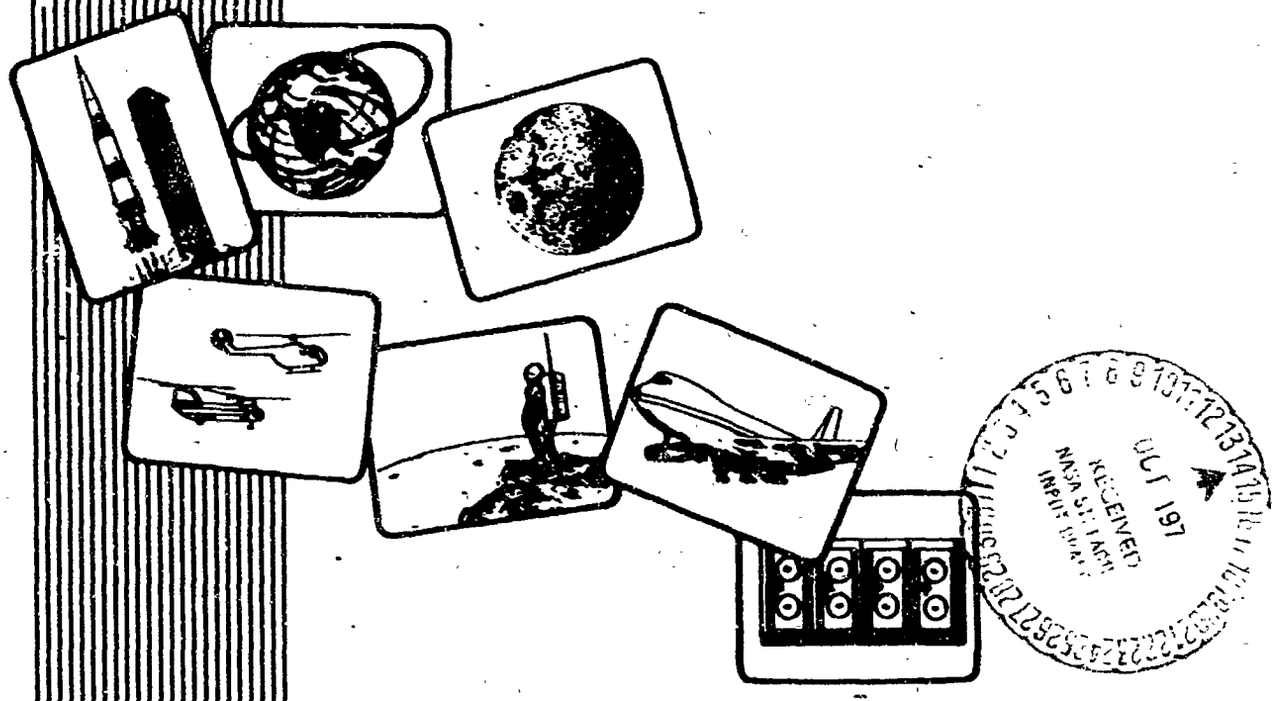
NASA CR-
140287

D2-118544-2

DYNAMIC DOCKING TEST SYSTEM (DDTS) ACTIVE TABLE COMPUTER PROGRAM NASA ADVANCED DOCKING SYSTEM (NADS)



THE BOEING COMPANY
HOUSTON, TEXAS

August 30, 1974

DOCUMENT NO. D2-118544-2

DYNAMIC DOCKING TEST SYSTEM (DDTS) ACTIVE TABLE COMPUTER PROGRAM NASA ADVANCED DOCKING SYSTEM (NADS)

Contract NAS 9-13136

August 30, 1974

Prepared by

R. M. Gates
R. E. Jantz

Approved by

R. K. Nuno

R. K. Nuno
Technical Program Manager

BOEING AEROSPACE COMPANY
Houston, Texas

REVISIONS

REV. SYM	DESCRIPTION	DATE	APPROVED

Form HOU-3-1116 (ISR) Approved 11/67 AJT

ABSTRACT

This document describes the computer program developed to describe the three-dimensional motion of the Dynamic Docking Test System (DDTS) active table. The input consists of inertia and geometry data, actuator structural data, forcing function data, hydraulics data, servo electronics data, and integration control data. The output consists of table responses, actuator bending responses, and actuator responses.

KEY WORDS

Docking Simulator
Dynamic Docking Test System (DDTS)
Hydraulic Actuator
Mathematical Model
Motion Simulator

TABLE OF CONTENTS

ILLUSTRATIONS

REFERENCE

Boeing Document D2-118544-1, "Mathematical Model for the Simulation of Dynamic Docking Test System Active Table Motion," August 30, 1974.

1.0 GENERAL INFORMATION

1.1 COMPUTER SYSTEM

This program was written in FORTRAN V language for use on the UNIVAC 1108 computer with the EXEC II operating system. The program can easily be converted to the EXEC 8 operating system. The plotted output is done on the Stromberg Datagraphix's SD-4060 microfilm plotter.

1.2 PURPOSE

The program simulates the motions of the NASA JSC Dynamic Docking Test System (DDTS) active table. Given a description of the table mass and geometry, the actuators, the hydraulic system, the electronics, and the forcing function, the program outputs time-histories of table responses, actuator bending data, and actuator responses. Responses to the following input forcing functions are calculated:

a. Step velocity command
b. Sinusoidal position commands
c. Step external force on table c.g.
d. Sinusoidal external force on table c.g.

1.3 LIMITATIONS

Forcing functions are limited to those listed in Paragraph 1.2. Dynamics of the simulator due to docking are not modeled. Actuator control system components are limited to those shown in Figure 4. In the actual DDTS, there are notch filters in both the velocity command line and the forward loop which are not included in this simulation.

2.0 PROCEDURE

2.1 PROGRAM NAME

The program acronym is NADS from NASA Advanced Docking System.

2.2 NOMENCLATURE

Nomenclature for NADS

Program	Engineering	Description
A	[A]	Transformation matrix from table to inertial coordinates
A	A_1, A_2	"Push" and "pull" stroke working areas of actuators
AA	$\ddot{l}_p$	Actuator acceleration
AL	l_p	Actuator length
ALPHA	α	Break frequency of first order filter
AL3D	$\dddot{l}_p$	Actuator jerk
AV	$\dot{l}_p$	Actuator velocity
BETA	β	Break frequency of first order filter
BETAE	β_e	Equivalent hydraulic system bulk modulus
BP	B_p	Viscous damping coefficient of actuator
C	-	Column of generalized forces for equations of motion solution
CAA	$\ddot{l}_c$	Commanded actuator acceleration
CAL	l_c	Commanded actuator length
CAV	$\dot{l}_c$	Commanded actuator velocity
CP	C_p	Leakage coefficient across piston seals
DLTAI	Δx_I, Δy_I, Δz_I, $\Delta\theta$, $\Delta\psi$, $\Delta\phi$	Sinusoidal amplitudes of translational commands for table c.g. and of table Euler angles
EIR	EI_r	Bending modulus of piston rod
FF	F_f	Coulomb friction force of actuator
FH	F_H	Total hydraulic and friction forces acting on pistons

2.2 (Continued)

Nomenclature for NADS (continued)

Program	Engineering	Description
FMEXT	F_{EXT}, M_{EXT}	External forces and moments
FP	F_P	Net forces on actuator piston
FRQNCY	ω_c	Command signal frequency
IAC	I_{AC}	Mass moment of inertia of cylinder (excluding the mass of the piston) about floor swivel joint
IFIRST	-	Initialization indicator for mass matrix and geometry
IM	-	Mass matrix and geometry update option indicator
INDKTR	-	Stroking or matrix inversion error indicator to terminate the integration process
INER	I_{xx}, I_{yy}, I_{zz}, I_{xy}, I_{xz}, I_{yz}	Moments and products of inertia
IPLOPT	-	Plot option indicator
IPROPT	-	Print option indicator
IXF	-	External force and moment option indicator
KC	K_c	Valve pressure flow coefficient
KF	K_f	Displacement feedback and command gain
KG	K_g	Electronics and valve forward loop gain
KPF	K_{pf}	Pressure feedback loop gain
KR	K_r	Velocity feedback loop gain
KRC	K_{rc}	Velocity command gain
LC	l_c	Distance from floor swivel to center line of piston rod seal at end of cylinder

2.2 (Continued)

Nomenclature for NADS (continued)

Program	Engineering	Description
LPM	l_{pm}	Maximum stroke of actuators
LR	l_r	Length of piston rod
LO	l_o	Retracted length (between swivel joints) of actuators
M	M, M^{-1}	Mass matrix and mass matrix inverse
MH	M_H	Moment acting about table c.g. from hydraulic and friction forces
ML	m_l	Effective rigid lateral mass of actuator assembly
MP	m_p	Mass of piston rod and piston
MQ	m_q	Effective bending mass lumped at rod seal of cylinder
MT	m_t	Table mass
NFREQ	-	Number of table displacement frequency cases
NFFREQ	-	Number of external force and moment frequency cases
NPLTS	-	Number of plotted time points
OMEGA	ω_1, ω_2	Break frequencies of first order filters
OMEGAC	ω_c	Displacement command signal frequency
OMEGAE	ω_e	Actuator bending frequency
OMEGAF	ω_f	Frequency of sinusoidal external forces and moments
OMEGAS	ω_s	Frequency of second order filter on displacement and velocity feedbacks
OMEGAV	ω_v	Frequency of valve dynamics
OMEGPF	ω_{pf1}, ω_{pf2}	Break frequencies of pressure feedback filters

2.2 (Continued)

Nomenclature for NADS (continued)

Program	Engineering	Description
OUTFRQ	-	Output frequency for printing and plotting
PS	P_s	Supply pressure
RS	r_s	Inertial vector components of actuator length
RXA	r_{xa}	X axis table station of actuator swivel joints with respect to the table c.g.
RYZA	r_{ya}, r_{za}	Y, Z table coordinates of swivel joints with respect to the table c.g.
T	[T]	Transformation matrix transforming vectors from table coordinates to local actuator coordinates
TCGCO	X_{I_o}, Y_{I_o}, Z_{I_o}	Initial inertial coordinates of table c.g.
TDIC	$\{R_{I_c}\}$, $\{\dot{R}_{I_c}\}$, $\{\theta_{I_c}\}$, $\{\dot{\theta}_{I_c}\}$	Time dependent inertial commands
TEAO	θ_o, ψ_o, ϕ_o	Initial Euler angles of the table coordinate system with respect to the inertial system
TEND	-	Last integration time
TIME	t	Time
TITLE	-	Title to be printed at top of first page of output
TPLOT	-	Time point at or after which output for plots is made
TPRINT	-	Time point at or after which printed output is made
TSTART	-	First integration time

2.2 (Continued)

Nomenclature for NADS (concluded)

Program	Engineering	Description
VO	V_o	Initial hydraulic volumes of push and pull strokes of fully retracted actuator
X	-	Variable array (output by integration procedure)
XDOT	-	Derivative array
XO	x_o	Initial condition array
YZF	y_f, z_f	Y and Z inertial coordinates of floor swivel joints
ZETAE	ζ_e	Damping constant for actuator bending
ZETAS	ζ_s	Damping constant of second order filter on displacement and velocity feedbacks
ZETAV	ζ_v	Damping constant of valve dynamics

2.3 METHOD

This section contains a brief description of the physical system for which the program was written and the mathematical equations used to describe the motion of the system. The equations are described in detail in the referenced document.

The DDTS active table is a triangular platform supported by six hydraulic actuators as shown in Figure 1. The table is capable of six-degree-of-freedom motion controlled by the six actuators.

Three coordinate systems are used to describe the motion of the table and actuators. These coordinate systems are shown in Figure 2. The inertial coordinate system origin is on the simulator centerline in the plane of the floor swivel joints. Table motion commands and responses are expressed in the inertial coordinate system. Table coordinates are body fixed coordinates whose origin is at the table center of gravity. Actuator coordinates are used to describe actuator motions.

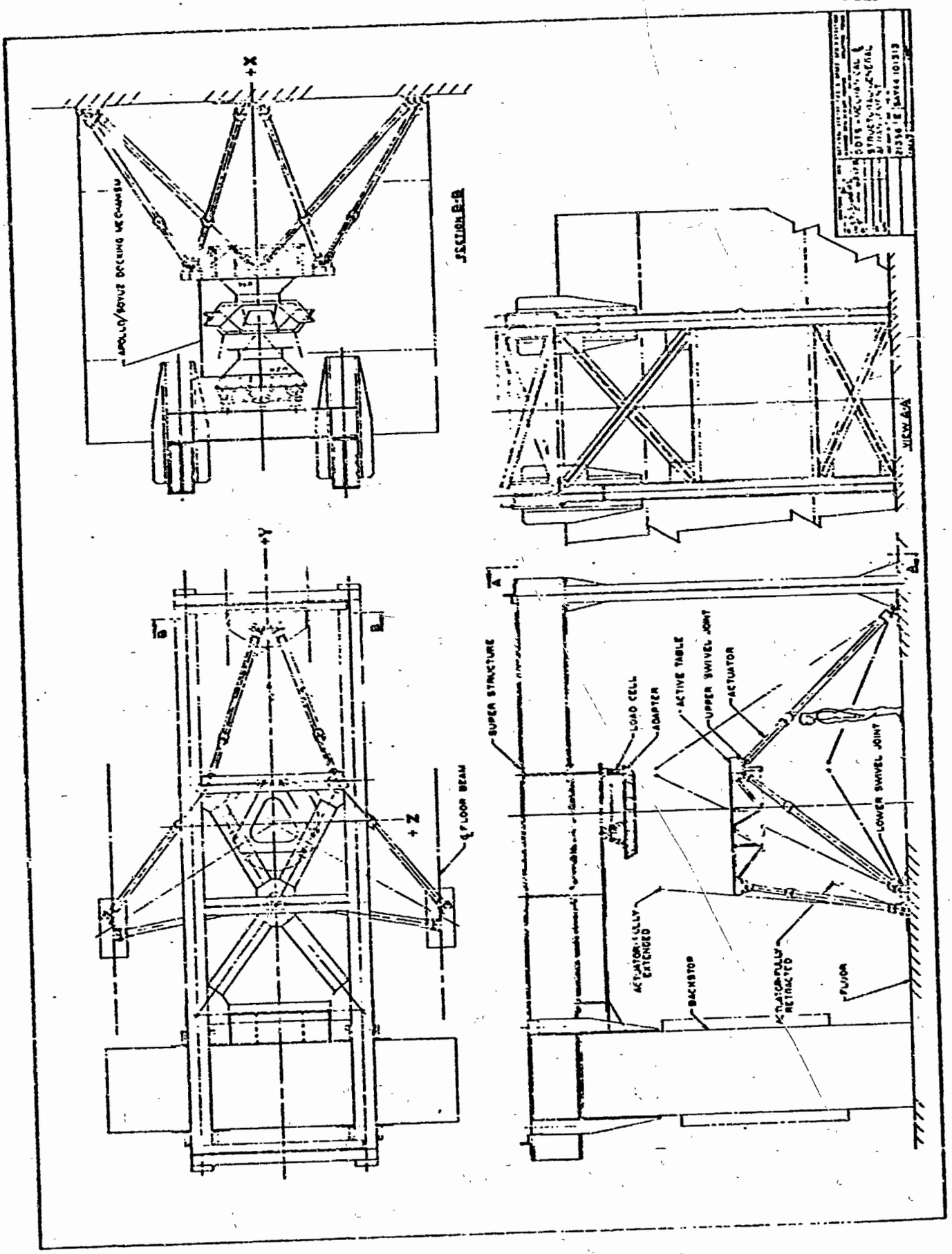


Figure 1. DDTS Simulator Facility

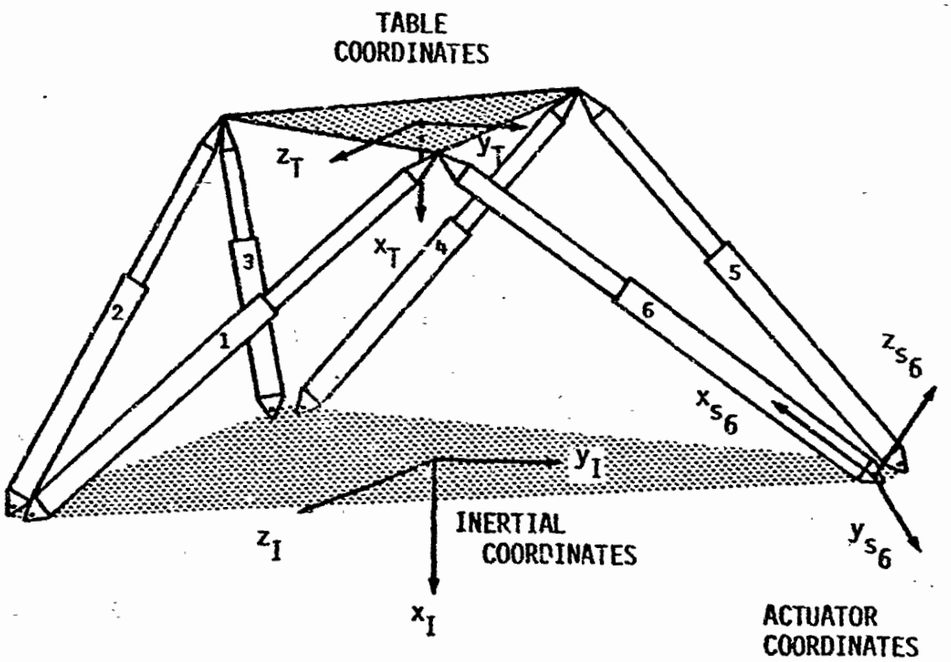


Figure 2. Active Table Coordinate Systems

2.3 (Continued)

Table equations of motion are written in the body fixed table coordinates as follows:

$$\{\ddot{X}\} = [M]^{-1} \{C\} \tag{1}$$

where: $\{\ddot{X}\}$ is a column of accelerations for each degree of freedom (six degrees of freedom for the table and two elastic degrees of freedom for each actuator)

$[M]$ is the 18 x 18 coupled mass matrix

$\{C\}$ is a column of generalized forces for each degree of freedom

The mass coupling effects of the actuators due to table motions are determined by Lagrange's method. The three-dimensional rigid motions of the actuators are completely constrained (i.e., they are dependent upon the table motions). The mass matrix is shown in Figure 3 in upper triangular form.

The column of generalized forces includes the velocity terms in the equations of motion, the total forces exerted on the table by the actuators, externally applied forces and moments, and actuator bending stiffness and damping.

$$\begin{Bmatrix} \ddot{x}_T \\ \ddot{y}_T \\ \ddot{z}_T \\ \hline \dot{\omega}_x \\ \dot{\omega}_y \\ \dot{\omega}_z \\ \hline \vdots \\ \ddot{y}_{e_i} \\ \vdots \\ \hline \ddot{z}_{e_i} \\ \vdots \end{Bmatrix} = [M]^{-1} \begin{Bmatrix} -m_T \begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix} \begin{Bmatrix} \dot{x}_T \\ \dot{y}_T \\ \dot{z}_T \end{Bmatrix} + \begin{Bmatrix} F_{H_x} \\ F_{H_y} \\ F_{H_z} \end{Bmatrix} + \begin{Bmatrix} F_{E_x} \\ F_{E_y} \\ F_{E_z} \end{Bmatrix} \\ \hline - \begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix} \begin{bmatrix} \tilde{I} \end{bmatrix} \begin{Bmatrix} \omega_x \\ \omega_y \\ \omega_z \end{Bmatrix} + \begin{Bmatrix} M_{H_x} \\ M_{H_y} \\ M_{H_z} \end{Bmatrix} + \begin{Bmatrix} M_{E_x} \\ M_{E_y} \\ M_{E_z} \end{Bmatrix} \\ \hline \vdots \\ -2\zeta_e \omega_{e_i} m_{q_i} \dot{y}_{e_i} - \omega_{e_i}^2 m_{q_i} y_{e_i} \\ \vdots \\ \hline -2\zeta_e \omega_{e_i} m_{q_i} \dot{z}_{e_i} - \omega_{e_i}^2 m_{q_i} z_{e_i} \\ \vdots \end{Bmatrix} \tag{2}$$

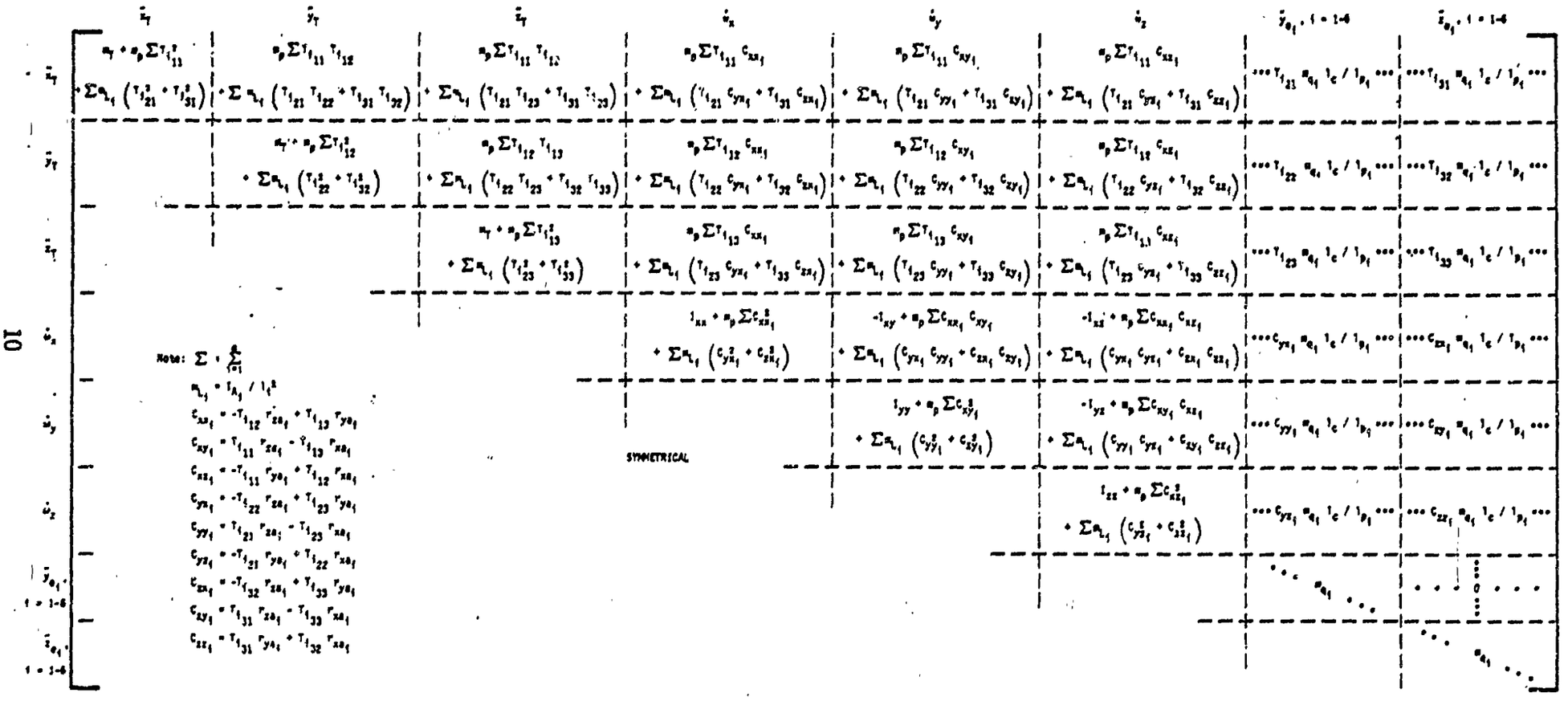


Figure 3. Mass Matrix

2.3 (Continued)

The Euler angles θ, ψ, ϕ are used to transform velocities in the table coordinate system to the inertial coordinate system

$$\begin{Bmatrix} \dot{x}_I \\ \dot{y}_I \\ \dot{z}_I \end{Bmatrix} = [A] \begin{Bmatrix} \dot{x}_T \\ \dot{y}_T \\ \dot{z}_T \end{Bmatrix} \tag{3}$$

$$\begin{Bmatrix} \dot{\theta} \\ \dot{\psi} \\ \dot{\phi} \end{Bmatrix} = \begin{bmatrix} 0 & \frac{\cos\phi}{\cos\psi} & -\frac{\sin\phi}{\cos\psi} \\ 0 & \sin\phi & \cos\phi \\ 1 & -\cos\phi\tan\psi & \sin\phi\tan\psi \end{bmatrix} \begin{Bmatrix} \omega_x \\ \omega_y \\ \omega_z \end{Bmatrix} \tag{4}$$

where:

$$[A] = \begin{bmatrix} C\theta \cdot C\psi & -C\phi \cdot C\theta \cdot S\psi + S\theta \cdot S\phi & S\phi \cdot C\theta \cdot S\psi + C\phi \cdot S\theta \\ S\psi & C\phi \cdot C\psi & -S\phi \cdot C\psi \\ -S\theta \cdot C\psi & C\phi \cdot S\theta \cdot S\psi + S\phi \cdot C\theta & -S\phi \cdot S\theta \cdot S\psi + C\phi \cdot C\theta \end{bmatrix} \tag{5}$$

C = cosine

S = sine

Each actuator is modeled as a flexible rod with pinned ends and is free to bend in its first lateral mode in two orthogonal directions.

Hydraulic forces are calculated using nonlinear hydraulic flow equations:

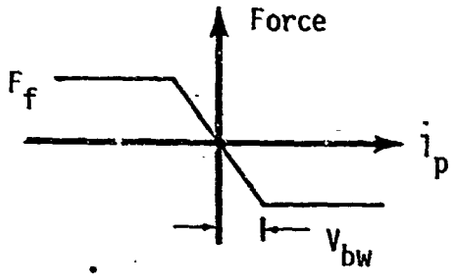
$$\begin{aligned} \dot{p}_1 &= \frac{\beta_e}{V_1} \left[Q_o - 2K_c\, p_1 - C_p\, (p_1 - p_2) - A_1\, \dot{i}_p \right] \\ \dot{p}_2 &= \frac{\beta_e}{V_2} \left[-Q_o - 2K_c\, p_2 + C_p\, (p_1 - p_2) + A_2\, \dot{i}_p \right] \end{aligned} \tag{6}$$

2.3 (Continued)

Piston forces calculated include the effects of viscous damping, B_p, and coulomb friction, F_f. For each actuator:

$$F_p = A_1 p_1 - A_2 p_2 - B_p \dot{i}_p - C_F F_f \tag{7}$$

The coefficient C_F is used to avoid a discontinuity at zero velocity.



$$\text{If } |\dot{i}_p| \geq V_{bw} \text{ , then } C_F = \frac{\dot{i}_p}{|\dot{i}_p|}$$

$$\text{If } |\dot{i}_p| < V_{bw} \text{ , then } C_F = \frac{\dot{i}_p}{V_{bw}} \tag{8}$$

Total hydraulic actuator forces and moments are then calculated for the equations of motion as follows:

$$\begin{Bmatrix} F_{H_x} \\ F_{H_y} \\ F_{H_z} \end{Bmatrix} = \begin{Bmatrix} \sum_{i=1}^{6} F_{p_i} T_{i_{11}} \\ \sum_{i=1}^{6} F_{p_i} T_{i_{12}} \\ \sum_{i=1}^{6} F_{p_i} T_{i_{13}} \end{Bmatrix} \tag{9}$$

2.3 (Continued)

$$\begin{Bmatrix} M_{H_x} \\ M_{H_y} \\ M_{H_z} \end{Bmatrix} = \begin{Bmatrix} \sum_{i=1}^{6} F_{p_i} \left(- T_{i_{12}} r_{za_i} + T_{i_{13}} r_{ya_i} \right) \\ \sum_{i=1}^{6} F_{p_i} \left(T_{i_{11}} r_{za_i} - T_{i_{13}} r_{xa_i} \right) \\ \sum_{i=1}^{6} F_{p_i} \left(- T_{i_{11}} r_{ya_i} + T_{i_{12}} r_{xa_i} \right) \end{Bmatrix} \tag{10}$$

where the terms $T_{i_{11}}$, $T_{i_{12}}$, ... etc. are the terms in the transformation from table coordinates to local actuator coordinates:

$$\left[T_i\right] = \left[TI_i\right]^T \left[A\right] \tag{11}$$

$\left[TI_i\right]$ is the transformation from actuator coordinates to inertial coordinates.

The servo electronics consist of actuator position and rate command signals and the electronic components shown in Figure 4. The use of the forward loop compensation network, the valve dynamics representation, and the position and rate feedback filter are optional. If β, for example, is input as a value less than unity, then the forward loop compensation network is not included in the simulation. Similarly, the valve dynamics and position feedback filter are neglected if $\omega_v < 1$ and $\omega_s < 1$, respectively.

Table motion commands are input in the inertial coordinate system and are transformed to commands to the six actuators as follows:

Define $\left[A_c\right]$ as the [A] matrix with the angles θ, ψ, ϕ replaced with the commanded Euler angles θ_c, ψ_c, ϕ_c. Then the commanded inertial components

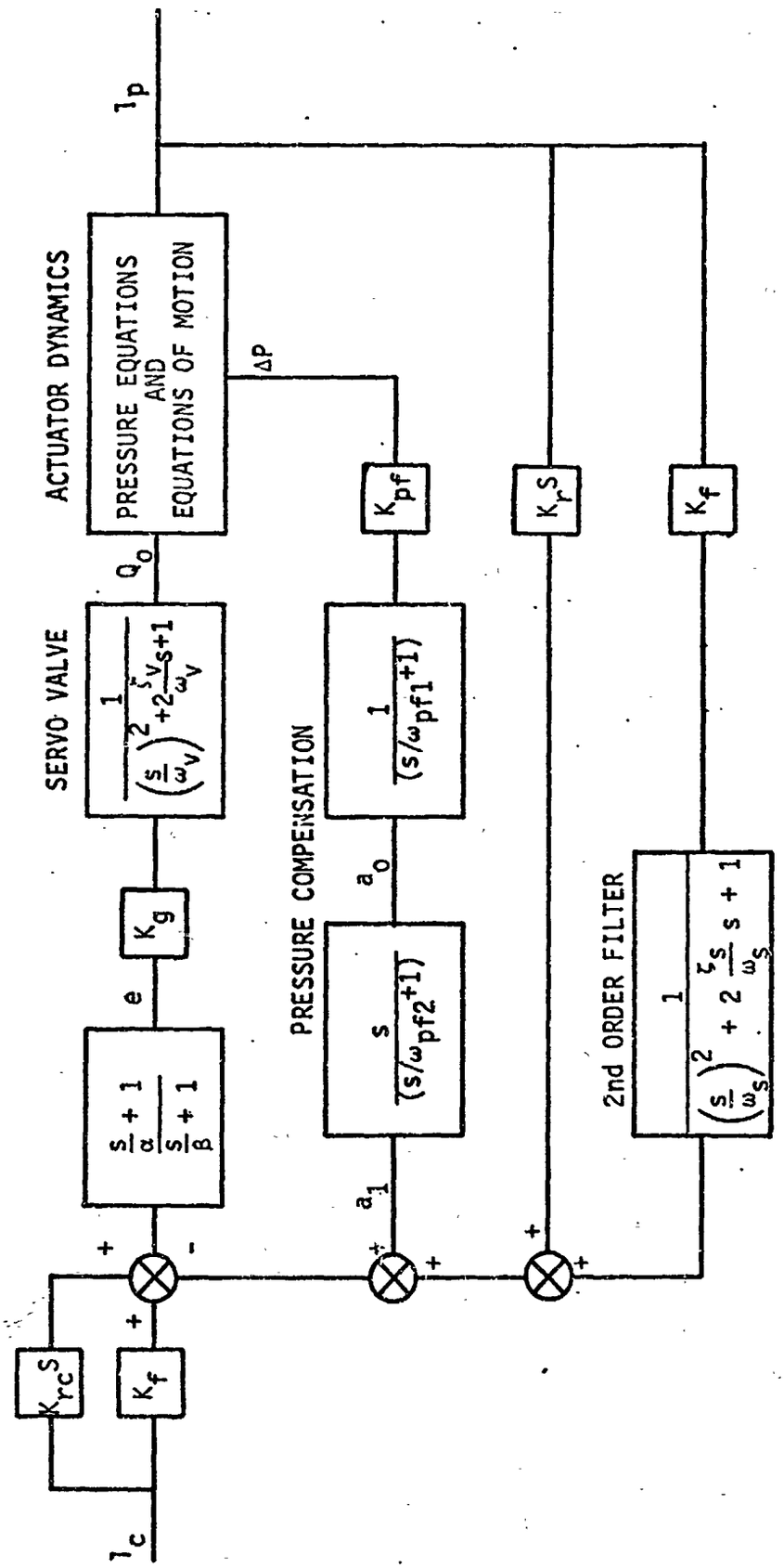


Figure 4. Servo Electronics Block Diagram

2.3 (Continued)

of actuator length are:

$$\begin{Bmatrix} r_{s_{x_i}} \\ r_{s_{y_i}} \\ r_{s_{z_i}} \end{Bmatrix} = \begin{Bmatrix} x_{I_c} \\ y_{I_c} \\ z_{I_c} \end{Bmatrix} + \left[A_c\right] \begin{Bmatrix} r_{xa_i} \\ r_{ya_i} \\ r_{za_i} \end{Bmatrix} - \begin{Bmatrix} 0 \\ y_{f_i} \\ z_{f_i} \end{Bmatrix} \tag{12}$$

and the commanded inertial velocities of the table/servo attachment points are:

$$\begin{Bmatrix} \dot{r}_{s_{x_i}} \\ \dot{r}_{s_{y_i}} \\ \dot{r}_{s_{z_i}} \end{Bmatrix} = \begin{Bmatrix} \dot{x}_{I_c} \\ \dot{y}_{I_c} \\ \dot{z}_{I_c} \end{Bmatrix} + \left[A_c\right] \begin{bmatrix} 0 & -\omega_{z_c} & \omega_{y_c} \\ \omega_{z_c} & 0 & -\omega_{x_c} \\ -\omega_{y_c} & \omega_{x_c} & 0 \end{bmatrix} \begin{Bmatrix} r_{xa_i} \\ r_{ya_i} \\ r_{za_i} \end{Bmatrix} \tag{13}$$

where:

$$\begin{Bmatrix} \omega_{x_c} \\ \omega_{y_c} \\ \omega_{z_c} \end{Bmatrix} = \begin{bmatrix} 1 & 0 & S\psi_c \\ 0 & S\phi_c & C\psi_c \cdot C\phi_c \\ 0 & C\phi_c & -C\psi_c \cdot S\phi_c \end{bmatrix} \begin{Bmatrix} \dot{\phi}_c \\ \dot{\psi}_c \\ \dot{\theta}_c \end{Bmatrix} \tag{14}$$

Then the commanded actuator lengths and velocities are:

$$l_{c_i} = \sqrt{r_{s_{x_i}}^2 + r_{s_{y_i}}^2 + r_{s_{z_i}}^2} \tag{15}$$

$$\dot{l}_{c_i} = \frac{1}{l_{c_i}} \left[r_{s_{x_i}} \cdot \dot{r}_{s_{x_i}} + r_{s_{y_i}} \cdot \dot{r}_{s_{y_i}} + r_{s_{z_i}} \cdot \dot{r}_{s_{z_i}} \right] \tag{16}$$

3.0 INPUT/OUTPUT DESCRIPTION

3.1 INPUT DESCRIPTION AND PREPARATION

Card 1 Format 13A6,A2

TITLE

TITLE - 80-character title to be printed on the top of the first page of output

INERTIA AND GEOMETRY DATA

Card 2 Format E12.6

MT

MT - Table mass

Card 3 Format 6E12.6

(INER(I),I=1,6)

INER - Table moments and products of inertia

(1) - I_{xx}

(2) - I_{yy}

(3) - I_{zz}

(4) - I_{xy}

(5) - I_{xz}

(6) - I_{yz}

Card 4 Format E12.6

RXA

RXA - X table station of actuator swivel joints w.r.t. table c.g.

3.1 (Continued)

Card 5 Format 6E12.6

((RYZA(J,I),J=1,2),I=1,6)

RYZA(1,I) - y-table coordinate of I'th swivel joint w.r.t. table c.g.

RYZA(2,I) - Z-table coordinate of I'th swivel joint w.r.t. table c.g.

Card 6 Format 6E12.6

((YZF(J,I),J=1,2),I=1,6)

YZF(1,I) - y-inertial coordinate of I'th floor swivel joint

YZF(2,I) - Z-inertial coordinate of I'th floor swivel joint

ACTUATOR STRUCTURAL DATA

Card 7 Format 6E12.6

ZETAE,MP,IAC,LC,LR,LO,EIR,LPM

ZETAE - Actuator bending damping constant

MP - Mass of rod and piston

IAC - Moment of inertia of cylinder about floor swivel joint

LC - Distance from floor swivel to center line of piston rod seal at end of cylinder

LR - Length of piston rod

LO - Retracted length of actuator

EIR - Bending modulus of piston rod

LPM - Maximum stroke of actuator

Note: The data above occupy two cards.

3.1 (Continued)

FORCING FUNCTION DATA

Card 8 Format 6E12.6

(TCGCO(I),I=1,3),(TEAO(I),I=1,3)

TCGCO - Initial inertial coordinates of table c.g.

TEAO - Initial Euler angles of table coordinate system w.r.t. inertial system (rad.)

Card 9 Format 4I4

IM,NFREQ,IXF,NFFREQ

IM - Mass matrix and geometry update option
= 0, do not update after initialization
= 1, update throughout time span

NFREQ - Number of displacement frequency cases to run (max. = 18) (see note after Card 11)

IXF - External force and moment option
= 0, no external forces or moments
= 1, constant external forces and moments are to be applied to the table c.g.
= 2, external forces and moments are sinusoidal

NFFREQ- Number of external force and moment frequencies (max. = 18)

Card 10 Format 6E12.6

(OMEGAC(I),I=1,NFREQ)

OMEGAC - Displacement command signal frequency (rad./sec.) If OMEGAC(I) < 0, the command amplitudes (Card 11) are assumed to be step velocities.

Card 11 Format 6E12.6

(DLTAI(I),I=1,6)

3.1 (Continued)

DLTAI - Sinusoidal amplitudes of X, Y and Z commands for table c.g., displacement and table Euler angles, θ, ψ and ϕ (if OMEGAC > 0) or step velocities (if OMEGAC < 0)

Note: Due to the interaction of Cards 10 and 11, it is logical that if one OMEGAC(I) is less than or equal to zero they must all be. Therefore, it is logical that NFREQ should be only one in that case.

If IXF=0, skip the next two cards

Card 12 Format 6E12.6

(FMEXT(I),I=1,6)

FMEXT - Magnitude of external forces and moments applied to the table c.g.

If IXF=1, skip the next card

Card 13 Format 6E12.6

(OMEGAF(I),I=1,NFFREQ)

OMEGAF = Frequencies of sinusoidal external forces and moments (rad./sec.)

HYDRAULICS DATA

Card 14 Format 3E12.6

PS,BETAE,KC

PS - Supply pressure

BETAE - Equivalent system bulk modulus

KC - Valve pressure flow coefficient

Card 15 Format 6E12.6

(CP(I),I=1,6),(BP(I),I=1,6)

3.1 (Continued)

CP - Leakage coefficient across piston seals for each actuator

BP - Actuator viscous damping coefficient for each actuator

Note: The data above occupy two cards.

Card 16 Format 4E12.6

(A(I),I=1,2) (VO(I),I=1,2)

A - Actuator push and pull stroke working areas

VO - Initial hydraulic volumes of fully retracted actuator

Card 17 Format 6E12.6

(FF(I),I=1,6)

FF - Coulomb friction force of each actuator

ELECTRONICS DATA

Card 18 Format 6E12.6

(KG(I),I=1,6)

KG - Electronics and valve forward loop gain

Card 19 Format 6E12.6

(KF(I),I=1,6)

KF - Displacement feedback and command gain

Card 20 Format 6E12.6

(KR(I),I=1,6)

KR - Velocity feedback loop gain

Card 21 Format 6E12.6

(KPF(I),I=1,6)

KPF - Pressure feedback loop gain

3.1 (Continued)

Card 22 Format 6E12.6

(KRC(I),I=1.6)

KRC - Velocity command gain

Card 23 Format 4E12.6

ALPHA,BETA,(OMEGPF(I),I=1,2)

ALPHA - α

BETA - β

OMEGPF ω_{PF1} and ω_{PF2}

} Break frequencies of first order filters (rad./sec.)

Card 24 Format 6E12.6

ZETAS,OMEGAS,ZETAV,OMEGAV

ZETAS - Damping constant of second order filter on displacement and velocity feedbacks

OMEGAS - Frequency of the displacement and velocity feedback filter (rad./sec.)

ZETAV - Damping constant of valve dynamics

OMEGAV - Frequency of the valve dynamics (rad./sec.)

INTEGRATION CONTROL DATA

Card 25 Format 4E12.6,2I5

TSTART,TEND,(OUTFRQ(I),I=1,2),IPROPT,IPLOPT

TSTART - Start time

TEND - Stop time

OUTFRQ(1) - Output frequency for printing (Δt, sec.)

OUTFRQ(2) - Output frequency for plotting (Δt, sec.)

3.1 (Continued)

IPROPT - Print option

IPLOPT - Plot option

Note: IPROPT and IPLOPT are of the form $I_1I_2I_3I_4$ where I_i is the group number of the i'th group of data to be printed. These groups are explained in the next paragraph, Output Description.

Cards 1 through 25 may be repeated as many times as desired.

3.2 OUTPUT DESCRIPTION

The output includes printed listings and plots of responses versus time. These responses are divided into four groups:

Group 1 - Table Response Data

a. Incremental inertial motions of the table c.g.
b. Incremental angular motions
c. Incremental velocities of the table c.g.
d. Euler angle rates
e. Table position errors

Group 2 - Actuator Bending Data

a. Bending frequencies of the actuators
b. Y and Z lateral elastic displacements at cylinder rod seal

Group 3 - Actuator Responses

a. Actuator strokes
b. Actuator velocities
c. Actuator position error
d. Net forces on the actuator pistons

3.2 (Continued)

Group 4 - Complete Derivative and Variable Arrays (may not be plotted)

The variables and their derivatives (indexed by row) are listed below.

Index	Derivative	Variable	Variable Definition
1	$\ddot{x}_T$	$\dot{x}_T$	Table c.g. velocities
2	$\ddot{y}_T$	$\dot{y}_T$	
3	$\ddot{z}_T$	$\dot{z}_T$	
4	$\dot{\omega}_x$	ω_x	Table rotational rates
5	$\dot{\omega}_y$	ω_y	
6	$\dot{\omega}_z$	ω_z	
7	$\ddot{y}_{e_1}$	$\dot{y}_{e_1}$	Lateral bending velocities of actuator along y_{s_i} axis
⋮	⋮	⋮	
12	$\ddot{y}_{e_6}$	$\dot{y}_{e_6}$	
13	$\ddot{z}_{e_1}$	$\dot{z}_{e_1}$	Lateral bending velocities along z_{s_i} axis
⋮	⋮	⋮	
18	$\ddot{z}_{e_6}$	$\dot{z}_{e_6}$	
19	$\dot{x}_I$	x_I	Inertial displacements of table c.g.
20	$\dot{y}_I$	y_I	
21	$\dot{z}_I$	z_I	
22	$\dot{\theta}$	θ	Table Euler angles
23	$\dot{\psi}$	ψ	
24	$\dot{\phi}$	ϕ	
25	$\dot{y}_{e_1}$	y_{e_1}	Bending deflections of actuators at top of cylinder
⋮	⋮	⋮	
30	$\dot{y}_{e_6}$	y_{e_6}	

3.2 (Continued)

Index	Derivative	Variable	Variable Definition
31	$\dot{z}_{e_1}$	z_{e_1}	Bending deflections of actuators at top of cylinder
⋮	⋮	⋮	
36	$\dot{z}_{e_6}$	z_{e_6}	
37	$\dot{P}_{1_1}$	P_{1_1}	"Push" hydraulic pressure on actuator pistons
⋮	⋮	⋮	
42	$\dot{P}_{1_6}$	P_{1_6}	
43	$\dot{P}_{2_1}$	P_{2_1}	"Pull" hydraulic pressure on actuator pistons
⋮	⋮	⋮	
48	$\dot{P}_{2_6}$	P_{2_6}	
49	$\ddot{Q}_{o_1}$	$\dot{Q}_{o_1}$	Derivatives of no-load valve flow
↓	↓	↓	
54	$\ddot{Q}_{o_6}$	$\dot{Q}_{o_6}$	
55	$\dot{Q}_{o_1}$	Q_{o_1}	No-load valve flow
↓	↓	↓	
60	$\dot{Q}_{o_6}$	Q_{o_6}	
61	$\ddot{x}_{s_1}$	$\dot{x}_{s_1}$	Filtered actuator feedback velocities from second order filter
↓	↓	↓	
66	$\ddot{x}_{s_2}$	$\dot{x}_{s_2}$	
67	$\dot{x}_{s_1}$	x_{s_1}	Filtered feedback displacements from second order filter
↓	↓	↓	
72	$\dot{x}_{s_6}$	x_{s_6}	

3.2 (Continued)

Index	Derivative	Variable	Variable Definition
73	$\dot{a}_{o_1}$	a_{o_1}	Voltage output of first order lag filter in pressure feedback
↓	↓	↓	
78	$\dot{a}_{o_6}$	a_{o_6}	
79	$\dot{a}_{1_1}$	a_{1_1}	Voltage output of high pass filter in pressure feedback
↓	↓	↓	
84	$\dot{a}_{1_6}$	a_{1_6}	
85	$\dot{e}_1$	e_1	Voltage output of forward loop compensation filters
↓	↓	↓	
90	$\dot{e}_6$	e_6	

3.3 ERROR MESSAGES

a. "THE INTEGRATION HAS FAILED AT T = XX.XXXX. ABORT AND GO TO NEXT CASE." - occurs if for some reason the integration procedure cannot continue. The program will abort the case and attempt to process another one.

b. "ACTUATOR XXX HAS STROKED OUT...ABORT AND GO TO NEXT CASE." - occurs when an actuator has exceeded the maximum stroke. The program will abort the case and attempt to process another.

c. "ERROR WHILE INVERTING MASS MATRIX...GO TO NEXT CASE." - is self-explanatory. The user should look for errors in input which may cause a singular or ill-conditioned mass matrix.

d. There are also several error messages output by the integration routine. When one of these messages occurs, it is likely that an instability has occurred in the hydraulics or electronics caused by improper data.

4.0 OPERATING INFORMATION

4.1 PROGRAM AND DATA SETUP

The program may be input via standard EXEC II control cards on source or relocatable decks. All data for the program are input on cards.

4.2 RUN INFORMATION

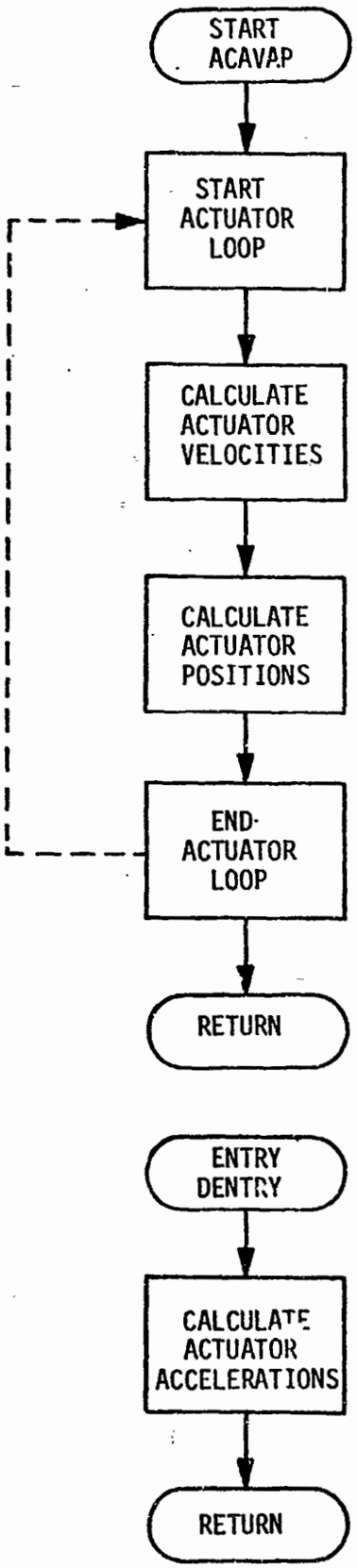
Compilation time for the program is about 40 seconds. Representative runs of about one second of simulation time have averaged approximately 8 minutes. Run time depends greatly upon the frequency of the hydraulics and electronics inputs.

5.0 PROGRAMING INFORMATION

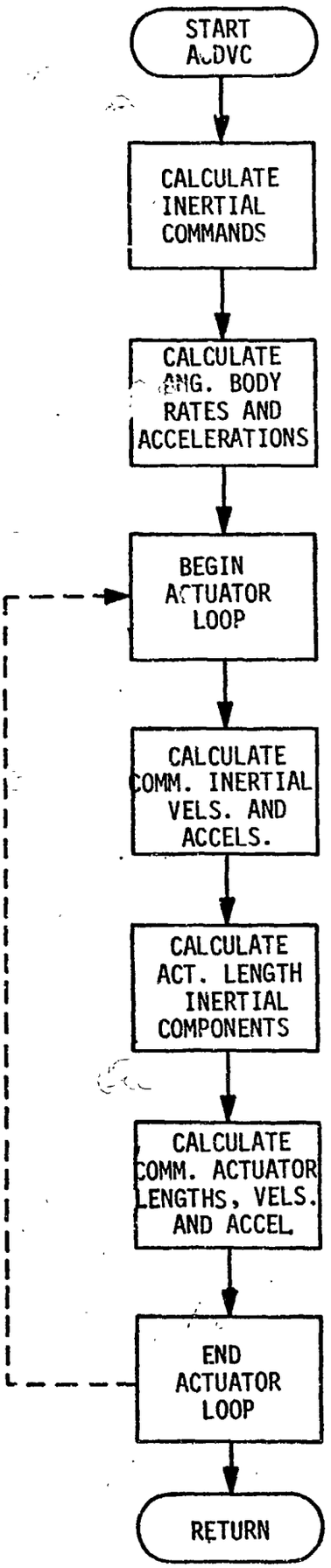
5.1 FLOW CHARTS

Program flow charts are shown on the following pages.

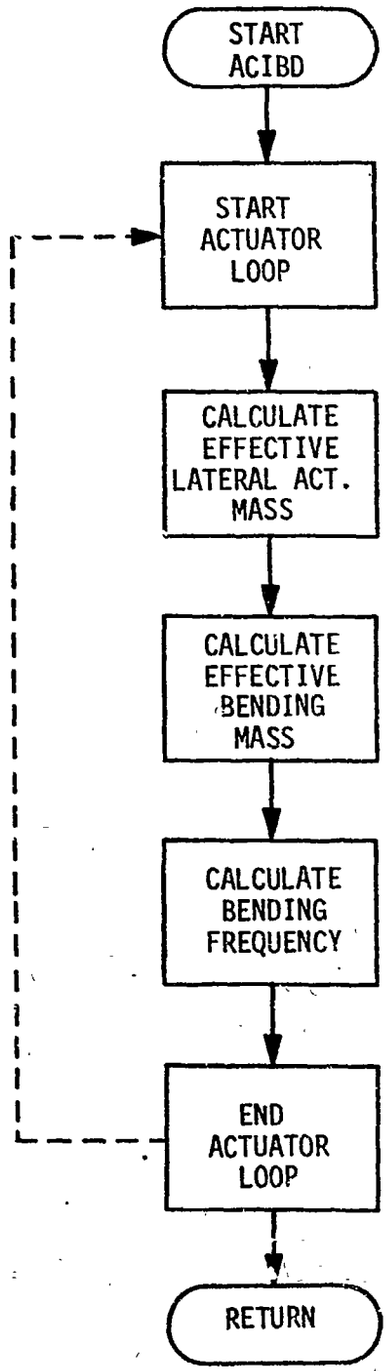
ACAVAP: Actual Actuator Positions, Velocities, and Accelerations



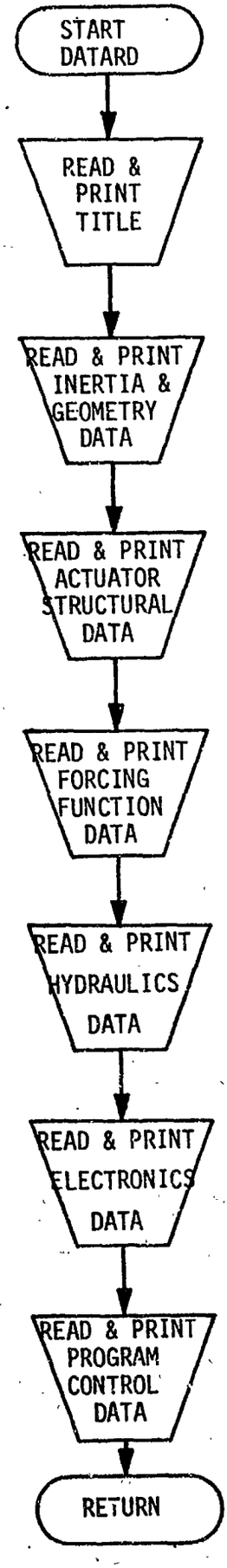
ACDVC: Actuator Displacement, Velocity, and Acceleration Commands



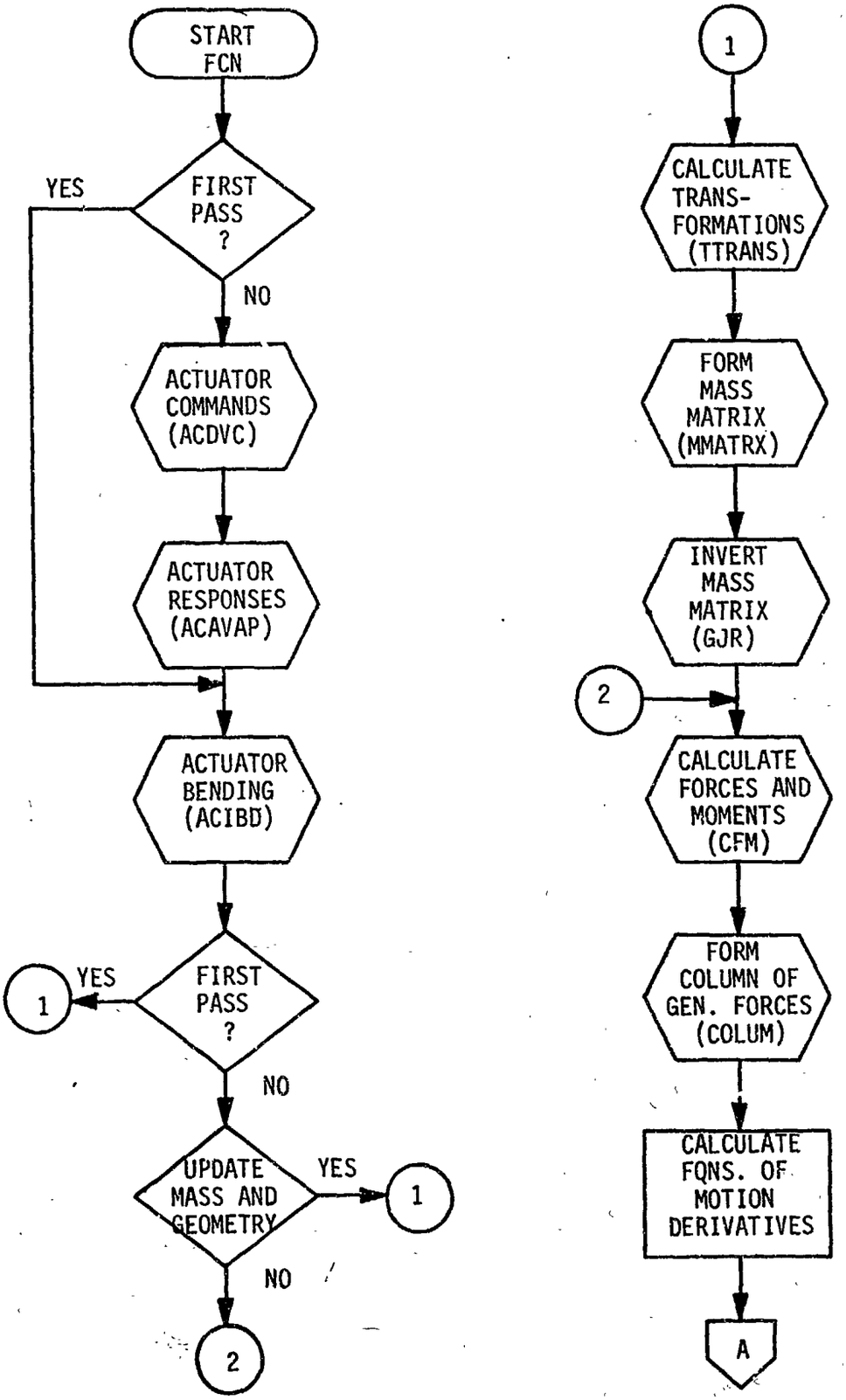
ACIBD: Actuator Inertia and Bending Dynamics Parameters



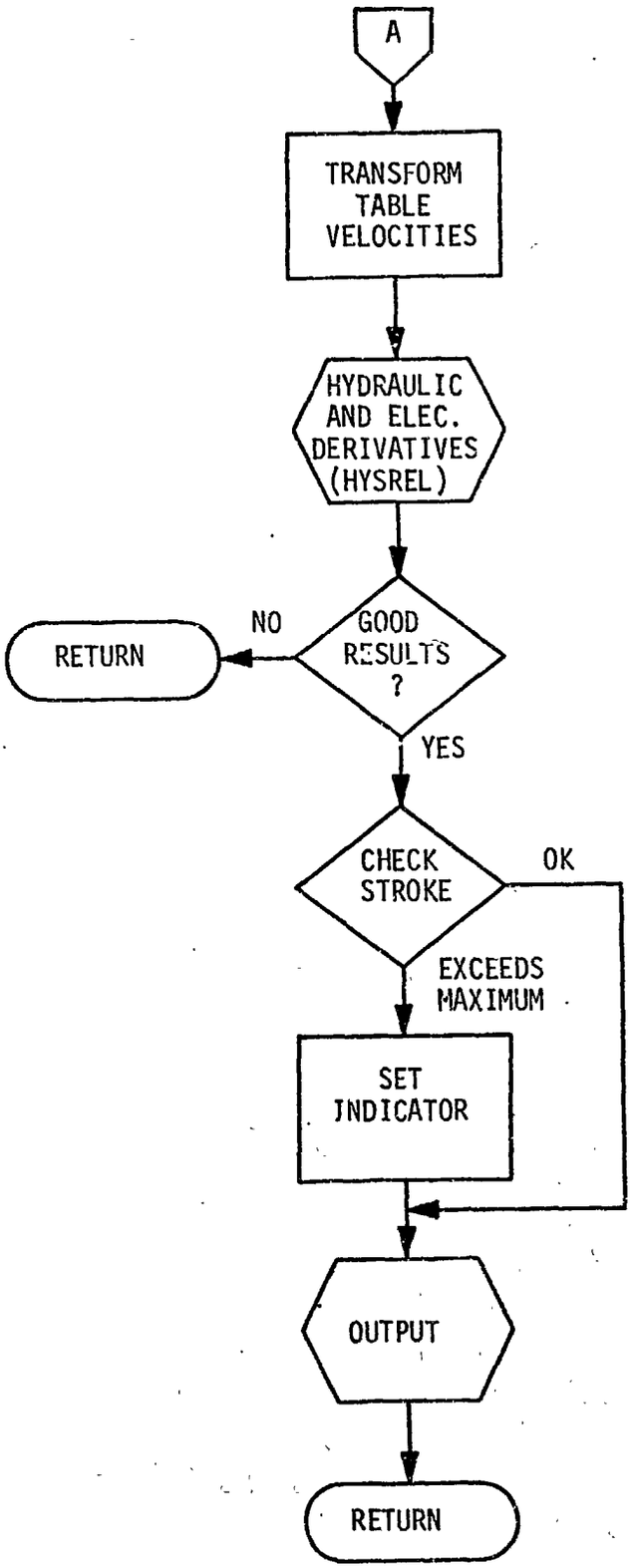
DATARD: Data Input Routine



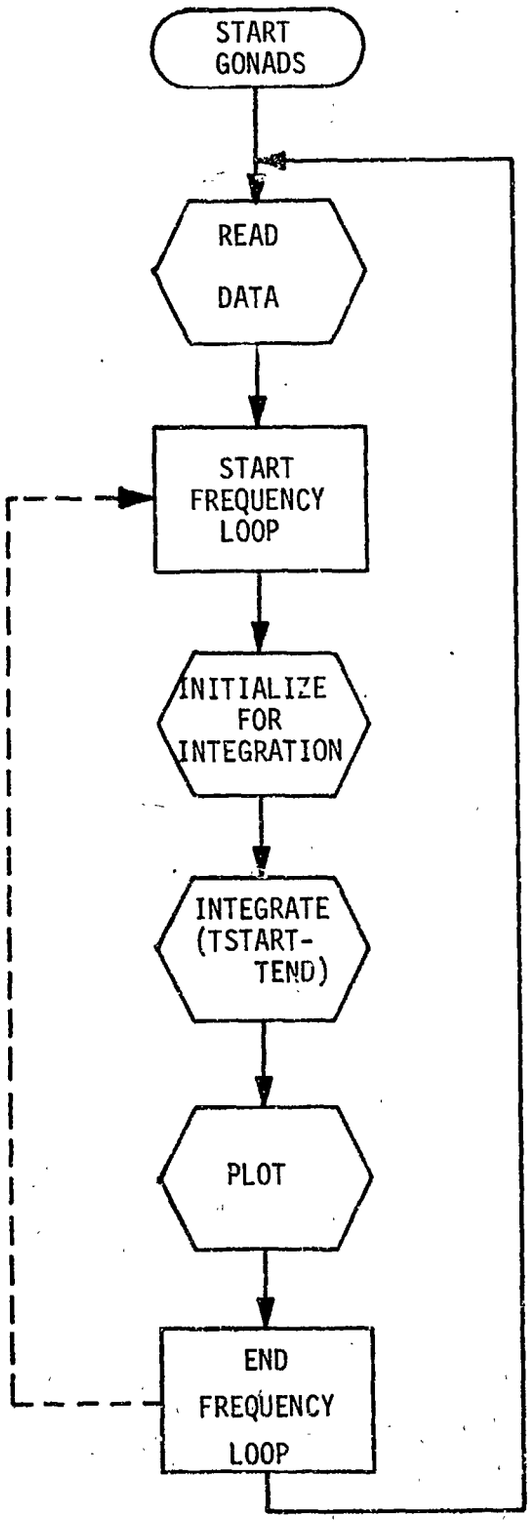
FCN: Derivative Evaluation Control Routine



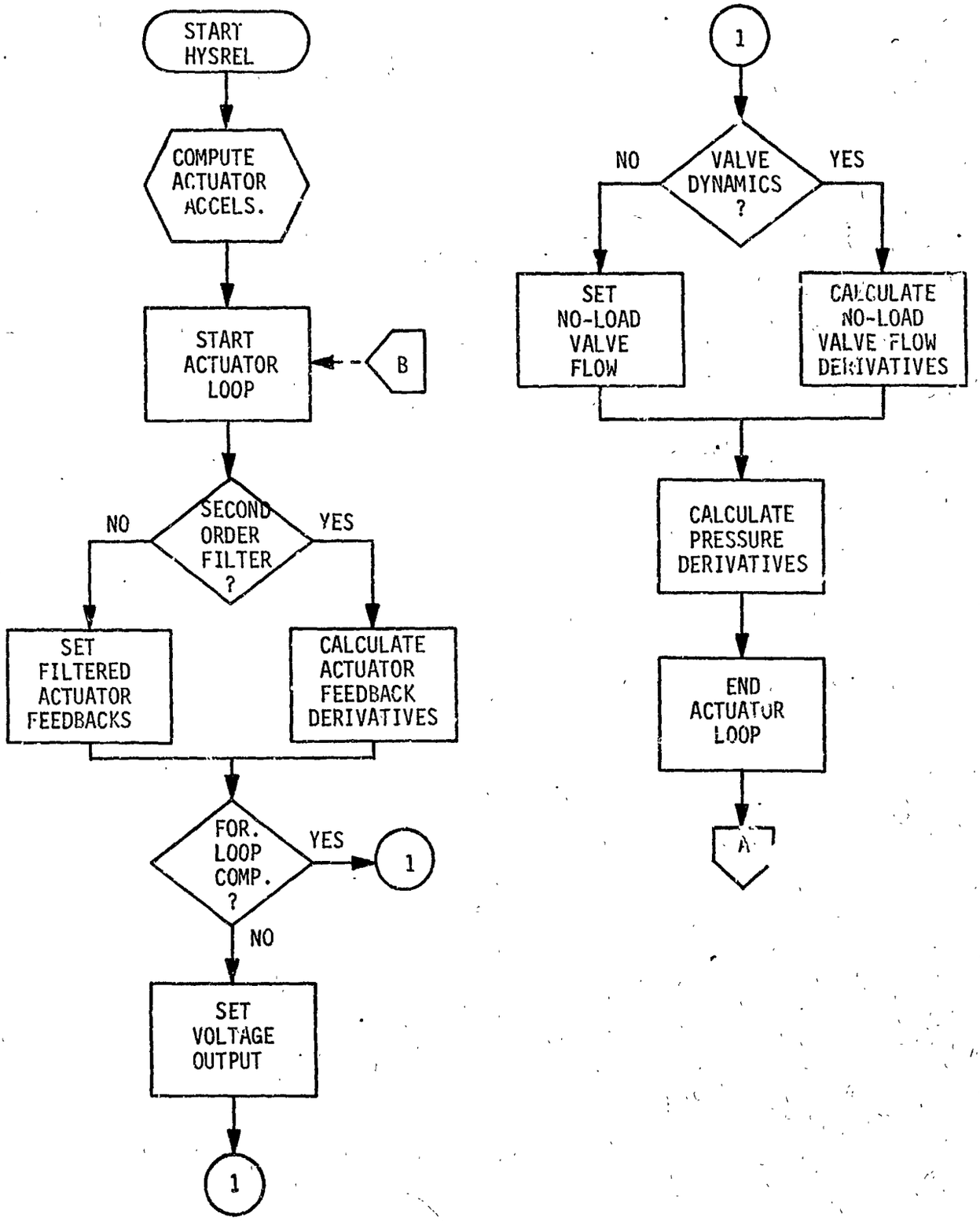
FCN (continued)



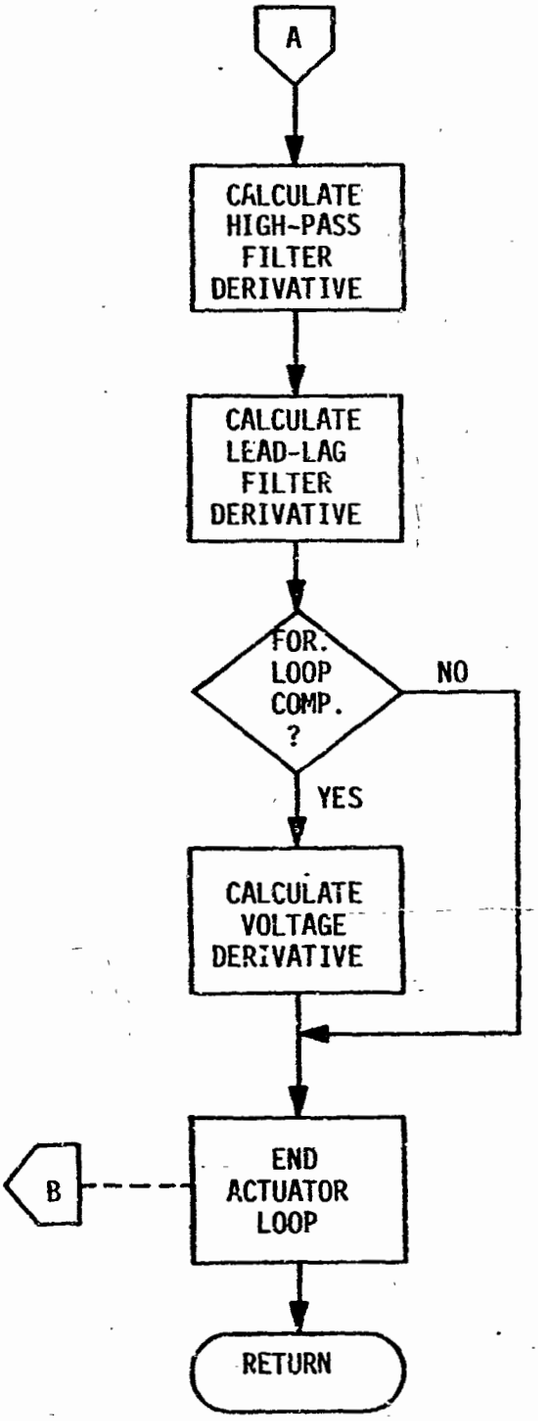
GONADS: Main Control Routine



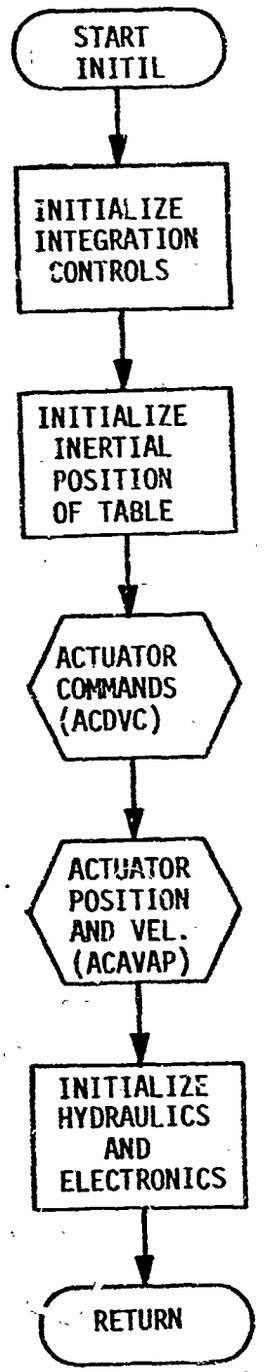
HYSREL: Hydraulic and Servo Electronic Derivatives



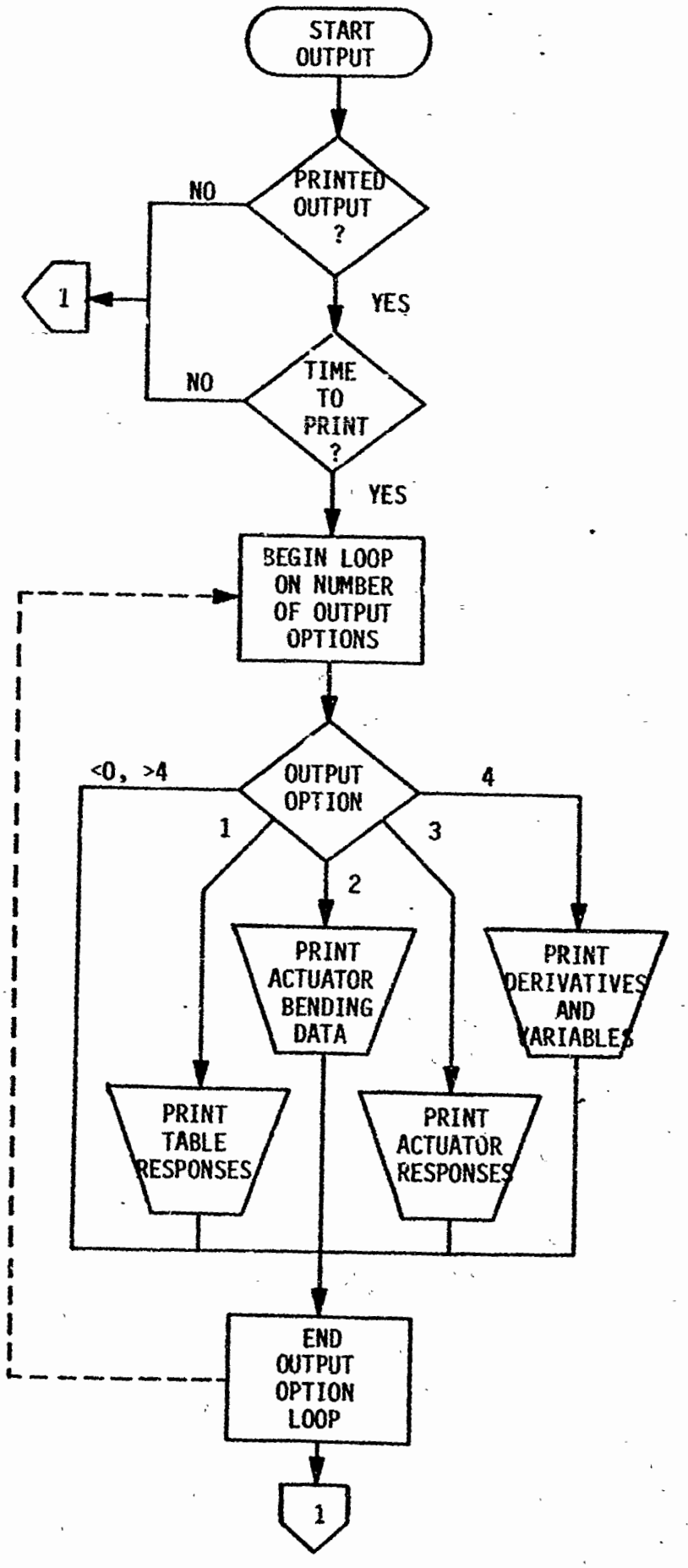
HYSREL (continued)



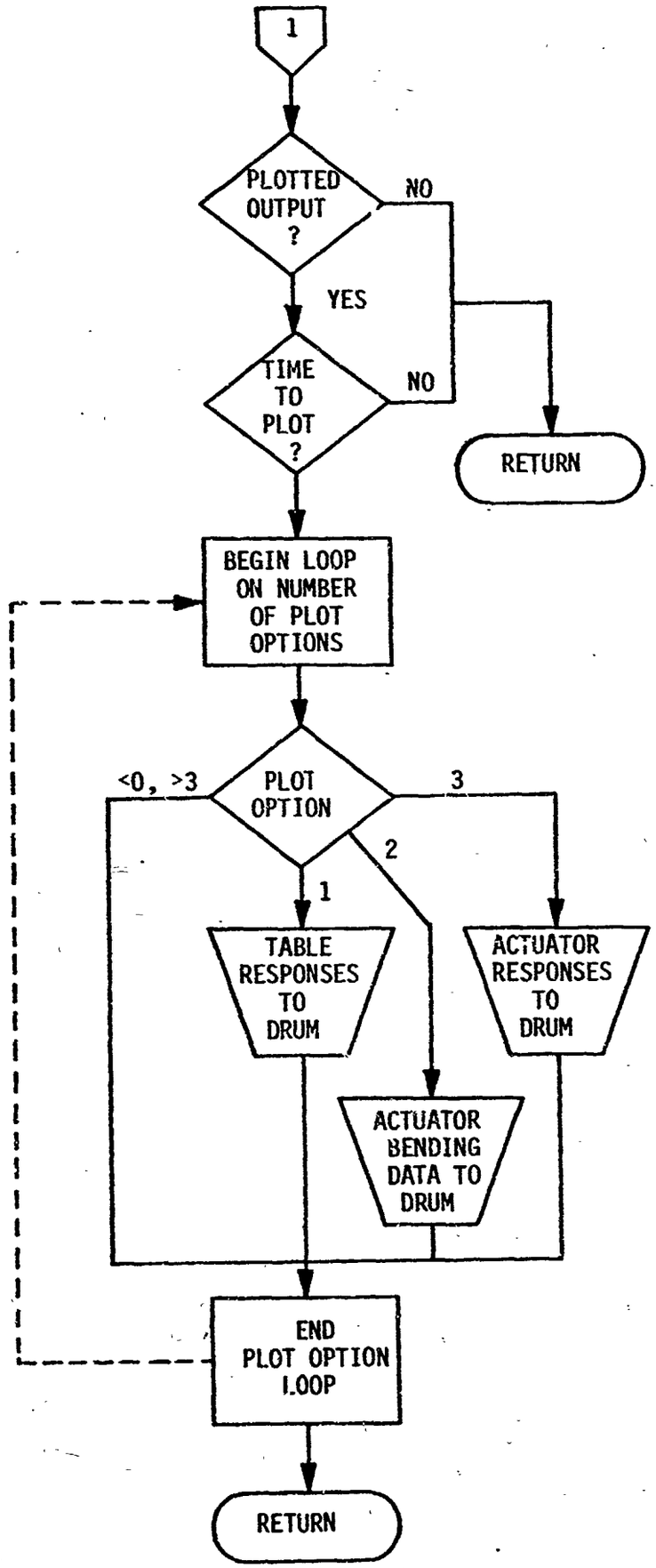
INITIL: Initialization Routine



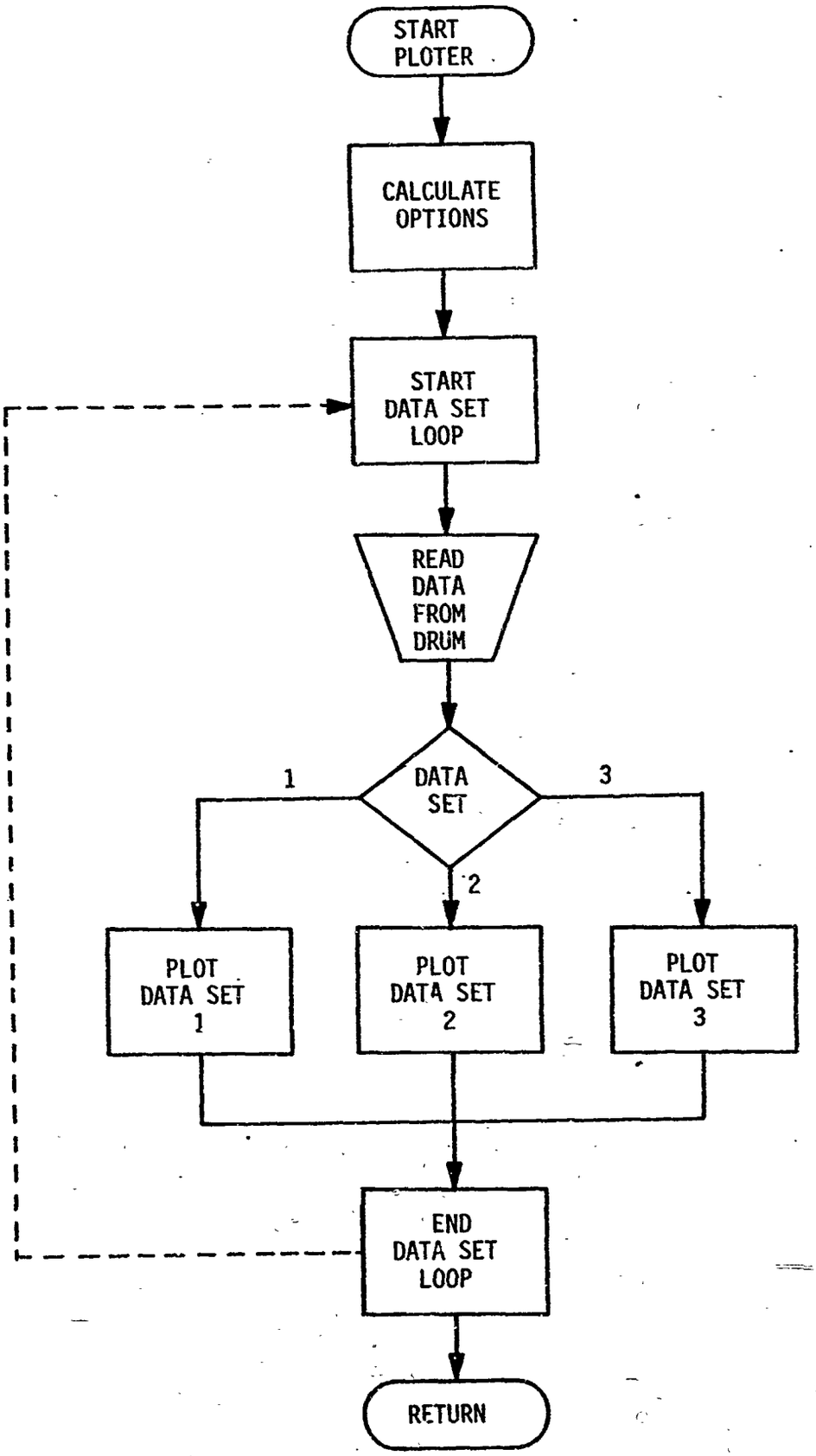
OUTPUT: Print and Write Output on Drum for Plots



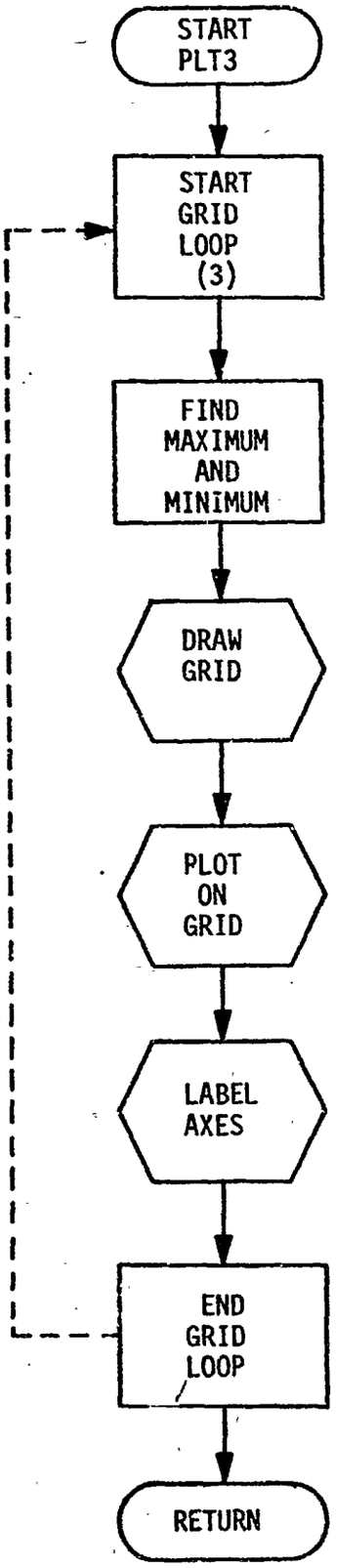
OUTPUT (continued)



PLOTER: Plot Control Routine



PLT3: Routine to Form Three Plots per Frame



5.2 SYSTEM STRUCTURE

No overlay structure is required for this program.

5.3 LIBRARY SUBROUTINES

Several routines from the Johnson Space Center plotting library are used. These routines and their functions are:

FILMAV - advances the film
GRDSET - sets line intensities
GRID - forms a grid
PLOTIV - plots an array of points
PRINT - prints axis titles.

These routines may not be available at another location; in which case, the best action would likely be to substitute routines with the same functions rather than obtaining these routines from the JSC library.

5.4 PROGRAM LISTING

A complete program listing is shown on the following pages.

```
                                                              29 JUN 74                5 35: 3.193
                                                                                       5:35: 3.45
B  XQT CUR                                                                             5:35: 7.193
   1.   IN B
     END OF FILE -- UNIT B
   2.   TOC
                                   ELEMENT TABLE
                                        15 AUG 73  15:49:26   0  01436670  14   32
                                        15 AUG 73  15:49:26   1  01437570  60    1
                                                              0  01437664  14   26
   CHKOUT           SYMBOLIC                                  0  01440440  14   28
   CHKOUT   CODE    RELOCATABLE         15 AUG 73  15:49:28   1  01441250  24    1
                                        15 AUG 73  15:49:28   0  01441300  14   12
                                                              0  01441550  14   20
   TYRANS           SYMBOLIC                                  1  01442200  24    1
   TYRANS   CODE    RELOCATABLE         15 AUG 73  15:49:29   0  01442230  14    9
                                        15 AUG 73  15:49:29   0  01442426  14    9
   AMATRX           SYMBOLIC                                  1  01442624  24    1
   AMATRX   CODE    RELOCATABLE         15 AUG 73  15:49:31   0  01442654  14    7
                                        15 AUG 73  15:49:31   0  01443016  14    7
   M3X3             SYMBOLIC                                  1  01443160  24    1
   M3X3     CODE    RELOCATABLE         15 AUG 73  15:49:32   0  01443210  14    4
                                        15 AUG 73  15:49:32   0  01443300  14   41
   CROSS            SYMBOLIC                                  1  01444376  36    1
   CROSS    CODE    RELOCATABLE         15 AUG 73  15:49:35   0  01444442  14   18
                                        15 AUG 73  15:49:35   0  01445036  14   22
   ACAVAP           SYMBOLIC                                  1  01445522  36    1
   ACAVAP   CODE    RELOCATABLE         15 AUG 73  15:49:37   0  01445566  14   11
                                        15 AUG 73  15:49:37   0  01446020  14   99
   ACIBD            SYMBOLIC                                  1  01450572  48    1
   ACIBD    CODE    RELOCATABLE         15 AUG 73  15:49:46   0  01450652  14   32
                                        15 AUG 73  15:49:46   0  01451552  14   24
   MMATRX           SYMBOLIC                                  1  01452272  24    1
   MMATRX   CODE    RELOCATABLE         15 AUG 73  15:49:48   0  01452322  14   17
                                        15 AUG 73  15:49:48   0  01452700  14  132
   PLT3             SYMBOLIC                                  1  01456370  36    1
   PLT3     CODE    RELOCATABLE         15 AUG 73  15:49:51   0  01456434  14   77
                                        15 AUG 73  15:49:51   0  01460522  24    1
   PLOTER           SYMBOLIC                                  0  01460552  14   44
   PLOTER   CODE    RELOCATABLE         11 DEC 72  18:19:59   1  01461722  24    1
                                                              0  01461752  14    5
   GJR      CODE    RELOCATABLE         15 AUG 73  15:49:53   0  01462060  14   46
                                                              1  01463264  48    1
   RKINIT   CODE    RELOCATABLE         16 AUG 73  13:39:12   0  01463344  14   13
                                        16 AUG 73  13:39:12   0  01463632  14  116
   COLUM            SYMBOLIC                                  1  01466762  60    1
   COLUM    CODE    RELOCATABLE         05 SEP 73  14:21:12   0  01467056  14   56
                                        05 SEP 73  14:21:12   0  01470476  14   72
   OUTPUT           SYMBOLIC                                  1  01472456  48    1
   OUTPUT   CODE    RELOCATABLE         05 SEP 73  14:21:16   0  01472536  14   23
                                        05 SEP 73  14:21:16   0  01473240  14  361
   HYSREL           SYMBOLIC                                  1  01505136  36    1
   HYSREL   CODE    RELOCATABLE         05 SEP 73  14:21:21   0  01505202  14   97
                                        05 SEP 73  14:21:21   0  01507720  14   26
   NRKVS            SYMBOLIC                                  1  01510474  36    1
   NRKVS    CODE    RELOCATABLE         28 JAN 74  23:27:16   0  01510540  14    9
                                        28 JAN 74  23:27:16   0  01510736  14   78
   GONADS           SYMBOLIC
   GONADS   CODE    RELOCATABLE         28 JAN 74  23:27:18
   FCN              SYMBOLIC
```

FCN	CODE	RELOCATABLE	28 JAN 74 23:27:18	1	01513042	72	1
				0	01513152	14	29
INITIL		SYMBOLIC	28 JAN 74 23:27:19	0	01513672	14	43
INITIL	CODE	RELOCATABLE	28 JAN 74 23:27:19	1	01515024	60	1
				0	01515120	14	16
CFM		SYMBOLIC	28 JAN 74 23:27:24	0	01515460	14	45
CFM	CODE	RELOCATABLE	28 JAN 74 23:27:24	1	01516646	48	1
				0	01516726	14	15
ACDVC		SYMBOLIC	28 JAN 74 23:27:26	0	01517250	14	86
ACDVC	CODE	RELOCATABLE	28 JAN 74 23:27:26	1	01521534	48	1
				0	01521614	14	31
DATARD		SYMBOLIC	31 JAN 74 21:52:34	0	01522476	14	156
DATARD	CODE	RELOCATABLE	31 JAN 74 21:52:34	1	01526706	48	1
				0	01526766	14	102

ENTRY POINT TABLE

ACAVAP	(ACAVAP/CODE)	1	000225	ACDVC	(ACDVC/CODE)	1	000411	ACIBD	(ACIBD/CODE)	1	000117
AMATRX	(AMATRX/CODE)	1	000107	CFM	(CFM/CODE)	1	000164	CHKOUT	(CHKOUT/CODE)	1	000244
COLUM	(COLUM/CODE)	1	000145	CROSS	(CROSS/CODE)	1	000036	DATARD	(DATARD/CODE)	1	001047
DENTRY	(ACAVAP/CODE)	1	000230	FCN	(FCN/CODE)	1	000254	GJR	(GJR/CODE)	1	000616
MYSREL	(MYSREL/CODE)	1	000302	INITIL	(INITIL/CODE)	1	000116	MMATRX	(MMATRX/CODE)	1	000437
M3X3	(M3X3/CODE)	1	000047	NRKVS	(NRKVS/CODE)	1	001360	OUTPUT	(OUTPUT/CODE)	1	000641
PLOTER	(PLOTER/CODE)	1	000772	PLT3	(PLT3/CODE)	1	000163	RKINIT	(RKINIT/CODE)	1	000033
TTRANS	(TTRANS/CODE)	1	000127								

BLOCK TABLE EMPTY

COBOL LIBRARY TABLE EMPTY

PROCEDURE NAME TABLE EMPTY

3, TRI 8 5:35: 7.303

END CUR LCC 1102-039C L9

```
                                                                29 JUN 74          5:35: 7.423

@ FOR,* ACAVAP;ACAVAP
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  -(EXEC8 LEVEL E)2010010A)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:07

   SUBROUTINE ACAVAP     ENTRY POINT 000225
              DENTRY     ENTRY POINT 000230

   STORAGE USED: CODE(1) 000233; DATA(0) 000057; BLANK COMMON(2) 000000

   COMMON BLOCKS:

   0003   TRANS   000006
   0004   NRKVSI  000265
   0005   ACLVA   000044
   0006   INGEOD  000090

   EXTERNAL REFERENCES (BLOCK, NAME)

   0007   AMATRX
   0010   CROSS
   0011   SQRT
   0012   NERR38

   STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0001   000016 15G      0001   000032 122G     0001   000050 132G     0001   000053 134G     0001   000132 153G
   0001   000140 162G     0000 R 000003 A        0005 R 000014 AA       0005 R 000000 AL       0005 R 000006 AV
   0000 I 000026 I        0006   000001 INER     0000   000034 INJPS    0000 I 000027 J        0000 I 000025 L
   0006   000000 MT       0000 R 000017 R        0000 R 000000 RAD      0000 R 000014 RADD     0005 R 000022 RS
   0006 R 000007 RXA      0006 R 000010 RYZA     0003 R 000000 T        0004   000000 TIME     0000 R 000022 V
   0004 R 000001 X        0004 R 000133 XDOT     0006 R 000024 YZF

00101    1*            SUBROUTINE ACAVAP
00101    2*      C
00101    3*      C     ROUTINE TO COMPUTE THE ACTUAL ACTUATOR VELOCITIES, ACCELERATIONS,
00101    4*      C       AND POSITIONS
00101    5*      C
00103    6*            COMMON / TRANS/ T(6,3,3)
00104    7*            COMMON /NRKVSI/ TIME,X(90),XDOT(90)
00105    8*            COMMON /ACLVA / AL(6),AV(6),AA(6),RS(3,6)
00106    9*            COMMON /INGEOD/ MT,INER(6),RXA,RYZA(2,6),YZF(2,6)
00107   10*            DIMENSION RADD(3),A(3,3),RADD(3),R(3),V(3)
00110   11*            CALL AMATRX(A)
00111   12*            R(1) = RXA
00112   13*            DO 50 L=1,6
00115   14*            R(2) = RYZA(1,L)
00116   15*            R(3) = RYZA(2,L)
00117   16*            CALL CROSS(X(4),R,RAD)
00120   17*            AV(L) = 0.
00121   18*            DO 20 I=1,3
00124   19*         20 AV(L) = AV(L)+(X(I)+RAD(I))*T(L,I,1)
```

```
00126    20*          V(1) = 0.
00127    21*          V(2) = YZF(1,L)
00130    22*          V(3) = YZF(2,L)
00131    23*          DO 40 I=1,3
00134    24*          RS(I,L) = 0.
00135    25*          DO 30 J=1,3
00140    26*       30 RS(I,L) = RS(I,L)+A(I,J)*R(J)
00142    27*       40 RS(I,L) = RS(I,L)+X(18*I)-V(I)
00144    28*          AL(L) = SQRT(RS(1,L)**2+RS(2,L)**2+RS(3,L)**2)
00145    29*       50 CONTINUE
00147    30*          RETURN
00150    31*          ENTRY DENTRY
00151    32*          R(1) = RXA
00152    33*          DO 60 L=1,6
00155    34*          AA(L) = 0.
00156    35*          R(2) = RYZA(1,L)
00157    36*          R(3) = RYZA(2,L)
06160    37*          CALL CROSS(XDOT(4),R,RADD)
00163    38*          DO 60 I=1,3
00164    39*       60 AA(L) = AA(L)+(XDOT(I)+RADD(I))*T(I,1,1)
00167    40*          RETURN
00170    41*          END

      END OF COMPILATION:        NO  DIAGNOSTICS.

ACAVAP          SYMBOLIC     15 AUG 73  15:49:35   0  01443300   14   41  (DELETED)
ACAVAP  CODE    RELOCATABLE  15 AUG 73  15:49:35   1  01444376   36    1  (DELETED)
                                                    0  01444442   14   18
```

```
@ FOR,* ACDVC,ACDVC                                                    29 JUN 74          5:55:8.994
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  -(EXEC8 LEVEL X1201001OA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:09

    SUBROUTINE ACDVC     ENTRY POINT 00041

    STORAGE USED: CODE(1) 000430; DATA(0) 000105; BLANK COMMON(2) 000000

    COMMON BLOCKS:

      0003   FRCFND 000036
      0004   NRKVS1 000265
      0005   NTGRTD 000001
      0006   INGEOD 000040
      0007   ACDVAC 000047

    EXTERNAL REFERENCES (BLOCK, NAME)

      0010   CROSS
      0011   COS
      0012   SIN
      0013   SQRT
      0014   NERR$S

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

      0001   000006 116G      0001   000037 126G      0001   000175 186G      0001   000179 173G      0001   000221 203G
      0001   000243 212G      0001   000247 217G      0001   000304 233G      0001   000307 237G      0001   000346 251G
      0001   000017 SOL       0001   000054 SOL       0000 R 000000 AC        0007 R 000014 CAA       0007 R 000000 CAL
      0007 R 000004 CAV       0000 R 000035 CP        0000 R 000033 CS        0000 R 000031 CT        0003 R 000030 DLTAI
      0005 R 000000 FRQNCY    0000 I 000030 I         0006   000001 INER      0000   000054 NJPS      0000 I 000037 J
      0000 I 000010 L         0006   000000 MT        0007 R 000044 OC        0000 R 000011 OCD       0003   000006 OMEGAC
      0000 R 000019 R         0000 R 000025 RS        0000 R 000017 RSD       0000 R 000022 RSDD      0006 R 000007 RXA
      0006 R 000010 RYZA      0000 R 000036 SP        0000 R 000034 SS        0000 R 000032 ST        0000 R 000041 T
      0007 R 000022 TOIC      0004 R 000000 TIME      0003 R 000000 TPO       0000 R 000041 TV        0000 R 000044 TVD
      0004   000001 X         0004   000133 XDOT      0006 R 000024 YZF

    1*            SUBROUTINE ACDVC
    2*      C
    3*      C     ROUTINE TO COMPUTE ACTUATOR DISPLACEMENT AND VELOCITY COMMANDS
    4*      C
    5*            COMMON /FRCFND/ TPO(6),OMEGAC(18),DLTAI(6)
    6*            COMMON /NRKVS1/ TIME,X(90),XDOT(90)
    7*            COMMON /NTGRTD/ FRQNCY
    8*            COMMON /INGEOD/ MT,INER(6),RXA,RYZA(2,6),YZF(2,6)
    9*            COMMON /ACDVAC/ CAL(6),CAV(6),CAA(6),TOIC(18),OC(3)
   10*            DIMENSION AC(3,3),T(3,3),OCD(3),TV(3),TVD(3),R(3)
   11*            EQUIVALENCE (TV,T(1,1)),(TVD,T(1,2))
   12*            DIMENSION RSD(3),RSDD(3),RS(3)
   13*      C     TIME-DEPENDENT INERTIAL COMMANDS
   14*      C
```

```
00113    15*          IF(FRQNCY        *GT*0.) GO TO 30
00115    16*          DO 20 I=1,6
00120    17*          TDIC(I) = TPD(I)+DLTAI(I)*TIME
00121    18*          TDIC(I+6) = DLTAI(I)
00122    19*       20 TDIC(I+12) = 0.
00124    20*          GO TO 50
00125    21*       30 DO 40 I=1,6
00130    22*          TDIC(I) = TPD(I)+DLTAI(I)*SIN(FRQNCY        *TIME)
00131    23*          TDIC(I+6) = FRQNCY        *DLTAI(I)*COS(FRQNCY        *TIME)
00132    24*       40 TDIC(I+12) = -FRQNCY        **2*DLTAI(I)*SIN(FRQNCY        *TIME)
00134    25*       50 CONTINUE
00135    26*          CT = COS(TDIC(4))
00136    27*          ST = SIN(TDIC(4))
00137    28*          CS = COS(TDIC(5))
00140    29*          SS = SIN(TDIC(5))
00141    30*          CP = COS(TDIC(6))
00142    31*          SP = SIN(TDIC(6))
00143    32*          AC(1,1) = CT*CS
00144    33*          AC(1,2) = -CT*CP*SS+ST*SP
00145    34*          AC(1,3) = SP*CT*SS+CP*ST
00146    35*          AC(2,1) = SS
00147    36*          AC(2,2) = CP*CS
00150    37*          AC(2,3) = -SP*CS
00151    38*          AC(3,1) = -ST*CS
00152    39*          AC(3,2) = CP*ST*SS+SP*CT
00153    40*          AC(3,3) = -SP*ST*SS+CP*CT
00154    41*          T(1,1) = SS
00155    42*          T(1,2) = 0.
00156    43*          T(1,3) = 1.
00157    44*          T(2,1) = CS*CP
00160    45*          T(2,2) = SP
00161    46*          T(2,3) = 0.
00162    47*          T(3,1) = -CS*ST
00163    48*          T(3,2) = CP
00164    49*          T(3,3) = 0.
00165    50*          DO 60 I=1,3
00170    51*          OC(I) = 0.
00171    52*          OCD(I) = 0.
00172    53*          DO 60 J=1,3
00175    54*          OC(I) = OC(I)+T(I,J)*TDIC(J+9)
00176    55*       60 OCD(I) = OCD(I)+T(I,J)*TDIC(J+15)
00201    56*          R(1) = RXA
00202    57*          DO 120 L=1,6
00205    58*          R(2) = RYZA(1,L)
00206    59*          R(3) = RYZA(2,L)
00207    60*          CALL CROSS(OC,R,TV)
00210    61*          CALL CROSS(OCD,R,TVD)
00211    62*          DO 80 I=1,3
00214    63*          RSD(I) = 0.
00215    64*          RSDD(I) = 0.
00216    65*          DO 70 J=1,3
00221    66*          RSD(I) = RSD(I)+AC(I,J)*TV(J)
00222    67*       70 RSDD(I) = RSDD(I)+AC(I,J)*TVD(J)
00224    68*          RSD(I) = RSD(I)+TDIC(I+6)
00225    69*       80 RSDD(I) = RSDD(I)+TDIC(I+12)
00227    70*          TV(1) = 0.
00230    71*          TV(2) = YZF(1,L)
00231    72*          TV(3) = YZF(2,L)
```

```
00232      73*            DO 100 I=1,3
00235      74*            RS(I) = 0.
00236      75*            DO 90 J=1,3
00241      76*         90 RS(I) = RS(I)+AC(I,J)*R(J)
00243      77*        100 RS(I) = RS(I)+TOTC(I)-TV(I)
00245      78*            CAL(L) = SQRT(RS(1)**2+RS(2)**2+RS(3)**2)
00246      79*            CAV(L) = 0.
00247      80*            CAA(L) = 0.
00250      81*            DO 110 I=1,3
00253      82*            CAV(L) = CAV(L)+RS(I)*RSD(I)/CAL(L)
00254      83*        110 CAA(L) = CAA(L)+RS(I)*RSDD(I)/CAL(L)
00256      84*        120 CONTINUE
00260      85*            RETURN
00261      86*            END

    END OF COMPILATION:        NO  DIAGNOSTICS.
  ACDVC            SYMBOLIC                    28 JAN 74  23:27:26   0  01517250   14    86  (DELETED)
  ACDVC    CODE    RELOCATABLE                 28 JAN 74  23:27:26   1  01521534   48     1  (DELETED)
                                                                     0  01521614   14    31
```

```
@   FOR,* AC18D,AC18D                                                              29 JUN 74        513611O.956
UNIVAC 1108 FORTRAN V EXEC II L VSL 25A  =(EXEC8 LEVEL E120100IOA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05135111

     SUBROUTINE AC18D     ENTRY POINT 000117

     STORAGE USED: CODE(1) 000126; DATA(0) 000036; BLANK COMMON(2) 000000

      COMMON BLOCKS:

      0003   ACSTRD 000010
      0004   ACLVA  000006
      0005   ACTBND 000022

     EXTERNAL REFERENCES (BLOCK, NAME)

      0006   SQRT
      0007   NERR3$

     STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

      0001   000032 111G      0004 R 000000 AL      0000 R 000005 C      0003 R 000006 EIR     0003 R 000002 IAC
      0000   000013 INJP$     0000 R 000000 IP      0000 I 000001 L      0003 R 000003 LC      0003   000007 LPM
      0003 R 000004 LR        0003   000005 LO      0005 R 000006 ML     0003 R 000001 MP      0005 R 000000 MO
      0005 R 000014 OMEGAE    0000 R 000002 PL      0000 R 000003 RL1    0000 R 000004 RL2     0003   000000 ZETAE

 00101      1*             SUBROUTINE AC18D
 00101      2*       C
 00101      3*       C    ROUTINE TO COMPUTE THE ACTUATOR INERTIA AND BENDING DYNAMICS
 00101      4*       C       PARAMETERS
 00101      5*       C
 00103      6*             REAL LR,LC,IAC,MP,MO,ML,IP
 00104      7*             COMMON /ACSTRD/ ZETAE,MP,IAC,LC,LR,LO,EIR,LPM
 00105      8*             COMMON /ACLVA / AL(6)
 00106      9*             COMMON /ACTBND/ MO(6),ML(6),OMEGAE(6)
 00107     10*             IP = MP*LR**2/12.
 00110     11*             DO 20 L=1,6
 00113     12*             PL = AL(L)-LR
 00114     13*             RL1 = AL(L)-LC
 00115     14*             RL2 = LR-RL1
 00116     15*             ML(L) = (IAC+IP+MP*(PL+LR/2)**2)/ AL(L)**2
 00117     16*             MO(L) = IAC/LC**2+MP/2.
 00120     17*             C = 3.*E(R*(.R*LC-RL1*PL)*(LR+PL)*(LC-PL)
 00120     18*            1     /((RL1*RL2*LC)**2*LR)
 00121     19*             OMEGAE(L) = SQRT(C/MO(L))
 00122     20*          20 CONTINUE
 00124     21*             RETURN
 00126     22*             END

      END OF COMPILATION:        NO  DIAGNOSTICS.
```

ACISD ACISD	CODE	SYMBOLIC RELOCATABLE						
			15 AUG 73	15:49:37	0	01448036	34	22 (DELETED)
			15 AUG 73	15:49:37	1	01448522	36	1 (DELETED)
					0	01448566	14	11

```
@  FOR,* ANATRX,ANATRX                                                                29 JUN 74              5:35:12.37
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  *(EXEC8 LEVEL E1201001OA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:12

   SUBROUTINE ANATRX    ENTRY POINT 000107

   STORAGE USED: CODE(1) 000114; DATA(0) 000021; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   NRKVS: 000133

   EXTERNAL REFERENCES (BLOCK, NAME)

    0004   COS
    0005   SIN
    0006   NERR3$

   STORAGE ASSIGNMENT   (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0000 R 000004 CP        0000 R 000002 CS        0000 R 000000 CT        0000   000006 INJP$     0000 R 000005 SP
    0000 R 000003 SS        0000 R 000001 ST        0003   000000 T         0003 R 000001 X

00101     1*        SUBROUTINE ANATRX(A)
00103     2*        DIMENSION A(3,3)
00104     3*        COMMON /NRKVS/ T,X(90)
00105     4*        CT = COS(X(22))
00106     5*        ST = SIN(X(22))
00107     6*        CS = COS(X(23))
00110     7*        SS = SIN(X(23))
00111     8*        CP = COS(X(24))
00112     9*        SP = SIN(X(24))
00113    10*        A(1,1) =  CT*CS
00114    11*        A(1,2) =  -CT*CP*SS+ST*SP
00115    12*        A(1,3) =  SP*CT*SS+CP*ST
00116    13*        A(2,1) =  SS
00117    14*        A(2,2) =  CP*CS
00120    15*        A(2,3) =  -SP*CS
00121    16*        A(3,1) =  -ST*CS
00122    17*        A(3,2) =  CP*ST*SS+SP*CT
00123    18*        A(3,3) =  -SP*ST*SS+CP*CT
00124    19*        RETURN
00125    20*        END

      END OF COMPILATION:         NO  DIAGNOSTICS.
    ANATRX        SYMBOLIC                                        15 AUG 73   15:49:29   0  01441550    14     20  (DELETED)
    ANATRX  CODE    RELOCATABLE                                   15 AUG 73   15:49:29   1  C1442200    24      1  (DELETED)
                                                                                          0  01442230    14      9
```

```
@ FOR,* CFM,CFM                                                    29 JUN 74          8:35:13.751
UNIVAC 1108 FORTRAN V EXEC II LEVEL 254  -(EXEC8 LEVEL E1.20100.0A)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 08:35:13

    SUBROUTINE CFM       ENTRY POINT 000164

    STORAGE USED: CODE(1) 000174; DATA(0) 000358; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   ACLVA  000014
    0004   FORCES 000014
    0005   TRANS  000066
    0006   INGEOD 000024
    0007   HYDRD  000031
    0010   NRKVS1 000265
    0011   FRCFND 000050
    0012   HYGRTD 000002

    EXTERNAL REFERENCES (BLOCK, NAME)

    0013   CROSS
    0014   SIN
    0015   NERR38

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000011 1216      0001   000051 1326      0001   000073 1SL       0001   000075 1SQ6      0001   000114 1S76
    0001   000122 164G      0001   000134 1726      0007 R 000001 A         0003   000000 AL        0003 R 000006 AV
    0007   000013 BETAE     0007 R 000023 BP        0000 R 000013 CF        0007   000005 CP        0012 R 000001 EXFFRQ
    0007 R 000015 FF        0004 R 000000 FH        0011   000000 FILL      0011 R 000042 FMEXT      0004 R 000006 FP
    0012   000000 FRQNCY    0000 I 000012 I         0006   000001 INER      0000   000021 INSPS      0011 I 000040 IXF
    0000 I 000014 J         0007   000014 KC        0004 R 000003 HH        0006   000000 HT        0011   000041 NFFREQ
    0007   000000 PS        0010 R 000C45 P1        0010 R 000053 P2        0000 R 000000 R          0004 R 000007 RXA
    0006 R 000010 RYZA      0006 R 000000 T         0010 R 000000 TIME      0000 R 000003 V          0000 R 000011 VBW
    0007   000003 VO        0000 R 000006 VI        0010   000001 X         0010   000133 XDOT

00101    1*          SUBROUTINE CFM
00101    2*     C
00101    3*     C   ROUTINE TO COMPUTE FORCES AND MOMENTS FOR THE EQUATIONS OF MOTION
00101    4*     C
00103    5*          REAL MM
00104    6*          COMMON /ACLVA / AL(6),AV(6)
00105    7*          COMMON /FORCES/ FM(3),MM(3),FP(6)
00104    8*          COMMON / TRANS/ T(6,3,3)
00107    9*          COMMON /INGEOD/ MT,INER(6),RXA,RYZA(2,6)
00110   10*          COMMON /HYDRD / PS,A(2),VO(2),CP(6),BETAE,KC,FF(6),BP(6)
00111   11*          COMMON /NRKVS1/ TIME,X(90),XDOT(90)
00112   12*          COMMON /FRCFND/ FILL(32),IXF,NFFREQ,FMEXT(6)
00113   13*          COMMON /HYGRTD/ FRQNCY,EXFFRQ
00114   14*          DIMENSION P1(6),P2(6),      R(3),V(3),VI(3)
```

```
00115            EQUIVALENCE (P1,X(37)),(P2,X(43))
00116            DATA VBW/.005/
00120            DO 10 I=1,6
00123            CF = 1.
00124            CF = SIGN(CF,AV(I))
00125            IF(ABS(AV(I)).LT.VBW) CF=AV(I)/VBW
00127         10 FP(I) = A(1)*P1(I)-A(2)*P2(I)-DP(I)*AV(I)-CF*FF(I)
00131            DO 20 I=1,3
00134            FM(I) = 0.
00135            MM(I) = 0.
00136            IF(IXF.EQ.0) GO TO 15
00140            FM(I) = FMEXT(I)
00141            MM(I) = FMEXT(I+3)
00142            IF(IXF.EQ.1) GO TO 15
00144            FM(I) = FMEXT(I)*SIN(EXFFRQ*TIME)
00145            MM(I) = FMEXT(I+3)*SIN(EXFFRQ*TIME)
00146         15 CONTINUE
00147            DO 20 J=1,6
00152         20 FM(I) = FM(I)+FP(J)*T(J,I,1)
00155            R(1) = RXA
00156            DO 50 I=1,6
00161            R(2) = RYZA(1,I)
00162            R(3) = RYZA(2,I)
00163            DO 30 J=1,3
00166         30 V(J) = T(I,1,J)
00170            CALL CROSS(R,V,V1)
00171            DO 40 J=1,3
00174         40 MM(J) = MM(J)+FP(I)*V1(J)
00176         50 CONTINUE
00200            RETURN
00201            END

   END OF COMPILATION:        NO  DIAGNOSTICS.
 CPM             SYMBOLIC                    28 JAN 74  23:27:24  0  01515460  14  45  (DELETED)
 CPM     CODE    RELOCATABLE                 28 JAN 74  23:27:24  1  01516646  40   1  (DELETED)
                                                                  0  01516726  14  15
```

```
@  FOR,* CHKOUT,CHKOUT                                                    29 JUN 74          5:35:15.168
UNIVAC 1108 FORTRAN V EXEC 11 LEVEL 25A  (EXEC8 LEVEL E120100108)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:15

    SUBROUTINE CHKOUT    ENTRY POINT 000244

    STORAGE USED: CODE(1) 000254; DATA(0) 000121; BLANK COMMON(2) 000000

    COMMON BLOCKS:

      0003  EQMC    000022
      0004  MASS    000504
      0005  FORCES  000014
      0006  NRKVS1  000265
      0007  ACDVAC  000022
      0010  ACLVA   000022
      0011  ACTBND  000022
      0012  TRANS   000066

    EXTERNAL REFERENCES (BLOCK, NAME)

      0013  NWDUS
      0014  NIO2S
      0015  NIO1S
      0016  NERR3S

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

      0001  000014 122G    0001  000023 143B    0001  000026 132G    0001  000040 141G    0001  000045 145G
      0001  000052 151G    0001  000064 140B    0001  000071 164G    0001  000076 170G    0001  000111 177G
      0001  000115 202G    0001  000116 204G    0001  000141 215G    0001  000142 217G    0001  000160 227G
      0001  000165 233G    0001  000177 242G    0001  000211 251G    0001  000223 260G    0000  000003 901F
      0000  000007 902F    0000  000020 903F    0000  000031 904F    0000  000042 905F    0000  000052 906F
      0000  000056 907F    0000  000064 908F    0000  000070 910F    0000  000074 911F    0010 R 000014 AA
      0010 R 000000 AL     0010 R 000006 AV     0003 R 000000 C      0007 R 000014 CAA     0007 R 000003 CAL
      0007 R 000006 CAV    0005 R 000000 FHHD   0005 R 000006 FP     0000 I 000000 I       0000  000104 INJPS
      0000 I 000001 J      0000 I 000002 K      0004 R 000000 M      0011 R 000006 ML      0011 R 000000 MQ
      0011 R 000014 OMEGAE 0012 R 000000 T      0006 R 000000 TIME   0006 R 000001 X       0006 R 000133 XDOT


 00101     1*          SUBROUTINE CHKOUT
 00103     2*          REAL M,MQ,ML
 00104     3*          COMMON / EQMC / C(18)
 00105     4*          COMMON / MASS / M(18,18)
 00106     5*          COMMON /FORCES/ FHHD(6),FP(6)
 00107     6*          COMMON /NRKVS1/ TIME,X(90),XDOT(90)
 00110     7*          COMMON /ACDVAC/ CAL(6),CAVT(6),CAA(6)
 00111     8*          COMMON /ACLVA / AL(6),AV(6),AA(6)
 00112     9*          COMMON /ACTBND/ MQ(6),ML(6),OMEGAE(6)
 00113    10*          COMMON / TRANS/ T(6,3,3)
 00114    11*          WRITE(6,901) TIME
 00117    12*      901 FORMAT(// 5X'TIME= G11.5)
```

```
00120            WRITE(6,902) CAL,CAV,CAA
00136        902 FORMAT(5X'CAL'6G15.5/ 5X'CAV'6G15.5/ 5X'CAA'6G15.5)
00137            WRITE(6,903) AL,AV,AA
00155        903 FORMAT(5X'AL '6G15.5/ 5X'AV '6G15.5/ 5X'AA '6G15.5)
00156            WRITE(6,904) MO,ML,OMEGAE
00174        904 FORMAT(5X'MO '6G15.5/ 5X'ML '6G15.5/  2X'OMEGAE'6G15.5)
00175            WRITE(6,905) (I,((T(I,J,K),K=1,3),J=1,3),I=1,6)
00212        905 FORMAT(5X'T='I1,T20,3G15.5/ T20,3G15.5/ T?0,3G15.5)
00213            WRITE(6,906) ((M(I,J),J=1,18),I=1,18)
00224        906 FORMAT(5X'MASS' (T10,6G15.5))
00225            WRITE(6,907) FMHO,FP
00237        907 FORMAT(5X'FMHO' 6G15.5/ 5X'FP   ' 6G15.5)
00240            WRITE(6,908) C
00246        908 FORMAT(5X'C' (T10,6G15.5))
00247            WRITE(6,910) X
00255        910 FORMAT(5X'X'(T10, 6G15.5))
00256            WRITE(6,911) XDOT
00264        911 FORMAT(5X'XDOT' (T10, 6G15.5))
00265            RETURN
00266            END

     END OF COMPILATION:         NO  DIAGNOSTICS.
    CHKOUT          SYMBOLIC                    15 AUG 73  15:49:26   0  01436670   14    32  (DELETED)
    CHKOUT  CODE    RELOCATABLE                 15 AUG 73  15:49:26   1  01437570   60     1  (DELETED)
                                                                      0  01437664   14    26
```

```
                                                                     29 JUN 74          5135:16..17
@   FOR,* COLUM,COLUM
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  -(EXEC8 LEVEL E1201001OA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05135116

    SUBROUTINE COLUM      ENTRY POINT 000155

    STORAGE USED: CODE(1) 000161; DATA(0) 000047; BLANK COMMON(2) 000000

     COMMON BLOCKS:

     0003   INGEOD 000007
     0004   ACSTRD 000001
     0005   NRKVS1 000265
     0006   FORCES 000006
     0007   ACTBND 000022
     0010   EQMC   000022

    EXTERNAL REFERENCES (BLOCK, NAME)

     0011   CROSS
     0012   NERR3$

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

     0001   000007 115G     0001   000037 133G     0001   000042 137G     0001   000047 146G     0001   000075 153G
     0010 R 000000 C        0006 R 000000 FM       0000 I 000014 I        0000 R 000000 IMATRX   0003 R 000001 INER
     0000   000023 INJP$    0000 I 000015 J        0000 I 000016 K        0007   000006 ML       0007 R 000000 MQ
     0003 R 000000 MT       0007 R 000014 OMEGAE   0000 R 000011 Q        0005   000000 T        0005 R 000001 X
     0005   000133 XDOT     0004 R 000000 ZETAE

 00100      1*       C      ROUTINE TO CALCULATE THE EQUATIONS OF MOTION COLUMN
 00100      2*       C
 00100      3*       C
 00101      4*               SUBROUTINE COLUM
 00103      5*               REAL IMATRX(3,3),INER,MQ,MT
 00104      6*               DIMENSION Q(3)
 00105      7*               COMMON /INGEOD/ MT,INER(6)
 00106      8*               COMMON /ACSTRD/ ZETAE
 00107      9*               COMMON /NRKVS1/ T,X(90),XDOT(90)
 00110     10*               COMMON /FORCES/ FM(6)
 00111     11*               COMMON /ACTBND/ MQ(6),ML(6),OMEGAE(6)
 00112     12*               COMMON / EQMC / C(18)
 00112     13*       C
 00112     14*       C      ROWS 1-3
 00112     15*       C
 00113     16*                CALL CROSS(X(4),X,C)
 00114     17*                DO 20 I=1,3
 00117     18*           20 C(I) = -MT*C(I)+FM(I)
 00117     19*        C
 00117     20*        C       ROWS 4-6
 00117     21*        C
```

```
00121     22*          IMATRX(1,1) = INER(1)
00122     23*          IMATRX(1,2) = -INER(4)
00123     24*          IMATRX(2,1) = -INER(4)
00124     25*          IMATRX(1,3) = -INER(5)
00125     26*          IMATRX(3,1) = -INER(5)
00126     27*          IMATRX(2,3) = -INER(6)
00127     28*          IMATRX(3,2) = -INER(6)
00130     29*          IMATRX(2,2) = INER(2)
00131     30*          IMATRX(3,3) = INER(3)
00132     31*          DO 25 I=1,3
00135     32*          Q(I) = 0.
00136     33*          DO 25 J=1,3
00141     34*       25 Q(I) = Q(I)+IMATRX(I,J)*X(J+3)
00144     35*          CALL CROSS(X(4),Q,C(4))
00145     36*          DO 30 I=4,6
00150     37*       30 C(I) = -C(I)+FM(I)
00150     38*     C
00150     39*     C    ROWS 7-18
00150     40*     C
00152     41*          DO 40 I=1,12
00155     42*          K=I
00156     43*          IF(I.GT.6) K=I-6
00160     44*       40 C(I+6) = OMEGAE(K)*MQ(K)*(-2.*ZETAE*X(I+6)-OMEGAE(K)*X(I+24))
00162     45*          RETURN
00163     46*          END

     END OF COMPILATION:       NO  DIAGNOSTICS.
   COLUM         SYMBOLIC                       16 AUG 73  13:39:12   0  01442060   14   46  (DELETED)
   COLUM   CODE  RELOCATABLE                    16 AUG 73  13:39:12   1  01443264   40    1  (DELETED)
                                                                      0  01443344   14   13
```

```
@  FOR,* CROSS,CROSS                                                    29 JUN 74          5:35:18.  2
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  -(EXEC8 LEVEL E1.20100.10A)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:18

    SUBROUTINE CROSS     ENTRY POINT 00003₆

    STORAGE USED: CODE(1) 000043; DATA(0) 000010; BLANK COMMON(2) 000000

    EXTERNAL REFERENCES (BLOCK, NAME)

     0003   NERR)$

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

     0000   000000 INJP$

00101      1*            SUBROUTINE CROSS(V1,V2,R)
00103      2*            DIMENSION V1(1),V2(1),R(1)
00104      3*            R(1) = V1(2)*V2(3)-V1(3)*V2(2)
00106      4*            R(2) = V1(3)*V2(1)-V1(1)*V2(3)
00106      5*            R(3) = V1(1)*V2(2)-V1(2)*V2(1)
00107      6*            RETURN
00110      7*            END

     END OF COMPILATION:       NO  DIAGNOSTICS.
  CROSS          SYMBOLIC
  CROSS   CODE   RELOCATABLE      15 AUG 73  15:49:32   0  01443016   14    7  (DELETED)
                                  15 AUG 73  15:49:32   1  01443160   24    1  (DELETED)
                                                        0  01443210   14    4
```

```
@  FOR,* DATARD.DATARD
UNIVAC 1108 FORTRAN V EXEC 11 LEVEL 25A  -(EXEC8 LEVEL R1R0100108A)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:19

   SUBROUTINE DATARD    ENTRY POINT 001047

   STORAGE USED: CODE(1) 001055; DATA(0) 000760; BLANK COMMON(2) 000000

   COMMON BLOCKS:

   0003   INGEOD 000040
   0004   ACSTRD 000010
   0005   FRCFND 000072
   0006   HYDRO  000031
   0007   ELECD  000046
   0010   MYGRTC 000006

   EXTERNAL REFERENCES (BLOCK, NAME)

   0011   NRDUS
   0012   NIO1S
   0013   NIO2S
   0014   NWDUS
   0015   NSTOPS
   0016   NERRJS

   STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

   0000  001032 100L     0001  000007 153G     0001  000021 161G     0001  000054 177G     0001  000356 20L
   0001  000066 205G     0001  000106 214G     0001  000106 227G     0001  000121 230G     0001  000121 232G
   0001  000133 241G     0001  000133 243G     0001  000145 252G     0001  000145 254G     0001  000307 353G
   0001  000223 313G     0001  000230 317G     0001  000242 325G     0001  000247 331G     0001  000364 406G
   0001  000321 361G     0001  000333 367G     0001  000351 377G     0001  000451 40L      0001  000374 461G
   0001  000403 417G     0001  000415 425G     0001  000433 435G     0001  000445 443G     0001  000542 514G
   0001  000501 465G     0001  000516 476G     0001  000523 502G     0001  000535 510G     0001  000624 552G
   0001  000554 522G     0001  000561 526G     0001  000573 534G     0001  000605 542G     0001  000662 600G
   0001  000631 554G     0001  000634 562G     0001  000643 566G     0001  000650 572G     0001  000722 630G
   0001  000647 604G     0001  000674 610G     0001  000701 614G     0001  000706 620G     0000  000026 902F
   0001  000736 640G     0001  001001 646G     0001  001020 700G     0000  000020 901F     0000  000126 907F
   0000  000030 903F     0000  000035 904F     0000  000053 905F     0000  000110 906F     0000  000306 912F
   0000  000134 908F     0000  000245 909F     0000  000253 910F     0000  000305 911F     0000  000314 917F
   0000  000346 913F     0000  000356 914F     0000  000364 915F     0000  000407 916F     0000  000601 922F
   0000  000444 918F     0000  000514 919F     0000  000525 920F     0000  000532 921F     0000  000713 927F
   0000  000613 923F     0000  000653 924F     0000  000661 925F     0000  000711 926F     0007 R 000036 ALPHA
   0000  000716 928F     0000  000720 929F     0000  000730 930F     0006 R 000001 A        0005 R 000030 DLTAI
   0007 R 000037 BETA     0006 R 000013 BETAE    0006 R 000023 BP     0004 R 000005 CP       0004 R 000002 IAC
   0004 R 000004 EIR      0006 R 000015 FF       0005 R 000042 FMEXT  0000 I 000016 I        0010 I 000004 IPROPT
   0006 I 000034 IM       0003 R 000001 INER     0000   000745 INJPS  0010 I 000005 IPLOPT     0007 R 000000 KG
   0005 I 000040 IXF      0000 I 000   7 J       0006 R 000014 KC     0007 R 000006 KF       0004 R 000007 LPM
   0007 R 000022 KPF      0007 R 000014 KR       0007 R 000030 KRC    0004 R 000003 LC       0005 I 000041 NFFREQ
   0004 R 000009 LR       0004 R 000005 LU       0004 R 000001 MP     0003 R 000000 MT       0007 R 000045 OMEGAV
   0005 I 000037 NFREQ    0005 R 000006 OMEGAC   0005 R 000050 OMEGAF 0007 R 000043 OMEGAS   0003 R 000010 RYZA
   0007 R 000040 OMEGPF   0010 R 000002 OUTFLG   0006 R 000000 PS     0003 R 000007 RXA      0010 R 000000 TSTART
   0005 R 000000 TC6CO    0005 R 000003 TEAO     0010 R 000001 TEND   0000 R 000000 TITLE
```

0006 R 000003 VO 0003 R 000024 YZF 0004 R 000000 ZETAE 0007 R 000042 ZETAS 0007 R 000044 ZETAV

```
00100     1*     C    ROUTINE TO READ THE CARD INPUT
00100     2*     C
                      SUBROUTINE DATARD
00101     3*          REAL MT,INER,MP,IAC,LC,LR,LO,LPH,KC,KG,KF,KR,KPF,KRC
00103     4*          COMMON /INGEOC/ MT,INER(6),RXA,RYZA(2,6),YZF(2,6)
00104     5*          COMMON /ACSTRO/ ZETAE,MP,IAC,LC,LR,LO,EIR,LPH
00105     6*          COMMON /FRCEND/ TCGCO(3),TEAD(3),OMEGAC(18),DLTAI(6),IN,NFREQ,
00106     7*         1                IXF,NFFREQ,FMEXT(6),OMEGAF(18)
00106     8*          COMMON /HYDRD / PS,X(2),VO(2),CP(6),BETAE,KC,FF(6),BP(6)
00107     9*          COMMON /ELECO / KG(6),KF(6),KR(6),KPF(6),KRC(6),ALPHA,BETA,
00110    10*         1                OMEGPF(2),ZETAS,OMEGAS,ZETAV,OMEGAV
00110    11*          COMMON /NTGRTC/ TSTART,TEND,OUTFRQ(2),IPROPT,IPLOPT
00111    12*          DIMENSION TITLE(14)
00112    13*     901 FORMAT(1// 54X 'INERTIA AND GEOMETRY DATA')
00113    14*     902 FORMAT(6E12.6)
00114    15*     903 FORMAT(/ 10X 'TABLE MASS' T60, G11.5)
00115    16*     904 FORMAT(/10X'MOMENTS AND PRODUCTS OF INERTIA'/
00116    17*         1    12X'FOR ACTIVE TABLE SYSTEM' T60, 6G11.5)
00116    18*     905 FORMAT(10X'X TABLE STATION OF ACTUATOR SWIVEL JOINTS'/
00117    19*         1    12X'W.R.T. TABLE C.G.' T60, G11.5/
00117    20*         2    10X 'Y AND Z TABLE COORDINATES OF SWIVEL JOINTS'
00117    21*         3    12X 'W.R.T. TABLE C.G.' (T60,6G11.5))
00117    22*     906 FORMAT(10X'Y AND Z INERTIAL COORDINATES'/
00120    23*         1    12X'OF FLOOR SWIVEL JOINTS' (T60, 6G11.5))
00120    24*     907 FORMAT(// 54X'ACTUATOR STRUCTURAL DATA')
00121    25*     908 FORMAT(/10X'ACTUATOR BENDING DAMPING CONSTANT'      T60,G11.5/
00122    26*         1    10X'MASS OF ROD AND PISTON'                   T60,G11.5/
00122    27*         2    10X'MOMENT OF INERTIA OF CYLINDER'/
00122    28*         +    12X'ABOUT FLOOR SWIVEL JOINT'                 T60,G11.5/
00122    29*         3    10X'DISTANCE FROM FLOOR SWIVEL TO C.L.'/
00122    30*         +    12X'OF PISTON ROD SEAL AT END OF CYLINDER'    T60,G11.5/
00122    31*         4    10X'LENGTH OF PISTON ROD'                     T60,G11.5/
00122    32*         5    10X'RETRACTED LENGTH OF ACTUATOR'             T60,G11.5/
00122    33*         6    10X'BENDING MODULUS OF PISTON ROD'            T60,G11.5/
00122    34*         7    10X'MAXIMUM STROKE OF ACTUATOR'               T60,G11.5)
00122    35*     909 FORMAT(// 56X 'FORCING FUNCTION DATA')
00123    36*     910 FORMAT(/ 10X'INITIAL INERTIAL COORDINATES OF TABLE CG'T60,3G11.5/
00124    37*         1    10X'INITIAL EULER ANGLES OF TABLE COORDINATE'/
00124    38*         2    12X'SYSTEM W.R.T. INERTIAL SYSTEM'            T60,3G11.5)
00124    39*     911 FORMAT(18I4)
00125    40*     912 FORMAT(  10X'MASS MATRIX AND GEOMETRY UPDATE OPTION'  T60,I4/
00126    41*         1    10X'NUMBER OF FREQUENCY CASES'                T60,I4/
00126    42*         2    10X'EXTERNAL FORCE AND MOMENT OPTION'         T60,I4/
00126    43*         3    10X'NUMBER OF EXTERNAL FORCE FREQUENCIES'     T60,I4)
00126    44*     913 FORMAT(10X'COMMAND SIGNAL FREQUENCIES' (T60, 6G11.5))
00127    45*     914 FORMAT(10X 'STEP VELOCITIES' T60, 6G11.5)
00130    46*     915 FORMAT(10X'SINUSOIDAL AMPLITUDES OF TRANSLATIONAL COMMANDS'/
00131    47*         1    12X'FOR TABLE CG AND OF TABLE EULER COMMANDS' T60,6G11.5)
00131    48*     916 FORMAT(// 58X 'HYDRAULICS DATA')
00132    49*     917 FORMAT(/ 10X'SUPPLY PRESSURE'                      T60,G11.5/
00133    50*         2    10X'EQUIVALENT SYSTEM BULK MODULUS'           T60,G11.5/
00133    51*         3    10X'VALVE PRESSURE FLOW COEFFICIENT'          T60,G11.5/
00133    52*         1    10X'LEAKAGE COEFFICIENT ACROSS PISTON SEALS'  T60,6G11.5/
00133    53*
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00133          4        10X'ACTUATOR VISCOUS DAMPING COEFFICIENT'    T60,6G11.5)
00134       918 FORMAT(10X'ACTUATOR PUSH AND PULL STROKE WORKING AREAS'T60,2G11.5/
00134          1        10X'INITIAL HYDRAULIC VOLUMES OF'/
00134          +        12X'FULLY RETRACTED ACTUATOR'                        T60,2G11.5)
00135       919 FORMAT(10X'COULOMB FRICTION FORCE OF ACTUATORS' T60,6G11.5)
00136       920 FORMAT(// 58X 'ELECTRONICS DATA')
00137       921 FORMAT(/ 10X'GAINS'/
00137          1        12X'ELECTRONICS AND VALVE FORWARD LOOP'  T60,6G11.5/
00137          2        12X'DISPLACEMENT FEEDBACK AND COMMAND'   T60,6G11.5/
00137          3        12X'VELOCITY FEEDBACK LOOP'              T60,6G11.5/
00137          4        12X'PRESSURE FEEDBACK LOOP'              T60,6G11.5/
00137          5        12X'VELOCITY COMMANDS'                   T60,6G11.5)
00140       922 FORMAT(10X'BREAK FREQUENCIES OF FIRST ORDER FILTERS' T60,6G11.5)
00141       925 FORMAT(10X'DISPLACEMENT AND VELOCITY FEEDBACK'/
00141          +        12X'SECOND ORDER FILTER DAMPING CONSTANT'/
00141          +        12X'AND FREQUENCY'                          T60,2G11.5/
00141          1        10X'VALVE DYNAMICS DAMPING CONSTANT'/
00141          +        12X'AND FREQUENCY'                          T60,2G11.5)
00142       924 FORMAT(// 56X ' PROGRAM CONTROL DATA')
00143       925 FORMAT(/ 10X 'START TIME'          T60, G11.5/
00143          1          10X 'STOP TIME'           T60, G11.5/
00143          2          10X 'OUTPUT FREQUENCIES'  T60,2G11.5/
00143          3          10X 'PRINT OPTION'        T60,I4/
00143          4          10X 'PLOT OPTION'         T60,I4)
00144       926 FORMAT(13A6,A2)
00145       927 FORMAT('1'26X 13A6,A2)
00146       928 FORMAT(4E12.6,2I5)
00147       929 FORMAT(10X'EXTERNAL FORCES AND MOMENTS'     T60,6G11.5)
00150       930 FORMAT(10X'EXTERNAL FORCE FREQUENCIES '    T60,6G11.5)
00151           READ(5,926,END=100) TITLE
00157           WRITE(6,927) TITLE
00157     C
00157     C     INERTIA AND GEOMETRY DATA
00165           WRITE(6,901)
00167           READ(5,902) MT
00172           WRITE(6,903) MT
00175           READ(5,902) (INER(I),I=1,6)
00203           WRITE(6,904) INER
00211           READ(5,902) RXA
00214           READ(5,902) ((RYZA(J,I),J=1,2),I=1,6)
00225           WRITE(6,905) RXA,((RYZA(J,I),J=1,2),I=1,6)
00237           READ(5,902) ((YZF(J,I),J=1,2),I=1,6)
00250           WRITE(6,906) ((YZF(J,I),J=1,2),I=1,6)
00250     C
00250     C     ACTUATOR STRUCTURAL DATA
00250     C
00261           WRITE(6,907)
00263           READ(5,902) ZETAE,MP,IAC,LC,LR,LO,EIR,LPM
00275           WRITE(6,908) ZETAE,MP,IAC,LC,LR,LO,EIR,LPM
00275     C
00275     C     FORCING FUNCTION DATA
00275     C
00307           WRITE(6,909)
00311           READ(5,902) (TCGCO(I),I=1,3),(TEAO(I),I=1,3)
00323           WRITE(6,910) TCGCO,TEAO
00335           READ(5,911) IM,NFREQ,IXF,NFFREQ
00343           WRITE(6,912) IM,NFREQ,IXF,NFFREQ
00351           READ(5,902) (OMEGAC(I),I=1,NFREQ)
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00357   112*          WRITE(6,913) (OMEGAC(I),I=1,NFREQ)
00365   113*          READ(5,902) (DLTAI(I),I=1,6)
00373   114*          IF(OMEGAC(1).GT.0.) GO TO 20
00375   115*          WRITE(6,914) DLTAI
00403   116*          GO TO 30
00404   117*       20 WRITE(6,915) DLTAI
00412   118*       30 CONTINUE
00413   119*          IF(IXF.EQ.0) GO TO 40
00415   120*          READ(5,902) FMEXT
00423   121*          WRITE(6,929) FMEXT
00431   122*          IF(IXF.EQ.1) GO TO 40
00433   123*          READ(5,902) (OMEGAF(I),I=1,NFFREQ )
00441   124*          WRITE(6,930) (OMEGAF(I),I=1,NFFREQ)
00447   125*       40 CONTINUE
00447   126*    C
00447   127*    C     HYDRAULICS DATA
00447   128*    C
00450   129*          WRITE(6,916)
00452   130*          READ(5,902) PS,BETAE,KC
00457   131*          READ(5,902) CP,BP
00471   132*          WRITE(6,917) PS,BETAE,KC,CP,BP
00506   133*          READ(5,902) (A(I),I=1,2),(VO(I),I=1,2)
00520   134*          WRITE(6,918) A,VO
00532   135*          READ(5,902) (FF(I),I=1,6)
00540   136*          WRITE(6,919) FF
00540   137*    C
00540   138*    C     ELECTRONICS DATA
00540   139*    C
00546   140*          WRITE(6,920)
00550   141*          READ(5,902) KG,KF,KR,KPF,KRC
00576   142*          WRITE(6,921) KG,KF,KR,KPF,KRC
00634   143*          READ(5,902) ALPHA,BETA,OMEGPF
00634   144*          WRITE(6,922) ALPHA,BETA,OMEGPF
00644   145*          READ(5,902) ZETAS,OMEGAS,ZETAV,OMEGAV
00652   146*          WRITE(6,923) ZETAS,OMEGAS,ZETAV,OMEGAV
00652   147*    C
00652   148*    C     PROGRAM CONTROL DATA
00652   149*    C
00660   150*          WRITE(6,924)
00662   151*          READ(5,928) TSTART,TEND,OUTFRQ,IPROPT,IPLOPT
00674   152*          WRITE(6,925) TSTART,TEND,OUTFRQ,IPROPT,IPLOPT
00706   153*          RETURN
00707   154*      100 CONTINUE
00710   155*          STOP
00711   156*          END

     END OF COMPILATION:      NO DIAGNOSTICS.
   DATARD        SYMBOLIC           31 JAN 74  21:52:34   0  01552476   14   156  (DELETED)
   DATARD  CODE  RELOCATABLE        31 JAN 74  21:52:34   1  01526706   48     1  (DELETED)
                                                          0  01526766   14   102
```

```
R  FOR,* FCN,FCN
UNIVAC 1108 FORTRAN V EXEC 1) LEVEL 28A  =(EXEC8 LEVEL F1201001OA)
THIS COMPILATION WAS DONE 01 29 JUN 74 AT 08135121

    SUBROUTINE FCN        ENTRY POINT 00028H

    STORAGE USED: CODE(1) 000265, DATA(0) 000121; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   NRKVSI 000264
    0004   NTGRTD 000006
    0005   NTGRTC 000003
    0006   FRCFND 000040
    0007   EQMC   000022
    0010   MASS   000504
    0011   ACSTRD 000010
    0012   ACLVA  000006

    EXTERNAL REFERENCES (BLOCK, NAME)

    0013   ACOVC
    0014   ACAYAP
    0015   ACIBD
    0016   TTRANS
    0017   MMATRX
    0020   SJR
    0021   CFM
    0022   COLUM
    0023   AMATRX
    0024   MYSRE
    0025   OUTPUT
    0026   COS
    0027   SIN
    0030   MPOUT
    0031   MIO2S
    0032   MERR3S

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000042 154G      0001   000245 140B      0001   000062 146G      0001   000074 154G      0001   000077 160G
    0001   000206 180L      0001   000222 190L      0001   000164 200G      0001   000234 200L      0001   000012 40L
    0001   000032 50L       0000   000041 90DF      0000   000044 90IF      0000 R 000024 A         0012 R 000000 AL
    0007 R 000000 C         0000 R 000037 CP        0000 R 000041 CS        0011   000006 EIR       0004   000001 EXFFRQ
    0006   000000 FILL      0004   000000 FRQNCY    0000 I 000035 I         0011   000002 IAC       0004 I 000004 IFIRST
    0006 I 000036 IH        0003 I 000265 IND       0004 I 000005 INDKTR    0000   000104 INJPS     0000 I 000042 IX
    0000 I 000036 J         0000 I 000000 JC        0011   000003 LC        0011 R 000007 LPM       0011   000004 LR
    0011 R 000005 LO        0010 R 000000 M         0011   000001 MP        0006   000037 NFREQ     0005   000002 OUTFRQ
    0000 R 000043 PL        0000 R 000040 SP        0005   000001 TEND      0003 R 000000 TIME      0004 R 000003 TPLOT
    0004 R 000002 TPRINT    0005   000000 TSTART    0000 R 000322 W         0003 R 000001 X         0003 R 000133 XDOT
    0011   000000 ZETAE
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```
00101     1*          SUBROUTINE FCN
00103     2*          COMMON /NRKVS1/ TIME,X(90),XDOT(90),IND
00104     3*          COMMON /NTGRTO/ FRQNCY,EXFRQ,TORINT,TPLOT,IFIRST,INDKTR
00105     4*          COMMON /NTGRTC/ TSTART,TEND,OUTFRQ
00106     5*          COMMON /FRCEND/ FILL(30),IM,NFREQ
00107     6*          COMMON / EQMC / C(18)
00110     7*          COMMON / MASS / H(18,18)
00111     8*          COMMON /ACSTRD/ ZETAE,MP,IAC,LC,LR,LD,EIR,LPM
00112     9*          COMMON /ACLVA / AL(4)
00113    10*          REAL M,LD,LPM
00114    11*          DIMENSION JC(18),W(2)
00115    12*          DIMENSION A(3,3)
00116    13*    C
00116    14*    C
00116    15*    C     DERIVATIVE EVALUATION SECTION
00116    16*    C
00117    17*          CALL ACDVC                    @ ACTUATOR DISP. AND VEL. COMMANDS
00117    18*          CALL ACAVAP                   @ ACTUAL ACTUATOR VELOCITIES,
                                                     ACCELERATIONS, AND POSITIONS
00117    19*    C
00120    20*          CALL ACIBD                    @ ACTUATOR INERTIA AND BENDING
                                                     DYNAMICS PARAMETERS
00120    21*    C
00120    22*    C
00121    23*          IF(IFIRST.EQ.0) GO TO 40
00123    24*          IF(IM.EQ.0) GO TO 50
00125    25*       40 CALL TTRANS                   @ TRANSFORMATION FROM TABLE COORD.
                                                     TO LOCAL ACTUATOR COORD.
00125    26*    C
00126    27*          CALL MMATRX                   @ CALCULATE MASS MATRIX
00127    28*          W(1) = 1.
00130     9*          CALL GJRIM,18,18,18,18,9,90,JC,W)
00131    30*       50 CALL CFM                      @ CALCULATE FORCES AND MOMENTS
00132    31*          CALL COLUM                    @ CALCULATE EQUATIONS OF MOTION COLUMN
00132    32*    C
00133    33*          DO 60 I=1,18
00136    34*          XDOT(I) = 0.
00137    35*          DO 60 J=1,18
00142    36*       60 XDOT(I) = XDOT(I)+H(I,J)*C(J)
00142    37*    C
00145    38*          DO 70 I=7,18
00150    39*       70 XDOT(18+I) = X(I)
00152    40*          CALL AMATRX(A)
00153    41*          DO 75 I=1,3
00156    42*          XDOT(18+I) = 0.
00157    43*          DO 75 J=1,3
00162    44*       75 XDOT(18+I) = XDOT(18+I)+A(I,J)*X(J)
00165    45*          CP = COS(X(24))
00166    46*          SP = SIN(X(24))
00167    47*          CS = COS(X(23))
00170    48*          XDOT(22) = (X(5)*CP-X(6)*SP)/CS
00171    49*         *XDOT(23) = X(5)*SP+X(6)*CP
00172    50*          XDOT(24) = X(4)-XDOT(22)*SIN(X(23))
00173    51*          CALL HYSREL                   @ HYDRAULICS AND SERVO ELECTRONICS
                                                     DERIVATIVES
00173    52*    C
00174    53*          IFIRST = 1
00175    54*          IF(IND.EQ.0) RETURN
00177    55*      100 DO 120 I=1,6
00202    56*          IX = I
00203    57*          PL = AL(I)-LD
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00204          IF (PL) 180,110,110
00207      110 IF(PL-LPM) 120,120,180
00212      120 CONTINUE
00214          CALL OUTPUT
00215          RETURN
00216      180 WRITE(6,901) IX
00221      901 FORMAT(//10X 'ACTUATOR'I3,' HAS STROKED OUT... ABORT AND GO TO '
00221        1            'NEXT CASE.')
00222          TPRINT = TIME
00223          TPLOT = TIME
00224          CALL OUTPUT
00225          GO TO 200
00226      190 WRITE(6,900)
00230      900 FORMAT(// 10X 'ERROR WHILE INVERTING MASS MATRIX... '
00230        1            'GO TO NEXT CASE ')
00231          TPRINT = TIME
00232          TPLOT = TIME
00233          CALL OUTPUT
00234      200 INDKTR = 1
00235          RETURN
00236          END

     END OF COMPILATION:         NO  DIAGNOSTICS.
   FCN           SYMBOLIC                      28 JAN 74  23:27:18  0  015:0736  14  78  (DELETED)
   FCN   CODE    RELOCATABLE                   28 JAN 74  23:27:18  1  015:3042  72   1  (DELETED)
                                                                    0  015:3152  14  24
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                                                                  29 JUN 74        8:35:23.172
@   FOR,* GONADS,GONADS
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  -(EXEC8 LEVEL E1201001OA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 08:35:23

   MAIN PROGRAM

   STORAGE USED: CODE(1) 000067; DATA(0) 000026; BLANK COMMON(2) 000000

   COMMON BLOCKS:

    0003   NITILC 000132
    0004   NTGRTC 000002
    0005   FRCFND 000042
    0006   NRKVS1 000266

   EXTERNAL REFERENCES (BLOCK, NAME)

    0007   FCN
    0010   DAYARD
    0011   INITIL
    0012   RKINIT
    0013   NRKVS
    0014   PLOTER
    0015   NRDU8
    0016   NIO2$
    0017   NSTOP$

   STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

                             0001   000022 114G     0001   000025 117G     0001   000054 150L     0001   000000 20L
    0001   000050 100L       0007 R 000000 FCN      0005   000000 FILL     0000 I 000003 IN       0006   000265 IND
    0000   000004 900F       0000 I 000001 L        0000 I 000000 LOOP     0000 I 000002 M        0005 I 000041 NFFREQ
    0005 I 000040 IXF        0004 R 000001 TEND     0006 R 000000 TIME     0004 R 000000 TSTART   0006 R 000001 X
    0005 I 000037 NFREQ      0003 R 000000 XO
    0006 R 000133 XDOT


 00100       1*      C        MAIN PROGRAM
 00100       2*      C
 00101       3*                 EXTERNAL FCN
 00103       4*                 COMMON /NITILC/ XO(90)
 00104       5*                 COMMON /NTGRTC/ TSTART,TEND
 00105       6*                 COMMON /FRCFND/ FILL(31),NFREQ,IXF,NFFREQ
 00106       7*                 COMMON /NRKVS1/ TIME,X(90),XDOT(90),IND
 00106       8*      C                                           * INPUT DATA
 00107       9*            20   CALL DAYARD
 00110      10*                 LOOP = 1
 00111      11*                 IF(IXF.EQ.2) LOOP = NFFREQ
 00113      12*                 DO 200 L=1,NFREQ
 00114      13*                 DO 200 M=1,LOOP
 00116      14*      C                                           * INITILIZE FOR INTEGRATION
 00121      15*                 CALL INITIL(L,M)
 00122      16*                 CALL RKINIT
 00123      17*                 IN = 0
 00124      18*                 CALL NRKVS($100,TSTART,TEND,XO,X,XD,IN,FCN)
```

```
00125     19*          GO TO 150
00126     20*      100 WRITE(6,900) TIME
00131     21*      900 FORMAT(// 10X'THE INTEGRATION HAS FAILED AT T =' G12.4,
00131     22*        1       ', ABORT AND GO TO NEXT CASE.')
00132     23*      150 CALL PLOTER
00133     24*      200 CONTINUE
00136     25*          GO TO 20
00137     26*          END

     END OF COMPIL     N?         NO  DIAGNOSTICS.
  GONADS                SYMBOLIC                             28 JAN 74  23:27:16   0  01507720   14   24  (DELETED)
  GONADS  CODE          RELOCATABLE                          28 JAN 74  23:27:16   1  01510474   36    1  (DELETED)
                                                                                   0  01510540   14    9
```

```
@   FOR,* HYSREL,HYSREL                                                    29 JUN 74          5:35:24.386
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  -(EXEC8 LEVEL E)20100108)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:24

    SUBROUTINE HYSREL     ENTRY POINT 000302

    STORAGE USED: CODE(1) 000316; DATA(0) 000401; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   ACSTRD 000010
    0004   ACLVA  000044
    0005   ACDVAC 000022
    0006   HYDRD  000031
    0007   ELECD  000046
    0010   NRKVSI 000265

    EXTERNAL REFERENCES (BLOCK, NAME)

    0011   DENTRY
    0012   NERR32

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000122 100L      0001   000017 114G      0001   000255 140L      0001   000135 154G      0001   000034 30L
    0001   000047 40L       0001   000072 70L       0001   000105 90L       0006 R 000001 A         0004 R 000014 AA
    0004 R 000000 AL        0007 R 000036 ALPHA     0004 R 000004 AV        0007 R 000037 BETA      0006 R 000013 BETAE
    0006   000023 BP        0006 R 000014 CAA       0005 R 000020 CAL       0005 R 000006 CAV       0006 R 000005 CP
    0000 R 000001 DELTA     0000 R 000007 DELTAD    0003   000006 EIR       0000 R 000002 FACT      0006   000015 FF
    0000 I 000000 I         0003   000002 IAC       0000   000012 INJPS     0000 I 000004 J         0000 I 000006 K
    0006 R 000014 KC        0007 R 000006 KF        0007 R 000000 KG        0007 R 000022 KPF       0007 R 000014 KR
    0007 R 000030 KRC       0003   000003 LC        0003   000007 LPM       0003   000004 LR        0003 R 000005 LO
    0003   000001 MP        0007 R 000043 OMEGAS    0007 R 000045 OMEGAV    0007 R 000040 OMEGPF    0000 R 000003 PL
    0006   000000 PS        0004   000022 RS        0000 R 000003 TERM      0010   000000 TIME      0006 R 000003 VO
    0010 R 000001 X         0010 R 000133 XDOT      0003   000000 ZETAE     0007 R 000042 ZETAS     0007 R 000044 ZETAV

00101     1*          SUBROUTINE HYSREL
00101     2*    C
00101     3*    C     ROUTINE TO COMPUTE HYDRAULIC AND SERVO ELECTRONIC DERIVATIVES
00101     4*    C
00103     5*          REAL KC,KG,KR,LO,KRC,KPF,KF
00104     6*          COMMON /ACSTRD/ ZETAE,MP,IAC,LC,LR,LO,EIR,LPM
00105     7*         *COMMON /ACLVA / AL(6),AV(6),AA(6),RS(3,6)
00106     8*          COMMON /ACDVAC/ CAL(6),CAV(6),CAA(6)
00107     9*          COMMON /HYDRD / PS,A(2),VO(2),CP(6),BETAE,KC,FF(6),BP(6)
00110     10*         COMMON /ELECD / KG(6),KF(6),KR(6),KPF(6),KRC(6),ALPHA,BETA,
00110     11*        1                OMEGPF(2),ZETAS,OMEGAS,ZETAV,OMEGAV
00111     12*         COMMON /NRKVSI/ TIME,X(90), XDOT(90)
00112     13*         CALL DENTRY                 @ CALCULATE ACTUATOR ACCELERATIONS
00113     14*         DO 140 I=1,6
00113     15*   C
```

```
00113    14.      C    FILTERED ACTUATOR FEEDBACK VELOCITIES
00113    17.      C
00116    18.           IF(OMEGAS-1.) 20,20,30
00121    19.        20 XDOT(I+60) = AA(I)
00122    20.           X(I+60) = AV(I)
00123    21.           X(I+66) = AL(I)
00124    22.           XDOT(I+66)=AV(I)
00125    23.           GO TO 40
00126    24.        30 XDOT(I+60) = OMEGAS**2*(AL(I)-2.*ZETAS/OMEGAS*X(I+60)-X(I+66))
00127    25.           XDOT(I+66) = X(I+60)
00127    26.      C
00127    27.      C
00130    28.        40 IF(BETA-1.) 50,50,70
00133    29.        50 DELTA = KF(I)*CAL(I)+KRC(I)*CAV(I)
00134    30.           X(I+84) = DELTA-X(I+78)-KR(I)*X(I+60)-KF(I)*X(I+66)
00135    31.           XDOT(I+84) = 0.
00135    32.      C
00135    33.      C    NO-LOAD VALVE FLOWS
00135    34.      C
00136    35.        70 IF(OMEGAV-1.) 80,80,90
00141    36.        80 X(I+54) = KG(I)*X(I+84)
00142    37.           XDOT(I+48) = 0.
00143    38.           X(I+48) = 0.
00144    39.           XDOT(I+54) = 0.
00145    40.           GO TO 100
00146    41.        90 XDOT(I+48) = OMEGAV**2*(KG(I)*X(I+84)-2.*ZETAV*X(I+48)
00146    42.          1            /OMEGAV-X(I+54))
00147    43.           XDOT(I+54) = X(I+48)
00147    44.      C
00147    45.      C    PUSH AND PULL HYDRAULIC PRESSURE ON ACTUATOR PISTONS
00147    46.      C
00150    47.       100 CONTINUE
00151    48.           FACT = 1.
00152    49.           PL = AL(I)-LO
00153    50.           DO 110 J=1,2
00156    51.           TERM = -CP(I)*(X(I+36)-X(I+42))-A(J)*AV(I)
00157    52.           IF(J.EQ.2) FACT = -1.
00161    53.           K = 6*(J-1)+36
00162    54.       110 XDOT(K+1) = BETAE/(VO(J)+FACT*A(J)*PL)*
00162    55.          1            (FACT*X(I+54)-2.*KC*X(K+1)+FACT*TERM)
00162    56.      C
00162    57.      C    PRESSURE FEEDBACK
00162    58.      C
00164    59.           XDOT(I+72) = OMEGPF(1)*(KPF(I)*(X(I+36)-X(I+42))-X(I+72))
00165    60.           XDOT(I+78) = OMEGPF(2)*(XDOT(I+72)-X(I+78))
00165    61.      C
00165    62.      C    VOLTAGE OUTPUT OF FORWARD LOOP COMPENSATION FILTERS
00165    63.      C
00166    64.           IF(BETA-1.) 140,140,120
00171    65.       120 DELTA = KF(I)*CAL(I)+KRC(I)*CAV(I)
00172    66.           DELTAD = KF(I)*CAV(I)+KRC(I)*CAA(I)
00173    67.           XDOT(I+84) = BETA*((DELTAD-XDOT(I+78)-KR(I)*XDOT(I+60)
00173    68.          1            -KF(I)*X(I+60))/ALPHA+(DELTA-X(I+78)-KR(I)*X(I+60)
00173    69.          2            -KF(I)*X(I+66))-X(I+84))
00174    70.       140 CONTINUE
00174    71.           RETURN
00177    72.           END
```

```
      END OF COMPILATION!      NO  DIAGNOSTICS.
MySREL          SYMBOLIC                    05 SEP 73  14:21:14   0  01470476    14    72  (DELETED)
MySREL  CODE    RELOCATABLE                 05 SEP 73  14:21:14   1  01472456    48     1  (DELETED)
                                                                   0  01472536    14    23
```

```
@ FOR,* INITIL.INITIL
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  (EXEC8 LEVEL E!20100104)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:26

SUBROUTINE INITIL   ENTRY POINT 000116

 STORAGE USED: CODE(1) 000127  DATA(0) 000110  BLANK COMMON(2) 000000

 COMMON BLOCKS:

 0003  FRCFND 000072
 0004  HYDRD  000031
 0005  NTGRTC 000006
 0006  NTGRTD 000004
 0007  NITILC 000132
 0010  MASS   000504
 0011  NRKVS1 000265
 0012  ELECD  000036
 0013  PLOTD  000001

 EXTERNAL REFERENCES (BLOCK, NAME)

 0014  NREWS
 0015  N*DUS
 0016  NIO2S
 0017  NERR3S

 STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001  000033 131G    0001  000041 190G    0001  000046 146G    0001  000047 151G    0001  000070 166G
 0000  000003 901F    0004 R 000001 A      0004  000013 BETAE   0004  000023 BP      0004  000005 CP
 0006 R 000001 EXFFRQ  0004  000015 FF     0005  000002 FILL    0003  000030 FILL1   0006 R 000000 FRQNCY
 0000 I 000001 I       0006 I 000004 IFIRST 0006 I 000005 INDKTR 0000  000071 INJPS   0005 I 000005 IPLOPT
 0000 I 000002 J       0004  000014 KC     0012  000006 KF      0012  000000 KG      0012 R 000022 KPF
 0012  000014 KR       0012  000030 KRC    0010 I 000000 M      0013 I 000000 NPLTS   0003 R 000006 OMEGAC
 0003 R 000050 OMEGAF  0004 R 000000 PS     0005 R 000001 TEND   0011  000000 TIME    0006 R 000003 TPLOT
 0006 R 000002 TPRINT  0005 R 000000 TSTART 0000 R 000000 VBW    0004  000003 VO      0011 R 000001 X
 0011 R 000133 XDOT    0003 R 000000 XI     0007 R 000000 XO


00101    1*        SUBROUTINE INITIL(IFREQ,IFFREQ)
00103    2*        COMMON /FRCFND/ XI(6),OMEGAC(18),FILL1(16),OMEGAF(18)
00104    3*        COMMON /HYDRD / PS,A(2),VO(2),CP(6),BETAE,KC,FF(6),BP(6)
00105    4*        COMMON /NTGRTC/ TSTART,TEND,FILL(3),IPLOPT
00106    5*        COMMON /NTGRTD/ FRQNCY,EXFFRQ,TPRINT,TPLOT,IFIRST,INDKTR
00107    6*        COMMON /NITILC/ XO(90)
00110    7*        COMMON / MASS / M(18,18)
00111    8*        COMMON /NRKVS1/ TIME,X(90),XDOT(90)
00112    9*        COMMON /ELECD / KG(6),KF(6),KM(6),KPF(6),KRC(6)
00113   10*        COMMON / PLOTD/ NPLTS
00114   11*        REAL KPF
00115   12*        DATA VBW /.005/
```

```
00117        FRQNCY = OMEGAC(IFREQ)
00120        EXFFRQ = OMEGAF(IFFREQ)
00121        INDKTR = 0
00122        IFIRST = 0
00123        TPRINT = TSTART
00124        TPLOT = TSTART
00125        NPLTS = 0
00126        IF(IPLOPT.GT.0) REWIND 3
00130        DO 10 I=1,90
00133        X(I) = 0.
00134        XDOT(I) = 0.
00135     10 XD(I) = 0.
00137        DO 20 I=1,6
00142        XD(18+I) = X(I)
00143     20 CONTINUE
00145        DO 30 I=1,18
00150        DO 30 J=1,18
00153     30 H(I,J) = 0
00156        WRITE(6,901) FRQNCY,EXFFRQ,TSTART,TEND
00164    901 FORMAT('1'///////////////////////////////////39X54('*')/39X'*'52X'*'/
00164       1        39X'*'3X'COMMAND SIGNAL FREQUENCY :'G12.6,' RAD/SEC'3X'*'/
00164       +        39X'*'3X'EXTERNAL FORCE FREQUENCY :'G12.6,' RAD/SEC'3X'*'/
00164       2        39X'*'5X'START TIME :'F5.2,7X'STOP TIME :'F5.2,7X'*'/
00164       3        39X'*'52X'*'/ 39X 54('*'))
00165        DO 40 I=1,6
00170        XD(36+I) = PS/(1.+A(I)/A(2))
00171        XD(42+I) = PS-XD(36+I)
00172        XD(72+I) = KPF(I)*(XD(36+I)-XD(42+I))
00173     40 CONTINUE
00175        RETURN
00176        END

    END OF COMPILATION:          NO  DIAGNOSTICS.
 INITIL        SYMBOLIC                     28 JAN 74  23:27:19   0  015:3472   14   43  (DELETED)
 INITIL  CODE  RELOCATABLE                  28 JAN 74  23:27:19   1  015:5024   60    1  (DELETED)
                                                                  0  015:5120   14   16
```

```
29 JUN 74                    5:35:27.49T

* FOR,* MATRX,MATRX
INPUT SOURCE LANGUAGE ELEMENT NOT AVAILABLE
```

```
                                                                    29 JUN 74          5:35:27.535

@  FOR,* M3X3,M3X3
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A - (EXEC8 LEVEL E12010010A)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:27


    SUBROUTINE M3X3      ENTRY POINT 000047

    STORAGE USED: CODE(1) 000066; DATA(0) 000241 BLANK COMMON(2) 000000

    EXTERNAL REFERENCES (BLOCK, NAME)

      0003   NERR35

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

      0001   000005 I05G       0001   000010 I10G       0001   000012 I14G       0000 I 000000 I          0000   000005 INJPS
      0000 I 000001 J          0000 I 000002 K


00101     1*          SUBROUTINE M3X3(A,B,C)
00103     2*          DIMENSION A(3,3),B(3,3),C(3,3)
00104     3*          DO 10 I=1,3
00107     4*          DO 10 J=1,3
00112     5*          C(I,J) = 0.
00113     6*          DO 10 K=1,3
00116     7*       10 C(I,J) = C(I,J)+A(I,K)*B(K,J)
00122     8*          RETURN
00123     9*          END

      END OF COMPILATION:      NO  DIAGNOSTICS.

      M3X3          SYMBOLIC      15 AUG 73  15:49:31   0  01442426   14    9  (DELETED)
      M3X3    CODE  RELOCATABLE   15 AUG 73  15:49:31   1  01442624   24    1  (DELETED)
                                                        0  01442654   14    7
```

```
@  FOR,* NRKVS,NRKVS                                                    29 JUN 74          5:35:38.467
UNIVAC 1108 FORTRAN V EXEC 17 LEVEL 25A  -(EXEC8 LEVEL 51201001041
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:38

    SUBROUTINE NRKVS     ENTRY POINT 001360

    STORAGE USED: CODE(1) 001443; DATA(0) 001424; BLANK COMMON(2) 000000

    COMMON BLOCKS:

    0003   NRKVS1 000267
    0004   NRKVS2 000264
    0005   NRKVS3 000007
    0006   NTGRTD 000006

    EXTERNAL REFERENCES (BLOCK, NAME)

    0007   NWDUS
    0010   NIO1S
    0011   NIO2S
    0012   NERR4S
    0013   NERR3S

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001  000039 104L   0001  000040 108L   0001  000111 114L   0001  000045 120L   0001  000117 122L
0001  000124 123L   0001  000132 125L   0001  000045 144G   0001  000137 200L   0001  000150 215G
0001  000215 237G   0001  000230 246G   0001  000250 256G   0001  000275 270G   0001  000312 277G
0001  000170 300L   0001  000332 307G   0001  000347 316G   0001  000366 327G   0001  000402 336G
0001  000422 346G   0001  000437 355G   0001  000475 372G   0001  000445 400L   0001  000511 401G
0001  000531 411G   0001  000545 420G   0001  000574 432G   0001  000556 500L   0001  001001 506G
0001  000615 506L   0001  000646 510L   0001  000664 513L   0001  000711 514L   0001  000733 516L
0001  000736 518L   0001  000757 520L   0001  001041 526G   0001  001124 564G   0001  000773 600L
0001  001151 601G   0001  000774 610L   0001  001032 622L   0001  001037 624L   0001  001207 625G
0001  001055 636L   0001  001063 640L   0001  001247 650G   0001  001266 660G   0001  001271 664G
0001  001115 700L   0000  001117 702F   0000  001136 704F   0000  001150 706F   0001  001327 706G
0000  001172 708F   0001  001170 710L   0000  001220 712F   0001  001230 730L   0000  001256 742F
0001  001254 750L   0001  001303 760L   0000  001265 780F   0000 R 001041 A      0000 R 001101 AH
0000 R 001072 AHMIN  0005 R 000001 AHMINM 0000 R 001071 AHS   0005 R 000002 AHSTRT 0005 R 000132 AMAG
0000 R 001062 B      0000 R 001063 C      0000 R 001274 CHNG   0003 R 000133 D      0000 R 000264 DHIST
0000 R 001426 DIFF   0000 R 001060 DRHO   0000 R 000000 ES     0003 R 000266 ENDT   0004 R 000000 ERR
0000 R 001274 ERRSTO 0006 I 000000 FILL   0000 R 000550 FINAGL 0000 R 001102 H      0000 R 001106 H12
0000 R 001103 H2     0000 R 001105 H4     0000 R 001104 H6     0000 I 001064 I      0005 I 000000 IDIAG
0003 I 000265 IND    0006 I 000005 INDKTR 0000  001601 INJPS  0000 I 001065 INTEG  0005 I 000003 INTFLG
0000 I 001072 IREJEC 0000 I 000555 IS/VE  0000 I 001115 J      0000 I 001116 K      0005 I 000004 MAXN
0005 I 000005 MFAILI 0005 I 000004 MSTEP2 0000 I 001100 NFAILI 0000 I 001113 NSORT  0000 I 001076 NSTEP
0000 I 001077 NSTEP2 0000 R 001110 RETIP  0000 L 001055 REJECT 0000 R 001274 RERR   0000 L 001056 RETRN
0000 R 000562 RSAVE  0000 R 001114 SORT   0003 R 000000 T      0000 D 000567 TD     0000 R 001107 TERR
0000 R 001075 TEST   0000 R 001111 TF1    0000 R 001112 TF2    0000 R 001070 TR     0000 R 001067 TS
0000 R 001074 TTEST  0000 R 001066 UPDS   0003 R 000001 X      0000 D 000571 XD     0000 R 000416 XHIST
0000 R 001057 XRHO   0000 R 001274 XS     0000 R 001426 Z      0000 R 000132 ZZ
```

```
      SUBROUTINE NRKVS (S,TT,TP,XO,XX,NV,IN,FCN)
C     ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C
      PARAMETER  ND=90
      DIMENSION XO(1),XX(1),XS(ND),DS(ND),Z(ND),ZZ(ND),CHNG(ND),
     1DIFF(ND),DHIST(ND),XHIST(ND),RERR(ND),ERRSTD(ND)
      DIMENSION FINAGL(5),ISAVE(5),RSAVE(5)
      DOUBLE PRECISION TD,XD(ND)
      LOGICAL REJECT,RETRN
      EQUIVALENCE (XS,CHNG,RERR,ERRSTD),(DIFF,Z)
      COMMON/NRKVS1/T,X(ND),D(ND),IND,ENDT
      COMMON/NRKVS2/ERR(ND),AMAG(ND)
      COMMON/NRKVS3/IDIAG,AHMINM,AHSTRT,INTFLG,MAXN,MFA,L1,MSTEP2
      COMMON /NTGRTD / FILL(5),INDKYR
      DATA XRHO,DRHO/.99 ,.75/A,B,C/.45460211,2.2761459,2.7327480/
      DATA (FINAGL(I),I=1,5)/5*1H/
C
C     ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C
C     INITIALIZATION FOR FIRST CALL TO THIS PROGRAM.
C         ASSIGNMENTS ARE MADE SO AS
C       • TO USE EITHER SIMPSONS RULE OR RUNGE KUTTA FORMULAS
C
      IF (ABS(TT-TP) .LT. 1.E-6) RETURN
    2 RETRN = .FALSE.
      REJECT = .FALSE.
      IF(IN.GT.0) GO TO 200
      IN = 1
      IF(INTFLG.EQ.0) GO TO 104
      ASSIGN 400 TO INTEG
      ASSIGN 624 TO UPDS
      GO TO 108
  104 ASSIGN 300 TO INTEG
      ASSIGN 622 TO UPDS
  108 DO 120 I=1,NV
      DHIST(I) = 0.0
      X(I) = XO(I)
      XX(I) = X(I)
      XD(I) = DBLE(X(I))
      XHIST(I) = AMAX1(ABS(X(I)),AMAG(I))
      IF (XHIST(I)) 110,110,120
  110 XHIST(I) = 1.0
  120 CONTINUE
      T = TT
      TS = T
      TD = DBLE(T)
      TR=TP-TS
      IF(TR)11,10,11
   10 CALL FCN
      IN=0
      RETURN
   11 CONTINUE
C••••
C     INITIAL STEP AND MINIMUM STEP = SET BY USER OR PROGRAM
      IF(AHSTRT)122,122,121
  121 AHS = ABS(AHSTRT)
      GO TO 123
```

```
00201   58*       122 AHS =.01*ABS(TP-TS)
00202   59*           IF(AHMINM)125,125,124
00205   60*       124 AHMIN = ABS(AHMINM)
00206   61*           GO TO 200
00207   62*       125 AHMIN  1.E-5*ABS(TP-TS)
00207   63*      C****
00207   64*      C
00207   65*      C     ********************************************************************
00207   66*      C
00207   67*      C     INITIALIZATION FOR SUBSEQUENT CALLS TO THIS PROGRAM
00207   68*      C          CONTINUATION OF AN INTEGRATION AFTER A NEW
00207   69*      C          PRINT TIME (TP) IS SET
00207   70*      C****
00207   71*      C     EVALUATE D ' VATIVES AT STARTING POINT
00207   72*      C
00207   73*          200 ENDT = TP
00210   74*              IND = 1
00211   75*              CALL FCN
00212   76*              IND = 0
00213   77*      C****
00214   78*              DO 210 I=1,NV
00217   79*          210 DS(I) = D(I)
00217   80*              TR = TP-TS
00221   81*              IREJEC = 0
00222   82*              TTEST = TS
00223   83*              TEST = .005*ABS(TR)
00224   84*              NSTEP = 0
00225   85*              NSTEP2= 0
00226   86*              NFAIL= 0
00227   87*              GO TO INTEG,(300,900)
00230   88*      C
00230   89*      C     ********************************************************************
00230   90*      C
00230   91*      C     RUNGE KUTTA FORMULAS
00230   92*      C          A ONE STEP,FOLLOWED BY A TWO STEP,INTEGRATION IS PERFORMED.
00230   93*      C          THE INCREMENTS TO THE DEPENDENT VARIABLES ARE FOUND IN Z,ZZ
00230   94*      C****
00230   95*      C                    DO ONE STEP OF LENGTH H
00230   96*          300 AH =AHINI(AHS,ABS(TR))
00231   97*              H=SIGN(AH,TR)
00232   98*              H2= .5*H
00233   99*              H6= H2/3.
00234  100*              T = TS+ H2
00235  101*              DO 302 I=1,NV
00236  102*              XS(I)=SNGL(X0(I))
00241  103*          302 X(I)=XS(I)+H2*DS(I)
00242  104*              CALL FCN
00244  105*              DO 304 I=1,NV
00245  106*              Z(I)= DS(I)+2.*D(I)
00250  107*          304 X(I)= XS(I)+H2*D(I)
00251  108*              CALL FCN
00253  109*              T =TS +H
00254  110*              DO 306 I=1,NV
00255  111*              Z(I)= Z(I)+ 2.*D(I)
00260  112*          306 X(I)= XS(I)+H*D(I)
00261  113*              CALL FCN
00263  114*              H4=.25*H
00264  115*              H12=H4/3.
00265
```

```
00266   1160*            T=TS+ H4
00267   1170*            DO 310 I=1,NV
00272   1180*            Z(I)=H6*(Z(I)+D(I))
00272   1190*      C****
00272   1200*      C
00272   1210*      C****                  DO FIRST HALF STEP OF LENGTH H/2
00272   1220*      C
00273   1230*        310 X(I)=XS(I)+H4*DS(I)
00275   1240*            CALL FCN
00276   1250*            DO 314 I=1,NV
00301   1260*            ZZ(I)=DS(I)+2.*D(I)
00302   1270*        314 X(I)= XS(I)+H4*D(I)
00304   1280*            CALL FCN
00305   1290*            T=TS+H2
00306   1300*            DO 316 I=1,NV
00311   1310*            ZZ(I)=ZZ(I)+2.*D(I)
00312   1320*        316 X(I)= XS(I)+H2*D(I)
00314   1330*            CALL FCN
00314   1340*      C****
00314   1350*      C
00314   1360*      C****                  SET UP SECOND HALF STEP
00314   1370*      C
00314   1380*      C
00315   1390*            DO 320 I=1,NV
00320   1400*            ZZ(I)=ZZ(I)+D(I)
00321   1410*            X(I)= XS(I)+H12*ZZ(I)
00322   1420*        320 XS(I)=X(I)
00324   1430*            CALL FCN
00324   1440*      C****
00324   1450*      C                      DO SECOND HALF STEP OF LENGTH H/2
00324   1460*      C
00324   1470*      C
00324   1480*      C****
00325   1490*            T=T+H4
00326   1500*            DO 322 I=1,NV
00331   1510*            X(I)=XS(I)+H4*D(I)
00332   1520*        322 ZZ(I)=ZZ(I)+D(I)
00334   1530*            CALL FCN
00335   1540*            DO 324 I=1,NV
00340   1550*            ZZ(I)=ZZ(I)+2.*D(I)
00341   1560*        324 X(I)= XS(I)+H4*D(I)
00343   1570*            CALL FCN
00344   1580*            T=TS+H
00345   1590*            DO 326 I=1,NV
00350   1600*            ZZ(I)=ZZ(I)+2.*D(I)
00351   1610*        326 X(I)= XS(I)+H2*D(I)
00353   1620*            CALL FCN
00354   1630*            DO 330 I=1,NV
00357   1640*        330 ZZ(I)=H12*(ZZ(I)+D(I))
00357   1650*      C****                  NOW GO TO ERROR CHECKING SEQUENCE
00357   1660*      C
00361   1670*            GO TO 500
00361   1680*      C
00361   1690*      C     ****************************************************************
00361   1700*      C
00361   1710*      C     SIMPSONS RULE FORMULAS.
00361   1720*      C         AS WITH THE ABOVE RUNGE KUTTA FORMULAS,STEPS OF LENG   H AND
00361   1730*      C         H/2 ARE MADE WITH INCREMENTS IN Z AND ZZ
```

```
00361   1740    C
00362   1750      400 AH= AMIN1(AMS,ABS(TR))
00363   1760          H=SIGN(AH,TR)
00364   1770          H9= .25*H
00365   1780          H6= H/6.
00366   1790          H12=H6/2.
00367   1800          T=TS+ H9
00370   1810          CALL FCN
00371   1820          DO 402 I=1,NV
00372   1830      402 ZZ(I)=DS(I)+9.*D(I)
00376   1840          T=T+H9
00377   1850          CALL FCN
00400   1860          DO 404 I=1,NV
00403   1870          ZZ(I)=ZZ(I)+2.*D(I)
00404   1880      404 Z(I)= DS(I)+9.*D(I)
00406   1890          T=T+H9
00407   1900          CALL FCN
00410   1910          DO 406 I=1,NV
00413   1920      406 Z(I)=ZZ(I)+9.*D(I)
00415   1930          T=TS+ H
00416   1940          CALL FCN
00417   1950          DO 408 I=1,NV
00422   1960          ZZ(I)=H12*(ZZ(I)+D(I))
00423   1970      408 Z(I)= H6*(Z(I)+D(I))
00423   1980    C
00423   1990    C     ********************************************************************
00423   2000    C
00423   2010    C     ERROR CHECKING SEQUENCE.
00423   2020    C          IN THIS SECTION,THE SIZE STANDARD IS UPDATED,THE ERRORS ARE
00423   2030    C          COMPUTED,THE WORST ERROR IS COMPUTED,AND DECISIONS ARE MADE
00423   2040    C          AS TO HOW TO PROCEED.
00425   2050      500 TERR= 0.
00426   2060          IF(INDKTR.EQ.1) RETURN 1
00430   2070          RECIP = 1./AH
00431   2080          DO 510 I=1,NV
00434   2090          CHNG(I)=AMAX1(ABS(Z(I)),ABS(ZZ(I)))
00435   2100          DIFF(I)=(ZZ(I)-Z(I))/15.
00436   2110          IF(CHNG(I)) 504,504,506
00441   2120      504 RERR(I)= 0.
00442   2130          DHIST(I)= 0.
00443   2140          GO TO 510
00444   2150      506 DHIST(I)= AMAX1(CHNG(I)*RECIP,DRHO*DHIST(I))
00445   2160    C****
00445   2170    C          SIZE STANDARD
00445   2180          ERRSTD(I)=AMAX1(DHIST(I)*AH,XHIST(I))
00445   2190    C****
00445   2200    C          ERROR FOR EACH EQUATION
00446   2210          RERR(I)=ABS(DIFF(I)/(ERRSTD(I)*ERR(I)))
00446   2220    C****
00446   2230    C          WORST ERROR FOR ALL EQUATIONS
00447   2240          TERR=AMAX1(RERR(I),TERR)
00450   2250      510 CONTINUE
00450   2260    C****
00450   2270    C
00450   2280    C****
00450   2290    C               NOW PROCESS ITEST TO DECIDE WHAT TO DO WITH THIS
00450   2300    C               INTEGRATION CYCLE
00450   2310    C
```

```
00452   232*          IF(TERR.GT.10.) GO TO 514
00454   233*          IF(ABS(TR)-AH) 512,512,513
00457   234*      512 RETRN =.TRUE.
00460   235*          GO TO 600
00461   236*      513 IF(TERR.GT.1.) GO TO 520
00463   237*          IF(REJECT) GO TO 600
00465   238*          AHS=AMIN1(2.0,(1.+C*TERR)/(A+B*TERR))*AH
00466   239*          GO TO 600
00467   240*      514 REJECT =.TRUE.
00470   241*          IREJEC = IREJEC +1
00471   242*          IF(AHS.GT.AHMIN) GO TO 518
00473   243*          NFAIL1 =NFAIL1 +1
00474   244*          IF(NFAIL1.GT.1) GO TO 516
00476   245*          TF1=TS
00477   246*      516 TF2=TS
00500   247*          GO TO 700
00501   248*      518 AHS=AMAX1(AHMIN,AMAX1(.5,(TERR*A+B)/(TERR*C))*AH)
00502   249*          GO TO INTEG,(300,400)
00503   250*      520 AHS=AMAX1(AHMIN,((TERR*A+B)/(TERR*C))*AH)
00503   251*     C****
00503   252*     C
00503   253*     C     ********************************************************************.
00503   254*     C     SYSTEM UPDATE SECTION.
00503   255*     C          AT THIS POINT A STEP HAS BEEN ACCEPTED,UPDATE THE SYSTEM
00503   256*     C          VARIABLES AND PREPARE FOR A NEW STEP UNLE S TP HAS BEEN
00503   257*     C          REACHED OR A DIAGNOSTIC MESSAGE IS REQUIRED.
00504   258*      600 REJECT =.FALSE.
00505   259*      610 DO 620 I=1,NV
00510   260*          Z(I)=ZZ(I)+DIFF(I)
00511   261*          XD(I)= XD(I)+DBLE(Y(I))
00512   262*          X(I)= SNGL(XD(I))
00513   263*          XX(I) = X(I)
00514   264*      620 XHIST(I)= AMAX1'ABS(X(I)),XRHO*XHIST(I))
00516   265*          TD= TD+ DBLE(H)
00517   266*          T = SNGL(TD)
00520   267*          TS=T
00521   268*          GO TO UPDS,(622,624)
00522   269*      622 IND = 1
00523   270*          CALL FCN
00524   271*          IND = 0
00525   272*      624 DO 630 I=1,NV
00530   273*      630 DS(I)=D(I)
00532   274*          NSTEP=NSTEP+1
00533   275*          IF(IDIAG.EQ.0) GO TO 636
00535   276*          IF(NSTEP.LE.MAXN)   GO TO 730
00537   277*      636 IF(TP-ENDT)638,640,638
00542   278*      638 TP=ENDT
00543   279*          RETRN = .FALSE.
00544   280*      640 TN= TP- TS
00545   281*          IREJEC = 0
00546   282*          IF(RETRN) RETURN
00550   283*          NSTEP2 = NSTEP2 + 1
00551   284*          IF(NSTEP2.LT.MSTEP2) GO TO INTEG,(300,400)
00553   285*          IF (ABS(TS-TTEST)-TEST) 710,710,644
00556   286*      644 TTEST =TS
00557   287*          NSTEP2= 0
00560   288*          GO TO INTEG,(300,400)
00560   289*     C
```

```
00560   290*    C     ***********************************************************************
00560   291*    C
00560   292*    C     DIAGNOSTIC SECTION.
00560   293*    C         THREE LEVELS OF DIAGNOSTICS ARE POSSIBLE. TWO OF
00560   294*    C         WHICH CAUSE AN ERROR RETURN
00560   295*    C
00560   296*    C****
00560   297*    C
00560   298*    C                   1.IF AN ERROR TEST IS NOT SATISFIED AT MINIMUM STEP,
00560   299*    C                     A MESSAGE IS PRINTED. THIS IS ALLOWED TO HAPPEN
00560   300*    C                     AT MOST MFAIL1 TIMES AT WHICH TIME
00560   301*    C                     THE ERROR RETURN IS MADE
00560   302*    C
00561   303*          700 WRITE(6,702) TS,(RERR(I),I=1,NV)
00570   304*          702 FORMAT(1HO,23HERROR CHECK FAILURE AT , E14.8,10X,23HERROR INDICATO
00570   305*             1RS FOLLOW./,(1H E9.3,9E9.3))
00571   306*              IF(NFAIL1.LE.MFAIL1) GO TO 610
00573   307*              WRITE(6,704)
00575   308*          704 FORMAT(1HO,51HEXCESSIVE ERROR CHECK FAILURES AT MINIMUM STEP SIZE)
00576   309*              WRITE(6,706) TS,(X(I),I=1,NV)
00605   310*          706 FORMAT(1HO,26HINTEGRATION TERMINATED AT ,E14.8,
00605   311*             150H WITH THE FOLLOWING DEPENDENT VARIABLE EVALUATIONS:/(2E14.8))
00606   312*              WRITE(6,708)TF1,TF2
00612   313*          708 FORMAT(1HO,51HFIRST ERROR FAILURE AT MINIMUM STEP FOR INDEP VAR =,
00612   314*             1E13.8/52H  LAST ERROR FAILURE AT MINIMUM STEP FOR INDEP VAR =,E13.
00612   315*             28)
00613   316*              RETURN 1
00613   317*    C
00613   318*    C****
00613   319*    C
00613   320*    C                   2. IF AN INTEGRATION TAKES HSTEP2 STEPS IN A SMALL
00613   321*    C                     FRACTION OF THE CURRENT PRINT INTERVAL (TEST IS
00613   322*    C                     THE VARIABLE SET TO THIS FRACTION) IT IS LIKELY
00613   323*    C                     THAT EXCESSIVE COMPUTER TIME WILL BE CONSUMED
00613   324*    C                     BEFORE THE PROBLEM IS COMPLETED,THEREFORE
00613   325*    C                     THE ERROR RETURN IS MADE
00613   326*    C
00614   327*          710 WRITE (6,712) HSTEP2,TTEST,TS
00621   328*          712 FORMAT(1HO,31HINTEGRATION PROCEDURE REQUIRED ,I3,6H STEPS/1HO,27HF
00621   329*             1ROM INDEPENDENT VARIABLE =,E14.8/28H    TO INDEPENDENT VARIABLE =,E
00621   330*             214.8/1HO,40HCOMPUTATION CONSIDERED PROHIBITIVLY SLOW)
00622   331*              WRITE(6,706) TS,(X(I),I=1,NV)
00631   332*              IF (NFAIL1.NE.0) WRITE (6,708) TF1,TF2
00636   333*              RETURN 1
00636   334*    C
00636   335*    C                   3. AS A DEBUGGING AID,A DIAGNOSTIC MAY BE PRINTED
00636   336*    C                     EACH STEP, HOWEVER,NO MORE THAN  MAXN  OF THESE
00636   337*    C                     CAN BE PRINTED IN EACH PRINT INTERVAL. THIS IS TO
00636   338*    C                     PREVENT THE INADVERTENT  GENERATION  OF
00636   339*    C                     EXCESSIVE OUTPUT.
00636   340*    C
00644   341*          730 IF(IDIAG.EQ.1) GO TO 750
00   4  342*              WRITE(6,742)NSTEP,IREJEC,TS,H,TERR,(RERR(I),I=1,NV)
00   4  343*          742 FORMAT(1H ,214,3E14.5,10F8.2,/,(1H 10X,15F8.2))
00655   344*              GO TO 636
00656   345*          750 NSORT =MIND(5,NV)
00657   346*              DO 770 I=1,NSORT
00642   347*              SORT = 0.
```

```
00663    348*          DO 760 J=1,NV
00666    349*          IF(RERR(J).LT.SORT) GO TO 760
00670    350*          SORT = RERR(J)
00671    351*          K=J
00672    352*      740 CONTINUE
00674    353*          ISAVE(I)=K
00675    354*          RSAVE(I)= SORT
00676    355*      770 RERR(K) = -1.
00700    356*          WRITE(6,780)NSTEP,IREJEC,TS,H,(FINAGL(I),ISAVE(I),RSAVE(I),
00700    357*         1      I=1,NSCRT)
00714    358*      780 FORMAT(1H ,2I4,2E17.8,5(4X,A1,I3,1H,,F6.2,1H)))
00715    359*          GO TO 636
00715    360*    C     ************************************************************
00716    361*          END

        END OF COMPILATION:          NO DIAGNOSTICS.
    NRKVS            SYMBOLIC                        05 SEP 73  14:21:21   0  01493240   14   361  (DELETED)
    NRKVS   CODE     RELOCATABLE                     05 SEP 73  14:21:21   1  01505136   36     1  (DELETED)
                                                                           0  015n5202   14    97
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@   FOR,* OUTPUT,OUTPUT                                                              29 JUN 74          5:35:32.494
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  *(EXEC4 LEVEL E1201D010A)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:32

     SUBROUTINE OUTPUT    ENTRY POINT 000451

     STORAGE USED: CODE(1) 000647; DATA(0) 000243; BLANK COMMON(2) 000000

      COMMON BLOCKS:

      0003    NRKVSI 000265
      0004    FRCFND 000006
      0005    ACDVAC 000030
      0006    ACTBND 000022
      0007    ACLVA  000014
      0010    FORCES 000014
      0011    NTGRTC 000006
      0012    NTGRTD 000006
      0013    ACSTRD 000006
      0014    FLOTD  001751

     EXTERNAL REFERENCES (BLOCK, NAME)

      0015    NWDUS
      0016    NIO2S
      0017    NERR2S
      0020    NIOIS
      0021    NWBUS
      0022    NERR3S

     STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

      0001    000077 10L       0001    000502 100L      0001    000537 120L      0001    000563 130L      0001    000063 142G
      0001    000624 150L      0001    000127 164G      0001    000161 175G      0001    000114 20L       0001    000176 204G
      0001    000203 210G      0001    000210 214G      0001    000224 225G      0001    000233 231G      0001    000240 235G
      0001    000252 245G      0001    000272 255G      0001    0' 277 261G      0001    000304 265G      0001    000311 271G
      0001    000157 30L       0001    000327 302G      0001    000341 310G      0001    000463 334G      0001    000504 343G
      0001    000520 352G      0001    000525 356G      0001    000532 362G      0001    000544 371G      0001    000551 375G
      0001    000556 401G      0001    000565 407G      0001    000661 416G      0001    000606 422G      0001    000613 426G
      0001    000620 432G      0001    000220 50L       0001    000250 60L       0001    000316 70L       0001    000345 80L
      0001    000347 90L       0000    000030 901F      0000    000032 902F      0000    000060 903F      0000    000111 904F
      0000    000154 905F      0000    000163 906F      0000    000171 907F      0007 R  000000 AL        0007 R  000006 AV
      0005    000004 CA        0005 R  000000 CAL       0012    000001 EXFFRQ    0006    000000 FILL      0013    000000 FILLI
      0010    000000 FMH       0010 R  000006 FP        0012    000000 FRQNCY    0000 I  000025 I         0012    000004 IFIRST
      0000 I  000027 IGO       0012    000005 INDKTR    0000    000232 INJPS     0011 I  000005 IPLOPT    0011 I  000004 IPROPT
      0000 I  000026 K         0000 I  000024 LINES     0013 R  000005 LO        0000 I  000004 M         0000 I  000000 N
      0014 I  000000 NPLTS     0006 R  000014 OMEGAE    0011 R  000002 OUTFRQ    0005 R  000022 TDIC      0011 R  000001 TEND
      0003 R  000000 TIME      0012 R  000003 TPLOT     0014 R  000001 TPLT      0012 R  000002 TPRINT    0011    000000 TSTART
      0003 R  000001 X         0003 R  000133 XDOT      0004 R  000000 X10       0000 R  000010 XP1       0000 R  000016 XP2

 00101        1*          SUBROUTINE OUTPUT
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```
00103    2*          COMMON /NRKVS1/ TIME,X(90),XDOT(90)
00104    3*          COMMON /FRCEND/ X10(6)
00105    4*          COMMON /ACDVAC/ CAL(6),CAI(12),TDIC(6)
00106    5*          COMMON /ACTBND/ FILL(12),OMEGAE(6)
00107    6*          COMMON /ACLVA / AL(6),AV(6)
00110    7*          COMMON /FORCES/ FMH(6),FP(6)
00111    8*          COMMON /NTGRTC/ TSTART,TEND,OUTFRQ(2),IPROPT,IPLOPT
00112    9*          COMMON /NTGRTO/ FRQNCY,EXFFRQ,TPRINT,TPLOT,IFIRST,INDKTR
00113   10*          COMMON /ACSTRO/ FILL1(5),LO
00114   11*          COMMON / PLOTO/ NPLTS,TPLT (1000)
00115   12*          DIMENSION N(4),M(4),XP1(6),XP2(6)
00116   13*          REAL LO
00117   14*          DATA LINES/60/
00121   15*      901 FORMAT(1H1)
00122   16*      902 FORMAT(/ 55X 'TIME =' 1PE12.6, ' SEC')
00123   17*      903 FORMAT(/ 4X'INCREMENTAL INERTIAL MOTIONS OF TABLE C.G.'T58,3G12.6
00123   18*     1      / 4X'INCREMENTAL ANGULAR MOTIONS'                    T58,3G12.6
00123   19*     2      / 4X'INERTIAL VELOCITIES OF TABLE C.G.'              T58,3G12.6
00123   20*     3      / 4X'EULER ANGLE RATES'                              T58,3G12.6
00123   21*     4      /4X'TABLE POSITION ERROR (ACTUAL-COMMAND)'           T58,6G12.6)
00123   22*      904 FORMAT(/4X'BENDING FREQUENCIES AT CYLINDER ROD SEAL'    T58,6G12.6
00124   23*     1      /4X'Y LATERAL ELASTIC DISPLACEMENTS AT CYLINDER'
00124   24*     *          ' ROD SEALS'                                     T58,6G12.6
00124   25*     2      /4X'Z LATERAL ELASTIC DISPLACEMENTS AT CYLINDER'
00124   26*     *          ' ROD SEALS'                                     T58,6G12.6)
00125   27*      905 FORMAT(/4X'DERIVATIVE ARRAY'(T58,6G12.6))
00126   28*      906 FORMAT( 4X'VARIABLE ARRAY'(T58,6G12.6))
00127   29*      907 FORMAT(/4X'ACTUATOR STROKES'                          T58,6G12.6
00127   30*     1      /4X'ACTUATOR VELOCITIES'                           T58,6G12.6
00127   31*     2      /4X'ACTUATOR POSITION ERROR (ACTUAL-COMMAND)'T58,6G12.6
00127   32*     3      /4X'NET FORCES ON ACTUATOR PISTONS'                T58,6G12.6)
00130   33*          IF(IPROPT.LE.0.OR.TIME.LT.TPRINT) GO TO 90
00132   34*          TPRINT = TIME+OUTFRQ(1)
00133   35*          IF(TPRINT.GT.TEND) TPRINT = TEND
00135   36*          N(1) = IPROPT/1000
00136   37*          N(2) = (IPROPT-N(1)*1000)/100
00137   38*          N(3) = (IPROPT-N(1)*1000-N(2)*100)/10
00140   39*          N(4) =  IPROPT-N(1)*1000-N(2)*100-N(3)*10
00141   40*          DO 10 I=1,4
00144   41*          IF(N(I).LT.4) GO TO 10
00146   42*          WRITE(6,901)
00150   43*          GO TO 20
00151   44*       10 CONTINUE
00153   45*          IF(LINES.LE.40) GO TO 20
00155   46*          WRITE(6,901)
00157   47*          LINES = 0
00160   48*       20 CONTINUE
00161   49*          WRITE(6,902) TIME
00164   50*          LINES = LINES+2
00165   51*          DO 80 K=1,4
00170   52*          IGO = N(K)
00171   53*          IF(IGO.LE.0.OR.IGO.GT.4) GO TO 80
00173   54*          GO TO (30,50,60,70),IGO
00173   55*      C
00173   56*      C   DATA SET NO. 1    TABLE RESPONSE DATA
00173   57*      C
00174   58*       30 DO 40 I=1,6
00177   59*          XP1(I) = X(18+I)+X10(I)
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00200   60*         90 XP2(I) = X(18+I)-TDIC(I)
00202   61*            WRITE(6,903) XP1,(XDOT(18+I),I=1,6),XP2
00220   62*            LINES = LINES+6
00221   63*            GO TO 80
00221   64*      C
00221   65*      C     DATA SET NO.2   ACTUATOR BENDING DATA
00221   66*      C
00222   67*         50 CONTINUE
00223   68*            WRITE(6,904) OMEGAE,(X(24+I),I=1,6),(X(30+I),I=1,6)
00241   69*            LINES = LINES+4
00242   70*            GO TO 80
00242   71*      C
00242   72*      C     DATA SET NO. 3   ACTUATOR RESPONSE
00242   73*      C
00243   74*         60 CONTINUE
00244   75*            DO 65 I=1,6
00247   76*            XP1(I) = AL(I)-LO
00250   77*         65 XP2(I) = AL(I)-CAL(I)
00252   78*            LINES = LINES+5
00263   79*            WRITE(6,907) XP1,AV,XP2,FP
00275   80*            GO TO 80
00276   81*         70 CONTINUE
00277   82*            LINES = LINES+31
00300   83*            WRITE(6,905) XDOT
00306   84*            WRITE(6,906) X
00314   85*         80 CONTINUE
00314   86*      C
00314   87*      C     PLOTTED OUTPUT TO UNIT 3 FOR PROCESSING AT END OF CASE
00314   88*      C
00316   89*         90 IF(IPLOPT.LE.0.OR.TIME.LT.TPLOT) RETURN
00320   90*            TPLOT = TIME+OUTFRQ(2)
00321   91*            IF(TPLOT.GT.TEND) TPLOT = TEND
00327   92*            M(1) = IPLOPT/1000
00324   93*            M(2) = (IPLOPT-M(1)*1000)/100
00325   94*            M(3) = (IPLOPT-M(1)*1000-M(2)*100)/10
00326   95*            M(4) = IPLOPT-M(1)*1000-M(2)*100-M(3)*10
00327   96*            NPLTS = NPLTS+1
00330   97*            IF(NPLTS.GT.1000) RETURN
00332   98*            TPLT (NPLTS) = TIME
00333   99*            DO 150 K=1,4
00336  100*            IGO = M(K)
00337  101*            IF(IGO.LE.0.OR.IGO.GT.3) GO TO 150
00341  102*            GO TO (100,120,130), IGO
00342  103*        100 DO 110 I=1,6
00345  104*            XP1(I) = X(18+I)-XIC(I)
00346  105*        110 XP2(I) = X(18+I)-TDIC(I)
00350  106*            WRITE(3) XP1,(XDOT(18+I),I=1,6),XP2
00366  107*            GO TO 150
00367  108*        120 WRITE(3) OMEGAE,(X(24+I),I=1,6),(X(30+I),I=1,6)
00405  109*            GO TO 150
00406  110*        130 DO 140 I=1,6
00411  111*            XP1(I) = AL(I)-LO
00412  112*        140 XP2(I) = AL(I)-CAL(I)
00414  113*            WRITE(3) XP1,AV,XP2,FP
00436  114*        150 CONTINUE
00440  115*            RETURN
00441  116*            END
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    END OF COMPILATION:        NO  DIAGNOSTICS.
OUTPUT           SYMBOLIC                                       05 SEP 73  14:21:12   0  01423632   14   116  (DELETED)
OUTPUT   CODE    RELOCATABLE                                    05 SEP 73  14:21:12   1  01446762   60     1  (DELETED)
                                                                                      0  01467056   14    56
```

```
                                                                          29 JUN 74          5:35:39.66.
@   FOR,* PLOTER,PLOTER
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  =(EXEC8 LEVEL E1201001DA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:34

SUBROUTINE PLOTER    ENTRY POINT 000772

STORAGE USED: CODE(1) 001113; DATA(0) 065116; BLANK COMMON(2) 000000

COMMON BLOCKS:

0003   PLOTD   000001
0004   NTGR    000006

EXTERNAL REFERENCES (BLOCK, NAME)

0005   PLT3
0006   PRINT
0007   NR?
0010   N?
0011   NI?
0012   NIO2$
0013   NERR2$
0014   NBOU$
0015   NERR3$

STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001   000420 100L      0001   000423 110L      0001   000052 131G      0001   000532 140L      0001   000141 142G
0001   000150 150G      0001   000617 140L      0001   000625 141L      0001   000201 162G      0001   000633 162L
0001   000641 163L      0001   000646 145L      0001   000656 166L      0001   000707 167L      0001   000737 170L
0001   000214 172G      0001   000745 180L      0001   000242 203G      0001   000266 213G      0001   000307 217G
0001   000310 222G      0001   000425 265G      0001   000437 270G      0001   000445 273G      0001   000174 30L
0001   000535 315G      0001   000543 321G      0001   000567 325G      0001   000570 330G      0001   000240 50L
0001   000264 70L       0001   000341 90L       0000   064636 901F      0000   064647 902F      0000   064660 903F
0000   064665 904F      0000   064673 905F      0000   064704 906F      0000   064715 907F      0000   064722 908F
0000   064727 909F      0001   000351 91L       0000   064740 910F      0001   000361 92L       0001   000371 93L
0001   000401 94L       0001   000411 95L       0000 R 000034 A         0000 R 056734 B         0000 R 000004 BUFF
0000 R 064631 DUM       0004 R 000000 FILL      0000 I 064630 I         0000 I 064632 IGO       0000   065035 INJPS
0000   065051 INJPS     0000   065041 INJPS     0004 I 000005 IPLOPT    0000 I 064633 II        0000 I 064635 I2
0000 I 064626 J         0000 I 064624 K         0000 I 064634 L         0000 I 000000 MO        0000 I 064627 N
0003 I 000000 NPLPTS    0000 I 064625 NUM


00101      1*           SUBROUTINE PLOTER
00103      2*           COMMON / PLOTD/ NPLPTS
00104      3*           COMMON /NTGPTC/ FILL(5),IPLOPT
00105      4*           DIMENSION MO(4),BUFF(24),A(1000,24),B(1000,3)
00106      5*       901 FORMAT(/ 40X'INCREMENTAL INERTIAL MOTIONS OF TABLE C.G.')
00107      6*       902 FORMAT(/ 40X'INCREMENTAL ANGULAR MOTIONS OF TABLE C.G.')
00110      7*       903 FORMAT(/ 50X 'INERTIAL VELOCITIES')
00111      8*       904 FORMAT(/ 45X 'EULER ANGLE VELOCITIES')
00112      9*       905 FORMAT(/ 40X'TABLE POSITION ERROR (ACTUAL-COMMANDED)')
```

```
00113   10.       906 FORMAT(/ 40X'ACTUATOR BENDING DATA FOR ACTUATOR NO.' I3)
00114   11.       907 FORMAT(/ 52X'ACTUATOR STROKES')
00115   12.       908 FORMAT(/ 50X'ACTUATOR VELOCITIES')
00116   13.       909 FORMAT(/ 39X'ACTUATOR POSITION ERROR (ACTUAL-COMMANDED)')
00117   14.       910 FORMAT(/ 45X'NET FORCES ON ACTUATOR PISTONS')
00120   15.           IF(IPLOPT.LE.0) RETURN
00122   16.           IF(NPLPTS.GT.1000) NPLPTS = 1000
00124   17.           MO(1) = IPLOPT/1000
00125   18.           MO(2) = (IPLOPT-MO(1)*1000)/100
00126   19.           MO(3) = (IPLOPT-MO(1)*1000-MO(2)*100)/10
00127   20.           MO(4) = IPLOPT-MO(1)*1000-MO(2)*100-MO(3)*10
00130   21.           DO 180 K=1,4
00133   22.           IF(MO(K).LE.0.OR.MO(K).GT.3) GO TO 180
00135   23.           REWIND 3
00136   24.           NUM = 18
00137   25.           IF(MO(K).EQ.3) NUM = 24
00137   26.       C
00137   27.       C    READ DATA FROM TAPE
00137   28.       C
00141   29.           DO 60 J=1,NPLPTS
00143   30.           IF(K.EQ.1) GO TO 30
00146   31.           N = K-1
00147   32.           DO 20 I=1,N
00152   33.           IF(MO(I).GT.0.AND.MO(I).LT.4) READ(3) DUM
00156   34.        20 CONTINUE
00160   35.        30 READ(3) (BUFF(I),I=1,NUM)
00166   36.           IF(K.EQ.4) GO TO 50
00170   37.           N = K+1
00171   38.           DO 40 I=N,4
00174   39.           IF(MO(I).GT.0.AND.MO(I).LT.4) READ(3) DUM
00200   40.        40 CONTINUE
00202   41.        50 DO 60 I=1,NUM
00205   42.        60 A(J,I) = BUFF(I)
00210   43.           IGO = MO(K)
00211   44.           GO TO(70,110,140), IGO
00211   45.       C
00211   46.       C    DATA SET 1  TABLE RESPONSE DATA
00211   47.       C
00212   48.        70 DO 100 I1=1,6
00215   49.           L = 3*(I1-1)
00216   50.           DO 80 I2=1,3
00221   51.           DO 80 I=1,NPLPTS
00224   52.        80 B(I,I2) = A(I,L+I2)
00227   53.           CALL PLT3(B)
00230   54.           GO TO (90,91,92,93,94,95), I1
00231   55.        90 WRITE(17,901)
00233   56.           CALL XYZ
00234   57.           GO TO 100
00235   58.        91 WRITE(17,902)
00237   59.           CALL ROT
00240   60.           GO TO 100
00241   61.        92 WRITE(17,903)
00243   62.           CALL XYZ
00244   63.           GO TO 100
00245   64.        93 WRITE(17,904)
00247   65.           CALL ROT
00250   66.           GO TO 100
00251   67.        94 WRITE(17,905)
```

```
00253    58*          CALL XYZ
00254    69*          GO TO 100
00255    70*       95 A ITE(17,905)
00257    71*          CALL ROT
00260    72*      100 CONTINUE
00262    73*          GO TO 180
00262    74*     C
00262    75*     C    DATA SET 2   ACTUATOR BENDING DATA
00262    76*     C
00263    77*      110 CONTINUE
00264    78*          DO 130 I1=1,6
00267    79*          DO 120 J=1,NPLPTS
00272    80*          DO 120 I=1,3
00275    81*          L = 6*(I-1)
00276    82*      120 B(J,I) = A(J,I1+L)
00301    83*          CALL PLT3(B)
00322    84*          WRITE(17,906) I1
00305    85*          CALL PRINT(12,130,0,16,9,'FREQUENCY')
00306    86*          CALL PRINT(12,420,0,16,14,'Y DISPLACEMENT')
00307    87*          CALL PRINT(12,750,0,16,14,'Z DISPLACEMENT')
00310    88*      130 CONTINUE
00312    89*          GO TO 180
00312    90*     C
00312    91*     C    DATA SET 3   ACTUATOR RESPONSES
00312    92*     C
00313    93*      140 CONTINUE
00314    94*          DO 170 I1=1,4
00317    95*          L = 6*(I1-1)
00320    96*          DO 170 I2=1,2
00323    97*          N = 3*(I2-1)
00326    98*          DO 150 J=1,3
00327    99*          DO 150 I=1,NPLPTS
00331   100*      150 B(I,J) = A(I,L+N+J)
00335   101*          CALL PLT3(B)
00336   102*          GO TO (160,161,162,163), I1
00337   103*      160 WRITE(17,907)
00341   104*          GO TO 165
00342   105*      161 WRITE(17,908)
00344   106*          GO TO 165
00345   107*      162 WRITE(17,909)
00347   108*          GO TO 165
00350   109*      163 WRITE(17,910)
00352   110*      165 CONTINUE
00353   111*          GO TO (166,167), I2
00354   112*      166 CALL PRINT(12,210,0,16,1,'1')
00355   113*          CALL PRINT(12,530,0,16,1,'2')
00356   114*          CALL PRINT(12,860,0,16,1,'3')
00357   115*          GO TO 170
00360   116*      167 CALL PRINT(12,210,0,16,1,'4')
00361                CALL PRINT(12,530,0,16,1,'5')
00362                CALL PRINT(12,860,0,16,1,'6')
00363   119*      170 CONTINUE
00366   120*      180 CONTINUE
00370   121*          RETURN
00371   122*          SUBROUTINE XYZ
00374   123*          CALL PRINT(12,210,0,16,1,'X')
00375   124*          CALL PRINT(12,530,0,16,1,'Y')
00376   125*          CALL PRINT(12,860,0,16,1,'Z')
```

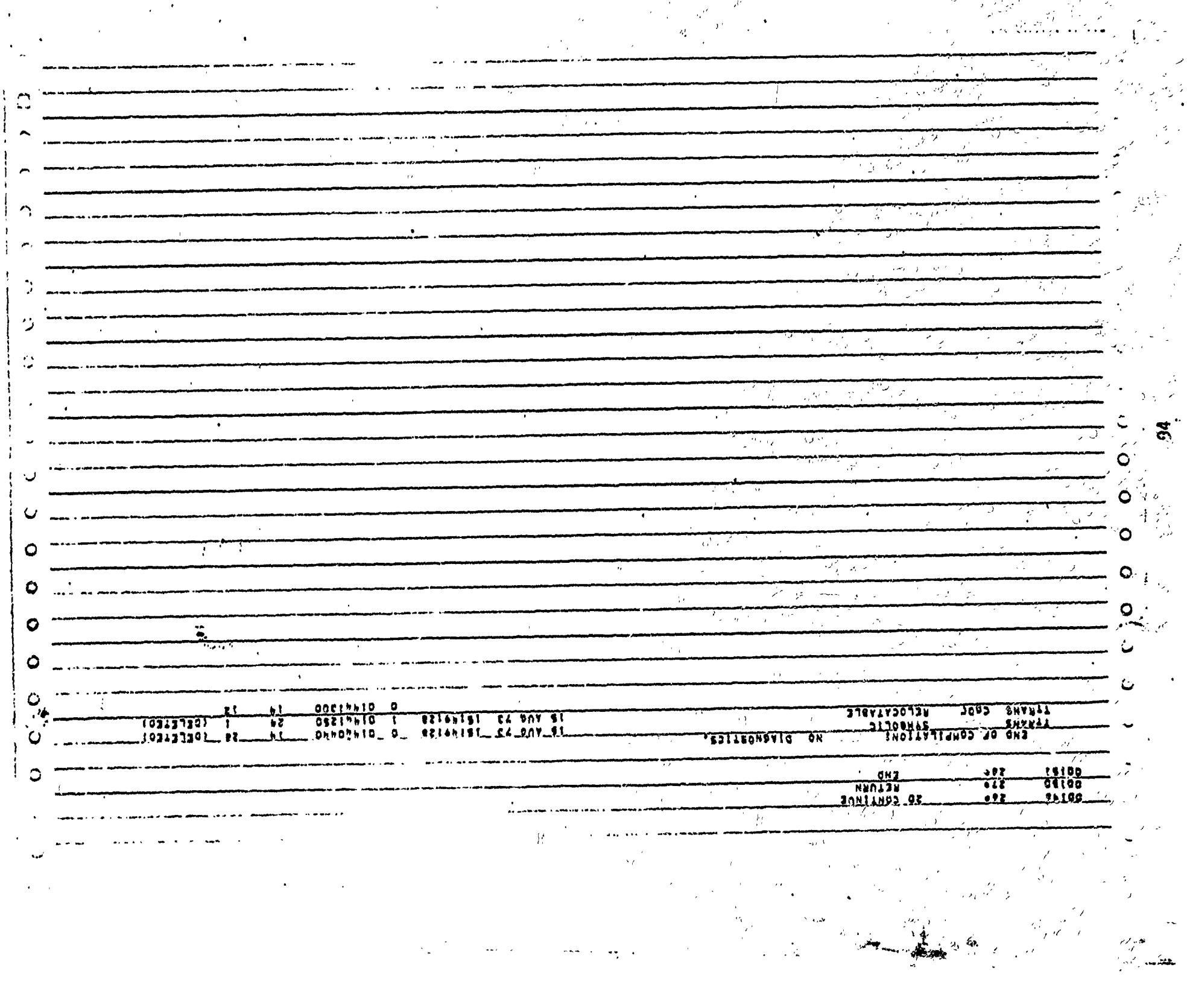
```
00377    124*          RETURN
00400    127*          SUBROUTINE POT
00403    128*          CALL PRINT(12,160,0,16,5,'THETA')
00404    129*          CALL PRINT(12,500,0,16,3,'PSI')
00405    130*          CALL PRINT(12,830,0,16,3,'PHI')
00406    131*          RETURN
00407    132*          END

      END OF COMPILATION:      NO DIAGNOSTICS.

      PLOTER                   SYMBOLIC                  15 AUG 73  15:40:51   0  01462700   14   132  (DELETED)
      PLOTER  CODE             RELOCATABLE               15 AUG 73  15:42:15   1  01456370   36     1  (DELETED)
                                                                                0  01466434   14    77
```

```
@   FOR,* PLT3,PLT3                                                            29 JUN 74          5135137.13
UNIVAC 1108 FORTRAN V EXEC II LEVEL 25A  *(EXEC8 LEVEL E1201001GA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05135137

    SUBROUTINE PLT3       ENTRY POINT 000163

    STORAGE USED: CODE(1) 000175; DATA(0) 000057; BLANK COMMON(2) 000000

     COMMON BLOCKS:

     0003   PLOTD  001751

    EXTERNAL REFERENCES (BLOCK, NAME)

     0004   FILMAV
     0005   GRDSET
     0006   GRID
     0007   PLOTIV
     0010   PRINT
     0011   NERR3$

    STORAGE ASSIGNMENT  (BLOCK, TYPE, RELATIVE LOCATION, NAME)

     0001   000023 115G      0001   000043 122G      0000 R 000013 AMAX      0000 R 000012 AMIN      0000 I 000006 HI+E
     0000 I 000014 I         0000 I 000000 IGRDB     0000   000035 INJP$     0000 I 000011 K         0003 I 000000 NPLPTS
     0003 R 000001 TPLOT


  00101      1*            SUBROUTINE PLT3(A)
  00103      2*            DIMENSION A(1000,1),IGRDB(2,3),HITE(3)
  00104      3*            INTEGER HITE
  00105      4*            COMMON / PLOTD/ NPLPTS,TPLOT(1000)
  00106      5*            DATA IGRDB/70,349,393,672,716,995/
  00110      6*            DATA HITE/369,692,1015/
  00112      7*            CALL FILMAV(0)                      @ ADVANCE FILM
  00113      8*            CALL GRDSET(3,1,2)                  @ SET LINE INTENSITIES
  00114      9*            DO 50 K=1,3
  00117     10*            AMIN = A(1,K)
  00120     11*            AMAX = A(1,K)
  00121     12*            DO 20 I=2,NPLPTS
  00124     13*            IF(A(I,K).GT.AMAX) AMAX=A(I,K)
  00126     14*            IF(A(I,K).LT.AMIN) AMIN=A(I,K)
  00130     15*         20 CONTINUE
  00132     16*            AMIN = AMIN-.01*(AMAX-AMIN)
  00133     17*            AMAX = AMAX+.01*(AMAX-AMIN)
  00134     18*            CALL GRID(100,1000,IGRDB(1,K),IGRDB(2,K),TPLOT(1),TPLOT(NPLPTS),
  00134     19*           1          AMIN,AMAX)
  00135     20*            CALL PLOTIV(1,K,TPLOT,A(1,K),-NPLPTS,1,'0')
  00136     21*            CALL PRINT(620,HITE(K),10,0,4,'TIME')
  00137     22*         50 CONTINUE
  00141     23*            RETURN
  00142     24*            END
```

C-2

```
    END OF COMPILATION:         NO  DIAGNOSTICS.
  PLT3            SYMBOLIC                          15 AUG 73  15:49:48   0  01441852   14   24  (DELETED)
  PLT3    CODE    RELOCATABLE                       15 AUG 73  15:49:43   1  01442272   24    1  (DELETED)
                                                                          0  01442322   14   17
```

```
@   FOR,* TTRANS,TTRANS                                                    29 JUN 74        5:35:38.394
UNIVAC 1108 FORTRAN V EXEC II LEVEL 28A  *(EXEC8 LEVEL E1201001OA)
THIS COMPILATION WAS DONE ON 29 JUN 74 AT 05:35:38

     SUBROUTINE TTRANS      ENTRY POINT 000127

     STORAGE USED: CODE(1) 000144; DATA(0) 000056; BLANK COMMON(2) 000000

      COMMON BLOCKS:

      0003   ACLVA   000044
      0004   TRANS   000044

     EXTERNAL REFERENCES (BLOCK, NAME)

      0005   AMATRX
      0006   SQRT
      0007   NERR3$

     STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

      0001   000010 110G       0001   000055 131G       0001   000057 134G       0001   000061 140G       0000 R 000011 A
      0003 R 000000 AL         0000 R 000027 CB         0000 R 000025 CT         0003   000006 FILL       0000 I 000030 I
      0000   000034 INJP$      0000 I 000031 J          0000 I 000022 K          0000 I 000032 L       0003 R 000022 RS
      0000 R 000023 RSSQ       0000 R 000026 SB         0000 R 000024 ST         0004 R 000000 T       0000 R 000000 TI


  00101      1*              SUBROUTINE TTRANS
  00103      2*              DIMENSION TI(3,3),A(3,3)
  00104      3*              COMMON /ACLVA / AL(6),FILL(16),RS(3,6)
  00105      4*              COMMON / TRANS/ T(6,3,3)
  00106      5*              CALL AMATRX(A)
  00107      6*              DO 20 K=1,6
  00112      7*              RSSQ = SQRT(RS(2,K)**2+RS(3,K)**2)
  00113      8*              ST = -RS(1,K)/AL(K)
  00114      9*              CT = RSSQ/AL(K)
  00115     10*              SB = RS(2,K)/RSSQ
  00116     11*              CB = RS(3,K)/RSSQ
  00117     12*              TI(1,1) = -ST
  00120     13*              TI(1,2) = 0.
  00121     14*              TI(1,3) = -CT
  00122     15*              TI(2,1) = CT*SB
  00123     16*              TI(2,2) = CB
  00124     17*              TI(2,3) = -ST*SB
  00125     18*              TI(3,1) = CB*CT
  00126     19*              TI(3,2) = -SB
  00127     20*              TI(3,3) = -CB*ST
  00130     21*              DO 10 I=1,3
  00133     22*              DO 10 J=1,3
  00136     23*              T(K,I,J) = 0.
  00137     24*              DO 10 L =1,3
  00142     25*           10 T(K,I,J) = T(K,I,J)+TI(L,I)*A(L,J)
```


00146 26* CONTINUE
00150 27* RETURN
00151 26* END
END OF COMPILATION: NO DIAGNOSTICS.
TYPING SYNBOLIC
TYPING CARD RELOCATABLE
15 AUG 73 15:49:28 0 01441300 14 12
15 AUG 73 15:49:28 1 01441250 24 1 (DELETED)
15 AUG 73 15:49:28 0 01440440 14 24 (DELETED)

$A XGT GONADS

STARTING ADDRESS 014000

CORE LIMITS 014000 041277 062442 163771 163772 163777

GONADS/CODE
0 062442=062467
1 014000=014066

NSTOPS/RLECS
1 014067=014100

NERRS /RLECS
0 062470=062470
1 014101=014406
2 062471=062565

NFNTS /RLECS
1 014407=015344
2 062566=062602

NFTYS /RL22
1 015345=015367

NCNVTS/RLECS
1 015370=015614
2 062603=062671

NOTINS/RLECS
1 015615=016264
2 062672=062735

FPACKS/CODE
1 016265=016330

DEPTH /******
0 062736=062743

NERRS /RLECS
0 062744=063133
1 016331=016773

NIOINS/RLECS
1 016774=017045
2 063134=063164

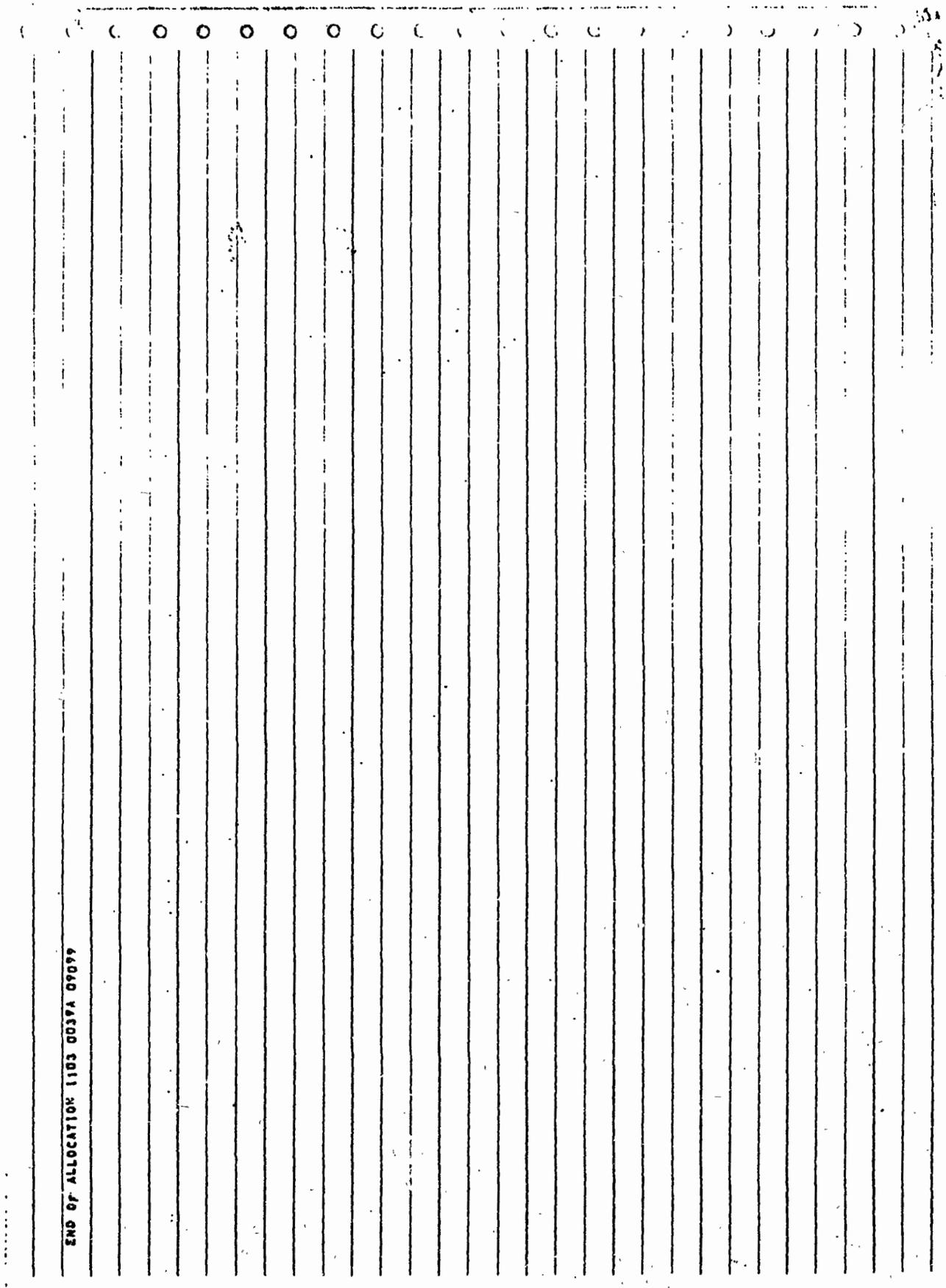
```
NOUTS /RLEC4
0    063165-063171
1    017046-020050
2    063172-063207

NTABS /CODE
0    063210-063356

NBDCYS/RLEC4
0    063357-063543

PLOTER/CODE
0    063544-150661
1    020051-021163

NFINPS/RLEC5
1    021164-021425
2    150662-150662

NBUFFS/RL23
1    021426-021450
2    150663-151673

NRWNDS/RLEC4
1    021451-021543

PRINT /CODE
0    151674-151730
1    021544-021712

NEXPIS/RL29
1    021713-021746
2    151731-151731

NPLNKS/CODE
0    151732-151781
1    021747-022072

ETODS /CODE
1    022073-022127

JUNK  /CODE
0    151782-151782

FNODES/CODE
1    022130-022235

SCCTAB/CODE
0    151783-152056

PLT3  /CODE
0    152057-152135
1    022236-022432

PLOT1 /CODE
1    022433-022556
2    152136-152144
```

```
PLOTR /CODE
1    022567-022763
2    152145-152177

VECTR /CODE
0    152200-152240
1    022764-023143

FIXPLT/CODE
0    152241-152251
1    023144-023425

SCALEX/CODE
0    152252-152264
1    023426-023526

ALOG  /RL24
1    023526-023643
2    152265-152325

COMSCL/CODE
0    152326-152341
1    023644-024002

GRID  /CODE
0    152342-152400
1    024003-024443

RVSX  /CODE
0    152401-152419
1    024444-024542

NEXP65/RL25
1    024543-024735
2    152419-152466

LABELY/CODE
0    152467-152516
1    024736-025146

CONV  /CODE
0    152517-152564
1    025147-025443

BINDEC/CODE
0    152565-152646
1    025444-026033

VLAG  /CODE
0    152647-152676
1    026034-026166

LABELX/CODE
0    152677-152737
1    026167-026413

FINDV /CODE
```

```
0   152730-152746
1   026414-027016

NEXPSS/RL24
1   027017-027102
2   152767-152774

LGRD  /CODE
0   152777-153044
1   027103-027447

LABL  /******
0   153045-153071

SC4020/******
0   153072-153214

NRKVS /CODE
0   153215-155040
1   027450-031112

RKINIT/CODE
0   155041-155055
1   031113-031152

NRKVS3/******
0   155056-155064

NRKVS2/******
0   155065-155350

INITIL/CODE
0   155351-155460
1   031153-031301

PLOTD /******
0   155461-157431

DATARD/CODE
0   157432-160411
1   031302-032356

NINPTS/RLEC5
0   160412-160414
1   032357-033474
2   160415-160452

NININS/RLEC4
1   033475-033632
2   160453-160502

ELECD /******
0   160503-160550

HYDRD /******
0   160551-160601

INGEOD/******
```

```
0   160602-160661

FCN   /CODE
0   160662-160762
1   033633-034117

SINCOS/RL24
1   034120-034251
2   160763-161004

OUTPUT/CODE
0   161005-161247
1   034252-035120

NFOUTS/RLECS
1   035121-035352
2   161250-161251

HYSREL/CODE
0   161252-161311
1   035353-035670

AMATRX/CODE
0   161312-161332
1   035671-036004

COLUM /CODE
0   161333-161401
1   036005-036165

CROSS /CODE
0   161402-161411
1   036166-036230

CFM   /CODE
0   161412-161446
1   036231-036424

FORCES/******
0   161447-161462

GJR   /CODE
0   161463-161550
1   036425-037304

OVERFL/RL22
1   037305-037313

MMATRX/CODE
0   161551-161723
1   037314-037774

M3X3  /CODE
0   161724-161747
1   037775-040042

TTRANS/CODE
0   161750-162026
```

```
1   040063-040226

SQRT  /RL24
0   162026-162031
1   040227-040266
2   162032-162037

ACIsD /CODE
0   162040-162075
1   040267-040414

ACIsND/******
0   162076-162117

ACAVAP/CODE
0   162120-162176
1   040415-040647

TRANS /******
0   162177-162264

ACDvC /CODE
0   162265-162371
1   040650-041277

ACDvAC/******
0   162372-162440

ACLVA /******
0   162441-162504

ACSTRD/******
0   162505-162514

MASS  /******
0   162515-163220

EQMC  /******
0   163221-163242

NTGRTD/******
0   163243-163250

NRKVSI/******
0   163251-163537

FRCPND/******
0   163540-163631

NTGRTC/******
0   163632-163637

NITILC/******
0   163640-163771
```


END OF ALLOCATION 1103 0035A 09099

5.5 SAMPLE PROBLEM

The input data and output, both printout and plots, for a sample case are presented on the following pages. In the example, the table is commanded to move sinusoidally in the y direction with an amplitude of 0.1 inch. Although 18 frequency cases are specified, output from the first frequency case only is presented. In this example the valve dynamics, forward loop compensation filter, and position and rate feedback second-order filter are ignored. Rate command and rate feedback gains are set to zero.

NADS CHECKOUT .1" Y-AMPLITUDE

INERTIA AND GEOMETRY DATA

TABLE MASS	2.9000					
MOMENTS AND PRODUCTS OF INERTIA FOR ACTIVE TABLE SYSTEM	2915.0	1496.0	1496.0	.00000	.00000	.00000
X TABLE STATION OF ACTUATOR SWIVEL JOINTS	3.0000					
W.R.T. TABLE C.G.	25.102	49.500	-55.419	3.0000	-55.419	-3.0000
Y AND Z TABLE COORDINATES OF SWIVEL JOINTS	25.102	-49.500	30.298	-46.500	30.298	46.500
Y AND Z INERTIAL COORDINATES OF FLOOR SWIVEL JOINTS	-64.311	123.18	-76.380	114.12	-74.573	-116.82
	-63.412	-122.68	138.46	-5.4750	138.39	48.0050

ACTUATOR STRUCTURAL DATA

ACTUATOR BENDING DAMPING CONSTANT	.20000-01
MASS OF ROD AND PISTON	.47900
MOMENT OF INERTIA OF CYLINDER ABOUT FLOOR SWIVEL JOINT	4290.0
DISTANCE FROM FLOOR SWIVEL TO C.L. OF PISTON ROD SEAL AT END OF CYLINDER	112.00
LENGTH OF PISTON ROD	112.00
RETRACTED LENGTH OF ACTUATOR	126.00
BENDING MODULUS OF PISTON ROD	.21000+09
MAXIMUM STROKE OF ACTUATOR	84.000

FORCING FUNCTION DATA

INITIAL INERTIAL COORDINATES OF TABLE CG	-125.30	.00000	.00000				
INITIAL EULER ANGLES OF TABLE COORDINATE SYSTEM W.R.T. INERTIAL SYSTEM	.00000	.00000	.00000				
MASS MATRIX AND GEOMETRY UPDATE OPTION	3						
NUMBER OF FREQUENCY CASES	8						
EXTERNAL FORCE AND MOMENT OPTION	0						
NUMBER OF EXTERNAL FORCE FREQUENCIES	0						
COMMAND SIGNAL FREQUENCIES	37.699	50.265	62.832	75.398	87.964	100.53	
	125.66	157.08	175.93	188.50	201.06	226.19	
	81.681	94.248	138.23	150.80	69.115	113.10	
SINUSOIDAL AMPLITUDES OF TRANSLATIONAL COMMANDS FOR TABLE CG AND OF TABLE EULER COMMANDS	.00000	.10000+00	.00000	.00000	.00000	.00000	

HYDRAULICS DATA

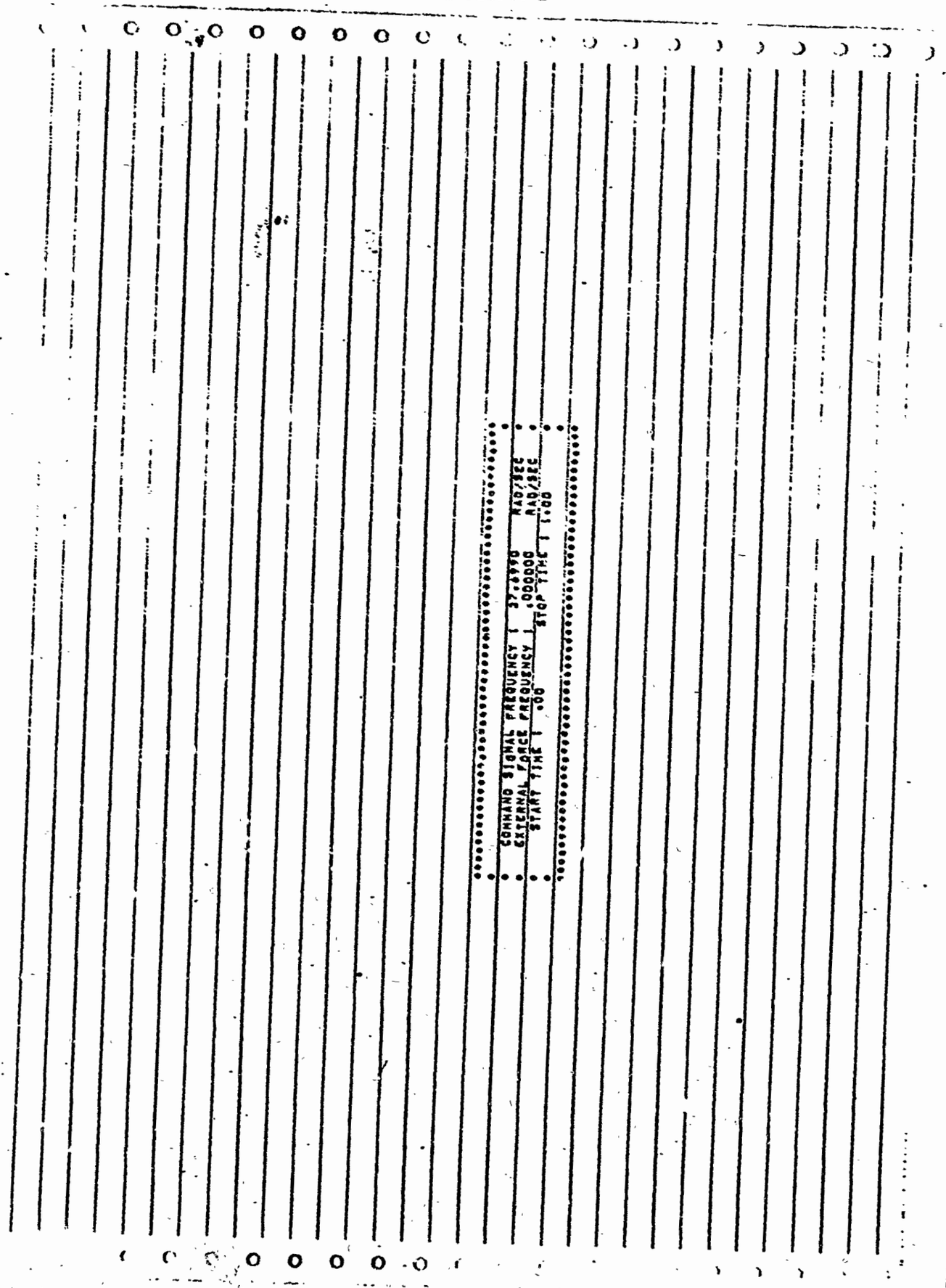
SUPPLY PRESSURE	3000.0						
EQUIVALENT SYSTEM BULK MODULUS	.10000+06						
VALVE PRESSURE FLOW COEFFICIENT	.00000						
LEAKAGE COEFFICIENT ACROSS PISTON SEALS	.12500-01	.12500-01	.12500-01	.12500-01	.12500-01	.12500-01	
ACTUATOR VISCOUS DAMPING COEFFICIENT	40.000	40.000	40.000	40.000	40.000	40.000	
ACTUATOR PUSH AND PULL STROKE WORKING AREAS	7.0000	7.0000					
INITIAL HYDRAULIC VOLUMES OF FULLY RETRACTED ACTUATOR	20.000	521.00					
	.00000	.00000	.00000	.00000	.00000	.00000	
COULOMB FRICTION FORCE OF ACTUATORS							

ELECTRONICS DATA

GAINS									
ELECTRONICS AND VALVE FORWARD LOOP	378.30	378.30	378.30	378.30	378.30	378.30	378.30	378.30	378.30
DISPLACEMENT FEEDBACK AND COMMAND	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
VELOCITY FEEDBACK LOOP	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
PRESSURE FEEDBACK LOOP	.10346-04	.10346-04	.10346-04	.10346-04	.10346-04	.10346-04	.10346-04	.10346-04	.10346-04
VELOCITY COMMANDS	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
BREAK FREQUENCIES OF FIRST ORDER FILTERS	.00000	.00000	.00000	18.850	628.32				
DISPLACEMENT AND VELOCITY FEEDBACK SECOND ORDER FILTER DAMPING CONSTANT AND FREQUENCY	.00000	.00000							
VALVE DYNAMICS DAMPING CONSTANT AND FREQUENCY	.62000	.00000							

PROGRAM CONTROL DATA

START TIME	.00000	
STOP TIME	1.0000	
OUTPUT FREQUENCIES	.20000	.10000E-03
PRINT OPTION	1234	
PLOT OPTION	123	


COMMAND SIGNAL FREQUENCY = 37.0000 RAD/SEC
EXTERNAL FORCE FREQUENCY = .000000 RAD/SEC
START TIME = .00
STOP TIME = 1.00

TIME = 0.000000 SEC

INCREMENTAL INERTIAL MOTIONS OF TABLE C.G.	.000000	.000000	.000000					
INCREMENTAL ANGULAR MOTIONS	.000000	.000000	.000000					
INERTIAL VELOCITIES OF TABLE C.G.	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
EULER ANGLE RATES	.000000	.000000	.000000					
TABLE POSITION ERROR (ACTUAL-COMMAND)	82.8814	85.3985	83.1472	83.6205	83.0875	83.6594		
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
BENDING FREQUENCIES AT CYLINDER ROD SEALS	.000000	.000030	.000000	.000000	.000000	.000000	.000000	
Y LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	.000000		.000000					
Z LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS		41.9078	42.1634	41.6675	42.2238	41.6784		
	42.4649	.000000	.000000	.000000	.000000	.000000	.000000	
ACTUATOR STROKES	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
ACTUATOR VELOCITIES	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
ACTUATOR POSITION ERROR (ACTUAL-COMMAND)	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
NET FORCES ON ACTUATOR PISTONS	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
DERIVATIVE ARRAY	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
VARIABLE ARRAY	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	-125.300	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	1500.00	1500.00	1500.00	1500.00	1500.00	1500.00	
	1500.00	1500.00	1500.00	1500.00	1500.00	1500.00	1500.00	
	1500.00	1500.00	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	167.910	168.163	167.688	168.224	167.699	.000000	
	168.248	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	.000000	

• CHAR UN/PLOT AT 035765

• CHAR UN/PLOT AT 035765

• CHAR UN/PLOT AT 035765

• CHAR UN/PLOT AT 035765

TIME = 2.088387-01 SEC

INCREMENTAL INERTIAL MOTIONS OF TABLE C.G.	-.209808-04	.679084-01	.141964-05				
INCREMENTAL ANGULAR MOTIONS	-.498957-04	.108733-04	.179728-06				
INERTIAL VELOCITIES OF TABLE C.G.	-.376025-03	2.26684	-.160902-02				
EULER ANGLE RATES	-.805047-05	.997180-03	.140383-04				
TABLE POSITION ERROR (ACTUAL-COMMAND)	-.209808-04	-.320765-01	.141964-05	-.498957-06	.108733-04	.179728-06	
BENDING FREQUENCIES AT CYLINDER ROD SEAL	82.8162	83.3904	83.1400	83.5847	83.1306	83.653-	
Y LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	.228056-02	.200879-02	-.269828-02	-.957827-03	.968954-03	-.493383-03	
Z LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	.433440-03	.382545-02	.385100-02	-.732793-03	-.386277-02	-.280615-02	
ACTUATOR STROKES	42.5012	41.9179	42.1707	41.7232	42.1803	41.6561	
ACTUATOR VELOCITIES	1.22360	.244962	.216988	1.20263	-1.43765	-1.44031	
ACTUATOR POSITION ERROR (ACTUAL-COMMAND)	-.167942-01	-.443268-02	-.409808-02	-.165291-01	.208263-01	.209236-01	
NET FORCES ON ACTUATOR PISTONS	-97.5207	-18.9628	-16.0117	-93.3033	112.782	109.836	
DERIVATIVE ARRAY	.188821	-64.8125	.162584	-.665164-03	.734028-02	.193798	
	-42.1228	-55.0188	59.8514	32.7692	-21.4325	17.4025	
	-27.5114	-29.1283	-28.6434	-19.8365	53.4459	46.9.84	
	-.376025-03	2.26684	-.160902-02	-.805047-05	.997180-03	.140383-04	
	-.454605	-.738747	.727318	.499070	-.256092	.251376	
	-.484151	.912930-01	.117900	-.812293	.381494	.428355	
	-583.698	-24.3502	-9.36224	-888.859	899.835	611.253	
	1082.68	47.1161	17.0448	1040.18	-1090.38	-1074.18	
	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	
	-33.0490	-14.3640	-13.3640	-31.8460	48.9811	45.6047	
	1.22360	.244962	.216988	1.20263	-1.43765	-1.44031	
	-.318367-02	-.357548-03	-.269097-03	-.306849-02	.343447-02	.336465-02	
	-.237066	-.118536-01	-.429809-02	-.231733	.241712	.241737	
	.000000	.000000	.000000	.000000	.000000	.000000	
VARIABLE ARRAY	-.381377-03	2.26684	-.160943-02	.140382-04	-.805049-05	.997180-03	
	-.454605	-.738747	.727318	.499070	-.256092	.251376	
	-.484151	.912930-01	.117900	-.812293	.381494	.428355	
	-129.300	.679084-01	.141964-05	-.498957-06	.108733-04	.179728-06	
	.228056-02	.200879-02	-.269828-02	-.957827-03	.968954-03	-.493383-03	
	.433440-03	.382545-02	.385100-02	-.732793-03	-.386277-02	-.280615-02	
	1497.88	1499.68	1499.67	1497.94	1502.66	1502.46	
	1504.08	1500.75	1500.61	1503.74	1495.48	1495.78	
	.000000	.000000	.000000	.000000	.000000	.000000	
	7.41468	1.30460	1.64802	7.27398	-9.03164	-9.04246	
	1.22360	.244962	.216988	1.20263	-1.43765	-1.44031	
	168.501	167.918	168.171	167.723	168.180	167.655	
	.104368-03	.679597-05	.483713-05	.102782-03	-.104782-03	-.109127-03	
	-.280637-02	-.338682-03	-.262257-03	-.269968-02	.304977-02	.297982-02	
	.195999-01	.477028-02	.435638-02	.192280-01	-.238743-01	-.239029-01	

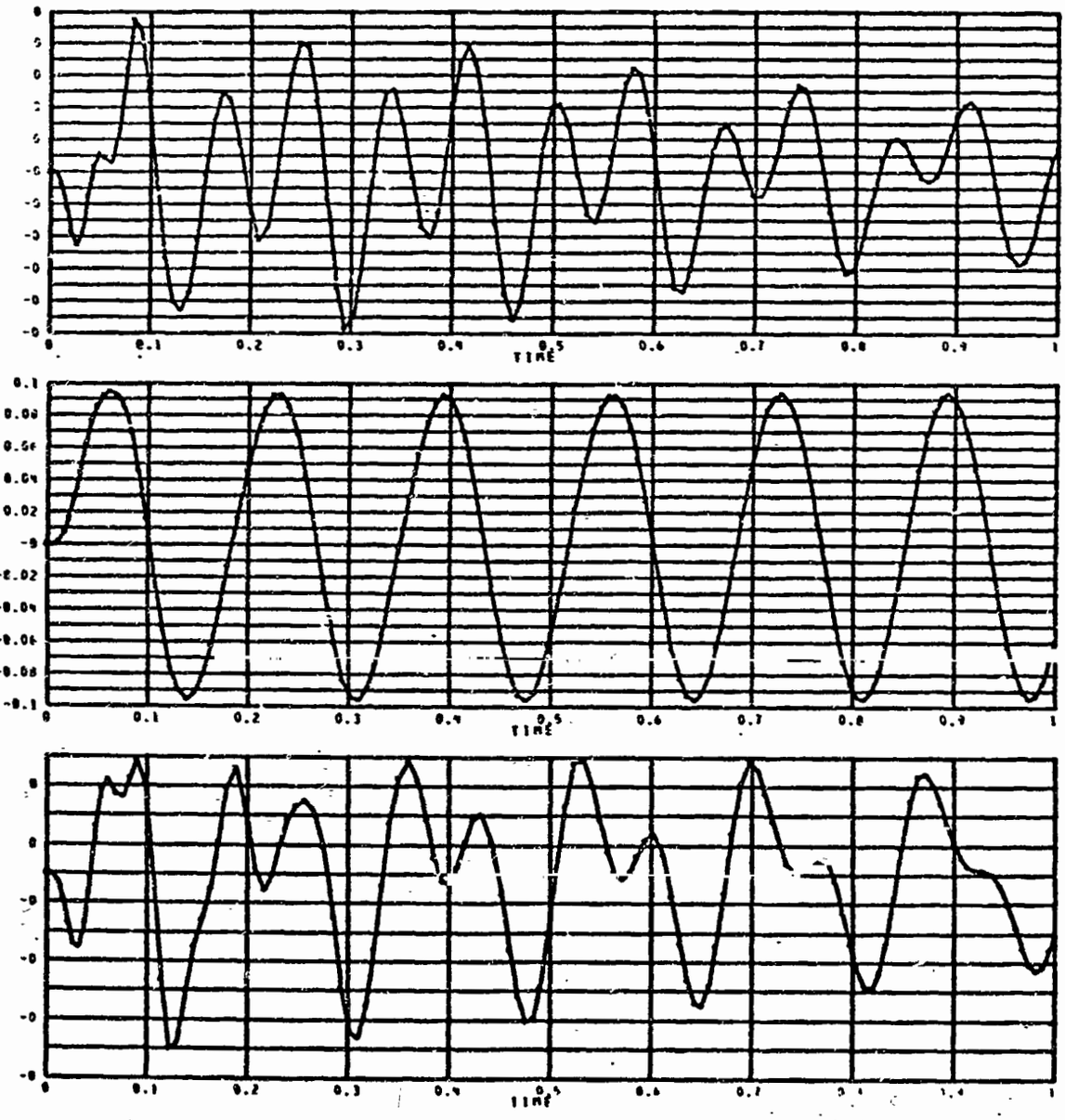
TIME = 4.162283-01 SEC

INCREMENTAL INERTIAL POSITIONS OF TABLE C.G.	.391006-04	-.243216-01	.109225-04				
INCREMENTAL ANGULAR NOTIONS	.171848-05	.531208-04	-.137062-06				
INERTIAL VELOCITIES OF TABLE C.G.	.391767-04	-2.65612	.114343-02				
EULER ANGLE RATES	-.562215-04	-.123880-02	-.119224-05				
TABLE POSITION ERROR (ACTUAL-COMMAND)	.391006-04	.626642-01	.109225-04	.171848-05	.531208-04	-.137062-06	
BENDING FREQUENCIES AT CYLINDER ROD SEAL	83.8173	83.5926	83.1421	83.6857	83.1274	83.6850	
Y LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	.124978-01	-.180167-01	.186278-01	-.115741-01	-.671081-02	.597049-02	
Z LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	-.932788-02	-.662934-02	-.663241-02	-.799844-02	.153846-01	.142182-01	
ACTUATOR STROKES	42.5000	41.9157	42.1686	41.7222	42.1636	41.6581	
ACTUATOR VELOCITIES	-1.43272	-.282767	-.252145	-1.41223	1.68084	1.68928	
ACTUATOR POSITION ERROR (ACTUAL-COMMAND)	.342531-01	.566864-02	.501060-02	.337982-01	-.391846-01	-.394039-01	
NET FORCES ON ACTUATOR PISTONS	-302.720	27.5577	31.5934	-302.530	272.046	277.002	
DERIVATIVE ARRAY	-.184481	-104.399	-.236801-01	.989350-03	-.914279-02	-.167025	
	40.3752	59.1432	-58.4317	-34.7128	21.5466	-17.8669	
	25.6237	32.3702	33.0330	18.2099	-58.4483	-48.3974	
	.391767-04	-2.65612	.114343-02	-.562215-04	-.123880-02	-.119224-05	
	.298111	.402487	-.434829	-.255108	.154192	-.124617	
	.265388	.430922-01	.164690-01	.226565	-.276043	.268978	
	301.927	-17.9407	-54.4828	307.628	-276.723	-289.823	
	-559.130	32.1106	48.1081	-543.363	503.128	539.876	
	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	
	-58.2956	-6.16466	-5.13628	-57.9612	63.5575	64.4056	
	-1.43272	-.282767	-.252145	-1.41223	1.68084	1.68928	
	-.557471-02	.242684-03	.316415-03	-.527768-02	.527727-02	.538194-02	
	.247544	-.100001-01	-.159241-01	.245193	-.230826	-.235589	
	.000000	.000000	.000000	.000000	.000000	.000000	
VARIABLE ARRAY	-.101921-03	-2.65612	.114306-02	-.119621-05	-.562213-04	-.123880-02	
	.298111	.402487	-.434829	-.255101	.154192	-.124617	
	.265388	.430922-01	.164690-01	.226565	-.276043	.268978	
	-125.300	.643216-01	.109225-04	.171848-05	.531208-04	-.137062-06	
	-.124978-01	-.180167-01	.186278-01	-.115741-01	-.671081-02	.597049-02	
	-.932788-02	-.662934-02	-.663241-02	-.799844-02	.153846-01	.142182-01	
	1483.90	1500.75	1500.98	1483.43	1515.52	1516.10	
	1530.06	1498.67	1498.22	1529.45	1472.02	1471.92	
	.000000	.000000	.000000	.000000	.000000	.000000	
	-10.6926	-2.24186	-2.02467	-10.5281	12.6885	12.7289	
	-1.43272	-.282767	-.252145	-1.41223	1.68084	1.68928	
	168.600	167.916	168.169	167.722	168.184	167.658	
	-.182452-03	.870601-05	.117809-04	-.180847-03	.170672-03	.172150-03	
	-.896869-02	.256899-03	.341759-03	-.896992-02	.644464-02	.876669-02	
	-.282650-01	-.892613-02	-.835202-02	-.276301-01	.335407-01	.336475-01	

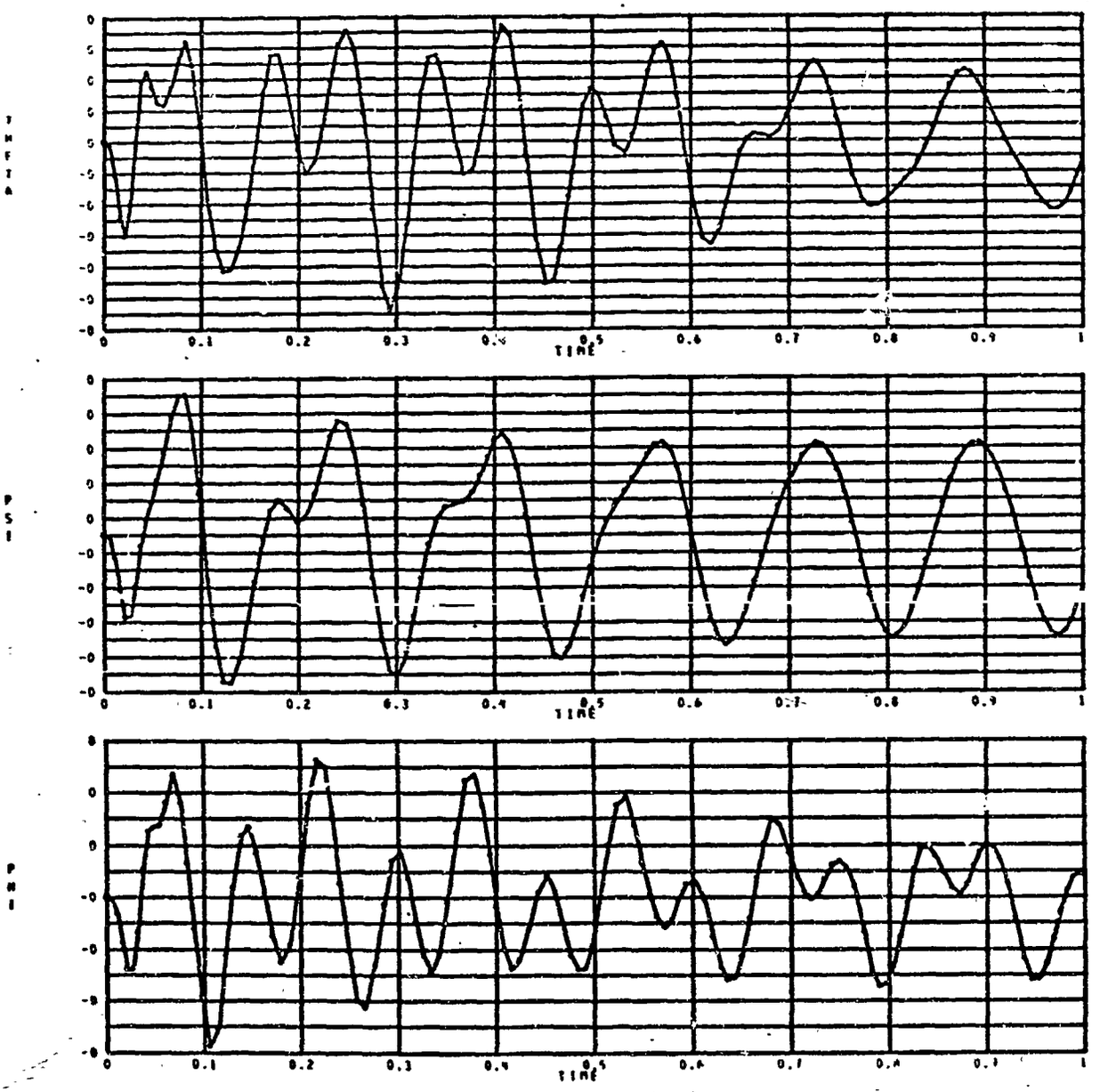
TIME = 6.210930-01 SEC

INCREMENTAL INERTIAL MOTIONS OF TABLE C.G.	-.362396-04	-.647505-01	-.754051-05				
INCREMENTAL ANGULAR MOTIONS	-.165920-05	-.490284-04	-.747682-07				
INERTIAL VELOCITIES OF TABLE C.G.	-.815374-03	-2.74050	-.191529-02				
EULER ANGLE RATES	.142240-04	-.183548-02	-.878372-05				
TABLE POSITION ERROR (ACTUAL-COMMAND)	-.362396-04	.341667-01	-.754051-05	-.165920-05	-.490284-04	-.747682-07	
BENDING FREQUENCIES AT CYLINDER ROD SEAL	82.4860	83.4045	83.1524	82.6564	83.0479	83.5685	
Y LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	.893815-02	.137951-01	-.138287-01	-.911281-02	.502184-02	-.465642-02	
Z LATERAL ELASTIC DISPLACEMENTS AT CYLINDER ROD SEALS	.729549-02	.383360-02	.389504-02	.679479-02	-.108751-01	-.103505-01	
ACTUATOR STROKES	42.4277	41.9037	42.1580	41.6527	42.2644	41.7394	
ACTUATOR VELOCITIES	-1.48973	-.267248	-.239267	-1.46689	1.72698	1.72864	
ACTUATOR POSITION ERROR (ACTUAL-COMMAND)	.172405-01	.624084-02	.585747-02	.168076-01	-.229893-01	-.229397-01	
NET FORCES ON ACTUATOR PISTONS	261.435	-16.4291	-20.9662	259.775	-241.599	-244.240	
DERIVATIVE ARRAY	.185237	97.2080	-.436183-01	.794493-04	.528079-02	.108076	
	-21.5590	-34.2304	33.7305	23.0925	-12.5818	11.4889	
	-16.0781	-15.3236	-16.4371	-15.9842	30.6791	27.7193	
	-.815374-03	-2.74050	-.191529-02	.142240-04	-.183548-02	-.878372-05	
	.409359	.667467	-.655037	-.439958	.230252	-.235356	
	.377707	.405105-01	.350034-01	.409344	-.425055	-.450616	
	603.790	-3.28730	-10.2764	615.397	-599.378	-607.356	
	-1114.98	5.87272	18.6543	-1082.28	1095.34	1073.94	
	.000000	.000000	.000000	.000000	.000000	.000000	
	.000000	.000000	.000000	.000000	.000000	.000000	
	53.4554	7.73127	6.60849	52.9335	-60.2539	-60.7798	
	-1.48973	-.267248	-.239267	-1.46689	1.72698	1.72864	
	.736157-02	-.527003-03	-.495372-03	.731392-02	-.669620-02	-.675655-02	
	.214663	.554745-02	.343167-02	.211677	-.218775	-.215405	
	.000000	.000000	.000000	.000000	.000000	.000000	
VARIABLE ARRAY	-.481018-03	-2.74050	-.191550-02	-.878442-05	.142242-04	-.183548-02	
	.409359	.667467	-.655037	-.439958	.230252	-.235356	
	.377707	.405105-01	.350034-01	.409344	-.425055	-.450616	
	-125.300	-.647505-01	-.754051-05	-.165920-05	-.490284-04	-.747682-07	
	.893815-02	.137951-01	-.138287-01	-.911281-02	.502184-02	-.465642-02	
	.729549-02	.383360-02	.389504-02	.679479-02	-.108751-01	-.103505-01	
	1509.19	1498.75	1498.61	1509.44	1492.31	1492.02	
	1483.31	1502.23	1502.53	1483.66	1514.43	1514.47	
	.000000	.000000	.000000	.000000	.000000	.000000	
	-9.17739	-2.13940	-1.95107	-8.99701	11.0982	11.1039	
	-1.48973	-.267248	-.239267	-1.46689	1.72698	1.72864	
	168.430	167.904	168.158	167.453	168.264	167.739	
	-.122442-03	-.540949-05	-.344942-05	-.120905-03	.126094-03	-.125875-03	
	.701993-02	-.585832-03	-.700834-03	.697702-02	-.634801-02	-.641372-02	
	-.242596-01	-.565529-02	-.515747-02	-.237827-01	.293369-01	.293522-01	

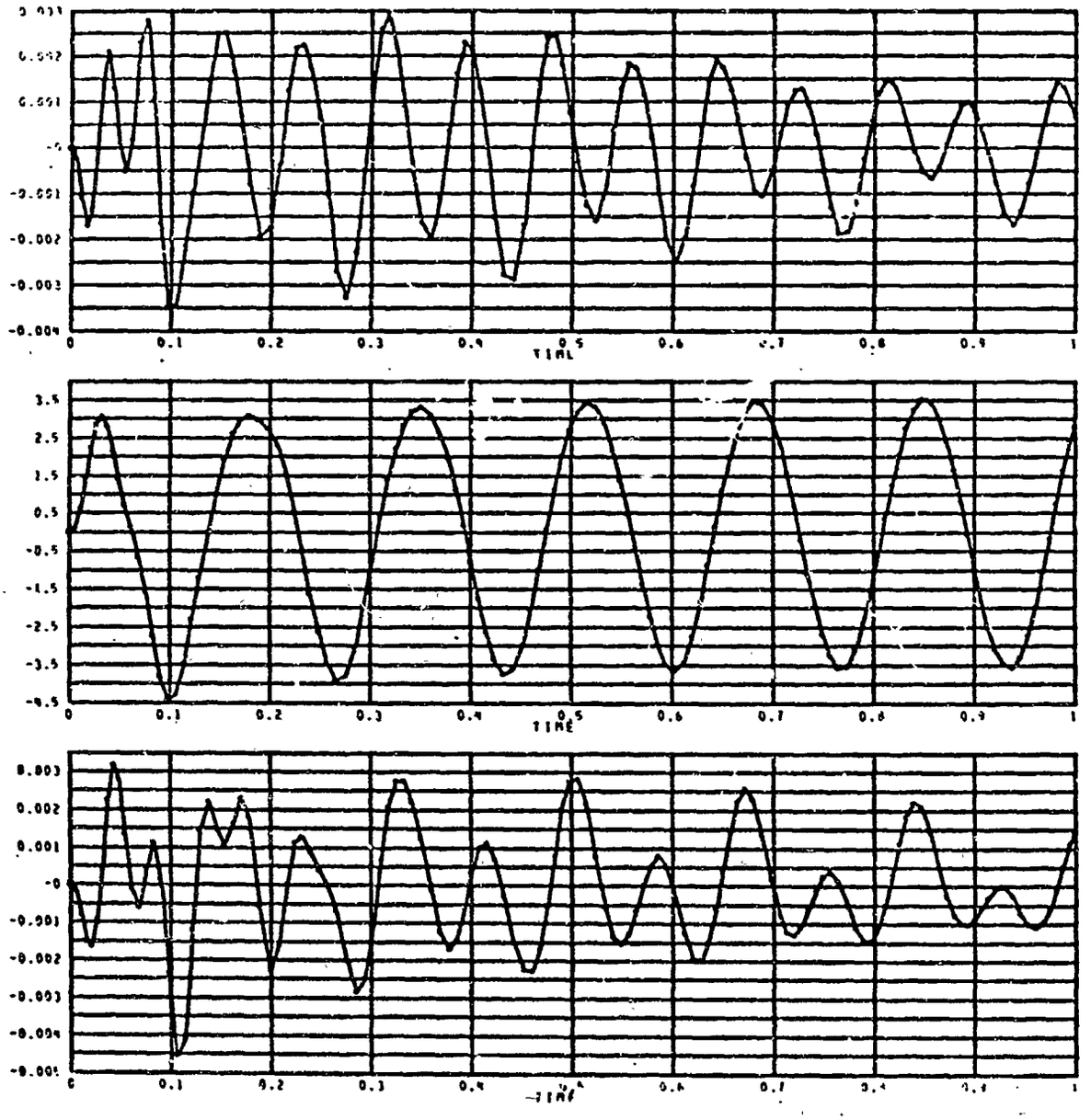
INCREMENTAL INERTIAL MOTIONS OF TABLE C.G.



INCREMENTAL ANGULAR MOTIONS OF TABLE C.G.



INERTIAL VELOCITIES



EULER ANGLE VELOCITIES

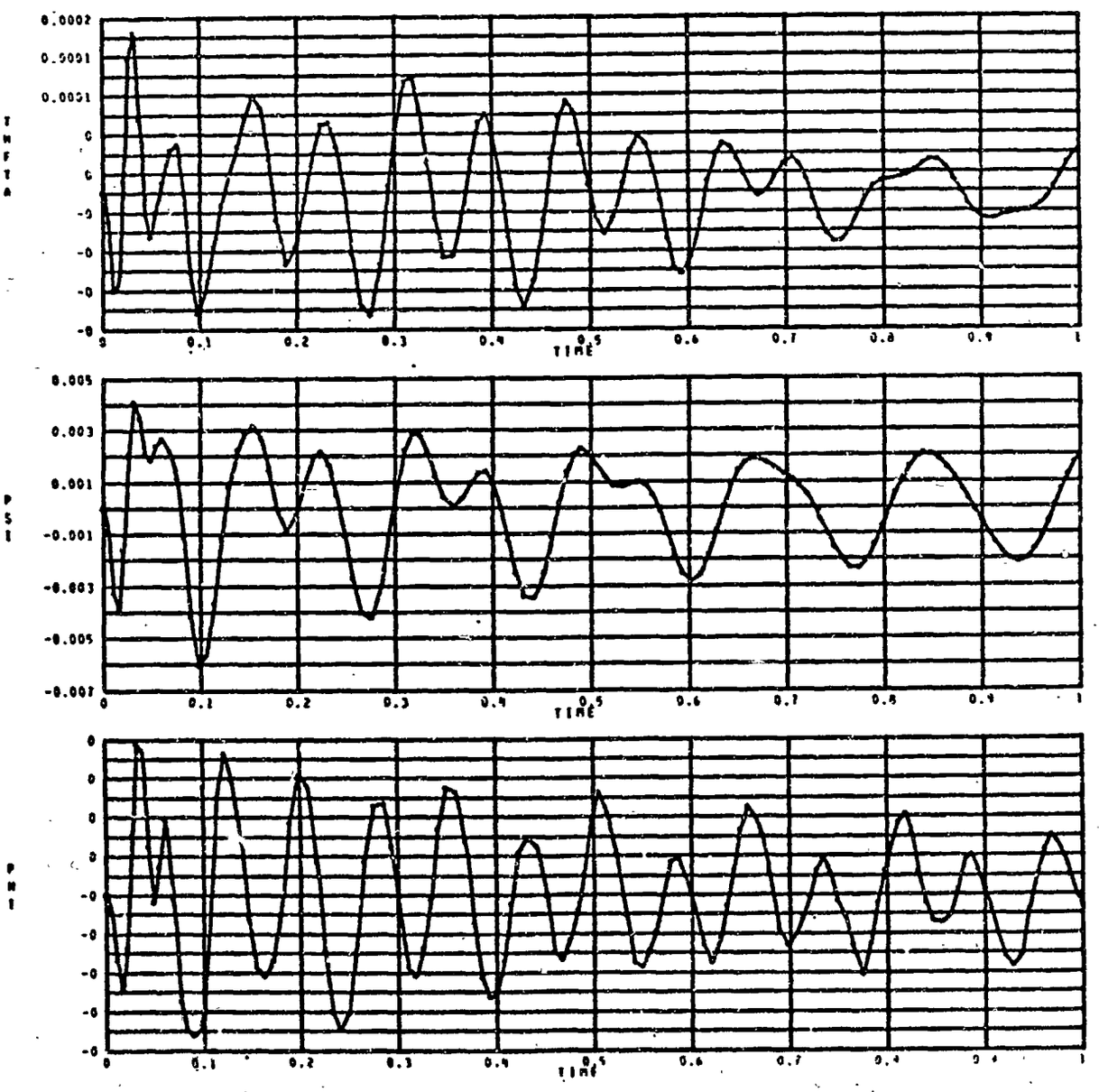
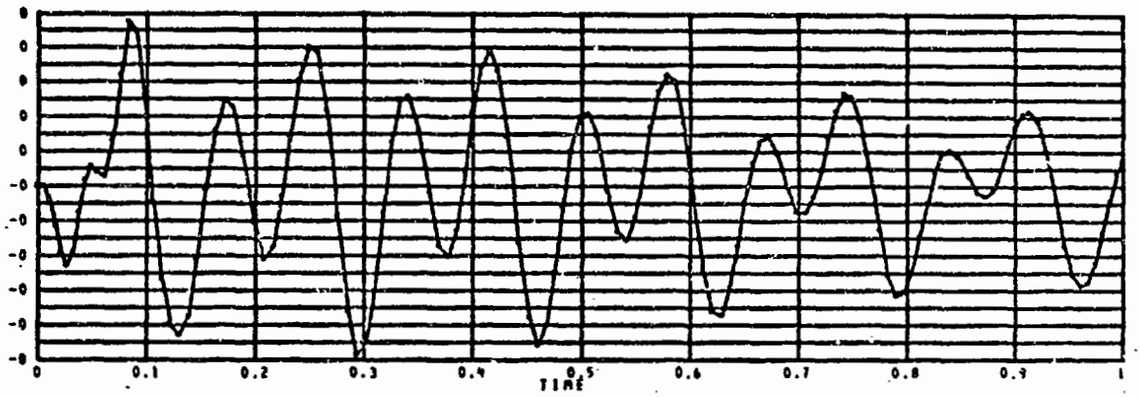
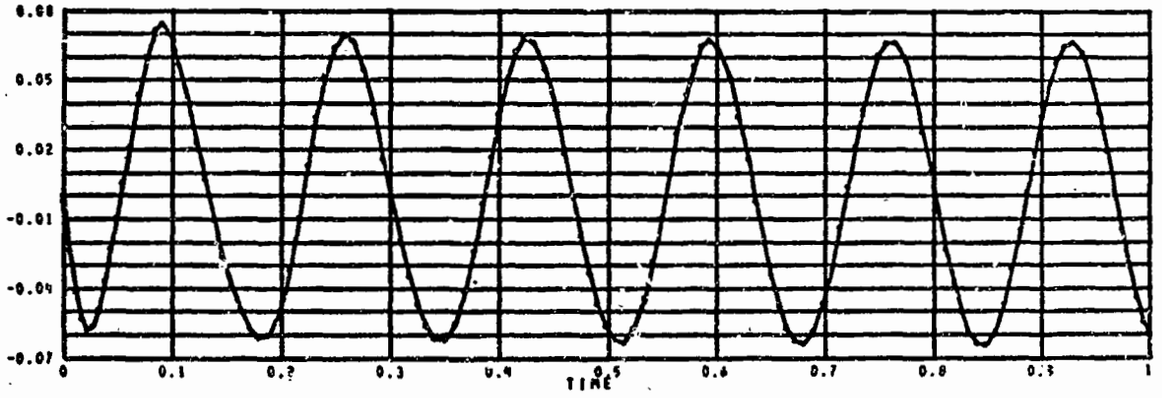


TABLE POSITION ERROR (ACTUAL-COMMANDED)





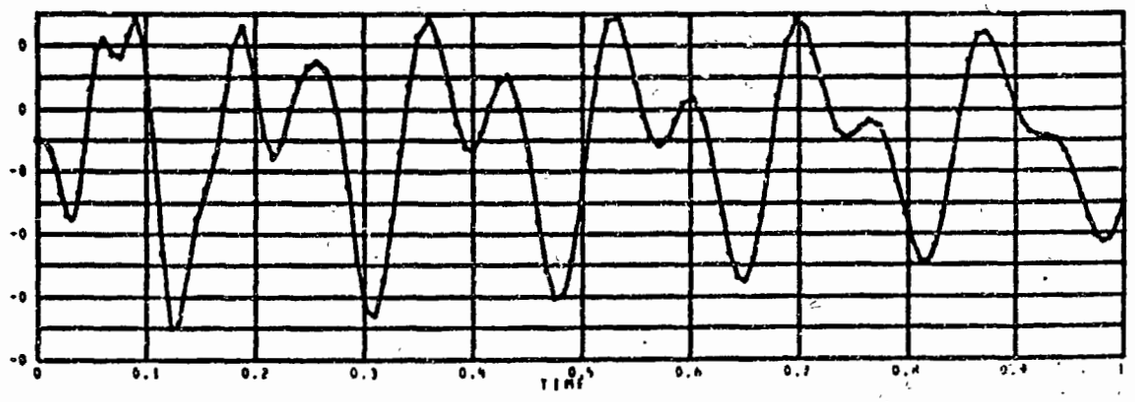
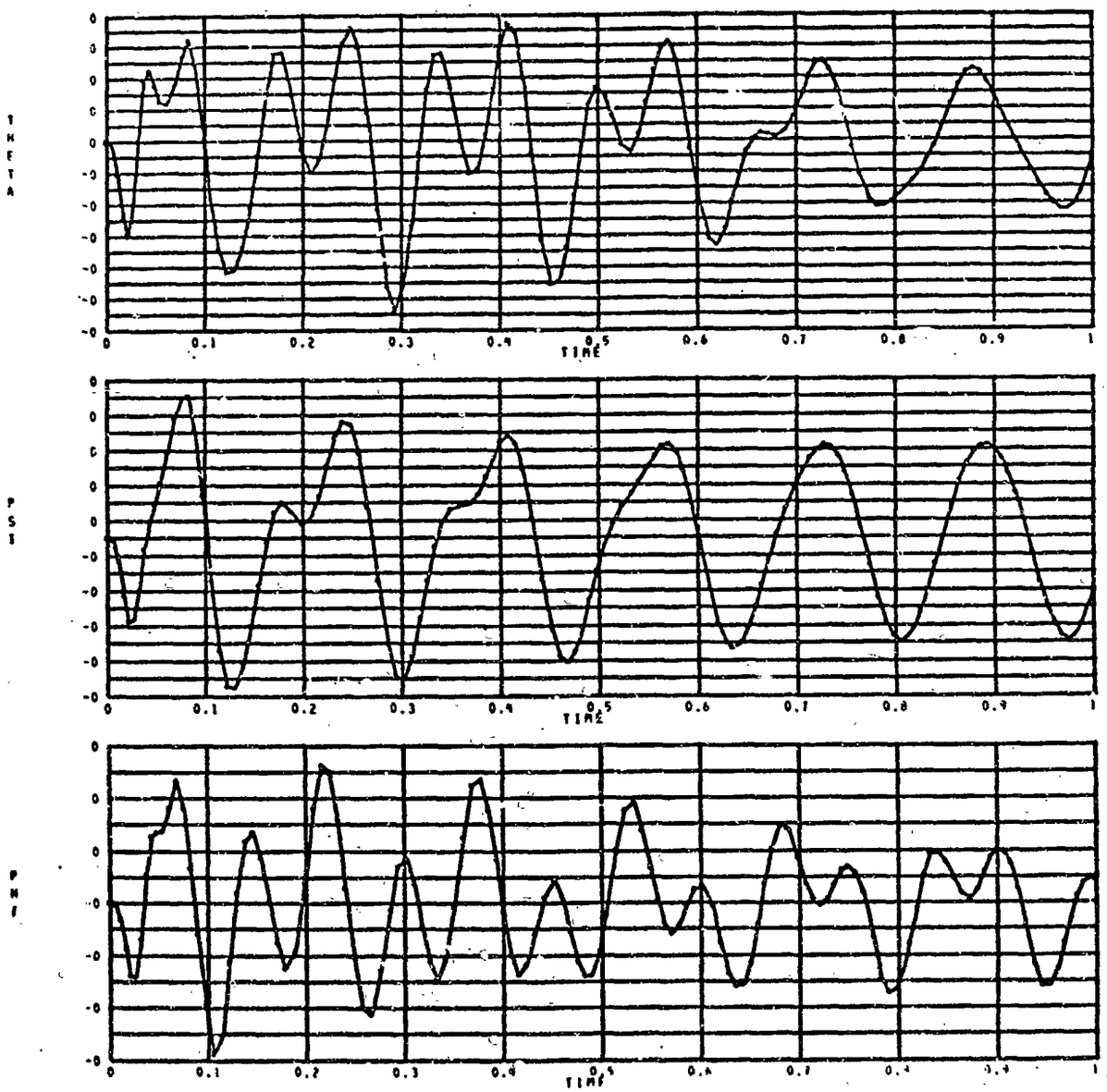
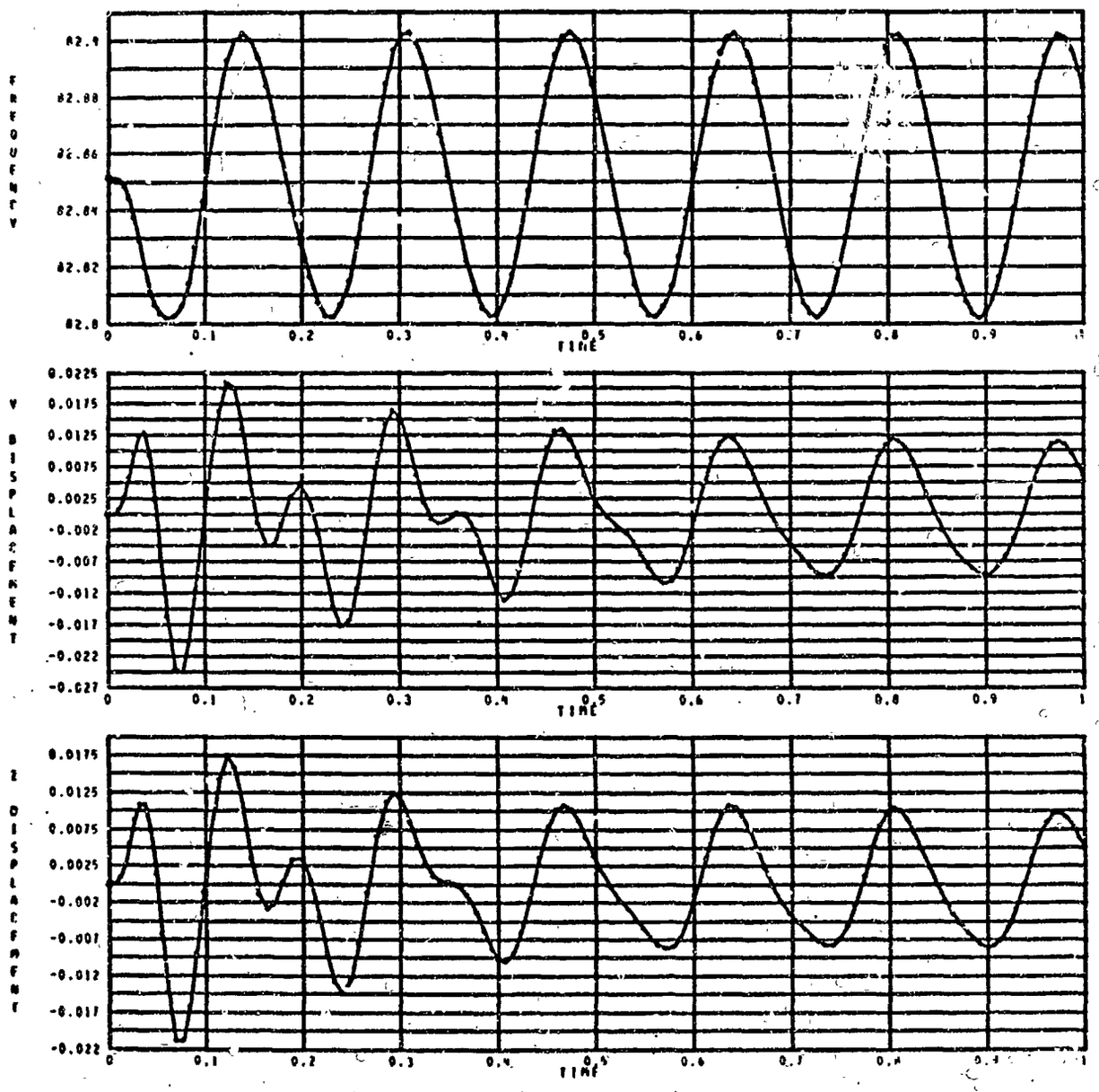


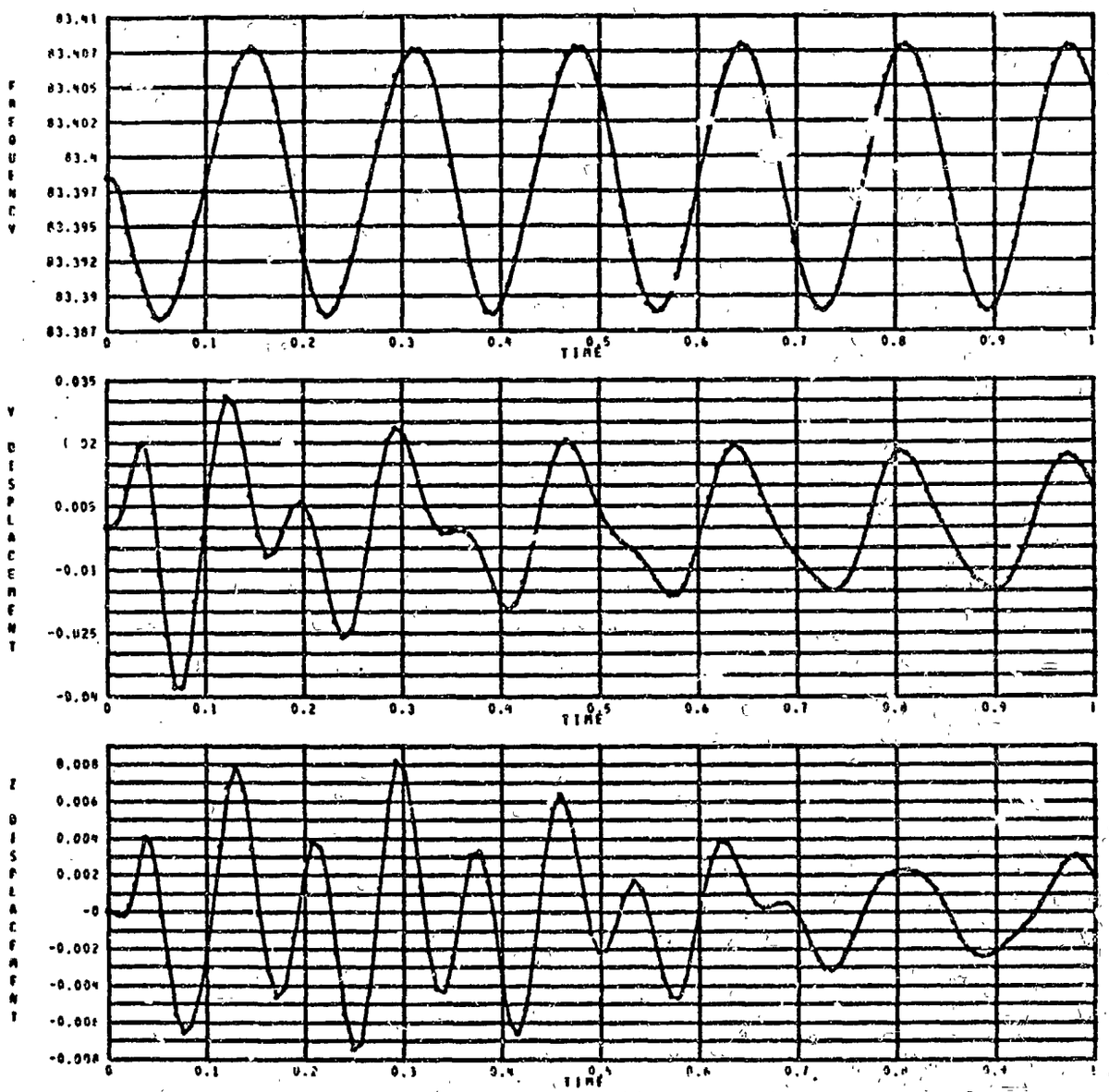
TABLE POSITION ERROR (ACTUAL-COMMANDED)

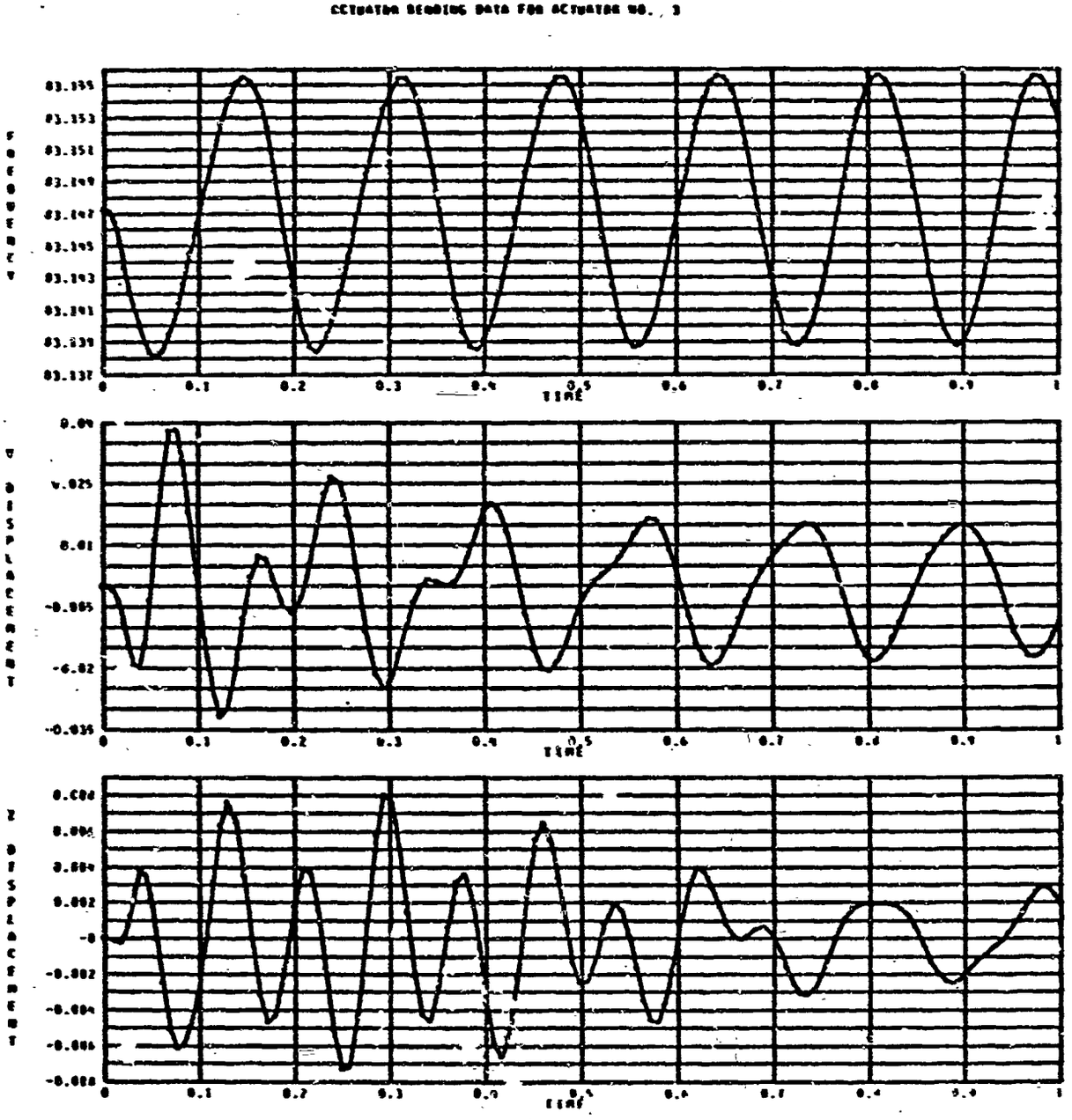


ACTUATOR BENDING DATA FOR ACTUATOR NO. 1



ACTUATOR BENDING DATA FOR ACTUATOR NO. 2




ACTUATOR RECORDING DATA FOR ACTUATOR NO. 3
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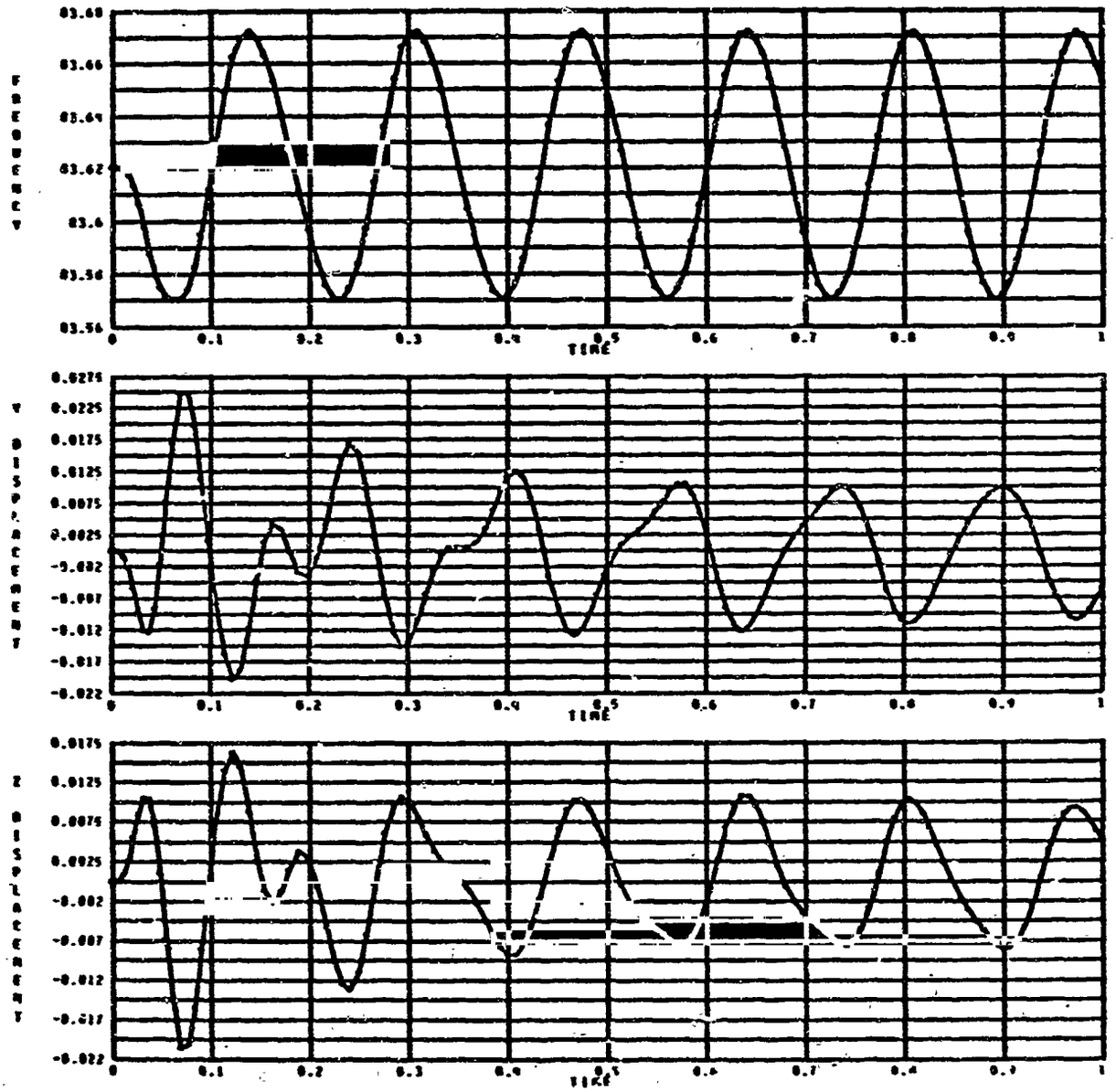
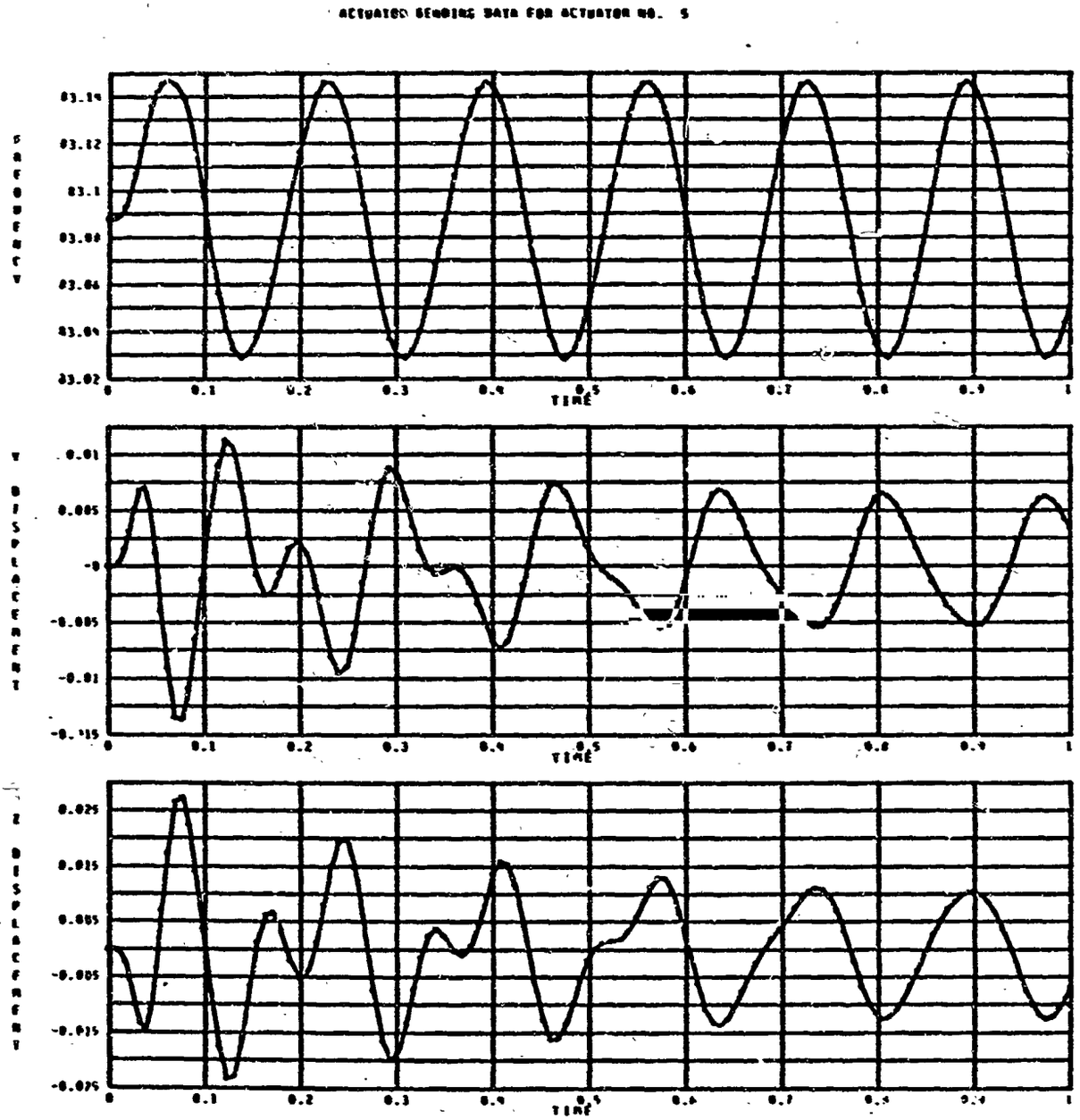
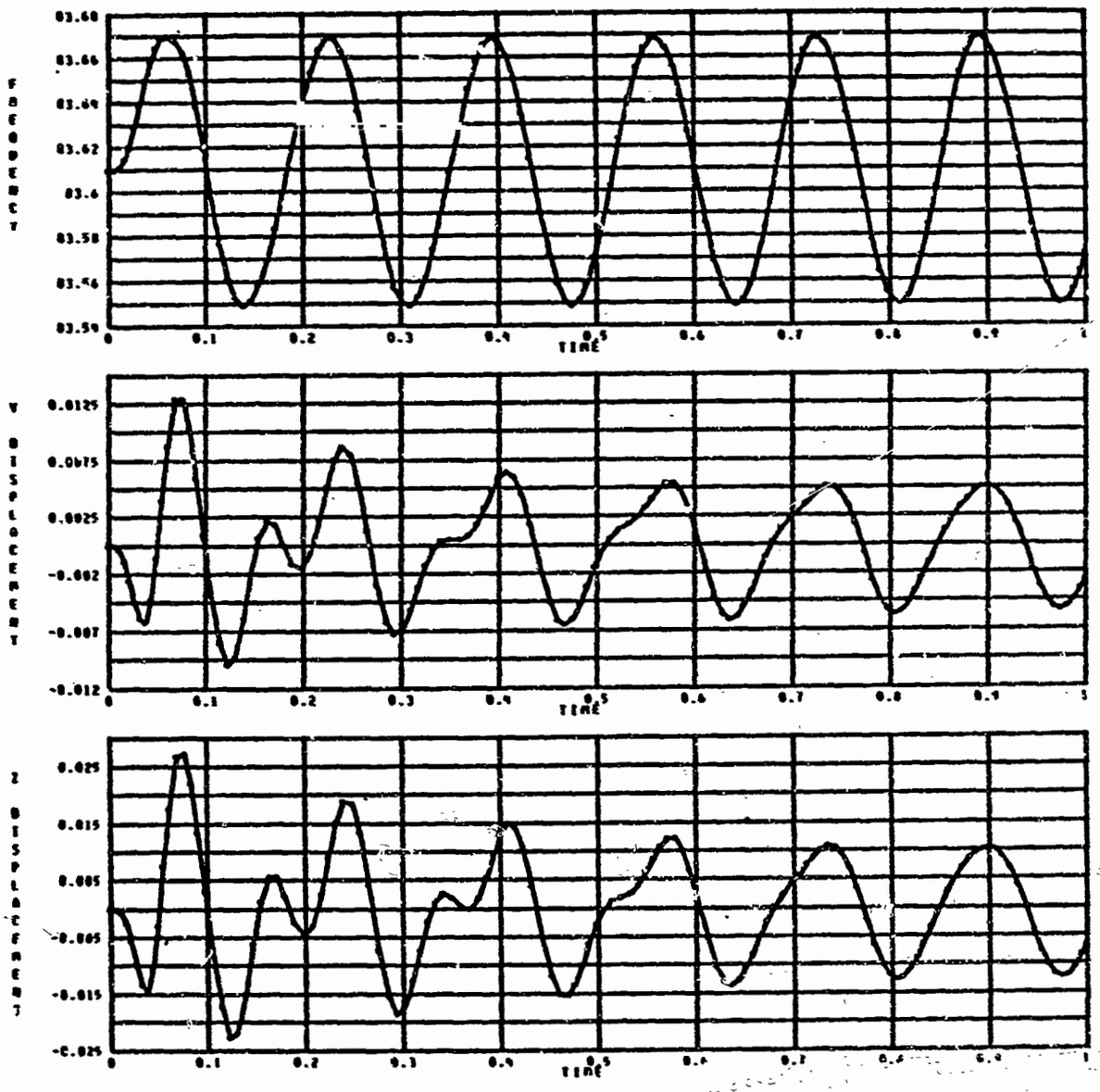
TIME
TIME

ACTUATOR BENDING DATA FOR ACTUATOR NO. 4

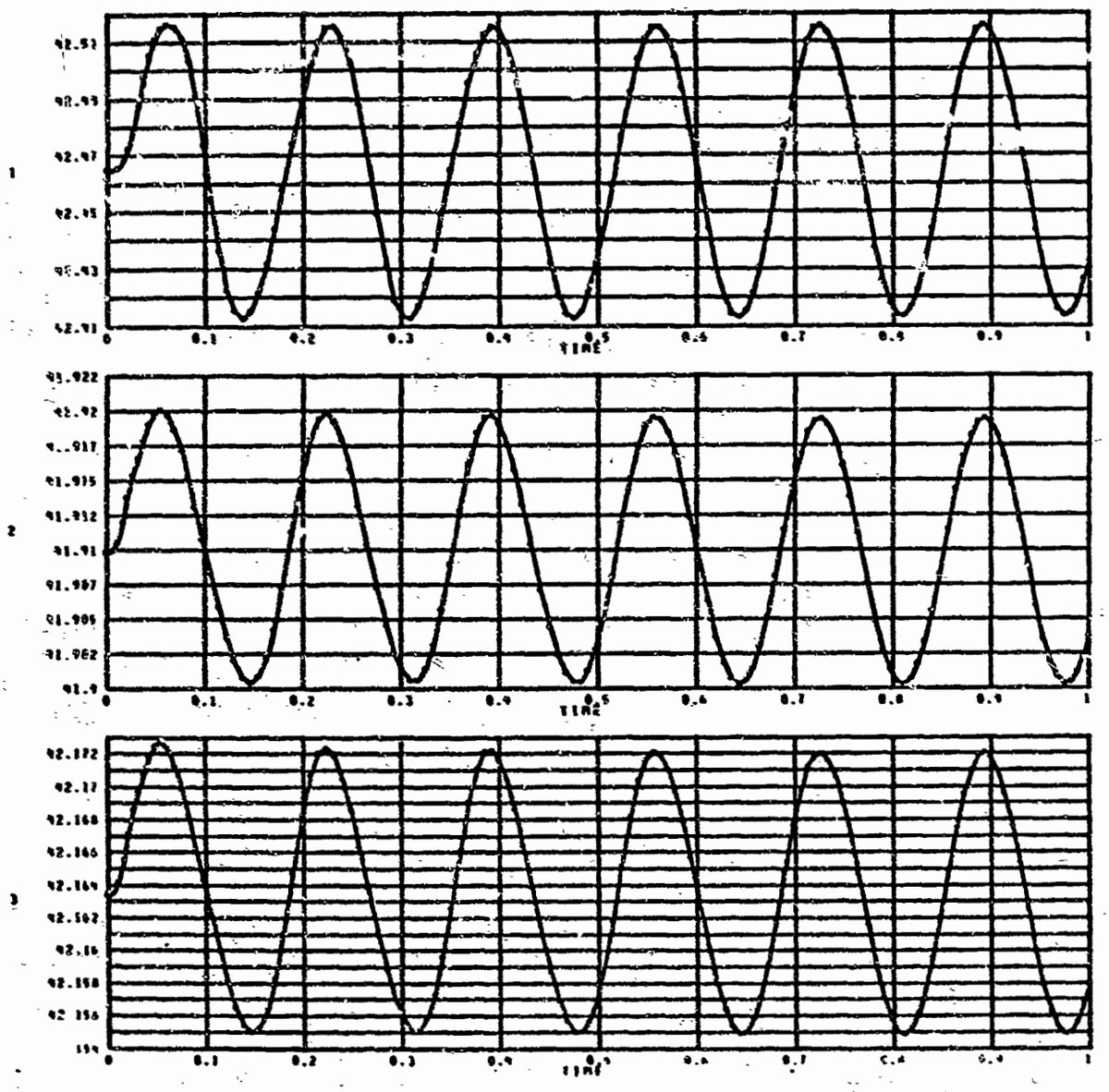



ACTUATOR BENDING DATA FOR ACTUATOR NO. 5
TIME
TIME
TIME

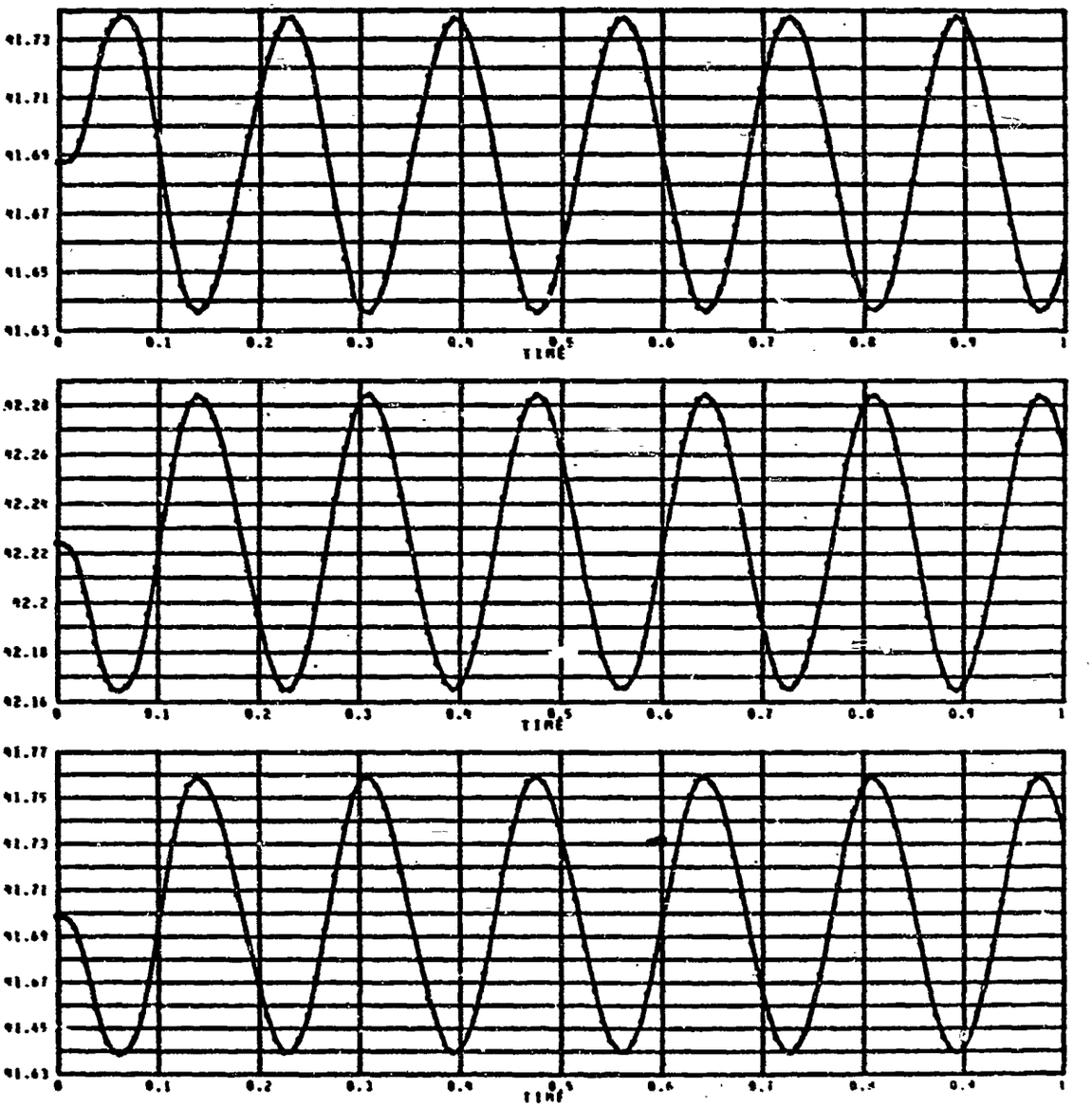
ACTUATOR BENDING DATA FOR ACTUATOR NO. 6



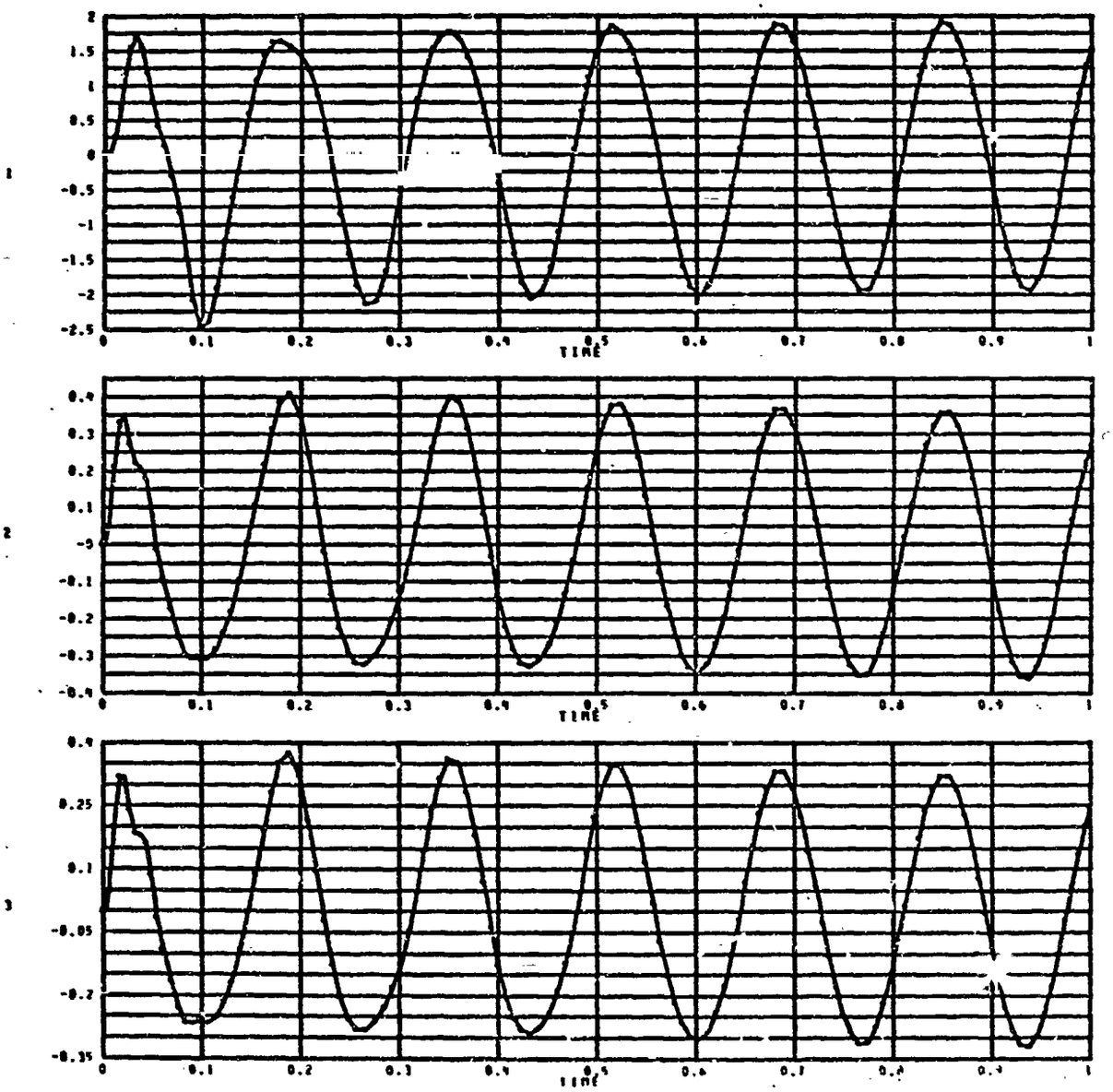
ACTUATOR STROKES



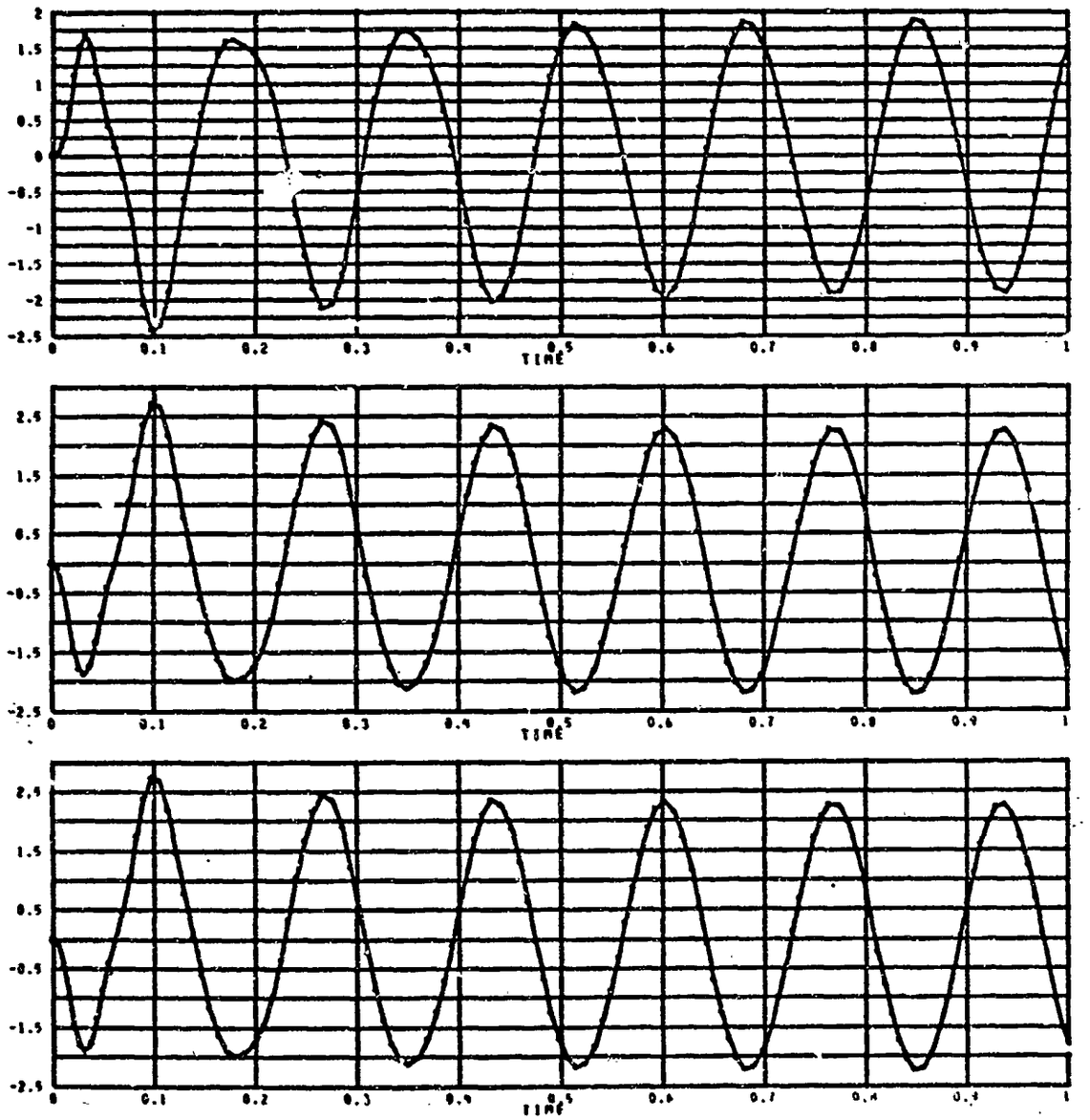
ACTUATOR STROKES



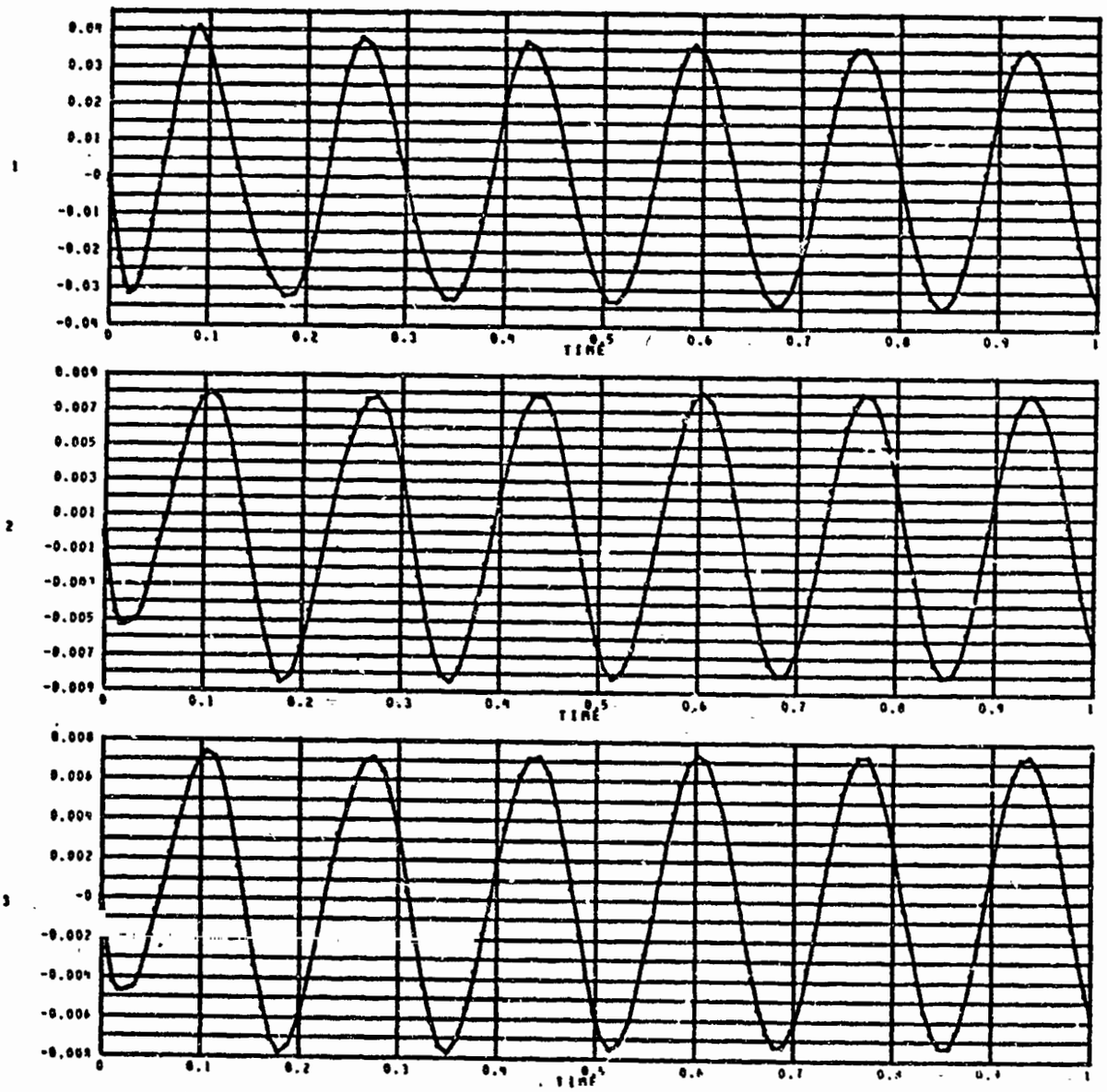
ACTUATOR VELOCITIES



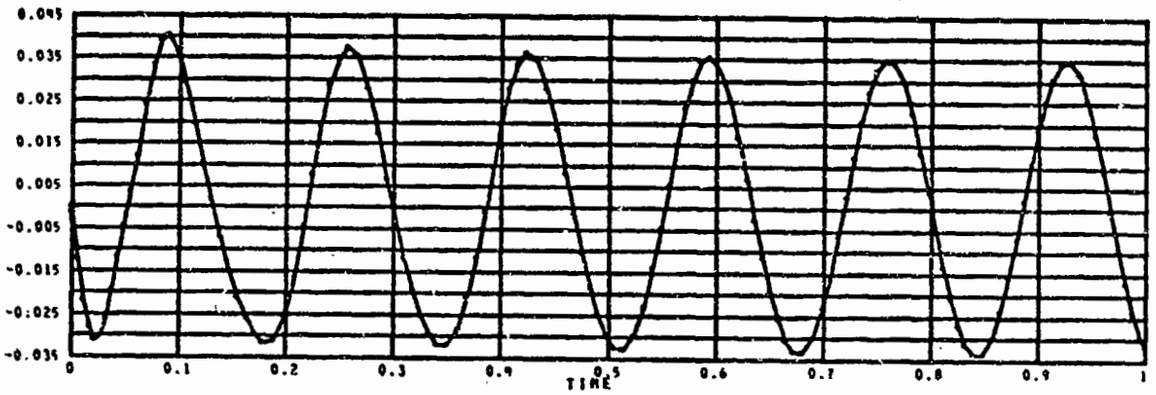
ACTUATOR VELOCITIES

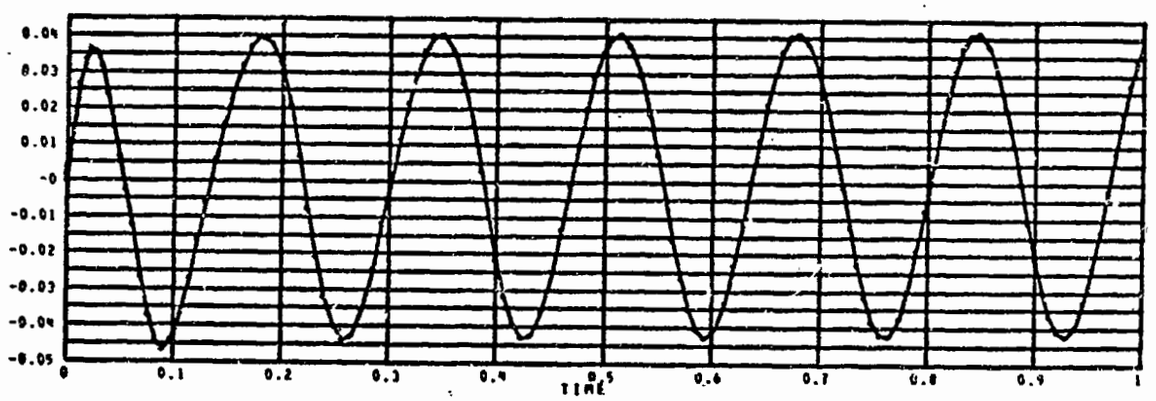


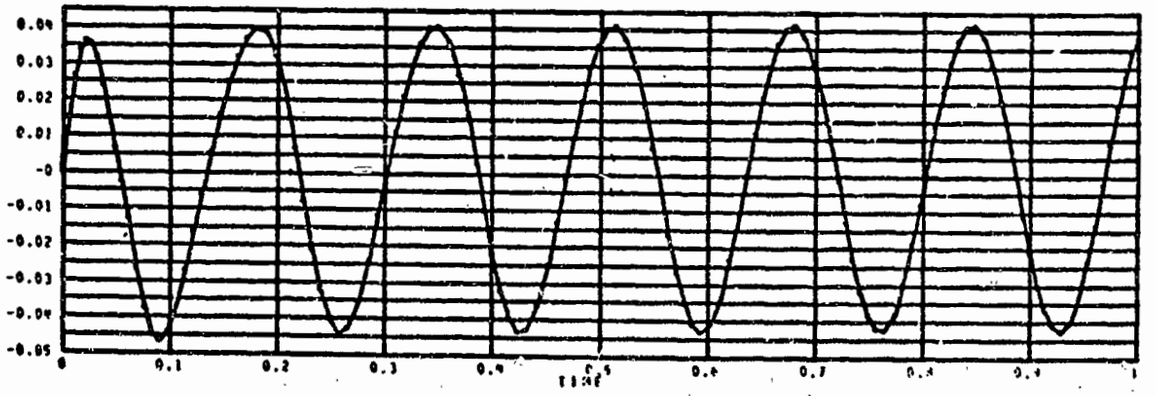
ACTUATOR POSITION ERROR (ACTUAL-COMMANDED)



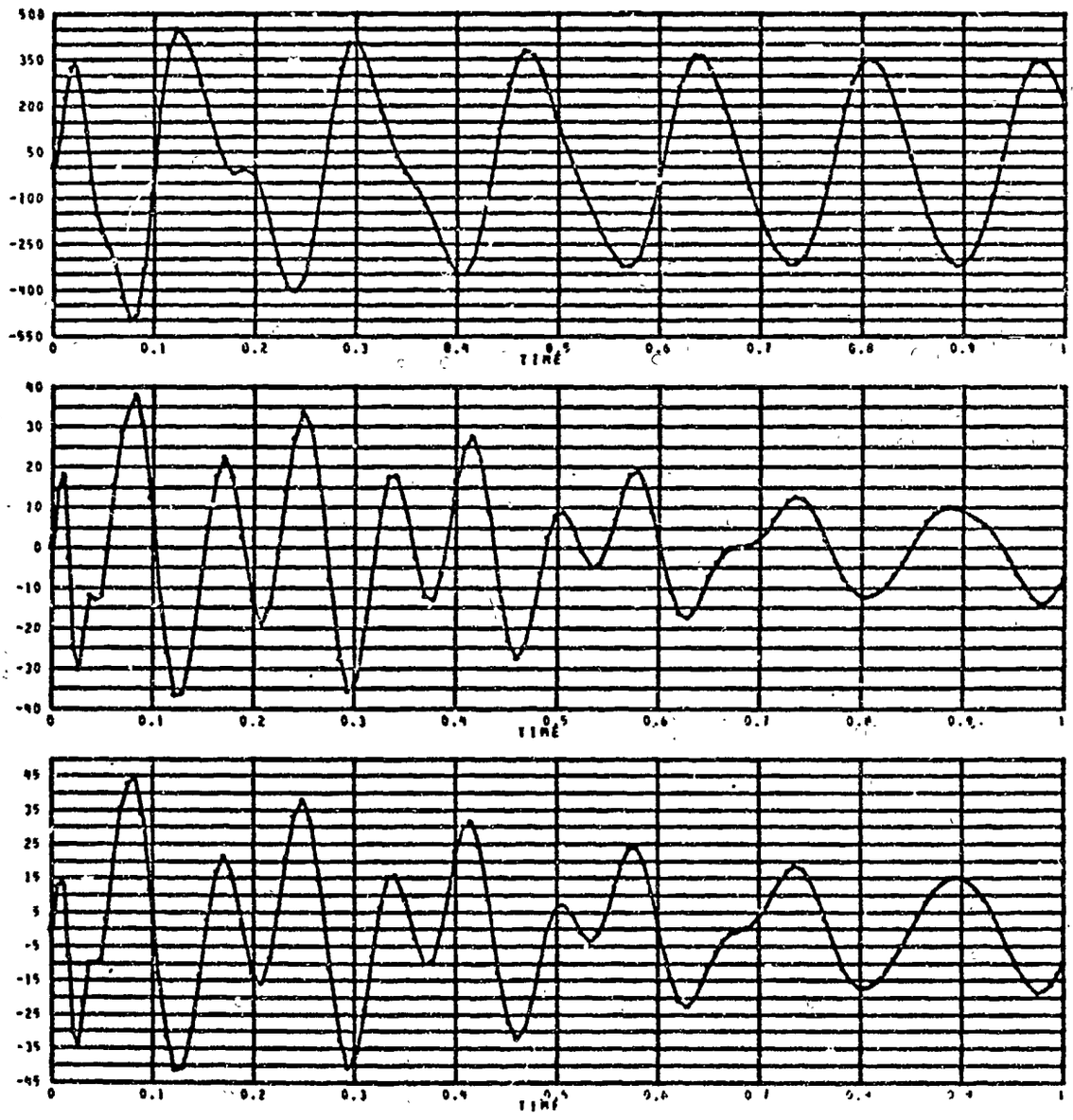
ACTUATOR POSITION ERROR (ACTUAL-COMMANDED)







NET FORCES ON ACTUATOR PISTONS



NET FORCES ON ACTUATOR PISTONS