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21171-SR1

DATA BASE REPORT
FOR
SATURN V/VOYAGER LOAD RELIEF STUDY

Prepared for
National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Contract NAS8-21171



15 September 1967
(Updated 30 January 1968)



HONEYWELL Aerospace Division

FACILITY FORM 602	N69-32348	
	(ACCESSION NUMBER)	(THRU)
	124	1
	(PAGES)	(CODE)
CR-61867		
(NASA CR OR TMX OR AD NUMBER)		
31		
(CATEGORY)		

547-55660

21171-SR1

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Prepared by:

L. D. Edinger
T. W. Hughes
M. J. Pluimer

Approved by:


J. C. Larson
Senior Staff Engineer
Aerospace Flight Systems

Honeywell Inc.
Aerospace Division
2600 Ridgway Road
Minneapolis, Minnesota 55413

FOREWORD

This document, a noncontractual item, prepared by Honeywell Inc. serves as the data reference for the Saturn V/Voyager load relief study under contract NAS8-21171. The study was performed for the Astrodynamics Laboratory, George C. Marshall Space Flight Center, Huntsville, Alabama. Results of the load relief study are contained in a separate report, Honeywell Report No. 21171-FR.

John Livingston was the MSFC project director. Mr. John Larson was the project engineer at Honeywell. Mr. Lester Edinger acted as the work director under Mr. Larson. This report was prepared by Messrs. Lester Edinger, Thomas Hughes, and Michael J. Pluimer.

CONTENTS

	Page
1.0 Summary	1
2.0 Present Saturn V/Voyager Load Relief Control System (LR-1)	2
3.0 Performance Requirements and Design Constraints	2
3.1 Terminal Condition Performance Requirements	2
3.2 Stability Requirements	2
3.3 Maximum Allowable Bending Moments	4
3.4 Design Constraints	4
4.0 Input Disturbances	6
5.0 Equations of Motion	8
5.1 Complete System of Equations for Saturn V/Voyager Study, Perturbed Vehicle Equations of Motion	16
5.2 Reduced Equations for Stability Analysis of Saturn V/Voyager, Perturbed Vehicle Equations of Motion	19
5.3 Reduced Equations for Time-Varying Digital Simulation of Saturn V/Voyager, Perturbed Vehicle Equations of Motion	22
5.4 Reduced Equations for Time-Varying Analog Simulation of Saturn V/Voyager, Perturbed Vehicle Equations of Motion	25
5.5 Definition of Force and Moment Derivatives	28
5.6 Nomenclature	30
6.0 Vehicle Data	35
6.1 Reduced Data	35
6.2 Basic Data	66
7.0 References	117

ILLUSTRATIONS

Figure		Page
1	Present Saturn V/Voyager Load Relief Control System (LR-1)	3
2	Bending Moment Capability During First-Stage Flight	5
3	Pitch Attitude Command (ϕ_c) vs. Time	7
4	MSFC 95% Synthetic Wind Profile - Maximum Annually	9
5	MSFC 95% Synthetic Wind Profile - Maximum During May - Dec. Period	10
6	MSFC Measured Wind Profile	11
7	MSFC Reverse Shear Wind Profile	12
8	Gross Coordinate System	15
9	Fine Coordinate System	15
10	Mach Number vs. Time	68
11	Nominal Flight Path Velocity Relative to the Atmosphere (V) vs. Time	69
12	Dynamic Pressure ($\bar{q}$) vs. Time	70
13	Total Mass of Rigid Booster (M) vs. Time	71
14	Pitch Moment of Inertia of Rigid Booster About the Center of Gravity (I_{yy}) vs. Time	72
15	Booster Center of Gravity (X_{cg}) vs. Time	73
16	Aerodynamic Center of Pressure (X_{cp})/Reference Length (l) vs. Time	74
17	Center of Gravity Minus Center of Pressure ($X_{cg} - X_{cp}$) vs. Time	75
18	Accelerometer Moment Arm ($X_{cg} - X_A$) vs. Time	76
19	Normal Force Gradient ($C_{N\alpha}$) vs. Flight Time	77
20	Aerodynamic Coupling Coefficient ($C_{M\dot{\phi}}$) vs. Time	78
21	Aerodynamic Coupling Coefficient ($C_{N\dot{n}_i}$) vs. Time	79
22	Aerodynamic Coupling Coefficient ($C_{M\dot{n}_i}$) vs. Time	80
23	Aerodynamic Coupling Coefficient ($C_{N\ddot{n}_i}$) vs. Time	81
24	Aerodynamic Coupling Coefficient ($C_{M\ddot{n}_i}$) vs. Time	82

Figure		Page
25	Aerodynamic Coupling Coefficient ($C_{N\eta_{ii}}$) vs. Time	83
26	Aerodynamic Coupling Coefficient ($C_{N\dot{\eta}_{ii}}$) vs. Time	84
27	Axial Acceration $\left(\frac{T - X_A}{M} \right)$ vs. Time	85
28	Total Thrust of Controllable Engines (R') vs. Time	86
29	Generalized Mass of the First and Second Bending Modes (m_1 and m_2) vs. Time	87
30	Generalized Mass of the Third Bending Mode (m_3) vs. Time	88
31	Generalized Mass of the Fourth Bending Mode (m_4) vs. Time	89
32	Natural Frequency of the i^{th} Bending Mode (ω_i) vs. Time	90
33	Normalized Modal Deflection of the First Bending Mode at Station X_β $[Y_1(x_\beta)]$ vs. Time	91
34	Normalized Modal Deflection of the Second Bending Mode at Station X_β $[Y_2(X_\beta)]$ vs. Time	92
35	Normalized Modal Deflection of the Third Bending Mode at Station X_β $[Y_3(X_\beta)]$ vs. Time	93
36	Normalized Model Deflection of the Fourth Bending Mode at Station X_β $[Y_4(X_\beta)]$ vs. Time	94
37	Normalized Modal Slope of the First Bending Mode at the Control Engine Center of Gravity Station $[Y'_1(X_E)]$ vs. Time	95
38	Normalized Modal Slope of the Second Bending Mode at the Control Engine Center of Gravity Station $[Y'_2(X_E)]$ vs. Time	96
39	Normalized Modal Slope of the Third and Fourth Bending Modes at the Control Engine Center of Gravity Station $[Y'_i(X_E)]$ vs. Time	97
40	Propellant Tank Sloshing Mass (m_{sj}) vs. Time	98
41	j^{th} Propellant Tank Sloshing Mass Station (X_{sj}) vs. Time	99
42	Equivalent Viscous Damping Factor of the j^{th} Propellant Tank Sloshing Mass (ζ_{sj}) vs. Time	100
43	Natural Frequency of the First and Second Propellant Tank Sloshing (ω_{sj}) vs. Time	101

Figure		Page
44	Natural Frequency of the Third Propellant Tank Sloshing (ω_{s3}) vs. Time	102
45	Normalized Modal Deflection of the i^{th} Bending Mode at the First Propellant Tank Sloshing Mass Station $[Y_i(X_{s1})]$ vs. Time	103
46	Normalized Modal Deflection of the i^{th} Bending Mode at the Second Propellant Tank Sloshing Mass Station $[Y_i(X_{s2})]$ vs. Time	104
47	Normalized Modal Deflection of the i^{th} Bending Mode at the Third Propellant Tank Sloshing Mass Station $[Y_i(X_{s3})]$ vs. Time	105
48	Normalized Modal Slope of the First Bending Mode at the j^{th} Propellant Tank Sloshing Mass Station $[Y'_1(X_{sj})]$ vs. Time	106
49	Normalized Modal Slope of the Second Bending Mode at the j^{th} Propellant Tank Sloshing Mass Station $[Y'_2(X_{sj})]$ vs. Time	107
50	Normalized Modal Slope of the Third Bending Mode at the j^{th} Propellant Tank Sloshing Mass Station $[Y'_3(X_{sj})]$ vs. Time	108
51	Normalized Modal Slope of the Fourth Bending Mode at the j^{th} Propellant Tank Sloshing Mass Station $[Y'_4(X_{sj})]$ vs. Time	109
52	Normalized Deflection of the i^{th} Bending Mode at Station 1541 $[Y_i(1541)]$ vs. Time	110
53	Normalized Modal Slope of the i^{th} Bending Mode at Station 3235 vs. Time	111
54	Normalized Modal Slope of the i^{th} Bending Mode at Station 2686 vs. Time	112
55	Rigid Body-Bending Moment Coefficient $[M'_\alpha(X)]$ vs. Time	113
56	Rigid Body-Bending Moment Coefficients $[M'_\alpha(1541)]$ and $[M'_\beta(1541)]$ vs. Time	114
57	Rigid Body-Bending Moment Coefficient $[M'_\beta(X)]$ vs. Time	115

SATURN V/VOYAGER LOAD RELIEF STUDY DATA BASE REPORT

1.0 SUMMARY

This data base report contains all pertinent information required for the Saturn V/Voyager Load Relief Study. The purpose of this study is to define a control system (to be referred to as LR-2) to improve the launch probability of the Saturn V booster with a Voyager payload. The particular Voyager payload configuration to be studied has a 45-foot-long cylindrical section. A load relief control system (herein referred to as LR-1) was designed under NASA contract NAS6-11206, modification 5 (see Reference 1), for a Voyager payload configuration having a 54-foot cylindrical section. In the present study, the LR-1 system will be reviewed and modified as necessary to meet the performance requirements for the shorter, 45-foot payload configuration.

This report describes the LR-1 load relief control system and the performance requirements, design constraints, equations of motion, input disturbances, and vehicle data to be used in the study of the shorter-length payload booster configuration. Vehicle data presented includes basic data extracted from NASA data sources and reduced data suitable for direct use in the equations of motion. The reduced data was computed from the extracted data with the aid of Honeywell digital computer programs. The data sources are listed on the basic data figures and are summarized in the list of references at the end of the report. If assumptions were made in order to compute or to extract data, these assumptions are also presented with the data.

2.0 PRESENT SATURN V/VOYAGER LOAD RELIEF CONTROL SYSTEM (LR-1)

Figure 1 shows gains, shaping, and feedback signals used in the LR-1 flight control system.

3.0 PERFORMANCE REQUIREMENTS AND DESIGN CONSTRAINTS

This section summarizes terminal condition performance requirements, stability requirements, allowed bending moment, and system design constraints which govern the analysis and design of the LR-2 load relief control system.

3.1 Terminal Condition Performance Requirements

The following are required first-stage cutoff conditions based on information contained in Reference 2:

- Maximum allowable drift: 30,000 meters
- Maximum allowable drift rate: 70 meters per second
- Maximum allowable angle of attack: 3.4 degrees

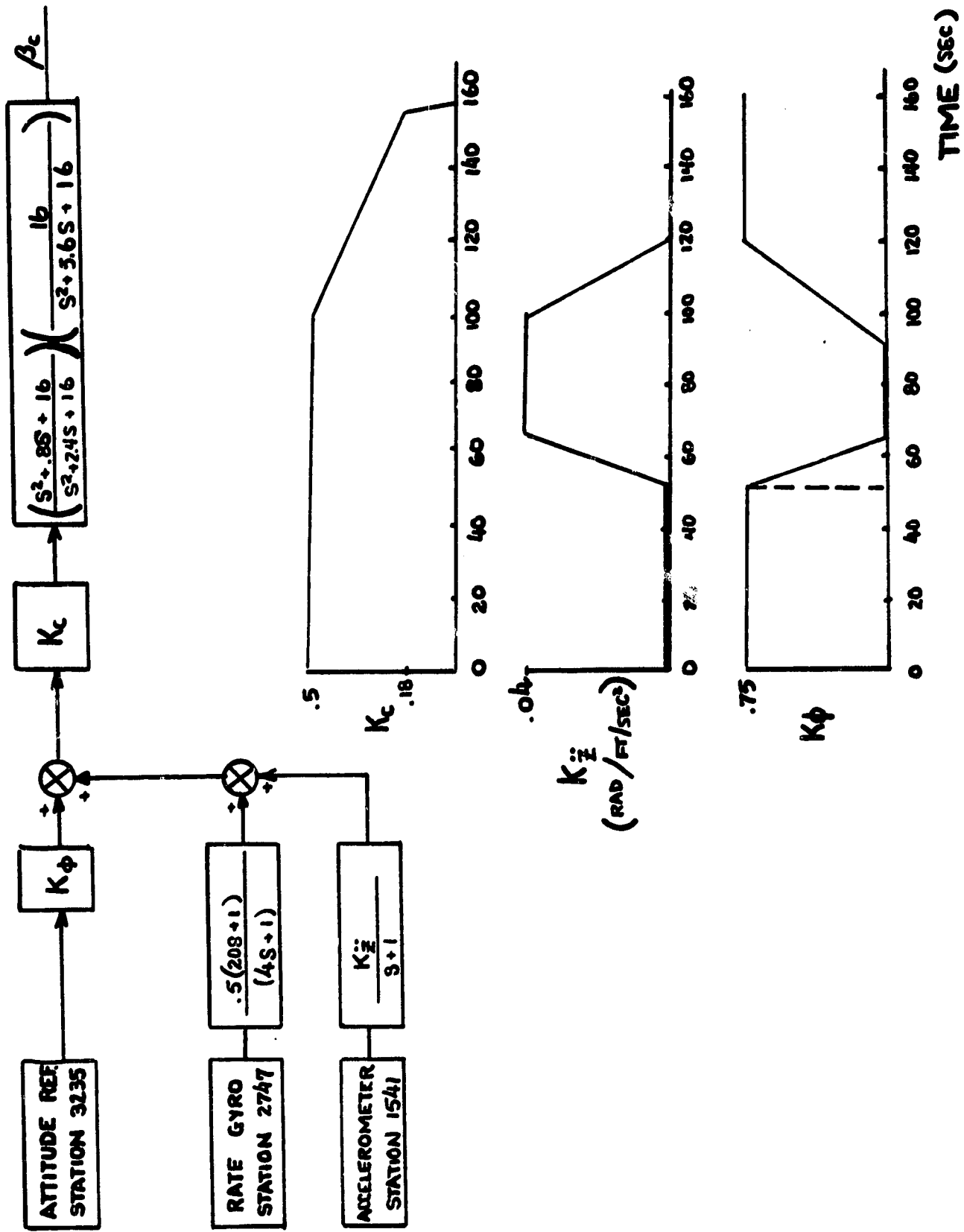
3.2 Stability Requirements

Stability requirements are as follows:

- 6-db gain margin at rigid-body frequency, slosh mode frequencies, and all structural mode frequencies.
- 30-degree phase margin at rigid-body and slosh mode frequencies.
- 40-degree phase margin at the first two structural mode frequencies.

FIGURE 1. PRESENT SATURN V/VOYAGER LOAD RELIEF CONTROL SYSTEM

- LR-1 -



3.3 Maximum Allowable Bending Moment

The maximum allowable bending moments at vehicle stations 1541, 2519, 2746, and 3256, as a function of time, are specified in Figure 2. Of these stations, 3256, located at the top of the instrument unit, represents the most critical body station.

3.4 Design Constraints

The following design constraints are to be imposed in accordance with information contained in References 2 and 3:

- Allowable sensors and sensor locations --
 - a) Attitude reference -- Station 3235.
 - b) Rate gyro -- Station 2686 is the present location.
Station 3235 could be used if desired.
 - c) Accelerometer -- Station 1541 is the present location.
Stations 2686 or 3235 could be used if desired.
- Wind design will be per modification 5 of NASA contract NAS8-11206 (see Reference 1). The load relief system will be evaluated using representative measured profiles, as well as annual (March) and most severe mission (December) synthetic wind profiles. These wind models are described in Section 5.0. Meeting performance requirements in the presence of annual wind magnitudes would be desirable: The system will meet the requirements for maximum mission wind.

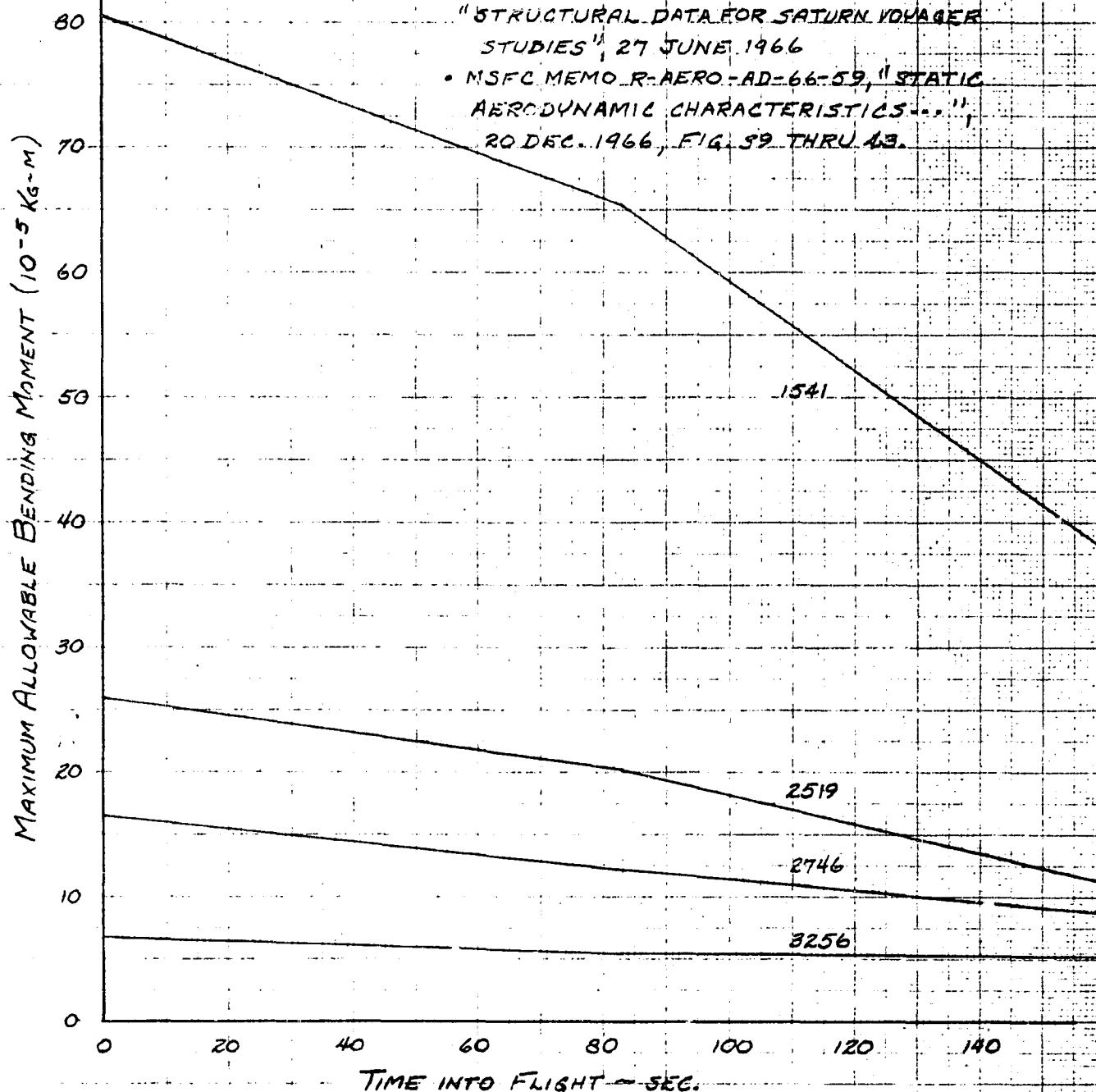
FIGURE 2

BENDING MOMENT CAPABILITY DURING FIRST
STAGE FLIGHT

NOTE:

1. DATA CURVES COMPUTED USING DATA
FROM FOLLOWING REFERENCES;

- MSFC MEMO R-P&VE-5J-66-132,
"STRUCTURAL DATA FOR SATURN VOYAGER
STUDIES", 27 JUNE 1966
- MSFC MEMO R-AERO-AD-66-59, "STATIC
AERODYNAMIC CHARACTERISTICS...",
20 DEC. 1966, FIG. 39 THRU 43.



- Gain scheduling and filtering will be done on individual feedbacks. No compensation will be permitted on summed signals into the gimbal actuator amplifier.
- Only two feedbacks (per channel) will be continuously scheduled. Other scheduling will be accomplished in a step manner.
- Passive filters are desired. If necessary, active filters will be permitted. (A passive filter is defined as having real roots in the denominator of its transfer function. Active filters will have complex roots in the denominator.)
- The following vehicle parameter variations will be considered in a root-sum-squared manner to produce the greatest deviation from nominal system performance:
 - a) Control system gains: ± 10 percent
 - b) Thrust: ± 1.5 percent
 - c) Center of pressure and center of gravity: ± 127.8 inches
 - d) Aerodynamic coefficient, C_{n_α} : ± 10 percent
 - e) Engine gimbal offset: 0.38 degree
 - f) Gain schedule errors: ± 5 seconds
 - g) Bending mode frequencies: ± 20 percent

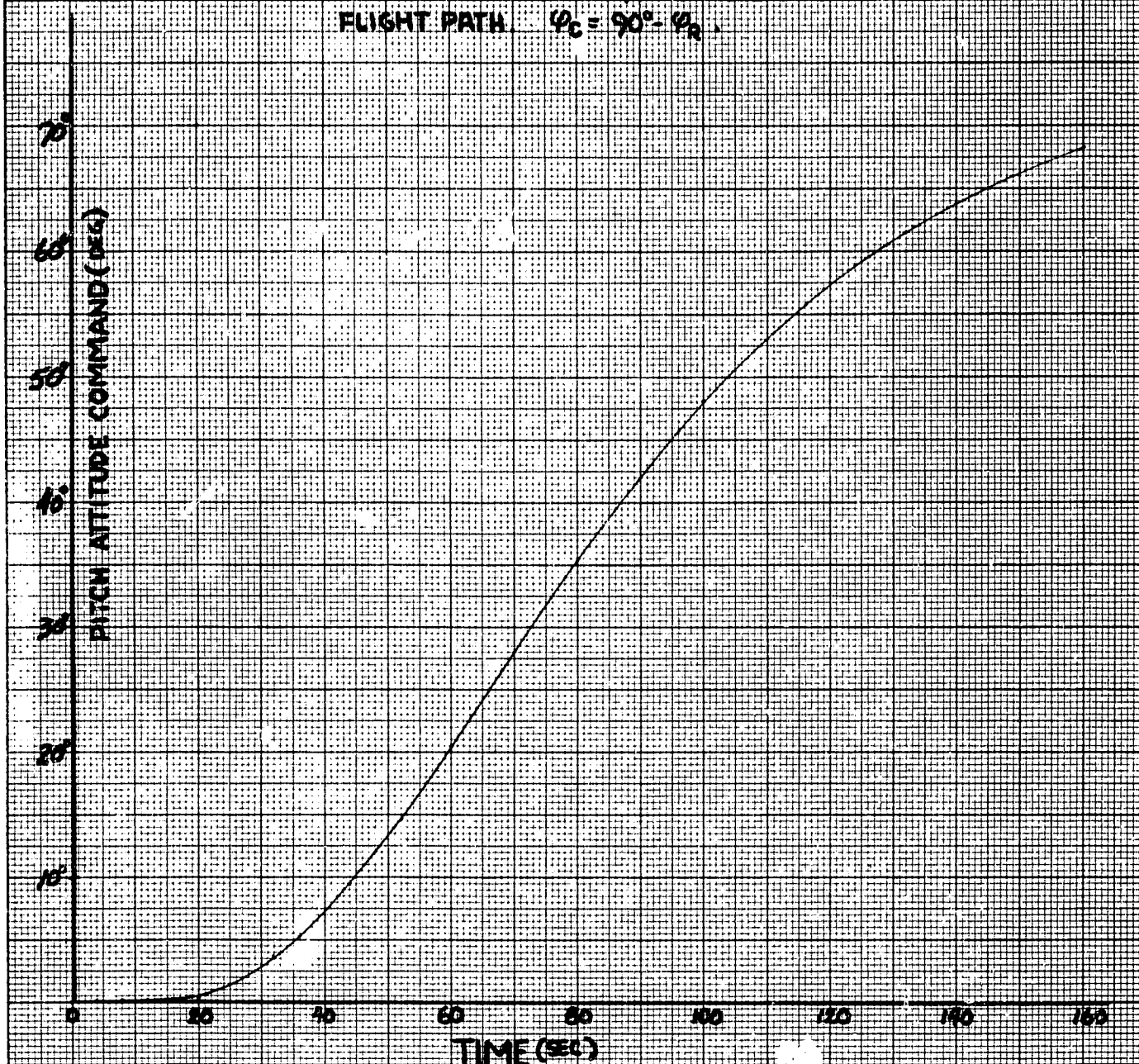
4.0 INPUT DISTURBANCES

This section contains the pitch program (Figure 3) to be flown by the Saturn V/Voyager vehicle and the different wind profile environments to be used to establish LR-2 load relief system performance. The wind models were extracted from Reference 5 as directed by Reference 2. They include:

FIGURE 3
PITCH ATTITUDE COMMAND (ϕ_c) vs TIME

NOTE :

1. REF: NASA TM X-53588, "PRELIMINARY SATURN V VOYAGER TRAJECTORY ...", 22 MAR. 1967, TABLE 2, PAGE 20.
2. ϕ_R IS VEHICLE ATTITUDE, REFERENCED TO LAUNCH PT. VERTICAL, REQUIRED FOR ZERO LIFT FLIGHT PATH $\phi_c = 90^\circ - \phi_R$.



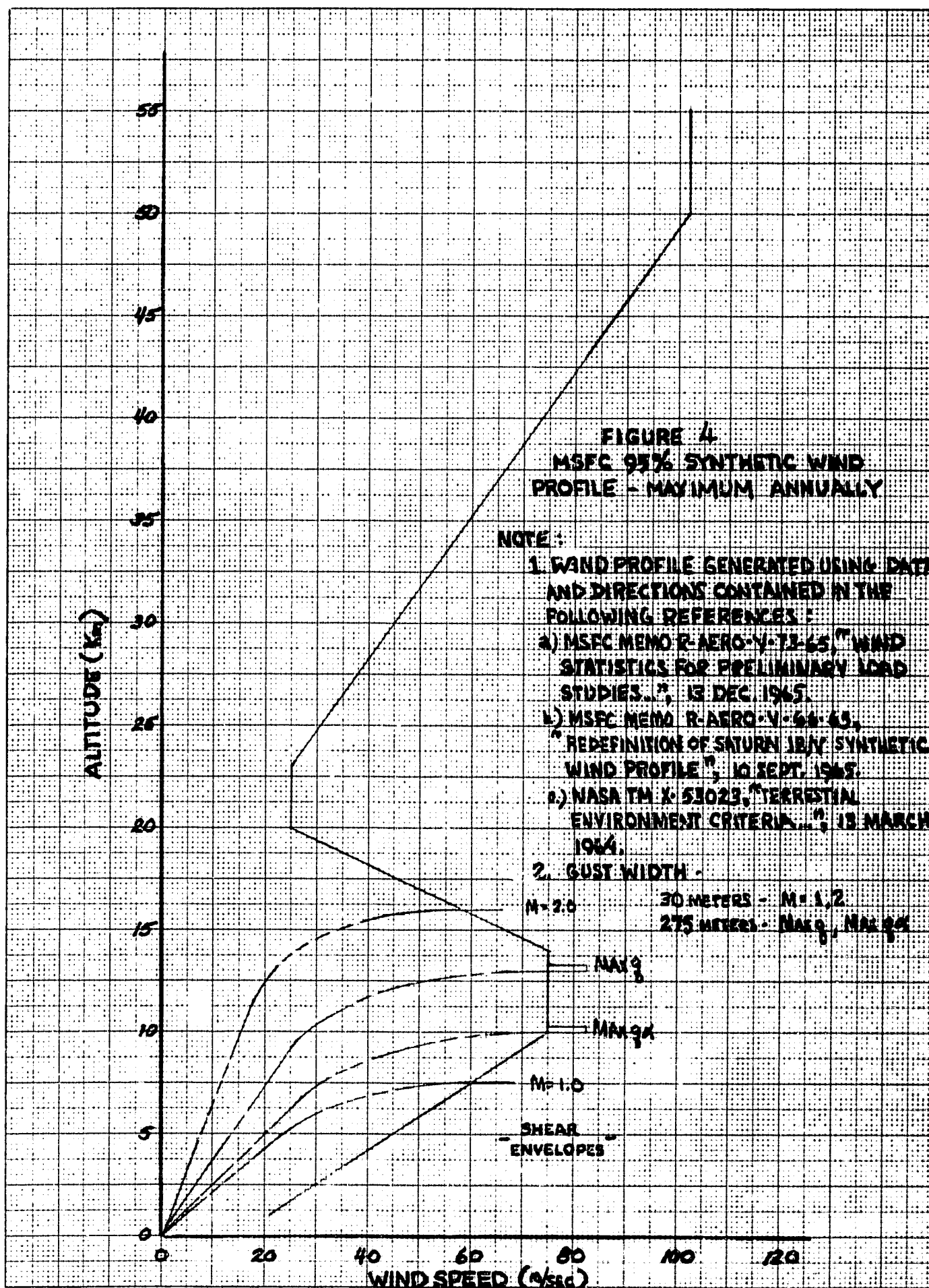
- MSFC 95-percent synthetic wind profiles:
 - a) Maximum annually (March), Figure 4.
 - b) Maximum during May-December launch period (December), Figure 5.
- MSFC measured wind profiles, Figure 6:
 - a) No. 1639. Maximum peak wind speed 79.02 meters per second at maximum dynamic pressure.
 - b) No. 515-06. Maximum shear rate to peak wind speed 60.61 meters per second.
- MSFC reverse shear wind profile, Figure 7.

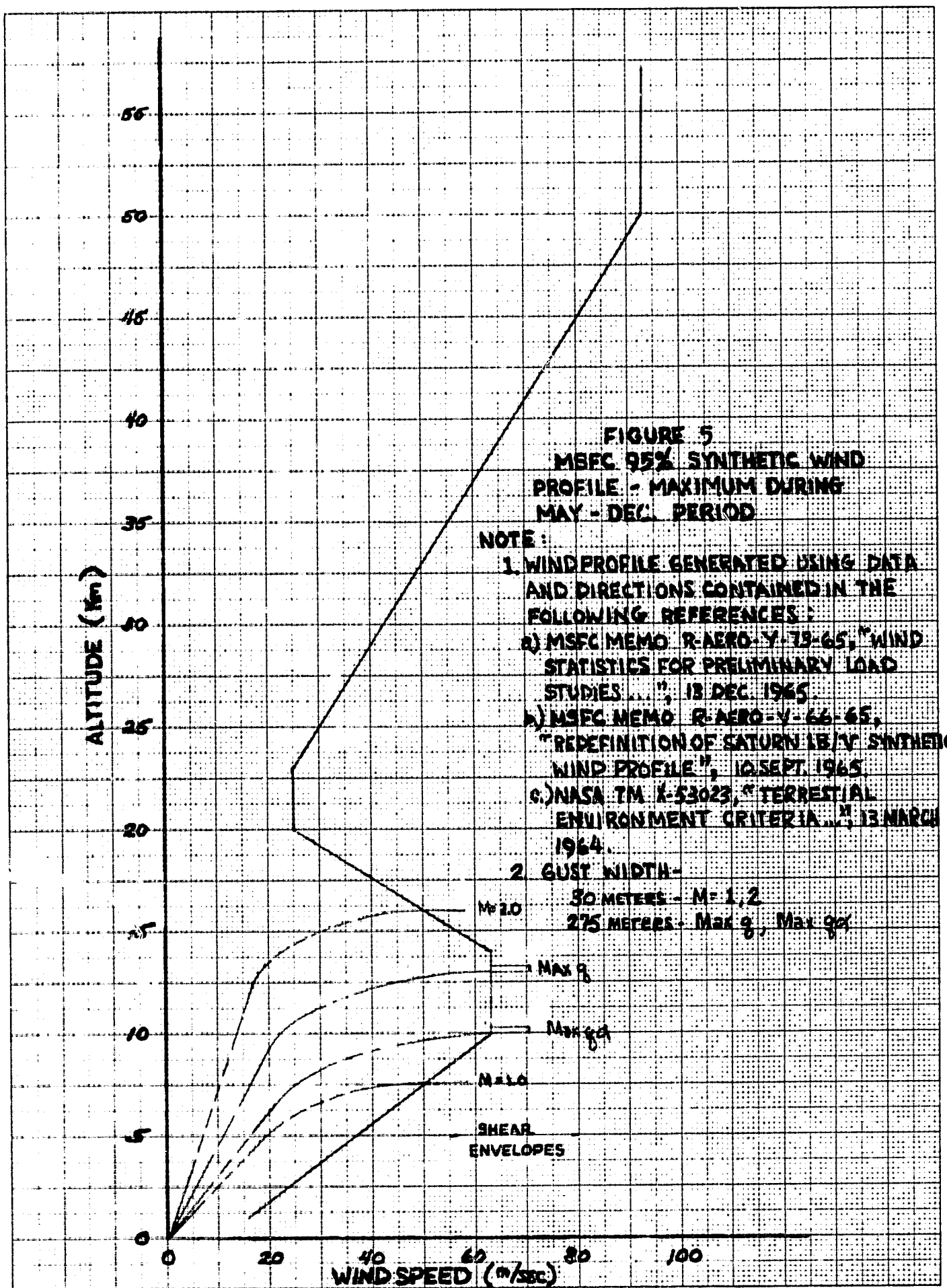
The most severe mission wind used during the study of the 54-foot Voyager payload load relief (Reference 1) was the maximum during the May-November launch period. This has been increased to the maximum magnitudes occurring during the May-December period in accordance with Reference 2.

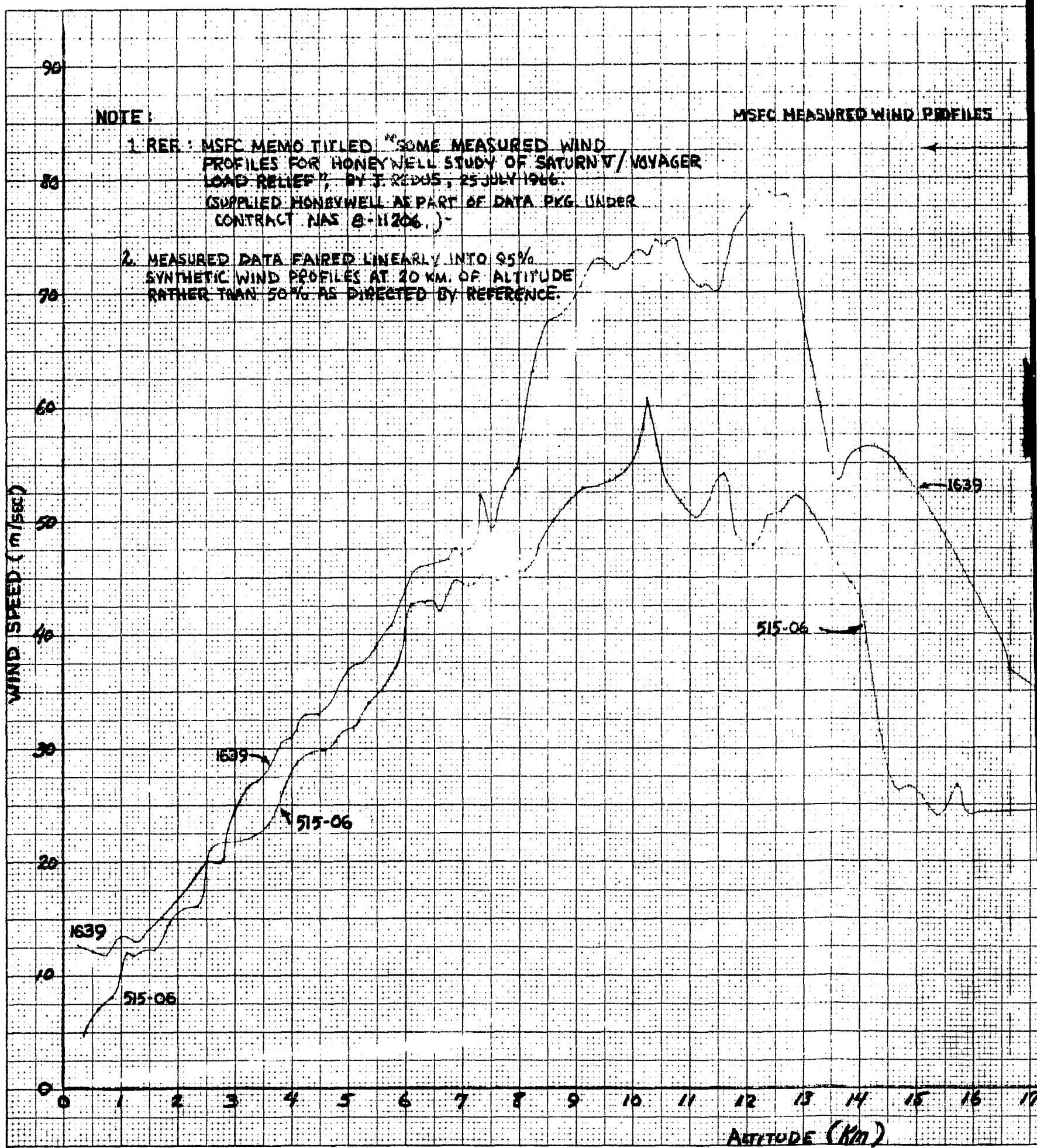
5.0 EQUATIONS OF MOTION

This section describes equations of motion, nomenclature, and coordinate systems used. Four sets of equations are presented. They are:

- Complete set of equations (Section 5.1)
- Reduced set for stability analysis (Section 5.2)
- Reduced set for digital computer PARTNER time-varying simulation (Section 5.3)
- Reduced set for analog computer time-varying analog simulation (Section 5.4).







MEASURED WIND PROFILES

MSFC 95% SYNTHETIC WIND PROFILES

FIGURE 6

MSFC MEASURED WIND PROFILE

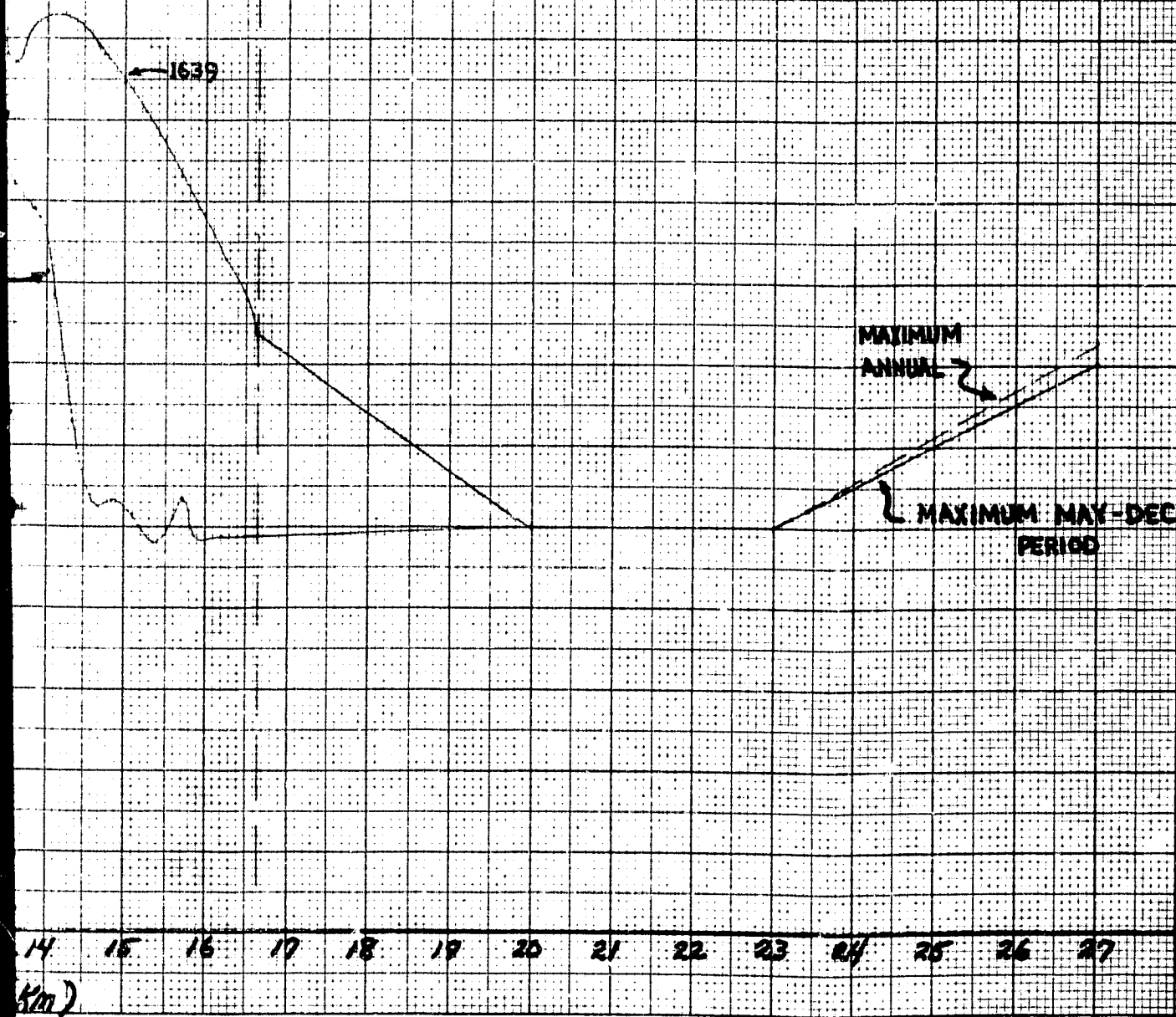
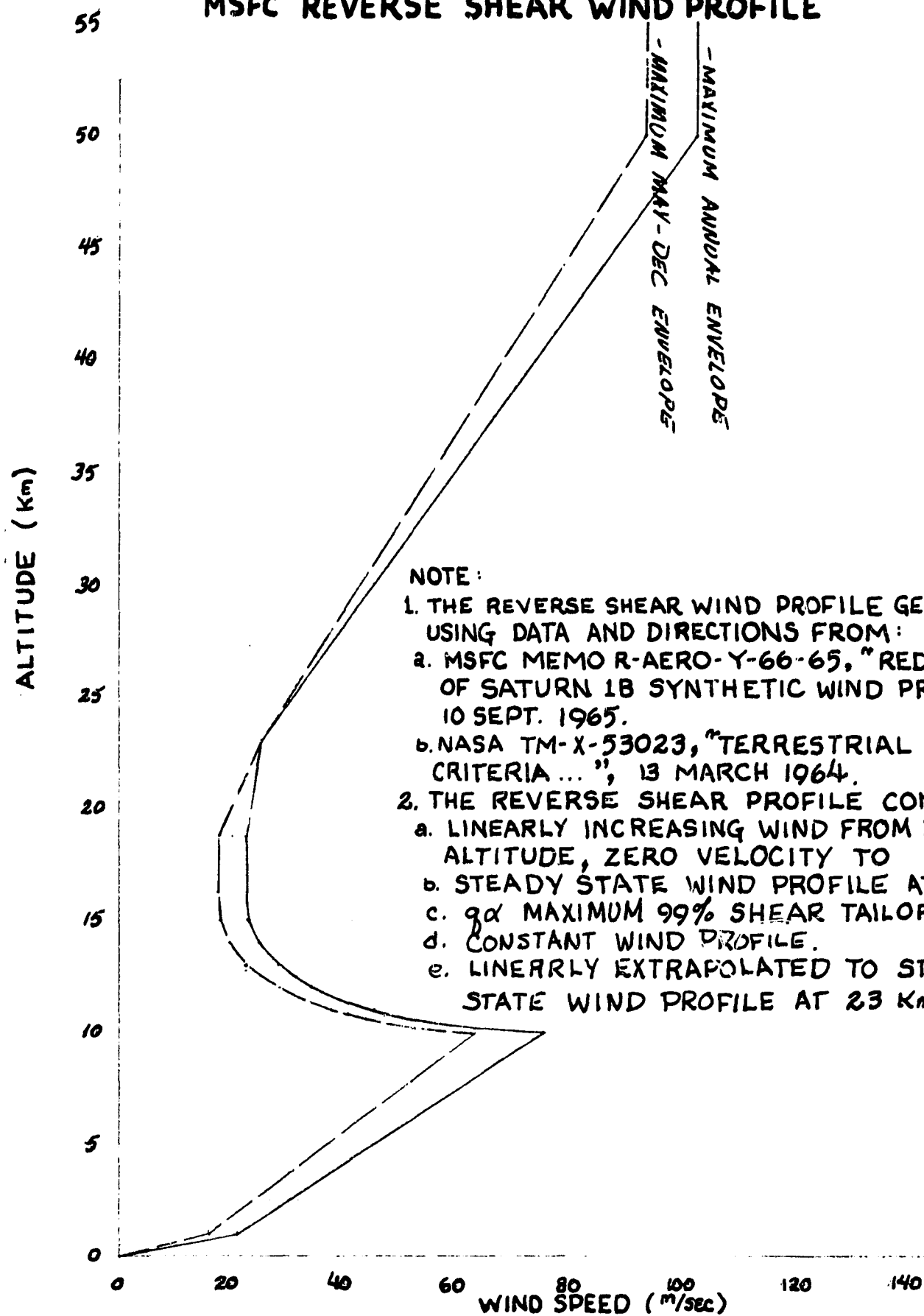


FIGURE 7

MSFC REVERSE SHEAR WIND PROFILE



To eliminate unnecessary simulation complexity, various simplifying assumptions were made for each set of equations. For example, the analog computer time-varying simulation was used to determine in-flight bending moments and terminal condition performance. Consequently, terms which had no significant effect on these performance parameters were dropped from the equations.

The complete equations are essentially identical with those used in the previous Saturn V/Voyager load relief study (see Reference 1). Some additional terms were added, however, to provide a more accurate model (circled terms of equations contained in Section 5.1). These additional terms will be included in the stability analysis and deleted for the time-varying digital or analog simulation analysis. The added terms take into account local attitude change due to vehicle bending. The effect of these additional terms will be evaluated by comparing eigenvalues with and without them to establish their significance. The only other difference between the complete set of equations and those used in the previous Saturn V/Voyager load relief study is a factor of 2 on the Coriolis terms in the trajectory relationships. This term is included in the complete set of equations but was missing in the equations used in the earlier study.

The set of equations to be used for the stability analysis is obtained from the complete set of equations by deleting pitch program and wind disturbance inputs and trajectory displacement and bending moment equations.

To obtain the equations for the digital computer PARTNER time-varying simulation, several small coupling terms, such as bending and slosh mode coupling into the pitching and plunging modes, were dropped. Aside from these coupling terms, the equations used for the PARTNER simulation will be identical with the complete set of equations.

The equations for the analog computer time-varying simulation are obtained from the complete set of equations by eliminating the three slosh modes, the third and fourth structural bending modes, and several intermodal coupling terms. In addition, several of the coefficients are held constant over the flight envelope to further reduce the simulation complexity. They are fixed at their maximum values.

The coordinate systems used when deriving the complete equations are defined by Figures 8 and 9. Figure 8 shows launch fixed-trajectory coordinates, vehicle rigid-body motion, and aerodynamic force relative to the nominal trajectory. Figure 9 defines engine actuator, slosh, structural, and rigid-body motion relative to the reference trajectory.

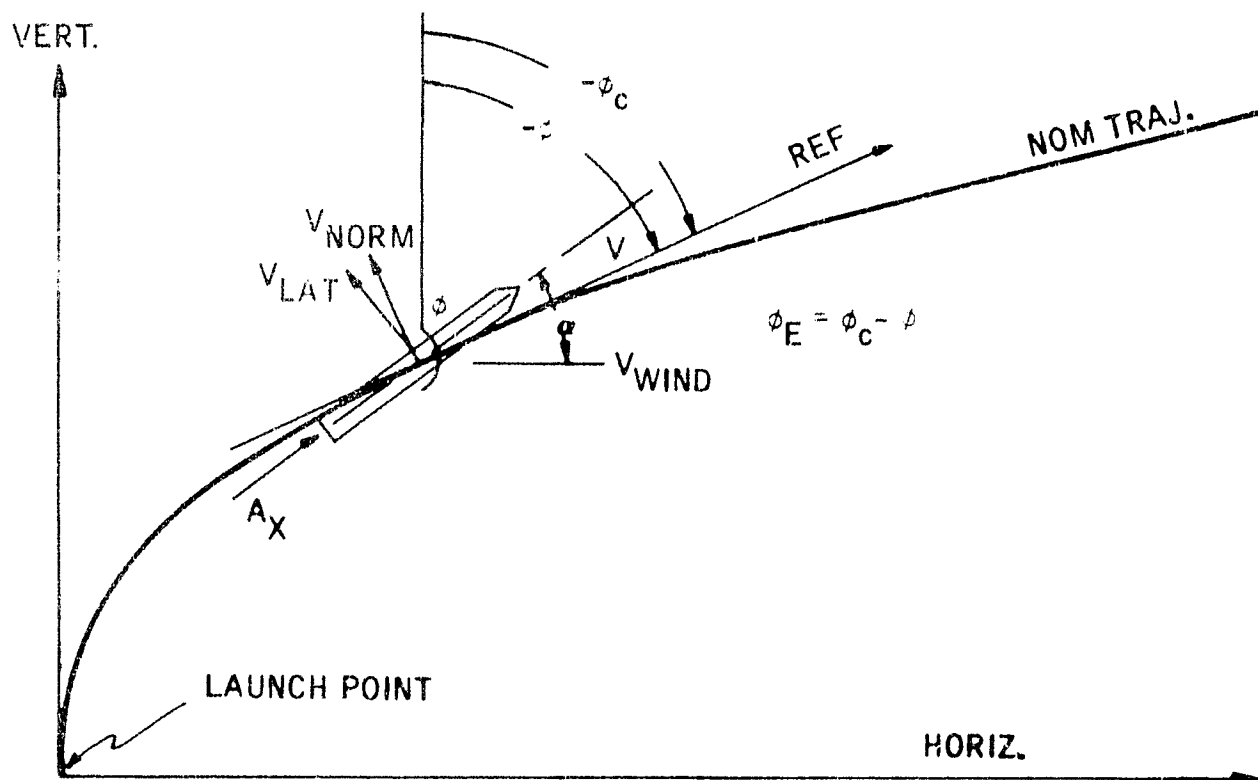


Figure 8. Gross Coordinate System

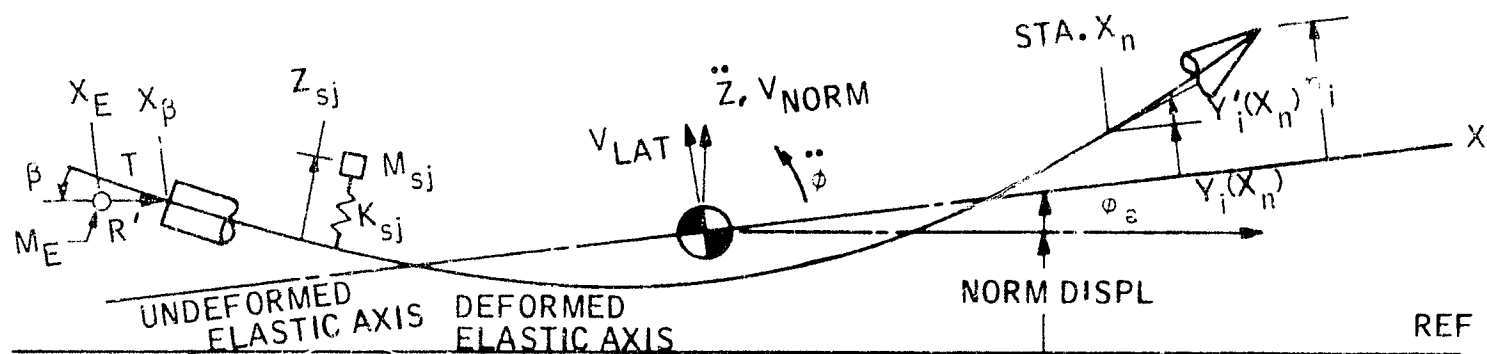


Figure 9. Fine Coordinate System

5.1 COMPLETE SYSTEM OF EQUATIONS FOR SATURN V/VOYAGER STUDY

Perturbed Vehicle Equations of Motion

- Pitching

$$\begin{aligned} \ddot{\phi} = & \left[\frac{C_{N\alpha} \bar{q}_S (\chi_{cg} - \chi_{cp})}{I_y} \right] \alpha - \left[\frac{R' (\chi_{cg} - \chi_{cp})}{I_y} \right] \beta - \left(\frac{C_{m\dot{\phi}/V} \bar{q}_S}{I_y V} \right) \dot{\phi} \\ & - 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) (\chi_{cg} - \chi_E) + I_{E0}}{I_y} \right] \ddot{\beta} - \sum_{i=1}^4 \left[\frac{C_{m\dot{\eta}_i/V} \bar{q}_S}{I_y V} \right] \dot{\eta}_i \\ & + \sum_{i=1}^4 \left(\frac{C_{m\eta_i} \bar{q}_S}{I_y} \right) \eta_i - \sum_{i=1}^4 \left[\frac{I}{I_y} (\chi_{cg} - \chi_{\beta}) y'_i(\chi_{\beta}) \right] \eta_i - \sum_{i=1}^4 \left[\frac{I}{I_y} y_i(\chi_{\beta}) \right] \eta_i \\ & + \sum_{j=1}^3 \left[M_{sj} \frac{(\chi_{cg} - \chi_{sj})}{I_y} \right] \ddot{Z}_{sj} + \sum_{j=1}^3 \left(M_{sj} \frac{A_x}{I_y} \right) Z_{sj} \end{aligned}$$

- Plunging

$$\begin{aligned} \ddot{Z} = & \left(C_{N\alpha} \frac{\bar{q}_S}{M} \right) \alpha + \left(\frac{R'}{M} \right) \beta - A_x \varphi_E + \left[C_{N\alpha} \bar{q}_S \frac{(\chi_{cg} - \chi_{cp})}{MV} \right] \dot{\phi} \\ & + \left[4 M_E \frac{(\chi_{\beta} - \chi_E)}{M} \right] \ddot{\beta} - \sum_{i=1}^4 \left(C_{N\dot{\eta}_i/V} \frac{\bar{q}_S}{MV} \right) \dot{\eta}_i + \sum_{i=1}^4 \left(C_{N\eta_i} \frac{\bar{q}_S}{M} \right) \eta_i \\ & + \sum_{i=1}^4 \left[A_x y'_i(\chi_{\beta}) \right] \eta_i - \sum_{j=1}^3 \frac{M_{sj}}{M} \ddot{Z}_{sj} \end{aligned}$$

- i^{th} Structural Mode

$$\begin{aligned} \ddot{\eta}_i = & - \left[2 \xi_i \omega_i + C_{N\dot{\eta}_i/V} \frac{\bar{q}_S}{M_i V} \right] \dot{\eta}_i - \left[\omega_i^2 - C_{N\eta_i} \frac{\bar{q}_S}{M_i} \right] \eta_i \\ & + \left(C_{N\dot{\eta}_i/V} \frac{\bar{q}_S}{M_i} \right) \alpha - \left(C_{m\dot{\eta}_i/V} \frac{\bar{q}_S}{M_i V} \right) \dot{\phi} + \left[R' \frac{y_i(\chi_{\beta})}{M_i} \right] \beta \\ & + 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) (y_i(\chi_E)) - I_{E0} y'_i(\chi_E)}{M_i} \right] \ddot{\beta} \quad \dots \end{aligned}$$

$$- \sum_{j=1}^3 \left[M_{sj} \frac{Y_L(x_{sj})}{M_i} \right] \ddot{Z}_{sj} + \sum_{j=1}^3 \left[M_{sj} A_x \frac{Y_i'(x_{sj})}{M_i} \right] Z_{sj}$$

- j^{th} Sloshing Mode

$$\ddot{Z}_{sj} = - (2 \delta_{sj} \omega_{sj}) \dot{Z}_{sj} - \omega_{sj}^2 Z_{sj} - A_x \left[\varphi_E - \sum_{i=1}^4 Y_i'(x_{sj}) \eta_i \right] \\ - \sum_{i=1}^4 Y_i(x_{sj}) \ddot{\eta}_i + (x_{cg} - x_{sj}) \ddot{\varphi} - \ddot{Z}$$

- Engine-Actuator

$$\ddot{\beta} = - (2 \delta_E \omega_E) \dot{\beta} - \omega_E^2 (\beta - \beta_c) + \left[M_E A_x \frac{(x_{\beta} - x_E)}{I_E} \right] \varphi_E \\ - \left[\frac{M_E (x_{cg} - x_E)(x_{\beta} - x_E) + I_{E0}}{I_E} \right] \ddot{\varphi} + \left[M_E \frac{(x_{\beta} - x_E)}{I_E} \right] \ddot{Z} \\ + \sum_{i=1}^4 \left[\frac{M_E (x_{\beta} - x_E) Y_i(x_E) - I_{E0} Y_i'(x_E)}{I_E} \right] \ddot{\eta}_i$$

- TRAJECTORY RELATIONSHIPS

► Velocity

$$V_{\text{NORM}} = \int_0^t [\ddot{Z} - (2 \delta V_{\text{TAN}}) \dot{\varphi}_E] dt$$

$$\delta V_{\text{TAN}} = \int_0^t \left[- \frac{A_x}{2} \varphi_E^2 - \left(C_{N\alpha} \frac{q_S}{M V} V_{\text{LAT}} \right) \varphi_E + \frac{R'}{M} \beta \varphi_E + (2 V_{\text{NORM}}) \dot{\varphi}_c \right] dt$$

$$V_{\text{LAT}} = V_{\text{NORM}} + V \varphi_E - V_{\text{WIND}} \cos \varphi_c$$

► Displacement

$$Z_{\text{NORM}} = \int_0^t [V_{\text{NORM}} - X_{\text{TAN}} \dot{\varphi}_c] dt$$

$$X_{\text{TAN}} = \int_0^t [\int V_{\text{TAN}} + Z_{\text{NORM}} \dot{\varphi}_c] dt$$

► Angle of Attack

$$\alpha = - \frac{V_{\text{LAT}}}{V}$$

● SENSOR OUTPUT EQUATIONS

► Accelerometer

$$\ddot{T}_{\text{ACC}} = \ddot{Z} - (X_{\text{CG}} - X_A) \ddot{\varphi} + A_X \left[\varphi_E - \sum_{i=1}^4 Y_i'(X_A) \eta_i \right] + \sum_{i=1}^4 Y_i(X_A) \ddot{\eta}_i$$

► Rate Gyro

$$\dot{\varphi}_{\text{GYRO}} = \dot{\varphi} + \sum_{i=1}^4 Y_i'(X_{\text{RG}}) \dot{\eta}_i$$

► Attitude Reference

$$\varphi_{\text{REF}} = -\varphi_E + \sum_{i=1}^4 [Y_i'(X_{\text{PLAT}})] \eta_i$$

● STRUCTURAL BENDING MOMENT

$$M'(X_N) = M'_\alpha(X_N) \alpha + M'_\beta(X_N) \beta - \sum_{i=1}^4 M'_i(X_N) \ddot{\eta}_i$$

5.2 REDUCED EQUATIONS FOR STABILITY ANALYSIS OF SATURN V/VOYAGER

PERTURBED VEHICLE EQUATIONS OF MOTION

- Pitching

$$\begin{aligned} \ddot{\beta} = & - \left[\frac{C_{N\alpha} \bar{q} S (\chi_{cg} - \chi_{cp})}{I_y} \right] \alpha - \left[\frac{R' (\chi_{cg} - \chi_{\beta})}{I_y} \right] \beta - \left(\frac{C_{m\dot{\beta}} \bar{q} S}{I_y V} \right) \dot{\beta} \\ & - 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) (\chi_{cg} - \chi_E) + I_{E0}}{I_y} \right] \ddot{\beta} - \sum_{i=1}^4 \left[\frac{C_{m\dot{\eta}_i} \bar{q} S}{I_y V} \right] \dot{\eta}_i \\ & + \sum_{i=1}^4 \left(\frac{C_{m\eta_i} \bar{q} S}{I_y} \right) \eta_i - \sum_{i=1}^4 \left[\frac{T}{I_y} (\chi_{cg} - \chi_{\beta}) y'_i(\chi_{\beta}) \right] \eta_i - \sum_{i=1}^4 \left[\frac{T}{I_y} y_i(\chi_{\beta}) \right] \eta_i \\ & + \sum_{j=1}^3 \left[M_{sj} \frac{(\chi_{cg} - \chi_{sj})}{I_y} \right] \ddot{Z}_{sj} + \sum_{j=1}^3 \left(M_{sj} \frac{A_x}{I_y} \right) Z_{sj} \end{aligned}$$

- Plunging

$$\begin{aligned} \ddot{Z} = & \left(C_{N\alpha} \frac{\bar{q} S}{M} \right) \alpha + \left(\frac{R'}{M} \right) \beta + A_x \dot{\beta} + \left[C_{N\alpha} \bar{q} S \frac{(\chi_{cg} - \chi_{cp})}{MV} \right] \dot{\beta} \\ & + \left[4 M_E \frac{(\chi_{\beta} - \chi_E)}{M} \right] \ddot{\beta} - \sum_{i=1}^4 \left(C_{N\dot{\eta}_i} \frac{\bar{q} S}{MV} \right) \dot{\eta}_i + \sum_{i=1}^4 \left(C_{N\eta_i} \frac{\bar{q} S}{M} \right) \eta_i \\ & + \sum_{i=1}^4 \left[A_x y'_i(\chi_{\beta}) \right] \eta_i - \sum_{j=1}^3 \frac{M_{sj}}{M} \ddot{Z}_{sj} \end{aligned}$$

- i^{th} Structural Mode

$$\begin{aligned} \ddot{\eta}_i = & - \left[2 \zeta_i \omega_i + C_{N\dot{\eta}_i} \frac{\bar{q} S}{M_i V} \right] \dot{\eta}_i - \left[\omega_i^2 - C_{N\eta_i} \frac{\bar{q} S}{M_i} \right] \eta_i \\ & + \left(C_{N\dot{\eta}_i} \frac{\bar{q} S}{M_i} \right) \alpha - \left(C_{m\dot{\eta}_i} \frac{\bar{q} S}{M_i V} \right) \dot{\beta} + \left[R' \frac{y_i(\chi_{\beta})}{M_i} \right] \beta \\ & + 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) (y_i(\chi_E)) - I_{E0} y'_i(\chi_E)}{M_i} \right] \ddot{\beta} \end{aligned}$$

$$- \sum_{j=1}^3 \left[M_{sj} \frac{y_i(x_{sj})}{M_i} \right] \ddot{Z}_{sj} + \sum_{j=1}^3 \left[M_{sj} A_x \frac{y_i'(x_{sj})}{M_i} \right] \dot{Z}_{sj}$$

- j^{th} Sloshing Mode

$$\begin{aligned} \ddot{Z}_{sj} = & - (2\beta_{sj} \omega_{sj}) \dot{Z}_{sj} - \omega_{sj}^2 Z_{sj} + A_x \left[\varphi + \sum_{i=1}^4 y_i'(x_{sj}) \eta_i \right] - \ddot{Z} \\ & - \sum_{i=1}^4 y_i(x_{sj}) \ddot{\eta}_i + (x_{cg} - x_{sj}) \ddot{\varphi} \end{aligned}$$

- Engine-Actuator

$$\begin{aligned} \ddot{\beta} = & - (2\beta_e \omega_e) \dot{\beta} - \omega_e^2 (\beta - \beta_e) - \left[M_e A_x \frac{(x_{\beta} - x_e)}{I_e} \right] \varphi \\ & - \left[\frac{M_e (x_{cg} - x_e)(x_{\beta} - x_e) + I_{e0}}{I_e} \right] \ddot{\varphi} + \left[\frac{M_e (x_{\beta} - x_e)}{I_e} \right] \ddot{Z} \\ & + \sum_{i=1}^4 \left[\frac{M_e (x_{\beta} - x_e) y_i(x_e) - I_{e0} y_i'(x_e)}{I_e} \right] \ddot{\eta}_i \end{aligned}$$

- TRAJECTORY RELATIONSHIPS

► Normal and Lateral Velocities

$$V_{\text{NORM}} = \int_0^t \ddot{Z} dt = \dot{Z}$$

$$V_{\text{LAT}} = V_{\text{NORM}} - V \varphi$$

► Angle of Attack

$$\alpha = - \frac{V_{\text{LAT}}}{V}$$

- **SENSOR OUTPUT EQUATIONS**

- **Accelerometer**

$$\ddot{T}_{acc} = \ddot{Z} - (X_{eq} - X_A) \ddot{\varphi} - A_x \left[\varphi + \sum_{i=1}^4 y_i(x_A) \eta_i \right] + \sum_{i=1}^4 y_i(x_A) \ddot{\eta}_i$$

- **Rate Gyro**

$$\dot{\varphi}_{gyro} = \dot{\varphi} + \sum_{i=1}^4 y_i'(x_{rg}) \dot{\eta}_i$$

- **Attitude Reference**

$$\varphi_{ref} = \varphi + \sum_{i=1}^4 [y_i'(x_{plat})] \eta_i$$

5.3 REDUCED EQUATIONS FOR TIME VARYING DIGITAL SIMULATION OF SATURN V/VOYAGER

PERTURBED VEHICLE EQUATIONS OF MOTION

- Pitching

$$\ddot{\varphi} = - \left[C_{N\alpha} \bar{q}_S \frac{(\chi_{cg} - \chi_{cp})}{I_y} \right] \alpha - \left[R' \frac{(\chi_{cg} - \chi_{\beta})}{I_y} \right] \beta - \left[C_{M\dot{\varphi}/V} \frac{\bar{q}_S}{I_y V} \right] \dot{\varphi} \\ - 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) (\chi_{cg} - \chi_E) + I_{E0}}{I_y} \right] \ddot{\beta} + \sum_{i=1}^4 \left(C_{M\eta_i} \frac{\bar{q}_S}{I_y} \right) \eta_i$$

- Plunging

$$\ddot{Z} = \left(C_{N\alpha} \frac{\bar{q}_S}{M} \right) \alpha + \left(\frac{R'}{M} \right) \beta - A_x \varphi_E + \left[C_{N\alpha} \bar{q}_S \frac{(\chi_{cg} - \chi_{cp})}{MV} \right] \dot{\varphi} \\ + \sum_{i=1}^4 \left(C_{N\eta_i} \frac{\bar{q}_S}{M} \right) \eta_i + \left[4 M_E \frac{(\chi_{\beta} - \chi_E)}{M} \right] \ddot{\beta}$$

- i^{th} Structural Mode

$$\ddot{\eta}_i = \left[- 2 \xi_i \omega_i + C_{N\eta_{i, \dot{\varphi}}} \frac{\bar{q}_S}{M_i V} \right] \dot{\eta}_i - \left[\omega_i^2 - C_{N\eta_{i, i}} \frac{\bar{q}_S}{M_i} \right] \eta_i \\ + \left(C_{N\eta_{i, \alpha}} \frac{\bar{q}_S}{M_i} \right) \alpha - \left(C_{M\eta_{i, \dot{\varphi}}} \frac{\bar{q}_S}{M_i V} \right) \dot{\varphi} + \left[R' y_i \frac{(\chi_{\beta})}{M_i} \right] \beta \\ + 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) Y_i (\chi_E) - I_{E0} Y_i' (\chi_E)}{M_i} \right] \ddot{\beta} \\ - \sum_{j=1}^3 \left[\frac{M_{sj} Y_i (\chi_{sj})}{M_i} \right] \ddot{Z}_{sj} + \sum_{j=1}^3 \left[\frac{M_{sj} A_x Y_i' (\chi_{sj})}{M_i} \right] Z_{sj}$$

- j^{th} Sloshing Mode

$$\ddot{Z}_{sj} = - (2\zeta_{sj} \omega_{sj}) \dot{Z}_{sj} - \omega_{sj}^2 Z_{sj} - A_x \varphi_E + (x_{cg} - x_{sj}) \ddot{\varphi} - \ddot{Z} - \sum_{i=1}^4 y_i(x_{sj}) \ddot{\eta}_i$$

- Engine-Actuator

$$\begin{aligned} \ddot{\beta} = & - (2\zeta_e \omega_e) \dot{\beta} - \omega_e^2 (\beta - \beta_c) + \left[M_E A_x \frac{(x_{\beta} - x_E)}{I_E} \right] \varphi_E \\ & - \left[\frac{M_E (x_{cg} - x_E)(x_{\beta} - x_E) + I_{E0}}{I_E} \right] \ddot{\varphi} + \left[\frac{M_E (x_{\beta} - x_E)}{I_E} \right] \ddot{Z} \\ & + \sum_{i=1}^4 \left[\frac{M_E (x_{\beta} - x_E) y_i(x_E) - I_{E0} y_i'(x_E)}{I_E} \right] \ddot{\eta}_i \end{aligned}$$

• TRAJECTORY RELATIONSHIPS

► Velocity

$$V_{\text{NORM}} = \int_0^t [\ddot{Z} - (2\delta V_{\text{TAN}}) \dot{\varphi}_E] dt$$

$$\delta V_{\text{TAN}} = \int_0^t \left[-\frac{A_x}{2} \varphi_E^2 - \left(C_{\text{ME}} \frac{\bar{q}_E}{M V} V_{\text{LAT}} \right) \varphi_E + \frac{R}{M} \beta \varphi_E + (2V_{\text{NORM}}) \dot{\varphi}_E \right] dt$$

$$V_{\text{LAT}} = V_{\text{NORM}} + V \varphi_E - V_{\text{WIND}} \cos \varphi_c$$

► Displacement

$$Z_{\text{NORM}} = \int_0^t [V_{\text{NORM}} - X_{\text{TAN}} \dot{\varphi}_c] dt$$

$$X_{\text{TAN}} = \int_0^t [\delta V_{\text{TAN}} + Z_{\text{NORM}} \dot{\varphi}_c] dt$$

► Angle of Attack

$$\alpha = - \frac{V_{\text{LAT}}}{V}$$

● SENSOR OUTPUT EQUATIONS

► Accelerometer

$$\ddot{\tau}_{\text{ACC}} = \ddot{Z} - (X_{\text{CG}} - X_A) \ddot{\varphi} + A_x \varphi_E + \sum_{i=1}^4 Y_i(X_A) \ddot{\eta}_i$$

► Rate Gyro

$$\dot{\varphi}_{\text{GYRO}} = \dot{\varphi} + \sum_{i=1}^4 Y_i'(X_{\text{RG}}) \dot{\eta}_i$$

► Attitude Reference

$$\varphi_{\text{REF}} = - \varphi_E + \sum_{i=1}^4 [Y_i'(X_{\text{RAT}})] \eta_i$$

● STRUCTURAL BENDING MOMENT

$$M'(X_N) = M'_\alpha(X_N) \alpha + M'_\beta(X_N) \beta - \sum_{i=1}^4 M'_i(X_N) \ddot{\eta}_i$$

5.4 REDUCED EQUATIONS FOR TIME VARYING ANALOG SIMULATION OF SATURN V/VOYAGER

PERTURBED VEHICLE EQUATIONS OF MOTION

- Pitching

$$\ddot{\phi} = - \left[C_{m\alpha} \frac{\bar{q} S}{I_y} (\chi_{cg} - \chi_{cp}) \right] \alpha - \left[R' \frac{(\chi_{cg} - \chi_{\beta})}{I_y} \right] \beta - \left[C_{m\dot{\phi}/V} \frac{\bar{q} S}{I_y V} \right]^* \dot{\phi} \\ + \sum_{i=1}^2 \left(C_{m\eta_i} \frac{\bar{q} S}{I_y} \right)^* \eta_i - 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) (\chi_{cg} - \chi_E) + I_{E0}}{I_y} \right]^* \ddot{\beta}$$

- Plunging

$$\ddot{Z} = \left(C_{mz} \frac{\bar{q} S}{M} \right) \alpha + \left(\frac{R'}{M} \right) \beta - A_x \phi_E + \sum_{i=1}^2 \left(C_{m\eta_i} \frac{\bar{q} S}{M} \right)^* \eta_i \\ + 4 \left[\frac{M_E (\chi_{\beta} - \chi_E)}{M} \right]^* \ddot{\beta}$$

- i^{th} Structural Mode

$$\ddot{\eta}_i = - \left[2 \rho_i \omega_i + C_{N\eta_i, \omega} \frac{\bar{q} S}{M_i V} \right]^* \dot{\eta}_i - \left[\omega_i^2 - C_{N\eta_i, \omega} \frac{\bar{q} S}{M_i} \right]^* \eta_i \\ + \left(C_{N\dot{\eta}_i/V} \frac{\bar{q} S}{M_i} \right)^* \alpha + \left(R' \frac{Y_i(\chi_{\beta})}{M_i} \right)^* \beta \\ + 4 \left[\frac{M_E (\chi_{\beta} - \chi_E) Y_i(\chi_E) - I_{E0} Y_i'(\chi_E)}{M_i} \right]^* \ddot{\beta}$$

- j^{th} Slosh Mode

$$\ddot{Z}_{sj} = 0$$

- Engine - Actuator

$$\ddot{\beta} = -(2 \dot{\beta}_c \omega_c) \dot{\beta} - \omega_c^2 (\beta - \beta_c) - \left[\frac{M_E (\chi_{eq} - \chi_E) (\chi_\beta - \chi_E) + I_{E0}}{I_E} \right]^* \ddot{\varphi} \\ + \left[\frac{M_E (\chi_\beta - \chi_E)}{I_E} \right]^* \ddot{Z} + \sum_{i=1}^8 \left[\frac{M_E (\chi_\beta - \chi_E) (Y_i(\chi_E)) - I_{E0} Y_i'(\chi_E)}{I_E} \right]^* \ddot{\eta}_i$$

* ~ INDICATES FIXED TIME COEFFICIENT

- TRAJECTORY RELATIONSHIPS

- Velocity

$$V_{NORM} = \int_0^t [\ddot{Z} - (2 \dot{V}_{TAN}) \dot{\varphi}_c] dt$$

$$\dot{V}_{TAN} = \int_0^t \left[-\frac{A_x}{2} \dot{\varphi}_c^2 - \left(C_{NG} \frac{q_s}{MV} V_{LAT} \right) \dot{\varphi}_c + \frac{R'}{M} \beta \dot{\varphi}_c + (2 V_{NORM}) \dot{\varphi}_c \right] dt$$

$$V_{LAT} = V_{NORM} + V \dot{\varphi}_c - V_{WIND} \cos \varphi_c$$

- Displacement

$$Z_{NORM} = \int_0^t [V_{NORM} - X_{TAN} \dot{\varphi}_c] dt$$

$$X_{TAN} = \int_0^t [\dot{V}_{TAN} + Z_{NORM} \dot{\varphi}_c] dt$$

- Angle of Attack

$$\alpha = - \frac{V_{LAT}}{V}$$

● SENSOR OUTPUT EQUATIONS

► Accelerometer

$$\ddot{\tau}_{acc} = \ddot{Z} - (x_{cg} - x_A) \ddot{\varphi} + A_n \left[\varphi_E - \sum_{i=1}^2 Y_i'(\alpha_A) \eta_i \right] + \sum_{i=1}^2 Y_i(x_A) \ddot{\eta}_i$$

► Rate Gyro

$$\dot{\varphi}_{GYRO} = \dot{\varphi} + \sum_{i=1}^2 Y_i'(\alpha_{RG}) \dot{\eta}_i$$

► Attitude Reference

$$\varphi_{REF} = -\varphi_E + \sum_{i=1}^2 [Y_i'(\alpha_{PLAT})] \eta_i$$

● STRUCTURAL BENDING MOMENT

$$M'(x_N) = M'_\alpha(x_N) \alpha + M'_\beta(x_N) \beta - \sum_{i=1}^2 M'_i(x_N) \ddot{\eta}_i$$

5.5 DEFINITION OF FORCE AND MOMENT DERIVATIVES

● AERODYNAMIC MOMENT COEFFICIENTS

$$C_{N\alpha} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} d(x/D)$$

$$C_{N\eta_i} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} Y_i'(x) d(x/D)$$

$$C_{N\dot{\eta}_i} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} Y_i(x) d(x/D)$$

$$C_{N\eta_i, \eta_k} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} Y_i(x) Y_k'(x) d(x/D)$$

$$C_{N\dot{\eta}_i, \eta_k} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} Y_i(x) Y_k(x) d(x/D)$$

$$C_{M\alpha} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} (x - x_{cg}) dx = C_{N\dot{\varphi}}$$

$$C_{M\dot{\varphi}/N} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} (x - x_{cg})^2 d(x/D)$$

$$C_{M\eta_i} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} Y_i'(x) (x - x_{cg}) d(x/D)$$

$$C_{M\dot{\eta}_i} = \int_{x_B}^x \frac{\partial C_{N\alpha}}{\partial (x/D)} (x - x_{cg}) Y_i(x) d(x/D)$$

- WHERE INTEGRALS ARE OVER THE TOTAL VEHICLE

● BENDING MOMENT COEFFICIENTS AT STATION x

$$M'_\alpha(x) = \bar{q}s \left[\int_{x_\beta}^x \left(\frac{\partial C_{N\alpha}(\lambda)}{\partial (x/D)} \right) (x-\lambda) d\lambda - C_{N\alpha} I_1(x) + C_{M\alpha} I_2(x) \right]$$

$$M'_\beta(x) = R' \left[x - I_1(x) - x_{cg} I_2(x) \right]$$

$$M'_{\ddot{\eta}_i} = \int_{x_\beta}^x M'(\lambda)(x-\lambda) Y_i(\lambda) d\lambda$$

$$I_1(x) = \int_{x_\beta}^x \frac{M'(\lambda)(x-\lambda) d\lambda}{M}$$

$$M'(\lambda) = \frac{\partial M}{\partial \lambda} \Big|_\lambda$$

$$I_2(x) = \int_{x_\beta}^x \frac{M'(\lambda)(x-\lambda)(x_{cg}-\lambda) d\lambda}{I_{yy}}$$

$$C_{M\alpha} = \int_{x_\beta}^x \left(\frac{\partial C_{N\alpha}}{\partial x/D} \right) (x - x_{cg}) d(x/D)$$

5.6 Nomenclature

A_x	- Axial acceleration of booster = $\frac{T-D}{M}$, ft/sec ²
δA_{TAN}	- Differential vehicle acceleration tangential to nominal trajectory, ft/sec
C_1	- Aerodynamic moment coefficient = $\frac{C_{N_\alpha} (X_{cg} - X_{cp}) \bar{q} S}{I_{yy}}$ 1/sec ²
C_2	- Control moment coefficient = $\frac{R'(X_{cg} - X_\beta)}{I_{yy}}$, 1/sec ²
D	- Axial aerodynamic drag of booster, $C_A \bar{q} S$
D_{ref}	- Reference length of booster = 396 feet
I_E	- Moment of inertia of gimbaled rocket engine about gimbal, slugs-ft ²
I_{E_O}	- Moment of inertia of gimbaled rocket engine about own c.g., slugs-ft ²
I_{yy}, I_y	- Pitch moment of inertia of rigid booster about c.g., slugs-ft ²
M	- Total mass of rigid booster, slugs
M_E	- Mass of single gimbaled engine, slugs
$M'(x_n)$	- Total structural bending moment at station x_n , ft-lb
$M'_\alpha(x_n)$	- Structural bending moment at station x_n due to angle of attack (γ), ft-lb/rad

$M'_{\beta}(x_n)$	- Structural bending moment at station x_n due to deflection of control rocket engines (β), ft-lb/rad
$M'_{\eta_i}(x_n)$	- Structural bending moment at station x_n due to acceleration of i^{th} bending mode generalized displacement (η_i), ft-lb/ft/sec ²
m_i	- Generalized mass of the i^{th} bending mode, slugs
M_{sj}	- Sloshing mass of the j^{th} propellant tank, slugs
N'	- Lateral aerodynamic force due to angle of attack, lb
$\bar{q}$	- Dynamic pressure, lb/ft ²
R'	- Lateral control force due to gimbal angle deflection of control engines = 0.80 τ , lb
S	- Reference area of booster, $\pi D^2/4$, ft ²
T	- Total axial thrust of booster engine cluster, lb
V	- Nominal flight path velocity of booster relative to atmosphere (tangent to nominal trajectory), ft/sec
V_{LAT}	- Vehicle velocity normal to reference trajectory, ft/sec
δV_{TAN}	- Differential velocity relative to nominal along reference trajectory, ft/sec
V_{WIND}	- Wind velocity in local horizontal plane, ft/sec

X_A	- Lateral accelerometer station
X_β	- Control engines gimbal station
X_{cg}	- Booster center of gravity station
X_{cp}	- Aerodynamic center of pressure station
X_E	- Control engine center of gravity station
X_n	- Station "n"
X_{sj}	- j^{th} propellant tank sloshing mass station
X_{TAN}	- Vehicle displacement along reference trajectory, ft
$Y_i(X_n)$	- Normalized modal deflection of i^{th} bending mode at station "n", dimensionless
$Y'_i(X_n)$	- Normalized modal slope of i^{th} bending mode at station "n", rad/ft
$\ddot{Z}$	- Lateral acceleration normal to referenced (nominal) flight path, ft/sec^2
Z_{sj}	- Displacement of j^{th} sloshing mass normal to booster center-line, ft
Z_{NORM}	- Vehicle normal displacement with respect to trajectory, ft
α	- Total angle of attack of booster, radians
α_w	- Angle of attack due to lateral wind $\approx \frac{V_w}{V}$, radians

δ	- Control deflection angle or gimbal angle, radians
δ_c	- Commanded control deflection angle, radians
δ_E	- Control engine deflection angle, radians
ζ_i	- Equivalent viscous damping factor of i^{th} structural bending mode
ζ_{sj}	- Equivalent viscous damping factor of j^{th} propellant tank sloshing mass
η_i	- Generalized deflection of i^{th} bending mode, ft
ϕ	- Angular pitch displacement with respect to launch point vertical, radians
$\dot{\phi}_c$	- Rate of pitch command, rad/sec
ϕ_e	- Pitch attitude error = $\phi_c - \phi$, radians
$\ddot{r}, \ddot{z}$	- Acceleration sensed by body-mounted lateral accelerometer, ft/sec ²
ω_i	- Natural frequency of i^{th} bending mode, rad/sec
ω_{sj}	- Natural frequency of j^{th} propellant tank sloshing, rad/sec
$\dot{\phi}_{\text{gyro}}$	- Angular rate sensed by rate gyro, rad/sec
ϕ_{rc}	- Vehicle attitude sensed by attitude gyro on platform, rad

- c_E - Viscous damping factor of gimbaled engine
- ω_E - Natural frequency of gimbaled engine, rad/sec
- λ - Integration variable along vehicle X-axis
- $d(X/D)$ - Normalized integration interval along vehicle X-axis, caliber
- $\frac{\partial C_{N_\alpha}}{\partial(X/D)}$ - Local normal force coefficient gradient per unit of length, 1/caliber
- C_{N_α} - Normal force coefficient gradient, 1/rad
- $C_{N_{\dot{\eta}_i}/V}$ - Aerodynamic normal force coefficient due to rate of displacement of i^{th} structural mode
- $C_{N_{\eta_i}}$ - Aerodynamic normal force coefficient due to displacement of i^{th} structural mode, 1/ft
- $C_{N_{\dot{\eta}_i}, i/V}$ - Aerodynamic coupling coefficient of i^{th} structural mode due to rate of displacement of i^{th} structural mode
- $C_{N_{\eta_i}, i}$ - Aerodynamic coupling coefficient of i^{th} structural mode due to displacement of i^{th} structural mode, 1/ft
- $C_{M_{\dot{\beta}}/V}$ - Aerodynamic moment coefficient due to pitch rate, ft^2
- $C_{M_{\dot{\eta}_i}/V}$ - Aerodynamic moment coefficient due to rate of displacement of i^{th} structural mode
- $C_{M_{\eta_i}}$ - Aerodynamic moment coefficient due to displacement of i^{th} structural mode, 1/ft

6.0 VEHICLE DATA

This section presents numerical values for coefficients of the study equations and the basic data from which they were extracted.

6.1 Reduced Data

Numerical values for coefficients of the complete equations of motion, sensor relationships, and bending moment equations are given in Tables 1 through 17. These values, computed at four-second intervals during first-stage flight, were obtained using a digital computation routine and the basic data transmitted by NASA-MSFC through references listed in Section 7.0.

The equations at the bottom of each table identify the column within that table in which the numerical value of individual coefficients may be found. To further simplify the identification process, Table 18 equates digital numbers with specific coefficients; e.g., 060 = $M'_{\alpha}(3222)$; 082 = $M_E \Lambda_N (X_{\beta} - X_E)/I_E$, etc.

The English system of units was used in computing coefficient values. This will ease further digital work since the stability and the PARTNER time-varying digital simulations are programmed to take input data in English units only.

The following information was used during the data reduction process:

- Only four structural modes were considered. MSFC provided data for only four modes.

- Only the three significant slosh modes were considered per Reference 6.
- Errors contained in the MSFC data package included:
 - a) Improper signs on the third and fourth structural-mode slope data at 140 and 60 seconds respectively.
 - b) Aerodynamic coupling coefficients that were applicable to the 54-foot payload rather than to the 45-foot payload being considered (Reference 3).
 - c) Incorrect bending moment coefficients (M'_{η_i}) at all time points (Reference 7).
 - d) Incompatible structural frequencies supplied with M'_{η_i} data and mode deflection data.

Errors in the data supplied by MSFC through the data packages were corrected where possible prior to computing the time-varying coefficients. Aerodynamic coupling coefficients were computed by Honeywell using the equations of Section 5.5. This data was used pending receipt of MSFC coupling coefficients for the 45-foot Voyager payload. When, after direct comparison (Figures 20 through 26), no serious discrepancies between sets of coefficients were discovered, the Honeywell-computed data was used for the remainder of the study. Correct bending-moment coefficients (M'_{η_i}) were not available when required. Data for the 54-foot Voyager payload, taken from Reference 15, was therefore used during the study. Structural frequencies supplied with the mode deflection data were used for data reduction and study analysis purposes.

The following assumptions were made during the data reduction process:

- Structural mode deflections and slopes at engine mass center of gravity are equivalent to deflections and slopes at engine gimbal point.

- Bending-moment aerodynamic coefficient data (M'_{α}) will be extrapolated and faired to zero at time = 0 and 160 seconds. (See Figure 56.)
- Bending-moment coefficient data (M'_{β}) will be extrapolated linearly tangential to supplied data for flight times less than 52 seconds and greater than 120 seconds. (See Figure 57.)
- Data required at body stations other than those for which data is given, e. g., $M'_{\alpha}(3222)$, will be interpolated linearly.
- Data required at times other than those for which data is given will be taken from curve-fitted plots of basic data rather than interpolated linearly. The only exception is M'_{η_i} data.
- Axial loads to determine bending-moment capability can be determined using the following equation:

$$C_A = \int_{10.19}^X \frac{\partial C_D}{\partial (X/D)} dX$$

where $\frac{\partial C_D}{\partial (X/D)}$ data at Mach numbers 1 and 2 was used for Mach numbers less than and greater than 1 and 2 respectively.

- Control thrust (R') is 80 percent of total thrust, T .
- For computation of aerodynamic coupling coefficients:
 - a) Integrations over 1-meter body increments will provide sufficient accuracy.
 - b) Structural mode deflection and slope data can be taken at time points between those where data given can be interpolated linearly. If there are only slight variations in given data at successive time points, data can be considered constant.
- Aerodynamic coupling coefficients can be determined by linear interpolation from data computed at the specified Mach numbers. Data can be considered constant for Mach numbers between 0 and 0.6 at the value computed for $M = 0.6$.

H

214E	208	209	210	211	164	165	166	167
0000000E+00	-6641798E-03	+9245650E-03	-1236139E-02	+1192707E-01	+5009772E-03	-9076870E-04	-6322938E-03	+3360077E-03
4000000E+00	-6900281E-03	+712476E-03	-1215459E-02	+7093599E-02	+610139E-03	-7631044E-04	-6374022E-03	+4110670E-03
8000000E+00	+1188792E-03	+124474E-02	-1198922E-02	+2177105E-02	+7270316E-03	-5913749E-04	-6459346E-03	+4918160E-03
1200000E+02	-1512705E-03	+1083190E-02	-1186376E-02	+3047302E-02	+8212792E-03	-3517803E-04	-6514977E-03	+5576505E-03
1600000E+02	-7801049E-03	+1128048E-02	-1170499E-02	-8597862E-02	+8273467E-03	-8246249E-05	-6557033E-03	+6046979E-03
2000000E+02	-8271627E-03	+1191498E-02	-1167662E-02	-1446550E-01	+9544208E-03	+1412007E-04	-6610669E-03	+6560464E-03
2400000E+02	-8553051E-03	+1264488E-02	-1189176E-02	-1636554E-01	+9785186E-03	+4924116E-04	-6647777E-03	+6793528E-03
2800000E+02	-9070018E-03	+1303086E-02	-118761E-02	-1949249E-01	+1002579E-02	-8985531E-04	-6685448E-03	+7052802E-03
3200000E+02	-9260214E-03	+1335817E-02	-1180705E-02	-1983365E-01	+1027802E-02	-1126817E-03	-6728166E-03	+7322536E-03
3600000E+02	-9687783E-03	+1390375E-02	-1196859E-02	-1762615E-01	+1055402E-02	+1487786E-03	-6758397E-03	+7624577E-03
4000000E+02	-1012696E-02	+1446690E-02	-1213179E-02	-1699730E-01	+1085651E-02	+152009E-03	-6788163E-03	+7933952E-03
4400000E+02	-1042200E-02	+1505389E-02	-1227225E-02	-1034223E-01	+1102296E-02	+2177803E-03	-6810620E-03	+8190839E-03
4800000E+02	-1072271E-02	+1565557E-02	-1241400E-02	-3482573E-02	+1119080E-02	+2499056E-03	-6832313E-03	+8449758E-03
5200000E+02	-1109208E-02	+1632654E-02	-1263688E-02	-2325089E-02	+1140750E-02	-2881476E-03	-6831758E-03	+8742233E-03
5600000E+02	-1144207E-02	+1757963E-02	-1287686E-02	-7865799E-02	+1163870E-02	-3277291E-03	-6838356E-03	+9047171E-03
6000000E+02	-1180234E-02	+1867517E-02	-1312423E-02	-1604429E-01	+1187290E-02	-3669056E-03	-6845057E-03	+9358457E-03
6400000E+02	-1213768E-02	+2027034E-02	-1327949E-02	-7496066E-02	+1205242E-02	-4061256E-03	-6851862E-03	+9640587E-03
6800000E+02	-1248985E-02	+2179580E-02	-1344551E-02	-4308900E-02	+1223878E-02	-4467024E-03	-6854074E-03	+9913382E-03
7200000E+02	-1280964E-02	+2324198E-02	-1360204E-02	-8836552E-02	+1241304E-02	-4477304E-03	-68584915E-01	+1017897E-03
7600000E+02	-1314934E-02	+2459418E-02	-1378472E-02	-3719589E-02	+1260056E-02	+5321507E-03	-6807604E-03	+1058194E-03
8000000E+02	-1347828E-02	+2594040E-02	-1395947E-02	-1327340E-02	+1277420E-02	+5767570E-03	-6758461E-03	+1093558E-03
8400000E+02	-1389551E-02	+2722401E-02	-1608714E-02	-1196279E-02	+1302721E-02	-6253924E-03	-6758254E-03	+1145878E-03
8800000E+02	-1422467E-02	+2850353E-02	-1830036E-02	+1056551E-02	+1315873E-02	-6681371E-03	-6750503E-03	+1183551E-03
9200000E+02	-1466019E-02	+2974127E-02	-2189378E-02	+8789598E-03	+1330220E-02	+7175858E-03	-6668147E-03	+1232213E-03
9600000E+02	-1508992E-02	+3085931E-02	-2690765E-02	+6614567E-03	+1344168E-02	-7679737E-03	-6658447E-03	+1273672E-03
1000000E+03	-1577109E-02	+3245141E-02	-3256588E-02	+4389792E-03	+1375206E-02	-8334446E-03	-6514155E-03	+1332165E-03
1040000E+03	-1635479E-02	+3317808E-02	-4120623E-02	+4169600E-03	+1372308E-02	-8715500E-03	-6396252E-03	+1415588E-03
1080000E+03	-1665519E-02	+3422119E-02	-5038470E-02	+3942049E-03	+1369383E-02	-910099E-03	-6283154E-03	+1385538E-03
1120000E+03	-1779370E-02	+3530140E-02	-6354544E-02	+3729965E-03	+1366830E-02	+9556651E-03	-6149414E-03	+1418370E-03
1160000E+03	-1849533E-02	+3625628E-02	-8098911E-02	+3509123E-03	+1356329E-02	+9992003E-03	-6032976E-03	+1425646E-03
1200000E+03	-1934233E-02	+3778911E-02	-9980130E-02	+3263335E-03	+1341589E-02	+1044169E-03	-5848189E-03	+1437463E-03
1240000E+03	-1984024E-02	+3809431E-02	-1323419E-01	+4285463E-03	+1312143E-02	+1065652E-02	-5645575E-03	+1431414E-03
1280000E+03	-2053332E-02	+3833457E-02	-1685190E-01	+5414855E-03	+1285501E-02	+1091164E-02	-5426046E-03	+1431948E-03
1320000E+03	-2183864E-02	+3872306E-02	-2107321E-01	+6669070E-03	+1238932E-02	+1105593E-02	-5216422E-03	+1407235E-03
1360000E+03	-2290849E-02	+3953588E-02	-2612151E-01	+8698153E-03	+1170840E-02	+1113442E-02	-4926005E-03	+1358196E-03
1400000E+03	-2433689E-02	+400843E-02	-3160931E-01	+9631369E-03	+1085356E-02	+117453E-02	-4593529E-03	+1283858E-03
1440000E+03	-2672407E-02	+4207838E-02	-3200688E-01	+2239264E-03	+9615110E-03	+9986524E-03	-4177049E-03	+1161195E-03
1480000E+03	-2976426E-02	+4460749E-02	-3259343E-01	+3750984E-02	+8208430E-03	+8672696E-03	-3763527E-03	+1010368E-03
1520000E+03	-3460905E-02	+4467561E-02	-3334468E-01	+6437881E-02	+5271556E-03	+6704144E-03	-3148450E-03	+7893122E-03
1560000E+03	-4086121E-02	+5442341E-02	-3403083E-01	+1071607E-01	+329011E-03	+3872835E-03	-2470282E-03	+4532019E-03
1600000E+03	-4818761E-02	+5178548E-02	-2904642E-01	+1349988E-01	+0000000E+00	+0000000E+00	-1095289E-03	+0000000E-03

$$\begin{aligned} \vec{\phi} = & -(100) \alpha - (101) \beta - (106) \vec{\phi} + (107) \eta_1 + (108) \eta_2 + (109) \eta_3 + (110) \eta_4 - (115) \vec{\beta} - (401) \\ & - (209) \eta_1 - (210) \eta_2 - (211) \eta_3 + (164) \vec{Z}_{s1} + (165) \vec{z} - (166) \vec{Z}_{s3} + (167) \end{aligned}$$

FOLDOUT FRAME

Table 1

163	164	165	166	167	168	169
192707E-01	5009751E-03	7676870E-04	6322938E-03	3360077E-03	6801893E-03	4761382E-03
097599E-02	6102339E-03	7631044E-04	6370402E-03	4110670E-03	7429677E-03	4895469E-03
177105E-02	7270316E-03	5913749E-04	6450346E-03	4918160E-03	8114954E-03	5051086E-03
047302E-02	8212792E-03	381233E-04	6514977E-03	5576505E-03	8680552E-03	5218470E-03
077862E-02	8873467E-03	8746249E-05	655133E-03	6046979E-03	9079487E-03	5377647E-03
445650E-01	9349208E-03	1412007E-04	6640669E-03	6560464E-03	9521603E-03	5558200E-03
0554E-01	9785186E-03	4926116E-04	6647787E-03	6793528E-03	9410777E-03	5727188E-03
1249E-01	1022579E-02	4035531E-04	6685448E-03	7052802E-03	1013474E-02	5916500E-03
065E-01	1027802E-02	1129811E-03	672166E-03	7322536E-03	1047047E-02	6112689E-03
70615E-01	1056402E-02	1487786E-03	6758397E-03	7624577E-03	1084887E-02	6333804E-03
999730E-01	1085651E-02	1852109E-03	6780163E-03	7933952E-03	1121396E-02	6558836E-03
034223E-01	1102296E-02	2171803E-03	6810620E-03	8190839E-03	1161636E-02	6780053E-03
082573E-02	1119080E-02	2499056E-03	6832313E-03	8449758E-03	1200289E-02	7009743E-03
025089E-02	1140730E-02	2861476E-03	683173E-03	8742233E-03	1243842E-02	7265116E-03
065799E-02	1163870E-02	3272291E-03	6838356E-03	9047171E-03	1281313E-02	7531742E-03
064429E-01	1187290E-02	3669706E-03	6845057E-03	9358457E-03	1335837E-02	7804644E-03
096000E-02	1205242E-02	4061256E-03	6851862E-03	9640587E-03	1382086E-02	8081786E-03
008900E-02	1223878E-02	4467024E-03	6854074E-03	9913464E-03	1427417E-02	8354031E-03
036552E-02	1241304E-02	4873304E-03	684919E-03	1017705E-02	1471813E-02	8621271E-03
079589E-02	1260015E-02	5341507E-03	6807604E-03	1056196E-02	1534237E-02	8994660E-03
027340E-02	1277420E-02	5767570E-03	6758461E-03	1093505E-02	1595504E-02	9161901E-03
06279E-02	1302721E-02	6254924E-03	6758254E-03	1115660E-02	1680154E-02	9470640E-03
056551E-02	1318073E-02	6661371E-03	6750503E-03	1188750E-02	1760252E-02	1037990E-03
089598E-03	1330220E-02	7174588E-03	6668147E-03	1232595E-02	1843185E-02	1090977E-02
14567E-03	1344168E-02	7679737E-03	6504547E-03	1275697E-02	1926791E-02	1144764E-02
08792E-03	1375406E-02	8334446E-03	6514155E-03	1332365E-02	2032948E-02	1212407E-02
06900E-03	1372308E-02	8714500E-03	6396252E-03	1359545E-02	2096168E-02	1276199E-02
042049E-03	1369383E-02	915009E-03	6283154E-03	1385513E-02	2159812E-02	1342952E-02
029965E-03	1366830E-02	9556651E-03	6149414E-03	1410370E-02	2230638E-02	1423470E-02
009125E-03	1356329E-02	9992003E-03	6032976E-03	1425646E-02	2297164E-02	1512408E-02
063335E-03	1341589E-02	1044149E-03	6042819E-03	1437463E-02	2363521E-02	1607058E-02
06463E-03	1312143E-02	1105852E-02	6645575E-03	1431414E-02	2378847E-02	1705231E-02
14855E-03	1285501E-02	1091164E-02	6425046E-03	1431943E-02	2408553E-02	1825570E-02
069070E-03	1238932E-02	110453E-02	6216612E-03	1407235E-02	2416003E-02	1961112E-02
08153E-03	1179840E-02	1113442E-02	6246005E-03	135815E-02	2407946E-02	212504E-02
031369E-03	1085365E-02	115453E-02	6593529E-03	1283658E-02	2368305E-02	2291063E-02
039264E-02	9615110E-03	9586924E-03	6177049E-03	1161195E-02	2121120E-02	2523923E-02
05084E-02	8208430E-03	8627696E-03	6373527E-03	1010368E-02	1817266E-02	2808335E-02
07881E-02	6271556E-03	6744144E-03	614450E-03	7893122E-03	1403221E-02	3186574E-02
1607E-01	329011E-03	3872835E-03	2470282E-03	4532019E-03	8056923E-03	3659291E-02
49948E-01	0000000E+00	0000000E+00	1095229E-03	0000000E+00	0000000E+00	3476687E-02

$$\eta_1 + (108)\eta_2 + (109)\eta_3 + (110)\eta_4 - (115)\beta - (401)\eta_1 - (402)\eta_2 - (403)\eta_3 - (404)\eta_4 - (208)\eta_1$$

$$\eta_3 - (211)\eta_4 + (164)\bar{Z}_{s1} + (165)\bar{Z}_{s2} + (166)\bar{Z}_{s3} + (167)Z_{s4} + (168)Z_{s5} + (169)Z_{s6}$$



Table 2

COEF-2

TIME	122	121	119	127	128	129	130	131
0000000E+00	0000000E+00	3060173E+02	3850000E+02	0000000E+00	0000000E+00	0000000E+00	0000000E+00	0000000E+00
0000000E+01	1610350E+01	3117934E+02	9920000E+02	1732689E+01	4716056E+04	6038835E+04	8836490E+05	2099770E
0000000E+01	1375286E+00	3177848E+02	3998000E+02	8030171E+01	4463972E+03	5919542E+03	7538096E+04	1791320E
1200000E+02	1904419E+00	3241022E+02	4082000E+02	6816886E+01	2026129E+03	8192609E+03	1043267E+03	2479176E
1600000E+02	3799274E+00	3312757E+02	4168000E+02	9736018E+01	4039892E+03	1633571E+02	2080168E+03	4943223E
2000000E+02	6623862E+00	3389481E+02	4264000E+02	1257706E+00	7035746E+03	2844888E+02	3622759E+03	8608956E
2400000E+02	1059181E+01	3469233E+02	4362000E+02	1588772E+00	4123828E+02	4544169E+02	5786661E+03	1375117E
2800000E+02	1659950E+01	3557467E+02	4473500E+02	1960123E+00	1756515E+02	7102431E+02	9044417E+13	2149276E
3200000E+02	2289092E+01	3649403E+02	4585000E+02	2209625E+00	2415745E+02	9768014E+02	1243883E+02	295912E
3600000E+02	3256527E+01	3751274E+02	4705000E+02	2512009E+00	3411033E+02	1379243E+01	1756364E+02	4173748E
4000000E+02	4289145E+01	3857606E+02	4834000E+02	2709608E+00	4449902E+02	1799308E+01	2291289E+02	5444911E
4400000E+02	5718175E+01	3973709E+02	4972000E+02	2876156E+00	5858181E+02	2368742E+01	3016417E+02	7168085E
4800000E+02	7260318E+01	4098130E+02	5110000E+02	2951236E+00	7330949E+02	2964253E+01	3774756E+02	8970168E
5200000E+02	9247229E+01	4226175E+02	5261500E+02	2970305E+00	9099456E+02	3729600E+01	4742197E+02	1116533E
5600000E+02	1151087E+02	4361509E+02	5413000E+02	2941877E+00	1051597E+01	4798653E+01	6032732E+02	1320698E
6000000E+02	1415106E+02	4508678E+02	5566000E+02	2248679E+03	1196524E+01	6068691E+01	7552466E+02	1540538E
6400000E+02	1729267E+02	4661043E+02	5719000E+02	1435618E+00	1331819E+01	7800277E+01	9249292E+02	1761050E
6800000E+02	2080238E+02	4820205E+02	5865000E+02	2519891E+00	1702369E+01	9095213E+01	1077368E+01	1950254E
7200000E+02	2256257E+02	4987480E+02	6012000E+02	3378186E+00	2495766E+01	1089455E+00	1126676E+01	2040499E
7600000E+02	2235753E+02	5159849E+02	6238500E+02	5179717E+00	4088501E+01	1093973E+00	1036299E+01	1901287E
8000000E+02	2237099E+02	5341344E+03	6465000E+02	6630773E+00	5015708E+01	1055888E+00	9081981E+02	1726247E
8400000E+02	2224723E+02	5525257E+02	6737000E+02	6892995E+00	6633410E+01	9955339E+01	7630439E+02	1549933E
8800000E+02	2168854E+02	5720422E+02	7009000E+02	6950622E+00	6203846E+01	1084436E+00	2370720E+01	1602907E
9200000E+02	2087765E+02	5916982E+02	7312000E+02	6351541E+00	6245665E+01	1070797E+00	3241461E+01	1539183E
9600000E+02	1952314E+02	6128316E+02	7615000E+02	5674740E+00	5770720E+01	9609298E+01	3337335E+01	1369207E
1000000E+03	1792747E+02	6341543E+02	7931000E+02	4887745E+00	5238528E+01	8473228E+01	3330362E+01	1196430E
1040000E+03	1634090E+02	6565617E+02	8258500E+02	4099002E+00	4737206E+01	7443533E+01	375063E+01	1041209E
1080000E+03	1451485E+02	6805320E+02	8586000E+02	3378186E+00	4175580E+01	6374646E+01	3111962E+01	8830525E
1120000E+03	1285827E+02	7056784E+02	8943500E+02	2701186E+00	3519003E+01	5354428E+01	2392261E+01	7597518E
1160000E+03	1101407E+02	7327102E+02	9301000E+02	2104464E+00	2863782E+01	4342130E+01	1744829E+01	6319855E
1200000E+03	9475483E+01	7615752E+02	9705000E+02	1585300E+00	2355669E+01	3558078E+01	1255528E+01	5320387E
1240000E+03	7791722E+01	7927799E+02	1011000E+03	1147082E+00	1849074E+01	2781284E+01	8324535E+02	4279997E
1280000E+03	6573696E+01	8264433E+02	1058050E+03	8341217E+01	1496574E+01	2240834E+01	5388645E+02	3555532E
1320000E+03	5254434E+01	8630759E+02	1106100E+03	1145319E+01	1145319E+01	1706334E+01	2995001E+02	2797524E
1360000E+03	4402131E+01	9030242E+02	1160950E+03	3993173E+01	6194058E+02	1162216E+01	1410180E+02	2313108E
1400000E+03	3478303E+01	9468369E+02	1216800E+03	2593073E+01	6944362E+02	1022614E+01	2377955E+03	1803234E
1440000E+03	2940375E+01	9950321E+02	1284700E+03	1774263E+01	5959151E+02	8177917E+02	5470639E+03	1502010E
1480000E+03	2350648E+01	1048388E+03	1352200E+03	1131001E+01	4245395E+02	6161687E+02	1040083E+02	1182756E
1520000E+03	1973426E+01	1107704E+03	1437100E+03	7385149E+02	5347248E+02	4845032E+02	1350468E+02	9757784E
1560000E+03	1553082E+01	1176133E+03	1521700E+03	4379282E+02	6561724E+02	3700626E+02	1267981E+02	7626670E
1600000E+03	1183343E+01	9492668E+02	1281756E+03	2188899E+02	1968013E+02	2819626E+02	9661158E+03	5811007E

TIME	212	213	214	215	136	170	171	172
0000000E+00	9775088E+01	8789365E+01	8625078E+01	7169962E+00	5915188E+01	2825177E+01	8719081E+01	4003405E
0000000E+01	1003473E+00	9125748E+01	8539691E+01	4336823E+00	6023376E+01	3423097E+01	6186991E+01	4076627E
0000000E+01	1029708E+00	9468447E+01	8444831E+01	1391630E+00	6135596E+01	4043297E+01	6672233E+01	4152577E
1200000E+02	1057813E+00	9841571E+01	8369600E+01	1731617E+00	6252076E+01	4511726E+01	7039705E+01	4231411E
1600000E+02	1085168E+00	1022186E+00	8266377E+01	5048712E+00	6373065E+01	4850153E+01	7282464E+01	4313297E
2000000E+02	1116414E+00	1064477E+00	8187903E+01	8525816E+00	6498829E+01	5191543E+01	7534804E+01	4398414E
2400000E+02	1147656E+00	1115747E+00	8101632E+01	1044848E+01	6629656E+01	5722380E+01	7686240E+01	4486958E
2800000E+02	1182719E+00	1171811E+00	8437479E+01	1247896E+01	6765859E+01	5458593E+01	7843897E+01	4579140E
3200000E+02	1216670E+00	1229248E+00	8569519E+01	189620E+01	6907775E+01	5600591E+01	8008169E+01	4675189E
3600000E+02	1252865E+00	1291622E+00	8721828E+01	1160422E+01	7055773E+01	5748529E+01	8179480E+01	4775354E
4000000E+02	1289227E+00	1355530E+00	886887E+01	1022541E+01	7210251E+01	5903019E+01	8358291E+01	4879905E
4400000E+02	1325426E+00	1430599E+00	9126133E+01	6189161E+00	7371545E+01	6024675E+01	8544181E+01	4989137E
4800000E+02	1361590E+00	1507687E+00	9382548E+01	1912644E+00	7540429E+01	6151758E+01	8738584E+01	5103370E
5200000E+02	1399713E+00	1583288E+00	9663927E+01	2078401E+00	7717124E+01	6284871E+01	8942047E+01	5222957E
5600000E+02	1436057E+00	1693109E+00	994491E+01	5754789E+00	7902299E+01	6424371E+01	9155377E+01	5348284E
6000000E+02	1472576E+00	1793218E+00	1022999E+01	7636215E+00	8096578E+01	6570731E+01	9379144E+01	5479772E
6400000E+02	1507477E+00	1903833E+00	1048551E+00	7265454E+00	8300651E+01	6701458E+01	9607295E+01	5617889E
6800000E+02	1540372E+00	2018419E+00	1113802E+00	4748408E+00	8515278E+01	6838945E+01	9847245E+01	5763149E
7200000E+02	1571882E+00	2111724E+00	1159945E+00	2934131E+00	8741298E+01	6981731E+01	1009993E+00	5916119E
7600000E+02	1622735E+00	2238439E+00	1222661E+00	1908340E+00	8979643E+01	7136413E+01	1036639E+00	6077432E
8000000E+02	1672981E+00	2368579E+00	1286727E+00	8000359E+01	9231351E+01	7297694E+01	1064780E+00	6247788E
8400000E+02	1732690E+00	2501908E+00	1474778E+00	7302024E+01	9497577E+01	7468784E+01	1094152E+00	6427970E
8800000E+02	1791537E+00	2637956E+00	1673611E+00	6520119E+01	9779614E+01	7680187E+01	1122443E+00	6618853E
9200000E+02	1856950E+00	2777402E+00	1949664E+00	5536084E+01	1007891E+00	7706849E+01	1152465E+00	6821420E
9600000E+02	1920902E+00	2907349E+00	2303412E+00	4298568E+01	1039711E+00	7841611E+01	1184383E+00	7036777E
1000000E+03	1987077E+00	3043467E+00	2683279E+00	2949189E+01	1073605E+00	7985106E+01	1218382E+00	7266176E
1040000E+03	2056041E+00	3133902E+00	3307588E+00	286570E+01	1109784E+00	8091633E+01	1233703E+00	7511035E
1080000E+03	2123967E+00	3221542E+00	3972625E+00	2765659E+01	1148867E+00	8219312E+01	1250093E+00	7772973E
1120000E+03	2201500E+00	3284804E+00	4895857E+00	2658374E+01	1189986E+00	7979723E+01	1262070E+00	8093840E
1160000E+03	2281563E+00	3308380E+00	6089461E+00	2533306E+01	1234597E+00	7874625E+01	1264139E+00	8355766E
1200000E+03	2372505E+00	3398648E+00	7395591E+00	2402087E+01	1282682E+00	776501E+01	1276798E+00	8681211E
1240000E+03	2473850E+00	3307712E+00	9614367E+00	3000175E+01	1334666E+00	7582559E+01	1280134E+00	9033035E
1280000E+03	2591558E+00	3282340E+00	1206126E+01	3660947E+01	1391041E+00	7384619E+01	1282109E+00	9414580E
1320000E+03	2715559E+00	3257189E+00	1492850E+01	4368069E+01	1452388E+00	705341E+01	1210972E+00	9689778E
1360000E+03	2868369E+00	3259028E+00	1838643E+01	5160658E+01	1519396E+00	6570709E+01	1164920E+00	1028328E
1400000E+03	3022677E+00	3245205E+00	2210448E+01	6008266E+01	1592886E+00	6041235E+01	1114413E+00	1078066E
1440000E+03	3294725E+00	3308821E+00	2152104E+01	1351722E+00	1673846E+00	5212017E+01	9520635E+01	1132860E
1480000E+03	3577700E+00	3360020E+00	2074555E+01	2178447E+00	1763477E+00	4293994E+01	772352E+01	1193523E
1520000E+03	3967923E+00	3473516E+00	1982584E+01	345346E+00	1863250E+00	3123611E+01	555387E+01	1261049E
1560000E+03	4431683E+00	3612581E+00	1845052E+01	5380244E+00	1974990E+00	1655467E+01	2443633E+01	1336675E
1600000E+03	392893E+00	2987953E+00	1340030E+01	993827E+00	210097E+00	0000000E+00	6800682E+00	1421950E

$$\tilde{Z} = (122)\alpha + (121)\beta - (119)\phi + (127)\delta + (128)\eta + (129)\eta_1 + (130)\eta_2 + (131)\eta_3 - (40$$

$$-(212)\eta_4 - (213)\eta_5 - (214)\eta_6 - (215)\eta_7 + (136)\beta$$

Table 2

128	129	130	131	406	407	408	409
000E+00	+0000000E+00	+0000000E+00	+0000000E+00	+0000000E+00	+0000000E+00	+0000000E+00	+0000000E+00
89E+01	+1716055E+04	+6938835E+04	+8836498E+05	+1284482E+03	+9440249E+05	+6609140E+04	+1844674E+04
71E+01	+1463972E+03	+5919542E+03	+7538096E+04	+1791320E+02	+2961283E+03	+3067303E+03	+8561137E+04
86E+01	+2026129E+03	+8192609E+03	+1043267E+03	+2479176E+02	+5121546E+03	+3803932E+04	+2635227E+03
01E+01	+4039892E+03	+1633521E+02	+2080168E+03	+4943223E+02	+7403984E+03	+5499171E+04	+3809627E+03
706E+00	+7036746E+03	+2844888E+02	+3622753E+03	+8608956E+02	+9677614E+03	+7187867E+04	+4979495E+03
772E+00	+1128262E+02	+4544169E+02	+5786661E+03	+1375117E+01	+1237167E+02	+9188828E+04	+6365688E+03
123E+00	+1756515E+02	+7102431E+02	+9044417E+03	+2149276E+01	+1558951E+02	+1157881E+03	+8021388E+03
625E+00	+2419745E+02	+9768014E+02	+1243883E+02	+2955912E+01	+1795999E+02	+1333945E+03	+9241089E+03
009E+00	+3411033E+02	+1379243E+01	+1756364E+02	+4173748E+01	+2123360E+02	+1977086E+03	+1092748E+02
608E+00	+4449902E+02	+1799308E+01	+2291289E+02	+5444911E+01	+2382438E+02	+1769511E+03	+1228853E+02
153E+00	+5858181E+02	+2368742E+01	+3016417E+02	+7168085E+01	+2687292E+02	+1995936E+03	+1382712E+02
236E+00	+7330949E+02	+2964253E+01	+3774756E+02	+8970168E+01	+2841651E+02	+2184856E+03	+1513590E+02
105E+00	+9099446E+02	+3729600E+01	+4742197E+02	+1116533E+00	+3214277E+02	+2399612E+03	+1648525E+02
877E+00	+1051597E+01	+4798643E+01	+6032732E+02	+1320698E+00	+3625282E+02	+2418633E+03	+1899002E+02
679E+00	+1196524E+01	+6068691E+01	+7552466E+02	+1540538E+00	+3997965E+02	+2426816E+03	+1945522E+02
18E+00	+1331819E+01	+7500217E+01	+9249422E+02	+1761050E+00	+4375890E+02	+2417750E+03	+2080392E+02
91E+00	+1702365E+01	+9098213E+01	+1077368E+01	+1950254E+00	+4656686E+02	+2805940E+03	+2276156E+02
91E+00	+2957665E+01	+1089455E+00	+1126676E+01	+2040499E+00	+4882428E+02	+4970360E+03	+2778573E+02
717E+00	+4088501E+01	+1093973E+00	+1036299E+01	+1901287E+00	+4479657E+02	+4967713E+03	+2682705E+02
773E+00	+5019708E+01	+1055888E+00	+9081981E+02	+1726247E+00	+4017264E+02	+5033577E+03	+2470932E+02
995E+00	+5633410E+01	+9955339E+01	+7630439E+02	+1549933E+00	+3482835E+02	+4818269E+03	+2168221E+02
622E+00	+6203846E+01	+1084436E+00	+2370720E+01	+1602907E+00	+3174253E+02	+6626044E+03	+2117647E+02
641E+00	+6245665E+01	+1070797E+00	+3241461E+01	+1539183E+00	+2717433E+02	+6942814E+03	+1871741E+02
740E+00	+5770720E+01	+9602988E+01	+3337135E+01	+1369207E+00	+2214846E+02	+6202841E+03	+1524017E+02
745E+00	+5238528E+01	+8473228E+01	+3390362E+01	+1196430E+00	+1770438E+02	+5405998E+03	+1216951E+02
602E+00	+4737206E+01	+7443533E+01	+3275063E+01	+1041209E+00	+1408723E+02	+4668452E+03	+9672744E+03
186E+00	+4175880E+01	+6376466E+01	+3111962E+01	+8830521E+00	+1102129E+02	+3948223E+03	+7559161E+03
186E+00	+3510003E+01	+5354428E+01	+2392261E+01	+7597518E+01	+8687701E+03	+3118725E+03	+5991845E+03
464E+00	+2863782E+01	+4342130E+01	+1744829E+01	+6319855E+01	+6673474E+03	+2400752E+03	+4566591E+03
350E+00	+2359669E+01	+3550788E+01	+1255528E+01	+5320387E+01	+5172779E+03	+1864930E+03	+3535449E+03
082E+00	+1849074E+01	+2781284E+01	+8324535E+02	+4279997E+01	+3858942E+03	+1394349E+03	+2634244E+03
217E+01	+1496574E+01	+2240834E+01	+5388645E+02	+3555532E+01	+2964155E+03	+1073471E+03	+2020885E+03
257E+01	+1149319E+01	+1706334E+01	+2995001E+02	+2797524E+01	+2170688E+03	+7879473E+04	+1478006E+03
173E+01	+4194058E+02	+1362216E+01	+1410680E+02	+2313108E+01	+1665341E+03	+6059454E+04	+1132416E+03
073E+01	+6944365E+02	+1022614E+01	+2377455E+03	+1803234E+01	+1212006E+03	+4420705E+04	+8230307E+04
263E+01	+2991516E+02	+8177917E+02	+5470639E+03	+1502010E+01	+9319882E+04	+3434195E+04	+6368832E+04
001E+01	+4249355E+02	+6161667E+02	+1040083E+02	+1182756E+01	+6920516E+04	+2536958E+04	+4686142E+04
149E+02	+3367248E+02	+4845032E+02	+1390468E+02	+9757784E+02	+5321445E+04	+1955863E+04	+3598018E+04
83E+02	+2582924E+02	+3700626E+02	+1267981E+02	+7626670E+02	+3884959E+04	+1429599E+04	+2624970E+04
99E+02	+1968013E+02	+2819826E+02	+9661158E+03	+5811007E+02	+2793429E+04	+1027939E+04	+1887452E+04
62E+00	+5915188E+01	+2829177E+01	+5719081E+01	+4003405E+01			
23E+00	+6023376E+01	+3423097E+01	+6186951E+01	+4076627E+01			
30E+00	+6135596E+01	+4043297E+01	+6672253E+01	+4152577E+01			
17E+00	+6252076E+01	+4571726E+01	+7039705E+01	+4231411E+01			
12E+00	+6373065E+01	+4850153E+01	+7282464E+01	+4313297E+01			
16E+00	+6498829E+01	+5191943E+01	+7534804E+01	+4398414E+01			
84E+00	+6629656E+01	+5322380E+01	+7686240E+01	+4486958E+01			
96E+00	+6765859E+01	+5458593E+01	+7843897E+01	+4579140E+01			
20E+01	+6907775E+01	+5600571E+01	+8008169E+01	+4675189E+01			
22E+01	+7055773E+01	+5748529E+01	+8179480E+01	+4775354E+01			
41E+01	+7210251E+01	+5903019E+01	+8358291E+01	+4879905E+01			
61E+00	+7371645E+01	+6024605E+01	+8544181E+01	+4989137E+01			
44E+00	+7540429E+01	+6151758E+01	+8738584E+01	+5103370E+01			
01E+00	+7717124E+01	+6284871E+01	+8942097E+01	+5222957E+01			
89E+00	+7902299E+01	+6424371E+01	+9155377E+01	+5348284E+01			
15E+00	+8096278E+01	+6570731E+01	+9379144E+01	+5479772E+01			
54E+00	+8300651E+01	+6701458E+01	+9607295E+01	+5617889E+01			
08E+00	+8515278E+01	+6838945E+01	+9847245E+01	+5763149E+01			
31E+00	+8741298E+01	+6983731E+01	+1009973E+00	+5916119E+01			
40E+00	+8979643E+01	+7136413E+01	+1036639E+00	+6077432E+01			
59E+00	+9231351E+01	+7297654E+01	+1064780E+00	+6247788E+01			
24E+01	+9497577E+01	+7468784E+01	+1094192E+00	+6427970E+01			
19E+01	+9779614E+01	+7580187E+01	+1122443E+00	+6618853E+01			
84E+01	+1007891E+00	+7706899E+01	+1152465E+00	+6821420E+01			
88E+01	+1039711E+00	+7841311E+01	+1184383E+00	+7036777E+01			
89E+01	+1073605E+00	+7985106E+01	+1218383E+00	+7266176E+01			
70E+01	+1109784E+00	+8001693E+01	+1233703E+00	+7511035E+01			
59E+01	+1148487E+00	+8049312E+01	+1250093E+00	+7772973E+01			
74E+01	+1189986E+00	+81723E+01	+1272070E+00	+8053840E+01			
06E+01	+1234597E+00	+82787425E+01	+1269139E+00	+8355766E+01			
87E+01	+1282682E+00	+7765081E+01	+1276758E+00	+8681211E+01			
75E+01	+1334666E+00	+7582559E+01	+1260134E+00	+9033035E+01			
47E+01	+1391041E+00	+7384819E+01	+1242105E+00	+9414580E+01			
69E+01	+1452388E+00	+7053441E+01	+1210972E+00	+9829778E+01			
58E+01	+1519396E+00	+6570709E+01	+1164920E+00	+1028328E+00			
66E+01	+1592886E+00	+6041235E+01	+1114413E+00	+1078066E+00			
22E+00	+1673846E+00	+5212017E+01	+9520630E+01	+1132860E+00			
47E+00	+1763477E+00	+4293994E+01	+7723256E+01	+1193523E+00			
46E+00	+1863250E+00	+3123611E+01	+5553087E+01	+1261049E+00			
44E+00	+1974990E+00	+1655467E+01	+2943053E+01	+1336675E+00			
27E+00	+2180987E+00	+0000000E+00	+0000000E+00	+1421950E+00			

+(128) η_1 + (129) η_2 + (130) η_3 + (131) η_4 - (406) η_1 - (407) η_2 - (408) η_3 - (409) η_4

- (214) η_3 - (215) η_4 + (136) β - (170) β - (171) β - (172) β



Table 3

COEF	080	143	082	076	077	078	079
TIME	0000000E+00	+8521345E+01	+8460000E-01	+3257100E+01	+1603360E-01	+1206006E-01	+9494342E-02
	+0000000E+01	+8521345E+01	+8460000E-01	+3319704E+01	+1604550E-01	+1212165E-01	+9198864E-02
	+8000000E+01	+8521345E+01	+8460000E-01	+3382308E+01	+1605740E-01	+1218325E-01	+8903427E-02
	+1200000E+02	+8535304E+01	+8460000E-01	+3453372E+01	+1606771E-01	+1229561E-01	+8607990E-02
	+1600000E+02	+8549263E+01	+8460000E-01	+3524436E+01	+1607643E-01	+1245873E-01	+8312553E-02
	+2000000E+02	+8605099E+01	+8460000E-01	+3607344E+01	+1608515E-01	+1262185E-01	+8017116E-02
	+2400000E+02	+8660935E+01	+8460000E-01	+3690252E+01	+1600888E-01	+1287170E-01	+7921412E-02
	+2800000E+02	+8619058E+01	+8460000E-01	+3784581E+01	+1593261E-01	+1312156E-01	+7825709E-02
	+3200000E+02	+8577181E+01	+8460000E-01	+3878910E+01	+1585435E-01	+1341542E-01	+7730006E-02
	+3600000E+02	+8595328E+01	+8460000E-01	+3984237E+01	+1577412E-01	+1375326E-01	+7634333E-02
	+4000000E+02	+8613475E+01	+8460000E-01	+4089564E+01	+1569388E-01	+1409110E-01	+7538599E-02
	+4400000E+02	+8623246E+01	+8460000E-01	+4206312E+01	+1560849E-01	+1447709E-01	+7572836E-02
	+4800000E+02	+8633017E+01	+8460000E-01	+4323060E+01	+1552309E-01	+1486307E-01	+7607072E-02
	+5200000E+02	+8660935E+01	+8460000E-01	+4451229E+01	+1543572E-01	+1525580E-01	+7641309E-02
	+5600000E+02	+8688853E+01	+8460000E-01	+4579398E+01	+1534636E-01	+1565527E-01	+7675546E-02
	+6000000E+02	+8716771E+01	+8460000E-01	+4708836E+01	+1525700E-01	+1605473E-01	+7709782E-02
	+6400000E+02	+8744689E+01	+8460000E-01	+4838274E+01	+1516605E-01	+1628976E-01	+8051089E-02
	+6800000E+02	+8775399E+01	+8460000E-01	+4962213E+01	+1507511E-01	+1652479E-01	+8392397E-02
	+7200000E+02	+8806109E+01	+8460000E-01	+5086152E+01	+1498298E-01	+1675149E-01	+8733704E-02
	+7600000E+02	+8852173E+01	+8460000E-01	+5277771E+01	+1488965E-01	+1696986E-01	+9075011E-02
	+8000000E+02	+8898238E+01	+8460000E-01	+5469390E+01	+1479633E-01	+1718823E-01	+9416318E-02
	+8400000E+02	+8944303E+01	+8460000E-01	+5699502E+01	+1470142E-01	+1734934E-01	+1020547E-01
	+8800000E+02	+8990368E+01	+8460000E-01	+5927614E+01	+1460651E-01	+1751045E-01	+1099462E-01
	+9200000E+02	+9065746E+01	+8460000E-01	+6185952E+01	+1451120E-01	+1761765E-01	+1183572E-01
	+9600000E+02	+9141125E+01	+8460000E-01	+6442290E+01	+1441550E-01	+1767095E-01	+1272877E-01
	+1000000E+03	+9241630E+01	+8460000E-01	+6709626E+01	+1431979E-01	+1772424E-01	+1362182E-01
	+1040000E+03	+9344926E+01	+8460000E-01	+6986691E+01	+1424180E-01	+1757466E-01	+1544757E-01
	+1080000E+03	+9448223E+01	+8460000E-01	+7263756E+01	+1416381E-01	+1728803E-01	+1727353E-01
	+1120000E+03	+9578041E+01	+8460000E-01	+7566201E+01	+1415588E-01	+1682363E-01	+1977033E-01
	+1160000E+03	+9707860E+01	+8460000E-01	+7868646E+01	+1421801E-01	+1613747E-01	+2293657E-01
	+1200000E+03	+9861409E+01	+8460000E-01	+8210853E+01	+1428014E-01	+1518229E-01	+2610641E-01
	+1240000E+03	+1001495E+02	+8460000E-01	+8553060E+01	+1462013E-01	+1425989E-01	+3156609E-01
	+1280000E+03	+1018665E+02	+8460000E-01	+8951103E+01	+1496011E-01	+1343901E-01	+3702538E-01
	+1320000E+03	+1035835E+02	+8460000E-01	+9349146E+01	+1530367E-01	+1272917E-01	+4389643E-01
	+1360000E+03	+1057052E+02	+8460000E-01	+9821637E+01	+1565079E-01	+1209652E-01	+5217923E-01
	+1400000E+03	+1078270E+02	+8460000E-01	+1029412E+02	+1599792E-01	+1146388E-01	+6046203E-01
	+1440000E+03	+1104792E+02	+8460000E-01	+1086856E+02	+1699778E-01	+1109307E-01	+5395845E-01
	+1480000E+03	+1131314E+02	+8460000E-01	+1144299E+02	+1799764E-01	+1072226E-01	+4745486E-01
	+1520000E+03	+1164536E+02	+8460000E-01	+1215828E+02	+1920668E-01	+1042697E-01	+4018649E-01
	+1560000E+03	+1197759E+02	+8460000E-01	+1267358E+02	+2082068E-01	+1020720E-01	+3215333E-01
	+1600000E+03	+1250504E+02	+8460000E-01	+1084366E+02	+2302200E-01	+9987437E-02	+2412017E-01

$$\beta = -30\beta - 1190(\beta - \beta^*) - (080)\beta + (143)\beta + (082)\beta + (076)\beta$$

$$+(077)\beta + (078)\beta + (079)\beta$$


$$\bar{\eta}_i = -(140)\bar{\eta}_i - (144)\eta_i + (152)\alpha - (156)\phi + (148)\beta + (160)\beta$$

$$-(251)\bar{Z}_s - (255)\bar{Z}_s - (259)\bar{Z}_s + (263)Z_s + (267)Z_s + (271)Z_s$$

Table 5

100

$$\bar{\eta}_k = -(141) \bar{\eta}_k - (145) \eta_k - (153) \alpha - (157) \phi - (149) \beta - (161) \beta$$

$$-(252) \bar{Z}_k - (256) \bar{Z}_k - (260) \bar{Z}_k - (264) Z_k - (268) Z_k - (272) Z_k$$

$$\tilde{\eta}_b = -(142)\tilde{\eta}_3 - (146)\eta_b - (154)\alpha - (158)\phi - (150)\beta - (162)\delta$$

$$-(253)\tilde{Z}_2 - (257)\tilde{Z}_2 - (261)\tilde{Z}_2 + (265)Z_2 + (269)Z_2 + (273)Z_2$$

[illegible]

$$\vec{\eta}_0 = - (143) \vec{\eta}_1 - (147) \eta_2 + (155) \alpha - (159) \dot{\phi} + (151) \beta + (163) \vec{\beta} - (254) \ddot{z}_s - (258) \dot{z}_s$$

$$-(262) \dot{Z}_3 + (266) Z_3 + (270) Z_3 - (274) Z_3$$

$$\vec{Z}_n = -(291) \dot{Z}_n - (294) Z_n + (297) \vec{\theta} - \vec{Z} - (119) \theta_c - (575) \vec{\eta}.$$
$$-(576)\bar{\eta}_2 - (577)\bar{\eta}_3 - (578)\bar{\eta}_4 + (217)\eta_1 + (218)\eta_2 + (219)\eta_3 - (220)\eta_4$$

[illegible]

$$\ddot{Z}_{32} = -(292)\ddot{Z}_{32} - (295)Z_{32} + (298)\dot{\theta} - \ddot{Z} - (119)\dot{\phi} - (579)\ddot{\eta}.$$

$$-(580)\ddot{\eta}_6 - (581)\ddot{\eta}_7 - (582)\ddot{\eta}_8 + (221)\eta_1 + (222)\eta_2 + (223)\eta_3 + (224)\eta_4$$

[illegible]

$$\ddot{Z}_n = -(293)Z_{n-1} - (296)Z_{n-2} + (299)\ddot{\theta} - \ddot{Z} - (119)\dot{\phi}_e - (583)\ddot{\eta};$$

$$-(584)\tilde{\eta}_2 - (585)\tilde{\eta}_3 - (586)\tilde{\eta}_4 + (225)\eta_1 + (226)\eta_2 + (227)\eta_3 + (228)\eta_4$$



Table 11

TIME	164	165	166	167	168	169	161	252	256	260
TIME	481	119	482	483	484	485	233	234	235	236
00000000+00	-31050000+02	-38550000+02	-87500000-01	00000000-01	00000000+00	-18000000+00	-16928720-02	-10561320+00	-96225360-01	-61373000-01
40000000+01	-31025000+02	-39240000+02	-88000000-01	00000000-01	00000000+00	-10400000+00	-27102150-02	-10696630+00	-939300520-01	-39586760-01
80000000+01	-31000000+02	-39940000+02	-88500000-01	00000000-01	00000000+00	-28000000+00	-38164250-02	-10772330+00	-102000030+00	-16935400-01
12000000+02	-30950000+02	-40820000+02	-89000000-01	00000000-01	00000000+00	-48000000+00	-49742860-02	-10899130+00	-10612970+00	-5942260-01
16000000+02	-30700000+02	-41660000+02	-89500000-01	00000000-01	00000000+00	-12400000+00	-61762910-02	-11021430+00	-10911040+00	-31110020-01
20000000+02	-30480000+02	-42540000+02	-89500000-01	00000000-01	00000000+00	-20000000+00	-74470930-02	-11171730+00	-11372080+00	-5615450-01
24000000+02	-30640000+02	-43200000+02	-91200000-01	10000000-01	00000000-01	-20500000+00	-84212910-02	-11487200+00	-11681310+00	-56079900+00
28000000+02	-30530000+02	-44735000+02	-92400000-01	20000000-02	03200000-01	-21000000+00	-94601210-02	-11835470+00	-12028990+00	-55440430+00
32000000+02	-30400000+02	-45850000+02	-93600000-01	30000000-02	03800000-01	-21500000+00	-10540000-01	-12196260+00	-123919120+00	-54698460+00
36000000+02	-30200000+02	-47050000+02	-94400000-01	40000000-02	08440000-01	-22000000+00	-11693220-01	-12574590+00	-12766940+00	-54001830+00
40000000+02	-30000000+02	-48380000+02	-96000000-01	50000000-02	05000000-01	-22500000+00	-12842270-01	-12945940+00	-13147490+00	-53148850+00
44000000+02	-29850000+02	-49720000+02	-96800000-01	70000000-02	08400000-01	-14000000+00	-14215060-01	-13363090+00	-13549470+00	-36916740+00
48000000+02	-29750000+02	-51100000+02	-97600000-01	90000000-02	08300000-01	-55000000+00	-15590850-01	-13708240+00	-13933480+00	-19656000+00
52000000+02	-29430000+02	-52615000+02	-98400000-01	11000000-01	02000000-01	-30000000+00	-17063420-01	-14112600+00	-14436550+00	-14112600-01
56000000+02	-29180000+02	-54130000+02	-99200000-01	13000000-01	01000000-01	-11500000+00	-18594170-01	-14210600+00	-14841430+00	-17917720-01
60000000+02	-28790000+02	-55650000+02	-10000000-01	15000000-01	00000000-01	-20000000+00	-20188540-01	-14929340+00	-15333470+00	-38341270+00
64000000+02	-28420000+02	-57180000+02	-10000000-01	19000000-01	00000000-01	-17040000+00	-22406460-01	-15179360+00	-15836620+00	-31798560+00
68000000+02	-28030000+02	-58650000+02	-10000000-01	23000000-01	00000000-01	-14080000+00	-24686000-01	-14037240+00	-16370100+00	-24821870+00
72000000+02	-27680000+02	-60190000+02	-10000000-01	27000000-01	00000000-01	-11120000+00	-27050730-01	-15619460+00	-16922580+00	-17455990+00
76000000+02	-27190000+02	-62385000+02	-10000000-01	31000000-01	00000000-01	-81600000+00	-29883890-01	-16033400+00	-17649670+00	-98263250-01
80000000+02	-26600000+02	-64650000+02	-10000000-01	35000000-01	00000000-01	-52000000+00	-32848760-01	-16434230+00	-18463470+00	-15961300-01
84000000+02	-25900000+02	-67370000+02	-10000000-01	40000000-01	07000000-01	-51600000+00	-36214420-01	-16740150+00	-20025120+00	-10308270-01
88000000+02	-25200000+02	-70080000+02	-10000000-01	45000000-01	08000000-01	-51200000+00	-39740250-01	-17056060+00	-20171370+00	-10382620-01
92000000+02	-24350000+02	-73170000+02	-10000000-01	50000000-01	07000000-01	-50800000+00	-43611150-01	-17397100+00	-22357070+00	-72209800-02
96000000+02	-23500000+02	-76150000+02	-10000000-01	55000000-01	07600000-01	-50400000+00	-47680480-01	-17709980+00	-25503710+00	-37601040-02
10000000+03	-22600000+02	-79310000+02	-10000000-01	60000000+00	07500000-01	-50000000+00	-51973420-01	-18009390+00	-27000000+00	-00000000+00
10400000+03	-21350000+02	-82595000+02	-10000000-01	64000000-01	06900000-01	-49600000+00	-55856460-01	-17746190+00	-22018660+00	-00000000+00
10800000+03	-20100000+02	-85850000+02	-10000000-01	68000000-01	06300000-01	-49200000+00	-59877720-01	-17402130+00	-36742250+00	-00000000+00
11200000+03	-18500000+02	-89435000+02	-10000000-01	72000000+00	05700000-01	-48800000+00	-64251320-01	-17037360+00	-41871030+00	-00000000+00
11600000+03	-16900000+02	-93010000+02	-10000000-01	76000000-01	05100000-01	-48400000+00	-68757600-01	-16584620+00	-47284620+00	-00000000+00
12000000+03	-15150000+02	-97085000+02	-10000000-01	80000000-01	04500000-01	-48000000+00	-73807990-01	-16123270+00	-53232250+00	-00000000+00
12400000+03	-13400000+02	-10110000+03	-90000000-01	82000000-01	04000000-01	-47400000+00	-80982550-01	-15062400+00	-68775700+00	-00000000+00
12800000+03	-11365000+02	-10580500+03	-90000000-01	84000000-01	03000000-01	-46800000+00	-89040490-01	-14879850+00	-85012300+00	-00000000+00
13200000+03	-9330000+01	-11051100+03	-90000000-01	86000000-01	02000000-01	-46200000+00	-97479890-01	-14135370+00	-10422390+00	-00000000+00
13600000+03	-6790000+01	-11694500+03	-96000000-01	88000000-01	01000000-01	-45600000+00	-10711260+00	-13366730+00	-12444090+00	-00000000+00
14000000+03	-4250000+01	-12168000+03	-95000000-01	90000000-01	00000000-01	-45000000+00	-11719220+00	-12461580+00	-14686870+00	-00000000+00
14400000+03	-1210000+01	-12887000+03	-91045470-01	90953170-01	12768160+00	-28153270-01	-13462400+00	-11723800+00	-14535320+00	-77375520-01
14800000+03	1630000+01	13526000+03	-87009550-01	91186350-01	15535330+00	-11386750-01	-15320040+00	-10838520+00	-14281100+00	-16293000+00
15200000+03	5840000+01	14371500+03	-83136430-01	91779530-01	18034490+00	-54201680-02	-17493450+00	-99085790+00	-14084700+00	-25967200+00
15600000+03	9850000+01	15217000+03	-79181490-01	92372710-01	21072660+00	-22268900+00	-19814140+00	-97939160-01	-13765000+00	-36659870+00
16000000+03	16088460+02	12817560+03	-75227380-01	92896980-01	23845890+00	-39033610+00	-17775910+00	-59773950-01	-10622480+00	-38599130+00

$$\ddot{\tau} \cdot \ddot{z} - (481)\ddot{\phi} \cdot (119)\phi_e \cdot (482)\ddot{\eta}_i \cdot (483)\ddot{\eta}_2 \cdot (484)\ddot{\eta}_3 \cdot (485)\ddot{\eta}_4 - (233)\eta_i - (234)\eta_2 - (235)\eta_3 - (236)\eta_4$$



CONF-2

Table 12

TIME	495	496	497	498	499	500	501	492	493
0000000E-00	+4724400E-02	+1042416E-02	-6827520E-02	-1600200E-01	+1132320E-02	+1132320E-02	+3869680E-02	+8168640E-02	+4149280E-02
0000000E-01	+4724400E-02	+1017422E-02	-6864096E-02	-1021080E-01	+1156704E-02	+1156704E-02	+8663944E-02	+8205216E-02	+2784692E-02
0000000E-02	+4724400E-02	+9824288E-03	-6900672E-02	-4419600E-02	+1181088E-02	+1181088E-02	+8577488E-02	+8241792E-02	+1424025E-02
0000000E-03	+4724400E-02	+967432E-03	-6937248E-02	-1371600E-02	+1205472E-02	+1205472E-02	+8451392E-02	+8278368E-02	+6339840E-04
0000000E-04	+4724400E-02	+9424416E-03	-6973824E-02	-162800E-02	+1229896E-02	+1229896E-02	+845246E-02	+8314944E-02	-1297228E-02
0000000E-05	+4724400E-02	+9174400E-03	-7010400E-02	-1295490E-01	+1254240E-02	+1254240E-02	+8439200E-02	+8351520E-02	-2657856E-02
0000000E-06	+4724400E-02	+8924454E-03	-7010400E-02	-1508760E-01	+1278624E-02	+1278624E-02	+8439200E-02	+8351520E-02	-2272944E-02
0000000E-07	+4724400E-02	+8674608E-03	-7010400E-02	-1722120E-01	+1303008E-02	+1303008E-02	+8439200E-02	+8351520E-02	-1888053E-02
0000000E-08	+4724400E-02	+8424672E-03	-7010400E-02	-1697126E-01	+1327392E-02	+1327392E-02	+8439200E-02	+8351520E-02	-1903151E-02
0000000E-09	+4724400E-02	+8174736E-03	-7010400E-02	-1433776E-01	+1351776E-02	+1351776E-02	+8439200E-02	+8351520E-02	-1118240E-02
0000000E-10	+4724400E-02	+7924800E-03	-7010400E-02	-1170432E-01	+1376160E-02	+1376160E-02	+8439200E-02	+8351520E-02	-733440E-03
0000000E-11	+4724400E-02	+7674864E-03	-7010400E-02	-8047232E-02	+1400544E-02	+1400544E-02	+8439200E-02	+8351520E-02	-1232895E-02
0000000E-12	+4724400E-02	+7424928E-03	-7010400E-02	-3901440E-03	+1424928E-02	+1424928E-02	+8439200E-02	+8351520E-02	-1732361E-02
0000000E-13	+4724400E-02	+7174992E-03	-7010400E-02	-151376E-02	+1449312E-02	+1449312E-02	+8439200E-02	+8351520E-02	-2231867E-02
0000000E-14	+4724400E-02	+6925056E-03	-7010400E-02	-7577328E-02	+1473696E-02	+1473696E-02	+8439200E-02	+8351520E-02	-2731375E-02
0000000E-15	+4724400E-02	+6675120E-03	-7010400E-02	-1100320E-01	+1498080E-02	+1498080E-02	+8439200E-02	+8351520E-02	-3230880E-02
0000000E-16	+4724400E-02	+6425184E-03	-7010400E-02	-8890760E-02	+1522464E-02	+1522464E-02	+8439200E-02	+8351520E-02	-3669792E-02
0000000E-17	+4724400E-02	+6175248E-03	-7022592E-02	-8778240E-02	+1546848E-02	+1546848E-02	+8439200E-02	+8351520E-02	-4108704E-02
0000000E-18	+4724400E-02	+5925312E-03	-7022592E-02	-1665720E-02	+1571232E-02	+1571232E-02	+8439200E-02	+8351520E-02	-4547616E-02
0000000E-19	+4724400E-02	+5675376E-03	-7034784E-02	-1553200E-02	+1595616E-02	+1595616E-02	+8439200E-02	+8351520E-02	-4986528E-02
0000000E-20	+4724400E-02	+5425440E-03	-7040800E-02	-1440600E-02	+1620000E-02	+1620000E-02	+8439200E-02	+8351520E-02	-5425440E-02
0000000E-21	+4724400E-02	+5175504E-03	-7120128E-02	-1328080E-02	+1644384E-02	+1644384E-02	+8439200E-02	+8351520E-02	-5864352E-02
0000000E-22	+4724400E-02	+4925568E-03	-7199376E-02	-1215560E-02	+1668768E-02	+1668768E-02	+8439200E-02	+8351520E-02	-6303264E-02
0000000E-23	+4724400E-02	+4675632E-03	-7276640E-02	-1103040E-02	+1693152E-02	+1693152E-02	+8439200E-02	+8351520E-02	-6742176E-02
0000000E-24	+4724400E-02	+4425696E-03	-7357872E-02	-990528E-02	+1717536E-02	+1717536E-02	+8439200E-02	+8351520E-02	-7181088E-02
0000000E-25	+4724400E-02	+4175760E-03	-7437120E-02	-878000E-02	+1741920E-02	+1741920E-02	+8439200E-02	+8351520E-02	-7620000E-02
0000000E-26	+4724400E-02	+3925824E-03	-7516384E-02	-765472E-02	+1766304E-02	+1766304E-02	+8439200E-02	+8351520E-02	-8058912E-02
0000000E-27	+4724400E-02	+3675888E-03	-7595200E-02	-652944E-02	+1790688E-02	+1790688E-02	+8439200E-02	+8351520E-02	-8497824E-02
0000000E-28	+4724400E-02	+3425952E-03	-7674528E-02	-540416E-02	+1815072E-02	+1815072E-02	+8439200E-02	+8351520E-02	-8936736E-02
0000000E-29	+4724400E-02	+3176016E-03	-7753776E-02	-427888E-02	+1839456E-02	+1839456E-02	+8439200E-02	+8351520E-02	-9375648E-02
0000000E-30	+4724400E-02	+2926080E-03	-7833024E-02	-315360E-02	+1863840E-02	+1863840E-02	+8439200E-02	+8351520E-02	-9814560E-02
0000000E-31	+4724400E-02	+2676144E-03	-7912288E-02	-202832E-02	+1888224E-02	+1888224E-02	+8439200E-02	+8351520E-02	-10253472E-02
0000000E-32	+4724400E-02	+2426208E-03	-7991552E-02	-90288E-02	+1912608E-02	+1912608E-02	+8439200E-02	+8351520E-02	-10692384E-02
0000000E-33	+4724400E-02	+2176272E-03	-8070816E-02	1893792E-02	+1936992E-02	+1936992E-02	+8439200E-02	+8351520E-02	-11131296E-02
0000000E-34	+4724400E-02	+1926336E-03	-8150080E-02	319792E-02	+1961376E-02	+1961376E-02	+8439200E-02	+8351520E-02	-11570208E-02
0000000E-35	+4724400E-02	+1676400E-03	-8229344E-02	1499080E-02	+1985760E-02	+1985760E-02	+8439200E-02	+8351520E-02	-12009120E-02
0000000E-36	+4724400E-02	+1426464E-03	-8308608E-02	279216E-02	+2010144E-02	+2010144E-02	+8439200E-02	+8351520E-02	-12448032E-02
0000000E-37	+4724400E-02	+1176528E-03	-8387872E-02	408912E-02	+2034528E-02	+2034528E-02	+8439200E-02	+8351520E-02	-12886944E-02
0000000E-38	+4724400E-02	+926592E-03	-8467136E-02	538816E-02	+2058912E-02	+2058912E-02	+8439200E-02	+8351520E-02	-13325856E-02
0000000E-39	+4724400E-02	+676656E-03	-8546400E-02	668720E-02	+2083296E-02	+2083296E-02	+8439200E-02	+8351520E-02	-13764768E-02
0000000E-40	+4724400E-02	+426720E-03	-8625664E-02	798624E-02	+2107680E-02	+2107680E-02	+8439200E-02	+8351520E-02	-14203680E-02
0000000E-41	+4724400E-02	+176784E-03	-8704928E-02	928528E-02	+2132064E-02	+2132064E-02	+8439200E-02	+8351520E-02	-14642592E-02
0000000E-42	+4724400E-02	+1517904E-03	-8784192E-02	1058080E-02	+2156448E-02	+2156448E-02	+8439200E-02	+8351520E-02	-15081504E-02
0000000E-43	+4724400E-02	+1267968E-03	-8863456E-02	1188000E-02	+2180832E-02	+2180832E-02	+8439200E-02	+8351520E-02	-15520416E-02
0000000E-44	+4724400E-02	+1018032E-03	-8942720E-02	1317920E-02	+2205216E-02	+2205216E-02	+8439200E-02	+8351520E-02	-15959328E-02
0000000E-45	+4724400E-02	+768096E-03	-9021984E-02	1447040E-02	+2229600E-02	+2229600E-02	+8439200E-02	+8351520E-02	-16398240E-02
0000000E-46	+4724400E-02	+518160E-03	-9101248E-02	1576160E-02	+2253984E-02	+2253984E-02	+8439200E-02	+8351520E-02	-16837152E-02
0000000E-47	+4724400E-02	+268224E-03	-9180512E-02	1705280E-02	+2278368E-02	+2278368E-02	+8439200E-02	+8351520E-02	-17276064E-02
0000000E-48	+4724400E-02	+192736E-03	-9259776E-02	1834400E-02	+2302752E-02	+2302752E-02	+8439200E-02	+8351520E-02	-17714976E-02
0000000E-49	+4724400E-02	+1677424E-03	-9339040E-02	1963520E-02	+2327136E-02	+2327136E-02	+8439200E-02	+8351520E-02	-18153888E-02
0000000E-50	+4724400E-02	+1427488E-03	-9418304E-02	2092640E-02	+2351520E-02	+2351520E-02	+8439200E-02	+8351520E-02	-18592800E-02
0000000E-51	+4724400E-02	+1177552E-03	-9497568E-02	2221760E-02	+2375904E-02	+2375904E-02	+8439200E-02	+8351520E-02	-19031712E-02
0000000E-52	+4724400E-02	+927616E-03	-9576832E-02	2351880E-02	+2400288E-02	+2400288E-02	+8439200E-02	+8351520E-02	-19470624E-02
0000000E-53	+4724400E-02	+677680E-03	-9656096E-02	2481000E-02	+2424672E-02	+2424672E-02	+8439200E-02	+8351520E-02	-19909536E-02
0000000E-54	+4724400E-02	+427744E-03	-9735360E-02	2610720E-02	+2449056E-02	+2449056E-02	+8439200E-02	+8351520E-02	-20348448E-02
0000000E-55	+4724400E-02	+177808E-03	-9814624E-02	2740440E-02	+2473440E-02	+2473440E-02	+8439200E-02	+8351520E-02	-20787360E-02
0000000E-56	+4724400E-02	+1528144E-03	-9893888E-02	2870160E-02	+2497824E-02	+2497824E-02	+8439200E-02	+8351520E-02	-21226272E-02
0000000E-57	+4724400E-02	+1278208E-03	-9973152E-02	3000000E-02	+2522208E-02	+2522208E-02	+8439200E-02	+8351520E-02	-21665184E-02
0000000E-58	+4724400E-02	+1028272E-03	-10052416E-02	3129720E-02	+2546592E-02	+2546592E-02	+8439200E-02	+8351520E-02	-22104096E-02
0000000E-59	+4724400E-02	+778336E-03	-10131680E-02	3259440E-02	+2570976E-02	+2570976E-02	+8439200E-02	+8351520E-02	-22543008E-02
0000000E-60	+4724400E-02	+528400E-03	-10210944E-02	3389160E-02	+2595360E-02	+2595360E-02	+8439200E-02	+8351520E-02	-22981920E-02
0000000E-61	+4724400E-02	+278464E-03	-10290208E-02	3518880E-02	+2619744E-02	+2619744E-02	+8439200E-02	+8351520E-02	-23420832E-02
0000000E-62	+4724400E-02	+2534704E-03	-10369472E-02	3648600E-02	+2644128E-02	+2644128E-02	+8439200E-02	+8351520E-02	-23859744E-02
0000000E-63	+4724400E-02	+2284768E-03	-10448736E-02	3778320E-02	+2668512E-02	+2668512E-02	+8439200E-02	+8351520E-02	-24298656E-02
0000000E-64	+4724400E-02	+2034832E-03	-10527999E-02	3908040E-02	+2692896E-02	+2692896E-02	+8439200E-02	+8351520E-02	-24737568E-02
0000000E-65	+4724400E-02	+1784896E-03	-10607264E-02	4037760E-02	+2717280E-02	+2717280E-02	+8439200E-02	+8351520E-02	-25176480E-02
0000000E-66	+4724400E-02	+1534960E-03	-10686528E-02	4167480E-02	+2741664E-02	+2741664E-02	+8439200E-02	+8351520E-02	-25615392E-02
0000000E-67	+4724400E-02	+1285024E-03	-10765792E-02	4297200E-02	+2766048E-02	+2766048E-02	+8439200E-02	+8351520E-02	-26054304E-02
0000000E-68	+4724400E-02	+1035088E-03	-10845056E-02	4426920E-02	+2790432E-02	+2790432E-02	+8439200E-02	+8351520E-02	-26493216E-02
0000000E-69	+4724400E-02	+785152E-03	-10924320E-02	4556640E-02	+2814816E-02	+2814816E-02	+8439200E-02	+8351520E-02	-26932128E-02
0000000E-70	+4724400E-02	+535216E-03	-11003584E-02	4686360E-02	+2839200E-02	+2839200E-02	+8439200E-02	+8351520E-02	-27371040E-02
0000000E-71	+4724400E-02	+285280E-03	-11082848E-02	4816080E-02	+2863584E-02	+2863584E-02	+8439200E-02	+8351520E-02	-27809952E-02
0000000E-72	+4724400E-02	+300288E-03	-11162112E-02	4945800E-02	+2887968E-02	+2887968E-02	+8439200E-02	+8351520E-02	-28248864E-02
0000000E-73	+4724400E-02	+275294E-03	-11241376E-02	5075520E-02	+2912352E-02	+2912352E-02	+8439200E-02	+8351520E-02	-28687776E-02
00									



Table 13

TIME	164	165	166	167	168	169
TIME	473	474	475	476	477	478
0000000E+00	0000000E+00	7234600E+07	4730342E+05	3875067E+03	3056019E+05	4077199E+05
0000000E+01	1736304E+06	7379202E+07	4730342E+05	3875067E+03	3056019E+05	4077199E+05
0000000E+01	3472608E+06	7523984E+07	4730342E+05	3875067E+03	3056019E+05	4077199E+05
0120000E+02	6655832E+06	7679737E+07	4732477E+05	3878418E+03	3043125E+05	4140370E+05
0160000E+02	1128597E+07	7726552E+07	4734613E+05	3881770E+03	3030230E+05	4203541E+05
0200000E+02	1591612E+07	7813368E+07	4736748E+05	3885121E+03	3017336E+05	4256713E+05
0240000E+02	2344010E+07	7929121E+07	4738884E+05	3888473E+03	3004441E+05	4329884E+05
0280000E+02	3096408E+07	8044875E+07	4741019E+05	3891824E+03	2991546E+05	4393055E+05
0320000E+02	4080314E+07	8175098E+07	4743155E+05	3895176E+03	2978652E+05	4456226E+05
0360000E+02	5295727E+07	8319790E+07	4745290E+05	3898528E+03	2965757E+05	4519398E+05
0400000E+02	6511140E+07	8464482E+07	4747426E+05	3901879E+03	2952863E+05	4582569E+05
0440000E+02	8321453E+07	8553395E+07	4749561E+05	3905231E+03	2939968E+05	4645740E+05
0480000E+02	1013176E+08	8642308E+07	4751697E+05	3908582E+03	2927074E+05	4708911E+05
0520000E+02	1194208E+08	8731221E+07	4753832E+05	3911934E+03	2914179E+05	4772083E+05
0560000E+02	1528246E+08	8871244E+07	4755968E+05	3915286E+03	2901284E+05	4835254E+05
0600000E+02	1862283E+08	9011268E+07	4758104E+05	3918637E+03	2888390E+05	4898425E+05
0640000E+02	2196321E+08	9151291E+07	4760239E+05	3921989E+03	2875495E+05	4961596E+05
0680000E+02	2554843E+08	9278104E+07	4762375E+05	3925340E+03	2862601E+05	5024768E+05
0720000E+02	2986814E+08	9365288E+07	4764510E+05	3928692E+03	2849706E+05	5087939E+05
0760000E+02	3132901E+08	9456668E+07	4741730E+05	3961943E+03	2854808E+05	4791244E+05
0800000E+02	3230863E+08	952475E+07	4694033E+05	4025095E+03	2877907E+05	4134683E+05
0840000E+02	3306971E+08	9799764E+07	4656684E+05	4064339E+03	2917844E+05	3601646E+05
0880000E+02	3096248E+08	9933626E+07	4650378E+05	4031865E+03	3008295E+05	3439180E+05
0920000E+02	2802279E+08	1010012E+08	4644071E+05	3999390E+03	3098747E+05	3276715E+05
0960000E+02	2480565E+08	1026416E+08	4637765E+05	3966915E+03	3189198E+05	3114249E+05
1000000E+03	2198847E+08	1042820E+08	4631459E+05	3934440E+03	3279650E+05	2951783E+05
1040000E+03	1837130E+08	1059223E+08	4625152E+05	3901966E+03	3370101E+05	2789317E+05
1080000E+03	1515414E+08	1075627E+08	4618846E+05	3869491E+03	3460553E+05	2626852E+05
1120000E+03	1250316E+08	1096817E+08	4612540E+05	3837016E+03	3551004E+05	2464386E+05
1160000E+03	1041838E+08	1122792E+08	4606233E+05	3804541E+03	3641456E+05	2301920E+05
1200000E+03	8333608E+07	1148767E+08	4599927E+05	3772067E+03	3731907E+05	2139454E+05
1240000E+03	6939037E+07	1172531E+08	4593621E+05	3739592E+03	3822359E+05	1976989E+05
1280000E+03	5544467E+07	1196296E+08	4587315E+05	3707117E+03	3912811E+05	1814523E+05
1320000E+03	455229E+07	1221200E+08	4581008E+05	3674642E+03	4003262E+05	1652057E+05
1360000E+03	3371323E+07	1247245E+08	4574702E+05	3642168E+03	4093714E+05	1489591E+05
1400000E+03	2387418E+07	1273289E+08	4568396E+05	3609693E+03	4184165E+05	1327126E+05
1440000E+03	1779711E+07	1296440E+08	4562089E+05	3577218E+03	4274417E+05	1164660E+05
1480000E+03	1172009E+07	1319591E+08	4555783E+05	3544743E+03	4365068E+05	1002194E+05
1520000E+03	6945216E+06	1344188E+08	4549477E+05	3512269E+03	4455520E+05	8397289E+04
1560000E+03	3472608E+06	1370233E+08	4544747E+05	3487913E+03	4523359E+05	7178796E+04
1600000E+03	0000000E+00	1396277E+08	4540707E+05	3467913E+03	4592359E+05	7178796E+04

$$M(3256) = (473) \alpha + (474) \beta - (475) \bar{n} - (476) \bar{n}_b - (477) \bar{n}_b - (478) \bar{n}_b$$



Table 14

TIME	164	165	166	167	168	169
TIME	060	061	062	063	064	065
0000000E+00	+0000000E+00	+7958060E+07	+4730342E+05	+3875067E+05	+3056019E+05	+4077199E+05
+4000000E+01	+1736304E+06	+8096958E+07	+4730342E+05	+3875067E+05	+3056019E+05	+4077199E+05
+8000000E+01	+3472608E+06	+8255857E+07	+4730342E+05	+3875067E+05	+3056019E+05	+4077199E+05
+1200000E+02	+6655832E+06	+8374756E+07	+4732477E+05	+3878418E+05	+3043125E+05	+4140370E+05
+1600000E+02	+1128597E+07	+8513655E+07	+4734613E+05	+3881770E+05	+3030230E+05	+4203511E+05
+2000000E+02	+1591612E+07	+8652553E+07	+4736748E+05	+3885121E+05	+3017336E+05	+4266713E+05
+2400000E+02	+2430825E+07	+8791452E+07	+4738884E+05	+3888473E+05	+3004441E+05	+4329884E+05
+2800000E+02	+3270039E+07	+8930351E+07	+4741019E+05	+3891824E+05	+2991546E+05	+4393055E+05
+3200000E+02	+4297352E+07	+9069250E+07	+4743155E+05	+3895176E+05	+2978652E+05	+4456226E+05
+3600000E+02	+5512765E+07	+9208148E+07	+4745290E+05	+3898528E+05	+2965757E+05	+4519398E+05
+4000000E+02	+6728178E+07	+9347047E+07	+4747426E+05	+3901879E+05	+2952863E+05	+4582569E+05
+4400000E+02	+8609174E+07	+9485946E+07	+4749561E+05	+3905231E+05	+2939968E+05	+4645740E+05
+4800000E+02	+1049017E+08	+9624845E+07	+4751697E+05	+3908582E+05	+2927074E+05	+4708911E+05
+5200000E+02	+1293546E+08	+9763743E+07	+4753832E+05	+3911934E+05	+2914179E+05	+4772083E+05
+5600000E+02	+1594505E+08	+9915458E+07	+4755968E+05	+3915286E+05	+2901284E+05	+4835254E+05
+6000000E+02	+1895465E+08	+1006717E+08	+4758104E+05	+3918637E+05	+2888390E+05	+4898425E+05
+6400000E+02	+2312178E+08	+1021888E+08	+4760239E+05	+3921989E+05	+2875495E+05	+4951596E+05
+6800000E+02	+2728891E+08	+1036099E+08	+4762375E+05	+3925340E+05	+2862601E+05	+5024768E+05
+7200000E+02	+3151391E+08	+1046900E+08	+4764510E+05	+3928692E+05	+2849706E+05	+5087939E+05
+7600000E+02	+3290006E+08	+1057315E+08	+4747130E+05	+3961943E+05	+2854808E+05	+4791244E+05
+8000000E+02	+3387239E+08	+1069868E+08	+4694033E+05	+4025095E+05	+2877307E+05	+4134683E+05
+8400000E+02	+3484472E+08	+1089349E+08	+4656684E+05	+4064339E+05	+2917844E+05	+3601646E+05
+8800000E+02	+3291743E+08	+1104686E+08	+4650378E+05	+4031865E+05	+3008295E+05	+3439180E+05
+9200000E+02	+2977037E+08	+1127211E+08	+4644071E+05	+3999390E+05	+3098747E+05	+3276715E+05
+9600000E+02	+2637011E+08	+1145466E+08	+4637765E+05	+3966915E+05	+3189198E+05	+3114249E+05
+1000000E+03	+2296985E+08	+1163720E+08	+4631459E+05	+3934440E+05	+3279650E+05	+2951783E+05
+1040000E+03	+1956959E+08	+1181975E+08	+4625152E+05	+3901966E+05	+3370101E+05	+2789317E+05
+1080000E+03	+1616933E+08	+1200230E+08	+4618846E+05	+3869491E+05	+3460553E+05	+2626852E+05
+1120000E+03	+1338401E+08	+1223806E+08	+4612540E+05	+3837016E+05	+3551004E+05	+2464386E+05
+1160000E+03	+1121363E+08	+1252704E+08	+4606233E+05	+3804541E+05	+3641456E+05	+2301920E+05
+1200000E+03	+9043250E+07	+1281602E+08	+4599927E+05	+3772067E+05	+3731907E+05	+2139454E+05
+1240000E+03	+7451638E+07	+1308262E+08	+4593621E+05	+3739592E+05	+3822359E+05	+1976989E+05
+1280000E+03	+5860026E+07	+1334922E+08	+4587315E+05	+3707117E+05	+3912811E+05	+1814523E+05
+1320000E+03	+4586736E+07	+1361582E+08	+4581008E+05	+3674642E+05	+4003262E+05	+1652057E+05
+1360000E+03	+3631769E+07	+1388243E+08	+4574702E+05	+3642168E+05	+4093714E+05	+1489591E+05
+1400000E+03	+2676802E+07	+1414903E+08	+4568396E+05	+3609693E+05	+4184165E+05	+1327126E+05
+1440000E+03	+1982280E+07	+1441563E+08	+4562089E+05	+3577210E+05	+4274617E+05	+1164660E+05
+1480000E+03	+1287758E+07	+1468223E+08	+4555783E+05	+3544743E+05	+4365068E+05	+1002194E+05
+1520000E+03	+7523984E+06	+1494883E+08	+4549477E+05	+3512269E+05	+4455520E+05	+8397289E+04
+1560000E+03	+3761992E+06	+1521544E+08	+4544474E+05	+3487913E+05	+4523359E+05	+7178796E+04
+1600000E+03	+0000000E+00	+1548204E+08	+4544474E+05	+3487913E+05	+4523359E+05	+7178796E+04

$$M'(3222) = (060) \alpha + (061) \beta - (062) \bar{\eta}_1 - (063) \bar{\eta}_2 - (064) \bar{\eta}_3 - (065) \bar{\eta}_4$$



Table 15

$$M'(2747) = (095)\alpha + (096)\beta - (097)\tilde{\eta}_1 - (098)\tilde{\eta}_2 - (074)\tilde{\eta}_3 - (075)\tilde{\eta}_4$$



Table 16

$$M'(2519) = (089) \alpha + (090)\beta - (091)\tilde{\eta}_1 - (092)\tilde{\eta}_2 - (093)\tilde{\eta}_3 - (094)\tilde{\eta}_4$$



Table 17

COEF-2	083	084	085	086	087	088
TIME						
-0000000E+00	+0000000E+00	+1591612E+09	+332A138E+06	-7003124E+05	-2027664E+05	+6A999863E+05
+4000000E+01	+5787680E+06	+1600293E+09	+332A138E+06	-7003124E+05	-2027664E+05	+6A999863E+05
+8000000E+01	+1157536E+07	+160A975E+09	+332A138E+06	-7003124E+05	-2027664E+05	+6A999863E+05
+1200000E+02	+2315072E+07	+1617656E+09	+3287834E+06	-7065309E+05	-4984882E+05	+6827425E+05
+1600000E+02	+4051376E+07	+1626338E+09	+3247529E+06	-7127494E+05	-4942099E+05	+6754986E+05
+2000000E+02	+5787680E+07	+1635619E+09	+3207224E+06	-7189679E+05	-4899317E+05	+6682547E+05
+2400000E+02	+8392136E+07	+1644807E+09	+3166919E+06	-7251864E+05	-4856535E+05	+6610108E+05
+2800000E+02	+1099659E+08	+1646594E+09	+3126615E+06	-7314049E+05	-4813752E+05	+6537669E+05
+3200000E+02	+1446920E+08	+1655276E+09	+3086310E+06	-7376234E+05	-4770970E+05	+6465230E+05
+3600000E+02	+1880996E+08	+1666851E+09	+3046005E+06	-7438419E+05	-4728186E+05	+6392791E+05
+4000000E+02	+2315072E+08	+1678427E+09	+3005700E+06	-7500604E+05	-4685405E+05	+6320352E+05
+4400000E+02	+2968476E+08	+1685661E+09	+2965396E+06	-7562789E+05	-4642623E+05	+6247913E+05
+4800000E+02	+3621881E+08	+1692896E+09	+2925091E+06	-7624974E+05	-4599841E+05	+6175474E+05
+5200000E+02	+4275286E+08	+1700131E+09	+2884786E+06	-7687159E+05	-4557058E+05	+6103035E+05
+5600000E+02	+5141606E+08	+1707847E+09	+2844482E+06	-7749344E+05	-4514276E+05	+6030596E+05
+6000000E+02	+6007925E+08	+1715564E+09	+2804177E+06	-7811529E+05	-4471494E+05	+5958157E+05
+6400000E+02	+6874244E+08	+1723281E+09	+2763872E+06	-7873714E+05	-4428711E+05	+5885718E+05
+6800000E+02	+7748966E+08	+1729990E+09	+2723567E+06	-7935899E+05	-4385929E+05	+58132A0E+05
+7200000E+02	+8648898E+08	+173673E+09	+2683263E+06	-7998084E+05	-4343147E+05	+5740841E+05
+7600000E+02	+9132519E+08	+1736322E+09	+2643697E+06	-8054896E+05	-4333927E+05	+5731953E+05
+8000000E+02	+9285059E+08	+1739199E+09	+2604869E+06	-8106337E+05	-435A270E+05	+5786618E+05
+8400000E+02	+8622775E+08	+1743198E+09	+2570170E+06	-8140213E+05	-4353437E+05	+5765347E+05
+8800000E+02	+7967609E+08	+1743175E+09	+2547857E+06	-8121400E+05	-4261076E+05	+5516272E+05
+9200000E+02	+734191E+08	+1742771E+09	+2525544E+06	-81025A6E+05	-4169715E+05	+5267197E+05
+9600000E+02	+6381356E+08	+1742241E+09	+2503232E+06	-8083773E+05	-4076353E+05	+5018122E+05
+1000000E+03	+5568520E+08	+1741710E+09	+2480910E+06	-8064959E+05	-3983992E+05	+4769046E+05
+1040000E+03	+4755684E+08	+17411A0E+09	+245A606E+06	-8046146E+05	-3891631E+05	+4519971E+05
+1080000E+03	+3942849E+08	+1740649E+09	+2436293E+06	-8027332E+05	-3799269E+05	+4270896E+05
+1120000E+03	+3257607E+08	+1741132E+09	+2413981E+06	-8008518E+05	-3706908E+05	+4021821E+05
+1160000E+03	+2699958E+08	+1742628E+09	+2391668E+06	-7989705E+05	-3614547E+05	+3772746E+05
+1200000E+03	+2142309E+08	+1744124E+09	+2369355E+06	-7970A51E+05	-3522185E+05	+3523670E+05
+1240000E+03	+1748400E+08	+17467A4E+09	+2347042E+06	-7952078E+05	-3429824E+05	+3274595E+05
+1280000E+03	+1354490E+08	+1749443E+09	+2324730E+06	-7933264E+05	-3337463E+05	+3025520E+05
+1320000E+03	+1027313E+08	+1752220E+09	+2302417E+06	-7914451E+05	-3245101E+05	+2776445E+05
+1360000E+03	+7668676E+07	+1755113E+09	+2280104E+06	-7895637E+05	-3152740E+05	+2527370E+05
+1400000E+03	+5064220E+07	+175807E+09	+2257791E+06	-7876824E+05	-3060379E+05	+2278294E+05
+1440000E+03	+3617300E+07	+1760901E+09	+2235479E+06	-7858010E+05	-2968017E+05	+2029219E+05
+1480000E+03	+2170380E+07	+1763795E+09	+2213166E+06	-7839197E+05	-2875656E+05	+1780144E+05
+1520000E+03	+1157536E+07	+17666A9E+09	+2190853E+06	-7820383E+05	-2783295E+05	+1531069E+05
+1560000E+03	+57A7680E+06	+17695A3E+09	+2174118E+06	-7806273E+05	-2714024E+05	+1344262E+05
+1600000E+03	+0000000E+00	+1772477E+09	+2174118E+06	-7806273E+05	-2714024E+05	+1344262E+05

$$M'(1541) = (083) \alpha + (084) \beta - (085) \ddot{\eta}_1 - (086) \ddot{\eta}_2 - (087) \ddot{\eta}_3 - (088) \ddot{\eta}_4$$

Table 18. Coefficient Nomenclature

000	Time
060	$M'_\alpha (3222)$
061	$M'_\beta (3222)$ $M'_{\ddot{\eta}_i} (3222)$
062	$i = 1$
063	$i = 2$
064	$i = 3$
065	$i = 4$
	$M'_{\ddot{\eta}_i} (2747)$
074	$i = 3$
075	$i = 4$
	$\frac{[M_E (X_\beta - X_E) Y_i (X_E) - I_{E_O} Y'_i (X_E)]}{I_E}$
076	$i = 1$
077	$i = 2$
078	$i = 3$
079	$i = 4$
080	$\frac{[M_E (X_{cg} - X_E) (X_\beta - X_E) + I_{E_O}]}{I_E}$
082	$M_E A_X (X_\beta - X_E) / I_E$

Table 18. Coefficient Nomenclature (Continued)

083	M'_{α} (1541)
084	M'_{β} (1541)
	M'_{η_i} (1541)
085	$i = 1$
086	$i = 2$
087	$i = 3$
088	$i = 4$
089	M'_{α} (2519)
090	M'_{β} (2519)
	M'_{η_i} (2519)
091	$i = 1$
092	$i = 2$
093	$i = 3$
094	$i = 4$
095	M'_{α} (2747)
096	M'_{β} (2747)
	M'_{η_i} (2747)
097	$i = 3$
098	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

100	$C_{N_\alpha} \bar{q} S (X_{cg} - X_{cp}) / I_y$
101	$R' (X_{cg} - X_\beta) / I_y$
106	$C_{M_\phi} \bar{q} S / I_y V$
	$C_{M_{\eta_i}} \bar{q} S / I_y$
107	$i = 1$
108	$i = 2$
109	$i = 3$
110	$i = 4$
115	$\frac{[4 M_E (X_\beta - X_E) (X_{cg} - X_\beta) + I_{EO}]}{I_y}$
119	A_X
121	R'/M
122	N'/M
127	$C_{N_\alpha} \bar{q} S (X_{cg} - X_{cp}) / MV$
	$C_{N_{\eta_i}} \bar{q} S/M$
123	$i = 1$
129	$i = 2$
130	$i = 3$
131	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

136	$4 M_E (X_\beta - X_E) / M$
	$2 \zeta_i \omega_i + C_{N_{\eta_{ii}}} \bar{q} S / M_i V$
140	$i = 1$
141	$i = 2$
142	$i = 3$
143	$i = 4$
143*	$M_E (X_\beta - X_E) / I_E$
	$\omega_i^2 - C_{N_{\eta_{ii}}} \bar{q} S / M_i$
144	$i = 1$
145	$i = 2$
146	$i = 3$
147	$i = 4$
	$R' Y_i (X_\beta) / M_i$
148	$i = 1$
149	$i = 2$
150	$i = 3$
151	$i = 4$

* 143 represents different coefficients in two equations:

- $2 \zeta_3 \omega_3 + C_{N_{\eta_{33}}} \bar{q} S / M_i V$ (Third structural mode)

- $M_E (X_\beta - X_E) / I_E$ (Engine - actuator equation)

Table 18. Coefficient Nomenclature (Continued)

	$C_{N, \eta_i} \bar{q} S / M_i$
152	$i = 1$
153	$i = 2$
154	$i = 3$
155	$i = 4$
	$C_{M, \eta_i} \bar{q} S / M_i V$
156	$i = 1$
157	$i = 2$
158	$i = 3$
159	$i = 4$
	$\frac{4 [M_E (X_\beta - X_E) Y_i (X_E) - I_{E_O} Y_i' (X_E)]}{M_i}$
160	$i = 1$
161	$i = 2$
162	$i = 3$
163	$i = 4$
	$M_{sj} (X_{cg} - X_{sj}) / I_y$
164	$j = 1$
165	$j = 2$
166	$j = 3$

Table 18. Coefficient Nomenclature (Continued)

	$M_{sj} A_X / I_y$
167	$j = 1$
168	$j = 2$
169	$j = 3$
	M_{sj} / M
170	$j = 1$
171	$j = 2$
172	$j = 3$
	$\frac{T [(X_{cg} - X_\beta) Y_i' (X_\beta) + Y_i (X_\beta)]}{I_y}$
208	$i = 1$
209	$i = 2$
210	$i = 3$
211	$i = 4$
	$A_X Y_i' (X_\beta)$
212	$i = 1$
213	$i = 2$
214	$i = 3$
215	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

	$A_X Y_i' (X_{sj})$
217	$j = 1, i = 1$
218	$i = 2$
219	$i = 3$
220	$i = 4$
221	$j = 2, i = 1$
222	$i = 2$
223	$i = 3$
224	$i = 4$
225	$j = 3, i = 1$
226	$i = 2$
227	$i = 3$
228	$i = 4$
	$A_X Y_i (X_A)$
233	$i = 1$
234	$i = 2$
235	$i = 3$
236	$i = 4$
	$(M_{sj} / M_i) Y_i (X_{sj})$
251	$j = 1, i = 1$
252	$i = 2$
253	$i = 3$
254	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

255	$j = 2, \quad i = 1$
256	$i = 2$
257	$i = 3$
258	$i = 4$
259	$j = 3, \quad i = 1$
260	$i = 2$
261	$i = 3$
262	$i = 4$
	$M_{sj} A_X Y_i' (X_{sj}) / M_i$
263	$j = 1, \quad i = 1$
264	$i = 2$
265	$i = 3$
266	$i = 4$
267	$j = 2, \quad i = 1$
268	$i = 2$
269	$i = 3$
270	$i = 4$
271	$j = 3, \quad i = 1$
272	$i = 2$
273	$i = 3$
274	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

	$2 \zeta_{sj} \omega_{sj}$
291	$j = 1$
292	$j = 2$
293	$j = 3$
	ω_{sj}^2
294	$j = 1$
295	$j = 2$
296	$j = 3$
	$(X_{cg} - X_{sj})$
297	$j = 1$
298	$j = 2$
299	$j = 3$
	$C_{M_{\dot{\eta}_i}} \bar{q} S / I_y V$
401	$i = 1$
402	$i = 2$
403	$i = 3$
404	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

	$C_{N_{\dot{\eta}_i}} \bar{q} S / M_V$
406	$i = 1$
407	$i = 2$
408	$i = 3$
409	$i = 4$
473	$M'_{\alpha} (3256)$
474	$M'_{\beta} (3256)$
	$M_{\ddot{\eta}_i} (3256)$
475	$i = 1$
476	$i = 2$
477	$i = 3$
478	$i = 4$
481	$(X_{cg} - X_A)$ $Y_i (X_A)$
482	$i = 1$
483	$i = 2$
484	$i = 3$
485	$i = 4$

Table 18. Coefficient Nomenclature (Continued)

	$Y_i' (X_{\text{PLAT}})$
490	$i = 1$
491	$i = 2$
492	$i = 3$
493	$i = 4$
	$Y_i' (X_{\text{RG}})$
495	$i = 1$
496	$i = 2$
497	$i = 3$
498	$i = 4$
	$Y_i (X_{\text{sj}})$
575	$j = 1, i = 1$
576	$i = 2$
577	$i = 3$
578	$i = 4$
579	$j = 2, i = 1$
580	$i = 2$
581	$i = 3$
582	$i = 4$
583	$j = 3, i = 1$
584	$i = 2$
585	$i = 3$
586	$i = 4$

6.2 Basic Data

This section summarizes the basic data received from MSFC under Reference 8 for use in the Saturn V load relief control study. The time-varying data is presented in graphical form (Figures 10 through 57), rather than in the digital format as received, to facilitate inclusion in this report and to illustrate the manner in which it was used when computing the time-varying numerical values for the study equation coefficients.

References from which the basic data was drawn are noted on the individual graphs. These references are summarized in Section 7.0 as Reference 5 and References 9 through 13.

Additional basic data supplied by MSFC included the following:

- i^{th} structural mode damping ratio, $\zeta_{sj} = 0.005$ (Reference 6).
- Nominal slosh-mode damping ratios as given in Figure B.1 of Reference 1 (Reference 6). Figure B.1 is reproduced as Figure 42 of this report.
- Actuator dynamics:
 - a) Second-order representation with frequency of 5.5 cps and damping ratio of 0.435 (Reference 6).
 - b) Actuator rate limit ± 5 deg/sec (Enclosure 8 to Reference 8).
 - c) Actuator displacement limit ± 5.15 degrees (Enclosure 8 to Reference 8).
- F-1 control engine data (Reference 14):
 - a) Mass = 24,067 pounds.
 - b) Moment of inertia about engine center of gravity, $I_{E_o} = 22,625.2 \text{ slug-ft}^2$

- c) Moment of inertia about engine gimbal point, $I_E = 34,781 \text{ slug-ft}^2$.
- d) Location of engine center of gravity relative to gimbal point = 3.936 feet.

Note: Moment of inertia data is average of inertia about engine X- and Z-axes.

- Vehicle reference area = 854 ft^2 , (Reference 11).
- Vehicle reference length = 396 ft (Reference 11).

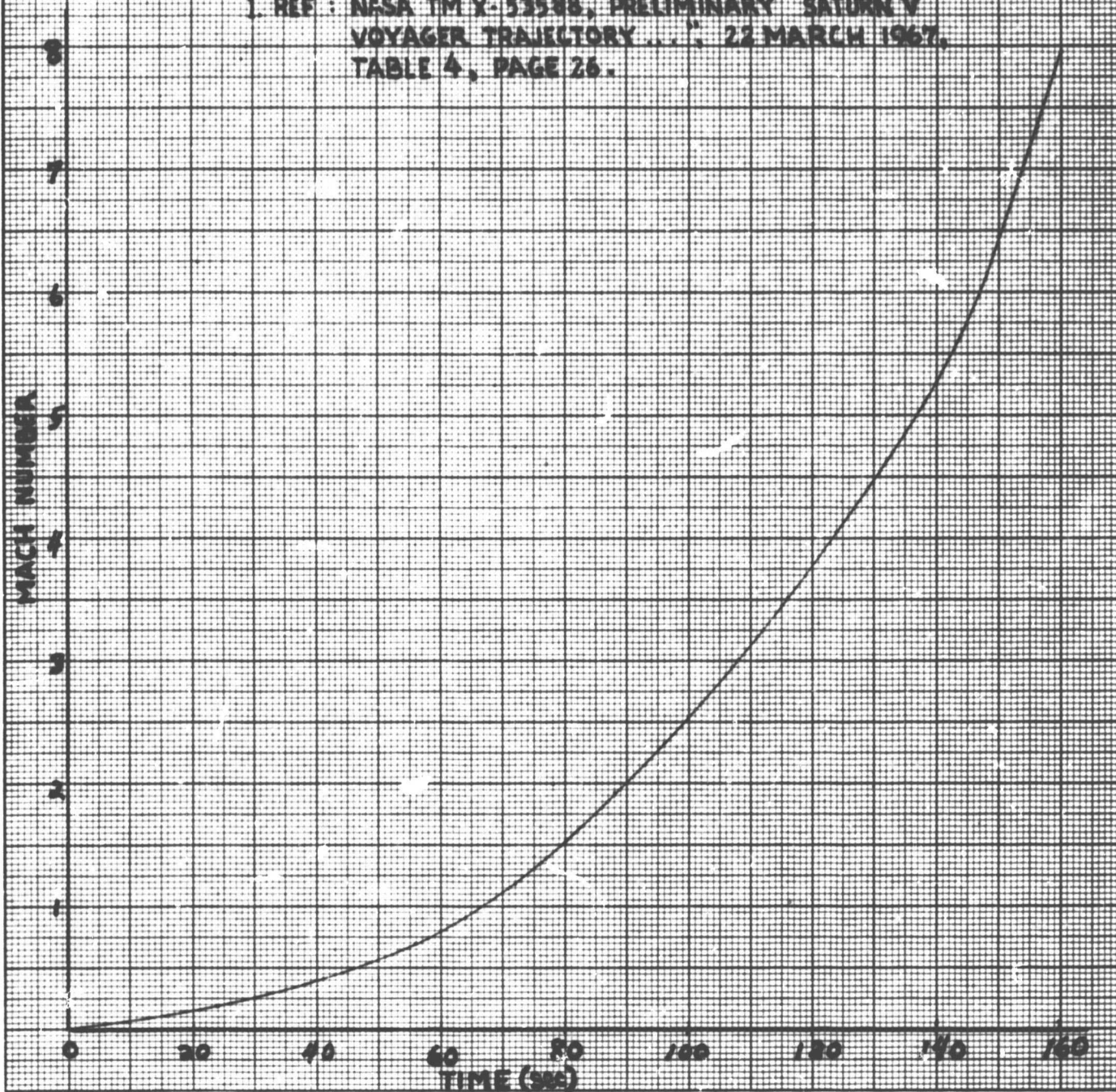
Bending-moment due to structural mode acceleration data (M_{η_i}) for the payload length under investigation was not available when required. In order to consider this flexible vehicle characteristic on peak loads encountered by the vehicle, M_{η_i} data transmitted to Honeywell by NASA-MSFC during the earlier study (contract NAS8 11206, modification 5) was utilized. This data, tabulated for vehicle stations 1541, 2519, 2746, and 3256, is presented in Table 19.

FIGURE 10

MACH NUMBER vs TIME

NOTE:

1. REF: NASA TM X-53588, "PRELIMINARY SATURN V
VOYAGER TRAJECTORY...", 22 MARCH 1967,
TABLE 4, PAGE 26.



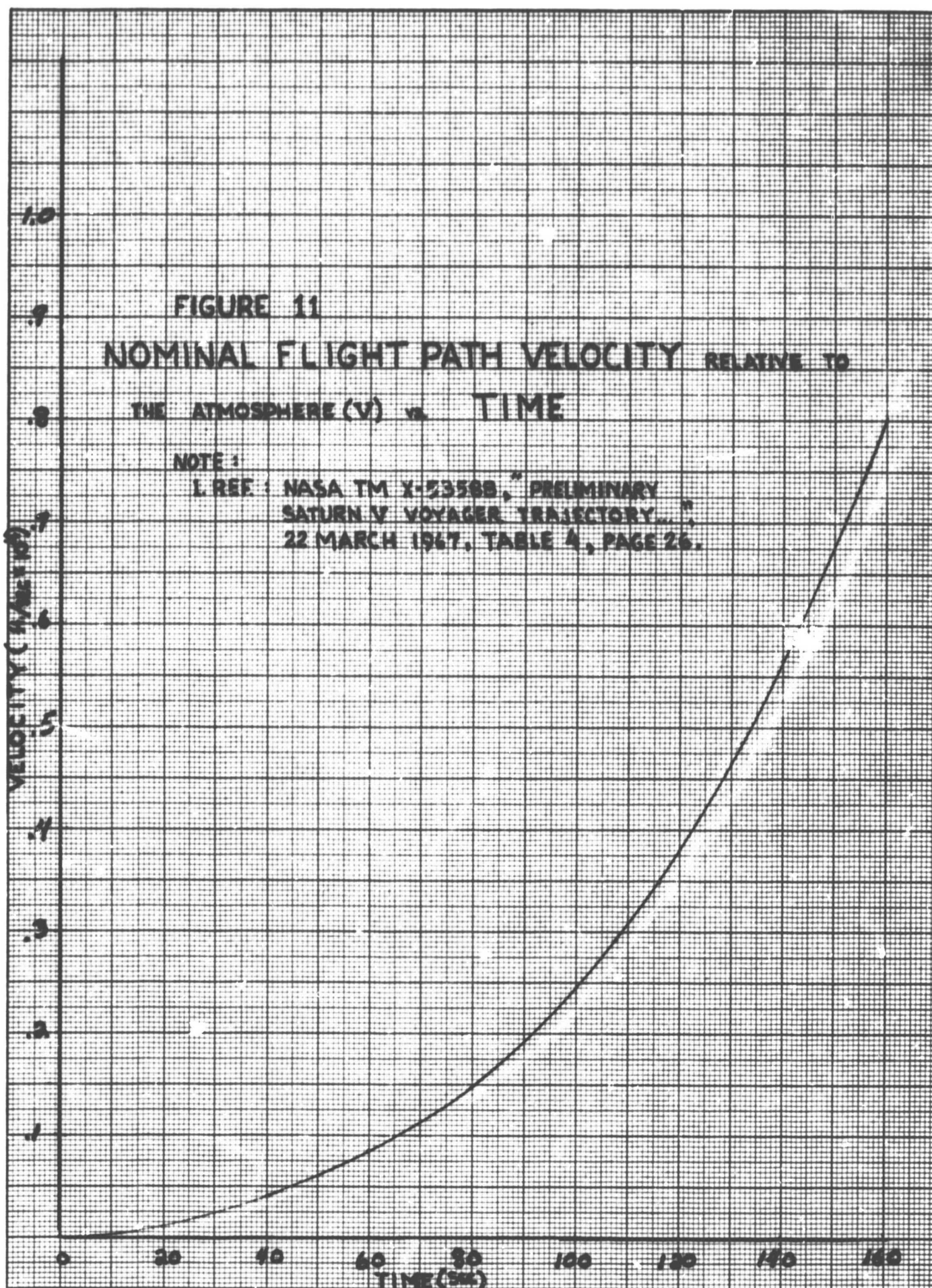


FIGURE 12
DYNAMIC PRESSURE (q) vs. TIME

NOTE:

1. REF: NASA TM X-53588, "PRELIMINARY SATURN V
 VOYAGER TRAJECTORY", 22 MARCH 1967,
 TABLE 4, PAGE 26.

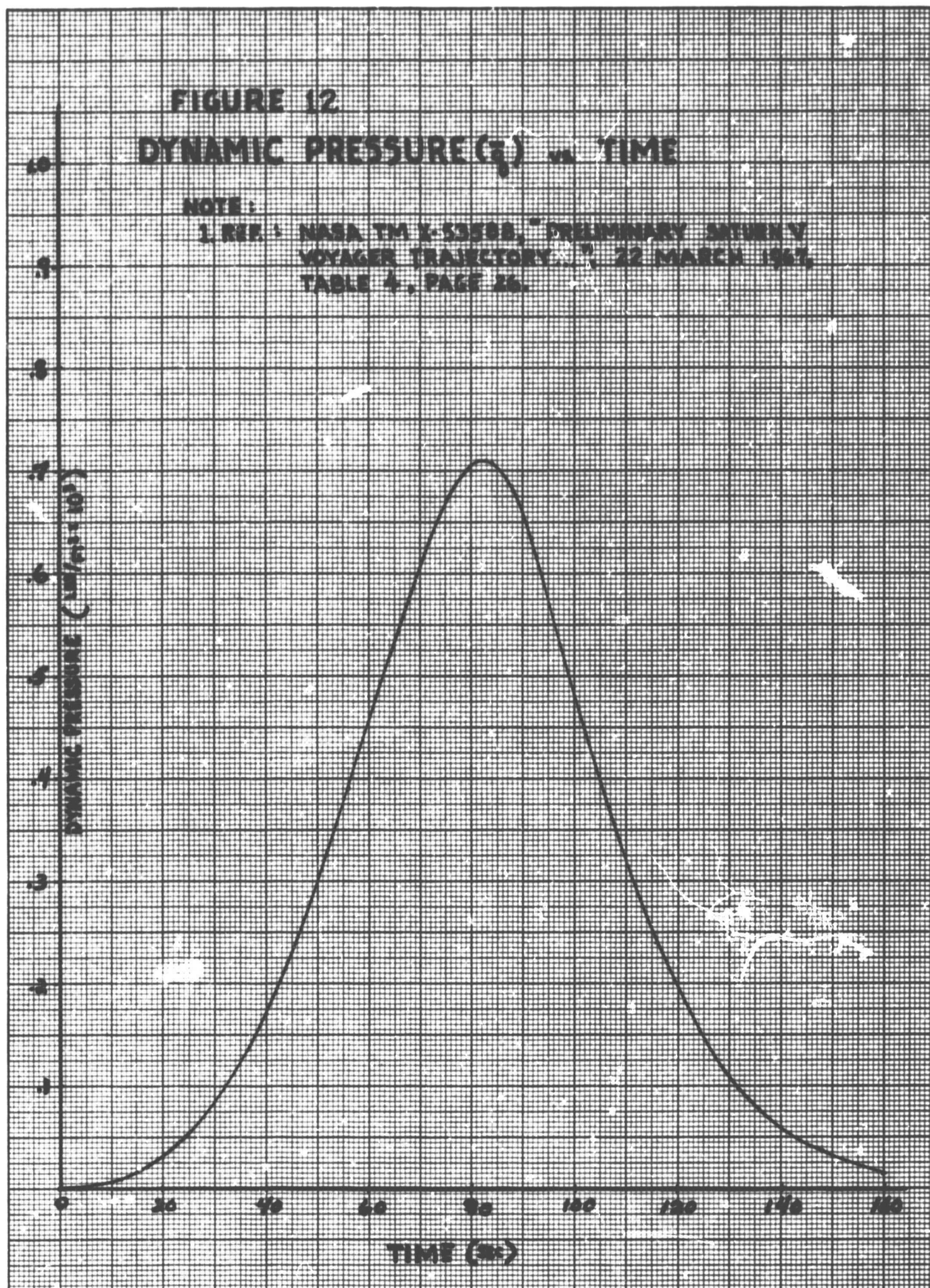


FIGURE 13
TOTAL MASS of RIGID BOOSTER (M)
vs. TIME

NOTE:

1. REF.: MSFC MEMO R-P/VE-AV-66-237,
"PRELIMINARY MASS CHARACTERISTICS
FOR SATURN V/VOYAGER," 13 DEC. 1966,
FIGURE 1.

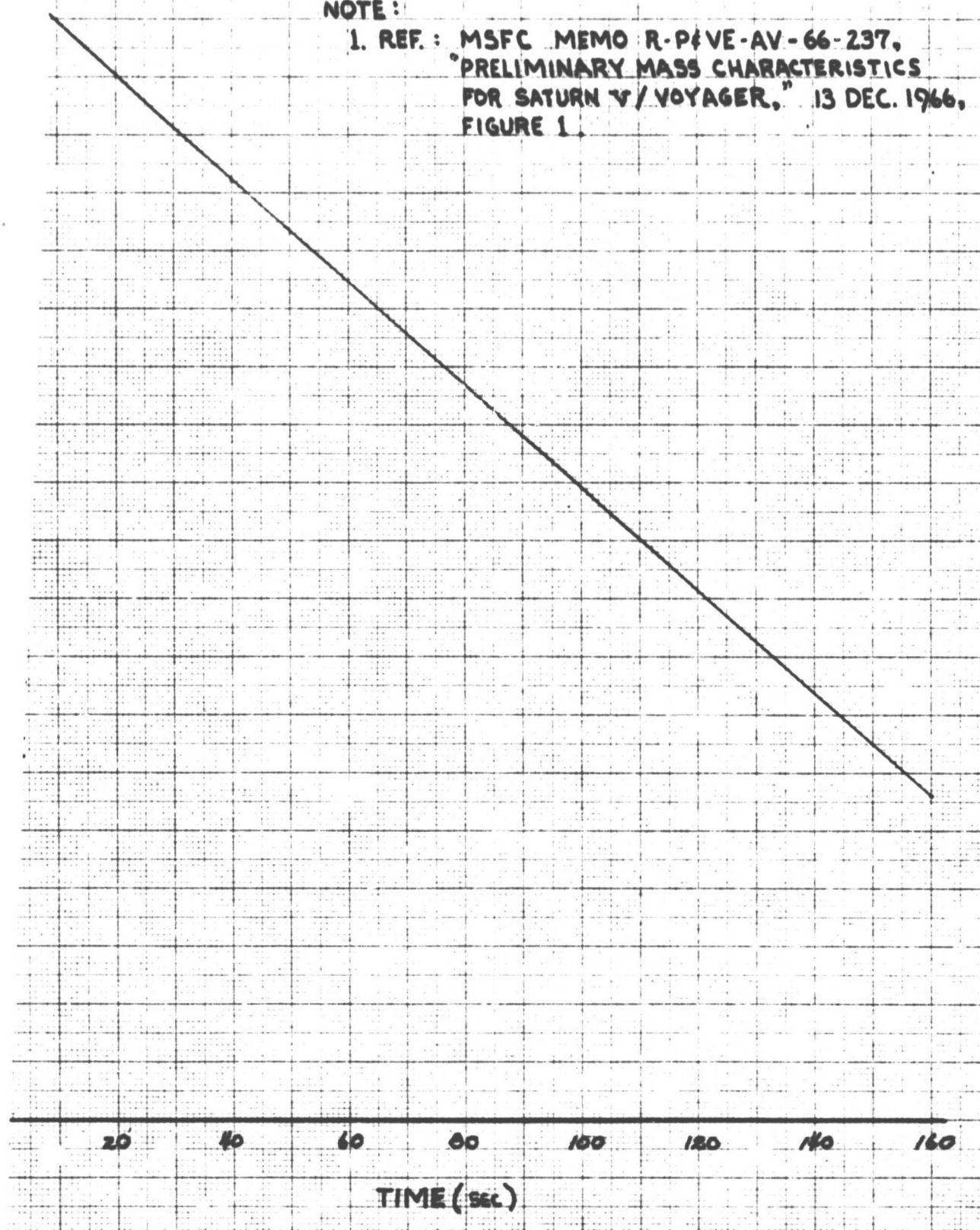
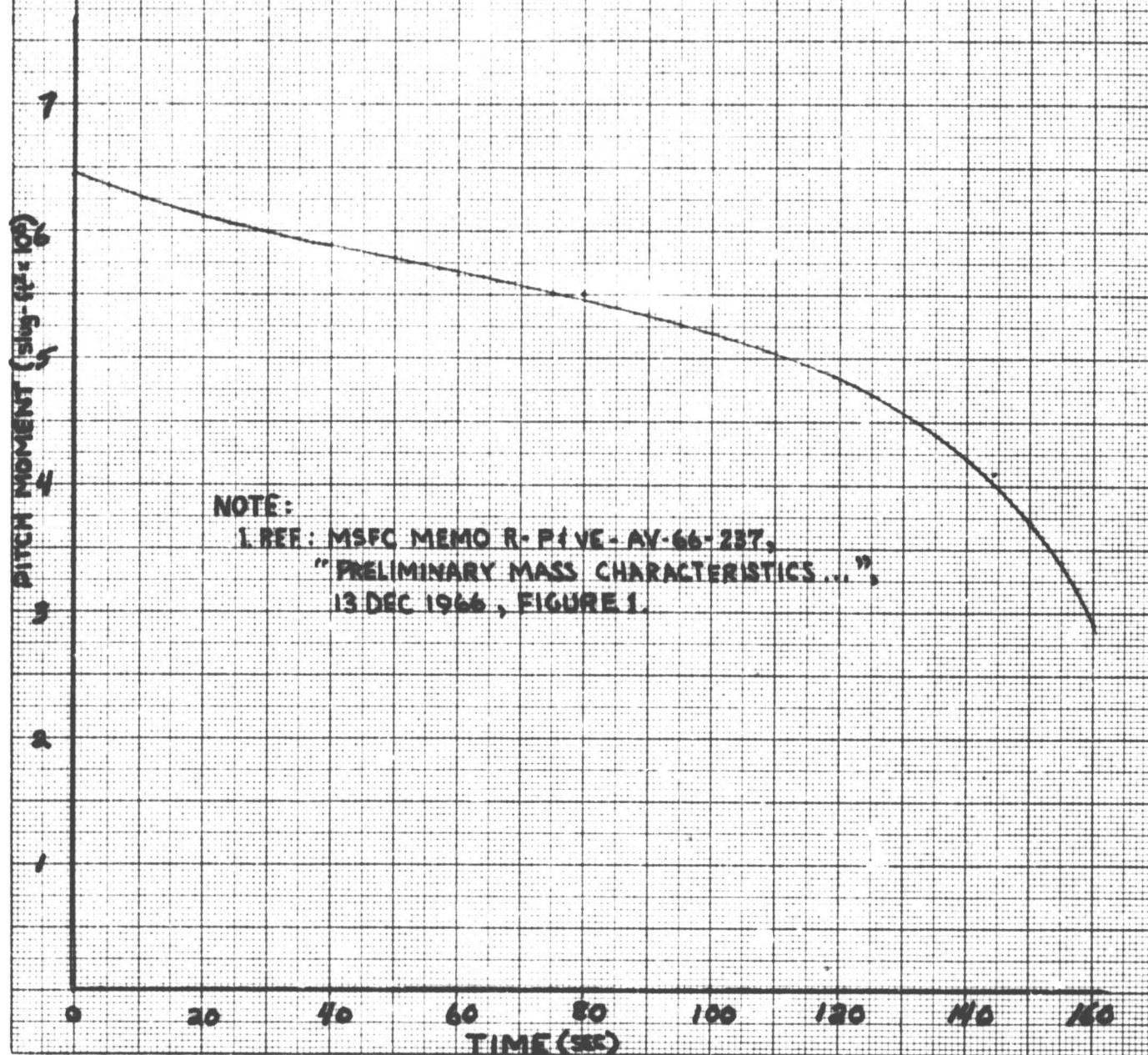
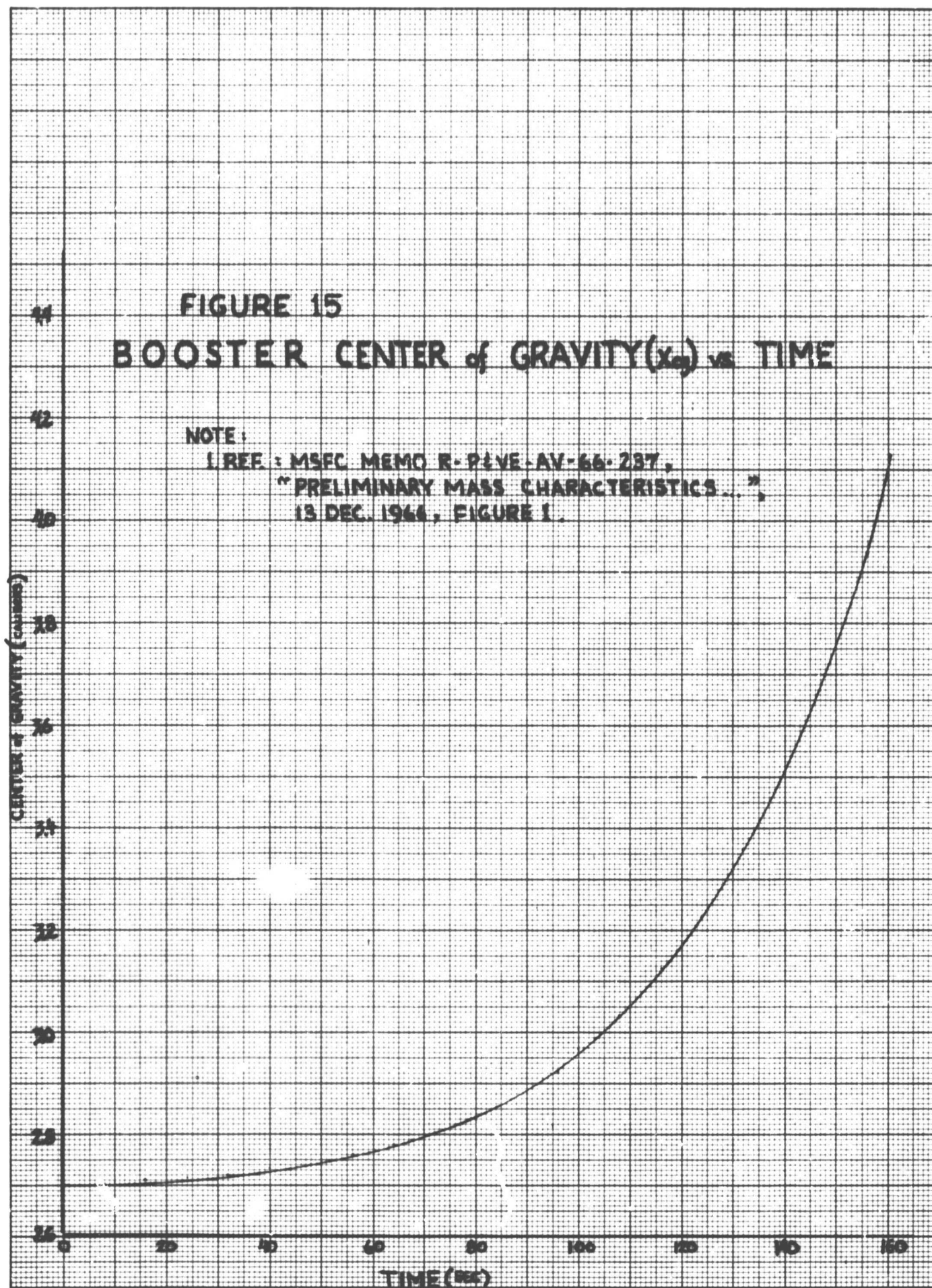
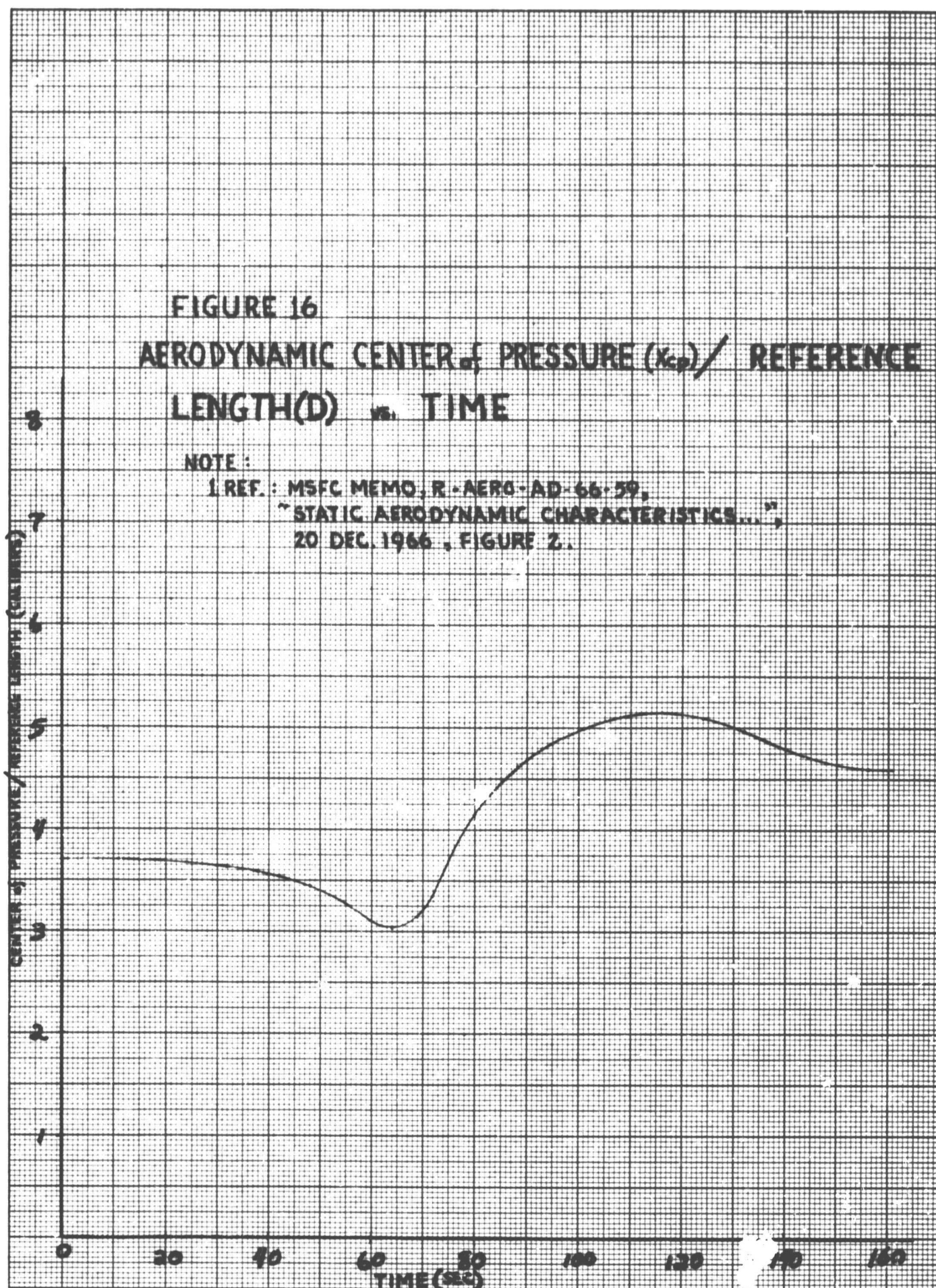
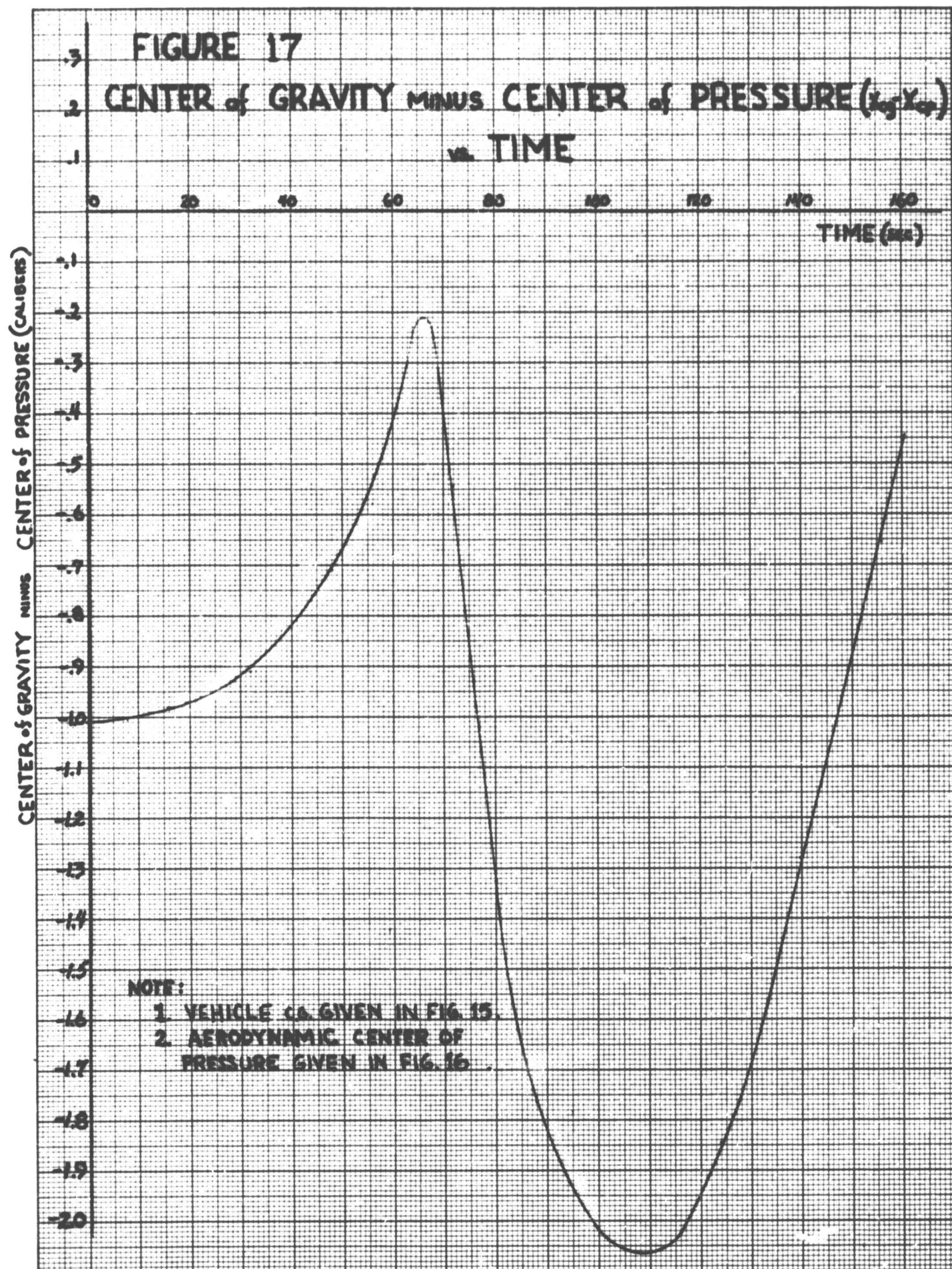


FIGURE 14
 PITCH-MOMENT of INERTIA of RIGID BOOSTER
 ABOUT the CENTER of GRAVITY (I_{yy}) vs. TIME









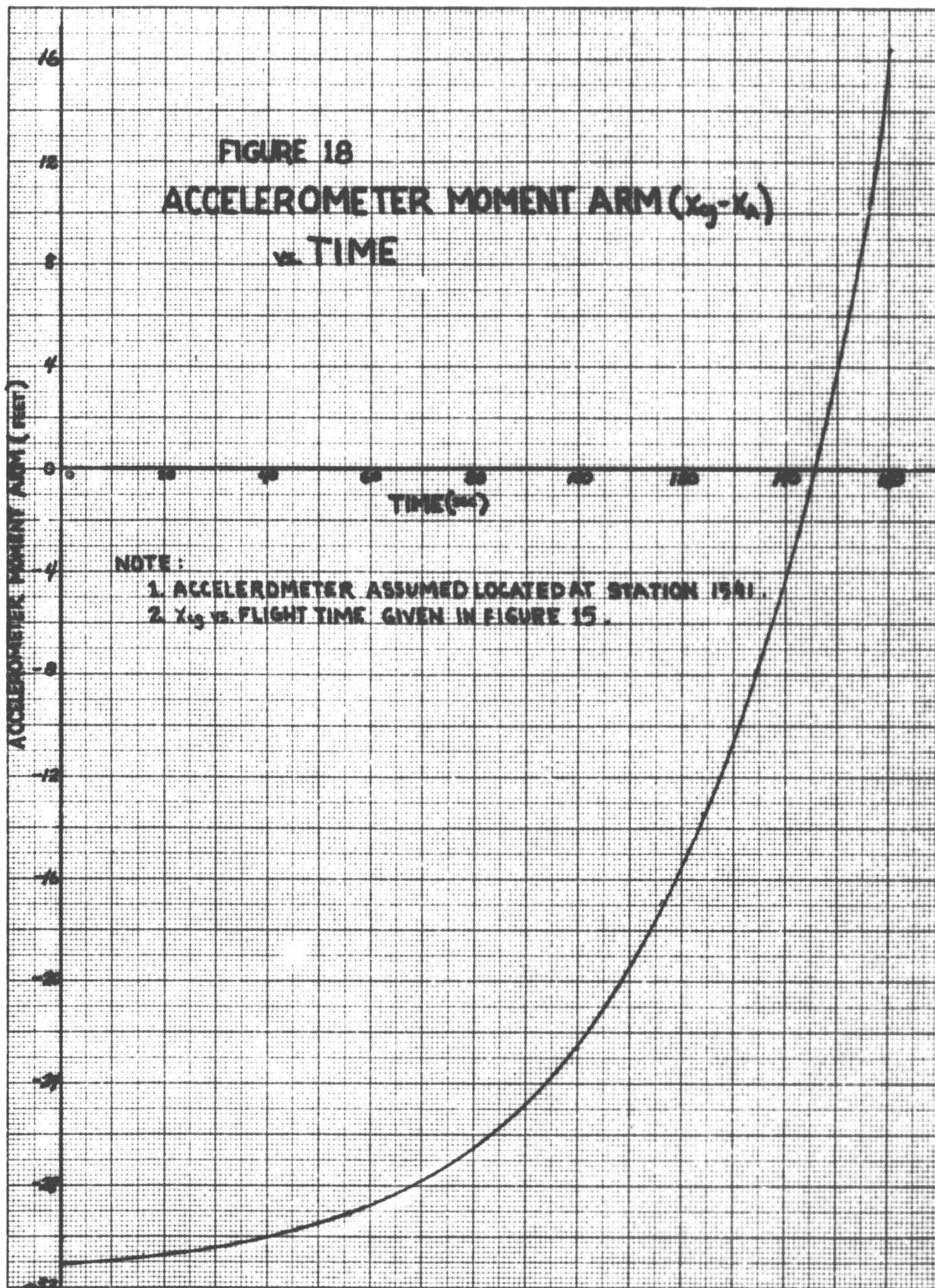
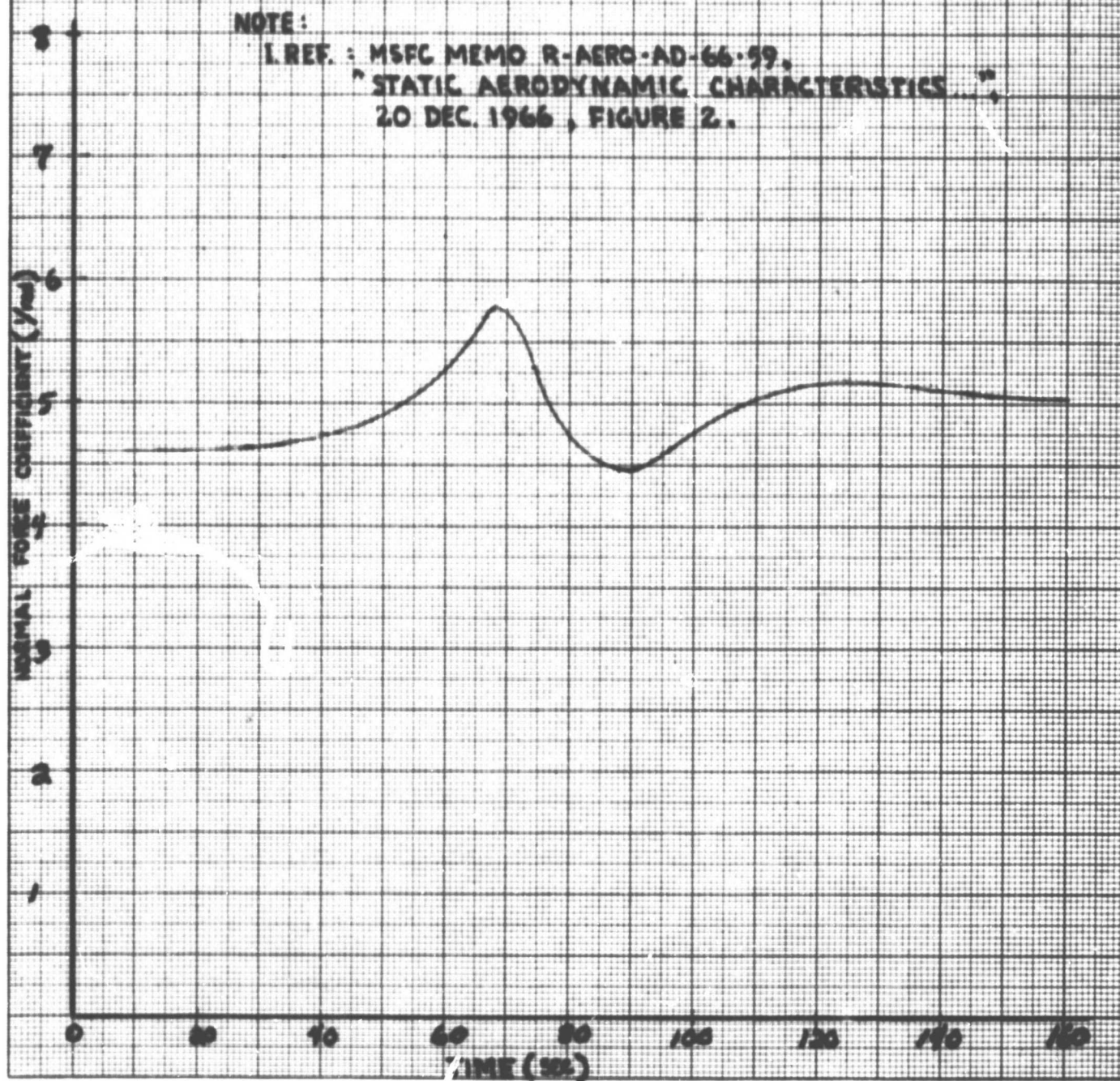


FIGURE 19
NORMAL FORCE GRADIENT (C_{Nz}) vs. FLIGHT TIME

NOTE:

1. REF. : MSFC MEMO R-AERO-AD-66-59,

"STATIC AERODYNAMIC CHARACTERISTICS",
 20 DEC. 1966, FIGURE 2.



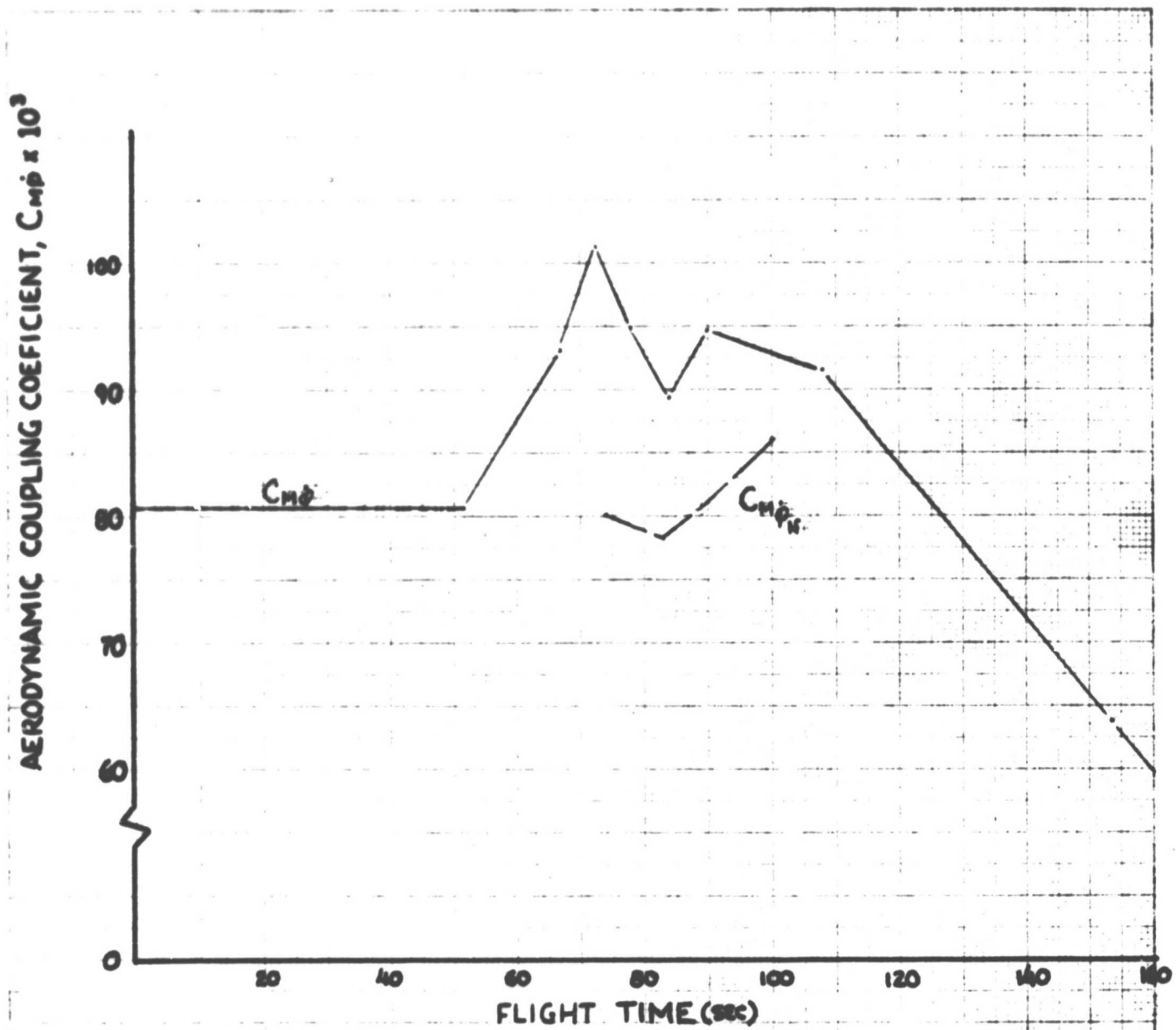
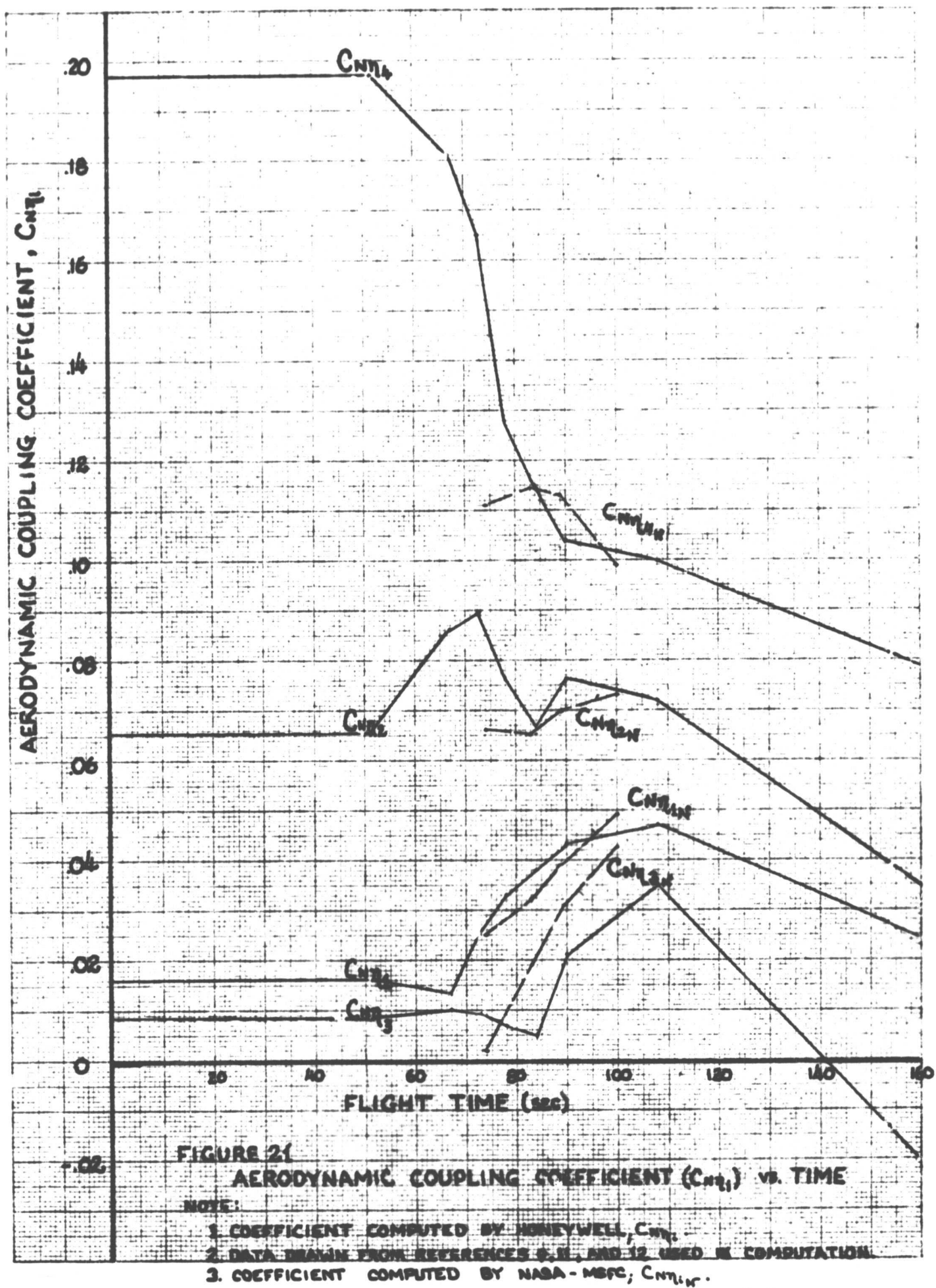


FIGURE 20

AERODYNAMIC COUPLING COEFFICIENT ($C_{m\phi}$) vs. TIME

NOTE :

1. COEFFICIENT COMPUTED BY HONEYWELL, $C_{m\phi}$.
2. DATA DRAWN FROM REFERENCES 9, 11, AND 12 USED IN COMPUTATION.
3. COEFFICIENT COMPUTED BY NASA-MSPC, $C_{m\phi N}$.



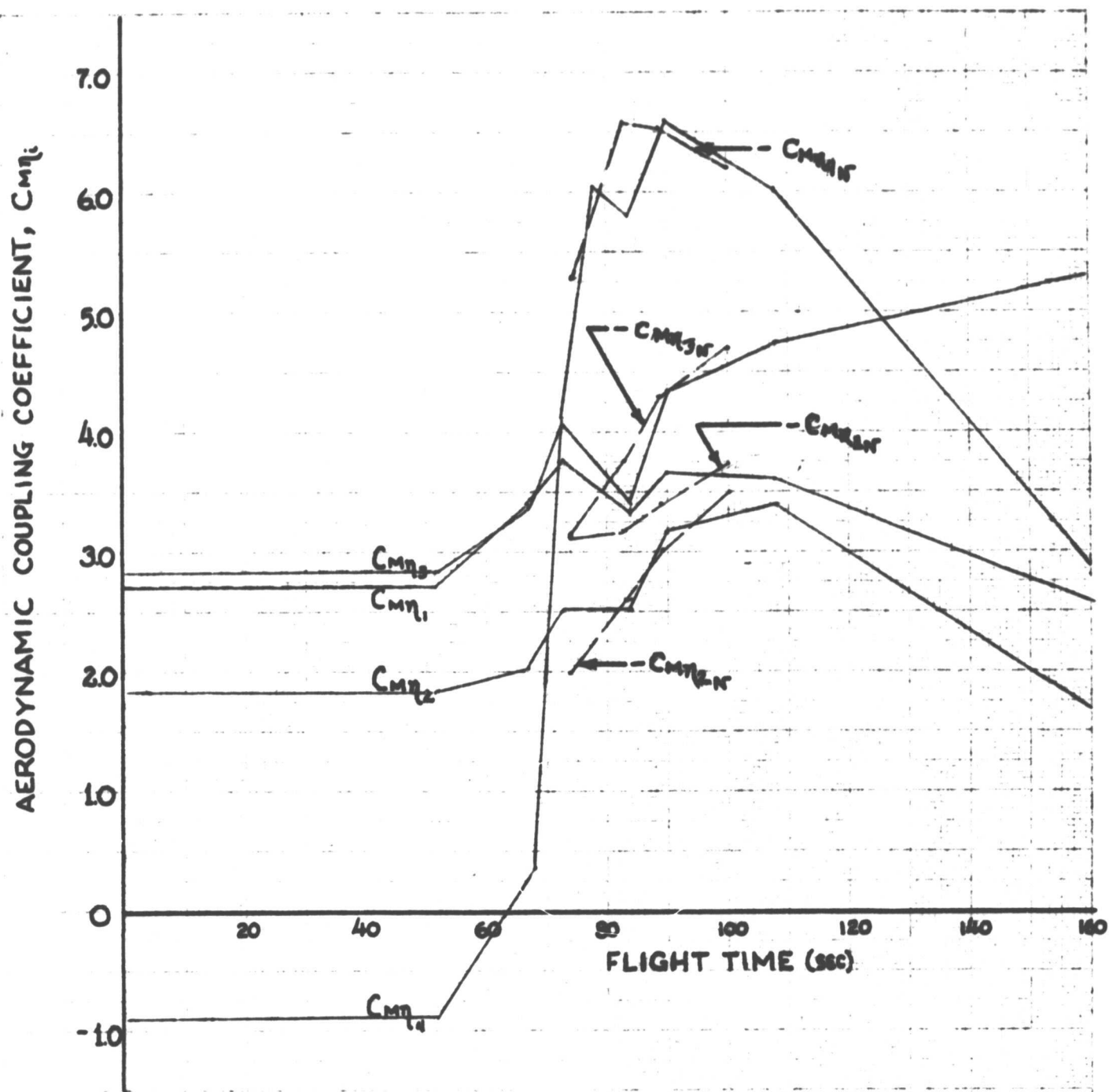


FIGURE 22

AERODYNAMIC COUPLING COEFFICIENT($C_{m\eta_i}$) vs. TIME

NOTE :

1. COEFFICIENT COMPUTED BY HONEYWELL; $C_{m\eta_i}$.
2. DATA DRAWN FROM REFERENCES 9, 11, AND 12 USED IN COMPUTATION.
3. COEFFICIENT COMPUTED BY NASA-MSFC; $C_{m\eta_iH}$.

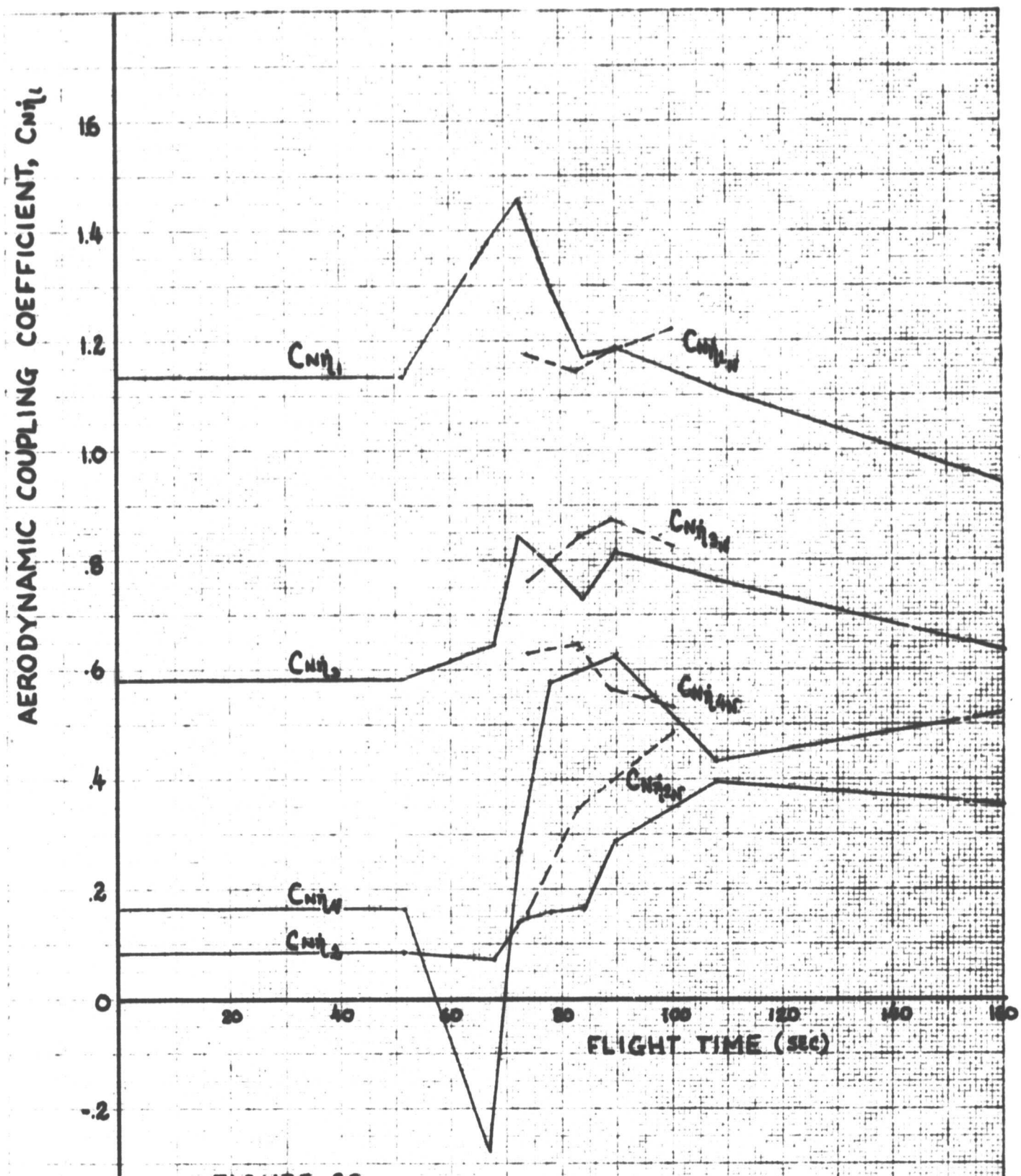


FIGURE 23

AERODYNAMIC COUPLING COEFFICIENT ($Cn\eta_i$) vs. TIME

NOTE:

1. COEFFICIENT COMPUTED BY HONEYWELL, $Cn\eta_{1H}$.
2. DATA DRAWN FROM REFERENCES 9, 11, AND 12 USED IN COMPUTATION.
3. COEFFICIENT COMPUTED BY NASA-MSC, $Cn\eta_{1N}$.

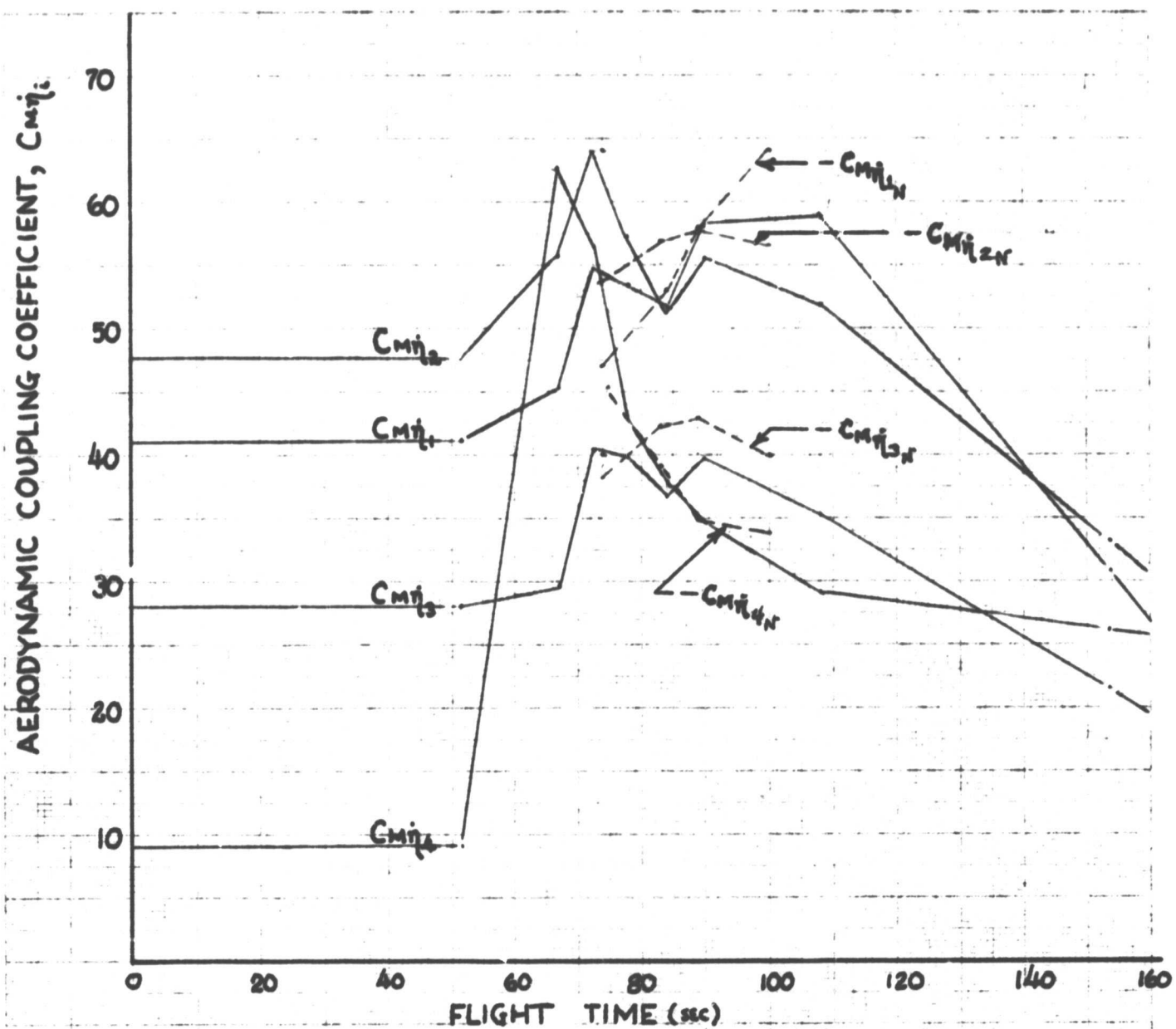
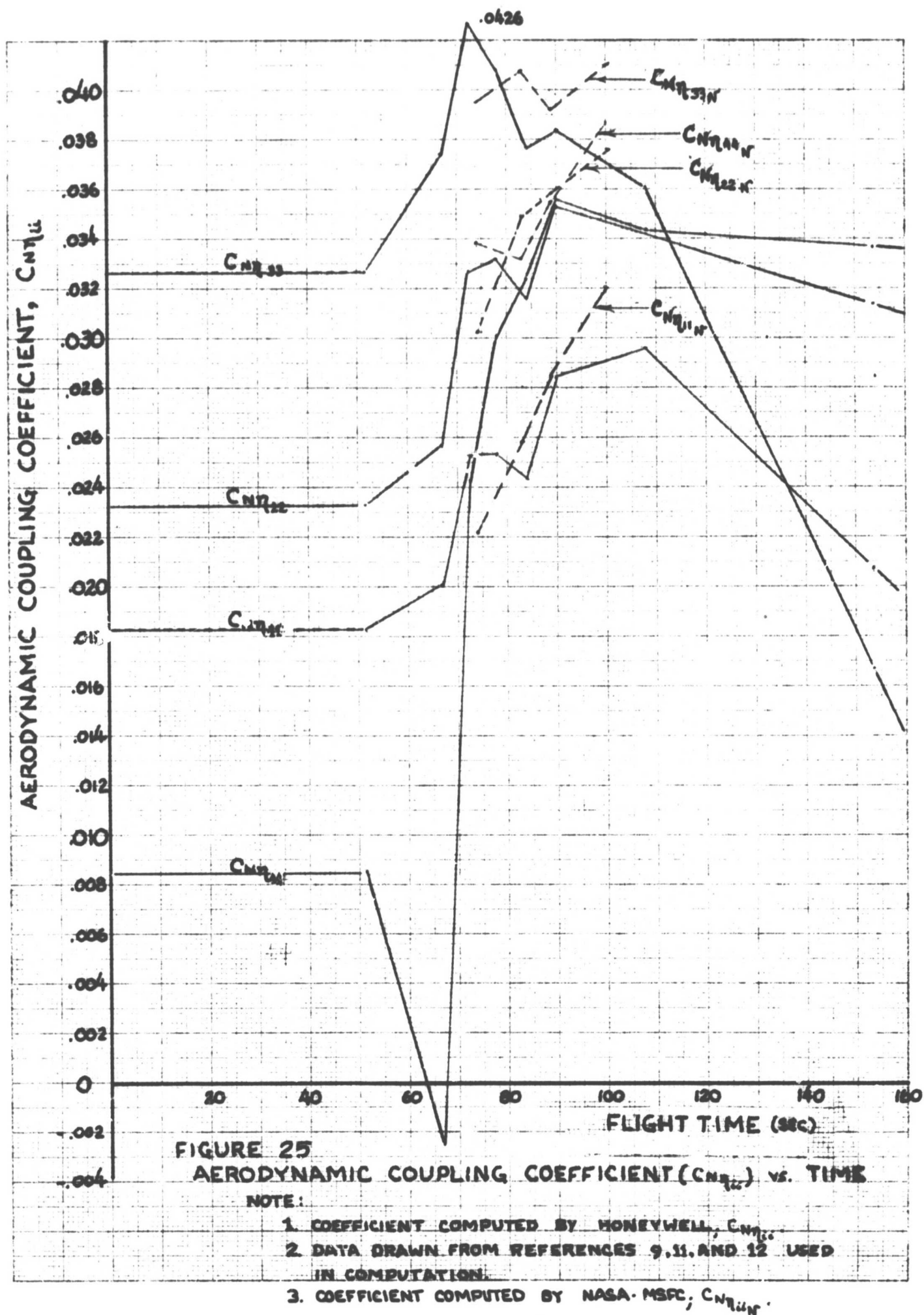


FIGURE 24

AERODYNAMIC COUPLING COEFFICIENT ($Cm\eta_i$) vs. TIME

NOTE :

1. COEFFICIENT COMPUTED BY HONEYWELL; $Cm\eta_i$.
2. DATA DRAWN FROM REFERENCES 9, 11, AND 12 USED IN COMPUTATION.
3. COEFFICIENT COMPUTED BY NASA-MSFC; $Cm\eta_{iN}$.



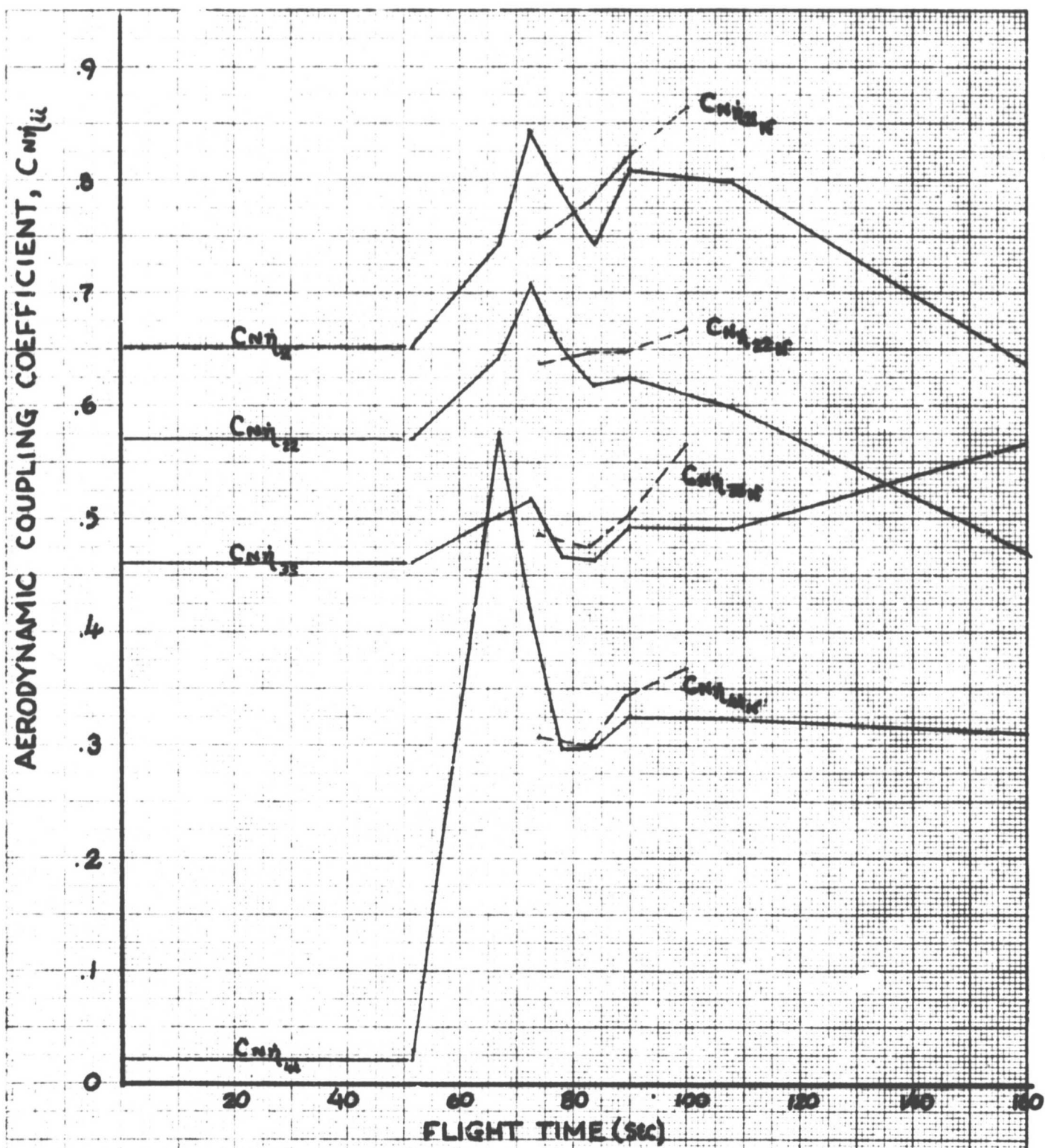


FIGURE 26

AERODYNAMIC COUPLING COEFFICIENT ($C_{n\dot{\eta}_u}$) vs TIME

NOTE:

1. COEFFICIENT COMPUTED BY HONEYWELL, $C_{n\dot{\eta}_u}$.
2. DATA DRAWN FROM REFERENCES 9, 11, AND 12 USED IN COMPUTATION.
3. COEFFICIENT COMPUTED BY NASA-MSPC, $C_{n\dot{\eta}_u}$.

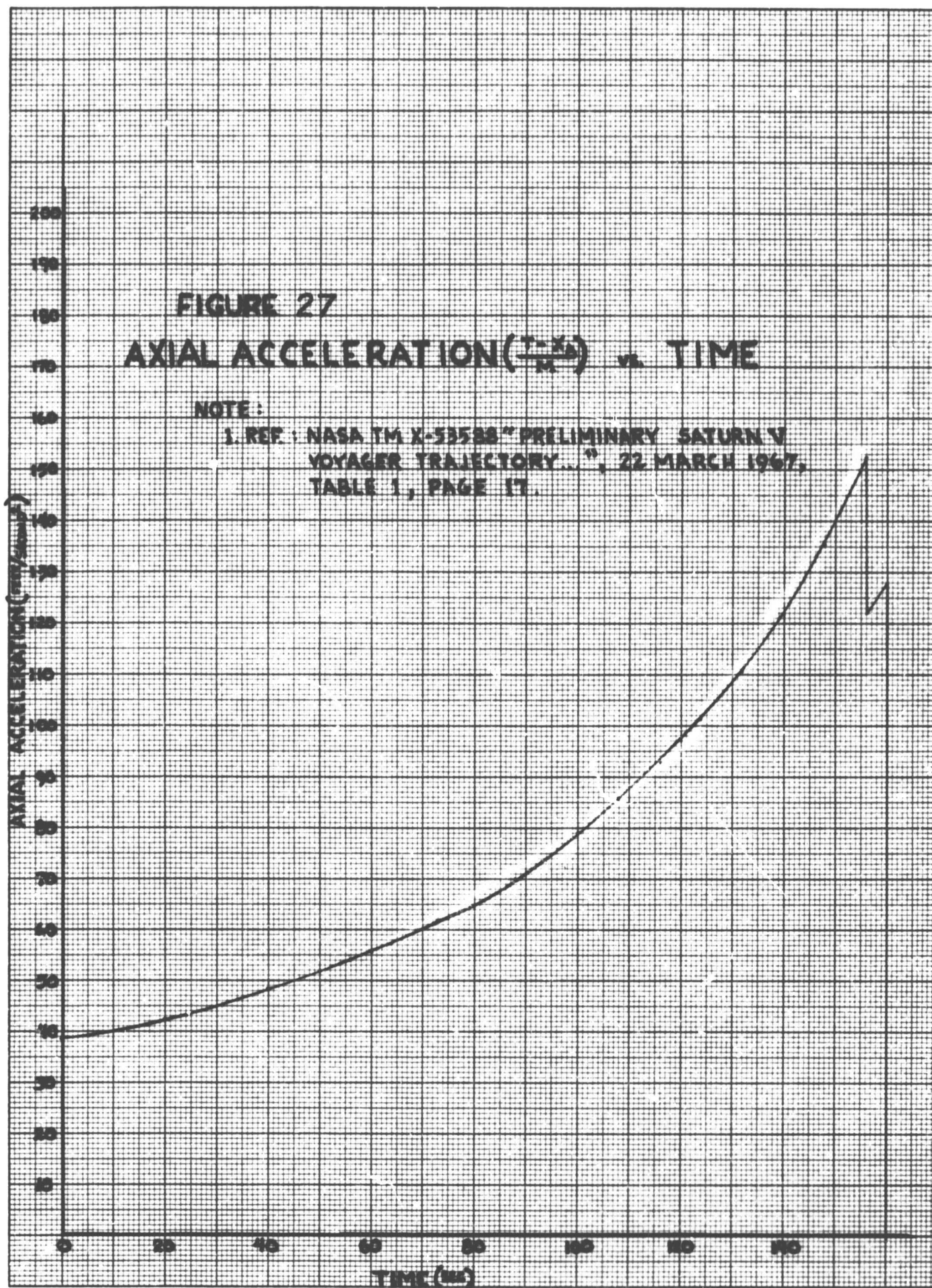


FIGURE 2B
TOTAL THRUST of CONTROLLABLE ENGINES (R)
vs TIME

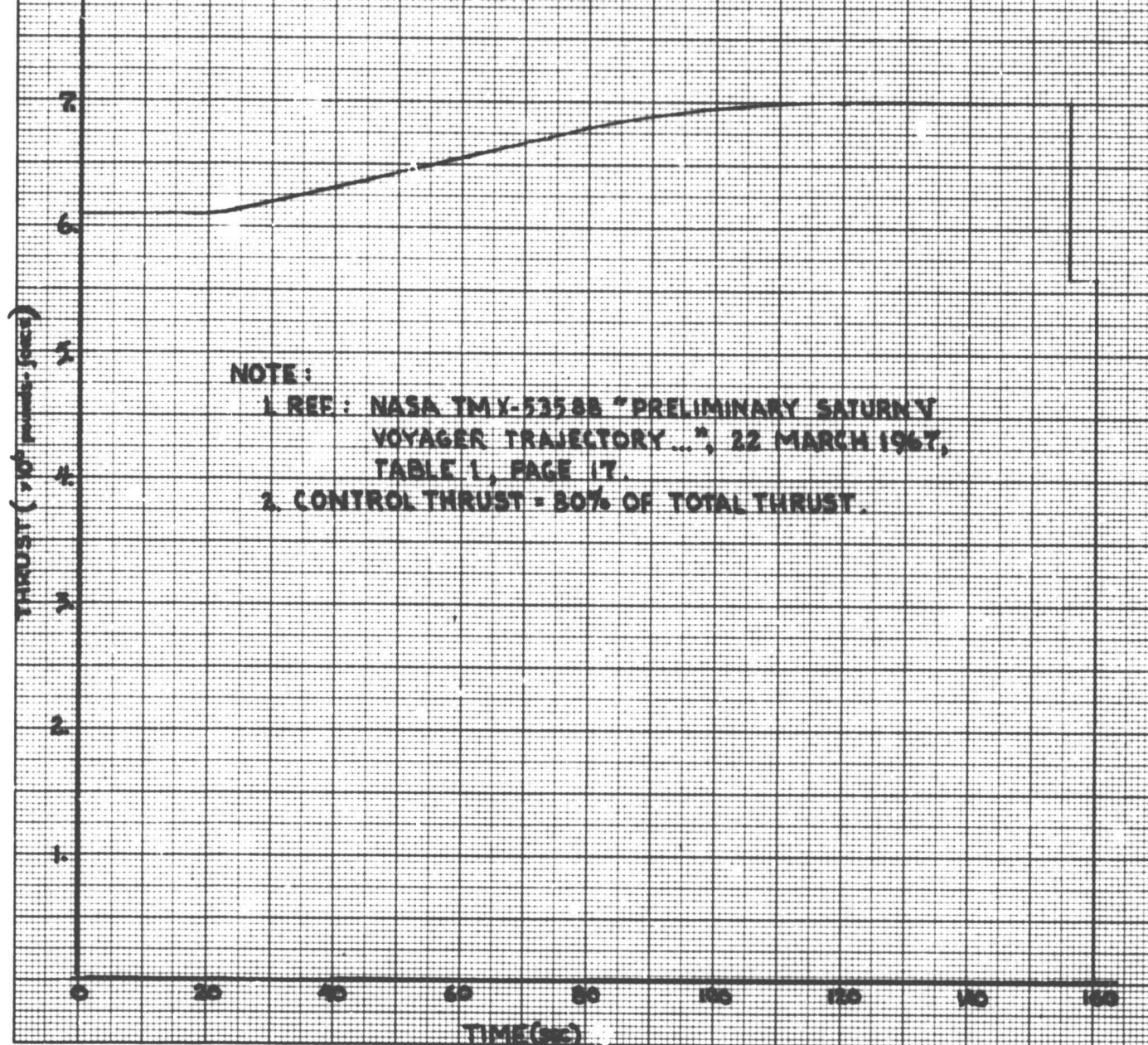
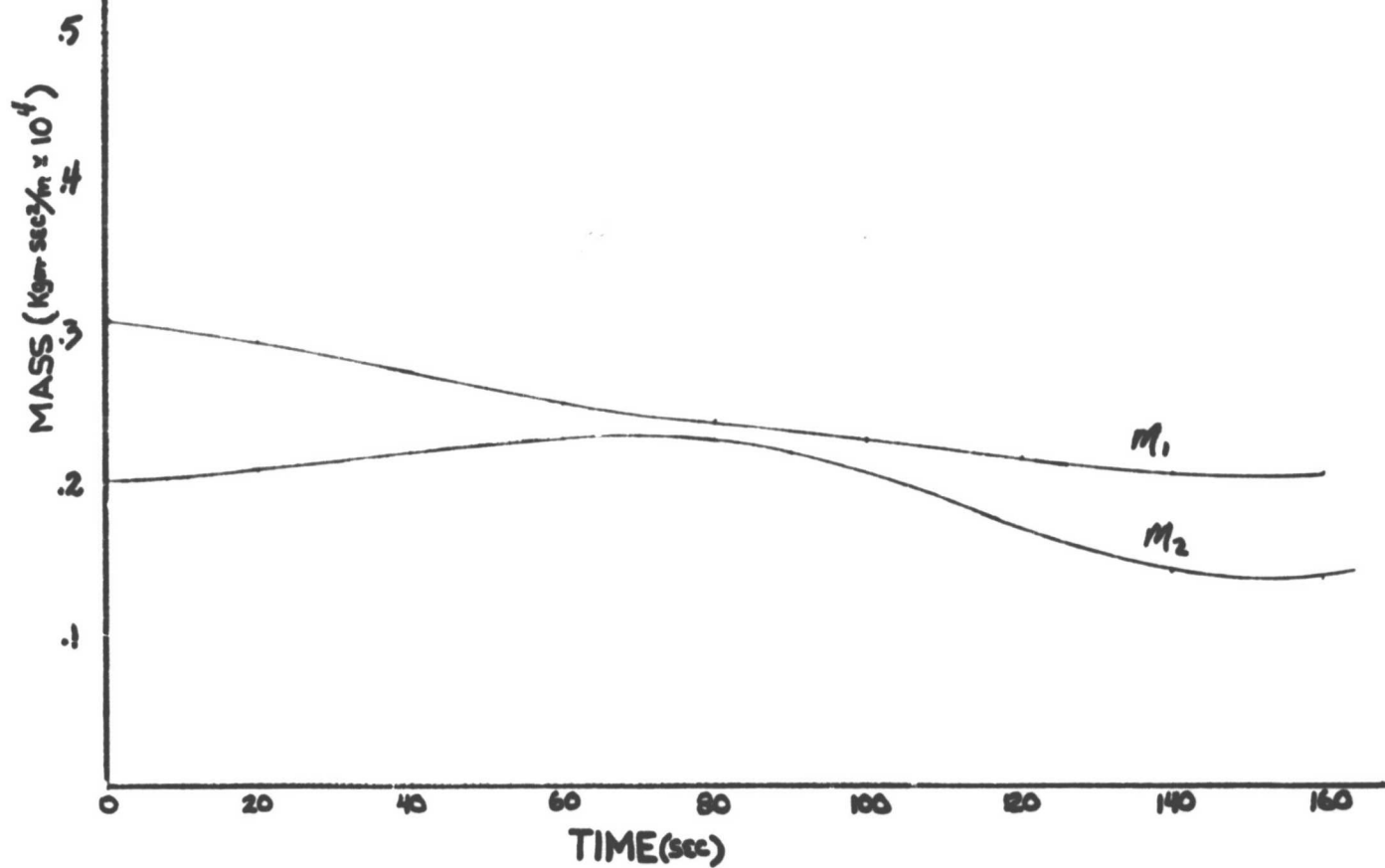


FIGURE 29
GENERALIZED MASS of the 1st & 2nd BENDING MODES (m_1, m_2)
vs. TIME

NOTE:

1. REF.: MSFC MEMO R-AERO-DD-16-67, "PRELIMINARY
VIBRATION ANALYSIS OF...", 3 APRIL 1967, TABLE 1.



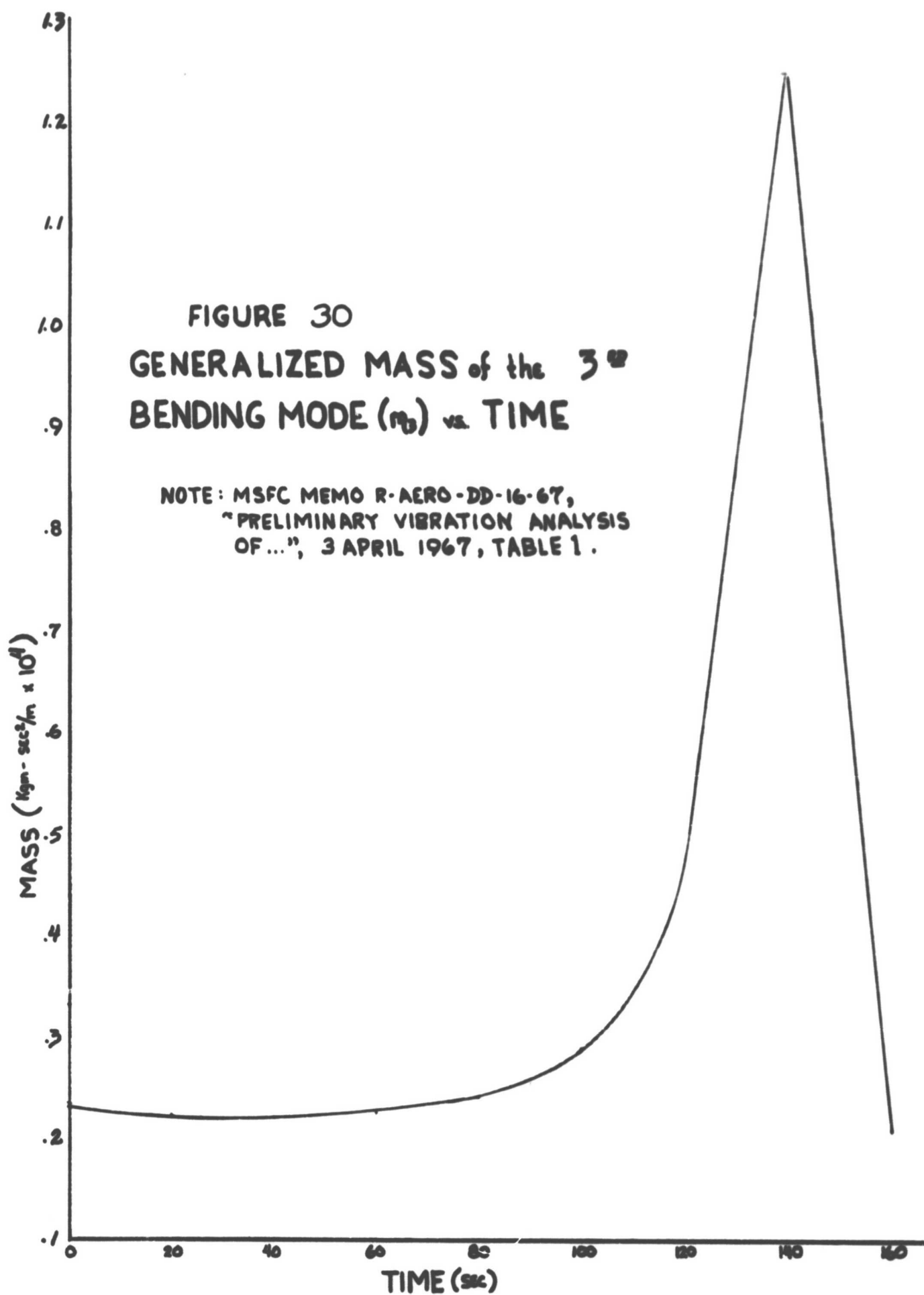
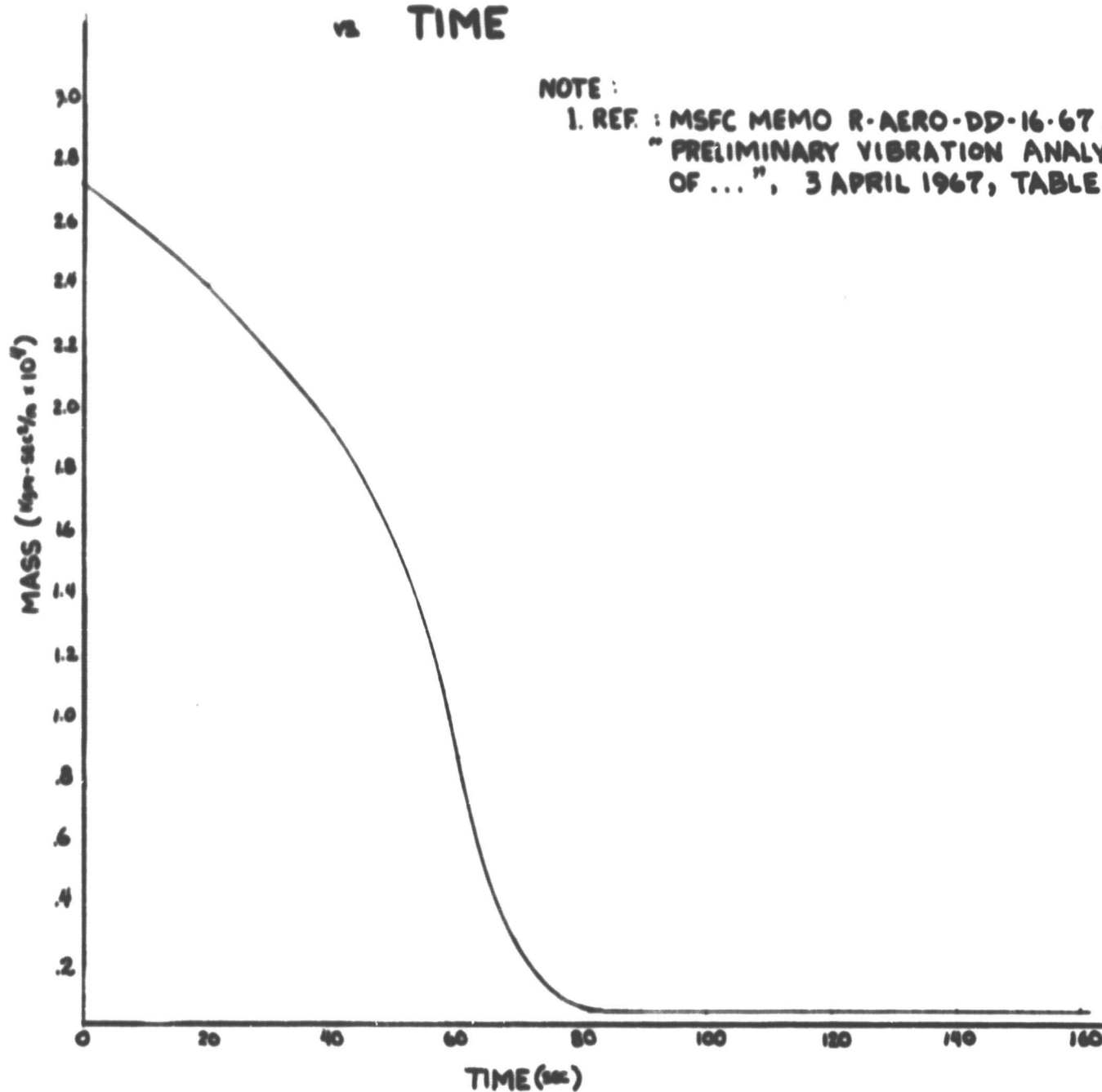
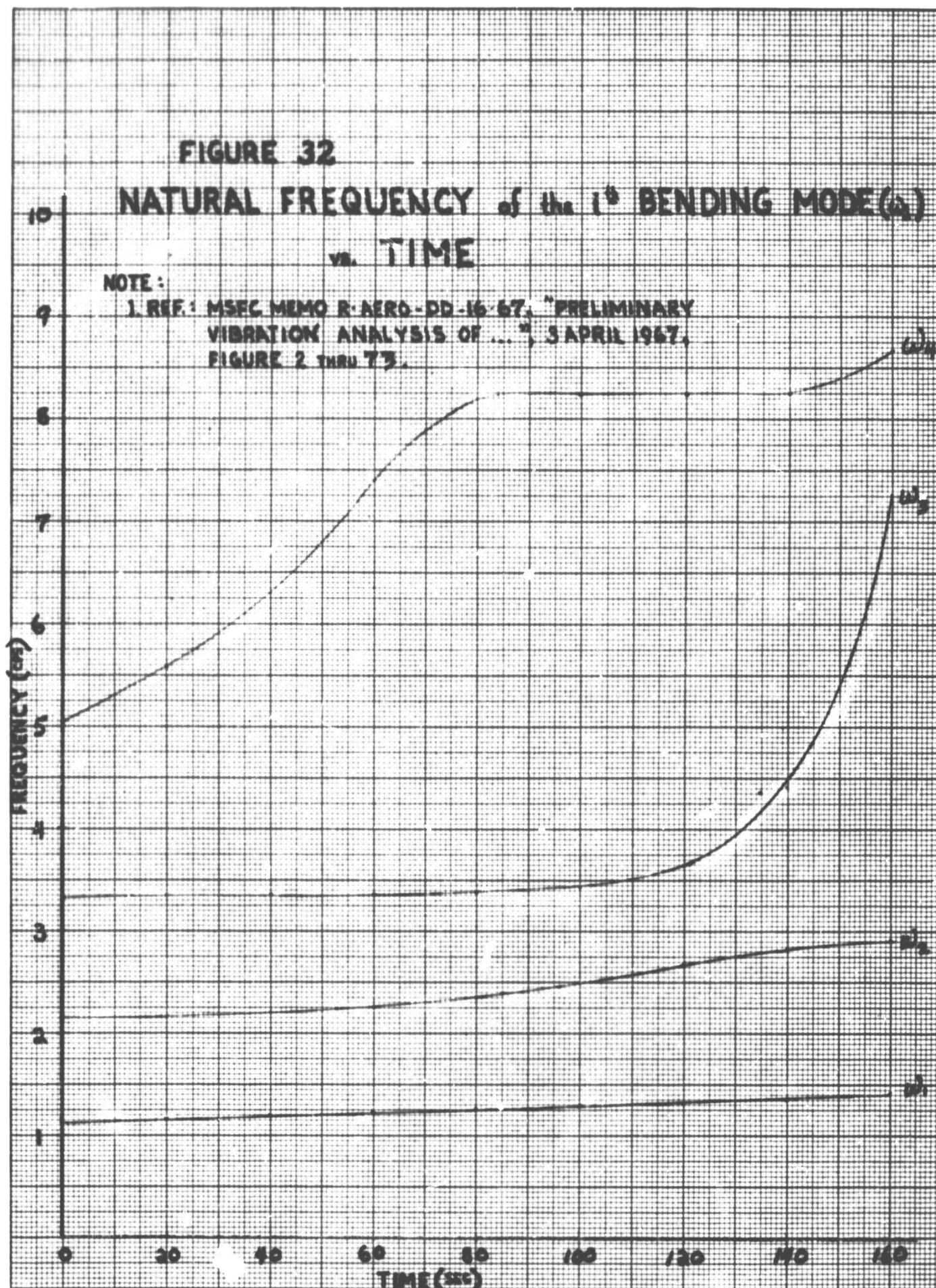
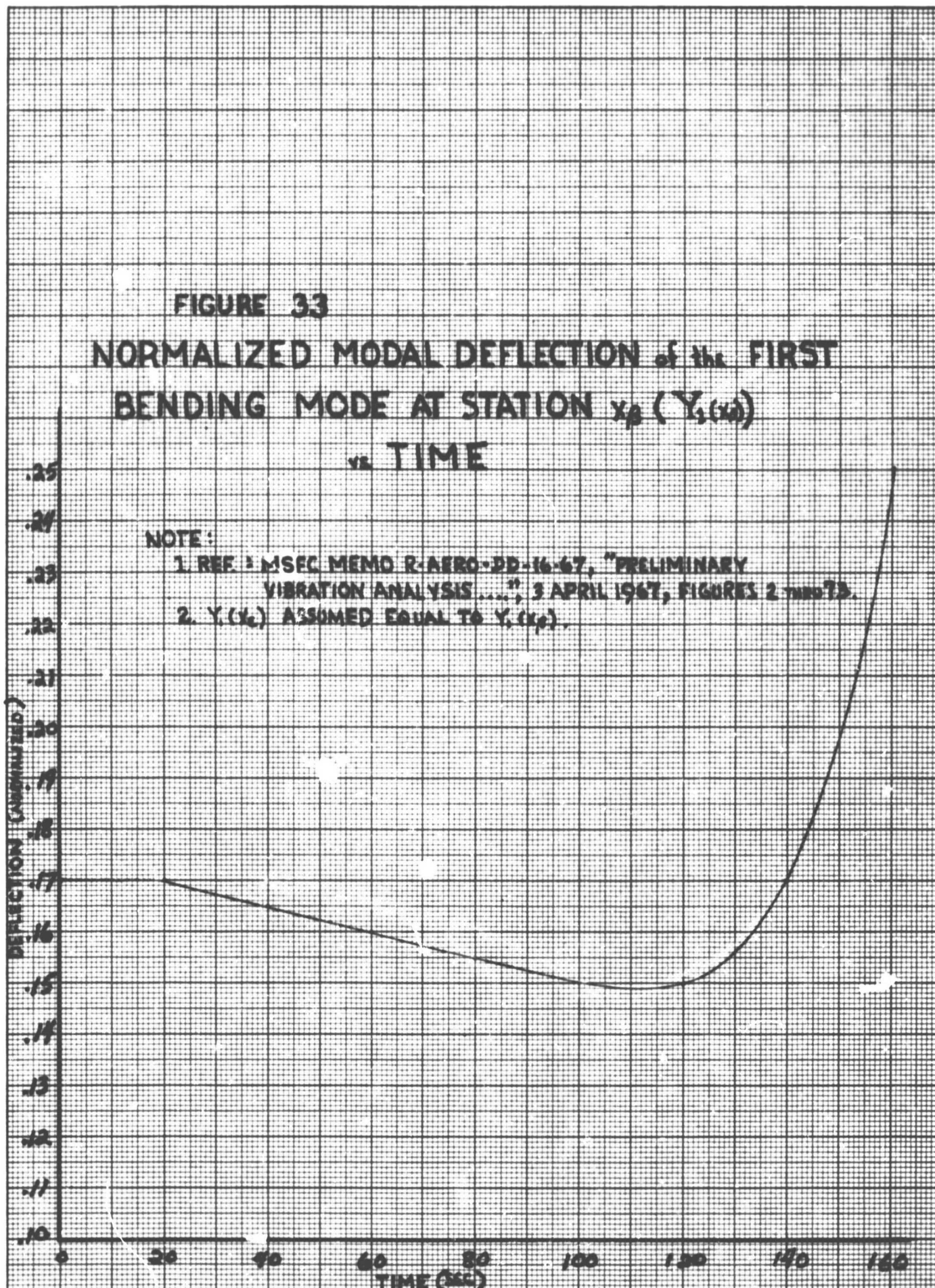


FIGURE 31
GENERALIZED MASS of the 4th BENDING MODE (m)
vs TIME







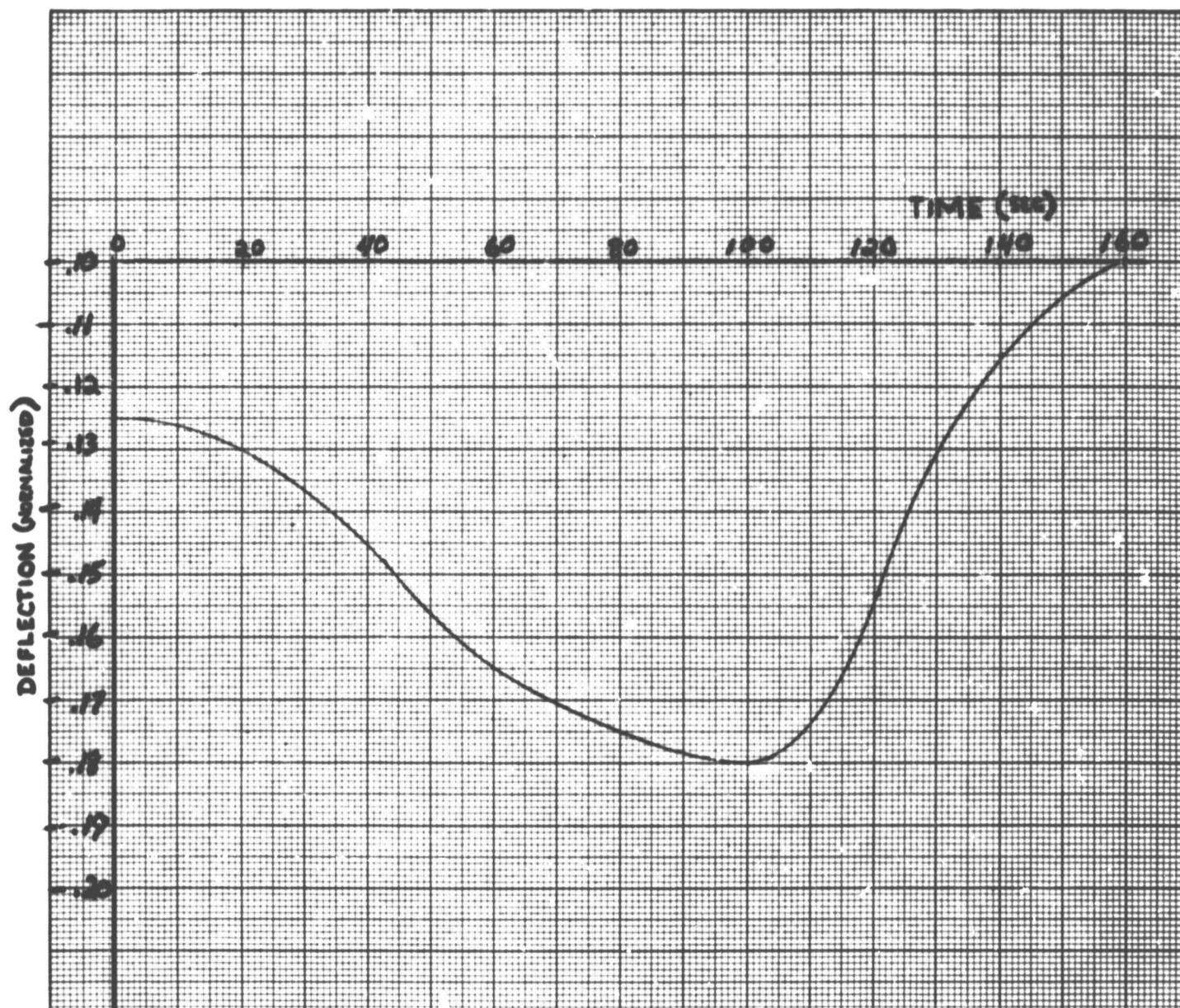
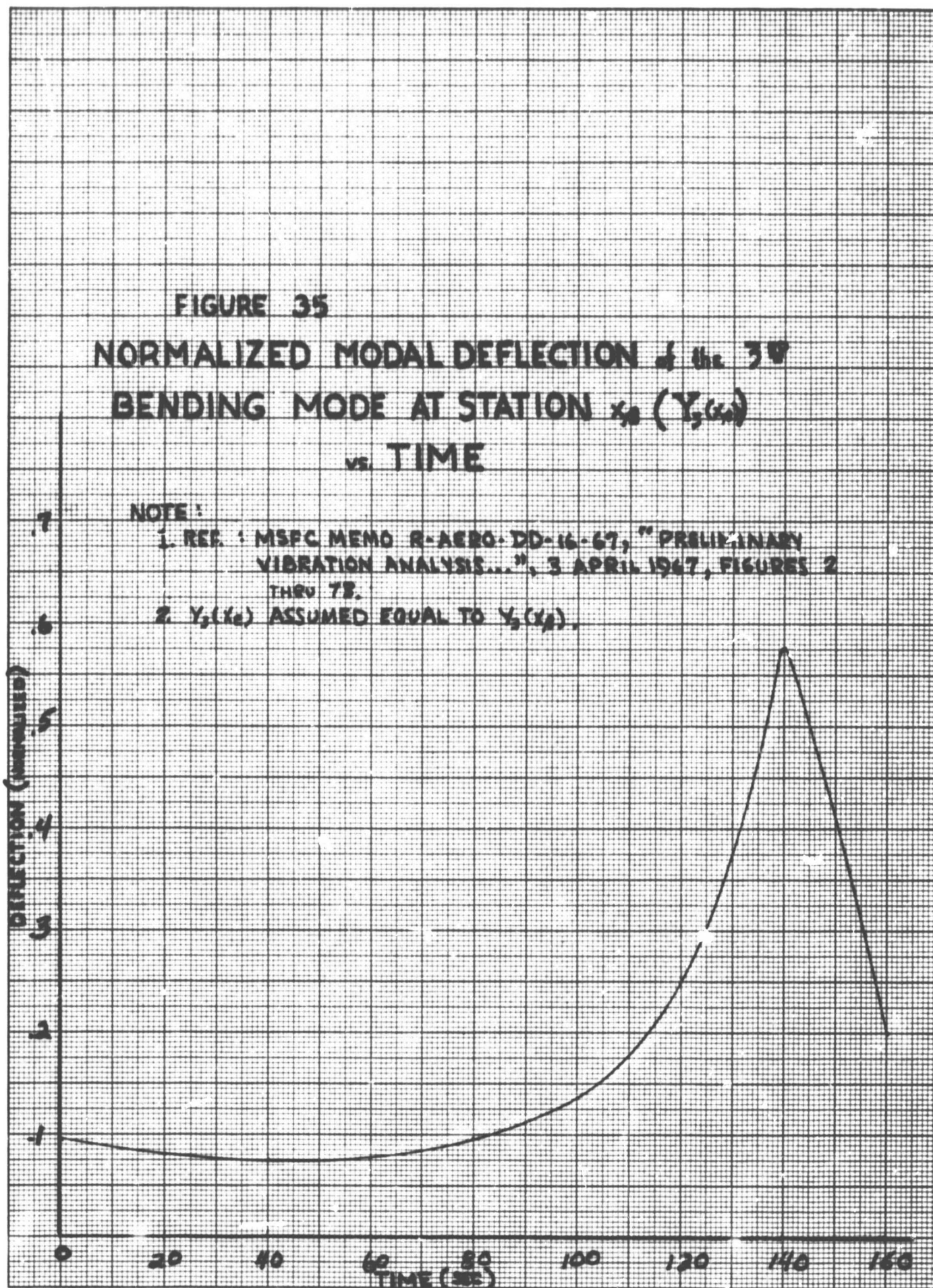
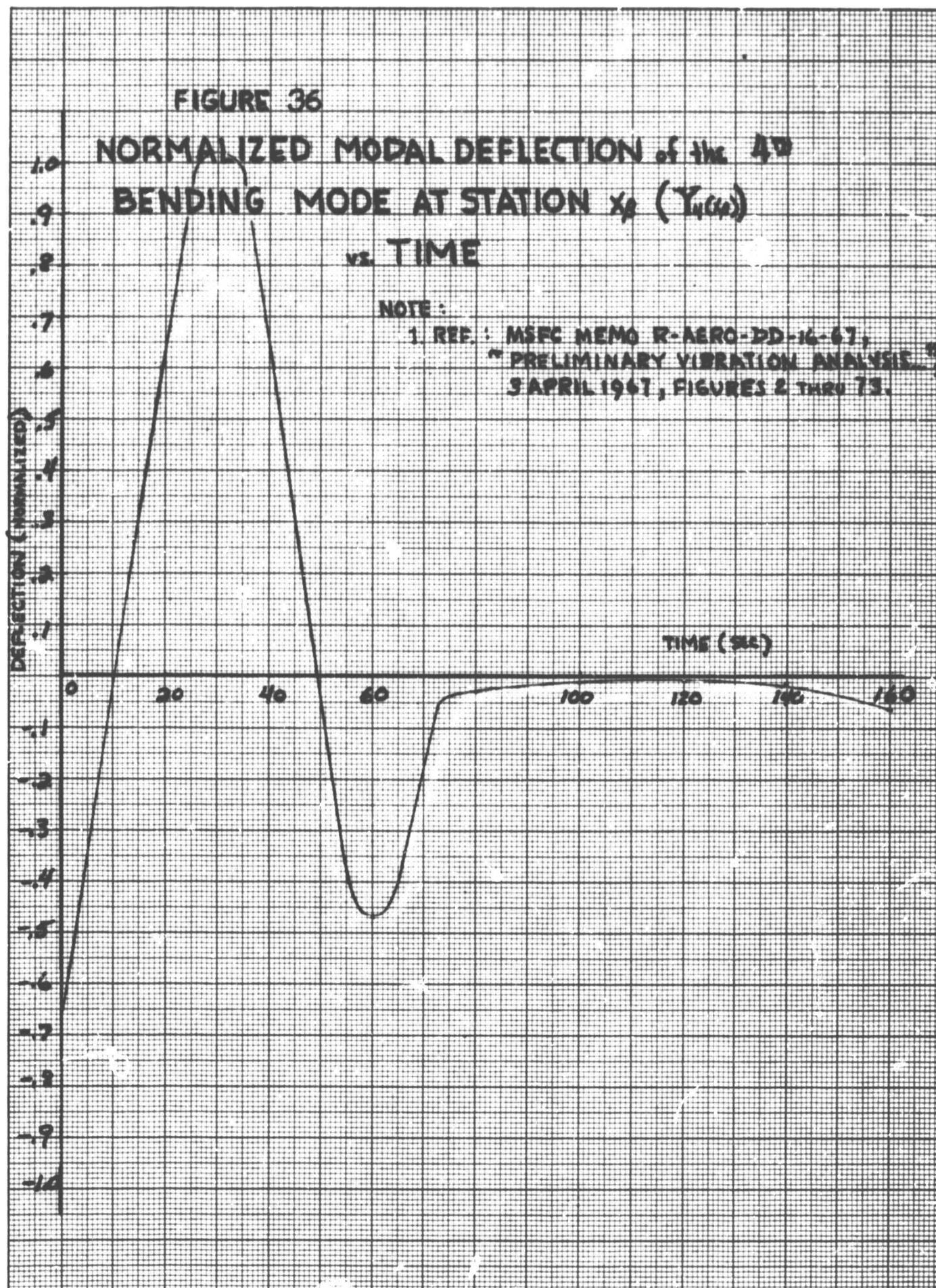


FIGURE 34
 NORMALIZED MODAL DEFLECTION of the 2nd
 BENDING MODE AT STATION x_2 ($Y_2(x_2)$)
 vs TIME

NOTE:

1. REF. : MSFC MEMO X-AERO-DD-16-67, "PRELIMINARY VIBRATION ANALYSIS...", 3 APRIL 1967, FIGURES 2 thru 13.
2. $Y_2(x_2)$ ASSUMED EQUAL TO $Y_1(x_2)$.





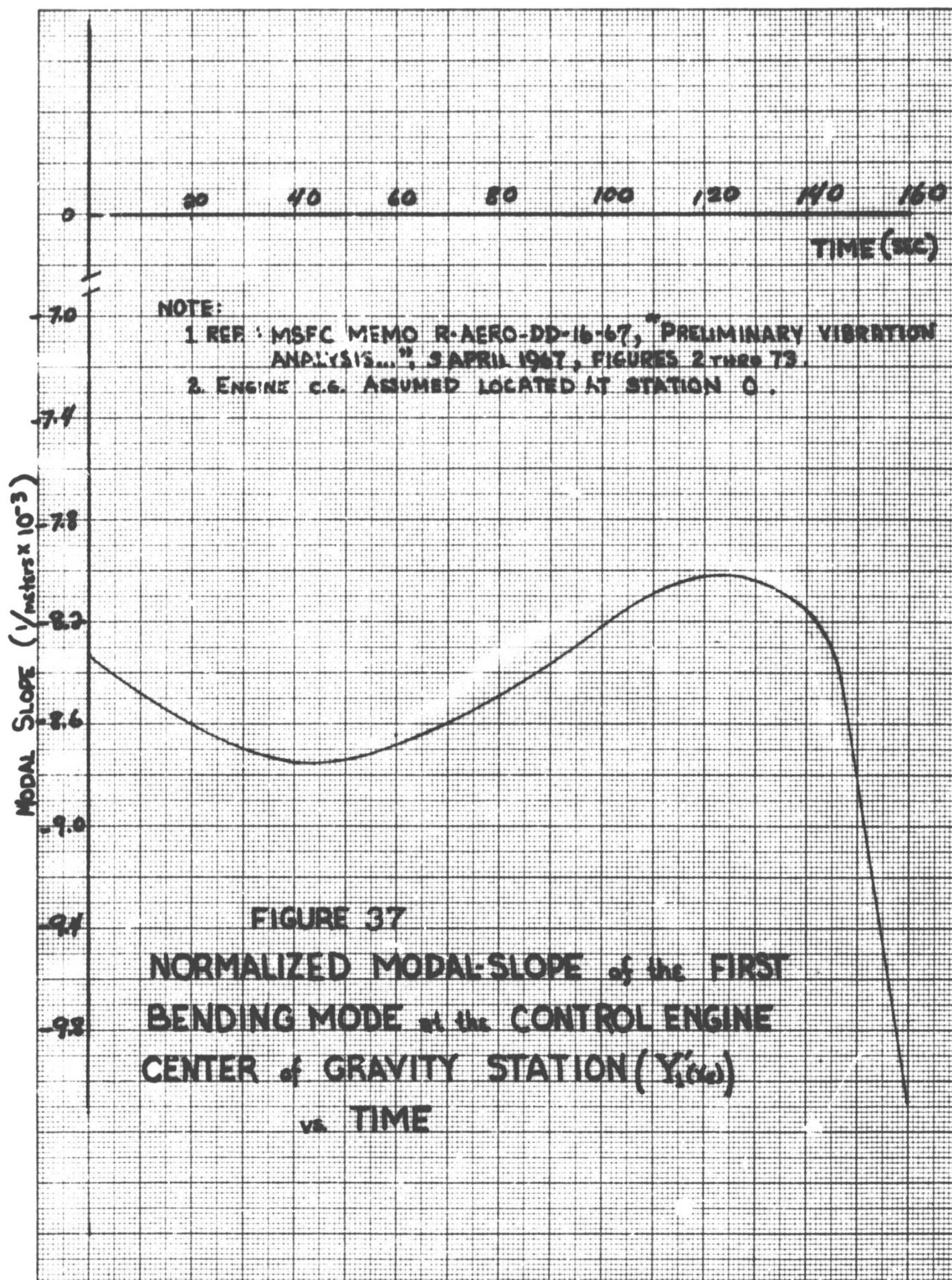
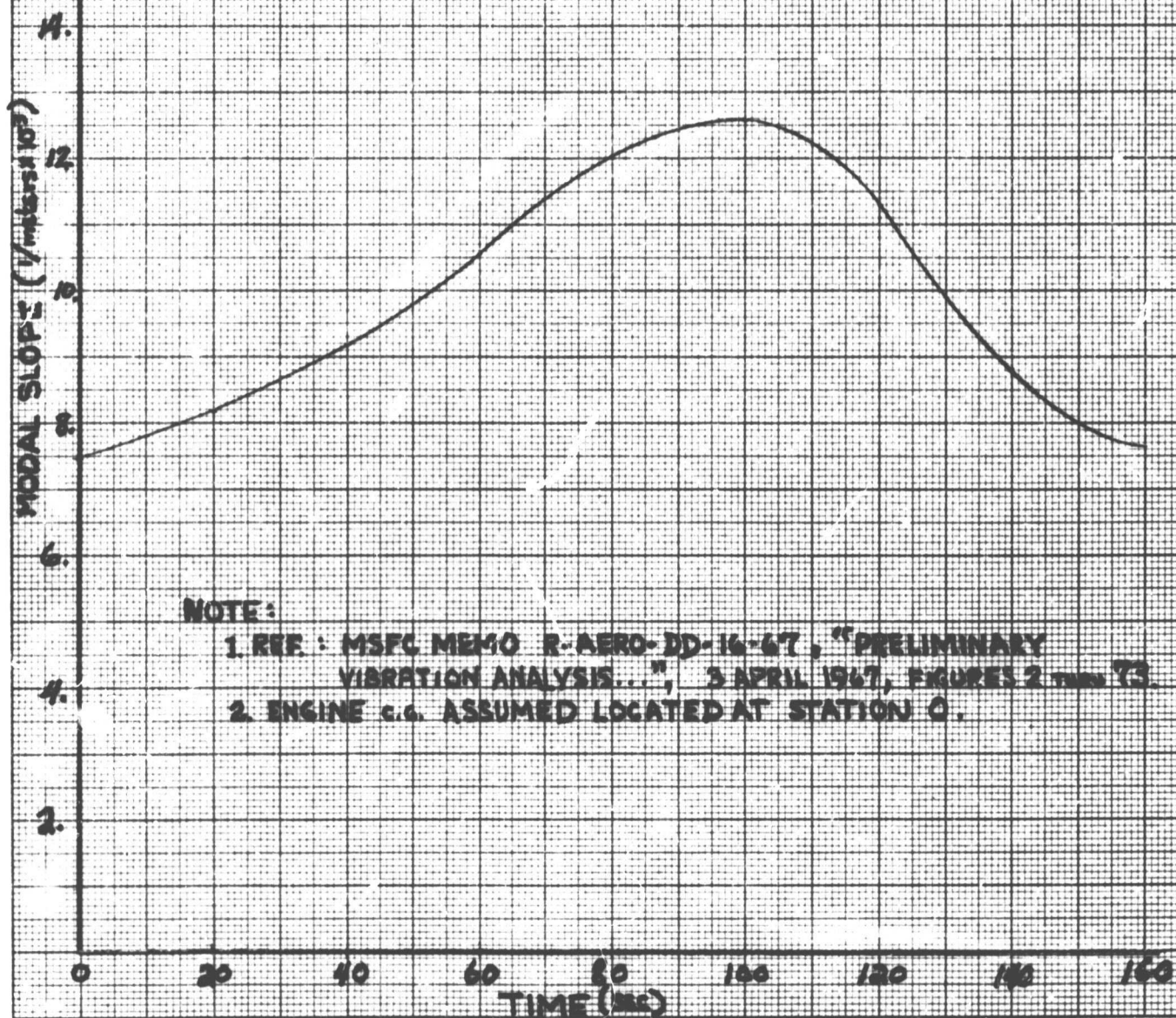
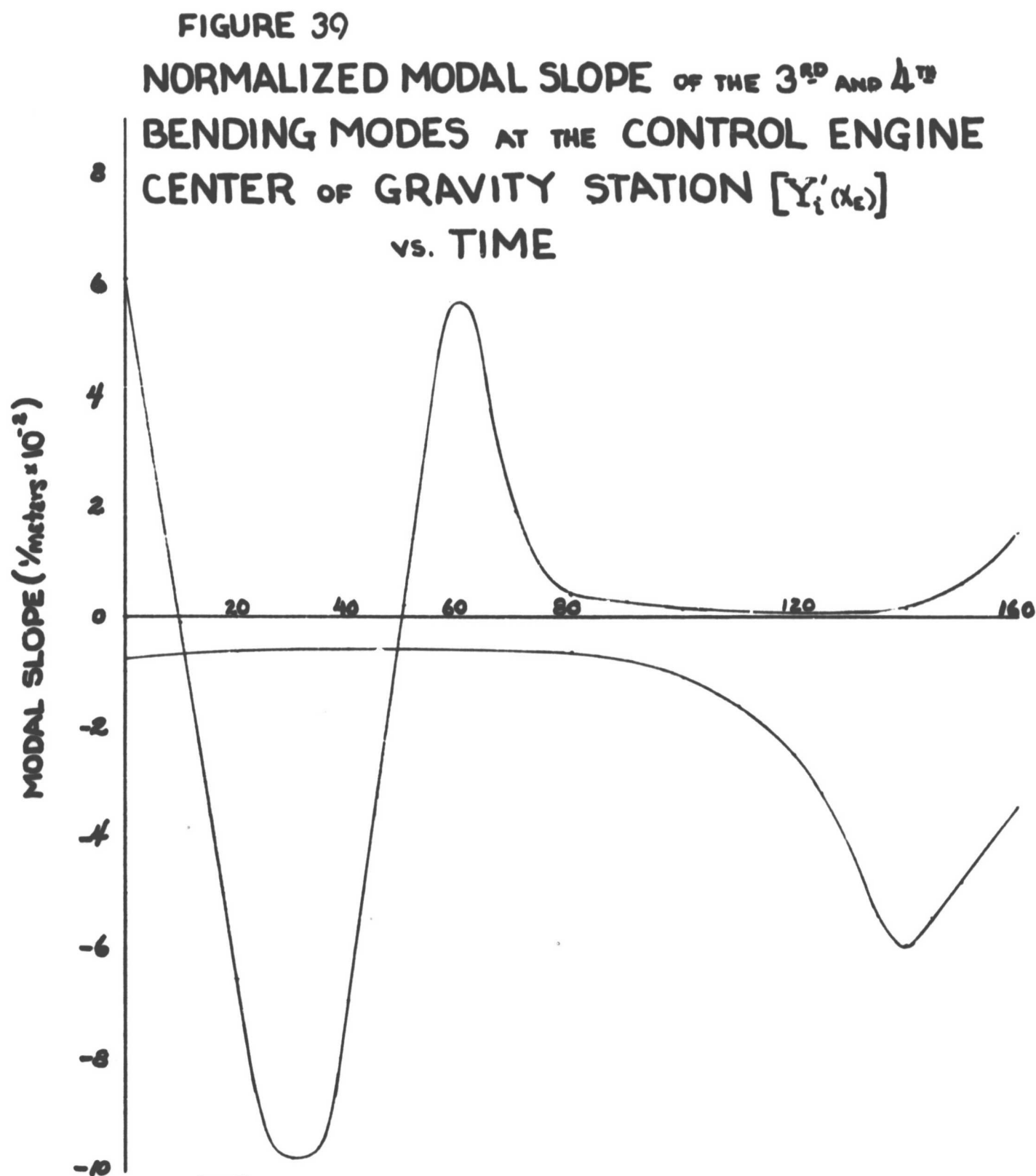


FIGURE 38
 NORMALIZED MODAL-SLOPE of the 2ND
 BENDING MODE at the CONTROL ENGINE
 CENTER of GRAVITY STATION ($Y_2'(t)$)
 vs TIME





NOTE :

1. REF. : MSFC MEMO R-AERO-DD-16-67, "PRELIMINARY VIBRATION ANALYSIS...", 3 APRIL 1967, FIGURES 2 THRU 73.
2. ENGINE C.G. ASSUMED LOCATED AT STATION 0.

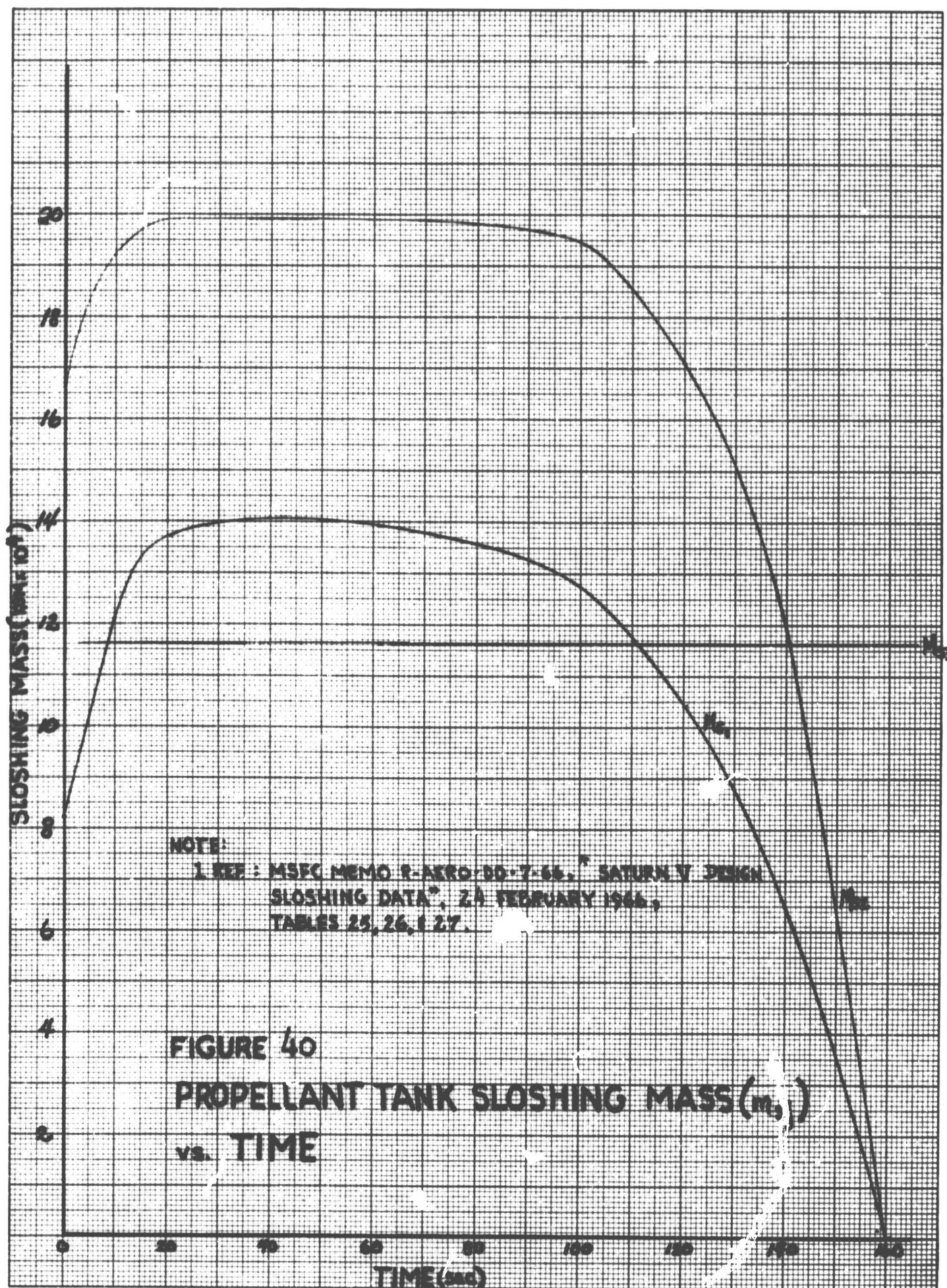


FIGURE 41
 $\dot{X}_y$ PROPELLANT TANK SLOSHING MASS
 STATION (X_y) vs TIME

NOTE:

1. REF. : MSFC MEMO R. AERO-DD-7-66, "SATURN V
 DESIGN SLOSHING DATA", 24 FEBRUARY 1966

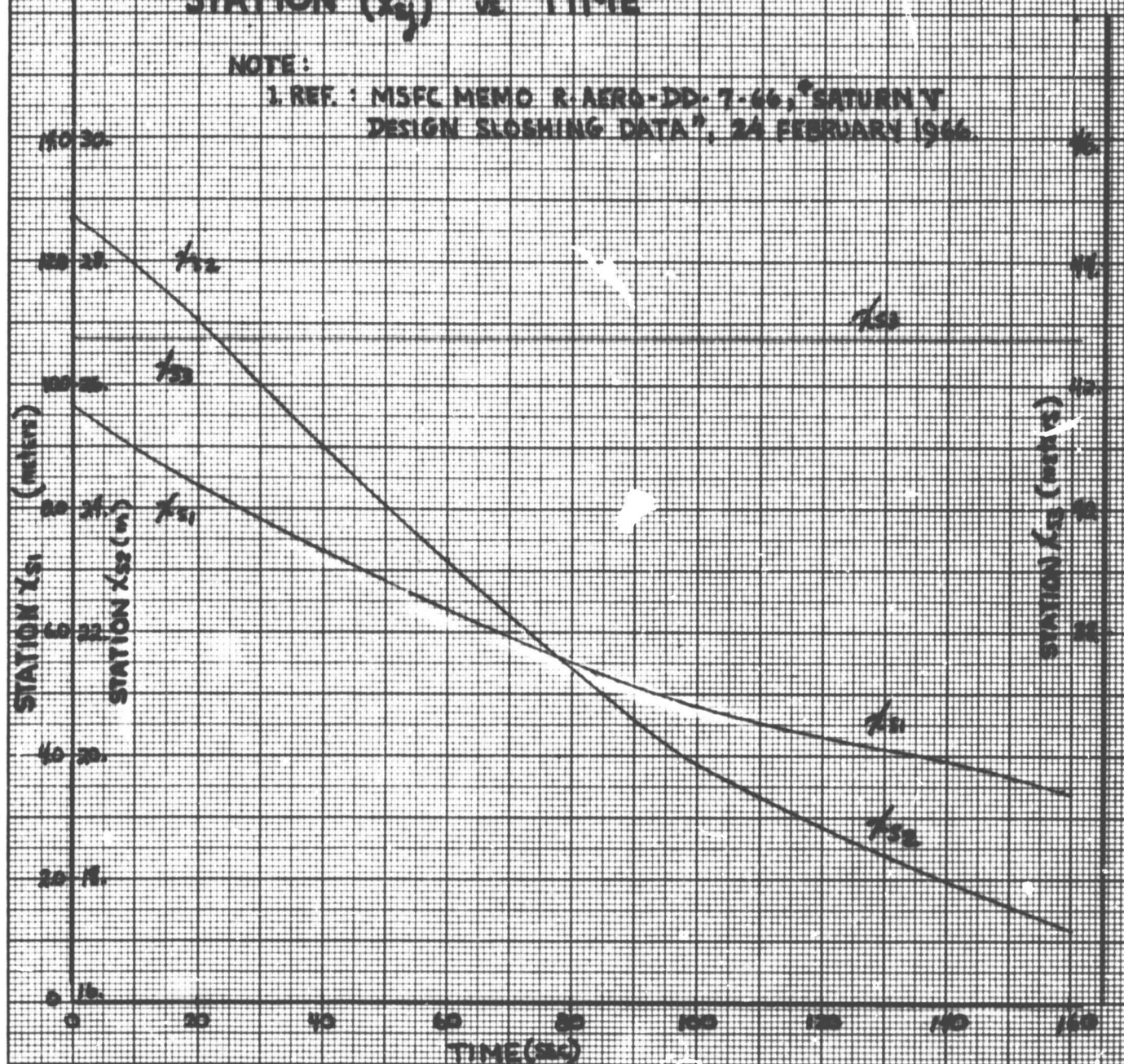


FIGURE 42
EQUIVALENT VISCOUS DAMPING FACTOR of the j^o
PROPELLANT TANK SLOSHING MASS (Z_o)
vs. TIME

NOTE:

- 1. REF. 1: VOYAGER TELCON #1, L. DEDINGER (Honeywell) to J. REDUS (NASA), 7/18/67
- 2. HONEYWELL REPORT 12003-SV6, "A LOAD RELIEF CONTROL SYSTEM FOR ...", 10 JANUARY 1967, FIGURE B.1 - SATURN V/VOYAGER SLOSH DAMPING.

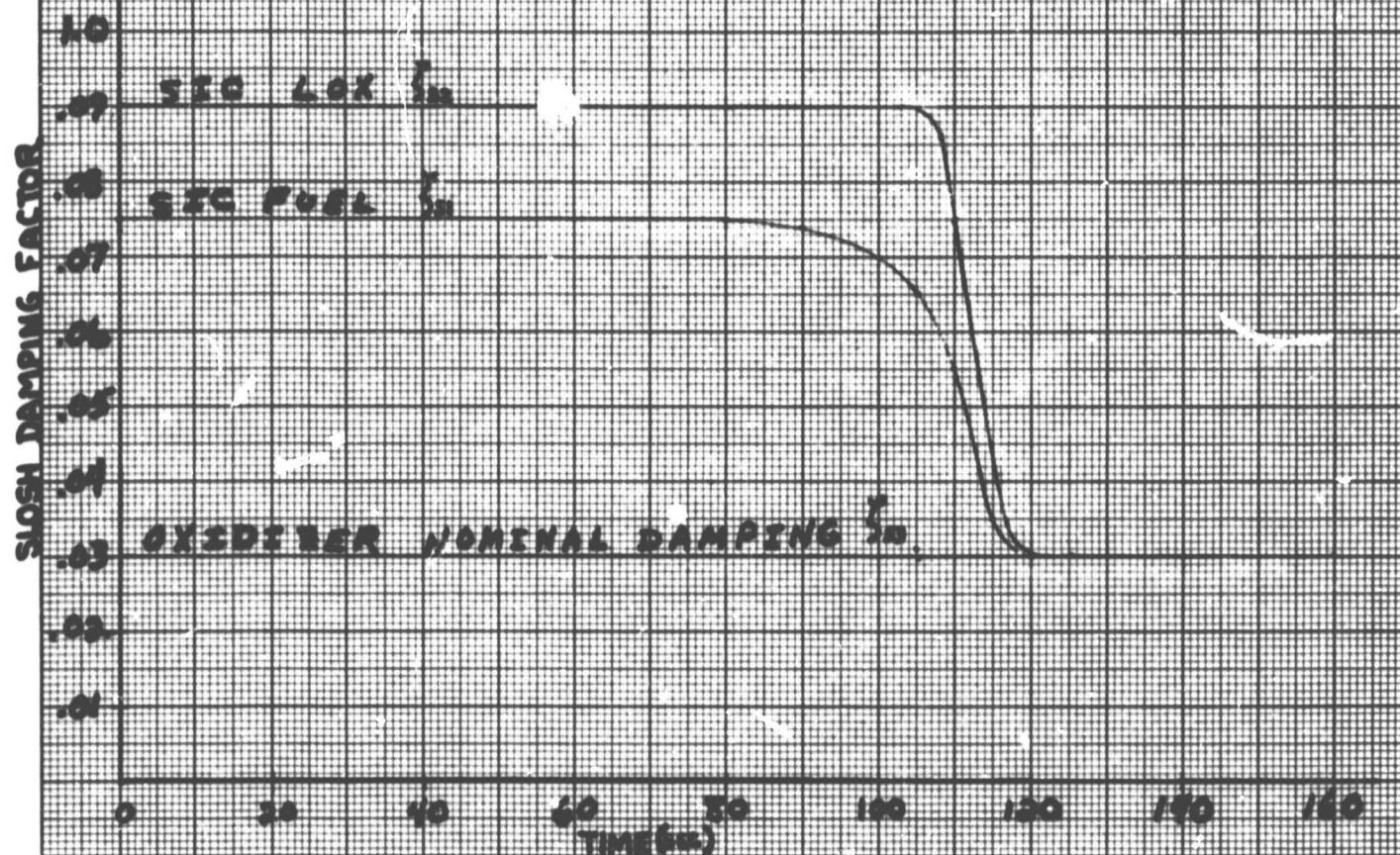


FIGURE 43
NATURAL FREQUENCY of the 1st & 2nd PROPELLANT TANK
SLOSHING (ω_j) vs. TIME

NOTE:

1. REF. : MSFC MEMO R-AERO-DD-7-66, "SATURN V
 DESIGN SLOSHING DATA", 24 FEBRUARY 1966,
 TABLES 25, 26.

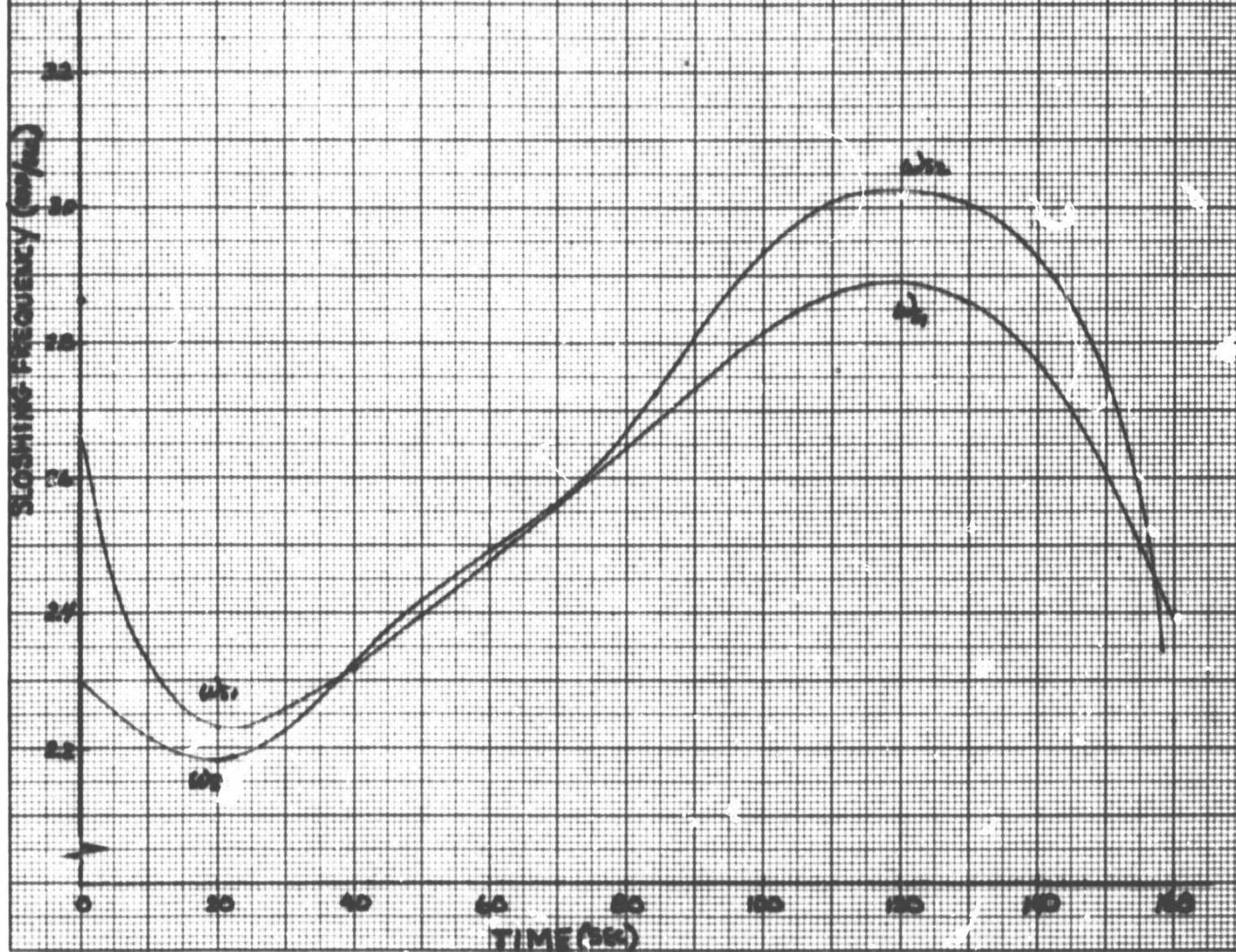
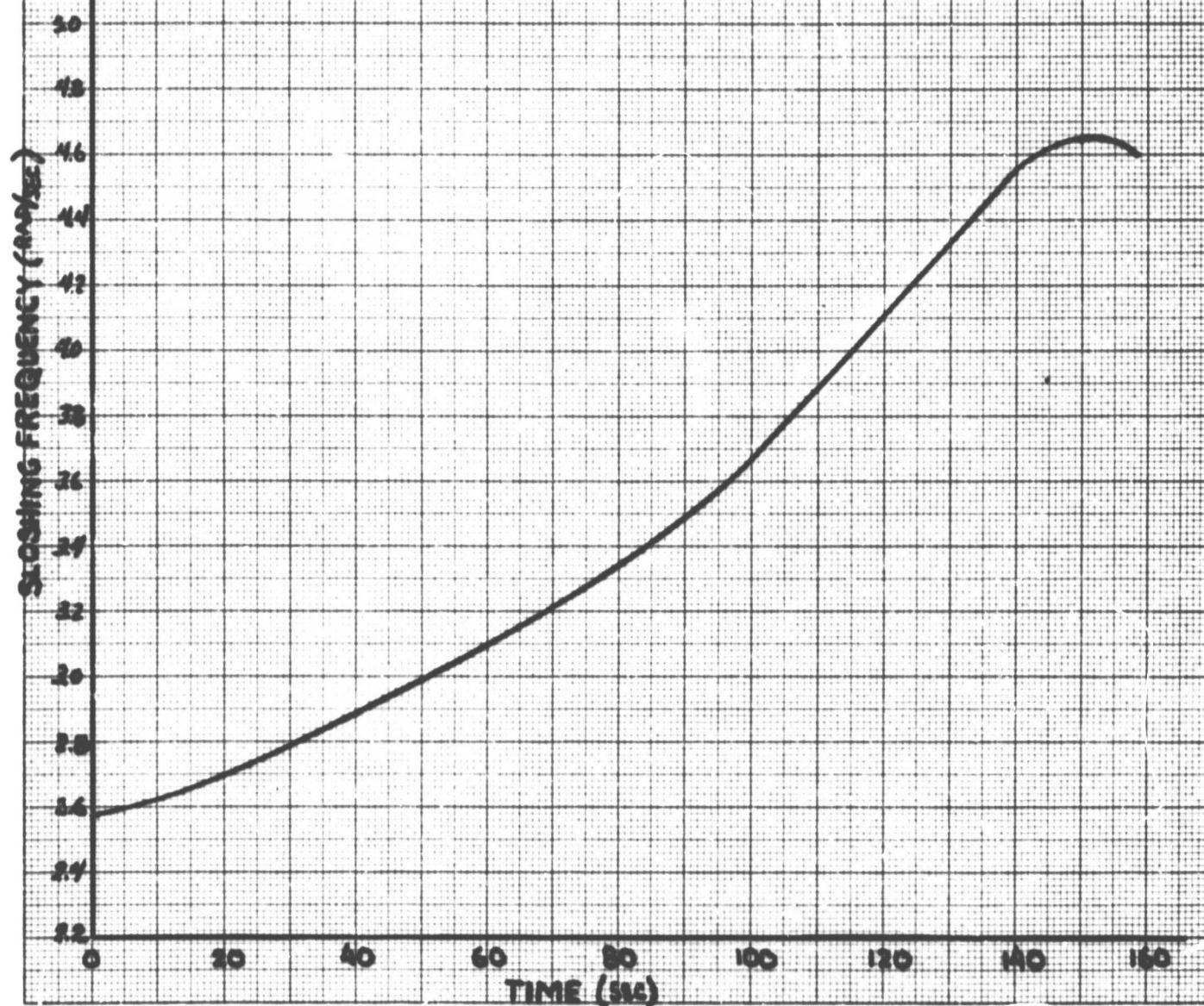
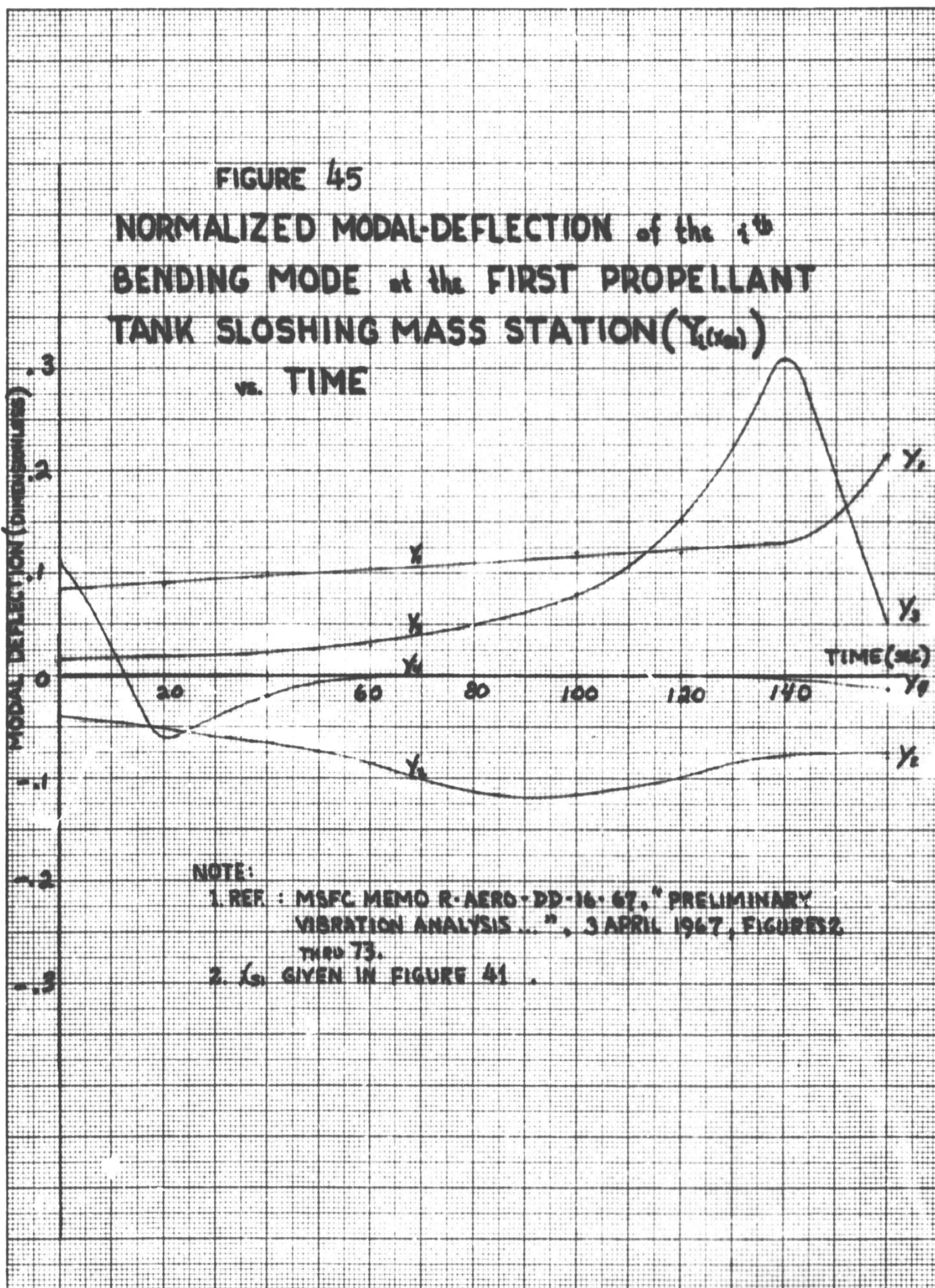


FIGURE 44
NATURAL FREQUENCY of the 3RD PROPELLANT
TANK SLOSHING (ω_{s3}) vs. TIME

NOTE :

1. REF. : MSFC MEMO R-AERO-DD-7-66, "SATURN V
DESIGN SLOSHING DATA", 24 FEBRUARY 1967,
TABLE 22.





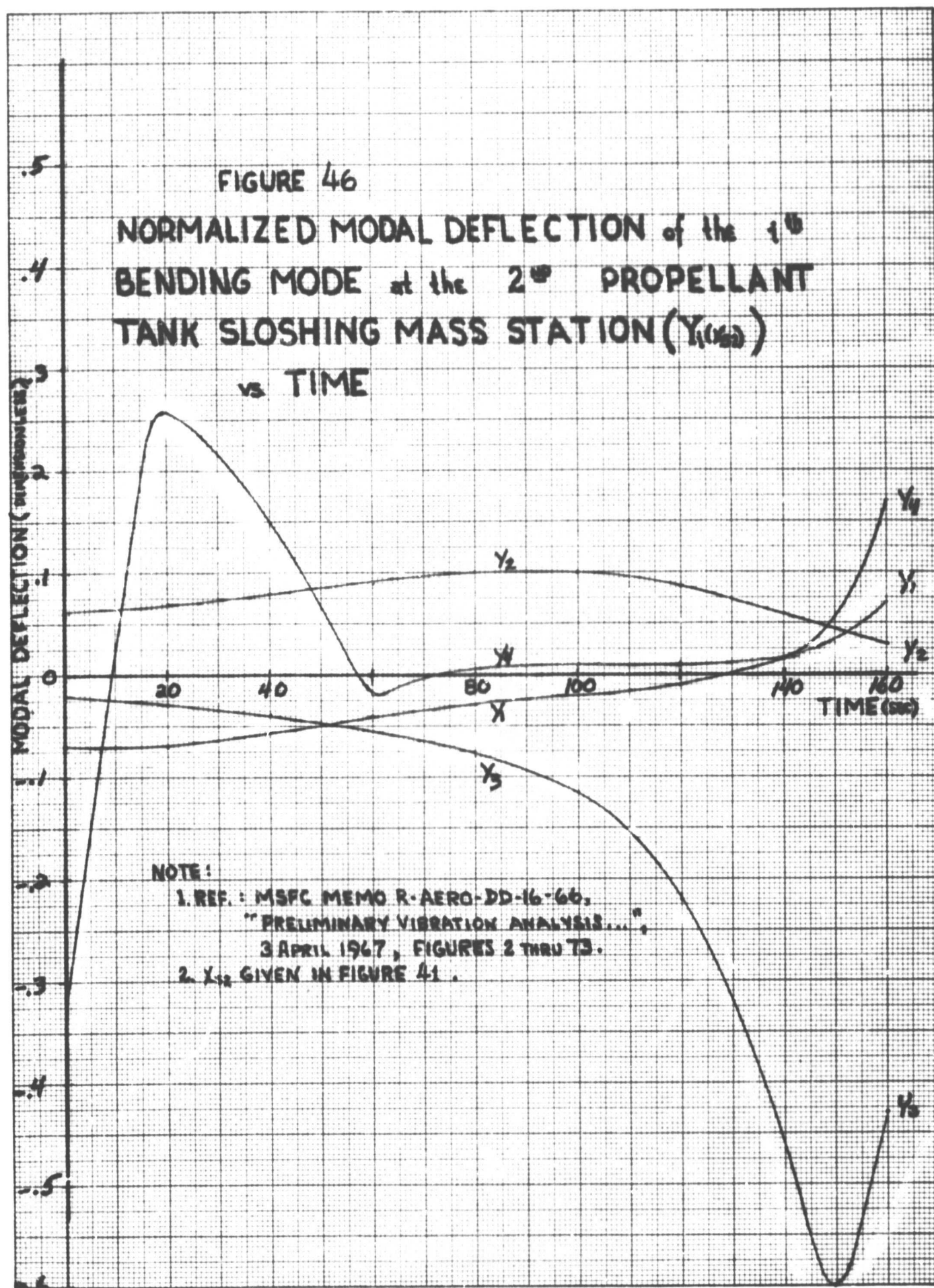
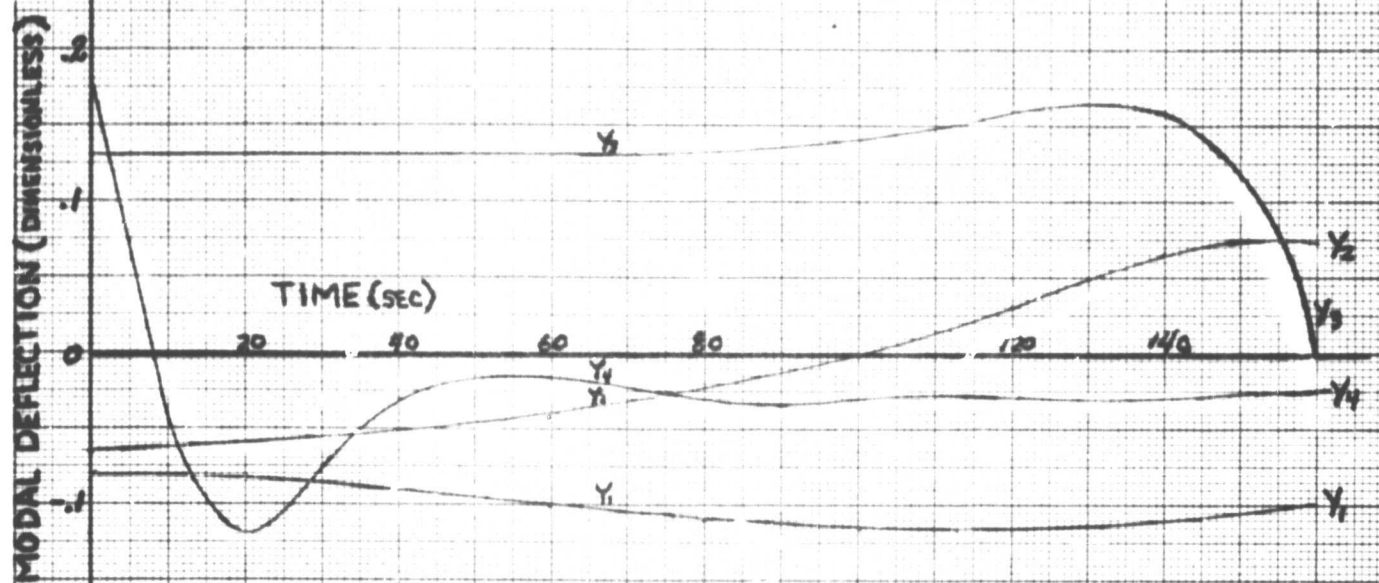
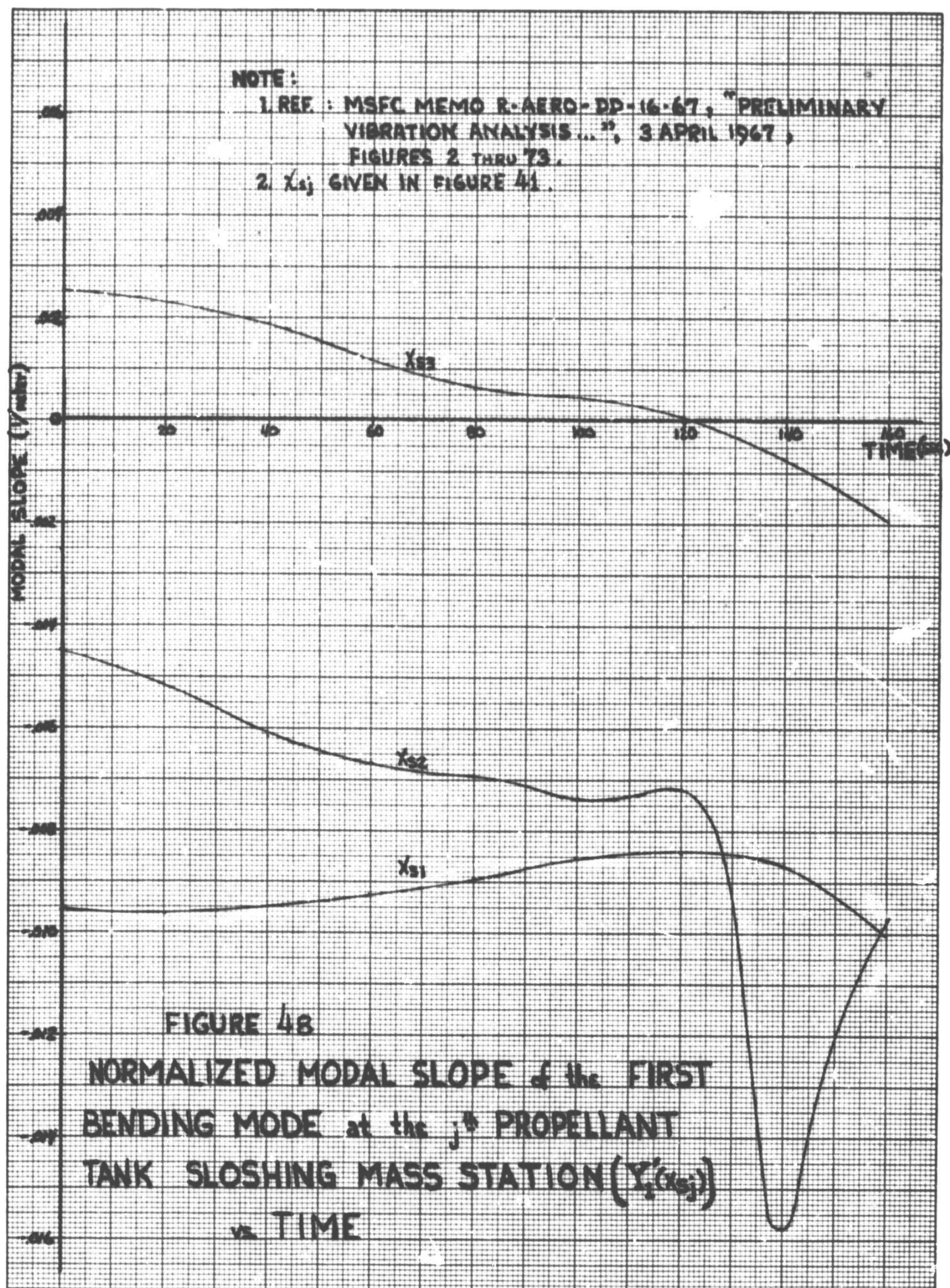


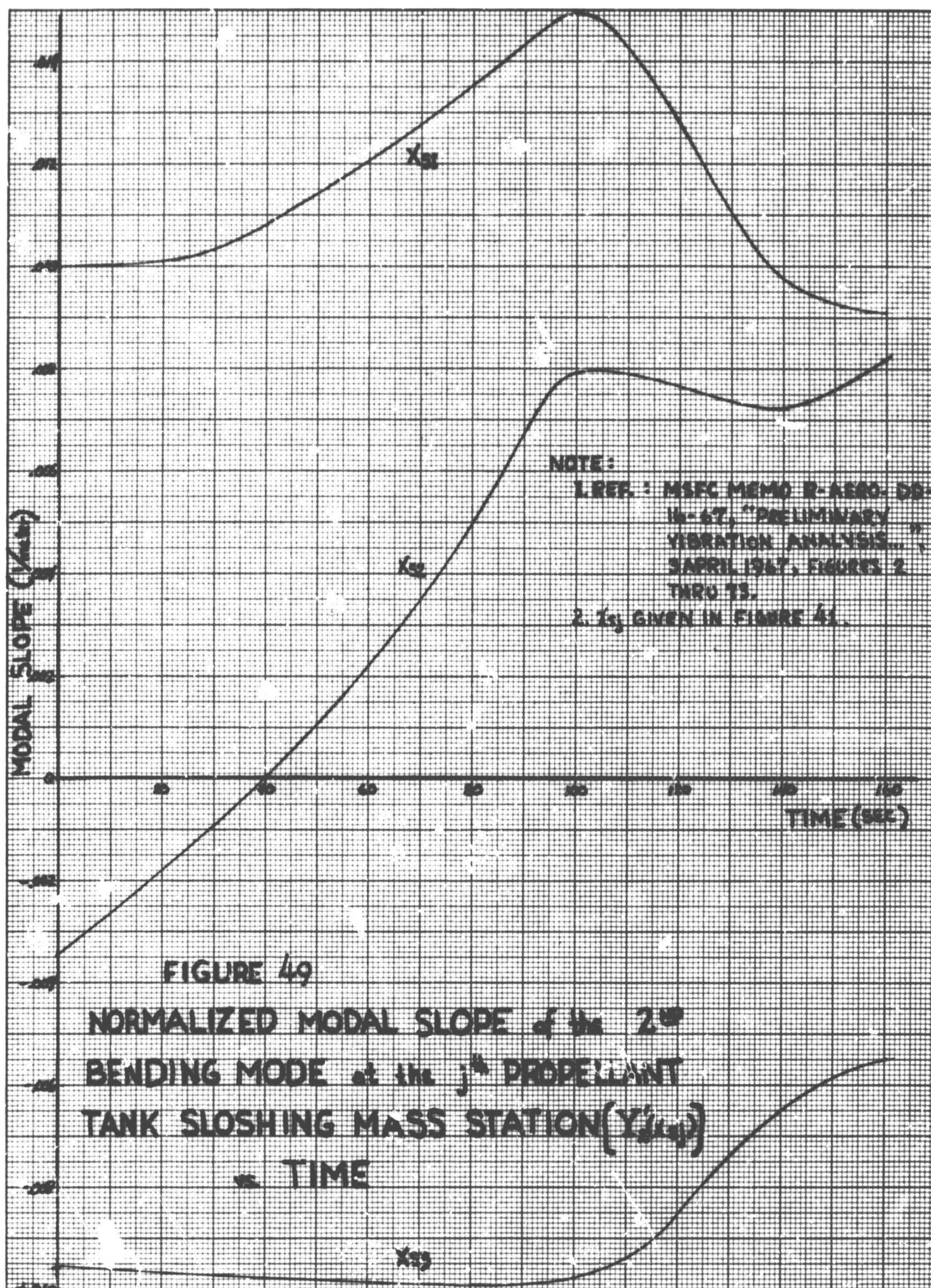
FIGURE 47
 NORMALIZED MODAL DEFLECTION of the 1st
 BENDING MODE at the 3rd PROPELLANT
 TANK SLOSHING MASS STATION ($Y_1(x_3)$)
 vs. TIME

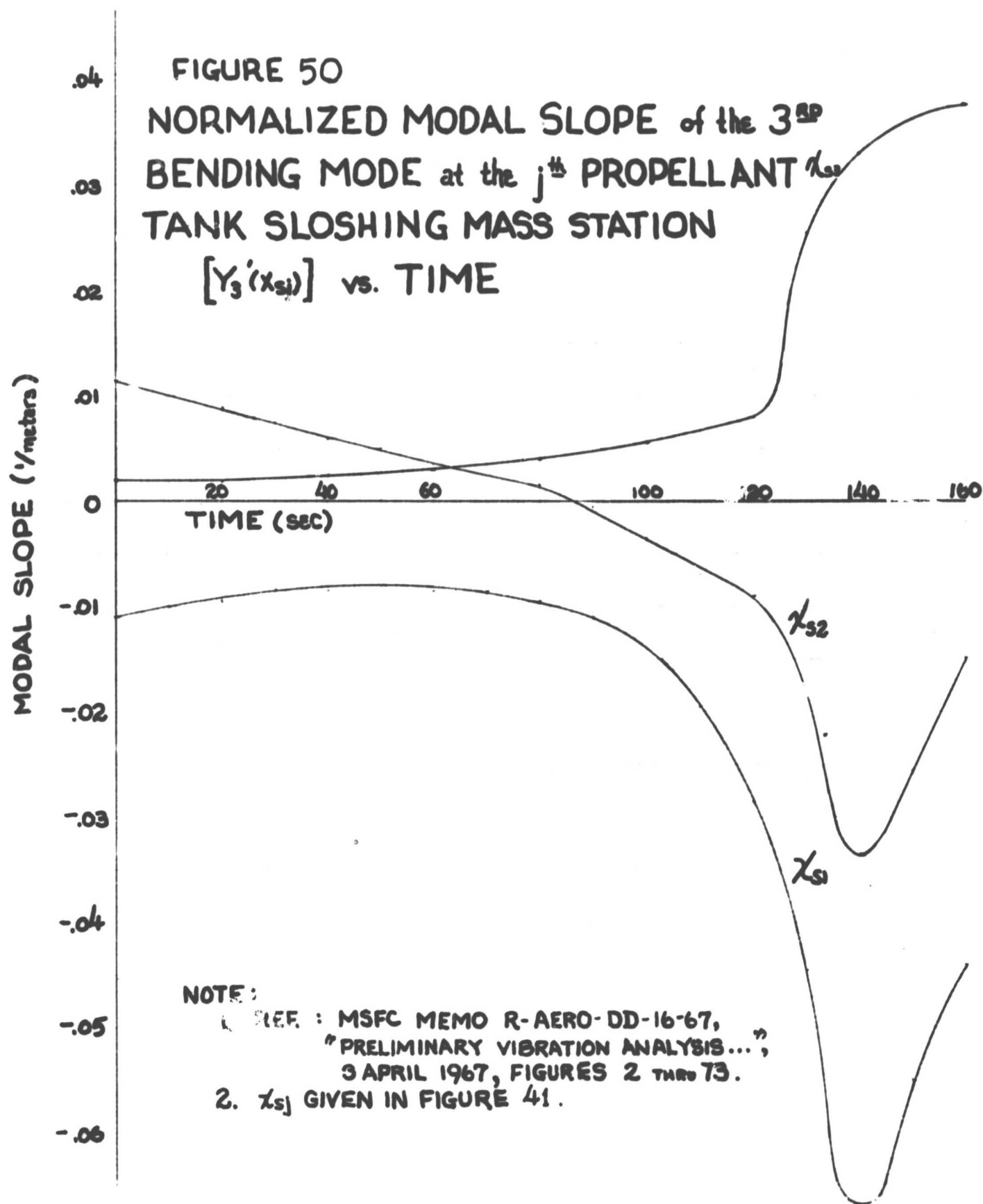


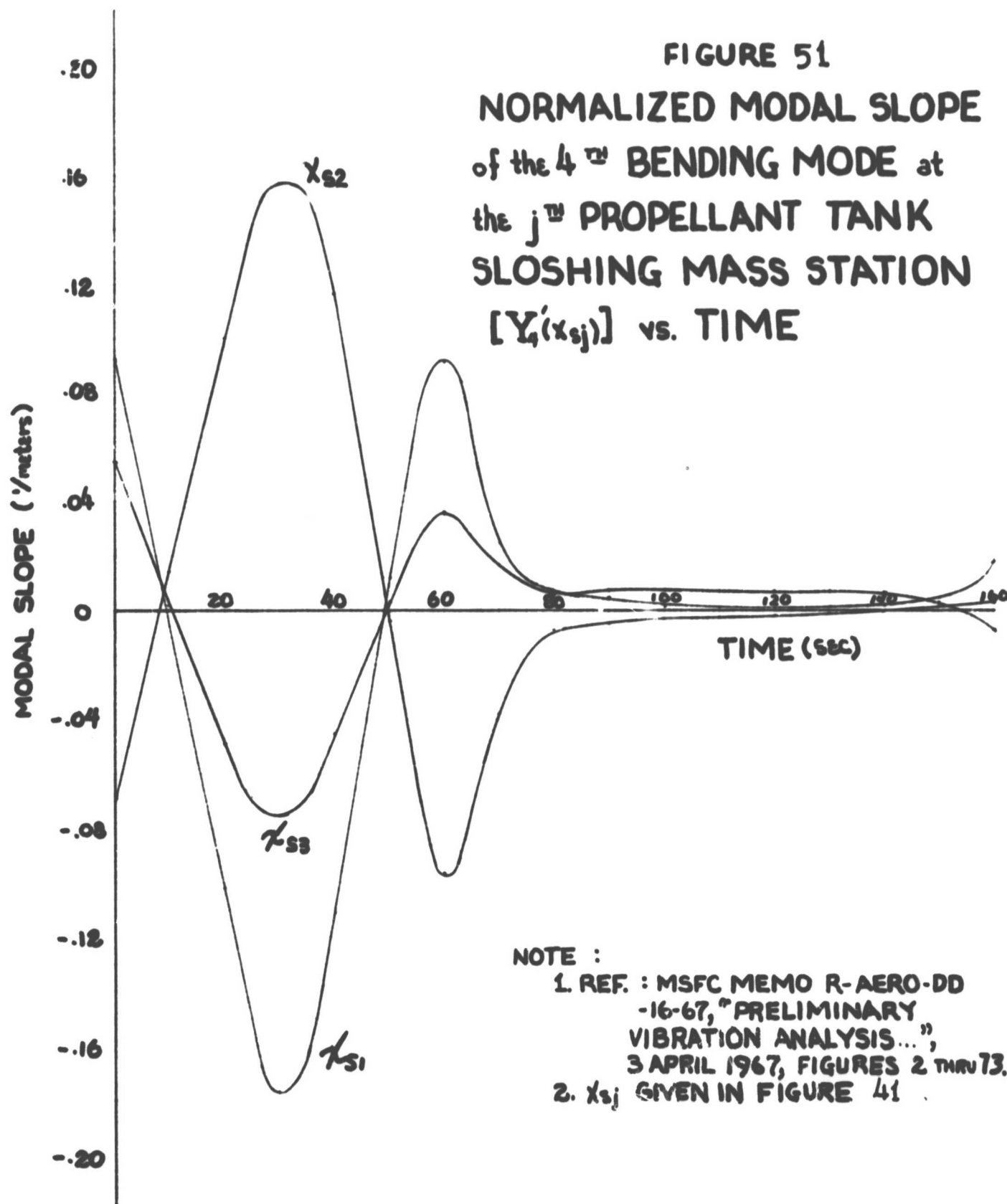
NOTE :

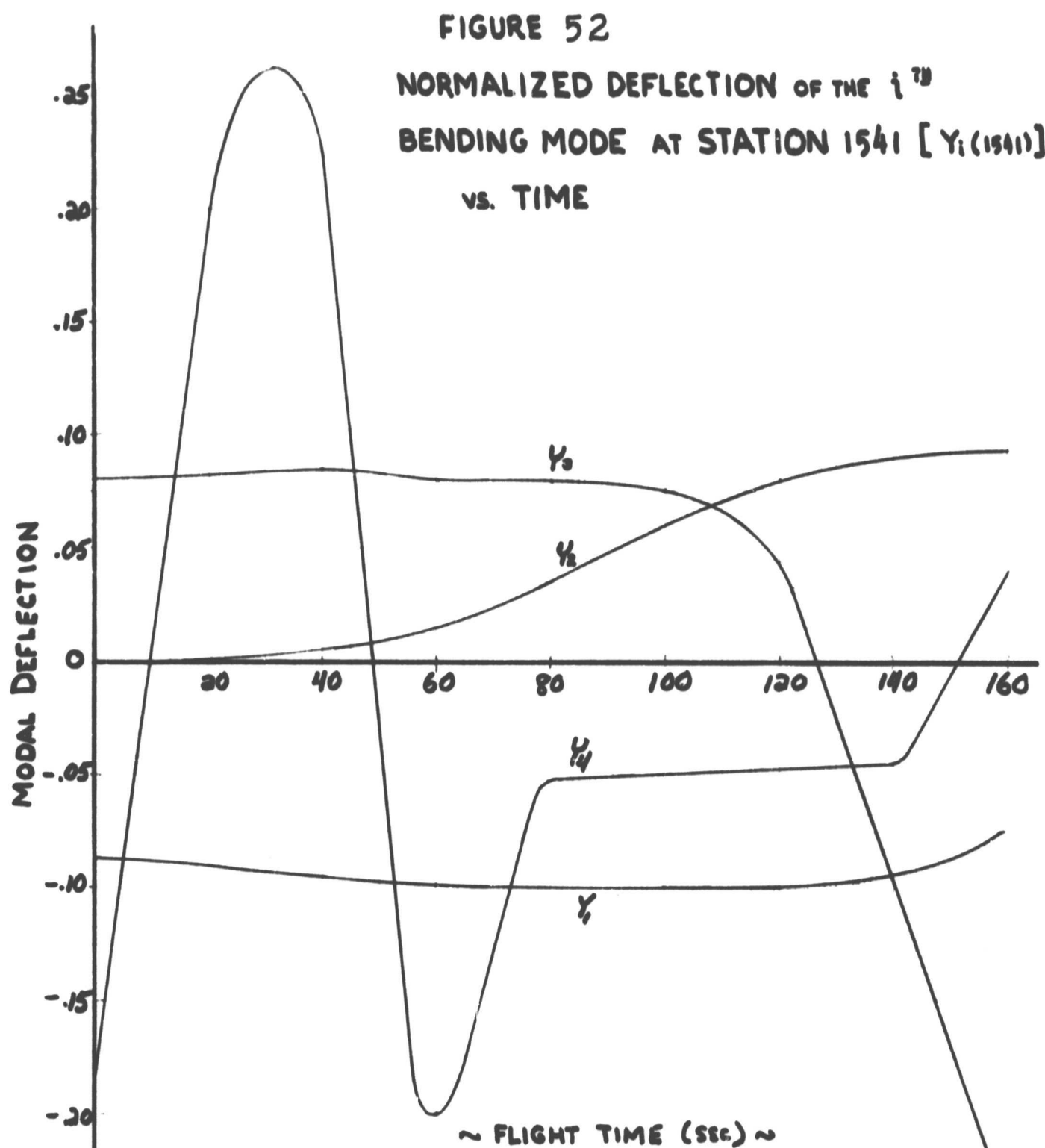
1. REF. : MSFC MEMO R-AERO-DD-16-67, "PRELIMINARY VIBRATION ANALYSIS...", 3 APRIL 1967, FIGURES 2 THRU 73.
2. X_3 GIVEN IN FIGURE 41.











NOTE :

1. REF. : MSFC MEMO R-AERO-DD-16-67, "PRELIMINARY
 VIBRATION ANALYSIS", 3 APRIL 1967, FIGURES 2 THRU 73.

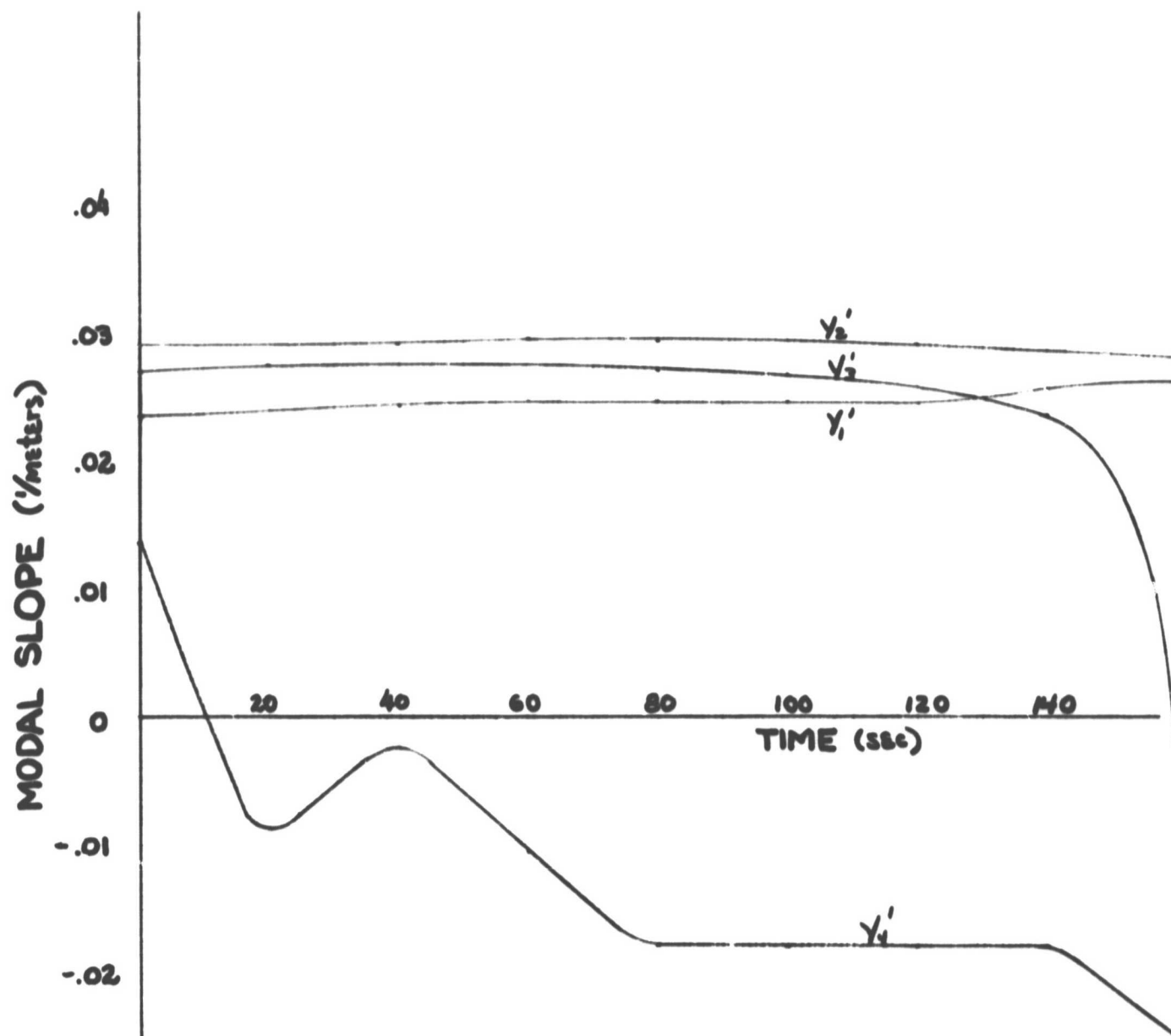


FIGURE 53
 NORMALIZED MODAL SLOPE OF THE 1TH
 BENDING MODE AT STATION 3235
 vs. TIME

NOTE :

1. REF : MSFC MEMO R-AERO-DD-16-67, "PRELIMINARY VIBRATION ANALYSIS ...", 3 APRIL 1967, FIGURES 2 THRU 73.

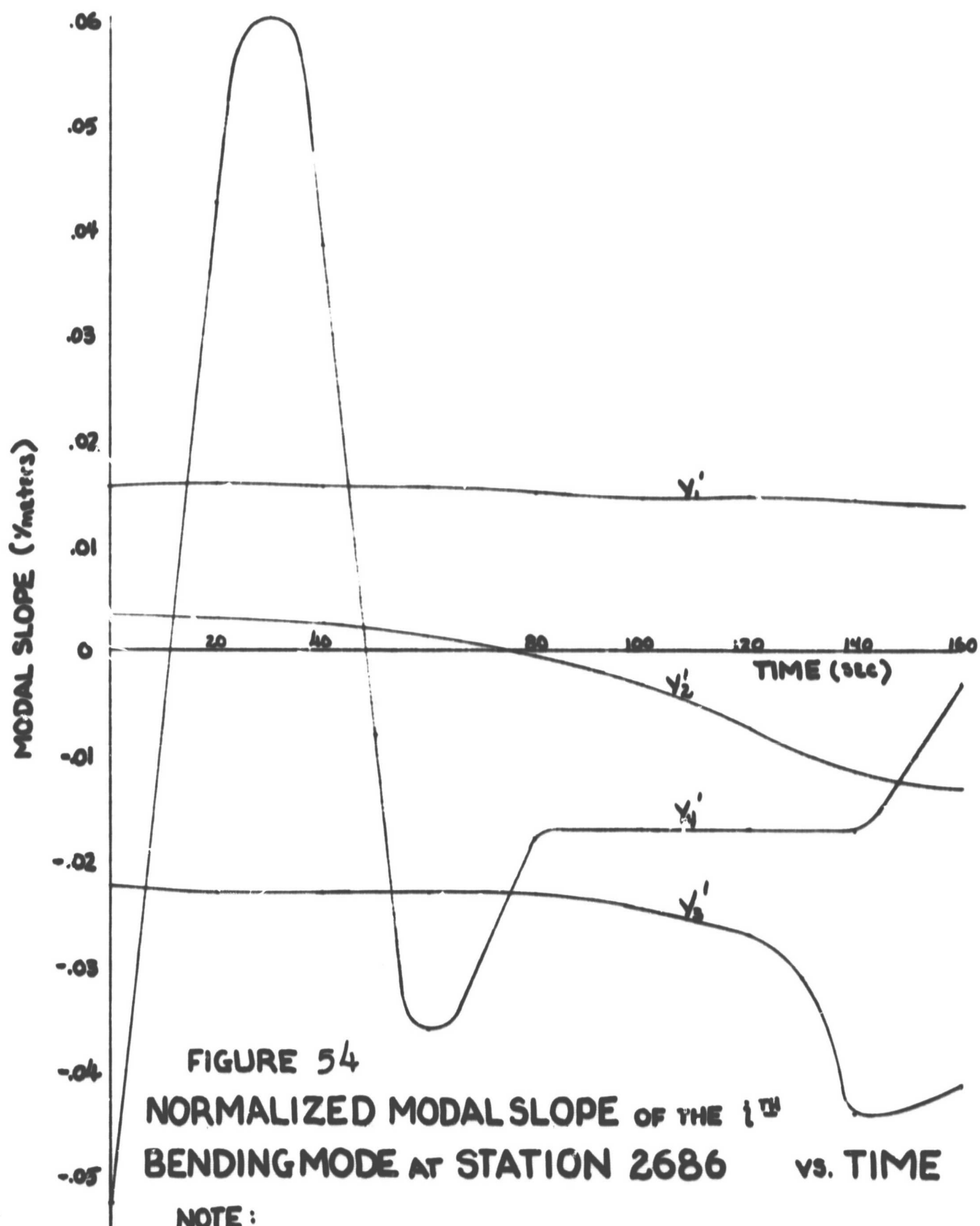


FIGURE 54
 NORMALIZED MODAL SLOPE OF THE 1st
 BENDING MODE AT STATION 2686 vs. TIME

NOTE:

1. REF.: MSFC MEMO R-AERO-DD-16-67, "PRELIMINARY
 VIBRATION ANALYSIS...", 3 APRIL 1967, FIGURES 2-73.

FIGURE 55

RIGID BODY BENDING MOMENT COEFFICIENT $M'_2(\omega)$ vs. TIME

NOTE:

1. REF. 1 ENCLOSURE #5 OF DATA PKG. TRANSMITTED TO HONEYWELL UNDER COVER LETTER R-AERO-60, J. LIVINGSTON TO L. EDINGER, 28 JULY 1967.
2. M'_2 EXTRAPOLATED TO ZERO FOR FLIGHT TIMES < 52 AND > 120 SECONDS, BECAUSE DYNAMIC PRESSURE GOES TO ZERO.

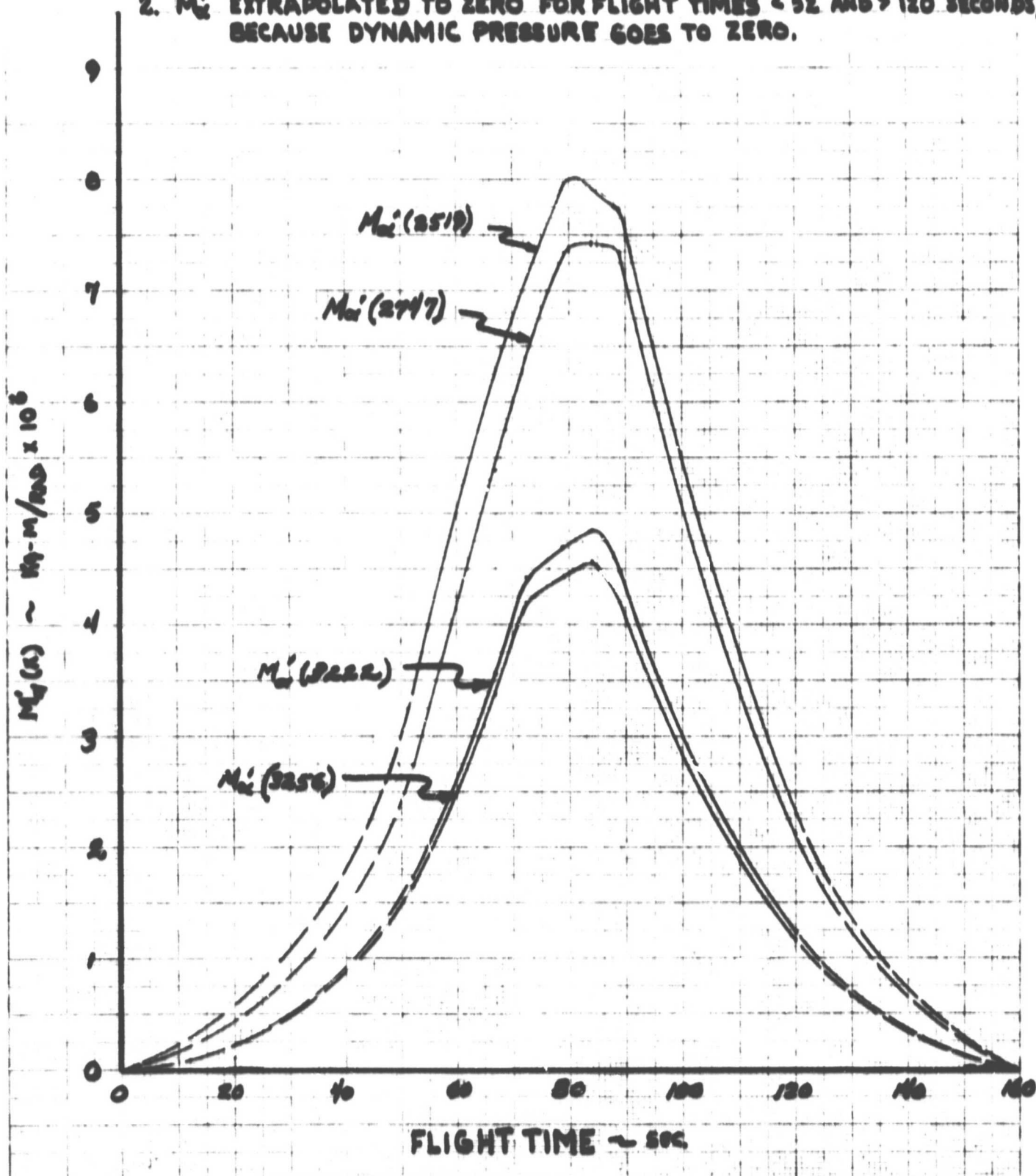


FIGURE 56.

RIGID BODY BENDING MOMENT COEFFICIENTS $M'_x(1541)$ AND $M'_y(1541)$ vs. TIME

NOTE:

1. REF.: ENCLOSURE #5 of DATA PK6. TRANSMITTED TO HONEYWELL UNDER COVER LETTER R-AERO-60, J. LIVINGSTON TO L. EDINGER, 28 JULY 1967.
2. DATA EXTRAPOLATED FOR FLIGHT TIMES < 52 AND > 120 SECONDS. M'_x EXTRAPOLATED TO ZERO BECAUSE ξ GOES TO ZERO.

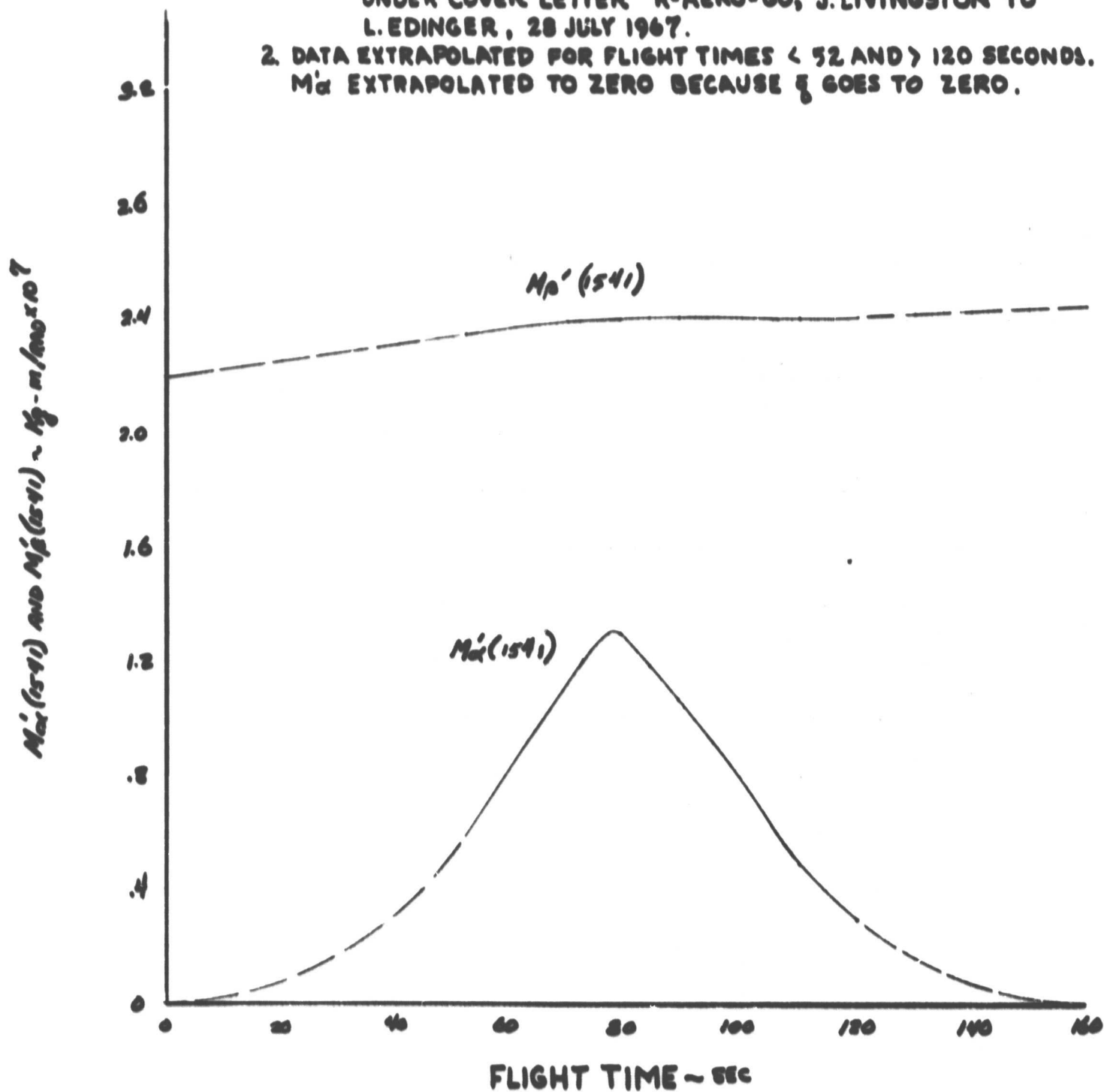


FIGURE 57

RIGID BODY BENDING MOMENT COEFFICIENT $M_b'(x)$ vs TIME

NOTE:

1. REF: ENCLOSURE #5 OF DATA PKG. TRANSMITTED TO HONEYWELL
UNDER COVER LETTER R-AERO-60, J. LIVINGSTON TO
L. EDINGER, 28 JULY 1967.

2. DATA LINEARLY EXTRAPOLATED OF FLIGHT TIMES
4.52 AND > 130 SECONDS.

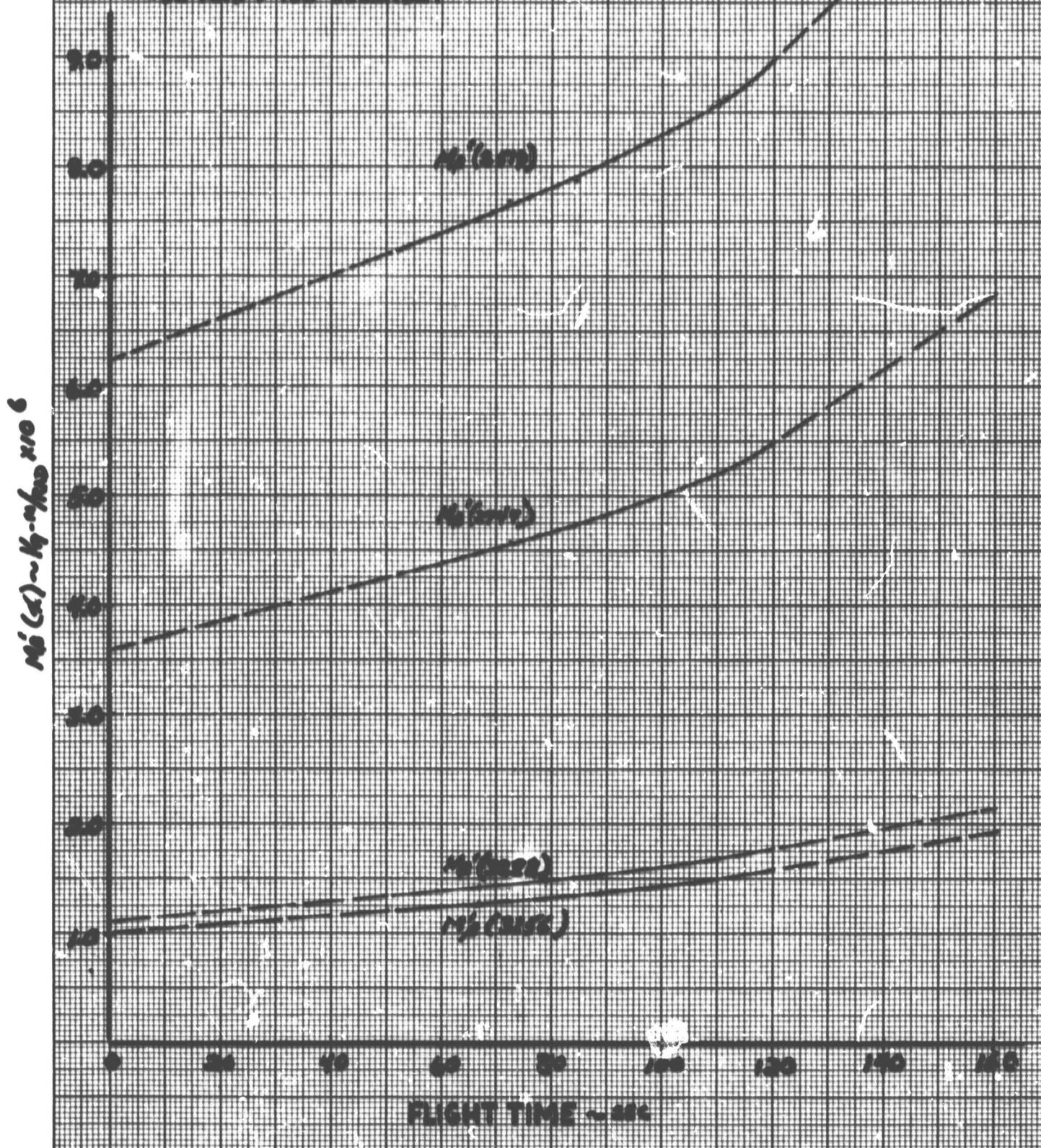


Table 19. Bending Moment Due to Structural Mode Acceleration
Coefficient M_{η_i}

Vehicle Station (inches)	Time Into Flight (seconds)	$M_{\eta_i} \times 10^{-4} \text{ kg-sec}^2$			
		First Mode	Second Mode	Third Mode	Fourth Mode
1541	8	15.09	-3.18	-2.28	3.13
	74	12.08	-3.64	-1.96	2.58
	83	11.68	-3.69	-1.98	2.64
	155	9.86	-3.54	-1.23	0.61
2519	8	7.66	2.96	0.17	-1.99
	74	7.12	2.84	-0.06	-3.32
	83	7.02	2.75	-0.07	-3.17
	155	6.74	1.47	-1.47	-0.60
2747	8	5.44	3.18	1.61	1.08
	74	5.21	3.27	1.44	-0.07
	83	5.10	3.18	1.46	-0.26
	155	5.01	2.41	1.25	-0.41
3256	8	2.15	1.76	1.39	1.85
	74	2.16	1.78	1.29	2.32
	83	2.11	1.85	1.31	1.65
	155	2.06	1.58	2.05	0.33

Note: Data taken from Reference 15 transmitted to Honeywell during course of study under NASA contract NAS8-11206, modification 5.

7.0 REFERENCES

- 1) Honeywell Final Report 12003-SV6, "A Load Relief Control System for the S-1C Stage of the Saturn V with Voyager Payload," 10 January 1967, prepared for NASA-MSFC, Contract NAS8-11206, mod 5.
- 2) MSFC Letter, J. M. Livingston to L. D. Edinger, 15 August 1967, Subject: Basic performance requirements and design guidelines, R-Aero-G.
- 3) MSFC Letter, J. R. Redus to L. D. Edinger, 28 August 1967, Subject: Aerodynamic-structural mode coupling coefficients; Rate gyro location; Terminal design constraints.
- 4) Honeywell Progress Report 12003-SV3, "Saturn V/Voyager Load Relief Study," 15 September 1966, prepared for NASA-MSFC, Contract NAS8-11206, mod 5.
- 5) MSFC Memorandum R-Aero-Y-66-65, "Redefinition of the Saturn I-B/V Synthetic Wind Profile," 10 September 1965.
- 6) TeleCon, L. D. Edinger, Honeywell, to J. R. Redus, NASA-MSFC, 18 July 1967, Subject: Answers to selected questions on slosh modes, structural modes, actuator dynamics, body station, etc.
- 7) TeleCon, J. R. Redus, NASA-MSFC, to L. D. Edinger, Honeywell, 29 August 1967, Subject: Bending moment coefficient.
- 8) MSFC Letter, J. M. Livingston, NASA-MSFC, to L. D. Edinger, Honeywell, 28 July 1967, Subject: Data package for NASA Contract NAS8-21171 study.
- 9) NASA TMX-53588, "Preliminary Saturn V/Voyager Trajectory from Earth to Mars," 22 March 1967.
- 10) MSFC Memorandum R-P & VE-AV-66-237, "Preliminary Mass Characteristics for Saturn V/Voyager," 13 December 1966.
- 11) MSFC Memorandum R-Aero-AD-66-59, "Static Aerodynamic Characteristics of the Saturn V/Voyager (45-Foot Shroud Length)," 20 December 1966.
- 12) MSFC Memorandum R-Aero-Ad-1667, "Preliminary Vibration Analysis of Saturn V/Voyager (45-Foot Length Cylindrical Payload)," 3 April 1967.
- 13) MSFC Memorandum R-Aero-DD-7-66, "Saturn V Design Sloshing Data," 24 February 1966.
- 14) MSFC Memorandum R-P & VE-VAW-65-54, "F-1 Engine and Associated Equipment Gimballed Mass Characteristics," 8 April 1965.
- 15) MSFC Letter, J. R. Redus to G. Broucek, 8 July 1966, Subject: Bending Mode data for Voyager study (NASA contract NAS8-11206/5).