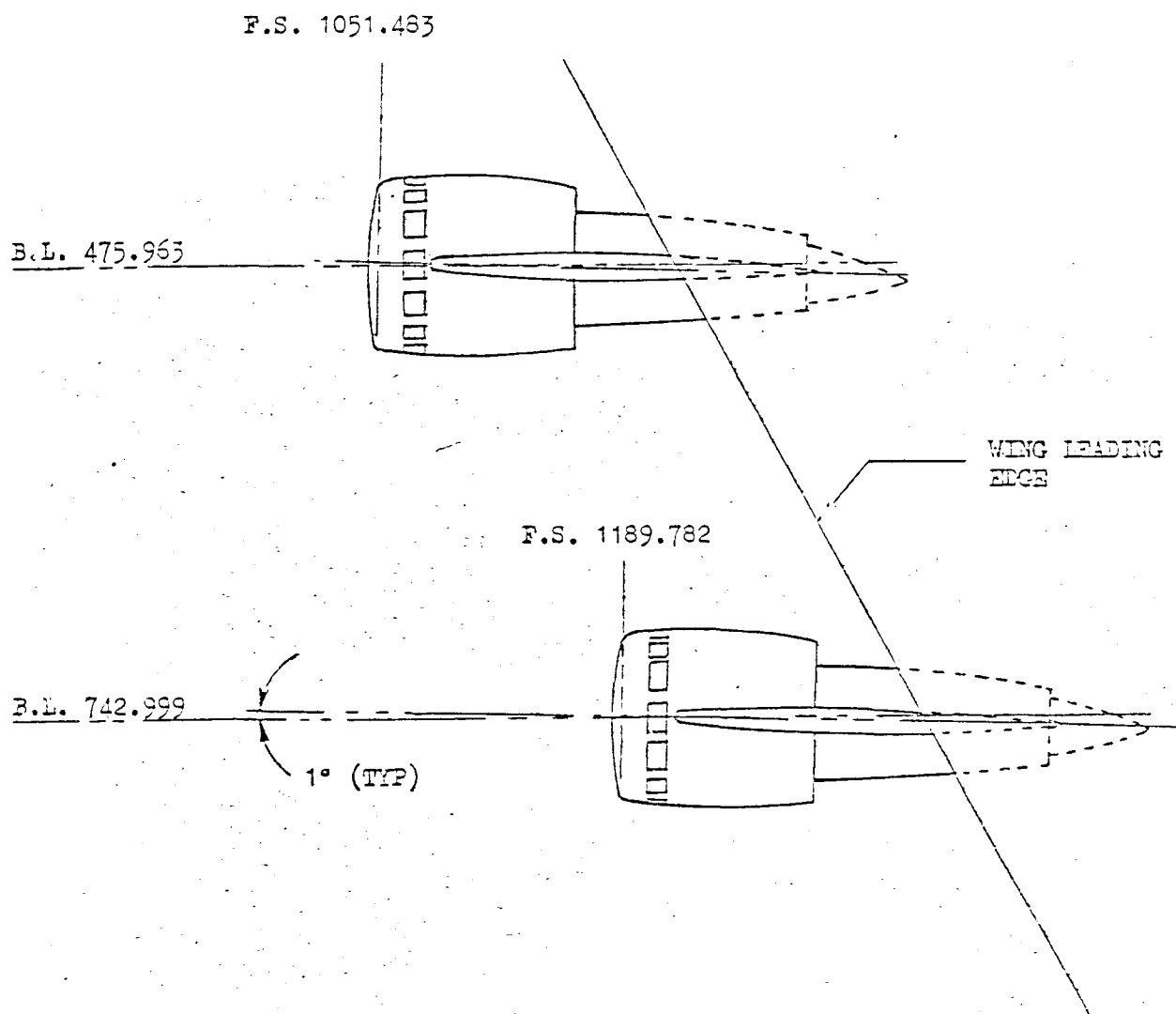


FIGURE 2.7-1

POWER PLANT AND PYLON GEOMETRY
(PLAN VIEW)

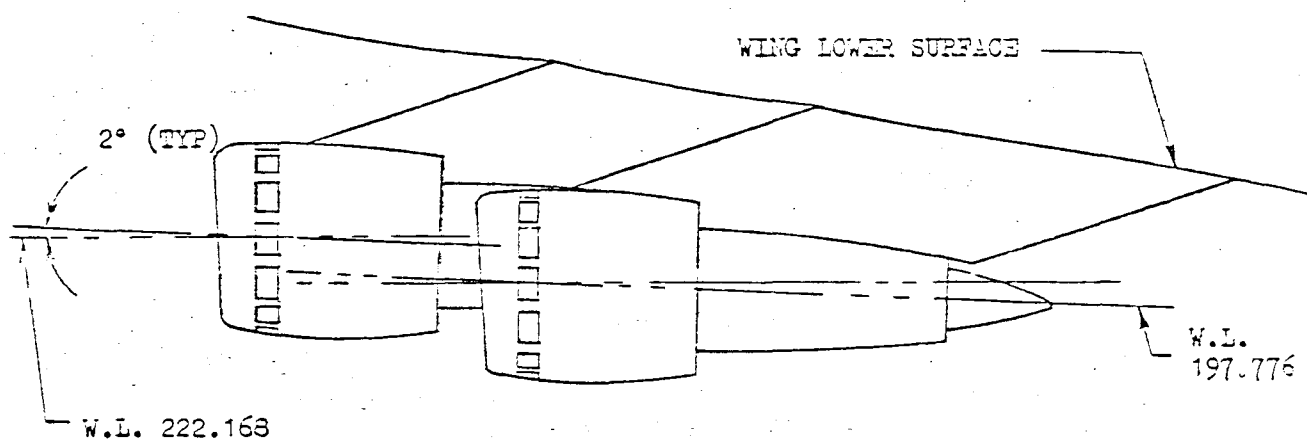


FIGURE 2.7-2
POWER PLANT AND PYLON GEOMETRY
(SIDE ELEVATION)

Table 2.7-I

POWER PLANT MASS DATA

Note: Data shown for one-half air vehicle.

SECTION	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)	I_{x_0}	I_{y_0}	I_{z_0}	I_{xy_0}	I_{xz_0}	I_{yz_0}
					(LB-IN ² x 10 ⁻⁶)					
INBOARD PACKAGE										
PYLON	1,238.5	1250.5	478.7	271.8	0.7	5.5	5.0	-0.1	0.5	0.0
POWER PLANT (WET)	9,673.0	1186.1	478.2	217.5	6.7	3.9	3.9	0.1	-0.4	0.0
TOTALS	10,911.5	1193.4	478.3	223.6	* 10.7	* 52.7	* 48.7	* 0.1	* 3.9	* 0.0
OUTBOARD PACKAGE										
PYLON	1,274.5	1392.0	746.2	252.7	0.7	5.8	5.3	-0.1	0.5	0.0
POWER PLANT (WET)	9,673.0	1324.0	745.2	193.3	6.7	39.4	39.1	0.1	-0.4	0.0
TOTALS	10,947.5	1331.9	745.4	200.2	* 11.4	* 54.4	* 49.6	* 0.2	* 4.6	* 0.0

*The inertia totals are taken about the package total C.G.

ITEMS TO BE REMOVED FROM POWER PLANT AND PYLON TO OBTAIN "WEIGHT EMPTY"

ITEM	WEIGHT (LB)	$\bar{X}$ (F.S.)	$\bar{Y}$ (B.L.)	$\bar{Z}$ (W.L.)
INB'D OIL - TOTAL (P.P.)	66.00	1141.9	476.1	223.4
OUTB'D OIL - TOTAL (P.P.)	66.00	1282.1	743.1	196.6
INB'D UNUSE. FUEL (P.P.)	15.60	1184.0	478.0	208.0
OUTB'D UNUSE. FUEL (P.P.)	15.60	1322.0	745.0	184.0

2.8 FUEL

This section presents the fuel mass data. Fuel tank geometry along with tank capacities are shown in Figure 2.8-1. Total fuel mass data are given graphically in Figures 2.8-2 through 2.8-9. Figures 2.8-5 through 2.8-9 give moment and product of inertia data for fuel quantities with respect to the fuel center of gravity shown by Figures 2.8-2 through 2.8-4. Table 2.8-I indicates individual tank fuel volumes corresponding to total fuel load during the standard fuel usage sequence. Fuel distribution data are not given in this section, however, data of this type may be obtained from the tabulated fuel unit inertia data in Section 3.

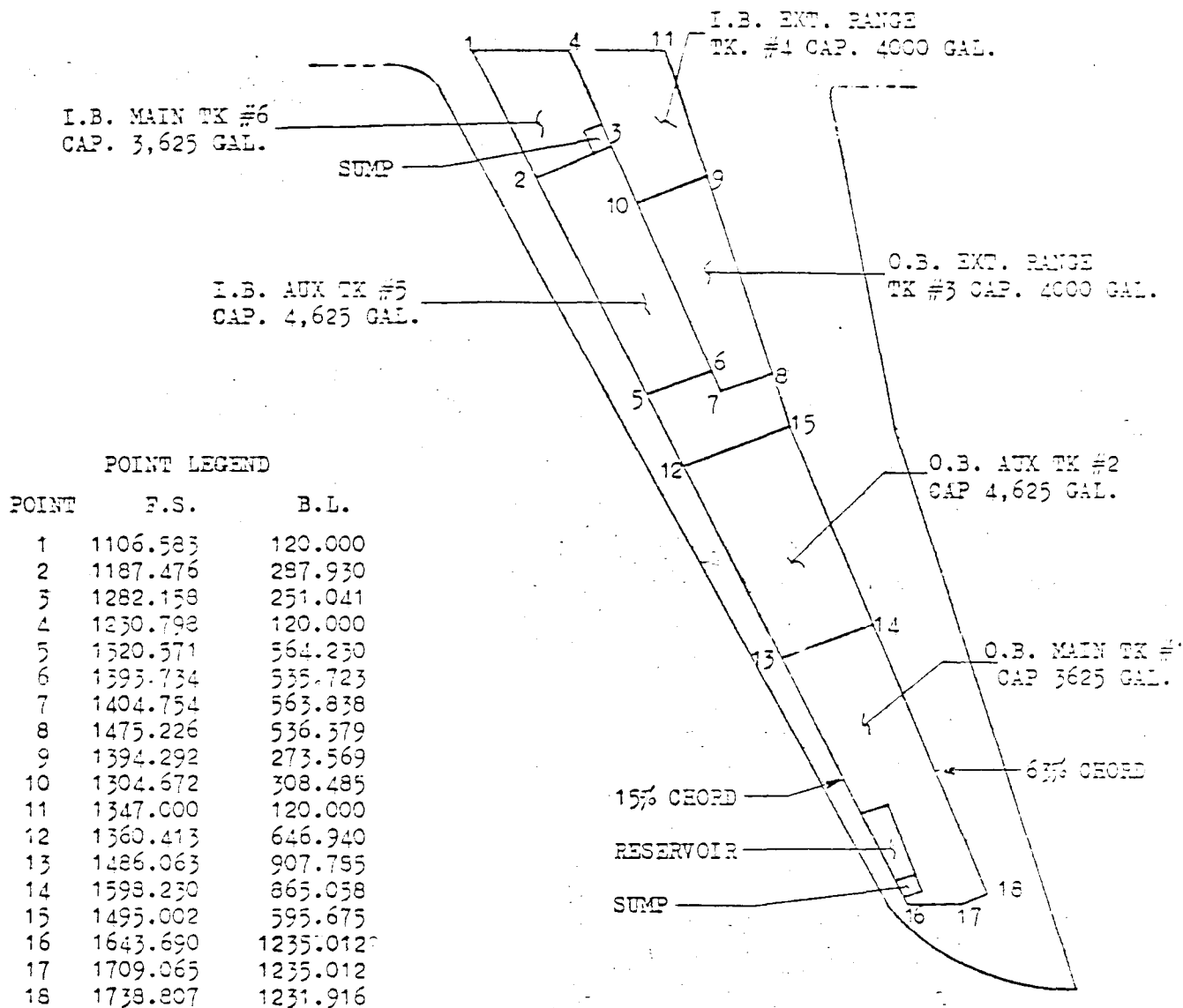
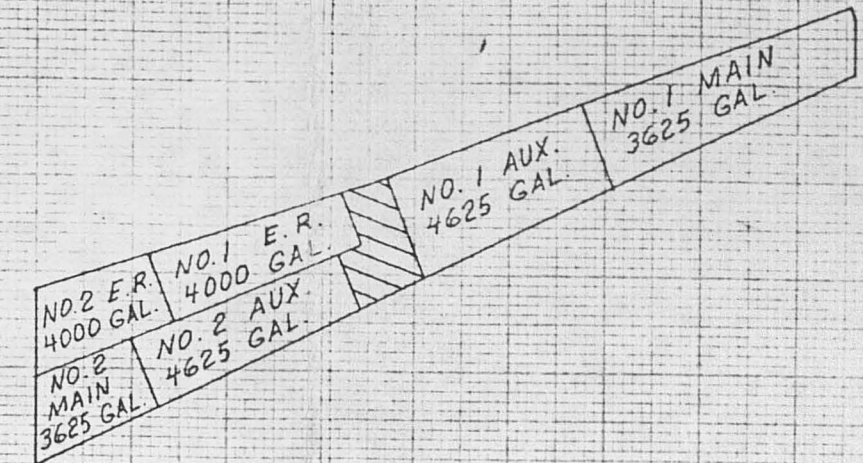
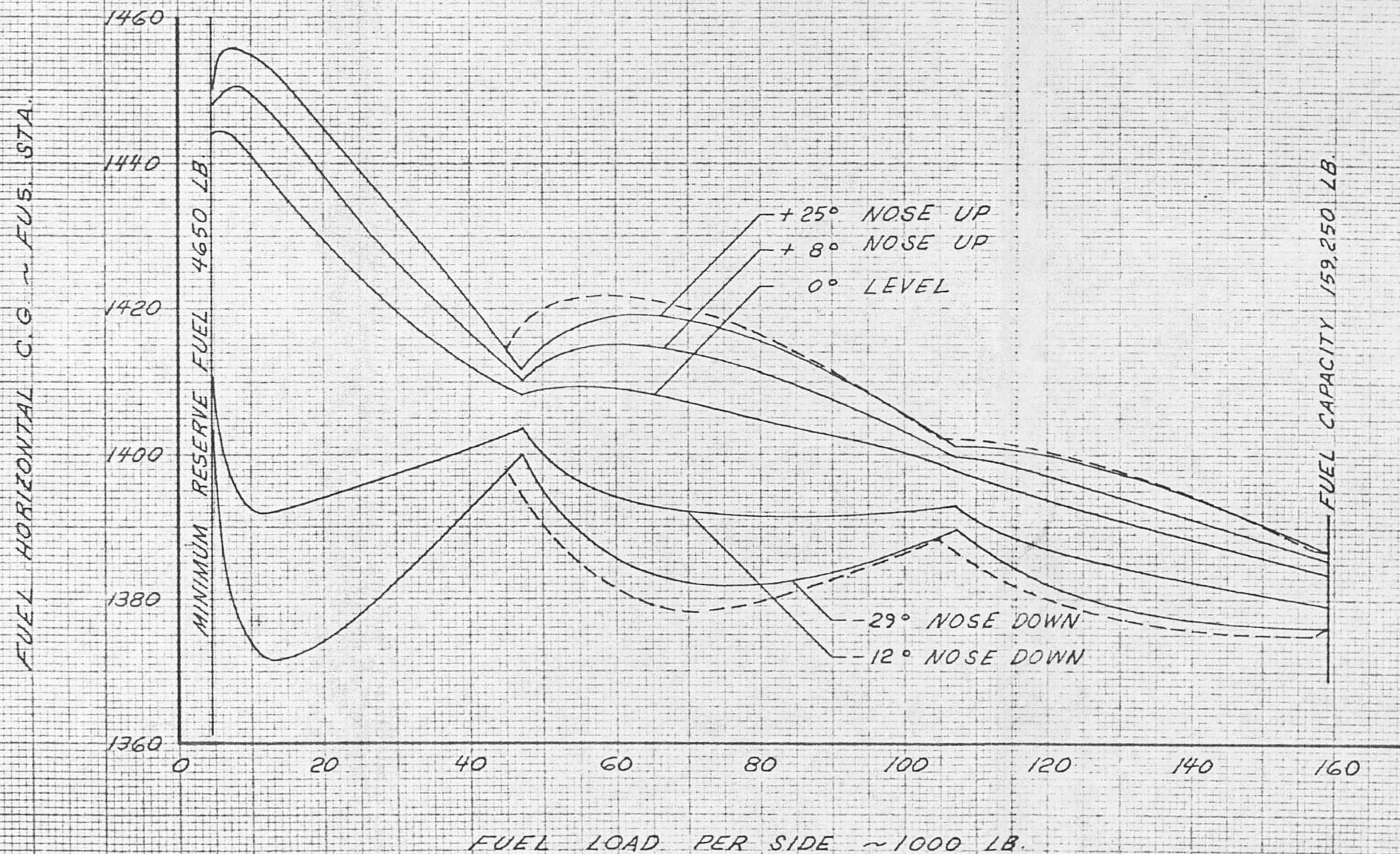


FIGURE 2.8-1

FUEL TANK GEOMETRY

NOTE:

1. DATA ARE BASED UPON FUEL SEQUENCE AND TANK ARRANGEMENT SHOWN AT THE RIGHT.
2. FUEL WEIGHT IS BASED UPON JP-4 @ 6.5 POUNDS PER GALLON.
3. THESE DATA ARE CALCULATED.



- FUEL USAGE SEQUENCE
 (LEFT WING SHOWN - RIGHT WING SIMILAR)
1. EQUALLY FROM NO. 1 AND NO. 2 EXTENDED RANGE UNTIL EMPTY.
 2. EQUALLY FROM NO. 1 AND NO. 2 AUXILIARY UNTIL EMPTY.
 3. EQUALLY FROM NO. 1 AND NO. 2 MAIN UNTIL EMPTY.

LEGEND:

- FUEL CENTER OF GRAVITY DURING NORMAL FUEL USAGE SEQUENCE WITH MAIN TANKS FULL.
- - - FUEL CENTER OF GRAVITY DURING TAKE OFF AND LANDING WITH A MAXIMUM OF 4500 LB. FUEL BURNED FROM THE MAIN TANKS.

FIGURE 2.8-2

C-5A FUEL
 HORIZONTAL CENTER OF GRAVITY

TABLE 2.3-I

FUEL DATA - STANDARD SEQUENCE

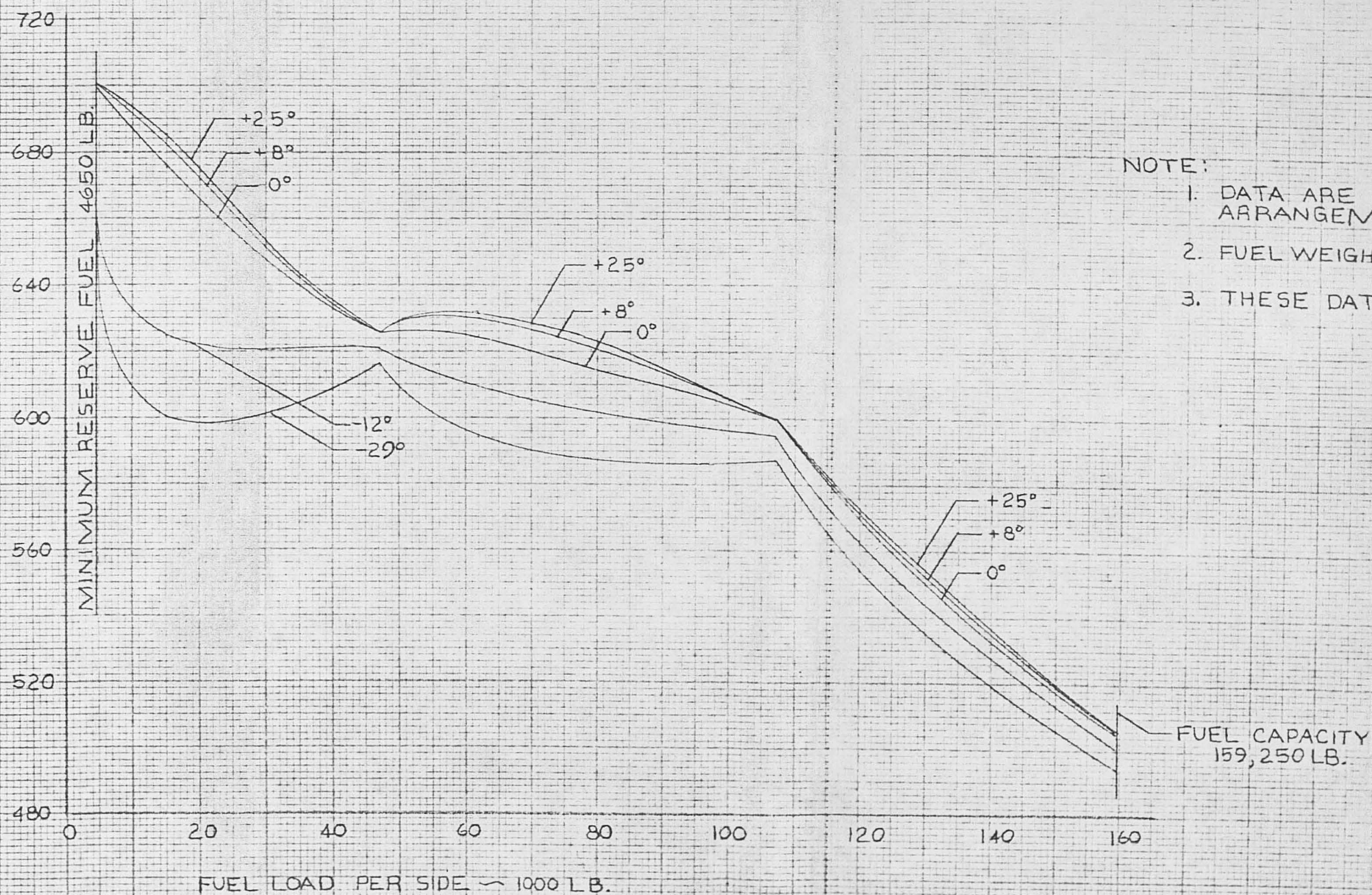
AIR VEHICLE TOTAL FUEL WT. (6.5#/G) LB	FUEL VOLUMES PER SIDE (GALLONS)					
	OUTBOARD MAIN TANK #1	OUTBOARD AUXILIARY TANK #2	OUTBOARD EXT. RANGE TANK #3	INBOARD EXT. RANGE TANK #4	INBOARD AUXILIARY TANK #5	INBOARD MAIN TANK #6
0	0	0	0	0	0	0
94,250	3,625	0	0	0	0	3,625
214,500	3,625	4,625	0	0	4,625	3,625
318,500	3,625	4,625	4,000	4,000	4,625	3,625

1. Warm-up, taxi, take off, and climb are performed with fuel supplied to each engine from its corresponding main tank until a total of approximately 4,500 pounds of fuel is consumed. During this time all extended range and auxiliary tanks are inoperative, and no fuel is being transferred into the main tanks.
2. Transfer extended range tank fuel into corresponding main tanks until all extended range fuel is used. All extended range tanks contain equal volumes and will be depleted at approximately the same time.
3. Transfer auxiliary tank fuel into corresponding main tanks until all auxiliary fuel is used. All auxiliary tanks contain equal volumes and will be depleted at approximately the same time.
4. Continue flight using fuel equally from all main tanks. Open manifold drain valve and drain manifold fuel into the outboard main tanks.

NOTE:

Main tanks are maintained full until extended range and auxiliary fuel is exhausted.

FUEL LATERAL CG. LOCATION ~ BUTTOCK LINE



NOTE:

1. DATA ARE BASED UPON SEQUENCE AND TANK ARRANGEMENT SHOWN IN FIGURE 2.8-2
2. FUEL WEIGHT IS BASED UPON JP-4 @ 6.5 LB./GAL.
3. THESE DATA ARE CALCULATED.

FIGURE 2.8-3

C-5A FUEL
LATERAL CENTER OF GRAVITY

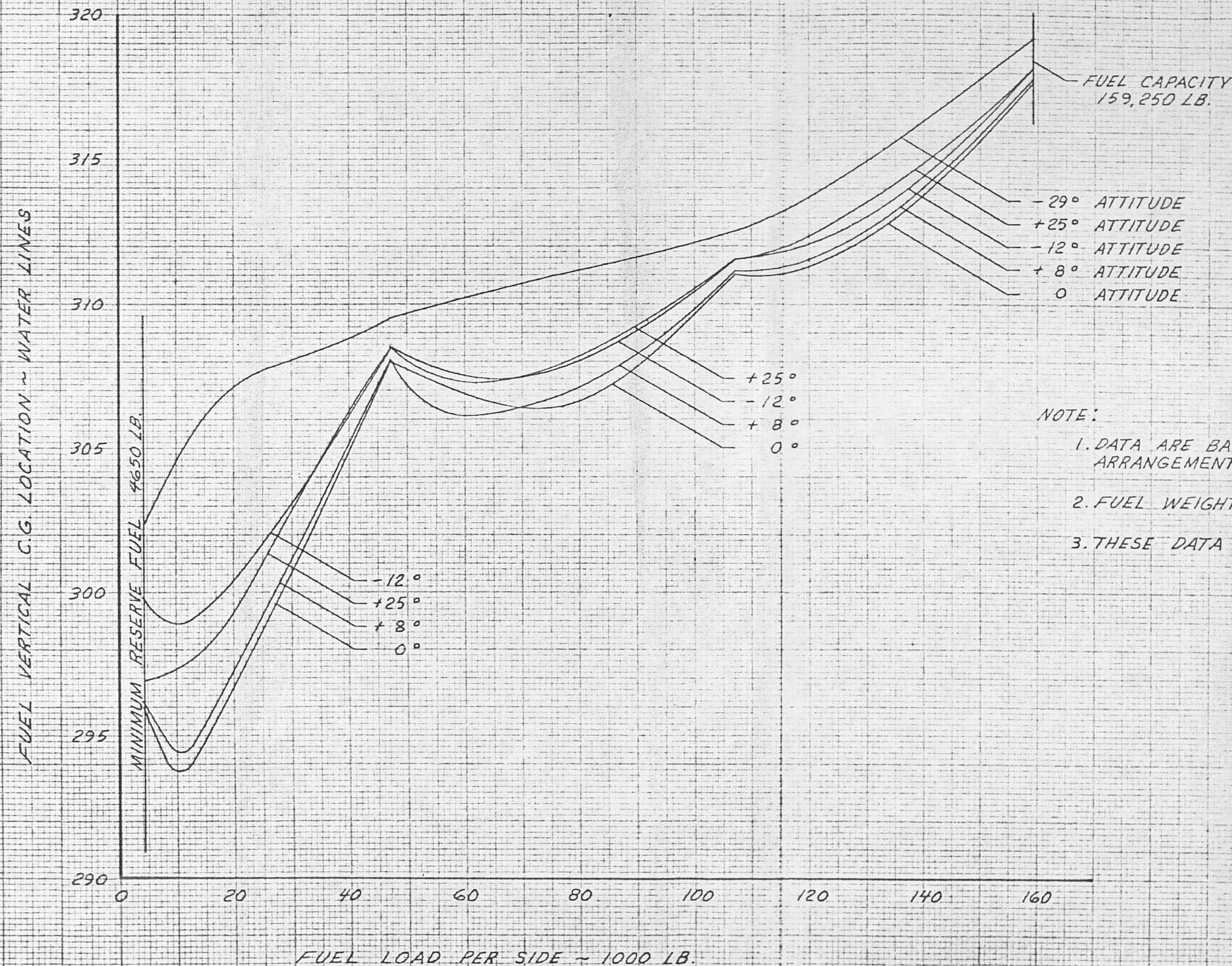
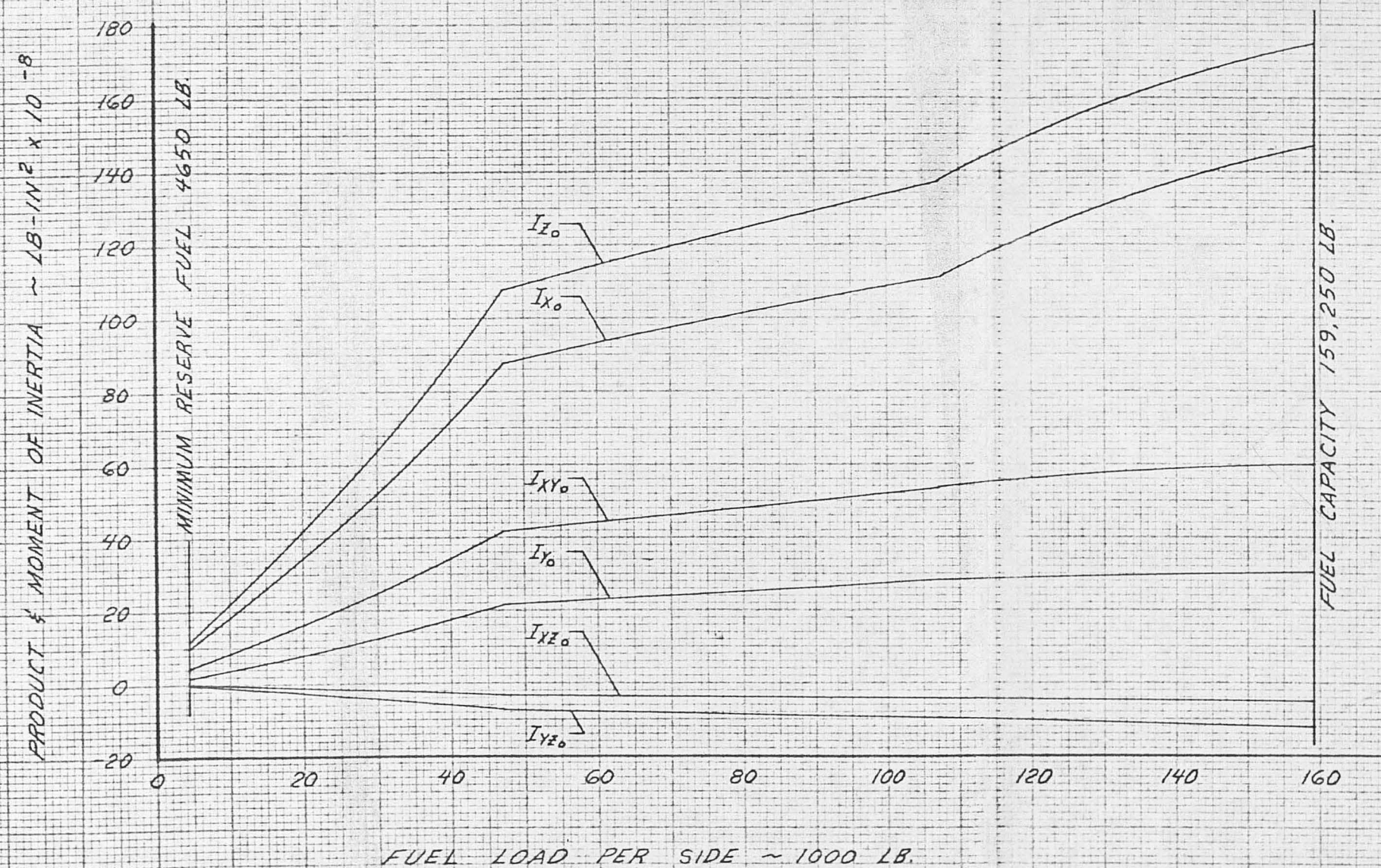


FIGURE 2.8-4

C-5A FUEL
 VERTICAL CENTER OF GRAVITY



NOTE:

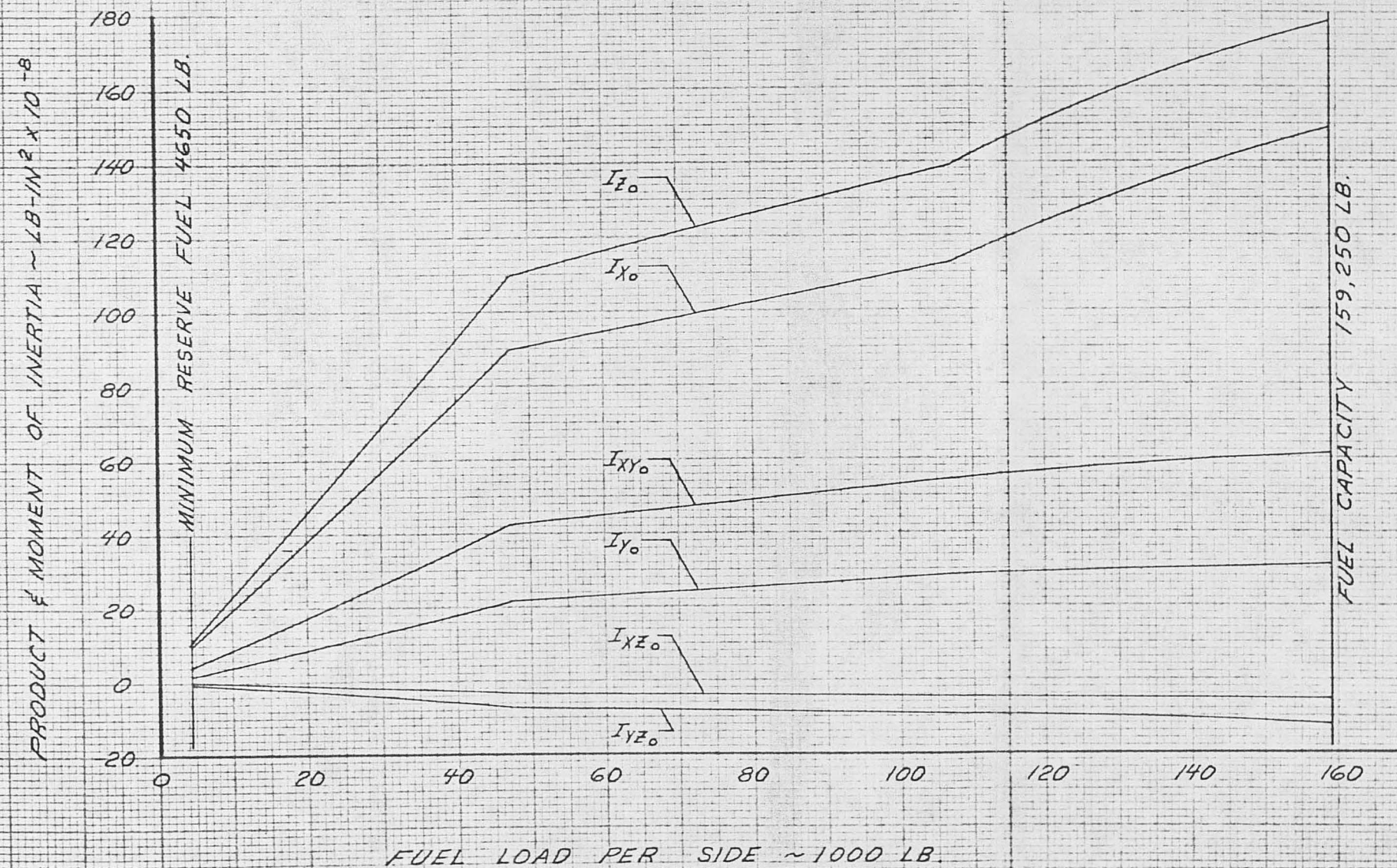
1. DATA ARE BASED ON FUEL SEQUENCE SHOWN IN FIGURE 2.8-2.
2. MASS PROPERTIES SHOWN ARE CENTROIDAL QUANTITIES ABOUT THE FUEL C.G. (FIGURES 2.8-2, 2.8-3 AND 2.8-4).

FIGURE 2.8-5

C-5A FUEL INERTIA

-VS-

WEIGHT PER SIDE
(-29° ATTITUDE)

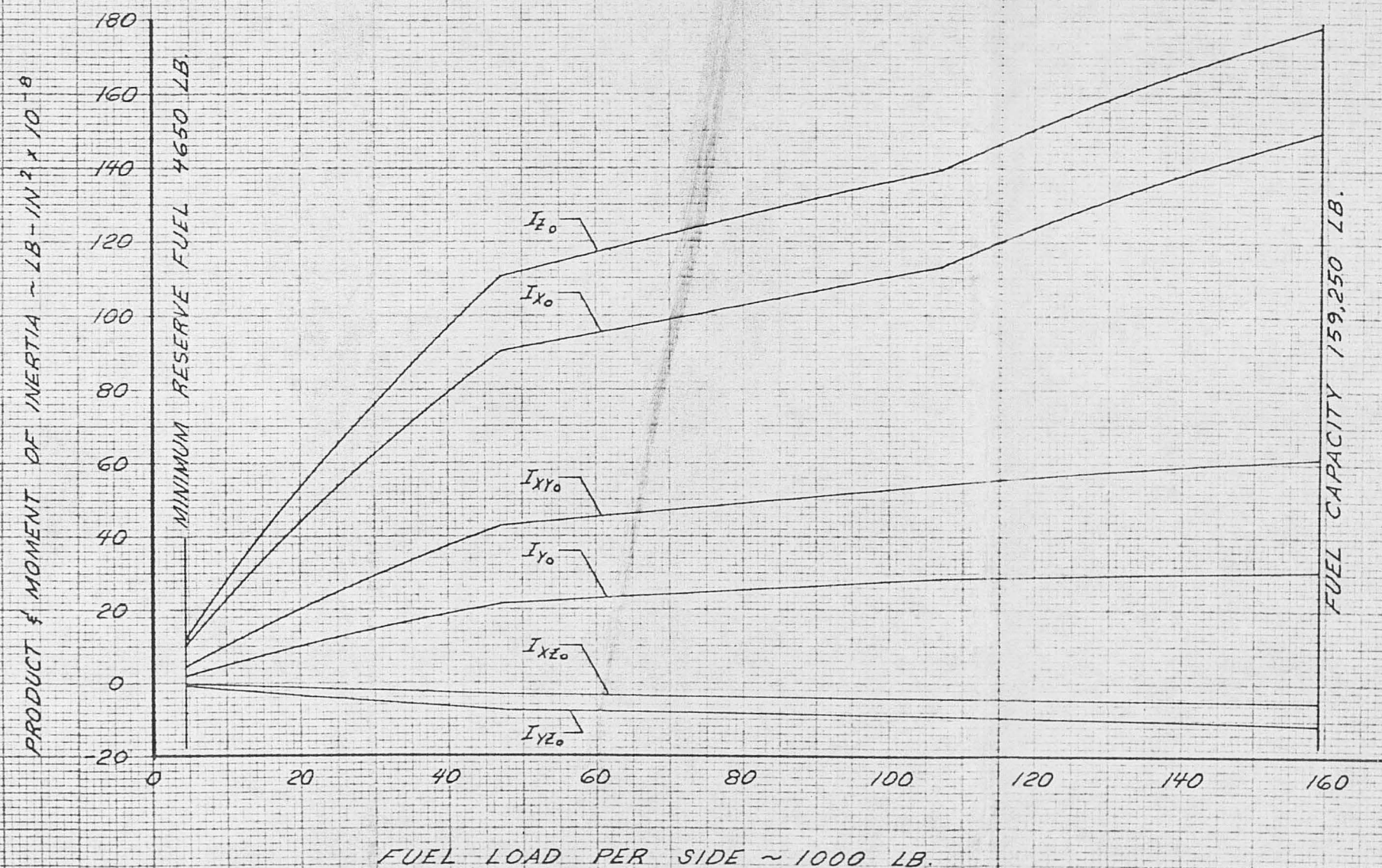


NOTE:

1. DATA ARE BASED ON FUEL SEQUENCE SHOWN IN FIGURE 2.8-2.
2. MASS PROPERTIES SHOWN ARE CENTROIDAL QUANTITIES ABOUT THE FUEL C.G. (FIGURES 2.8-2, 2.8-3 AND 2.8-4).

FIGURE 2.8-6

C-5A FUEL INERTIA
 -VS-
 WEIGHT PER SIDE
 (-12° ATTITUDE)



NOTE:

1. DATA ARE BASED ON FUEL SEQUENCE SHOWN IN FIGURE 2.8-2.

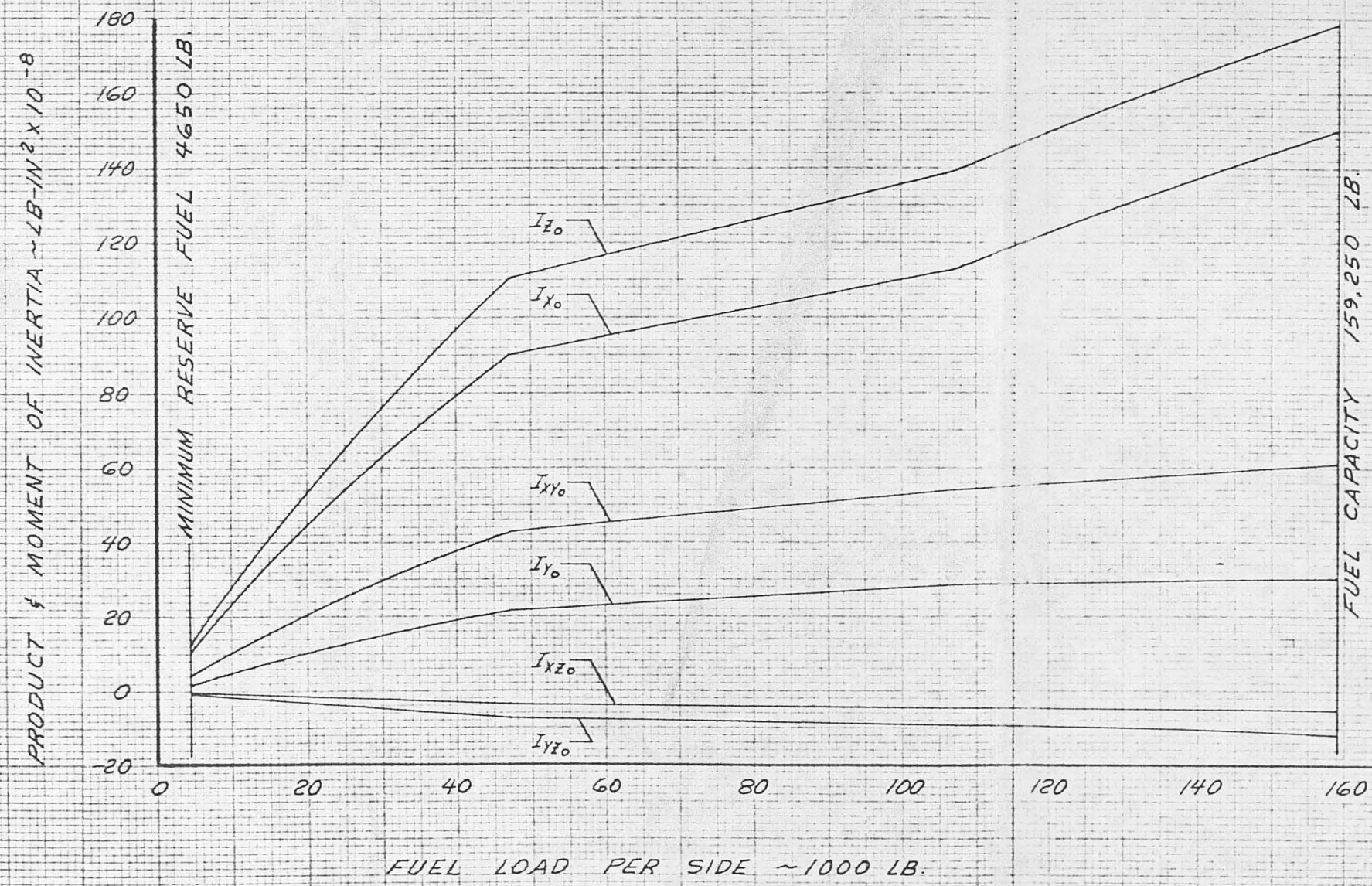
2. MASS PROPERTIES SHOWN ARE CENTROIDAL QUANTITIES ABOUT THE FUEL C.G. (FIGURES 2.8-2, 2.8-3 AND 2.8-4).

FIGURE 2.8-7

C-5A FUEL INERTIA

-VS-

WEIGHT PER SIDE
(0° ATTITUDE)

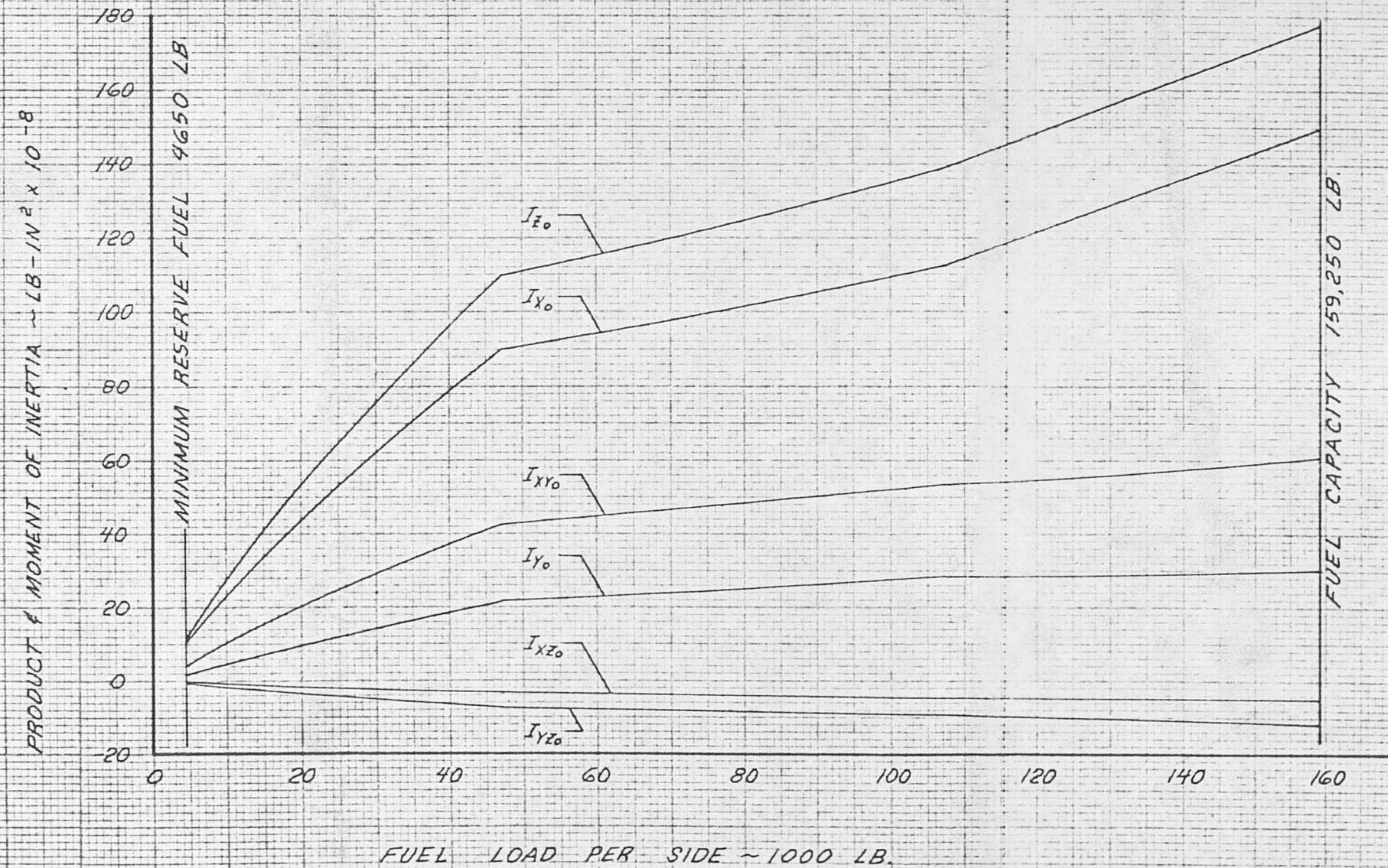


NOTE:

1. DATA ARE BASED ON FUEL SEQUENCE SHOWN IN FIGURE 2.8-2.

2. MASS PROPERTIES SHOWN ARE CENTROIDAL QUANTITIES ABOUT THE FUEL C.G. (FIGURES 2.8-2, 2.8-3 AND 2.8-4).

FIGURE 2.8-8
 C-5A FUEL INERTIA
 -VS-
 WEIGHT PER SIDE
 (8° ATTITUDE)



NOTE:

1. DATA ARE BASED ON FUEL SEQUENCE SHOWN IN FIGURE 2.8-2.
2. MASS PROPERTIES SHOWN ARE CENTROIDAL QUANTITIES ABOUT THE FUEL C.G. (FIGURES 2.8-2, 2.8-3 AND 2.8-4).

FIGURE 2.8-9

C-5A FUEL INERTIA
 -VS-
 WEIGHT PER SIDE
 (25° ATTITUDE)

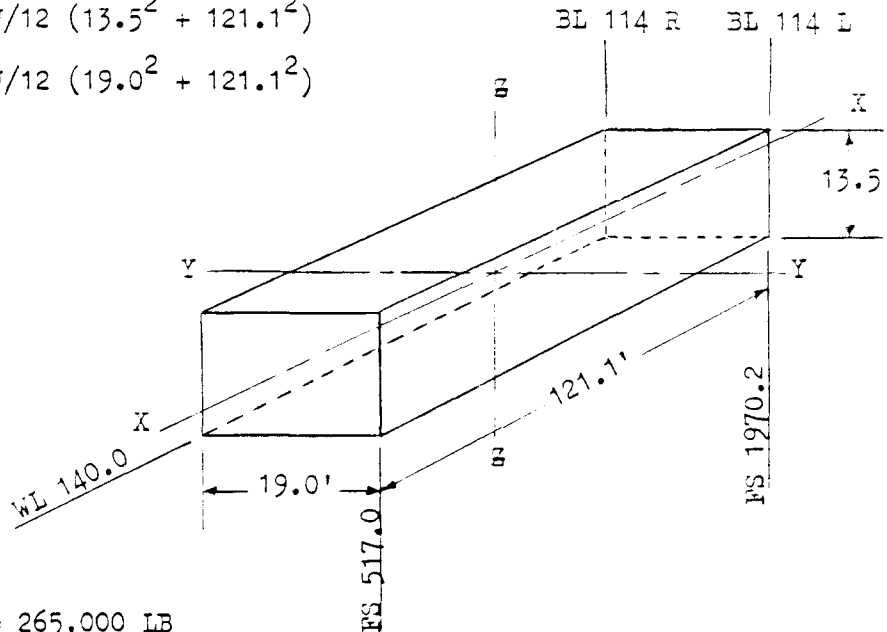
2.9 CARGO

This section presents a general method for obtaining cargo mass data. Sample calculations deriving the cargo mass data used in this report, utilizing an assumed uniformly distributed cargo density, are shown by Figure 2.9-1. It should be recognized that cargo may vary considerably in density and distribution thus increasing or decreasing the mass properties accordingly. Mass data for one cargo distribution are shown in Section 3.2. In this case the cargo is distributed such that the total air vehicle center of gravity is within acceptable limits and the floor limitations are not exceeded. With this basis, cargo is distributed in the compartment extremes to yield the maximum mass properties.

$$I_{x_o} = W/12 (13.5^2 + 19.0^2)$$

$$I_{y_o} = W/12 (13.5^2 + 121.1^2)$$

$$I_{z_o} = W/12 (19.0^2 + 121.1^2)$$



CARGO = 265,000 LB

$$I_{x_o} = 265,000/12(13.5^2 + 19.0^2)(144) = 1,727.5 \times 10^6 \text{ LB-IN}^2$$

$$I_{y_o} = 265,000/12(13.5^2 + 121.1^2)(144) = 47,214.9 \times 10^6 \text{ LB-IN}^2$$

$$I_{z_o} = 265,000/12(19.0^2 + 121.1^2)(144) = 47,783.3 \times 10^6 \text{ LB-IN}^2$$

$$\bar{Z} = 140 + 12(13.5)/2 = 221.0, \bar{X} = 1,243.6, \bar{Y} = 0.0$$

CARGO = 220,000 LB

$$I_{x_o} = 220,000/12(13.5^2 + 19.0^2)(144) = 1,434.2 \times 10^6 \text{ LB-IN}^2$$

$$I_{y_o} = 220,000/12(13.5^2 + 121.1^2)(144) = 39,197.3 \times 10^6 \text{ LB-IN}^2$$

$$I_{z_o} = 220,000/12(19.0^2 + 121.1^2)(144) = 39,669.2 \times 10^6 \text{ LB-IN}^2$$

$$\bar{Z} = 221.0, \bar{X} = 1243.6, \bar{Y} = 0.0$$

FIGURE 2.9-1

SAMPLE CALCULATION
CARGO MOMENT OF INERTIA

3 UNIT INERTIA LOADS

This section presents the unit inertia loads for the major structural components as derived from the solution of mass-acceleration equations utilizing the mass distributions in Section 2.

Subparagraph 3.1, pages 3.1-2 through 3.1-16, shows the derivation of the mass-acceleration equations used in the unit inertia analysis.

Subparagraph 3.2 contains the computer tabulated unit inertia data resulting from the solution of the foregoing equations for the following components:

- a. Wing (including wing stub and power plant packages)
- b. Horizontal Tail (including bullet sections 1 and 2 of Figure 2.4-1)
- c. Vertical Tail (including bullet sections 3 and 4 of Figure 2.5-1)
- d. Empennage complete
- e. Fuselage Forebody and Aftbody (with the landing gear up and down)
- f. Fuselage Aftbody including empennage (with landing gear up and down)
- g. Wing Stub (distributed in the same manner as the fuselage)
- h. Wing Fuel (Several quantities and air vehicle pitch attitudes are shown. For each quantity and attitude, the fuel data are tabulated, then the fuel data combined with the wing data are tabulated, then the fuel combined with the wing data are tabulated in the sweep axis system.)
- i. Cargo (212,145 pounds shown in fuselage forebody and aftbody distribution. Also shown combined with fuselage)

An index to these tabulations is shown beginning on page 3.2-1.

3.1 DERIVATION OF UNIT INERTIA EQUATIONS

3.1.1 Acceleration. Considering the left-hand rule orthogonal coordinate system pictured on page ivx, the general equations of the three components of acceleration for a rigidly fixed point are as follows:

$$a_x = \eta_x g - x_1 (\dot{\epsilon}^2 + \dot{\psi}^2) - y_1 (pq - \ddot{\psi}) - z_1 (\ddot{\epsilon} + rp)$$

$$a_y = \eta_y g + x_1 (\ddot{\psi} + pq) - y_1 (\dot{\psi}^2 + p^2) + z_1 (qr - \dot{p})$$

$$a_z = \eta_z g + x_1 (rp - \ddot{\epsilon}) + y_1 (qr + \dot{p}) - z_1 (p^2 + \dot{\epsilon}^2)$$

Air vehicle motion parameters are referenced to the air vehicle rotational axis, denoted by subscript "RA".

$$x_1 = (\bar{x} - x_{RA}) / l_z$$

$$y_1 = (\bar{y} - y_{RA}) / l_z$$

$$z_1 = (\bar{z} - z_{RA}) / l_z$$

3.1.2 Unit Inertia Shear. Since accelerations produce an opposite inertial force, the following equations for the three components of inertia shear are valid:

$$S_x = -\frac{W}{g} [\eta_x g - x_1 (\dot{\epsilon}^2 + \dot{\psi}^2) + y_1 (pq - \ddot{\psi}) - z_1 (\ddot{\epsilon} + rp)]$$

$$S_y = -\frac{W}{g} [\eta_y g + x_1 (\ddot{\psi} + pq) - y_1 (\dot{\psi}^2 + p^2) + z_1 (qr - \dot{p})]$$

$$S_z = -\frac{W}{g} [\eta_z g + x_1 (rp - \ddot{\epsilon}) + y_1 (qr + \dot{p}) - z_1 (p^2 + \dot{\epsilon}^2)]$$

3.1.2 Unit Inertia Shear (Cont'd). The air vehicle is broken down into several components with each component being sub-divided into panels. The panel weights and centers of gravity will be denoted by subscript "i" in the following equations.

The unit inertia shear loads relationships, derived from the preceding equations, are listed below, with distances, being described in final form in terms of Fuselage Station, Buttock Line, and Water Line.

a. Shear along (X) axis:

$$S_x / \eta_x = - \sum_{i=1}^n W_i$$

$$S_x / \ddot{\theta} = - \sum_{i=1}^n \frac{W_i}{386} (\bar{z}_i - z_{RA}) = S_x / r_p$$

$$S_x / \ddot{\psi} = \sum_{i=1}^n \frac{W_i}{386} (\bar{y}_i - y_{RA}) = -S_x / p_q$$

$$S_x / \dot{\psi}^2 = \sum_{i=1}^n \frac{W_i}{386} (\bar{x}_i - x_{RA}) = S_x / \dot{\theta}^2$$

b. Shear along (Y) axis:

$$S_y / \eta_y = - \sum_{i=1}^n W_i$$

$$S_y / \dot{p} = \sum_{i=1}^n \frac{W_i}{386} (\bar{z}_i - z_{RA}) = -S_y / q_r$$

$$S_y / \ddot{\psi} = - \sum_{i=1}^n \frac{W_i}{386} (\bar{x}_i - x_{RA}) = S_y / p_q$$

$$S_y / p^2 = \sum_{i=1}^n \frac{W_i}{386} (\bar{y}_i - y_{RA}) = S_y / \dot{\psi}^2$$

c. Shear along (Z) axis:

$$S_z / \eta_z = - \sum_{i=1}^n W_i$$

$$S_z / \dot{p} = - \sum_{i=1}^n \frac{W_i}{386} (\bar{y}_i - y_{RA}) = S_z / q_r$$

$$S_z / \ddot{\theta} = \sum_{i=1}^n \frac{W_i}{386} (\bar{x}_i - x_{RA}) = -S_z / r_p$$

$$S_z / p^2 = \sum_{i=1}^n \frac{W_i}{386} (\bar{z}_i - z_{RA}) = S_z / \dot{\psi}^2$$

3.1.3 Unit Inertia Moment. Each of the air vehicle components has its own particular component loads reference axis. These axes will be denoted by subscript "LA" in the succeeding equations. The equations of the three vector components of moment about the component loads reference axes due to inertia shear load, using sign conventions on Page ivx , are as follows:

$$M_x = -\frac{W}{g} (a_z Y_z - a_y Z_z)$$

$$M_y = -\frac{W}{g} (a_x Z_z - a_z X_z)$$

$$M_z = -\frac{W}{g} (a_y X_z - a_x Y_z)$$

Where,

$$X_z = \bar{X} - X_{LA}$$

$$Y_z = \bar{Y} - Y_{LA}$$

$$Z_z = \bar{Z} - Z_{LA}$$

Substituting the acceleration vector equations from paragraph 3.1.1, these unit inertia moment equations become:

$$\begin{aligned} M_x = & -\frac{W}{g} \left[-\eta_y g (Z_z) + \eta_z g (Y_z) + \dot{P} (Y_z + Z_z) \right. \\ & - \ddot{\Theta} (X_1 Y_z) - \dot{\Psi} (X_1 Z_z) + P^2 (Y_1 Z_z - Z_1 Y_z) \\ & - \dot{\Theta}^2 (Z_1 Y_z) + \dot{\Psi}^2 (Y_1 Z_z) - P \dot{q} (X_1 Z_z) \\ & \left. + q r (Y_1 Y_z - Z_1 Z_z) + r p (X_1 Y_z) \right] \end{aligned}$$

$$\begin{aligned} M_y = & -\frac{W}{g} \left[\eta_x g (Z_z) - \eta_z g (X_z) - \dot{P} (Y_1 X_z) \right. \\ & + \ddot{\Theta} (X_1 X_z + Z_1 Z_z) - \dot{\Psi} (Y_1 Z_z) + P^2 (Z_1 X_z) \\ & + \dot{\Theta}^2 (Z_1 X_z - X_1 Z_z) - \dot{\Psi}^2 (X_1 Z_z) + P \dot{q} (Y_1 Z_z) \\ & \left. - q r (Y_1 X_z) + r p (Z_1 Z_z - X_1 X_z) \right] \end{aligned}$$

3.1.3 Unit Inertia Moment (Cont'd)

$$M_{\bar{z}} = -\frac{W}{g} \left[-\ddot{x}_1 g(y_2) + \ddot{y}_1 g(x_2) - \dot{\phi}(\bar{z}, x_2) \right. \\ \left. - \ddot{\phi}(\bar{z}, y_2) - \ddot{\psi}(x_1 x_2 - y_1 y_2) - \dot{\phi}^2(y_1 y_2) \right. \\ \left. + \dot{\phi}^2(x_1 y_2) - \ddot{\psi}^2(x_1 y_2 - y_1 x_2) - \dot{\phi}^2(x_1 x_2 - y_1 y_2) \right. \\ \left. + q r(\bar{z}, x_2) - r p(\bar{z}, y_2) \right]$$

It is evident from above equations that the panel moments of inertia about the panel center of gravity must be included in the unit inertia moment loads. The unit inertia moment loads relationships including these parameters and derived from the above equations, with distances expressed in airplane coordinates (i.e., Fuselage Station) for each component, are as follows:

a. WING, FUEL, AND HORIZONTAL TAIL

1. Moment about (X) axis at B.L. "j":

$$M_x / m_y = \sum_{i=1}^n W_i (\bar{z}_i - \bar{z}_{LA})$$

$$M_x / m_{\bar{z}} = -\sum_{i=1}^n W_i (\bar{y}_i - y_{LA})$$

$$M_x / \dot{\phi} = -\sum_{i=1}^n \frac{W_i}{386} \left[(\bar{y}_i - y_{RA})(\bar{y}_i - y_{LA}) + (\bar{z}_i - \bar{z}_{RA})(\bar{z}_i - \bar{z}_{LA}) \right] - \sum_{i=1}^n \frac{\bar{I}_{x_{RA}}}{386}$$

$$M_x / \ddot{\phi} = \sum_{i=1}^n \frac{W_i}{386} \left[(\bar{x}_i - x_{RA})(\bar{y}_i - y_{LA}) \right] + \sum_{i=1}^n \frac{\bar{I}_{x_{RA}}}{386}$$

$$M_x / \ddot{\psi} = \sum_{i=1}^n \frac{W_i}{386} \left[(\bar{x}_i - x_{RA})(\bar{z}_i - \bar{z}_{LA}) \right] + \sum_{i=1}^n \frac{\bar{I}_{x_{RA}}}{386}$$

$$M_x / p^2 = -\sum_{i=1}^n \frac{W_i}{386} \left[(\bar{y}_i - y_{RA})(\bar{z}_i - \bar{z}_{LA}) - (\bar{z}_i - \bar{z}_{RA})(\bar{y}_i - y_{LA}) \right]$$

$$M_x / \dot{\phi}^2 = \sum_{i=1}^n \frac{W_i}{386} \left[(\bar{z}_i - \bar{z}_{RA})(\bar{y}_i - y_{LA}) \right] + \sum_{i=1}^n \frac{\bar{I}_{y_{RA}}}{386}$$

$$M_x / \dot{\psi}^2 = -\sum_{i=1}^n \frac{W_i}{386} \left[(\bar{y}_i - y_{RA})(\bar{z}_i - \bar{z}_{LA}) \right] - \sum_{i=1}^n \frac{\bar{I}_{y_{RA}}}{386}$$

3.1.3 Unit Inertia Moment (Cont'd)

a. WING, FUEL, AND HORIZONTAL TAIL (CONT'D)

1. Moment about (X) axis at B.L. "j" (cont'd)

$$M_x / p_z = M_x / \ddot{\psi}$$

$$M_x / q_r = - \sum_{TIP} \frac{W_i}{386} [(\bar{y}_i - y_{RA})(\bar{y}_i - y_{LA}) - (\bar{z}_i - z_{RA})(\bar{z}_i - z_{LA})] \\ - \sum_{TIP} \left(\frac{I_{z_{oi}} - I_{y_{oi}}}{386} \right)$$

$$M_x / r_P = - M_x / \ddot{\theta}$$

2. Moment about (Y) axis at B.L. "j":

$$M_y / \eta_x = - \sum_{TIP} W_i (\bar{z}_i - z_{LA})$$

$$M_y / \eta_z = \sum_{TIP} W_i (\bar{x}_i - x_{LA})$$

$$M_y / \dot{\phi} = \sum_{TIP} \frac{W_i}{386} (\bar{y}_i - y_{RA})(\bar{x}_i - x_{LA}) + \sum_{TIP} \frac{I_{xy_{oi}}}{386}$$

$$M_y / \ddot{\theta} = - \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA})(\bar{x}_i - x_{LA}) - (\bar{z}_i - z_{RA})(\bar{z}_i - z_{LA})] - \sum_{TIP} \frac{I_{x_{oi}}}{386}$$

$$M_y / \ddot{\psi} = \sum_{TIP} \frac{W_i}{386} [(\bar{y}_i - y_{RA})(\bar{z}_i - z_{LA})] + \sum_{TIP} \frac{I_{yz_{oi}}}{386}$$

$$M_y / p^2 = - \sum_{TIP} \frac{W_i}{386} [(\bar{z}_i - z_{RA})(\bar{x}_i - x_{LA})] - \sum_{TIP} \frac{I_{xz_{oi}}}{386}$$

$$M_y / \dot{\theta}^2 = - \sum_{TIP} \frac{W_i}{386} [(\bar{z}_i - z_{RA})(\bar{x}_i - x_{LA}) - (\bar{x}_i - x_{RA})(\bar{z}_i - z_{LA})]$$

$$M_y / \dot{\psi}^2 = \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA})(\bar{z}_i - z_{LA})] + \sum_{TIP} \frac{I_{xz_{oi}}}{386}$$

$$M_y / p_z = - M_y / \ddot{\psi}$$

$$M_y / q_r = M_y / \dot{\phi}$$

3.1.3 Unit Inertia Moment (Cont'd)

a. WING, FUEL, AND HORIZONTAL TAIL (CONT'D)

2. Moment about (Y) axis at B.L. "j" (cont'd)

$$M_y / r_p = - \sum_{TIP} \frac{W_i}{386} \left[(\bar{z}_i - z_{RA}) (\bar{z}_i - z_{LA}) - (\bar{x}_i - x_{RA}) (\bar{x}_i - x_{LA}) \right] - \sum_{TIP} \left[\frac{\bar{I}_{x_{RA}} - \bar{I}_{x_{LA}}}{386} \right]$$

3. Moment about (Z) axis at B.L. "j":

$$M_z / m_x = \sum_{TIP} W_i [\bar{y}_i - y_j]$$

$$M_z / m_y = - \sum_{TIP} W_i [\bar{x}_i - x_j]$$

$$M_z / \dot{p} = \sum_{TIP} \frac{W_i}{386} [(\bar{z}_i - z_{RA}) (\bar{x}_i - x_{LA})] + \sum_{TIP} \frac{\bar{I}_{x_{RA}}}{386}$$

$$M_z / \dot{\theta} = \sum_{TIP} \frac{W_i}{386} [(\bar{z}_i - z_{RA}) (\bar{y}_i - y_j)] - \sum_{TIP} \frac{\bar{I}_{y_{RA}}}{386}$$

$$M_z / \ddot{\psi} = - \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA}) (\bar{x}_i - x_{LA}) - (\bar{y}_i - y_{RA}) (\bar{y}_i - y_{LA})] - \sum_{TIP} \frac{\bar{I}_{z_{RA}}}{386}$$

$$M_z / p^2 = \sum_{TIP} \frac{W_i}{386} [(\bar{y}_i - y_{RA}) (\bar{x}_i - x_{LA})] + \sum_{TIP} \frac{\bar{I}_{x_{LA}}}{386}$$

$$M_z / \dot{\phi}^2 = - \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA}) (\bar{y}_i - y_j)] - \sum_{TIP} \frac{\bar{I}_{y_{LA}}}{386}$$

$$M_z / \psi^2 = - \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA}) (\bar{y}_i - y_j) - (\bar{y}_i - y_{RA}) (\bar{x}_i - x_{LA})]$$

$$M_z / p q = - \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA}) (\bar{x}_i - x_{LA}) - (\bar{y}_i - y_{RA}) (\bar{y}_i - y_{LA})] - \sum_{TIP} \left[\frac{\bar{I}_{y_{LA}} - \bar{I}_{x_{RA}}}{386} \right]$$

$$M_z / q r = - M_z / \dot{p}$$

3.1.3 Unit Inertia Moment (Cont'd)

a. WING, FUEL, AND HORIZONTAL TAIL (CONT'D)

1. Moment about (Z) axis at B.L. "j" (cont'd)

$$M_z / r_p = M_z / \ddot{\theta}$$

b. FUSELAGE - FOREBODY ($y_{RA} = y_{LA} = \bar{y}_1$)

1. Moment about (X) axis at F.S. "j":

$$M_x / n_y = \sum_{NOSE}^j W_i (\bar{z}_i - z_{LA})$$

$$M_x / n_z = 0$$

$$M_x / \dot{p} = - \sum_{NOSE}^j \frac{W_i}{386} (\bar{z}_i - z_{RA}) (\bar{z}_i - z_{LA}) - \sum_{NOSE}^j \frac{I_{x_{z_1}}}{386}$$

$$M_x / \ddot{\theta} = 0$$

$$M_x / \ddot{\psi} = \sum_{NOSE}^j \frac{W_i}{386} (\bar{x}_i - x_{RA}) (\bar{z}_i - z_{LA}) + \sum_{NOSE}^j \frac{I_{x_{z_1}}}{386}$$

$$M_x / p^2 = 0$$

$$M_x / \dot{\theta}^2 = 0$$

$$M_x / \psi^2 = 0$$

$$M_x / p q = M_x / \ddot{\psi}$$

$$M_x / q r = \sum_{NOSE}^j \frac{W_i}{386} (\bar{z}_i - z_{RA}) (\bar{z}_i - z_{LA}) - \sum_{NOSE}^j \left(\frac{I_{z_0} - I_{y_0}}{386} \right)$$

$$M_x / r_p = 0$$

3.1.3 Unit Inertia Moment (Cont'd)

b. FUSELAGE - FOREBODY ($Y_{RA} = Y_{LA} = \bar{Y}_i$)

2. Moment about (Y) axis at F.S. "j":

$$M_y / \eta_x = - \sum_{NOSE}^j W_i (\bar{z}_i - \bar{z}_{LA})$$

$$M_y / \eta_z = \sum_{NOSE}^j W_i (\bar{x}_i - x_j)$$

$$M_y / \dot{p} = 0$$

$$M_y / \ddot{\theta} = - \sum_{NOSE}^j \frac{W_i}{386} [(\bar{x}_i - x_{RA})(\bar{x}_i - x_j) + (\bar{z}_i - z_{RA})(\bar{z}_i - z_{LA})] - \sum_{NOSE}^j \frac{I_{y_{oi}}}{386}$$

$$M_y / \dot{\psi} = 0$$

$$M_y / p^2 = - \sum_{NOSE}^j \frac{W_i}{386} (\bar{z}_i - z_{RA})(\bar{x}_i - x_j) - \sum_{NOSE}^j \frac{I_{xz_{oi}}}{386}$$

$$M_y / \dot{\theta}^2 = - \sum_{NOSE}^j \frac{W_i}{386} [(\bar{z}_i - z_{RA})(\bar{x}_i - x_j) - (\bar{x}_i - x_{RA})(\bar{z}_i - z_{LA})]$$

$$M_y / \dot{\psi}^2 = \sum_{NOSE}^j \frac{W_i}{386} (\bar{x}_i - x_{RA})(\bar{z}_i - z_{LA}) + \sum_{NOSE}^j \frac{I_{xz_{oi}}}{386}$$

$$M_y / p \dot{q} = 0$$

$$M_y / \dot{q} r = 0$$

$$M_y / r p = - \sum_{NOSE}^j \frac{W_i}{386} [(\bar{z}_i - z_{RA})(\bar{z}_i - z_{LA}) - (\bar{x}_i - x_{RA})(\bar{x}_i - x_j)] - \sum_{NOSE}^j \left(\frac{I_{x_{oi}} - I_{z_{oi}}}{386} \right)$$

3.1.3 Unit Inertia Moment (Cont'd)

b. FUSELAGE - FOREBODY ($Y_{RA} = Y_{LA} = \bar{Y}_i$)

3. Moment about (Z) axis at F.S. "j":

$$M_z / \dot{\alpha}_x = 0$$

$$M_z / \dot{\alpha}_y = - \sum_{NOSE} \frac{W_i}{386} (\bar{x}_i - x_j)$$

$$M_z / \dot{\alpha} = \sum_{NOSE} \frac{W_i}{386} (\bar{z}_i - z_{RA}) (\bar{x}_i - x_j) + \sum_{NOSE} \frac{\bar{I}_{x_{z_{oi}}}}{386}$$

$$M_z / \ddot{\alpha} = 0$$

$$M_z / \ddot{\psi} = - \sum_{NOSE} \frac{W_i}{386} (\bar{x}_i - x_{RA}) (\bar{x}_i - x_j) - \sum_{NOSE} \frac{\bar{I}_{x_{z_{oi}}}}{386}$$

$$M_z / p^2 = 0$$

$$M_z / \dot{\alpha}^2 = 0$$

$$M_z / \dot{\psi}^2 = 0$$

$$M_z / p q = - \sum_{NOSE} \frac{W_i}{386} [(\bar{x}_i - x_{RA}) (\bar{x}_i - x_j) - (\bar{y}_i - y_{RA}) (\bar{y}_i - y_{LA})] - \sum_{NOSE} \left(\frac{\bar{I}_{y_{z_{oi}}} - \bar{I}_{x_{z_{oi}}}}{386} \right)$$

$$M_z / q r = - \sum_{NOSE} \frac{W_i}{386} (\bar{z}_i - z_{RA}) (\bar{x}_i - x_j) - \sum_{NOSE} \frac{\bar{I}_{x_{z_{oi}}}}{386}$$

$$M_z / r p = 0$$

3.1.3 Unit Inertia Moment (Cont'd)

c. FUSELAGE - AFT BODY

Equations are the same as the ones shown for the forebody except the summation is accomplished from the aft end forward to F.S. "j".

d. VERTICAL TAIL ($Y_{RA} = Y_{LA} = \bar{Y}_1$)

1. Moment about (X) axis at W.L. "j":

$$M_x / \eta_y = \sum_{TIP}^j W_i (\bar{x}_i - \bar{x}_j)$$

$$M_x / \eta_z = 0$$

$$M_x / \dot{p} = - \sum_{TIP}^j \frac{W_i}{386} (\bar{x}_i - \bar{x}_{RA}) (\bar{x}_i - \bar{x}_j) - \sum_{TIP}^j \frac{I_{x_{oi}}}{386}$$

$$M_x / \ddot{\theta} = 0$$

$$M_x / \ddot{\psi} = \sum_{TIP}^j \frac{W_i}{386} (\bar{x}_i - \bar{x}_{RA}) (\bar{x}_i - \bar{x}_j) + \sum_{TIP}^j \frac{I_{x_{oi}}}{386}$$

$$M_x / p^2 = 0$$

$$M_x / \dot{\theta}^2 = 0$$

$$M_x / \dot{\psi}^2 = 0$$

$$M_x / p \dot{q} = \sum_{TIP}^j \frac{W_i}{386} (\bar{x}_i - \bar{x}_{RA}) (\bar{x}_i - \bar{x}_j) + \sum_{TIP}^j \frac{I_{x_{oi}}}{386}$$

$$M_x / q r = \sum_{TIP}^j \frac{W_i}{386} (\bar{x}_i - \bar{x}_{RA}) (\bar{x}_i - \bar{x}_j) - \sum_{TIP}^j \left(\frac{I_{x_{oi}} - I_{y_{oi}}}{386} \right)$$

$$M_x / r p = 0$$

3.1.3 Unit Inertia Moment (Cont'd)

d. VERTICAL TAIL (CONT'D)

2. Moment about (Y) axis at W.L. "j":

$$M_y / \dot{m}_x = - \sum_{TIP} W_i (\bar{z}_i - z_j)$$

$$M_y / \dot{m}_z = \sum_{TIP} W_i (\bar{x}_i - x_{LA})$$

$$M_y / \dot{p} = 0$$

$$M_y / \ddot{\theta} = - \sum_{TIP} \frac{W_i}{386} [(\bar{x}_i - x_{RA})(\bar{x}_i - x_{LA}) + (\bar{z}_i - z_{RA})(\bar{z}_i - z_j)] - \sum_{TIP} \frac{I_{y_{21}}}{386}$$

$$M_y / \ddot{\psi} = 0$$

$$M_y / p^2 = - \sum_{TIP} \frac{W_i}{386} (\bar{z}_i - z_{RA})(\bar{x}_i - x_{LA}) - \sum_{TIP} \frac{I_{x_{22}}}{386}$$

$$M_y / \dot{\theta}^2 = - \sum_{TIP} \frac{W_i}{386} [(\bar{z}_i - z_{RA})(\bar{x}_i - x_{LA}) - (\bar{x}_i - x_{RA})(\bar{z}_i - z_j)]$$

$$M_y / \dot{\psi}^2 = \sum_{TIP} \frac{W_i}{386} (\bar{x}_i - x_{RA})(\bar{z}_i - z_j) + \sum_{TIP} \frac{I_{x_{21}}}{386}$$

$$M_y / p q = 0$$

$$M_y / q r = 0$$

$$M_y / r p = - \sum_{TIP} \frac{W_i}{386} [(\bar{z}_i - z_{RA})(\bar{z}_i - z_j) - (\bar{x}_i - x_{RA})(\bar{x}_i - x_{LA})] - \sum_{TIP} \left(\frac{I_{x_{21}} - I_{z_{21}}}{386} \right)$$

3.1.3 Unit Inertia Moment (Cont'd)

d. VERTICAL TAIL (CONT'D)

3. Moment about (Z) axis at W.L. "j":

$$M_z / \dot{\alpha}_x = 0$$

$$M_z / \dot{\alpha}_y = - \sum_{TIP} W_i (\bar{x}_i - x_{LA})$$

$$M_z / \dot{p} = \sum_{TIP} \frac{W_i}{386} (\bar{z}_i - z_{RA}) (\bar{x}_i - x_{LA}) + \sum_{TIP} \frac{I_{xz_i}}{386}$$

$$M_z / \ddot{\theta} = 0$$

$$M_z / \ddot{\psi} = - \sum_{TIP} \frac{W_i}{386} (\bar{x}_i - x_{RA}) (\bar{x}_i - x_{LA}) - \sum_{TIP} \frac{I_{yz_i}}{386}$$

$$M_z / p^2 = 0$$

$$M_z / \dot{\theta}^2 = 0$$

$$M_z / \dot{\psi}^2 = 0$$

$$M_z / pq = - \sum_{TIP} \frac{W_i}{386} (\bar{x}_i - x_{RA}) (\bar{x}_i - x_{LA}) - \sum_{TIP} \left(\frac{I_{yz_i} - I_{xz_i}}{386} \right)$$

$$M_z / qr = - \sum_{TIP} \frac{W_i}{386} (\bar{z}_i - z_{RA}) (\bar{x}_i - x_{LA}) - \sum_{TIP} \frac{I_{xz_i}}{386}$$

$$M_z / rp = 0$$

3.1.4 Unit Inertia Loads - Equalities. From the preceding equations, it is evident that some components of inertias are equal in magnitude to other components. To eliminate some unnecessary repetition only one of these components will be shown in the IBM tabulations. To aid in locating these equalities, the tables following were prepared. These tables indicate with an "X" the components that are shown in the tabulations. The equalities for the components not shown in the IBM tabulations are indicated.

- a. Unit Inertia Loads - Wing, Fuel, and Horizontal Tail.
Equalities are shown for the wing in the stream and swept axis systems described in Section 3.2.3.

STREAM AXIS

LOAD XX	S_x	S_y	S_z	M_x	M_y	M_z
$\ddot{x}_x$	$S_z/\ddot{x}_z$	C	C	C	X	$-M_x/\ddot{x}_z$
$\ddot{x}_y$	C	$S_z/\ddot{x}_z$	C	$-M_y/\ddot{x}_x$	C	$-M_y/\ddot{x}_z$
$\ddot{x}_z$	C	C	X	X	X	C
$\ddot{y}$	C	$-S_x/\ddot{\theta}$	X	X	X	X
$\ddot{\theta}$	X	C	X	X	X	X
$\ddot{z}$	$-S_z/\ddot{\phi}$	$-S_z/\ddot{\theta}$	C	X	X	X
$\ddot{\phi}^2$	C	$-S_z/\ddot{\phi}$	$-S_x/\ddot{\theta}$	X	$-M_z/\ddot{\phi}$	$M_y/\ddot{\phi}$
$\ddot{\theta}^2$	$S_z/\ddot{\theta}$	C	$-S_x/\ddot{\theta}$	$M_z/\ddot{\theta}$	X	$-M_x/\ddot{\theta}$
$\ddot{\phi}^2$	$S_z/\ddot{\theta}$	$-S_z/\ddot{\phi}$	C	$-M_y/\ddot{\phi}$	$M_x/\ddot{\phi}$	X
$\ddot{\phi}\ddot{\theta}$	$S_z/\ddot{\phi}$	$-S_z/\ddot{\theta}$	C	$M_x/\ddot{\phi}$	$-M_y/\ddot{\theta}$	X
$\ddot{\phi}\ddot{\theta}$	$S_x/\ddot{\theta}$	C	$-S_z/\ddot{\theta}$	$-M_x/\ddot{\theta}$	X	$M_z/\ddot{\theta}$
$\ddot{\phi}\ddot{\theta}$	C	$S_x/\ddot{\theta}$	$S_z/\ddot{\phi}$	X	$M_y/\ddot{\phi}$	$-M_z/\ddot{\phi}$

3.1.4 Unit Inertia Loads - Equalities (Cont'd)

a. Unit Inertia Loads - Wing, Fuel, and Horizontal Tail
(cont'd)

SWEPT AXIS (WING)

LOAD XX	SP_x	SP_y	SP_z	MP_x	MP_y	MP_z
η_x	X	X	C	X	X	X
η_y	$-SP_y/\eta_x$	SP_x/η_x	C	$-MPT/\eta_x$	MPB/η_x	X
η_z	C	C	X	X	X	C
$\ddot{\epsilon}$	X	X	X	X	X	X
$\dot{\epsilon}^2$	X	X	X	X	X	X
$\dot{p}$	$SP_y/\dot{\epsilon}$	$-SP_x/\dot{\epsilon}$	X	X	X	X
$\dot{\epsilon}^2$	X	X	$SP_z/\dot{\epsilon}^2$	X	X	X
$\ddot{\psi}$	X	X	C	X	X	X
$\dot{\psi}^2$	$-SP_y/\dot{\psi}$	$SP_x/\dot{\psi}$	C	$-MPT/\dot{\psi}$	$MPE/\dot{\psi}$	X
$p q$	X	X	C	X	X	X
$r p$	$SP_x/\dot{\epsilon}$	$SP_y/\dot{\epsilon}$	$-SP_z/\dot{\epsilon}$	X	X	$MP_z/\dot{\epsilon}$
$q r$	$-SP_y/\dot{\epsilon}$	$SP_x/\dot{\epsilon}$	$SP_z/\dot{\epsilon}$	X	X	$-MP_z/\dot{\epsilon}$

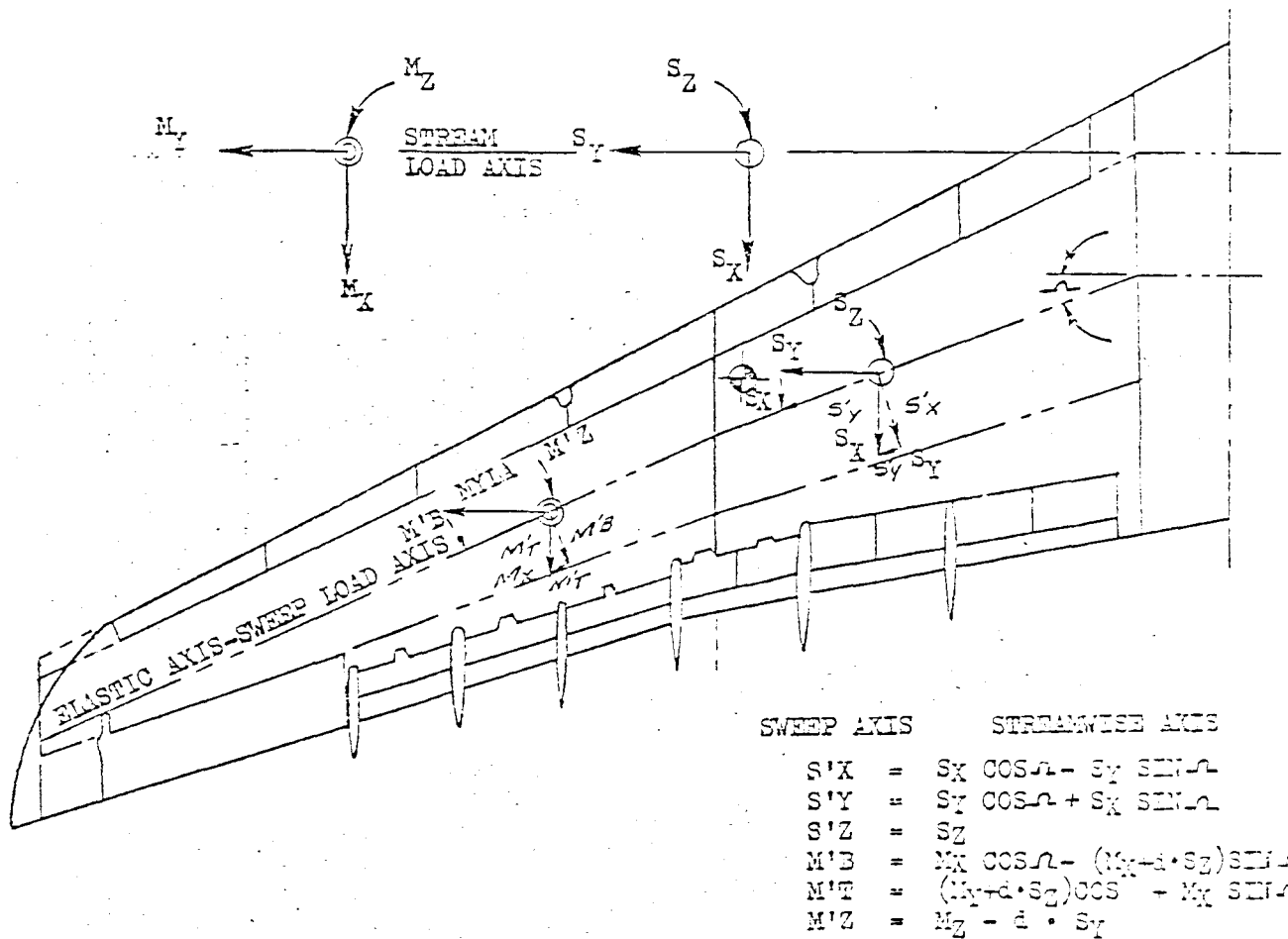


FIGURE 3.1-1

DEFINITION OF STREAM AND SWEEP LOAD AXIS SYSTEMS

3.1.4 Unit Inertia Loads - Equalities (Cont'd)

b. Unit Inertia Loads - Fuselage and Vertical Tail
(When shown separately)

LOAD XX	S_x	S_y	S_z	M_x	M_y	M_z
η_x	S_z/η_z	0	0	0	x	0
η_y	0	S_z/η_z	0	$-M_y/\eta_x$	0	$-M_y/\eta_x$
η_z	0	0	x	0	x	0
$\dot{p}$	0	$-S_x/\dot{\theta}$	0	x	0	x
$\dot{\theta}$	x	0	x	0	x	0
$\ddot{\psi}$	0	$-S_z/\ddot{\theta}$	0	x	0	x
p^2	0	0	$-S_x/\ddot{\theta}$	0	$-M_z/\dot{p}$	0
$\dot{\theta}^2$	$S_z/\ddot{\theta}$	0	$-S_x/\ddot{\theta}$	0	x	0
ψ^2	$S_z/\ddot{\theta}$	0	0	0	$M_x/\ddot{\psi}$	0
$p\dot{p}$	0	$-S_z/\ddot{\theta}$	0	$M_x/\ddot{\psi}$	0	x
$r\dot{p}$	$S_x/\ddot{\theta}$	0	$-S_z/\ddot{\theta}$	0	x	0
$q\dot{r}$	0	$S_x/\ddot{\theta}$	0	x	0	$-M_z/\dot{p}$