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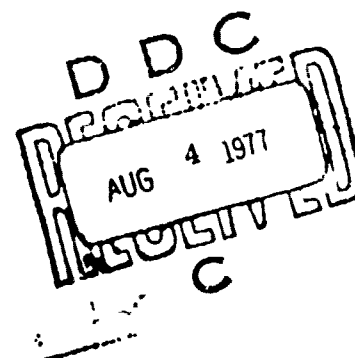
COLLECTION OF COMMERCIAL AIRCRAFT
CHARACTERISTICS FOR STUDY OF RUNWAY ROUGHNESS

Anthony G. Gerardi



Final Report

May 1977



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16. Abstract Engineering data compatible with the computer program "TAXI" (Ref. 1) has been collected for six commercial jet aircraft: These are the Boeing 707-320C, 727-200, and 747 and the McDonnell Douglas DC-8-63, DC-9-40 and the DC-10-10. The data is presented in the form required by "TAXI". A simulation was made for each aircraft taking off from two separate airfields, Dulles International in Washington D.C. and Will Rogers International Airport at Oklahoma City, Oklahoma. The purpose of using two profiles being to point out the differences in aircraft response to different runway profiles. The calcomp plotted results are presented in the results section of this report. This report also serves as a program users manual. A sample problem simulating a Boeing 707-320C during a constant speed taxi (100 feet per second) over the profile at the Will Rogers International Airport is included in the report. All of the fortran symbols used in "TAXI" are defined, and a complete listing of the program is contained in appendices A, B, C, and D. Appendix E contains airplane data representing a "Typical" wide body tri-jet transport and two simulations using this data.		
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LIST OF SYMBOLS

<u>Symbol</u>	<u>Definition</u>	<u>Unit</u>
A	Distance from rear main landing gear to aircraft CG	in
a_1, a_2, a_3, a_4	Coefficients calculated to fit a polynomial curve to a runway segment	Nil
A_h	Hydraulic piston area	in ²
A_o	Effective orifice area	in ²
B	Distance from nose landing gear to aircraft CG	in
C	Distance from front main landing gear to aircraft CG	in
c	Damping coefficient	1/sec
C_d	Orifice coefficient	ND
F_A	Pneumatic strut force	lbs
F_{AD}	Total airplane aerodynamic drag	lbs
F_D, F_N	Landing Gear Drag and Normal Forces	lbs
F_F	Friction force	lbs
F_{F_n}	Strut seal friction	lbs
F_h	Hydraulic strut force	lbs
F_{s1}, F_{s2}, F_{s3}	Total landing gear strut forces	lbs
$F_t, F_{t1}, F_{t2}, F_{t3}$	Landing gear tire forces	lbs
F_T	Total airplane thrust	lbs
F_{TD}	Main landing gear tire drag force	lbs
F_u, F_L	Strut bearing friction forces, upper and lower	lbs
g	Gravitational acceleration constant	in/sec ²
I_{yy}	Total airplane pitching inertia	lbs/in sec ²
k	Linear tire spring constant	lbs/in

<u>Symbol</u>	<u>Definition</u>	<u>Unit</u>
L	Total airplane lift	lbs
M_1, M_2, M_3	$W_1/g, W_2/g, W_3/g$	slugs
M_{cg}	Airplane mass	slugs
M_i	The generalized mass for the i th mode	lbs-sec ² /in
P	Fully extended strut air pressure	lb/in ²
q	Deflection due to bending	in
q_i	array of nondimensional time dependent coordinates which weigh the amount of motion due to the i th mode in the total motion of the aircraft	ND
$\dot{q}_i$	Time derivative of q_i	1/sec
$\ddot{q}_i$	Time derivative of $\dot{q}_i$	1/sec ²
S	Strut displacement	in
$\dot{S}$	Time derivative of S	in/sec
$\ddot{S}$	Second time derivative of $\dot{S}$	in/sec ²
Δt	Taylor series sample solution time step size	sec
T_D	Tire deflection	in
V	Fully extended strut volume	in ³
W	Total airplane weight	lbs
W_1, W_2, W_3	Unsprung landing gear weights	lbs
x	Coordinate for sample Taylor series solution	in
$\dot{x}$	Time derivative of x	in/sec
$\ddot{x}$	Time derivative of $\dot{x}$	in/sec ²
X	Horizontal translation of the aircraft down the runway	ft
$\dot{X}$	Time derivative of X	ft/sec
$\ddot{X}$	Time derivative of $\dot{X}$	ft/sec ²
Z	Vertical displacement of the vehicle CG	in
$\dot{Z}$	Time derivative of Z	in/sec

<u>Symbol</u>	<u>Definition</u>	<u>Unit</u>
$\ddot{z}$	Time derivative of $\dot{z}$	in/sec ²
z_1, z_2, z_3	Vertical displacement of the unsprung mass of gear number 1, 2 and 3	in
$\dot{z}_1, \dot{z}_2, \dot{z}_3$	Time derivative of z_1, z_2, z_3	in/sec
$\ddot{z}_1, \ddot{z}_2, \ddot{z}_3$	Time derivative of $\dot{z}_1, \dot{z}_2, \dot{z}_3$	in/sec ²
e_1	Distance from main gear axle to the waterline of the aircraft CG	in
$\xi_{i1}, \xi_{i2}, \xi_{i3}$	Modal deflection of the ith mode at gear 1, 2 and 3	in
θ	Aircraft pitch angle	rad
$\dot{\theta}$	Time derivative of θ	rad/sec
$\ddot{\theta}$	Time derivative of $\dot{\theta}$	rad/sec ²
ρ_h	Hydraulic fluid density	slugs/in ³
ζ_i	Percent of critical damping factor for the ith mode	ND
μ_L, μ_U	Sliding coefficients of friction for strut lower and upper bearings	ND
ω_i	Natural frequency of the ith mode	rad/sec

SECTION I

INTRODUCTION

Very early aircraft operated from grass airfields or graded and untreated runways. However, with the development of more sophisticated aircraft requiring higher and higher ground speeds, runway surfacing became of increasing concern. Today's modern aircraft require a pavement system structurally capable of supporting gross loads approaching a million pounds. In addition, the pavement surface must provide adequate skid resistance and must be of sufficient smoothness to prevent undue loss of fatigue life in the aircraft. The response of aircraft to the pavement irregularities has become of increasing concern in recent years. A great deal of emphasis has been placed upon the comfort and safety of aircraft ground operations and other factors related to the interaction between the pavement and the aircraft.

Because the runway and the aircraft form a coupled system with the pavement profile providing a displacement input that can radically affect the behavior of the vehicle, there is an urgent need for a means to measure pavement roughness. The Federal Aviation Administration has long been aware of this need, and in 1973 initiated research and development efforts to quantify pavement roughness. This effort began with the study of a means for rapidly collecting the runway profile. As a result of that effort, a profiling system using a laser beam as a horizontal reference datum was developed (Reference 1).

The next step was to establish roughness criteria. Considerable effort had been expended in this area, most of it dealing with the subjective rating of ride quality. However, ride quality did not deal directly with the pavement, which was the factor causing unacceptable aircraft response. Therefore, in its efforts to define runway roughness, a statistical approach to the runway profile itself was taken (Reference 2). This approach dealt with the root means square of the deviation of the profile about a normalized line. From this comes criteria for evaluating a runway profile as being acceptable as long as the RMS level is below 0.32 inches. Marginal conditions are equated to RMS levels of 0.32 to 0.36 inches and any runway having a RMS level of greater than 0.36 inches is considered to be unduly rough.

As a check of this criteria and as a means of evaluating the simulated repair of a runway having undesirable roughness, an existing taxi code developed for the US Air Force was modified to provide a way for calculating the dynamic response of commercial aircraft to runway irregularities. The modification of that computer code is the subject of this report. The use of this computer program is not to compare ride

quality between various classes of aircraft but rather to be used by the operating airlines and airport owners and operators as a means of identifying rough pavement areas and to help insure the timely maintenance of pavements in order to prevent the development of undue roughness.

Details of the development of the computer code modified in this report is provided in Reference 3. The development of the computer code is only briefly summarized in this report. In order to make the computer code useful to all commercial aircraft, these aircraft were divided into five classes based on gross weight as shown below:

Aircraft Classes

<u>Class</u>	<u>Weight Group</u>
Class A Aircraft	Less than 150,000 pounds
Class B Aircraft	150,000 - 300,000 pounds
Class C Aircraft	300,000 - 450,000 pounds
Class D Aircraft	450,000 - 600,000 pounds
Class E Aircraft	Greater than 600,000 pounds

SECTION II

MATHEMATICAL MODEL

The general airplane/runway mathematical model used for this study was the basic mathematical model developed in Reference 1. A detailed description of the components that make up this general model, as well as the assumptions made are shown in Reference 1. This report presents, in summary form, the landing gear strut and tire representation, the airplane rigid body and flexible body representation, the runway profile representation, the equations of motion and the solution technique.

The general model is represented as a symmetrical body with either a nose and single strut main landing gear typical of class A through D aircraft. Each landing gear strut is assumed to have point contact with the profile and it is assumed that the main landing gear traverses the same profile as the nose landing gear except at a later time. The model has aerodynamic lift and drag and thrust applied at the aircraft's center of gravity.

The fuselage is free to pitch, plunge and translate horizontally down the runway. In addition to these rigid body degrees of freedom, up to 15 flexible modes of vibration are included. This fuselage motion is controlled by the landing gear strut forces, lift, drag, thrust, and the resisting parameters of aircraft mass and inertia. Figure 1 is a schematic drawing of the mathematical model used for this simulation.

The landing gear struts are non-linear, single acting oleo-pneumatic energy absorbing devices (Figure 2) and are represented in the model as the sum of the three forces, pneumatic, hydraulic, and strut bearing friction forces. The pneumatic force, which is the largest of the three is represented by the equation:

$$F_a = \frac{PV}{V-S} \frac{1}{A} \quad (1)$$

where:

- F_a = pneumatic strut force
- P = the fully extended strut pressure
- V = the fully extended strut volume
- A = the pneumatic piston area
- S = strut stroke

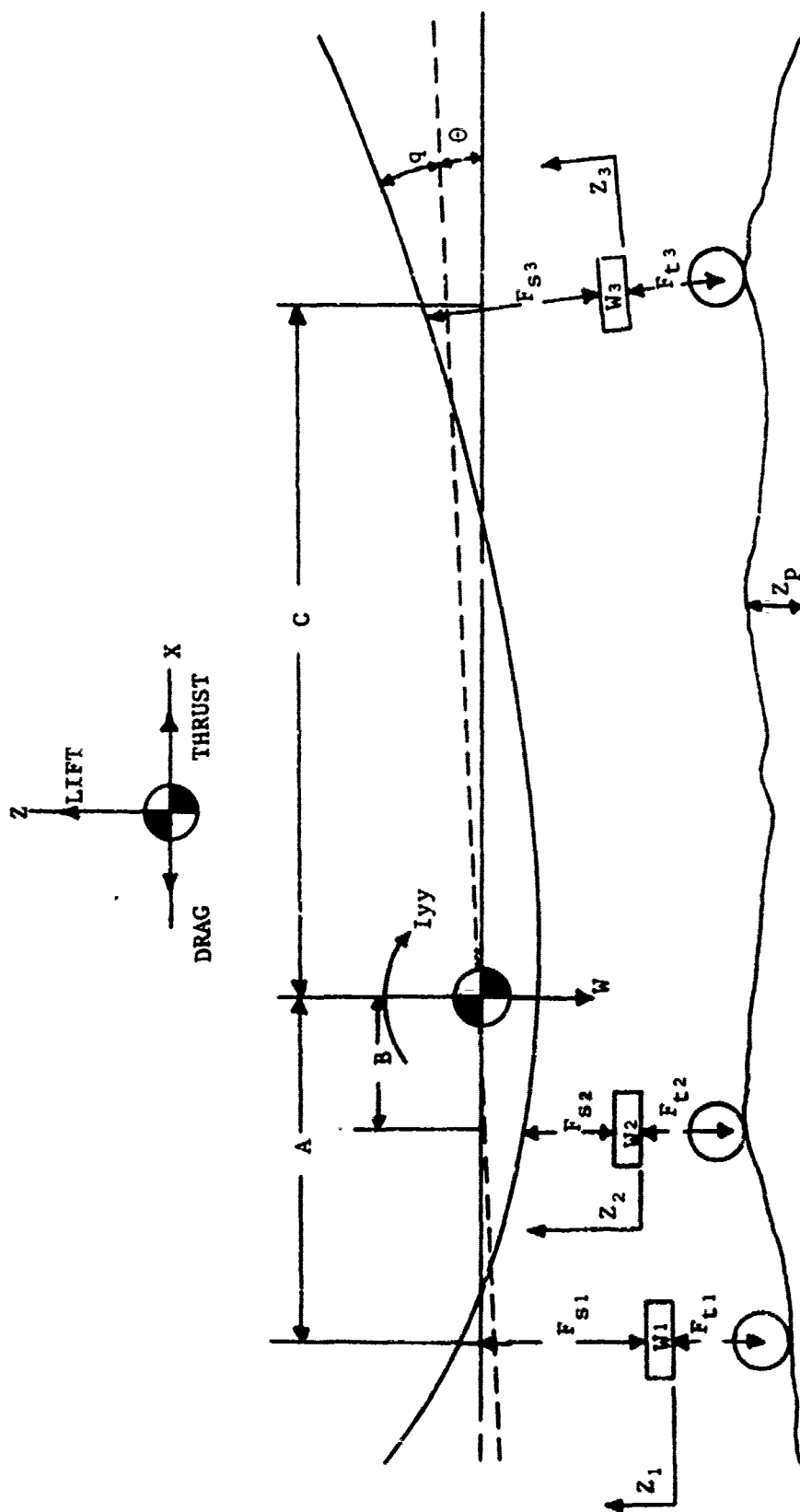


Figure 1 - Mathematical Model used in TAXI Simulation

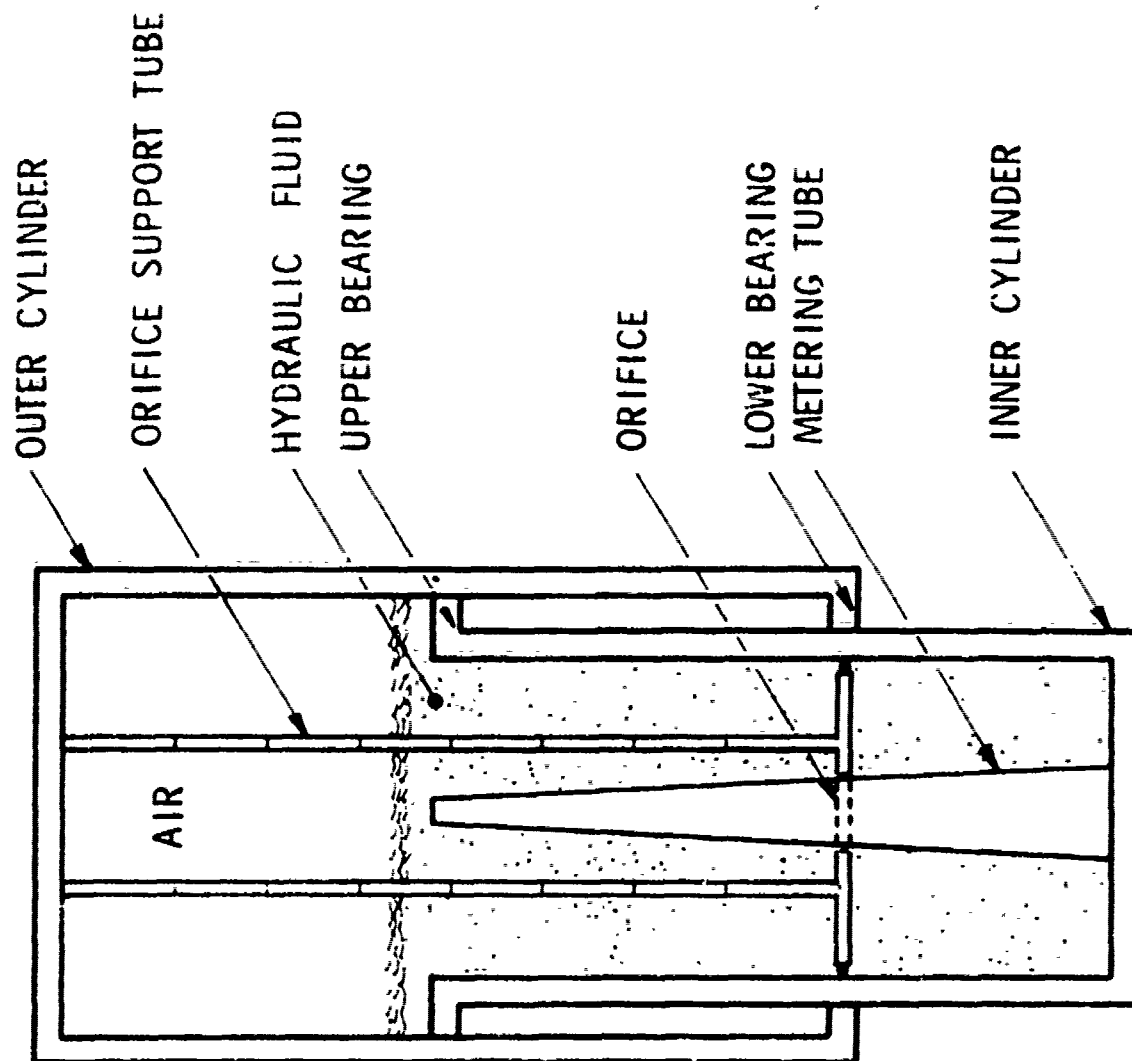


Figure 2. Typical Single Acting Oleo-Pneumatic Landing Gear Strut

The hydraulic or damping force is given by the equation:

$$F_h = \frac{\rho_h A_h^3 \dot{S} |\dot{S}|}{2 (C_d A_o)^2} \quad (2)$$

where:

F_h = hydraulic strut force

ρ_h = density of the hydraulic fluid

A_h = the hydraulic piston area

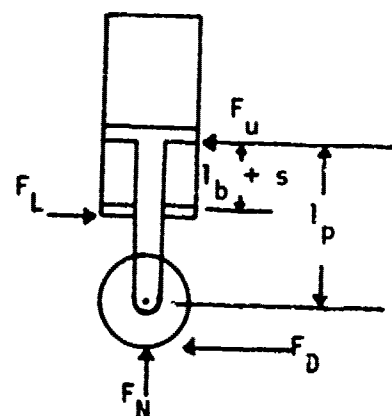
A_o = effective orifice area (constant orifice minus metering pin area)

C_d = orifice coefficient (use 0.9)

$\dot{S}$ = strut piston velocity

The third strut force is the strut bearing friction force and is included in the model only when articulated or asymmetrically loaded struts are being simulated. In symmetrically loaded struts the friction force is neglected (see Reference 1). The following derivation of the friction force was taken from Reference 2.

The force on upper and lower strut bearings due to rolling friction is shown in Figure 3:



$$F_{D1} = .025 F_N$$

$$F_{U1} = F_{D1} \left(\frac{l_p}{l_b + s} - 1 \right)$$

$$F_{L1} = F_{D1} \left(\frac{l_p}{l_b + s} \right)$$

Figure 3. Friction Force Due to Wheel Drag

where:

F_D = landing gear drag force

F_N = landing gear normal force

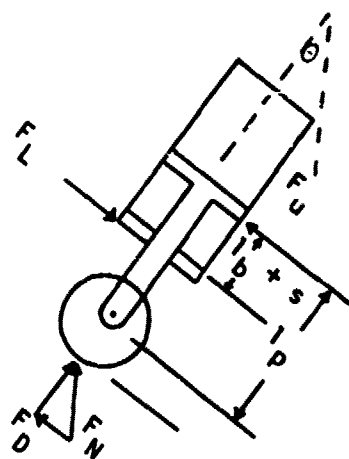
F_U, F_L = bearing forces at the upper and lower bearings respectively required to balance the lateral loading on the piston

l_p = the piston length

l_b = the strut fully extended bearing separation

s = the strut stroke

The force on upper and lower strut bearings due to nonperpendicular orientation is represented by Figure 4:



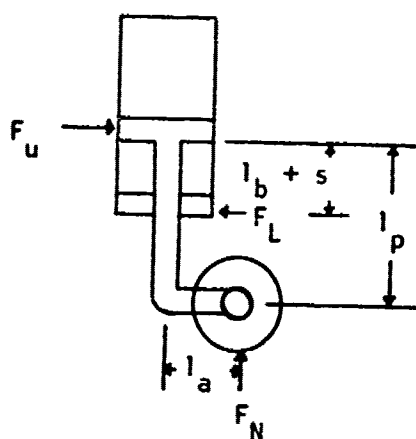
$$FD_2 = \sin F_N$$

$$F_{u2} = FD_2 \left(\frac{l_p}{l_b + s} - 1 \right)$$

$$F_{L2} = FD_2 \left(\frac{l_p}{l_b + s} \right)$$

Figure 4. Friction Force Due to Nonperpendicular Orientation

Finally, as represented in Figure 5, the force on the upper and lower strut bearings due to axle offset is:



$$F_{u3} = F_{L3} = \frac{F_N l_a}{(l_b + s)}$$

Figure 5. Friction Force Due to Axle Offset

For a landing gear strut having wheel drag, an angle from the vertical and an axle offset, the total friction force would be as follows:

$$F_u = F_{u1} + F_{u2} + F_{u3}$$

$$F_L = F_{L1} + F_{L2} \pm F_{L3}$$

$$F_f = [\mu_L F_L + \mu_u F_u + F_{F0}] \frac{|\dot{s}|}{\dot{s}}$$

where:

F_f = friction force

μ_u, μ_L = coefficients of sliding friction at the upper and lower bearings, respectively; $\mu_u = 0.10$, $\mu_L = 0.15$

(the lower bearing is generally not as well lubricated as the upper bearing.)

F_{F0} = strut seal friction at zero lateral loading

The tire force is represented by the linear equation

$$F_t = k T_D \quad (3)$$

where:

F_t = tire force

T_D = tire deflection

k = linear tire spring constant

The runway elevation data is input into the model in two-foot increments, three data points at a time for each landing gear as required. The profile is made continuous by fitting the following polynomial through the three elevation data points and the slope at the end of the previous profile segment:

$$Y(x) = a_1 + a_2x + a_3x^2 + a_4x^3 \quad (4)$$

where:

$a_{1,2,3,4}$ = coefficients derived from the elevation and slope data

SECTION III

EQUATIONS OF MOTION AND SOLUTION TECHNIQUE

Equations of Motion:

The differential equations of motion for the mathematical model were derived by application of Hamilton's principle of minimum energy. The general form of these equations is shown below and corresponds to the notation shown in Figure 1.

Rigid Body Equations of Motion

$$\ddot{Z} = (F_{s1} + F_{s2} + F_{s3} + L - W)/M_{cg} \quad [\text{c.g., vertical acceleration}] \quad (5)$$

$$\ddot{Z}_1 = (F_{t1} - F_{s1} - W_1)/M_1 \quad (6)$$

$$\ddot{Z}_2 = (F_{t2} - F_{s2} - W_2)/M_2 \quad \begin{matrix} [\text{unsprung landing gear} \\ \text{mass acceleration}] \end{matrix} \quad (7)$$

$$\ddot{Z}_3 = (F_{t3} - F_{s3} - W_3)/M_3 \quad (8)$$

$$\ddot{\theta} = (F_{s1} A + F_{s2} B + F_{TD} \epsilon_1 - F_{s3} C)/I_{yy} \quad [\text{pitching acceleration}] \quad (9)$$

$$\ddot{X} = (F_T - F_{TD} - F_{AD})/(12M_{cg}) \quad [\text{horizontal translation acceleration}] \quad (10)$$

where:

F_{s1}, F_{s2}, F_{s3} = total landing gear strut forces

F_{t1}, F_{t2}, F_{t3} = tire forces

M_{cg}, W, I_{yy} = aircraft mass, weight and pitching inertia

W_1, W_2, W_3 = unsprung landing gear weights

A, B, ϵ_1 = moment arms

L, F_T, F_{TD}, F_{AD} = lift, thrust and tire and aerodynamic drag forces

and F_{AD} act through the center of gravity]

Flexibility Equations of Motion

$$M_i \ddot{q}_i = \xi_{i1} F_{s1} + \xi_{i2} F_{s2} + \xi_{i3} F_{s3} - 2\zeta_i \omega_i M_i \dot{q}_i - \omega_i^2 M_i q_i \text{ for the } i\text{th mode (11)}$$

where:

M_i = the generalized mass

$\xi_{i1}, \xi_{i2}, \xi_{i3}$ = modal deflections at gear location 1, 2 and 3

ω_i = modal frequency

ζ_i = damping factor

$q_i, \dot{q}_i, \ddot{q}_i$ = generalized coordinate and time derivatives

The sign convention corresponding to Figure 1 and the equations of motion is as follows:

Z = Vertical Displacement + up

θ = Pitch + nose down

q = Deflection Due to Bending + up

X = Horizontal Translation + forward

Solution Algorithm:

The technique used for solving the coupled nonlinear differential equations of motion that describe the simulated aircraft is a three-term Taylor series. For example, the equation:

$$\ddot{x} = -c\dot{x} - kx \quad (12)$$

The three-term Taylor series representation can be written as:

$$x_{(I+1)} = x_I + \dot{x}_{(I)} (\Delta t) + \ddot{x}_{(I)} \frac{(\Delta t)^2}{2} \quad (13)$$

where: $I = 1 \rightarrow N$

The values for $\ddot{x}$, $\dot{x}$ and x from the previous step are substituted into

equation (13) and a new value for x is obtained. Differentiating equation (13) we obtain for the velocity $\dot{x}$, the expression

$$\dot{x}_{(I+1)} = \dot{x}_{(I)} + \ddot{x}_{(I)}(\Delta t) \quad (14)$$

The values for $\dot{x}$ and $\ddot{x}$ are then substituted into equation (14) and a new value of $\dot{x}$ is found. This entire process is repeated with the new values of x and $\dot{x}$ to obtain the next point in the solution.

In Section IV Table II identifies and shows the modifications of cards which are necessary for a Class E aircraft. All other data cards remain the same. Table III shows the format for inputting the runway profile data.

The sample problem at the end of this section simulates a Class C aircraft traversing the profile of Taxiway E at the Will Rogers International Airport at a constant speed of 100 feet per second. The sample problem output in order of occurrence is as follows:

TABLE IV	Runway Profile Listing
TABLE V	List of Input Data Used
TABLE VI	One Page of Listed Time History Output
Figure 6	Time History Plot

Class C Aircraft

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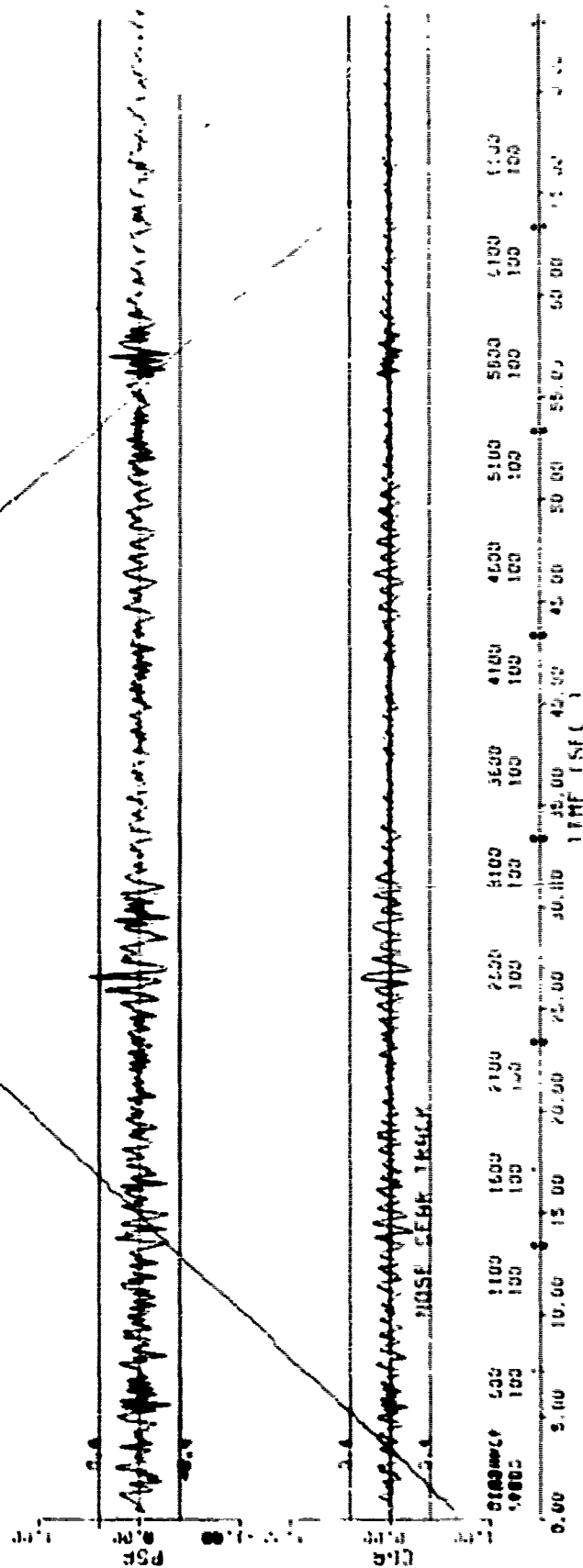


Figure 6 - Calcomp Plotted Results of Sample Problem

SECTION IV

COMPUTER PROGRAM

The computer program, used to predict the dynamic response of the commercial aircraft described in the next section, is the basic program described in Reference 1 with a few minor changes. These program changes include the capability to simulate strut bearing friction forces, multiple main landing gear struts, root mean square calculations, compressed plot capability, compressed or suppressed printing, and other minor improvements.

Appendix A contains a complete listing of the general computer program for all aircraft except the Class E aircraft. A complete listing for the program used to simulate the Class E aircraft is shown in Appendix B. To simulate a Class B aircraft with the inclusion of strut bearing friction, the separate "TAYLOR" subroutine listed in Appendix C, should be substituted for the "TAYLOR" subroutine included in the general program. If it is desired to run Class B aircraft without strut bearing friction, the general program can be used. Appendix D contains a complete listing of the FORTRAN symbols used.

The following tables I through V contain the form of the aircraft input data required for an aircraft airfield simulation. The data cards are sequenced as they must appear in the aircraft data deck. For each data card, variable names, definitions, units, card columns, and format field specifications are given.

Table I contains the form of the aircraft data deck for all conventional (Class A through D) landing gear aircraft. These aircraft all have main landing gear struts which are single acting and are non-articulated. Table I also contains the data used in the sample problem at the end of this section.

TABLE I

AIRCRAFT DATA FOR CONVENTIONAL AIRCRAFT

Section 1 (cards 1-5) - General Airplane Data

Card Column	Format	Variable Name	Data for Sample Problem	Definition
<u>Card 1</u>				
1-80	8A10	PLANE	Class C	Airplane Being Simulated
<u>Card 2</u>				
1-10	F10.1	W	306000.	Vehicle Weight (lb)
11-20	F10.1	A	30.	Distance Main Gear to CG (in)
21-30	F10.1	B	678.	Distance Nose Gear to CG (in)
31-42	F12.0	MMI	84700000.	Mass Moment of Inertia (lb in sec ²)
<u>Card 3</u>				
1-10	F10.2	PSARM	757	Distance of Pilot Station to CG (in)
11-20	F10.2	TAILRM	637	Distance of Tail Station to CG (in)
<u>Card 4</u>				
1-10	F10.2	SPEED	100	Initial Velocity of Airplane (ft/sec)
11-20	F10.2	THRUST	48000.	Total Airplane Thrust (lb)
21-30	F10.2	TAKEOFF	289.	Airplane Rotation Speed (ft/sec)
<u>Card 5</u>				
1-10	F10.4	CL	.603	Lift Coefficient
11-20	F10.4	AREA	2890.	Wing Area (ft ²)
21-30	F10.4	CD	.03	Drag Coefficient

Section 2 (cards 6-11) - Main and Nose Gear

<u>Card 6</u>				
1-10	F10.2	WM	1659.	Unsprung Weight of Each Main Gear (lb)
11-20	F10.2	WN	432.	Unsprung Weight of Nose Gear (lb)
21-30	F10.2	SXM	2.	Number of Main Gear Struts
31-40	F10.2	SXN	1.	Number of Nose Gear Struts

Card Column	Format	Variable Name	Data for Sample Problem	Definition
1-10	F10.5	AHN	13.91	Hydraulic Piston Area Nose (in ²)
11-20	F10.5	AAN	19.64	Pneumatic Piston Area Nose (in ²)
21-30	F10.5	AHM	66.80	Hydraulic Piston Area Main (in ²)
31-40	F10.5	AAM	78.47	Pneumatic Piston Area Main (in ²)

Card 8

1-10	F10.5	PAON	265.	Nose Strut Preload Pressure (lb/in ²)
11-20	F10.5	PAOM	243.	Main Strut Preload Pressure (lb/in ²)
21-30	F10.5	VON	335.	Fully Extended Nose Strut Air Volume (in ³)
31-40	F10.5	VOM	1816.6	Fully Extended Main Strut Air Volume (in ³)
41-50	F10.5	OAM	3.14	Orifice Area Main (in ²)
51-60	F10.5	OAN	1.23	Orifice Area Nose (in ²)

Card 9

1-10	F10.3	SLM	91.0	Distance from Axle to CG Waterline Main Gear Strut Unloaded (in)
11-20	F10.3	SLN	91.0	Distance from Axle to CG Waterline Nose Gear Strut Unloaded (in)

Card 10

1-10	F10.1	TSM	25050.	Main Tire Spring Constant Per Strut (lb/in)
11-20	F10.1	TSN	13000.	Nose Tire Spring Constant Per Strut (lb/in)

Card 11

1-10	F10.5	DX	.001	Integration Step Size
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Card 12

1-5	I5	IFPLOT	0	0-Plot; 1-No Plot
6-10	I5	IFLIST	0	0-List; 1-No Plot

Section 3 (cards 13-16)-Metering Pin Description

Card 13

1-5	I5	NSCN	7	Number of Slope Changes Nose Gear
-----	----	------	---	-----------------------------------

Card Column	Format	Variable Name	Data for Sample Problem	Definition
<u>*Card 14A, 14B,....</u>				
1-10	F10.3	STROKN (1)	*	Stroke Corresponding to Metering Pin Diameter, Nose Gear
11-20	F10.3	PINDN (1)	*	Metering Pin Diameter, Nose Gear (in)
<u>Card 15</u>				
1-5	15	NSCM	9	Number of Slope Changes Main Gear
<u>*Card 16A, 16B,....</u>				
1-10	F10.3	STROKM (1)	*	Stroke Corresponding to Metering Pin Diameter, Nose Gear
11-20	F10.3	PINDM (1)	*	Metering Pin Diameter, Main Gear (in)
<u>Section 4 (cards 17-19)-Flexibility Data</u>				
<u>Card 17</u>				
1-5	15	NFM	10	Number of Flexible Modes
<u>**Card 18A, 18B,....</u>				
1-10	F10.3	SIMAIN (1)	**	Mode Shape Deflection Main Gear
11-20	F10.3	SINOSE (1)	**	Mode Shape Deflection Nose Gear
21-30	F10.3	SICG (1)	**	Mode Shape Deflection CG
31-40	F10.3	SITAIL (1)	**	Mode Shape Deflection Tail Station
41-50	F10.3	SIPS (1)	**	Mode Shape Deflection Pilot Station
<u>**Card 19A, 19B,....</u>				
1-15	F15.2	GM (1)	**	Generalized Mass (lb sec ² /in)
16-25	F10.3	OMEGA (1)	**	Modal Frequency (rad/sec)

*One card is required for each stroke-metering pin combination read into the program.

Data for Sample Problem is shown in Table V.

**One card is required for each flexible mode. Data for Sample Problem is shown in Table V.

TABLE II
INPUT DATA CHANGES FOR CLASS E AIRCRAFT

Card Column	Format	Variable Name	Definition
<u>Card 2</u>			
1-10	F10.1	W	Vehicle Weight (lbs)
11-20	F10.1	A	Distance Front Main Gear to CG (in)
21-30	F10.1	B	Distance Nose Gear to CG (in)
31-40	F10.1	C	Distance Rear Main Gear to CG (in)
41-52	F12.0	MMI	Mass Moment of Inertia (lbin sec ²)
<u>Card 6</u>			
1-10	F10.2	WM	Unsprung Weight of Each Front Main Gear (lbs)
11-20	F10.2	WN	Unsprung Weight of Nose Gear (lbs)
21-30	F10.2	SXM	Number of Main Gear Struts
31-40	F10.2	SXN	Number of Nose Gear Struts
41-50	F10.2	WRM	Unsprung Weight of Each Rear Main Gear (lbs)
<u>Card 7</u>			
1-10	F10.5	AHN	Hydraulic Piston Area Nose (in ²)
11-20	F10.5	AAN	Pneumatic Piston Area Nose (in ²)
21-30	F10.5	AHM	Hydraulic Piston Area Front Main (in ²)
31-40	F10.5	AAM	Pneumatic Piston Area Front Main (in ²)
41-50	F10.5	AHRM	Hydraulic Piston Area Rear Main (in ²)
51-60	F10.5	AARM	Pneumatic Piston Area Rear Main (in ²)
<u>Card 8</u>			
1-10	F10.5	PAON	Nose Strut Preload Pressure (lbs/in ²)
11-20	F10.5	PAOM	Front Main Strut Preload Pressure (lbs/in ²)
21-30	F10.5	VON	Fully Extended Nose Strut Air Volume (in ³)
31-40	F10.5	VOM	Fully Extended Front Main Strut Air Volume (in ³)
41-50	F10.5	OAM	Orifice Area Front Main (in ²)
51-60	F10.5	OAN	Orifice Area Nose (in ²)
61-70	F10.5	PAORM	Rear Main Strut Preload Pressure (lbs/in ²)
71-80	F10.5	VORM	Fully Extended Rear Main Strut Air Volume (in ³)
<u>Card 10</u>			
1-10	F10.1	TSM	Front Main Tire Spring Constant Per Strut (lbs/in)
11-20	F10.1	TSN	Nose Tire Spring Constant Per Strut (lbs/in)
21-30	F10.1	TSRM	Rear Main Tire Spring Constant Per Strut (lbs/in)
31-40	F10.1	OARM	Orifice Area Rear Main (in ²)

Runway Profile Magnetic Tape

The runway profile is read into the program from a magnetic tape or permanent file. The format for this tape is shown in Table III.

TABLE III
RUNWAY PROFILE MAGNETIC TAPE

Column	Format	Variable Name	Definition
<u>Read 1</u>			
1-80	8A10	SITE	Runway Profile and Direction
<u>Read 2</u>			
1-6	16	NPTSS	Number of Runway Elevation Points
<u>*Read 3, 4, ..., N+2</u>			
1-70	10F7.3	ELEV	Runway Profile Data

*One read required for every ten runway profile elevation points.

Figure 7 contains a schematic diagram of the source deck setup for all aircraft simulations.

In order to simulate Class B aircraft with the strut friction force included, changes must be made to the basic program. This change is required as a result of the main and nose landing gear having a significant angle from the vertical and an axle offset on the main landing gear. The Class B aircraft source deck is formed by removing the subroutine Taylor from the basic source deck and replacing it with the Taylor shown in Appendix C.

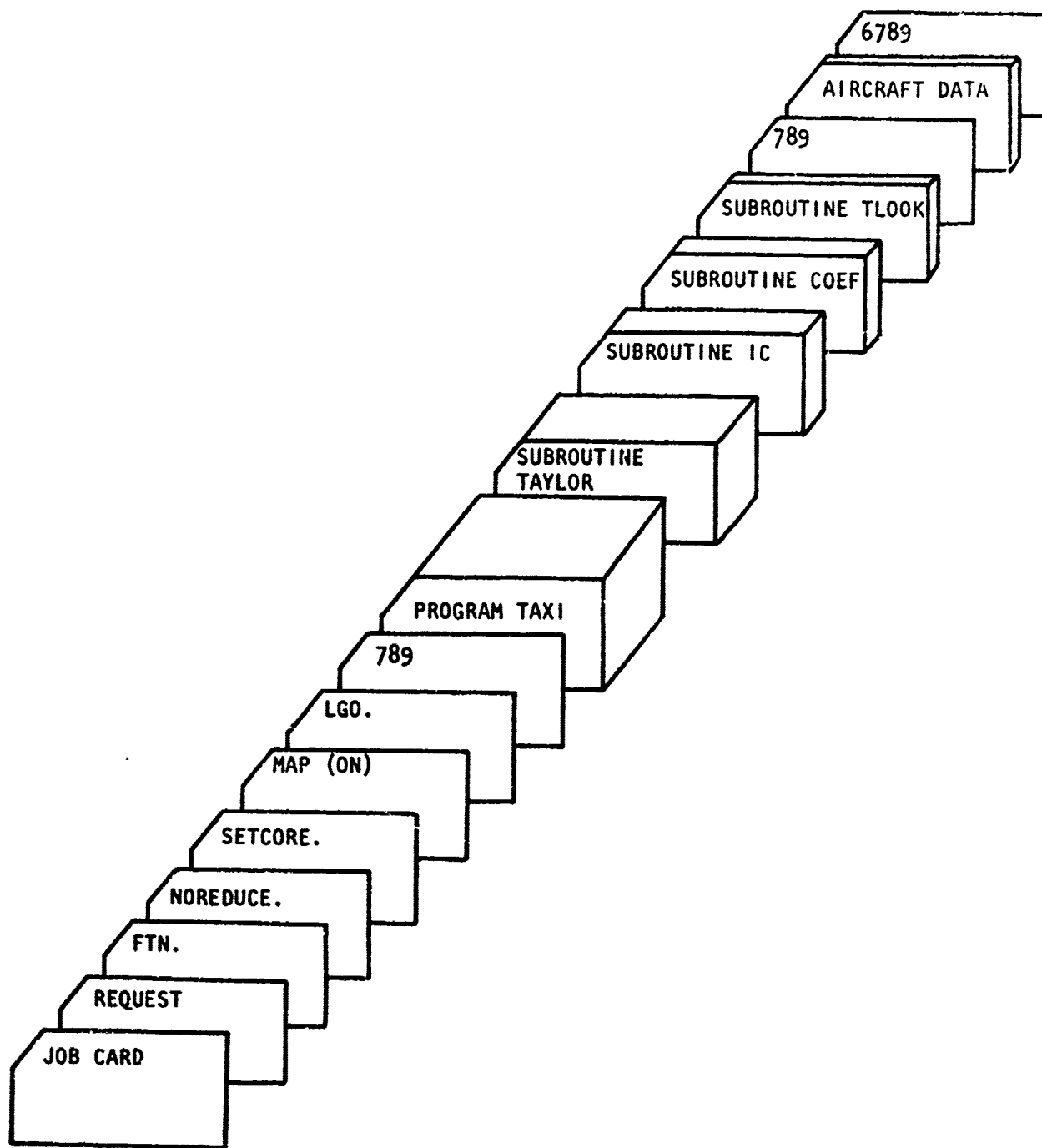


Figure 7 - Source Deck Setup for All Aircraft

TABLE IV - Profile Data of Will Rogers International Airport's Taxiway E used in the Sample Problem

WILL ROGERS INT AIRPORT	JUNE 6, 1974	TAXIWAY E	FEET DOWN THE RUNWAY									
RUNWAY PROFILE DATA NORMALIZED (SLOPE REMOVED)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	20
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	40
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	60
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	80
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	100
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	120
1.4405	1.46785	1.47366	1.49146	1.50912	1.52678	1.54444	1.56210	1.57976	1.59742	1.61508	1.63274	140
1.64010	1.64590	1.79571	1.84951	1.90332	1.95712	2.01093	2.06473	2.11854	2.17234	2.22614	2.27994	160
2.76115	2.87995	3.14976	3.28756	3.38937	3.46717	3.50898	3.52678	3.52059	3.50639	3.48459	3.45579	180
3.67620	3.76600	3.90381	4.01761	4.05942	4.04122	4.05903	4.08083	4.11264	4.15444	4.19624	4.23804	200
4.31025	4.37605	4.51386	4.61566	4.71747	4.75927	4.81308	4.93888	5.08859	5.17849	5.24429	5.28609	220
5.26830	5.32210	5.30391	5.23771	5.35152	5.36932	5.45913	5.59493	5.68674	5.78854	5.89034	5.99214	240
5.92635	5.96815	6.08196	6.18376	6.10957	6.26737	6.33318	6.37498	6.44079	6.54259	6.68839	6.87819	260
6.63240	6.79420	6.89601	6.94881	7.12362	7.29742	7.38723	7.43303	7.56884	7.66064	7.76244	7.86424	280
7.74645	7.87225	7.92606	7.91986	7.99767	8.09947	8.22528	8.30308	8.39289	8.49469	8.60649	8.71829	300
8.65650	8.77030	8.86011	8.92591	8.97972	9.02152	9.17133	9.24913	9.32693	9.42873	9.54053	9.65233	320
9.26555	9.30835	9.37416	9.36796	9.43377	9.47557	9.56538	9.63318	9.72099	9.80879	9.89659	9.98439	340
10.00860	10.18241	10.36820	10.53801	10.66781	10.69762	10.89542	10.98523	11.13503	11.22484	11.37464	11.52444	360
11.27864	11.33245	11.42225	11.45206	11.55386	11.66767	11.69747	11.73728	11.93708	11.95489	12.05469	12.15449	380
12.04469	12.07450	12.14030	12.20611	12.29591	12.39772	12.46752	12.57733	12.75113	12.79294	12.91274	13.03254	400
12.85674	12.94855	12.97835	13.06816	13.14596	13.20377	13.43357	13.53538	13.60118	13.65499	13.79679	13.93859	420
13.70879	13.78860	13.85240	13.90621	14.05601	14.18182	14.30762	14.44543	14.52323	14.68504	14.82684	14.96864	440
14.76284	14.81665	14.89445	15.00826	15.07406	15.16387	15.2167	15.33148	15.33728	15.42709	15.59889	15.76069	460
15.43289	15.49870	15.54050	15.58231	15.63611	15.76192	15.82772	15.94153	16.05533	16.13314	16.28494	16.43674	480
16.27094	16.38475	16.52255	16.66036	16.83416	16.97197	17.08577	17.18758	17.31338	17.34319	17.50499	17.65679	500
17.39699	17.51080	17.63660	17.71441	17.87621	17.95402	18.05582	18.16963	18.25943	18.25943	18.42123	18.57303	520
18.43304	18.38485	18.42665	18.50446	18.57026	18.63367	18.63367	18.63367	18.63367	18.63367	18.63367	18.63367	540
19.79909	19.79890	19.87670	19.93051	19.76831	19.70212	19.67192	19.65373	19.74353	19.88134	19.96914	20.00739	560
20.06895	20.06895	20.21075	20.36856	20.46236	20.67217	20.71397	20.76778	20.80158	21.00739	21.04543	21.04543	580
21.04519	21.04519	21.15680	21.17460	21.30041	21.37821	21.52802	21.64182	21.77963	21.84543	21.84543	21.84543	600
21.94724	22.00504	22.16245	22.26465	22.36646	22.48026	22.65487	22.73187	22.80968	23.00748	23.00748	23.00748	620
23.19329	23.37909	23.43290	23.47470	23.55251	23.61831	23.78812	23.8392	23.98373	24.08153	24.08153	24.08153	640
24.01934	23.96914	23.94695	24.00875	24.01856	24.02436	23.93417	24.10797	24.13778	24.23358	24.23358	24.23358	660
24.36539	24.46719	24.53300	24.58880	24.65261	24.79041	24.92822	25.05402	25.17983	25.29363	25.29363	25.29363	680
25.35944	25.46124	25.52705	25.56885	25.74266	25.83246	26.89232	26.82407	26.17388	26.31168	26.31168	26.31168	700
26.42549	26.59129	26.60510	26.67090	26.77271	26.82651	26.89232	26.93412	27.03593	27.03593	27.03593	27.03593	720
27.03544	27.19734	27.26315	27.30495	27.46676	27.54456	27.62237	27.74817	27.82598	27.86778	27.86778	27.86778	740
27.99359	28.03539	28.08920	28.21500	28.36481	28.44261	28.66442	28.82622	28.94003	29.01783	29.01783	29.01783	760
29.05964	29.17344	29.23925	29.40105	29.45486	29.58066	29.69447	29.82027	30.00608	30.17988	30.17988	30.17988	780
30.32969	30.40749	30.49730	30.62310	30.62091	30.58671	30.64052	30.73032	30.74813	30.86193	30.86193	30.86193	800
30.93974	31.02954	31.14335	31.25715	31.39496	31.43676	31.56257	31.73637	31.83818	31.90398	31.90398	31.90398	820
31.99379	32.25159	32.31740	32.41920	32.53300	32.51481	32.59261	32.71842	32.76022	32.86203	32.86203	32.86203	840
32.95764	32.98744	33.11325	33.11325	33.24486	33.24486	33.31066	33.24047	33.59427	33.58008	33.58008	33.58008	860
33.63386	33.72369	33.77749	33.86730	33.94510	33.99091	34.07671	34.15452	34.31632	34.44213	34.44213	34.44213	880
34.59193	34.69374	34.79554	34.92135	34.97515	34.99296	35.09476	35.26857	35.41837	35.53216	35.53216	35.53216	900
35.64598	35.73575	35.80340	35.90340	35.96920	36.08301	36.08881	36.20262	36.20842	36.22623	36.22623	36.22623	920
36.20803	36.18584	36.18364	36.18945	36.25525	36.29706	36.39886	36.41567	36.45847	36.47628	36.47628	36.47628	940
36.44208	36.57189	36.70969	36.91950	37.03330	37.20711	37.23691	37.23072	37.28452	37.31433	37.31433	37.31433	960

TABLE IV - Continued

37.38013	37.54194	37.61974	37.70955	37.76735	37.86516	38.03496	38.11577	38.17037	38.29038	980
38.32818	38.54799	38.55379	38.70360	38.75740	38.94321	38.92501	39.00282	39.08062	39.11043	1000
39.20023	39.27604	39.37984	39.47365	39.47345	39.55326	39.64306	39.58887	39.76257	39.83448	1020
39.91828	40.02709	40.13259	40.19170	40.49150	40.47531	40.60111	40.61892	40.62772	40.66553	1040
40.75633	40.74614	40.92394	40.97775	41.09155	41.18136	41.28316	41.38497	41.51377	41.60058	1060
41.85938	42.05519	42.22999	42.33180	42.37360	42.44740	42.54121	42.63701	42.66032	42.74462	1080
42.78943	42.98623	43.09204	43.24184	43.37955	43.49745	43.53526	43.60106	43.73387	43.84067	1100
43.88828	43.94789	44.04370	44.11550	44.16931	44.16931	44.25911	44.36032	44.43472	44.53472	1120
44.56453	44.66633	44.68414	44.73794	44.71975	44.84155	44.95536	45.07316	45.12037	45.22077	1140
45.31658	45.50438	45.65415	45.68399	45.78580	45.85160	45.95341	46.01921	46.15712	46.26982	1160
46.54063	46.72643	46.72624	46.83335	46.83335	46.90965	46.91146	46.93926	47.09107	47.26487	1180
47.34268	47.51648	47.58224	47.63609	47.73790	47.75270	47.91751	47.93531	48.01312	48.09092	1200
48.12073	48.34253	48.44434	48.56214	48.61195	48.64175	48.77956	48.93336	49.08317	49.08097	1220
49.13678	49.30058	49.42639	49.50419	49.63000	49.86180	50.00161	50.03141	50.19332	50.23362	1240
50.29293	50.30663	50.33644	50.42624	50.50405	50.58185	50.67166	50.72546	50.81527	50.89307	1260
50.98288	51.07268	51.19849	51.32429	51.46210	51.55190	51.50571	51.78552	51.87512	51.87512	1280
51.92893	52.06673	52.22054	52.33034	52.34315	52.44995	52.59976	52.67756	52.81537	52.90517	1300
52.97098	53.03678	53.15059	53.27639	53.33020	53.40900	53.55780	53.65961	53.72541	53.83922	1320
53.91702	54.04283	54.18463	54.13804	54.24824	54.30605	54.44385	54.51366	54.61146	54.72527	1340
54.71907	54.77288	54.76068	54.72449	54.77329	54.80010	54.93390	55.07171	55.18551	55.29932	1360
55.46312	55.57493	55.61673	55.77234	55.83815	55.92795	55.98176	56.05956	56.18537	56.28537	1380
56.32317	56.42498	56.57478	56.68859	56.80239	56.90420	57.00600	57.05981	57.18561	57.32342	1400
57.44322	57.43103	57.54463	57.59864	57.70044	57.79025	57.86405	57.93886	57.97956	57.98147	1420
57.94527	57.62108	57.80688	57.94469	58.04649	58.14340	58.29810	58.35391	58.51371	58.66752	1440
58.80132	58.89113	58.95693	58.98674	59.06454	59.17835	59.36415	59.51396	59.51396	59.53757	1460
59.59737	59.58518	59.71098	59.86079	59.87859	59.99240	60.11820	60.23201	60.30981	60.24362	1480
60.29742	60.35123	60.35703	60.50684	60.56064	60.61445	60.70425	60.81806	60.95986	61.03367	1500
61.128747	61.12928	61.14708	61.18889	61.27869	61.42850	61.54230	61.69211	61.84191	61.98572	1520
61.98552	62.07533	62.11713	62.15894	62.20374	62.14255	62.27235	62.35016	62.37936	62.42177	1540
62.48757	62.54138	62.64318	62.75699	62.81079	62.90060	63.06640	63.06201	63.06201	63.21181	1560
63.33762	63.41542	63.46923	63.49903	63.60864	63.65464	63.82845	63.84625	63.98406	64.07386	1580
64.16367	64.25347	64.29528	64.38508	64.53889	64.67269	64.64250	64.74430	64.85811	64.89991	1600
64.97772	65.00752	65.02933	65.05513	65.07234	65.23474	65.15155	65.73235	65.82816	66.01396	1620
66.27177	66.43357	66.43678	66.37318	66.34239	66.44079	66.39060	66.48040	66.53421	66.58401	1640
66.65382	66.73162	66.83343	67.01923	67.21704	67.36684	67.48065	67.63045	67.80426	67.94406	1660
68.16387	68.28967	68.45148	68.61328	68.69109	68.78089	68.88270	68.94650	69.06231	69.11011	1680
69.07922	69.11572	69.14553	69.23533	69.27714	69.30694	69.27675	69.27955	69.25236	69.30616	1700
69.28797	69.31777	69.43150	69.60538	69.68114	69.34499	69.69880	70.01260	70.11441	70.11441	1720
70.34882	70.44382	71.09363	70.74343	70.86324	71.04404	71.01285	71.03405	71.07225	71.14826	1740
71.31207	71.3387	71.35968	71.41348	71.56329	71.64404	71.74290	71.93470	71.99881	71.94231	1760
71.99992	72.02973	72.02973	72.08339	72.29334	72.35914	72.40095	72.41875	72.55655	72.61036	1780
72.74817	72.75397	72.66778	73.02950	73.08339	73.17319	73.25100	73.30480	73.32660	73.65241	1800
73.50221	74.02402	74.18582	74.27563	74.44943	74.59724	74.66504	74.74285	74.79065	74.86246	1820
74.94426	75.11407	75.16787	75.16168	75.17968	75.20929	75.26709	75.35490	75.40670	75.54451	1840
75.67031	75.66412	75.64592	75.71173	75.76553	75.87934	76.04114	76.15495	76.22075	76.24055	1860
76.28036	76.39417	76.57997	76.72978	76.70598	77.13739	77.25119	77.35300	77.37000	77.38861	1880
77.45441	77.58022	77.64602	77.77183	77.87363	78.02344	78.22124	78.32305	78.38485	78.46666	1900
78.53246	78.52627	77.55607	78.59788	78.67368	78.66949	78.78329	78.78910	78.86690	78.86071	1920
78.93851	79.07632	79.26212	79.41193	79.50173	79.61554	79.68134	79.74715	79.78435	79.87876	1940
79.96056	80.01037	80.02817	80.15398	80.24378	80.36959	80.47139	80.56120	80.57900	80.64481	1960

TABLE IV - Continued

60.66261	60.80042	60.90222	60.96803	61.00393	61.06364	61.14144	61.31525	61.41705	61.63886	1980
61.72866	61.74647	61.83627	62.02208	62.12388	62.27369	62.37549	62.41730	62.45910	62.63291	2000
62.68671	62.74052	62.89032	63.01613	63.12993	63.23174	63.29754	63.37535	63.45115	63.48296	2020
63.58476	63.71057	63.81237	63.83018	63.82398	63.87779	63.84759	63.90140	63.95520	64.00900	2040
64.11881	64.27261	64.33842	64.51222	64.71003	64.75183	64.85364	64.89544	64.90125	64.97905	2060
65.04486	65.09866	65.16447	65.20627	65.23808	65.39788	65.43969	65.56549	65.65530	65.73310	2080
65.84691	66.00071	66.09852	66.15232	66.37413	66.51193	66.60174	66.68754	66.70935	66.73915	2100
66.78096	66.83476	66.94857	67.06237	67.17618	67.25398	67.31979	67.42159	67.48740	67.57720	2120
67.65501	67.76881	67.85862	67.93642	67.94223	68.02003	68.06184	68.11564	68.21745	68.30725	2140
68.38506	68.52286	68.56467	68.67847	68.76828	68.89408	68.94789	69.02569	69.06750	69.19330	2160
69.34311	69.38491	69.52272	69.62452	69.75033	69.86413	69.90194	90.09174	90.18155	90.19935	2180
90.26516	90.3096	90.39677	90.52257	90.66038	90.75018	90.79199	90.91779	91.01960	91.18140	2200
91.31921	91.43301	91.47482	91.52862	91.69043	91.69623	91.81004	91.87584	92.03765	92.16345	2220
92.25326	92.35506	92.44487	92.53467	92.70848	92.81028	92.81609	92.84589	92.88770	92.95350	2240
92.99331	93.10911	93.19892	93.27672	93.29453	93.37233	93.51014	93.56394	93.62975	93.70755	2260
93.76336	93.80316	93.96497	94.03077	94.02458	94.05438	94.13219	94.45199	94.50380	94.65360	2280
94.74340	94.74921	94.85101	94.96482	95.06862	95.12043	95.16223	95.31204	95.41384	95.44365	2300
95.46145	95.55126	95.65306	95.65887	95.70067	95.74248	95.80828	95.86209	95.92789	95.99370	2320
96.19150	96.31731	96.41911	96.44892	96.47872	96.53253	96.64533	96.76014	96.78994	96.92775	2340
96.95755	97.03536	97.05316	97.11897	97.22377	97.23858	97.23038	97.33419	97.43599	97.54980	2360
97.57960	97.68141	97.74721	97.83702	97.84282	97.94463	98.15477	98.32824	98.58204	98.62785	2380
98.71765	98.73546	98.95726	98.97507	99.10887	99.14268	99.29244	99.38229	99.46009	99.46990	2400
99.49970	99.62151	99.65131	99.77712	99.78292	99.88473	100.08253	100.24434	100.45414	100.55595	2420
100.74175	100.79556	100.92136	100.99917	101.06497	101.23878	101.36458	101.45439	101.59219	101.75400	2440
101.80780	101.96961	102.09541	102.34122	102.56302	102.65683	102.59863	102.56844	102.58077	102.60405	2460
102.59785	102.53166	102.63346	102.69927	102.71787	102.77088	102.84868	102.97449	103.04029	103.15410	2480
103.18390	103.27371	103.38751	103.44132	103.50112	103.57293	103.61473	103.72854	103.83034	103.83615	2500
103.94995	103.99176	104.08156	104.19537	104.30917	104.36698	104.47078	104.63859	104.74039	104.85420	2520
104.99200	105.09380	105.30361	105.41741	105.48322	105.52102	105.71083	105.80063	105.86644	105.90824	2540
105.01005	106.03985	106.10566	106.20746	106.32127	106.42307	106.42888	106.44668	106.52449	106.60229	2560
106.62010	106.69790	106.72771	106.73351	106.78732	106.80512	107.01493	107.21273	107.38254	107.55634	2580
107.39815	107.43995	107.50576	107.64356	107.72137	107.91917	108.04498	108.20678	108.28459	108.38639	2600
108.50020	108.56600	108.59521	108.55361	108.61142	108.98522	109.05103	109.15283	109.18264	109.28444	2620
109.25425	109.16405	109.07386	109.05566	109.04397	109.05727	109.13308	109.16288	109.21669	109.28249	2640
109.42830	109.55810	109.73191	109.92971	109.99552	110.08932	111.06313	111.36893	111.65074	111.96854	2660
112.27435	112.42415	112.53796	112.61576	112.74157	112.90337	113.12518	113.37098	113.48479	113.58259	2680
113.61440	113.69420	113.78401	113.83781	113.92762	114.10142	114.19123	114.28103	114.39484	114.48064	2700
114.47845	114.64025	114.73006	114.79586	114.87167	114.99947	115.13728	115.19108	115.32089	115.48669	2720
115.40350	115.45430	115.54411	115.52591	115.51372	115.58552	115.65133	115.73513	115.73494	115.77674	2740
115.75855	115.80035	115.85416	115.97996	116.03377	116.07557	116.21338	116.25518	116.33299	116.39879	2760
116.46460	116.44640	116.59620	116.68601	116.75181	116.96162	117.05142	117.15323	117.25503	117.41684	2780
117.47064	117.53645	117.69825	117.83606	117.99786	118.06367	118.22547	118.38728	118.52508	118.66289	2800
118.82469	118.86650	119.04030	119.10611	119.24391	119.33372	119.39952	119.48933	119.57913	119.65694	2820
119.68674	119.75255	119.83035	119.90816	120.04596	120.13577	120.22557	120.26738	120.39318	120.43499	2840
120.47679	120.49460	120.52440	120.61421	120.63201	120.75782	120.82362	120.94943	121.06323	121.15304	2860
121.23084	121.32065	121.39845	121.44026	121.53006	121.52387	121.60167	121.65748	121.80528	121.84709	2880
121.97289	122.08670	122.14850	122.18971	122.20311	122.31592	122.35572	122.40953	122.46333	122.50514	2900
122.59494	122.67276	122.74855	122.80836	122.85416	122.87597	122.89577	122.89558	122.91734	122.91113	2920
123.30099	123.55880	123.74460	123.90641	124.18321	124.23002	124.42782	124.54163	124.63143	124.74524	2940
124.61904	124.61205	124.67075	124.55246	124.55226	124.54007	124.59387	124.61168	124.66548	124.69529	2960

TABLE IV - Continued

124.70109	124.69490	124.73670	124.80251	124.80831	124.88512	124.99992	125.14973	125.27553	125.36534	2980
125.47914	125.61695	125.71875	125.84456	125.91036	126.04317	126.17397	126.26378	126.28158	126.35539	3000
126.52119	126.63500	126.64080	126.74260	126.84441	126.98521	127.17902	127.33582	127.23953	127.29143	3020
127.31124	127.35300	127.50285	127.61665	127.65846	127.79027	127.93008	128.03387	127.93358	128.07148	3040
128.16129	128.26309	128.34090	128.40670	128.47251	128.53831	128.67512	128.83792	128.85573	128.90353	3060
129.03534	129.12514	129.20215	129.23275	129.27456	129.30776	129.35417	129.42397	129.63378	129.67558	3080
129.64539	129.62719	129.72900	129.73480	129.80861	129.82241	129.82422	129.84292	129.90703	129.97353	3100
130.02744	130.12924	130.17105	130.23685	130.32666	130.44546	130.55827	130.64407	130.61708	130.67968	3120
131.10549	131.15529	131.40510	131.49430	131.61671	131.71652	131.80612	131.88473	131.95173	131.99173	3140
132.01554	132.15324	132.31515	132.35695	132.47076	132.50056	132.63837	132.71617	132.93798	133.03776	3160
133.16559	133.30339	133.30920	133.45900	133.59681	133.68561	133.77642	133.85422	133.94403	134.03383	3180
134.07564	134.17744	134.24325	134.27305	134.35086	134.47666	134.50247	134.66827	134.69808	134.81188	3200
134.92569	135.00349	135.00930	135.11110	135.20091	135.24271	135.28452	135.32632	135.41613	135.44593	3220
135.42774	135.60154	135.71535	135.74515	135.84696	135.92476	136.02557	136.15217	136.20618	136.31498	3240
136.44579	136.59559	136.68540	136.78720	136.93700	137.12281	137.14061	137.25442	137.34422	137.38603	3260
137.52383	137.61364	137.64344	137.73325	137.87105	137.93886	137.97066	137.96047	138.05027	138.11197	3280
138.14598	138.21169	138.20549	138.16330	138.28910	138.34291	138.38471	138.48552	138.55232	138.55813	3300
138.57593	138.61774	138.71954	138.76135	138.87515	138.97696	139.05476	139.06057	139.12637	139.11218	3320
139.25798	139.28779	139.38959	139.39540	139.49720	139.55001	139.56881	139.58662	139.72442	139.73023	3340
139.78403	139.85564	139.85564	139.94545	139.96325	140.03806	140.10686	140.13607	140.25347	140.28026	3360
140.26208	140.33989	140.42969	140.41150	140.57330	140.62111	140.64491	140.63672	140.74052	140.81833	3380
140.84813	140.87794	140.93174	140.96155	140.99135	141.03316	141.07496	141.15277	141.14657	141.22438	3400
141.30210	141.34399	141.33779	141.33160	141.44540	141.46321	141.48101	141.60682	141.61262	141.64243	3420
141.59623	141.71404	141.70784	141.73765	141.79145	141.79725	141.80305	141.83287	141.83867	141.84448	3440
141.92228	141.89209	141.96989	142.01170	142.02950	142.09531	142.13711	142.16692	142.22072	142.23653	3460
142.24433	142.28614	142.27994	142.30975	142.42355	142.36336	142.42316	142.42897	142.35077	142.38858	3480
142.42238	142.39219	142.43399	142.41580	142.43300	142.45221	142.52921	142.51101	142.43082	142.54662	3500
142.62443	142.61823	142.68004	142.67784	142.66365	142.56545	142.64726	142.64106	142.73087	142.71267	3520
142.72448	142.74828	142.79009	142.81989	142.86170	142.87350	142.92131	142.89111	142.88432	142.86672	3540
142.92053	142.91433	142.92014	142.94994	142.90775	142.91355	142.94336	142.93516	142.95637	142.97277	3560
142.97858	142.96038	142.94219	142.87599	142.92980	142.97160	143.01341	142.97121	143.04902	143.06682	3580
143.08463	143.05443	143.46024	143.09004	143.03585	143.14365	143.10746	143.11326	143.15507	143.11287	3600
143.13068	143.11286	143.15429	143.12609	143.11790	143.09870	143.21351	143.15931	143.18312	143.18292	3620
143.12873	143.11053	143.20034	143.23614	143.21195	143.18175	143.17556	143.13736	143.16317	143.13697	3640
143.15078	143.02458	143.12639	143.10819	143.09000	143.10780	143.01761	142.99941	143.06522	143.14302	3660
143.11283	143.08283	143.04044	143.04624	143.04005	143.02385	142.95566	142.95146	142.94327	142.94307	3680
142.90688	142.91268	142.89449	142.86429	142.84610	142.83790	142.89171	142.89951	142.79732	142.82712	3700
142.85693	142.87473	142.78654	142.78634	142.74815	142.71795	142.68776	142.69356	142.74737	142.71717	3720
142.69898	142.69778	142.68259	142.64439	142.60220	142.57200	142.52980	142.57101	142.51741	142.48722	3740
142.46902	142.42683	142.40863	142.36644	142.33624	142.28205	142.21585	142.18566	142.23440	142.08332	3760
142.28707	142.29288	142.28668	142.23249	142.21429	142.20310	142.16590	142.15971	142.11751	142.08332	3780
142.05712	142.11693	142.02073	141.96654	142.09234	142.08615	141.98395	141.92976	141.82159	141.84537	3800
141.79117	141.83298	141.79078	141.77259	141.75439	141.75020	141.67000	141.62781	141.63351	141.57942	3820
141.50122	141.44703	141.39283	141.36264	141.33244	141.23025	141.23605	141.19386	141.13666	141.02547	3840
141.01927	140.90508	140.82688	140.84469	140.76649	140.65210	140.62210	140.67591	140.63871	140.57952	3860
140.56132	140.56733	140.52453	140.55474	140.51254	140.46835	140.40415	140.37396	140.36776	140.36157	3880
140.33137	140.27718	140.22298	140.20479	140.16259	140.08640	140.05620	140.01201	140.01781	139.99962	3900
139.99342	139.93923	139.82503	139.68684	139.62064	139.53625	139.53625	139.44606	139.34366	139.30167	3920
139.19947	139.10928	139.07908	138.96889	138.89469	138.84450	138.80230	138.72411	138.68131	138.65172	3940
138.59752	138.55533	138.46913	138.43494	138.40479	138.31455	138.22435	138.16216	138.17536	138.10977	3960

TABLE IV - Continued

136.01957	135.63738	137.94718	137.94099	137.88679	137.88660	137.80240	137.73620	137.64601	137.55581
137.50162	137.48342	137.42923	137.39903	137.35284	137.35064	137.28445	137.21825	137.15206	137.06186
137.00767	136.98547	136.83920	136.82108	136.69489	136.61669	136.59850	136.50830	136.46611	136.37591
136.33372	136.17152	136.02133	135.94313	135.88394	135.78674	135.72855	135.57035	135.49216	135.37596
135.33177	135.13757	135.00338	134.90918	134.83099	134.69279	134.62660	134.51240	134.49421	134.41601
134.30582	134.29562	134.27743	134.16723	134.14504	134.12684	134.03665	134.04245	133.88026	133.79006
133.74787	133.57367	133.51948	133.42928	133.32709	133.21289	133.13470	132.98450	132.97831	132.91211
132.80992	132.64772	132.52153	132.49133	132.50914	132.43094	132.29275	132.25055	132.18436	132.09416
132.00397	131.88977	131.86358	131.72138	131.66719	131.58899	131.49880	131.45660	131.40241	131.27621
131.23402	131.22762	131.03763	130.99943	130.92124	130.86704	130.78485	130.71065	130.58445	130.57826
130.47637	130.31387	130.22368	130.15748	130.15129	130.06109	130.04290	130.01270	129.94651	130.00031
129.91012	129.72392	129.57373	129.43553	129.35734	129.23114	129.14095	129.05275	128.98456	128.94236
128.84017	128.6197	128.65978	128.53358	128.51339	128.44919	128.34700	128.23080	128.23450	128.18441
128.17821	128.05402	127.93782	127.89133	127.83743	127.64324	127.60104	127.52285	127.46865	127.31846
127.32426	127.22207	127.16787	127.07768	127.02348	127.06529	126.93909	126.87290	126.84270	126.75251
126.61431	126.52412	126.40992	126.27173	126.09753	125.98334	125.84514	125.73095	125.71275	125.62256
125.48436	125.38217	125.29197	125.20178	125.13358	125.09339	124.95519	124.87700	124.81080	124.72061
124.66641	124.58822	124.48602	124.40783	124.31763	124.25144	124.13724	124.05905	123.92085	123.85466
123.76446	123.63827	123.52407	123.44588	123.33668	123.21749	123.06729	122.95510	122.81490	122.72471
122.61851	122.48432	122.40612	122.27993	122.21373	122.17154	122.03334	121.89315	121.79295	121.66676
121.58856	121.47437	121.39617	121.31798	121.17378	121.07759	120.98739	120.84920	120.78300	120.69281
120.59061	120.48842	120.43422	120.38003	120.27783	120.22364	120.16944	120.09125	120.07305	120.06686
119.97666	119.98847	119.84427	119.85008	119.95188	119.85569	119.87949	119.69330	119.57910	119.50091
119.39881	119.30852	119.19432	119.11613	119.03393	118.87574	118.83354	118.47315	118.32296	118.22296
118.25676	118.23857	118.13637	117.98618	117.84798	117.61379	117.35559	117.19140	116.98320	116.83308
116.77881	116.64681	116.58842	116.58022	116.52023	116.38783	116.33364	116.23344	116.17725	116.09905
116.08886	115.93866	115.82847	115.70227	115.64008	115.50988	115.41969	115.34149	115.27530	115.16110
115.10691	115.02871	114.97452	114.90832	114.80613	114.78793	114.66174	114.53554	114.45535	114.46315
114.38986	114.38676	114.24057	114.11437	113.98818	113.98198	113.93979	113.87359	113.72340	113.60920
113.45901	113.39281	113.33862	113.20042	113.19423	113.12803	113.03784	113.06764	112.98945	112.93525
112.89306	112.79886	112.76067	112.80247	112.73528	112.62208	112.56789	112.42969	112.37550	112.33330
112.28711	112.14891	112.06272	111.93652	111.84633	111.74413	111.61794	111.45774	111.32955	111.17935
111.06516	110.87896	110.77677	110.66257	110.46438	110.41018	110.25999	110.16979	110.09160	109.94140
109.82721	109.78101	109.56282	109.46862	109.33443	109.28823	109.85804	108.98784	108.79355	108.76345
108.63726	108.44786	108.43287	108.33067	108.18048	108.04228	107.98489	107.61389	107.74778	107.64558
107.57931	107.47711	107.41092	107.30872	107.18253	107.08033	107.08214	106.91194	106.77375	106.71955
106.66536	106.47916	106.36497	106.28677	106.22058	106.15438	106.08169	105.90199	105.78780	105.67360
105.55948	105.44521	105.39101	105.30082	105.22262	105.08443	105.03023	104.92804	104.86184	104.77165
104.56245	104.49526	104.42906	104.36287	104.28067	104.11048	104.08828	103.87809	103.77989	103.67770
103.56350	103.41331	103.29911	103.25692	103.05872	102.98053	102.87833	102.75214	102.63794	102.58375
102.58955	102.38736	102.24116	102.19897	102.09677	102.07858	101.96438	101.79819	101.74739	101.69300
101.57968	101.47741	101.47121	101.39382	101.33882	101.28463	101.19443	101.21224	101.03804	100.95185
100.78585	100.83346	100.76126	100.69507	100.58887	100.46668	100.38448	100.28829	100.20409	100.04598
99.97378	99.87751	99.79931	99.72112	99.68692	99.48253	99.27634	99.27634	99.13814	99.04795
98.93378	98.88756	98.68136	98.57917	98.50097	98.38678	98.24858	98.18239	98.12819	98.07488
98.03188	97.98561	97.83941	97.78522	97.73002	97.62883	97.44263	97.37644	97.21424	97.05285
96.96195	96.94366	96.84146	96.73927	96.64937	96.45088	96.34868	96.18649	96.09629	95.98218
95.85590	95.76571	95.73551	95.64532	95.54312	95.53593	95.39873	95.28454	95.12234	95.05615
94.92995	94.86376	94.84556	94.63537	94.56917	94.44298	94.34078	94.20259	94.07639	94.03428
93.94400	93.84180	93.63161	93.62541	93.52322	93.52902	93.48683	93.39663	93.29444	93.16824

TABLE IV - Continued

93.09005	92.93905	92.04966	92.72346	92.57327	92.44707	92.41688	92.31468	92.20849	92.09829	4980
91.97210	91.91796	91.77971	91.68951	91.56332	91.53312	91.45493	91.35273	91.25034	91.18434	5000
91.15415	91.12395	91.04576	90.94356	90.78137	90.70317	90.62498	90.52278	90.42059	90.34239	5020
90.31220	90.23400	90.11981	90.05361	89.96382	89.85122	89.81903	89.74083	89.72284	89.57244	5040
89.45825	89.33205	89.30106	89.12766	88.98547	88.88727	88.79708	88.59888	88.48459	88.38249	5060
89.30430	88.31010	88.14791	87.98571	87.87552	87.68532	87.60713	87.52893	87.45174	87.34854	5080
87.24635	87.18015	87.05396	86.93976	86.78957	86.62737	86.54918	86.45898	86.35879	86.24859	5100
86.16440	86.07420	85.97201	85.89381	85.75562	85.71142	85.57523	85.53903	85.47894	85.44264	5120
85.30245	85.22825	85.15406	85.07586	84.98567	84.89547	84.78928	84.68108	84.51889	84.46269	5140
84.39650	84.30630	84.19211	84.14991	84.01172	83.93352	83.86733	83.74694	83.74694	83.56874	5160
83.50655	83.35635	83.24216	83.12796	83.04577	82.98357	82.88138	82.77918	82.72439	82.59079	5180
82.50460	82.47800	82.36420	82.27401	82.13581	81.97662	81.88842	81.63723	81.47503	81.26484	5200
81.17464	81.08445	81.07825	81.02406	81.05386	80.99667	81.01747	80.94728	80.83338	80.86689	5220
81.78869	80.67450	80.58430	80.49411	80.40391	80.26572	80.11552	80.07333	79.95313	79.90494	5240
73.73074	79.64055	79.53635	73.41216	79.35796	79.25777	79.12957	79.02738	78.94318	78.81099	5260
78.72079	78.63060	78.55240	78.41421	78.31201	78.17382	78.05962	77.8743	77.71123	77.57304	5280
77.43404	77.29665	77.24245	77.14026	77.09806	76.93887	76.90567	76.82748	76.72528	76.65509	5300
76.53289	76.47870	76.36450	76.28631	76.14811	76.04592	75.95572	75.88953	75.79933	75.67314	5320
75.64294	75.58075	75.43855	75.32436	75.27016	75.11397	75.01777	74.87958	74.80138	74.74719	5340
74.72899	74.57886	74.50060	74.33841	74.29621	74.17302	74.11582	73.92963	73.86343	73.76124	5360
73.65904	73.58095	73.51465	73.42446	73.31026	73.29207	73.15387	73.01568	72.91348	72.83529	5380
72.79309	72.48070	72.48070	72.31051	72.25231	72.23012	72.05992	71.93373	71.90353	71.83734	5400
71.77114	71.63295	71.53075	71.46456	71.37436	71.23217	71.13397	71.07978	71.03758	70.98339	5420
70.94119	70.80300	70.71280	70.67060	70.54441	70.54441	70.37602	70.33382	70.24363	70.16543	5440
70.99924	70.02104	69.93085	69.85265	69.73846	69.68026	69.55807	69.51387	69.42568	69.39948	5460
69.19729	69.15509	68.98090	68.92070	68.80351	68.77031	68.65612	68.50592	68.46373	68.39753	5480
68.29534	68.25314	68.11895	68.09675	67.93456	67.92835	67.79017	67.67597	67.62178	67.51958	5500
67.38134	67.24319	67.14100	67.03880	66.92461	66.81041	66.79222	66.72602	66.61183	66.47363	5520
66.35944	66.22124	66.22705	66.07685	65.96266	65.88446	65.72227	65.63607	65.56388	65.47568	5540
65.37349	65.33129	65.24110	65.15090	65.06311	64.9451	64.86832	64.75612	64.66393	64.56873	5560
64.54354	64.44334	64.32715	64.12895	64.07476	63.94856	63.88237	63.80417	63.70138	63.51570	5580
63.44959	63.39539	63.28120	63.22700	63.17281	63.17061	63.00442	62.94622	62.95003	62.74583	5600
62.76364	62.62844	62.55925	62.48105	62.41486	62.27666	62.16247	62.07227	61.89808	62.01188	5620
61.98169	62.23949	62.18930	61.98710	62.00491	62.01371	61.74052	61.54232	61.36813	61.26533	5640
61.10374	61.24154	61.12735	61.04915	60.92296	60.83276	60.97057	60.96437	60.87418	60.86798	5660
60.78979	60.93959	60.93340	61.02320	60.93300	60.83381	60.65661	60.48242	60.32022	60.14603	5680
60.06588	60.03569	59.93544	59.90525	59.88003	59.85685	59.86266	59.84447	59.85827	59.807208	5700
59.82793	59.83374	59.84949	59.84135	59.82635	59.84896	59.82276	59.89657	59.78237	59.62018	5720
57.55393	57.46379	57.37359	57.36740	57.26320	57.24701	57.20481	57.10262	57.00042	56.87423	5740
56.68803	56.69384	56.55564	56.47745	56.32725	56.26106	56.14686	56.03267	56.05047	55.87628	5760
55.75008	55.56389	55.46169	55.40750	55.30530	55.24911	55.20891	55.11872	55.04352	54.99833	5800
54.93213	54.79394	54.65574	54.58355	54.49935	54.42116	54.33096	54.23277	54.15057	54.04838	5820
53.99418	53.87999	53.80179	53.74760	53.73340	53.63321	53.54901	53.41082	53.3252	53.24243	5840
53.11623	52.97804	52.85164	52.82165	52.65935	52.55726	52.50706	52.44887	52.3267	52.28048	5860
52.17828	52.02809	51.96189	51.82370	51.75750	51.59131	51.54111	51.43892	51.39672	51.26253	5880
51.16833	51.10214	50.98794	50.86175	50.74755	50.62136	50.53110	50.44097	50.44677	50.34458	5900
50.20638	50.02219	50.09799	49.94780	49.85760	49.68394	49.68921	49.53901	49.47282	49.38262	5920
49.34033	49.20223	49.12404	49.08584	48.98365	48.80545	48.70326	48.58906	48.43887	48.38467	5940
48.28248	48.20428	48.17469	47.99989	47.90370	47.83150	47.70531	47.57911	47.47632	47.33872	5960

TABLE IV - Continued

47.27253	47.16233	47.11614	47.04994	46.89375	46.84555	46.80736	46.55516	46.64097	46.54477	5980
46.53858	46.44836	46.29819	46.29199	46.20350	46.19360	46.00941	46.02721	45.91302	45.89482	6000
45.75863	45.71443	45.67224	45.51004	45.46785	45.32365	45.29945	45.25266	45.16707	45.11287	6020
45.03668	44.99248	44.91429	44.76409	44.66190	44.56370	44.49351	44.42731	44.29492	44.29492	6040
44.15673	44.07853	44.03834	43.93814	43.83995	43.75475	43.47156	43.33936	43.24317	43.10497	6060
42.93070	42.84056	42.75234	42.58819	42.46200	42.35980	42.19761	42.13741	41.93322	41.78302	6080
41.71683	41.57863	41.42844	41.28229	41.14005	40.97785	40.88766	40.73746	40.64727	40.48507	6100
41.38280	41.24460	41.14244	40.02829	39.92610	39.78790	39.64971	39.54751	39.44532	39.31912	6120
39.16593	39.09073	39.01254	38.94634	38.89215	38.77795	38.71176	38.73556	38.60337	38.52517	6140
38.42298	38.39276	38.35059	38.34439	38.26820	38.21200	38.13380	38.03161	38.04541	38.04322	6160
37.97702	37.93403	37.86863	37.80644	37.76024	37.71805	37.62785	37.55566	37.55546	37.42927	6180
37.53907	37.47288	37.21868	37.11649	37.01424	36.94810	36.85790	36.78771	36.86551	36.57532	6200
36.37712	36.29893	36.24473	36.08254	36.07834	35.91415	35.77595	35.63776	35.53556	35.39737	6220
35.27117	35.25298	35.11476	35.00059	34.86239	34.71223	34.57400	34.43581	34.33351	34.23142	6240
34.17722	34.03903	33.96083	33.85864	33.74444	33.61825	33.45605	33.33586	33.28766	33.20947	6260
33.08327	32.96906	32.84268	32.71669	32.59149	32.50030	32.41010	32.27191	32.20571	32.06752	6280
31.96532	31.86313	31.73693	31.65874	31.59254	31.49035	31.43615	31.33396	31.30376	31.23757	6300
31.12377	31.05716	31.95498	30.71459	30.62440	30.52425	30.43201	30.43201	30.41381	30.31162	6320
30.24542	30.15523	30.08903	29.90204	29.76464	29.65045	29.52425	29.47016	29.37986	29.24167	6340
29.11547	29.00128	28.89908	28.77469	28.77469	28.73650	28.67030	28.53811	28.38191	28.36372	6360
28.28552	28.19533	28.11713	28.06694	28.04474	27.90655	27.81635	27.73916	27.57536	27.50377	6380
27.33557	27.28136	27.21516	27.08899	27.03379	26.95660	26.81840	26.63628	26.60201	26.43381	6400
26.43362	26.30742	26.25323	26.12703	26.06084	25.94264	25.90445	25.83025	25.79606	25.72986	6420
25.63967	25.57347	25.48328	25.41308	25.43889	25.34469	25.20650	25.05630	25.01411	24.91191	6440
24.84972	24.77952	24.67253	24.61133	24.48494	24.43074	24.36455	24.20635	24.16016	24.14196	6460
23.94377	23.87797	23.75138	23.67318	23.59499	23.43279	23.33860	23.13240	23.12621	22.97601	6480
22.82582	22.73562	22.62143	22.47123	22.33384	22.29084	22.16465	22.03045	21.93626	21.79806	6500
21.73187	21.62967	21.51548	21.49208	21.35989	21.26809	21.13070	21.07650	20.97431	20.86011	6520
20.78192	20.70372	20.51753	20.37933	20.22314	20.11494	20.07275	19.97055	19.84436	19.70616	6540
19.65157	19.57377	19.51958	19.44138	19.37519	19.30899	19.19480	19.10460	19.01441	18.92421	6560
19.88202	19.79182	19.67763	19.57543	19.46124	19.33504	19.28085	19.23265	19.11246	17.96226	6580
17.88807	17.80587	17.66768	17.52948	17.43129	17.34909	17.24690	17.15870	17.07451	16.98831	6600
16.87412	16.74792	16.69373	16.53153	16.40534	16.29114	16.15295	16.02575	15.92456	15.85836	6620
15.78817	15.66597	15.63578	15.55758	15.49339	15.46119	15.26300	15.18880	15.08260	14.93241	6640
15.77821	15.68482	15.42182	15.34363	15.24143	15.18724	14.12184	14.03665	13.95265	13.87446	6660
15.04226	15.07007	15.57987	15.40968	15.32748	15.24929	13.85189	13.82900	12.98678	12.72851	6680
12.92331	12.85182	12.32992	12.27573	12.15553	12.18734	12.94614	11.73495	11.68075	11.67456	6700
11.58436	11.40817	11.34397	11.25378	11.21158	11.10939	11.04319	10.97700	10.97080	10.90461	6720
10.82641	10.76622	10.66202	10.51983	10.41763	10.39944	10.30924	10.25505	10.14085	10.15466	6740
10.11646	10.07427	9.98407	9.94188	9.86368	9.71349	9.62329	9.53310	9.55030	9.47271	6760
9.84251	9.83832	9.27412	9.17193	9.10373	9.07954	8.80934	8.84715	8.75695	8.73876	6780
8.78856	8.59637	8.50417	8.46198	8.44378	8.35359	8.32339	8.22120	8.16700	8.13681	6800
8.82261	7.98042	7.87822	7.82403	7.78184	7.75164	7.67344	7.63525	7.57705	7.59886	6820
7.42866	7.42647	7.39627	7.29408	7.23588	7.21569	7.08349	7.09330	7.07110	7.07691	6840
6.99871	6.94452	6.97432	6.90813	6.86593	6.79974	6.73354	6.64935	6.61315	6.53496	6860
6.93276	6.43857	6.30437	6.31818	6.27798	6.28979	6.17959	6.11140	6.04720	5.99300	6880
5.91481	5.94461	5.91442	5.86022	5.75803	5.69183	5.63764	5.55944	5.45725	5.42705	6900
5.36886	5.25866	5.18047	5.15027	5.09508	4.93384	4.93969	4.83349	4.78330	4.69310	6920
4.65891	4.58471	4.54252	4.51232	4.42213	4.33193	4.24174	4.15554	4.12135	4.04315	6940
3.97896	3.92276	3.80057	3.86237	3.70410	3.76590	3.69979	3.71759	3.65140	3.65720	6960

TABLE IV - Continued

3.63301	3.63201	3.59062	3.53062	3.49423	3.45203	3.36584	3.43364	3.34945	3.36725	6900
3.34206	3.34206	3.31267	3.31047	3.24320	3.25000	3.16704	3.13569	3.16750	3.17330	7000
3.07691	3.07691	3.14272	3.07652	3.01033	2.98013	2.93794	2.83374	2.87755	2.85335	7020
2.02916	2.03496	2.01677	2.07957	2.079230	2.05010	2.03199	2.070179	2.05960	2.05340	7040
2.65921	2.64101	2.61082	2.64062	2.64043	2.66423	2.65804	2.63984	2.65765	2.67945	7060
2.56326	2.54306	2.51287	2.48267	2.42840	2.45828	2.42809	2.39789	2.40370	2.33750	7080
2.27331	2.27711	2.27092	2.30072	2.23453	2.31233	2.23414	2.22794	2.19775	2.23955	7100
2.20936	2.22716	2.14897	2.20277	2.16358	2.14234	2.13619	2.03399	2.05100	2.03900	7120
2.06340	2.08121	2.05101	2.04482	1.97862	1.97243	2.00223	2.03234	2.01334	2.01165	7140
2.01345	2.06726	2.10906	2.13887	2.12067	2.11048	2.02228	2.04009	2.03589	2.01770	7160
1.90931	1.90931	1.91511	1.92092	1.85472	1.80053	1.78233	1.73414	1.72134	1.71375	7180
1.63755	1.66736	1.63716	1.54037	1.57677	1.51058	1.51638	1.45219	1.44393	1.41380	7200
1.37160	1.39941	1.29921	1.31702	1.34682	1.32863	1.33443	1.22024	1.22604	1.17185	7220
1.21365	1.14746	1.22526	1.19507	1.14087	1.11068	1.12448	1.17029	1.12809	1.13790	7240
1.16370	1.16951	1.16331	1.10312	1.09092	1.09673	1.04253	1.05034	1.00014	1.02395	7260
1.01775	1.01156	1.01736	1.02317	1.05297	1.10678	1.05458	1.04439	1.11219	1.07000	7280
1.06300	1.03361	1.03941	1.02122	1.02702	1.06883	1.03863	1.04444	1.00224	.93605	7300
.98985	1.03166	.96546	.93327	.85707	.80280	.77268	.73049	.68829	.64610	7320
.62790	.64571	.63951	.63332	.55512	.56093	.50673	.45454	.45834	.40415	7340
.34995	.24776	.26556	.18737	.14517	.12598	.08478	.06659	.06019	.01820	7360
-.01200	-.01820	-.14839	-.06659	-.03678	-.06598	-.10917	-.11537	-.10456	-.16376	7380
-.19395	-.20015	-.27834	-.34654	-.39473	-.40493	-.44712	-.42932	-.42351	-.39371	7400
-.45990	-.45410	-.46020	-.50219	-.54468	-.59888	-.62107	-.70727	-.71366	-.74366	7420
-.76185	-.78005	-.76224	-.74444	-.75063	-.75683	-.77502	-.72122	-.75141	-.69761	7440
-.69880	-.72200	-.70419	-.71039	-.75258	-.93878	-.83597	-.87917	-.92136	-.92756	7460
-.55775	-.59995	-.99414	-.106034	-.106653	-.107273	-.113892	-.113312	-.116331	-.115751	7480
-1.15170	-1.14590	-1.10409	-1.14629	-1.14048	-1.19468	-1.22487	-1.23507	-1.28525	-1.30346	7500
-1.30965	-1.27985	-1.27404	-1.22024	-1.22643	-1.23263	-1.25882	-1.25702	-1.27521	-1.23341	7520

***** END RUNWAY DATA ***** LDI= 3761

TABLE V - Airplane Data for Sample Problem

..... INPUT DATA

..... GENERAL AIRCRAFT DATA

Class C Aircraft

W=	30600.0	WY=	1059.3,	WM=	432.00	A=	30.300	B=	670.300	MMI=	0-73600L.
SYM=	2.C	SYM=	1.2	SLM=	91.0	SLM=	91.0	PSARM=	757.6	TAILON=	637.8
ADM=	78.67	ADM=	66.09	PADM=	243.00	WOM=	1016.00	OM=	3.14	YSM =	25050.0.
ADM=	19.64	ADM=	13.91	PADM=	205.00	WOM=	335.00	OM=	1.23	YSM =	13003.0L
CL=	.603	CD=	.333	AREA=	2000.00	SPEED=	1.0	THRUST=	40000.	TADOFF=	249.00

STROKE MODE PIN DIAMETER

0.001	1.100
1.003	1.130
4.103	1.130
11.650	1.170
13.150	1.170
15.400	1.205
50.000	1.205

STROKE WATN PIN DIAMETER

0.000	1.507
3.750	1.507
6.750	1.517
7.750	1.517
9.000	1.507
10.050	1.503
11.000	1.500
21.700	1.979
50.000	1.979

TABLE V - Continued

MODE	SIPS	SINOSL	SICG	SITAIL	OMEGA	GEN. MASS
1	-0.32	-0.03	-0.04	-0.21	0.22	29.5
2	-0.10	0.15	0.03	0.02	12.76	42.5
3	0.09	0.07	0.01	0.05	14.02	113.3
4	0.55	0.45	-0.03	0.43	13.74	111.7
5	0.54	0.46	-0.11	0.36	17.91	47.3
6	-0.07	-0.04	-0.03	0.07	23.50	43.1
7	-0.29	-0.20	0.15	-0.15	23.69	27.0
8	-0.04	-0.05	0.01	-0.05	31.80	2.3
9	0.16	0.09	-0.04	0.07	41.15	43.1
10	0.09	0.05	-0.05	0.05	41.90	19.5

***** INITIAL CONDITIONS *****

ZMI= -5.849 ZMI= -0.997 IMETAI= -0.02125 ZCGI= -25.318
 XMAIM= -20.103 XMOSE= -9.393 Q1CTM= -12966. REACTM= -293836.

TABLE VI - Typical Page of Tested Output Taken from the Results of the Sample Problem

TIME

PSA

CSAC

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SECTION V

RESULTS

The mathematical model and computer program presented in this report is capable of simulating five classes of commercial jet aircraft. Classification is made on the basis of gross weight as follows:

Class A	Less than 150,000 lb
Class B	150,000 - 300,000 lb
Class C	300,000 - 450,000 lb
Class D	450,000 - 600,000 lb
Class E	Greater than 600,000 lb

The data used to represent these aircraft and typical simulations using the data for each class of aircraft is presented in this section.

The data set for each aircraft class contains a general configuration, (Figures 8, 11, 14, 17, and 20), a description of input variable fortran names, (Tables VII, IX, XI, XIII, and XV), two pages of input data (Tables VIII, X, XII, XIV, and XVI), and a set of tire deflection curves, (Figures 9, 10, 12, 13, 15, 16, 18, 19, 21, and 22), for both main and nose landing gears. The first page of input data contains all of the rigid body airplane and landing gear data. The second page of data contains the aircraft's modal data and the aircraft's initial conditions as computed by TAXI.

The aircraft data presented was used to simulate each aircraft taking off from two separate profiles, Will Rogers International and Dulles International Airports. The calcomp plotted results are shown in Figures 23 through 32. It is evident that all airplanes responded to the prominent bump which occurred at approximately 2700 feet on the Will Rogers profile, although some to larger degree than others. With the exception of this one bump it is difficult to correlate runway roughness to the response of all aircraft. Some airplanes responded to a certain section of a profile while others did not. Some airplanes responded predominately in pitch such as the Class C and D aircraft while others responded in pitch and plunge such as the Class A and B aircraft. This points out the significance of such parameters as gear stiffness, degree of coupling between the rigid body masses, gear spacing and others.

For all aircraft classes except Class B the rms value of the Pilot's station vertical acceleration was less over the Dulles profile than that of the Will Rogers profile. For all aircraft classes except Class B and

D, the center of gravity vertical acceleration rms level is less for the Dulles profile. For these three exceptions, the rms level was the same for both profiles. From a purely response standpoint then, it can be said that the Dulles International runway profile is smoother than the Will Rogers International profile.

Figures 33 and 34 show the difference in response of Class B aircraft with and without strut bearing friction included in the simulation. The simulation for both runs were at a constant speed of 100 feet per second over the Will Rogers profile. The center of gravity rms level was increased with the inclusion of strut friction while it was reduced slightly at the pilot's station. The jerky motion evidenced by the response at the cg was expected and was caused by the constant "locking up" of the struts due to the binding forces on the upper and lower bearing surfaces of the landing gear struts. It is more evident at the cg because most of the aircraft's weight, and resulting strut forces, is on the main landing gear which is closest to the aircraft's cg.

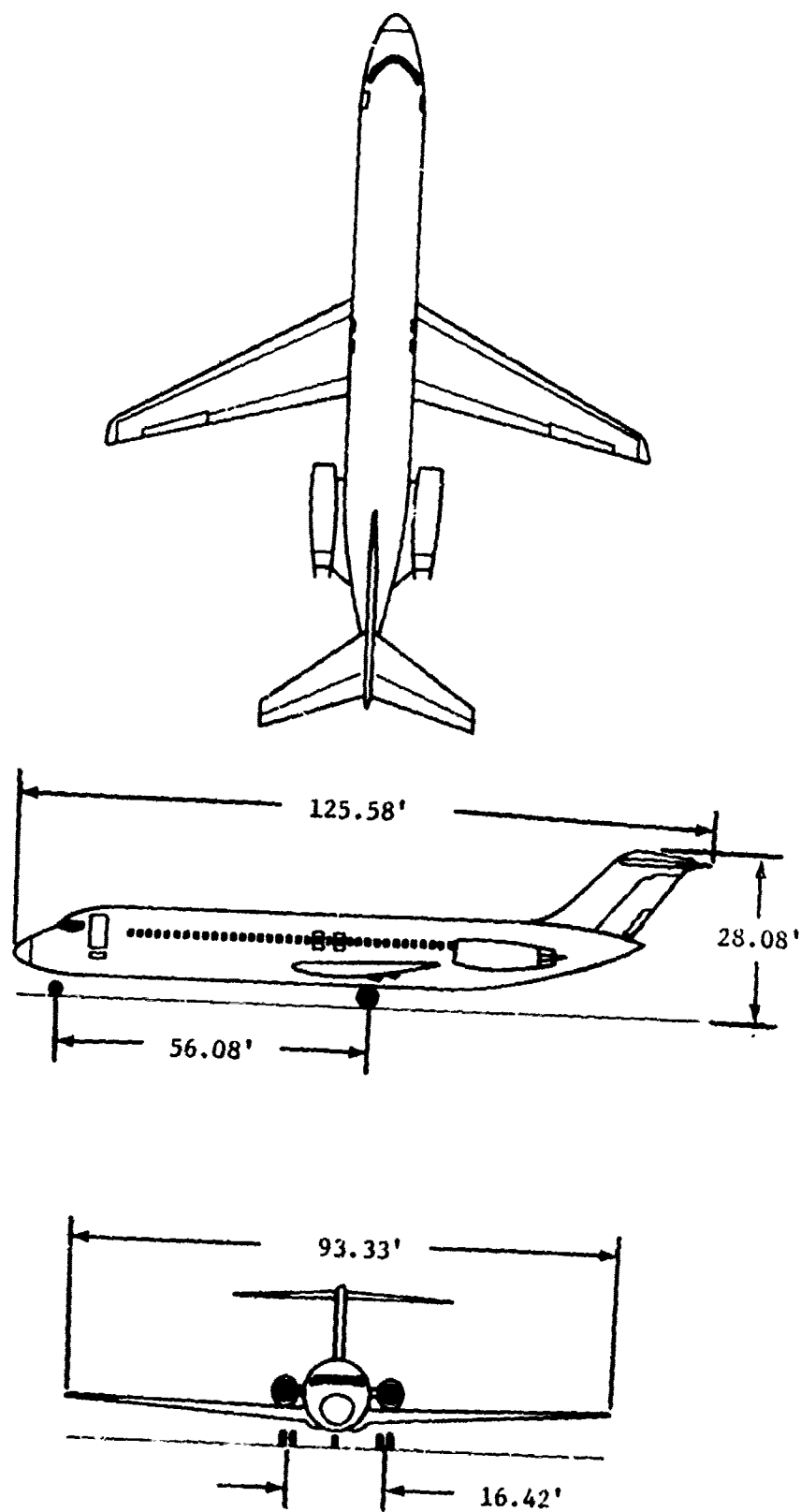


Figure 8 - Class A Aircraft General Configuration

TABLE VII - List of Input Data Fortran Names

65	C	READ AND PRINT INPUT DATA	TAXI0540
	C		TAXI0550
	C	WEIGHT - WEIGHT AT CG (POUNDS)	TAXI0560
	C	WEIGHT - MAIN GEAR TO CG (INCHES)	TAXI0570
	C	WEIGHT - NOSE GEAR TO CG (INCHES)	TAXI0580
	C	WEIGHT - MOMENT OF INERTIA (3 IN SEC SQ)	TAXI0590
66	C	WEIGHT - AIRPLANE BEING SIMULATED AND GROSS WEIGHT	TAXI0600
	C	WEIGHT - DISTANCE OF PILOT STATION TO CG	TAXI0610
	C	WEIGHT - DISTANCE OF TAIL STATION TO CG	TAXI0620
	C	WEIGHT - TAKE-OFF SPEED (FEET/SEC)	TAXI0630
	C	WEIGHT - INITIAL ALT OF AIRPLANE	TAXI0640
	C	WEIGHT - TOTAL AIRPLANE THRUST	TAXI0650
	C	WEIGHT - CLIFF COEFF.	TAXI0660
	C	WEIGHT - AIRPLANE AREA	TAXI0670
	C	WEIGHT - COEFF.	TAXI0680
	C	WEIGHT - WEIGHT OF MAIN GEAR (EA)	TAXI0690
	C	WEIGHT - WEIGHT OF NOSE GEAR	TAXI0700
70	C	WEIGHT - NUMBER OF MAIN GEAR STRUTS	TAXI0710
	C	WEIGHT - SAME NUMBER OF NOSE GEAR STRUTS	TAXI0720
	C	WEIGHT - HYDRAULIC PISTON AREA NOSE SQ INCHES	TAXI0730
	C	WEIGHT - HYDRAULIC PISTON AREA MAIN SQ INCHES	TAXI0740
75	C	WEIGHT - HYDRAULIC PISTON AREA MAIN SQ INCHES	TAXI0750
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0760
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0770
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0780
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0790
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0800
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0810
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0820
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0830
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0840
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0850
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0860
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0870
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0880
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0890
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0900
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0910
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0920
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0930
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0940
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0950
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0960
	C	WEIGHT - PNEUMATIC PISTON AREA MAIN SQ INCHES	TAXI0970

TABLE VIII - List of Data Used to Simulate Class A Aircraft

..... INPUT DATA

..... GENERAL AIRCRAFT DATA

Class A 114000 POUNDS GROSS WEIGHT 35 X MAC

W=	114000.0	WM=	1074.00	WN=	164.00	A=	24.430	B=	652.430	MMI=	21540000.
SXN=	2.0	SXM=	1.3	SLM=	97.9	SLN=	96.7	PSARM=	660.5	TAILRM=	513.0
AAM=	29.92	AMM=	20.61	PAOM=	332.00	VOM=	462.20	OAM=	.69	TSM=	25000.00
AAH=	0.20	AHM=	6.30	PAOH=	120.30	VOH=	126.66	OHM=	.42	TSN=	10320.00
CL=	.690	CO=	.065	AREA=	1000.70	SPEED=	1.0	THRUST=	23400.	TAKOFF=	205.00

STROKE NOSE PIN DIAMETER

0.000	.375
.565	.039
.684	.684
6.925	.733
12.425	.783
15.875	.783
15.167	

STROKE MAIN PIN DIAMETER

0.000	.421
.680	.421
1.500	.569
3.500	.641
6.000	.760
13.500	.826
17.000	.826

TABLE VIII - Continued

MODE	SIPS	SIMOSE	SIGS	SIMAIN	SITAIL	OMEGA	GEN. MASS
1	-.06	-.06	-.03	-.01	-.07	10.50	4.3
2	-.10	.09	-.03	-.03	.02	26.10	1.4
3	-.32	-.30	.10	.12	-.12	33.90	0.6
4	-.12	-.11	.01	.02	-.27	43.90	3.5
5	-.03	-.04	.04	.01	-.01	53.60	2.0
6	.12	.11	-.04	-.03	.11	56.90	32.7
7	-.04	-.04	.01	-.00	-.05	57.30	5.3
8	.25	.23	-.02	.01	.09	71.00	7.2
9	-.01	-.01	-.00	-.01	-.02	95.50	1.4
10	.09	.00	-.01	-.04	-.06	111.00	3.4
11	-.07	-.06	-.04	.03	.21	116.00	3.6

***** INITIAL CONDITIONS *****

ZWIS -2.190 ZWI --.399 TWETAIS -.007007 ZCIS -16.980
 XMAIS -14.975 XMOSE -11.449 REACTN -4115. REACTN -10905.

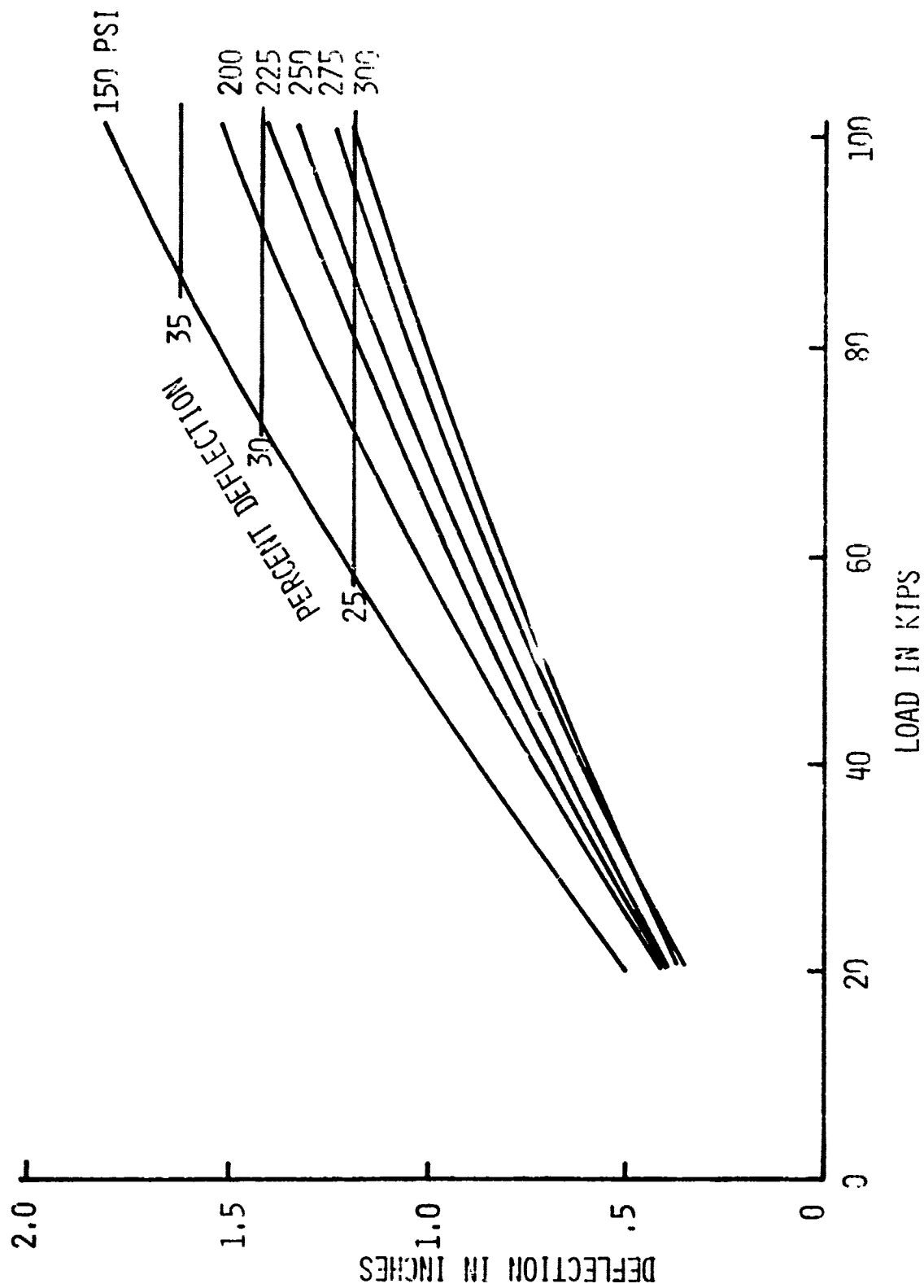


Figure 9 - Class A Aircraft Nose Landing Gear Tire Deflection Curves

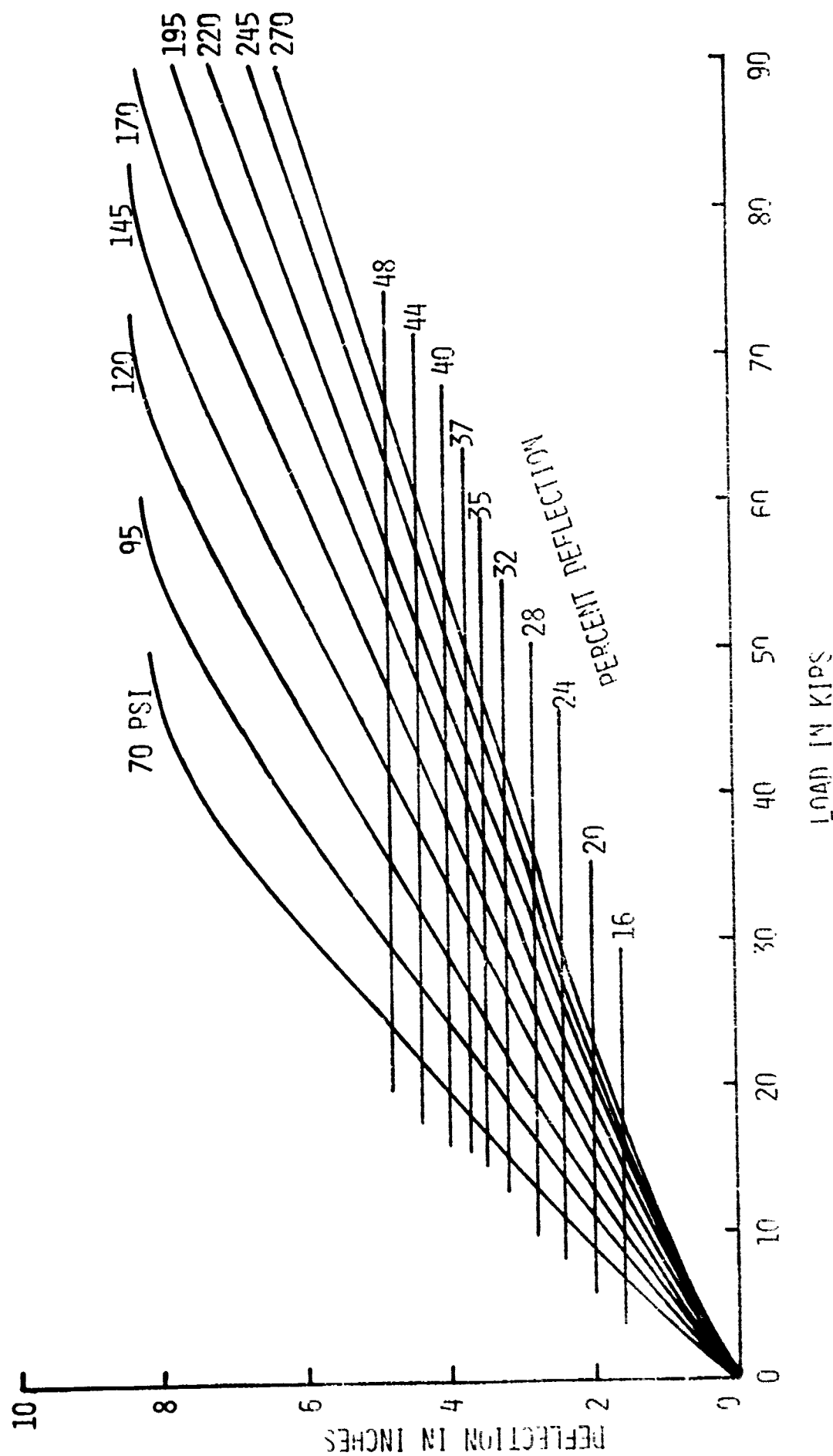


Figure 10 - Class A Aircraft Main Landing Gear Tire Deflection Curves

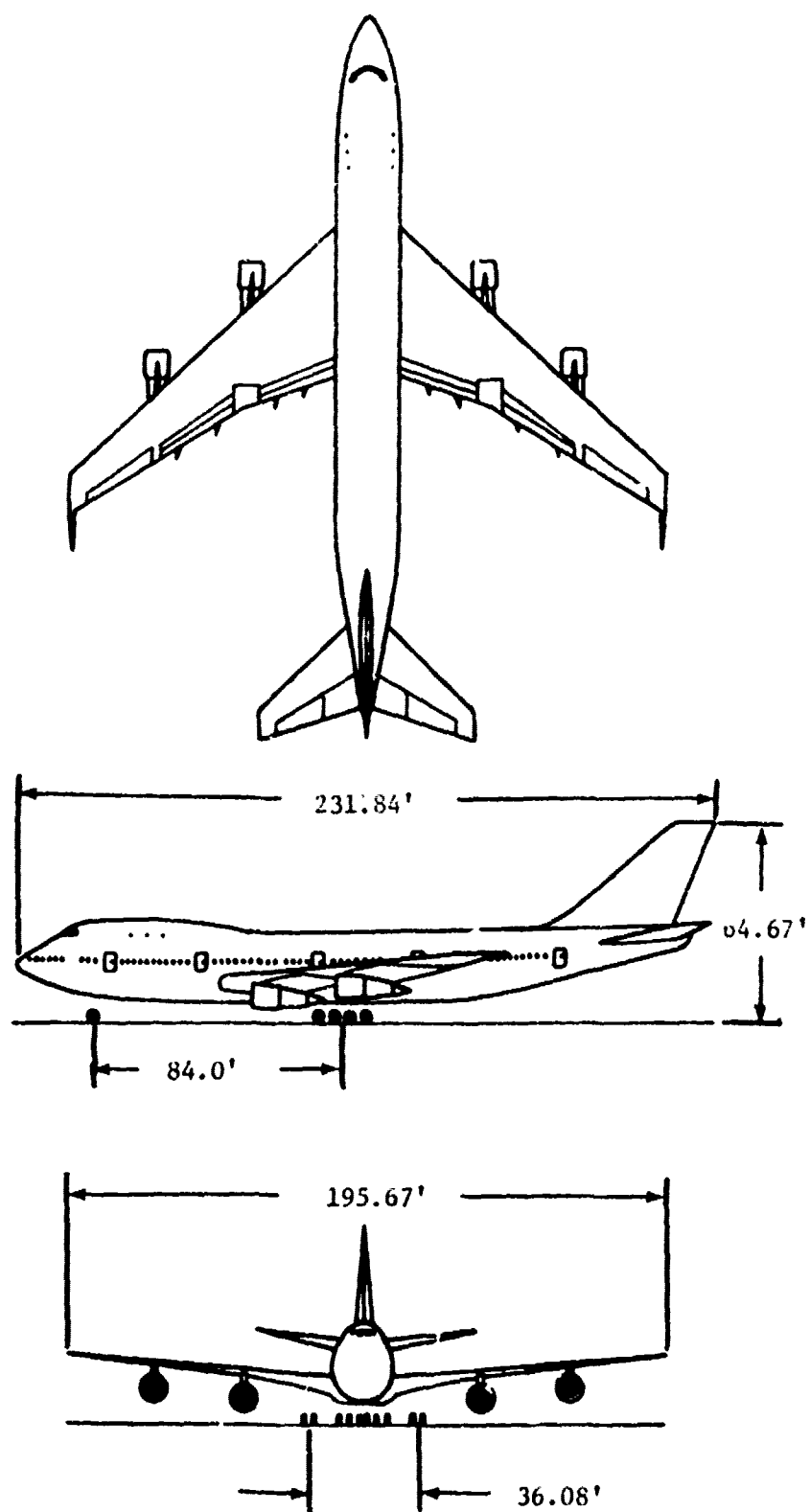


Figure 11 - Class E Aircraft General Configuration

TABLE IX - List of Input Data Fortran Names

PROGRAM TAXI

64	C READ AND PRINT INPUT DATA	TAXI0580
	C	TAXI0590
	C	TAXI0600
	C	TAXI0610
	C	TAXI0620
	C	TAXI0630
	C	TAXI0640
	C	TAXI0650
	C	TAXI0660
	C	TAXI0670
	C	TAXI0680
	C	TAXI0690
	C	TAXI0700
	C	TAXI0710
	C	TAXI0720
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	C	TAXI0740
	C	TAXI0750
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	C	TAXI0770
	C	TAXI0780
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	C	TAXI0980
	C	TAXI0990
	C	TAXI1000
	C	TAXI1010
	C	TAXI1020
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	C	TAXI1040
	C	TAXI1050
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	C	TAXI1080
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	C	TAXI1100
	C	TAXI1110
	C	TAXI1120
	C	TAXI1130
	C	TAXI1140
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	C	TAXI1170
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	C	TAXI4830
	C	TAXI4840
	C	TAXI4850
	C	TAXI4860
	C	TAXI4870
	C	TAXI4880
	C	TAXI4890
	C	TAXI4900
	C	TAXI4910
	C	TAXI4920
	C	TAXI4930
	C	TAXI4940
	C	TAXI4950
	C	TAXI4960
	C	TAXI4970
	C	TAXI4980
	C	TAXI4990
	C	TAXI5000
	C	TAXI5010
	C	TAXI5020
	C	TAXI5030
	C	TAXI5040
	C	TAXI5050
	C	TAXI5060
	C	TAXI5070
	C	TAXI5080
	C	TAXI5090
	C	TAXI5100
	C	TAXI5110
	C	TAXI5120
	C	TAXI5130
	C	TAXI5140
	C	TAXI5150
	C	TAXI5160
	C	TAXI5170
	C	TAXI5180
	C	TAXI5190
	C	TAXI5200
	C	TAXI5210
	C	TAXI5220
	C	TAXI5230
	C	TAXI5240
	C	TAXI5250
	C	TAXI5260
	C	TAXI5270
	C	TAXI5280
	C	

TABLE X - List of Data Used to Simulate Class E Aircraft

***** INPUT DATA *****

***** GENERAL AIRCRAFT DATA *****

Class E at 630,000 pounds Gross Weight

WM= 630000.0 WM= 3400.00 WPM= 3900.00 WM= 1750.00 A= 32.000 B= 915.500 MWI= 400000000.0
 SXN= 2.0 SXN= 1.0 SLM= 175.0 SLM= 170.0 PSARM= 1000.5 TAILRM= 1149.50= 153.00
 AAM= 35.00 AMR= 91.59 PARM= 450.00 VOM= 2735.00 OAM= 3.45 TSM= 56600.00
 AARM= 35.00 AARM= 74.00 PADRM= 325.00 VORM= 2690.00 TSRM= 56650.00
 AAN= 63.60 AMY= 51.30 PARM= 130.00 VOM= 1600.00 OAN= 4.34 TSM= 26334.00
 CL= .615 CD= .055 AREA= 5500.00 SPEED= 1.0 THRUST=100000. TAKEOFF= 241.00

STROKE NOSE PIN DIAMETER

1.000 2.000
 2.000 2.110
 13.000 2.150
 19.000 2.250
 25.000 2.200

STROKE MAIN PIN DIAMETER

3.000 1.470
 4.000 1.280
 6.000 1.410
 13.000 1.430
 19.000 1.540
 21.000 1.930
 24.000 1.930
 26.000 2.000
 33.000 2.000

THROW REAR WCG PIN DIAMETER

1.000 1.540
 5.540 1.410
 9.000 1.750
 13.000 1.970
 16.000 2.000
 21.000 2.130
 24.000 2.120
 33.000 2.120

TABLE X - Continued

MODE	SIPS	MINUSE	CIC	SINAM	SIPAM	SITAIL	OMEGA	GEN.	MASS
1	-0.07	-0.04	-0.05	-0.03	-0.06	-0.08	6.35		46.4
2	-0.2	0.1	0.00	0.02	0.00	-0.02	10.05		81.4
3	-0.10	0.17	0.00	-0.01	0.01	0.05	11.59		73.3
4	-0.75	0.61	-0.10	-0.16	-0.19	0.01	14.63		735.7
	0.11	0.24	-0.13	-0.14	-0.14	0.72	16.93		56.2
5	-0.13	-0.01	0.03	-0.02	0.02	-0.12	24.13		206.0
6	0.04	0.00	-0.13	0.01	-0.08	0.16	26.23		52.2
7	-0.05	-0.02	0.02	-0.03	0.03	-0.07	27.63		46.5
8	-0.12	-0.07	0.04	0.15	-0.13	-0.13	34.70		77.2
9	0.00	0.00	-0.04	0.00	-0.02	-0.00	41.73		14.9

```

***** INITIAL CONDITIONS *****
54223.0 316451.0 25992.00 -2.0 -21.3 -21.6 -21.9 -21.3 .0
PMI= -2.2944 2MI= -2.2944 7MI= -1.917 7METAI= .000 2CGI= -23.021
4MI= -21.321 11052= -21.029 91C10= -54330. REACT= -31.050. REACT0= -250920.

```

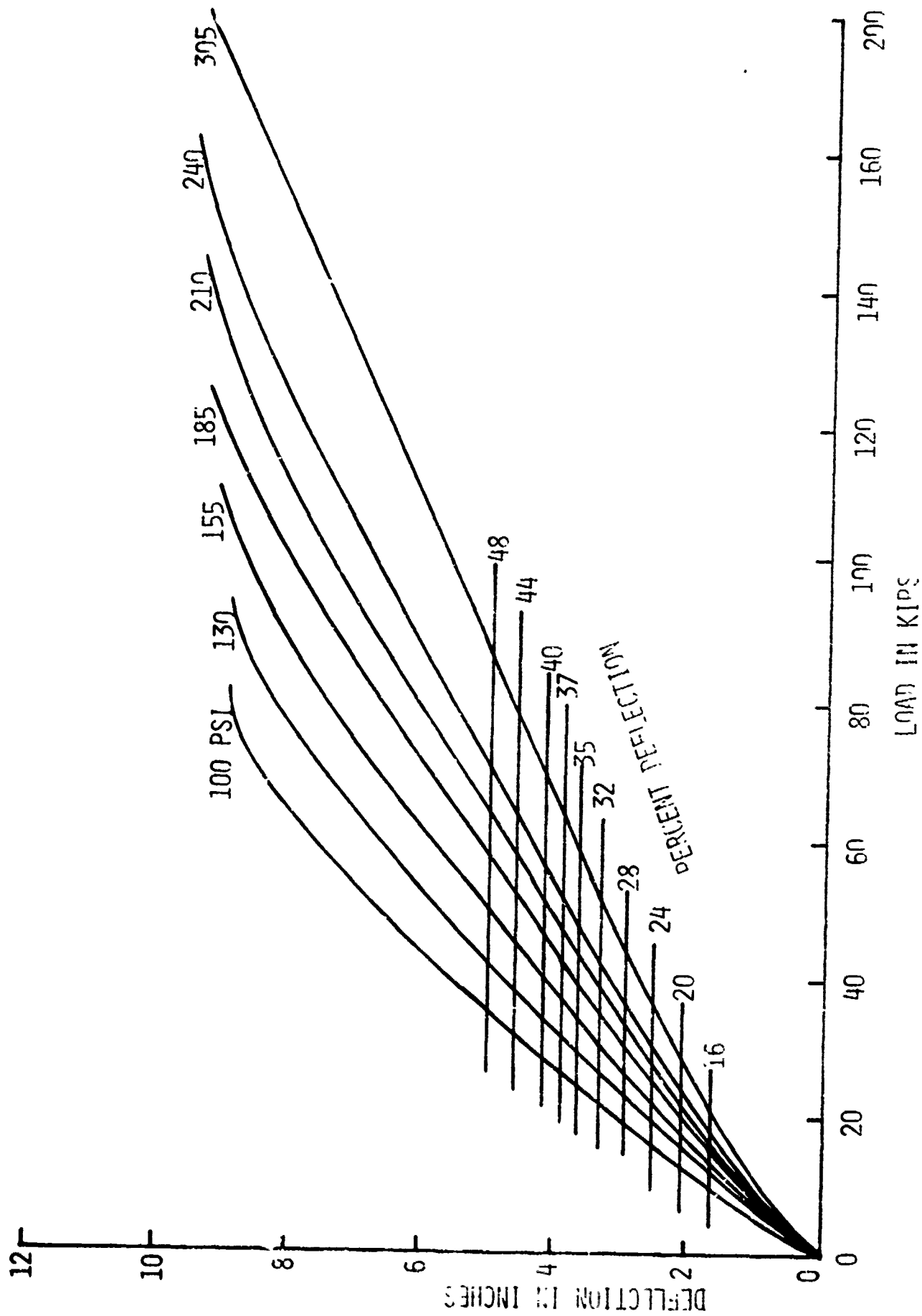


Figure 12 - Class I Aircraft Nose Landing Gear Tire Deflection Curves

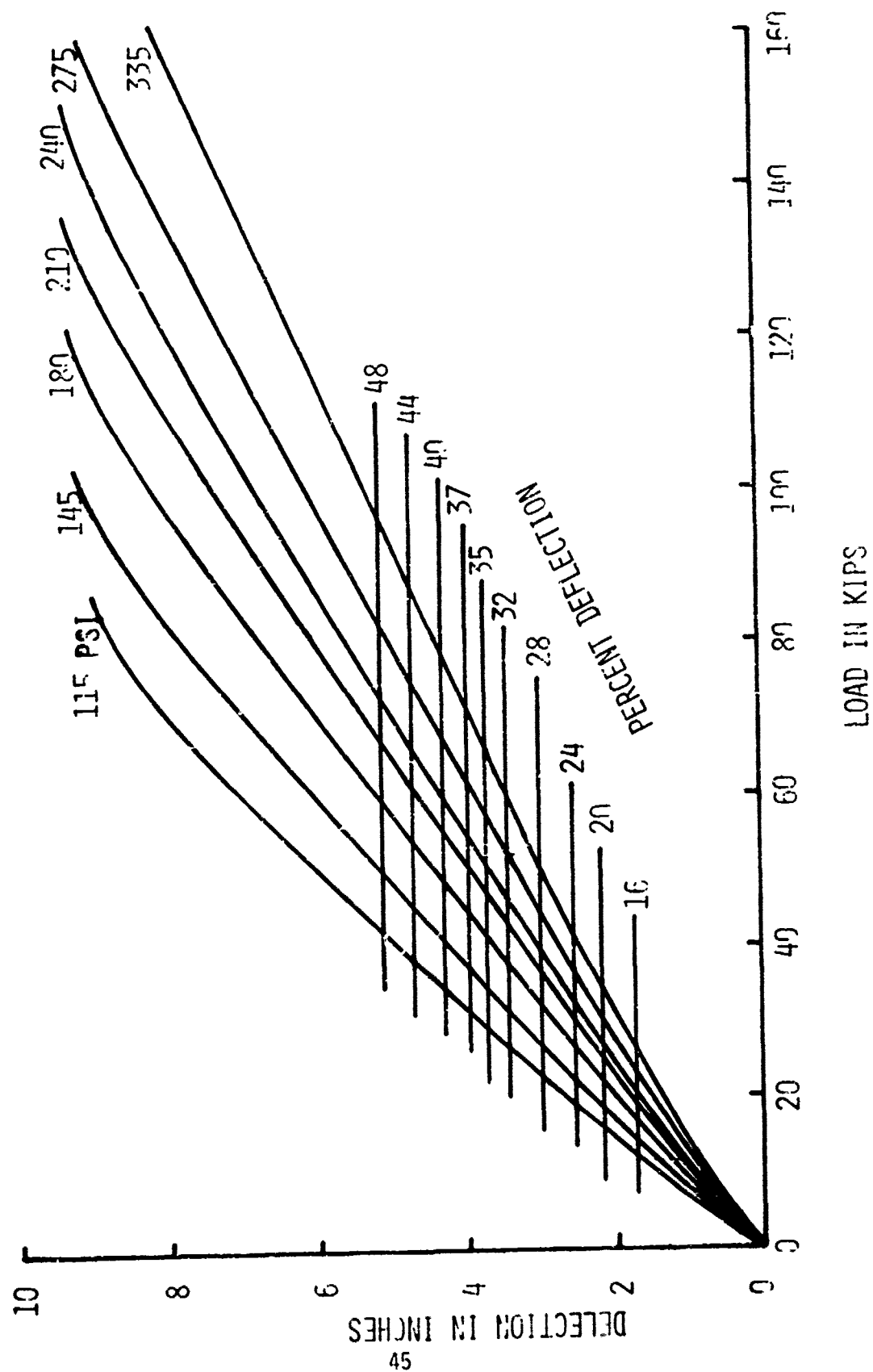


Figure 13 - Class E Aircraft Main Landing Gear Tire Deflection Curves

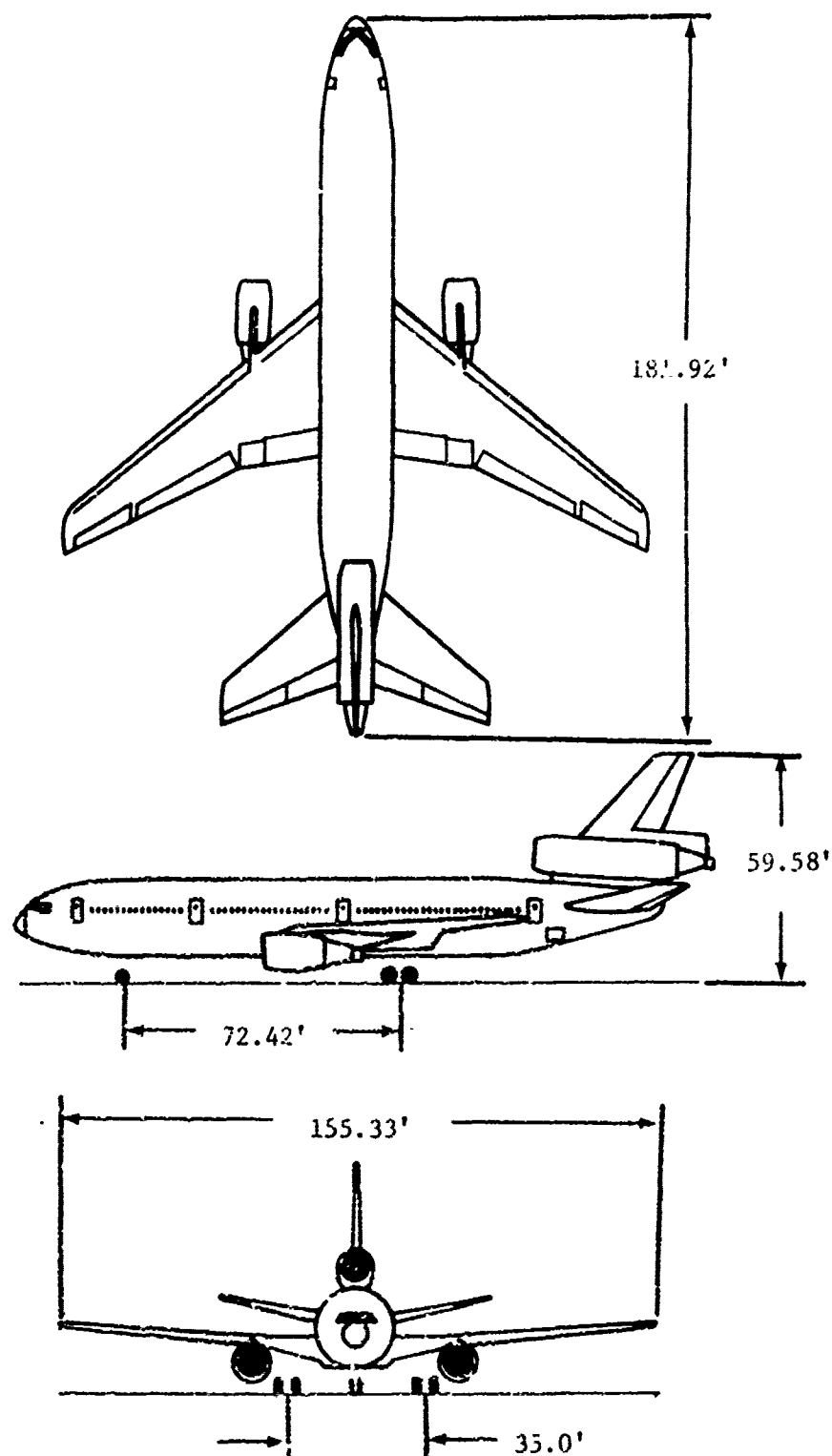


Figure 14 - Class D Aircraft General Configuration

TABLE XI - List of Input Data Fortran Names

65	C READ AND PRINT INPUT DATA	TAXI052J
	C WE=WEIGHT AT CG (POUNDS)	TAXI053J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI054J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI055J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI056J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI057J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI058J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI059J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI060J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI061J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI062J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI063J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI064J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI065J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI066J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI067J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI068J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI069J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI070J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI071J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI072J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI073J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI074J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI075J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI076J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI077J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI078J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI079J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI080J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI081J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI082J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI083J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI084J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI085J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI086J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI087J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI088J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI089J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI090J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI091J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI092J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI093J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI094J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI095J
	C WE=WEIGHT MAIN GEAR TO CG (INCHES)	TAXI096J
	C WE=WEIGHT NOSE GEAR TO CG (INCHES)	TAXI097J

TABLE XII - List of Data Used to Simulate Class D Aircraft

..... INPUT DATA

..... GENERAL AIRCRAFT DATA

Class D Aircraft 440000 pounds Gross Weight

W= 440000.0 WM= 5104.24 MW= 651.05 A= 73.000 B= 790.000 MWI= 211000000.
 SW= 2.0 SXN= 1.0 SLN= 150.0 PSAR= 1015.0 TAILRM= 557.0
 AAM= 103.05 AMN= 89.24 PAOM= 230.00 VOM= 2540.71 OAM= 2.50 TSM= 57600.00
 AAN= 30.40 AMN= 31.74 PAOM= 100.00 VOM= 600.56 OAM= 1.24 TSM= 21040.00
 CL= .460 CD= .080 AREA= 3647.00 SPEED= 1.0 THRUST=110000. TAKEOFF= 200.00

STROKE NOSE PIN DIAMETER

0.000 .660
 3.000 .850
 9.000 1.020
 15.000 1.130
 17.000 1.140

STROKE MAIN PIN DIAMETER

0.000 1.600
 4.000 1.000
 9.000 2.150
 10.000 2.250
 23.500 2.250

TABLE XII - Continued

MODE	SIMS	SIMOSE	SICG	SIMAIN	SITAIL	OMEGA	GEN. MASS
1	.51	-.01	-.14	-.33	-.10	7.92	26.1
2	.51	.01	.00	.01	-.38	12.62	77.2
3	.41	.25	-.18	-.13	.08	18.10	39.3
4	.08	.05	-.30	.07	.32	22.64	18.2
5	-.37	-.04	-.00	-.09	.06	22.98	17.0
6	.05	.02	-.35	-.04	-.36	24.22	39.9
7	-.51	-.31	-.32	-.03	-.06	24.75	7.9
8	-.25	-.11	.12	.14	-.04	27.98	32.8
9	-.20	-.38	.12	.04	.04	32.16	1124.3
10	.21	.07	-.13	-.37	.18	43.20	18.4

***** INITIAL CONDITIONS *****

ZMI= -3.499 ZVI= -1.688 THETA= -.89816 ZCGI= -24.226
 XMAIN= -21.385 XMOSE= -15.363 REACTM= -36875. REACTM= -48125.

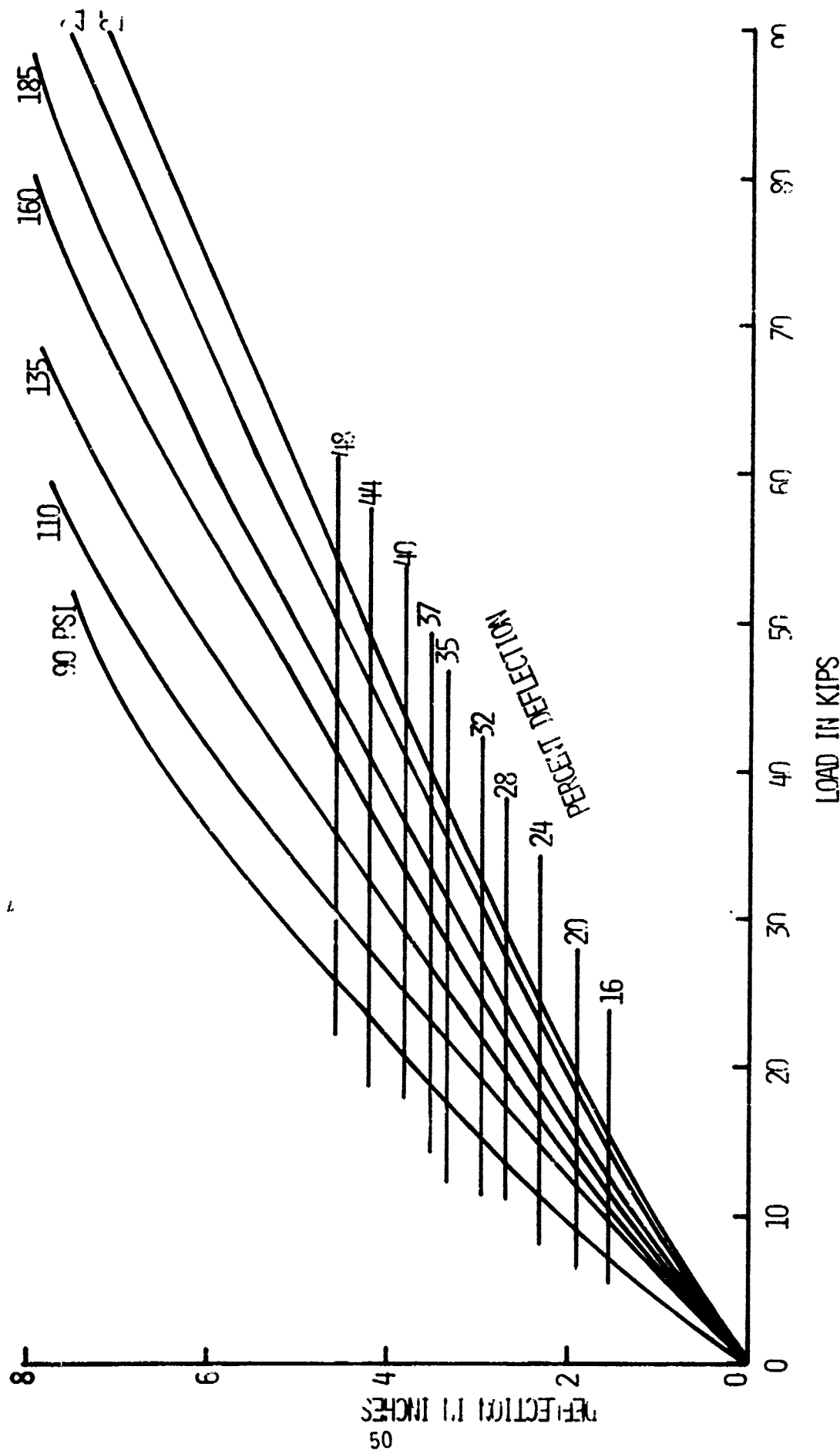


Figure 15 - Class D Aircraft Landing Gear Tire Deflection Curves

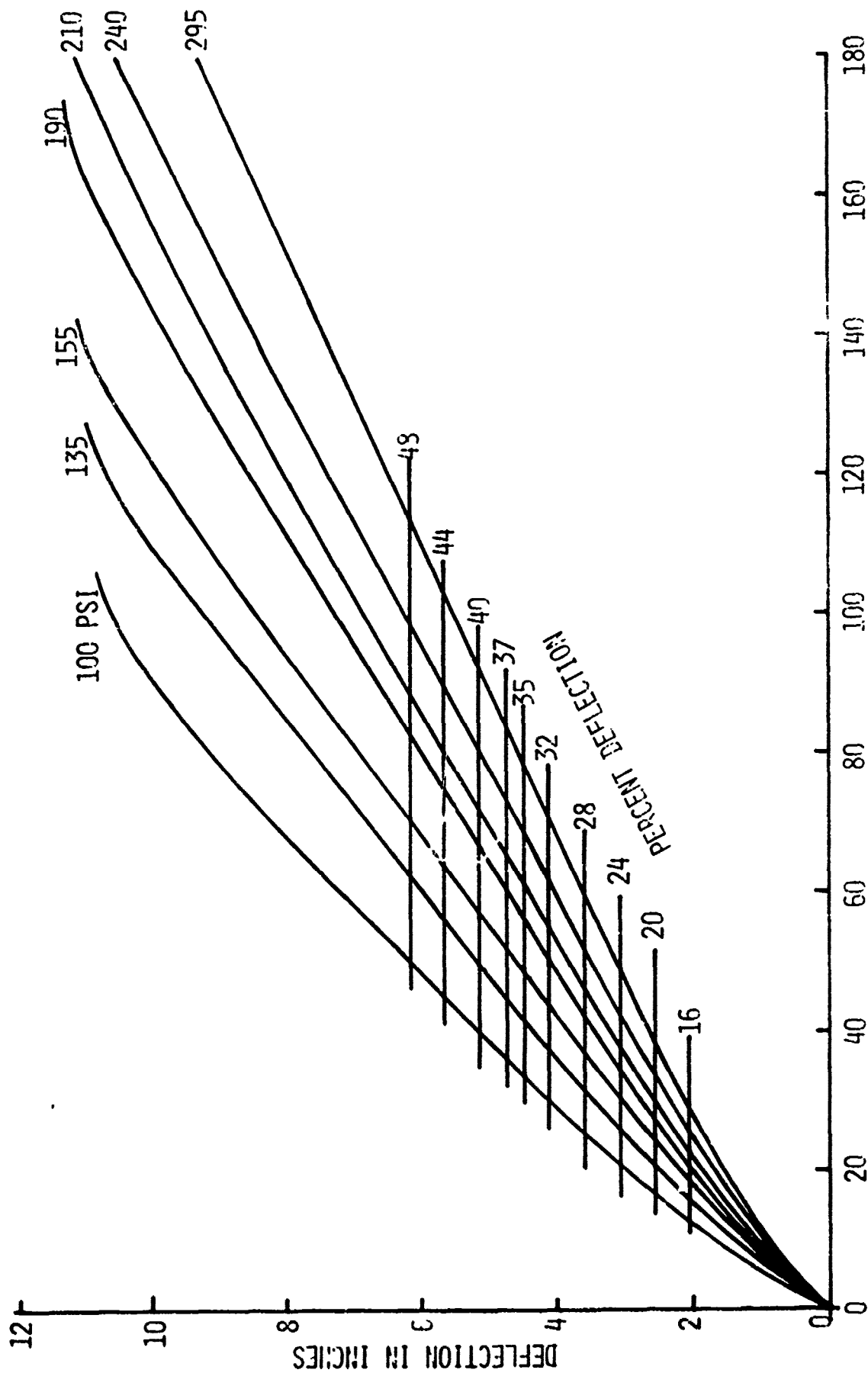


Figure 16 - Class D Aircraft Main Landing Gear Tire Deflection Curves

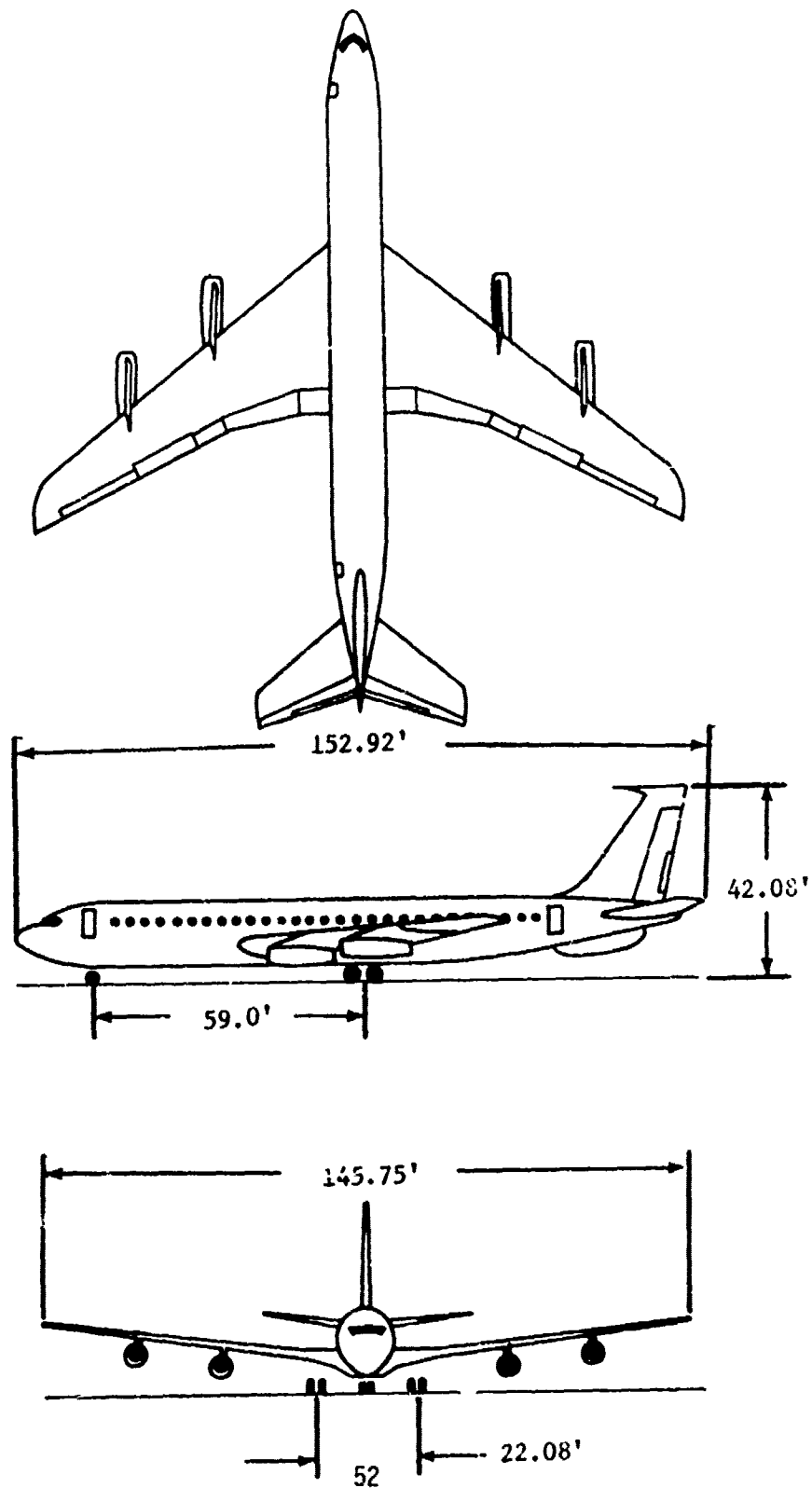


Figure 17. Class C Aircraft General Configuration

TABLE XIV - List of Data Used to Simulate Class C Aircraft

..... INPUT DATA

..... GENERAL AIRCRAFT DATA

Class C 306000 pounds Gross Weight

W=	306000.0	W4=	1659.3,	W4=	612.00	A=	30.300	B=	670.300	MMI=	0.73000.
SW=	2.0	SW=	1.3	SL=	91.0	CL=	91.0	PSAR=	757.0	TAIL=	637.0
AM=	75.47	AM=	56.00	PAOM=	243.00	VOM=	1016.00	OAM=	3.14	YS=	25050.0.
AM=	19.64	AM=	13.91	PAOK=	205.00	VOM=	335.90	OAM=	1.23	YS=	13000.00
CL=	.003	CD=	.013	AREA=	2091.00	SPED=	1.0	THRUST=	49000.	TAKOFF=	299.00

STROKE NOSE PIN DIAMETER

C.003	1.160
1.003	1.130
4.193	1.130
11.650	1.170
13.150	1.170
15.460	1.245
50.000	1.245

STROKE MAIN FIN DIAMETER

0.000	1.567
3.750	1.567
6.750	1.517
7.750	1.517
9.000	1.567
10.050	1.503
11.500	1.500
21.750	1.979
50.000	1.979

TABLE XIV - Continued

MODE	SIPS	SINDEL	SICC	SINDEL	SITAIL	OMEGA	GEN. MASS
1	-.02	-.03	-.04	-.13	-.21	6.22	29.5
2	.14	.15	.03	.33	.02	12.76	42.5
3	.09	.17	.01	.01	.05	14.62	113.3
4	.55	.45	-.03	-.02	.43	15.74	131.7
5	.54	.46	-.11	-.13	.36	17.91	17.3
6	-.07	-.05	-.03	-.03	.07	20.50	43.1
7	-.29	-.23	.15	.13	-.15	23.69	27.0
8	-.09	-.05	.01	.13	-.05	-	2.3
9	.16	.09	-.09	-.17	.07	41.15	43.1
10	.09	.05	-.05	-.15	.05	41.90	19.6

***** INITIAL CONDITIONS *****

ZMI= -5.849 ZMI= -.997 IMETAI= -.02125 ZCGI= -25.310
 XMAI= -20.133 XMOSE= -9.193 XCACT= -12966. XFACT= -293036.

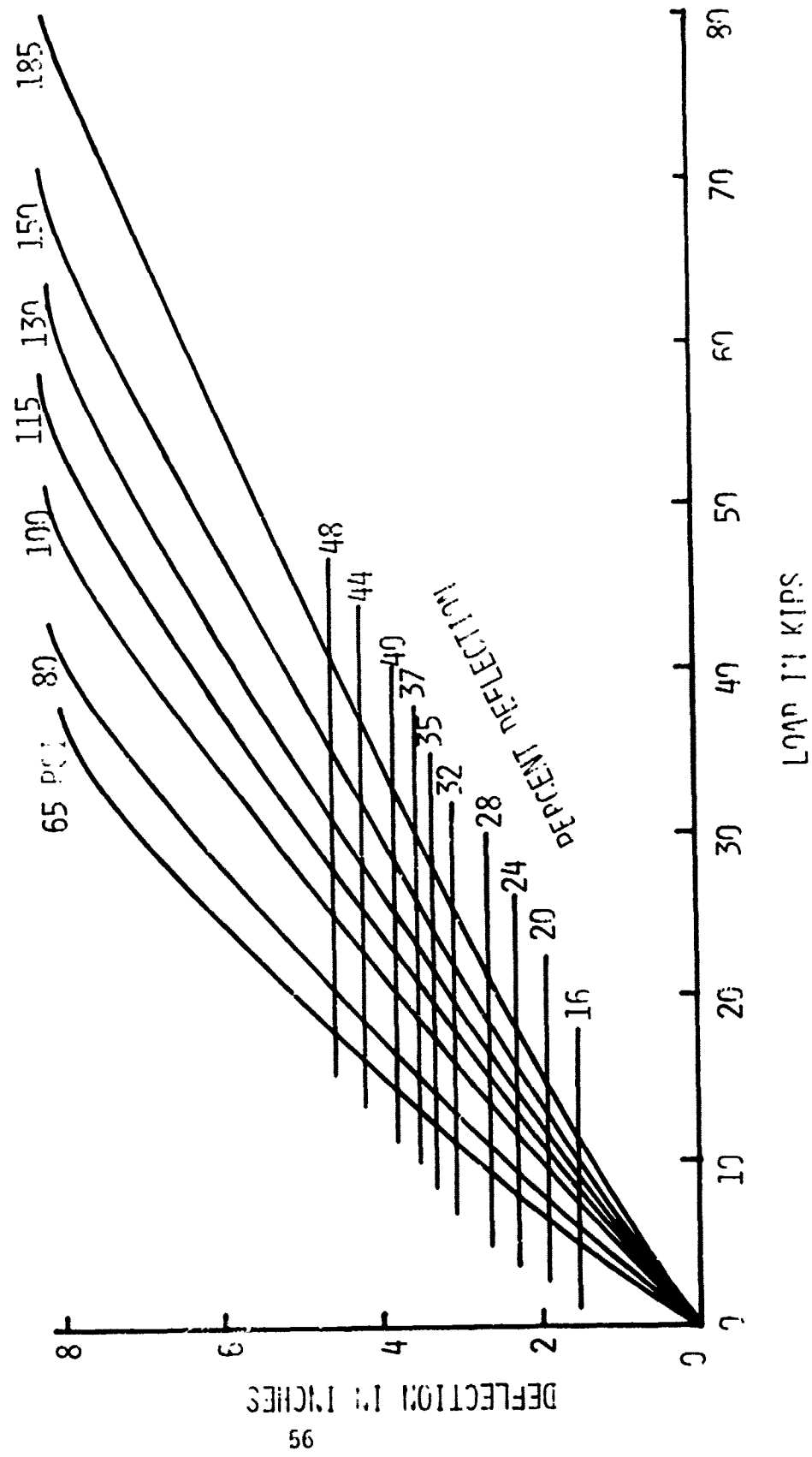


Figure 18. Class C Aircraft Nose Landing Gear Tire Deflection Curves

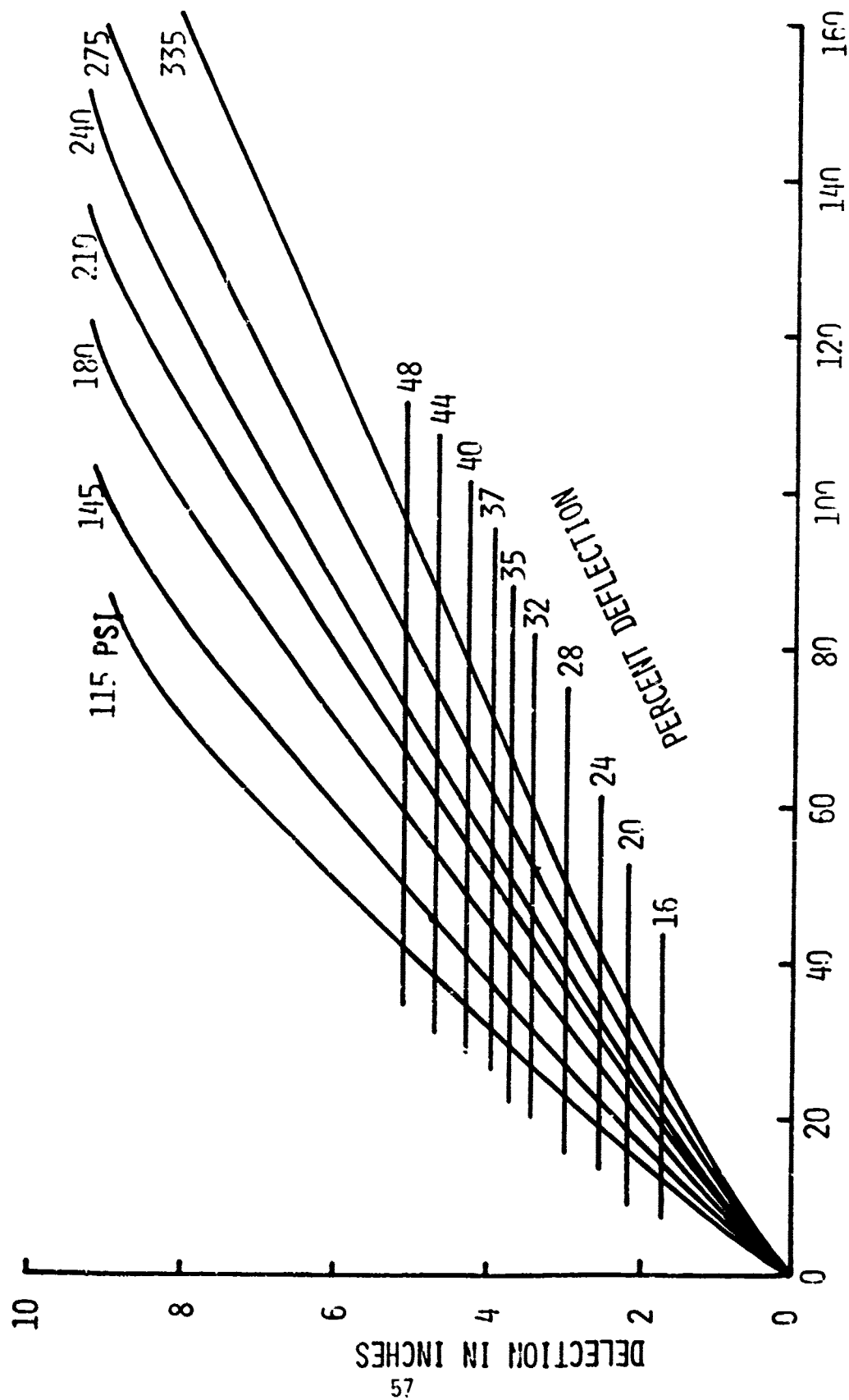


Figure 19. Class C Aircraft Main Landing Gear Tire Deflection Curves

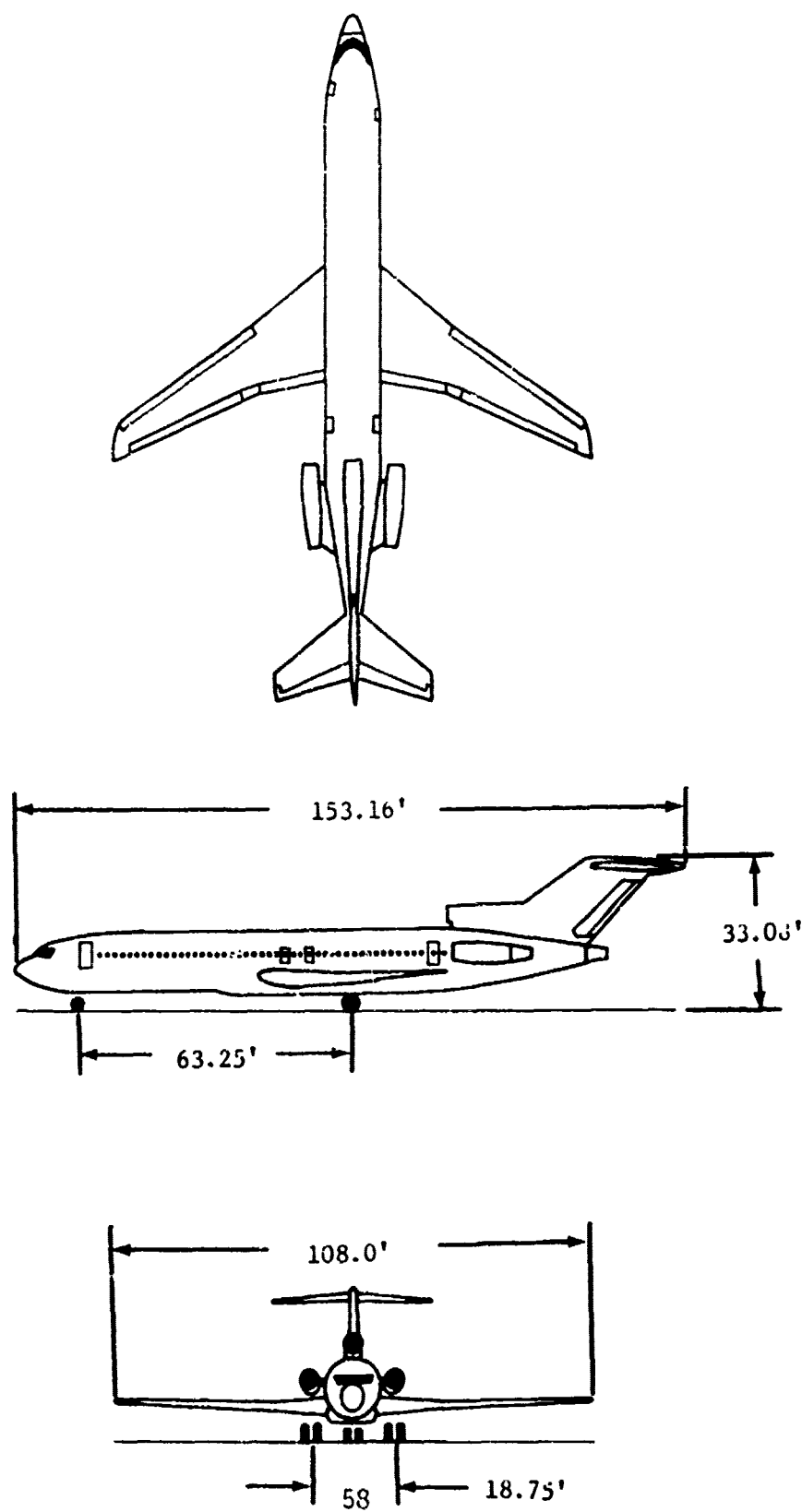


Figure 20. Class B Aircraft General Configuration

3

[illegible]

TABLE XVI - List of Data Used to Simulate Class B Aircraft

..... INPUT DATA

..... GENERAL AIRCRAFT DATA

Class B 160000 pounds Gross Weight

W= 160000.0	WM= 1363.00	MM= 495.00	A= 30.700	B= 717.500	MMI= 62000000.
SLM= 2.3	SXM= 1.0	SLM= 112.0	SLM= 104.0	PSARM= 833.9	TAILRM= 336.7
AMM= 50.20	AMM= 40.38	PAOM= 205.00	VOM= 702.00	OAM= 1.77	TSM = 20748.00
AMM= 19.00	AMM= 14.13	PAOM= 110.00	VOM= 229.90	OAM= .95	TSM = 8594.00
CL= .910	CD= .085	AREA= 1560.00	SPEED= 1.0	THRUST= 39000.	TAKOFF= 252.00

STROKE NOSE PIN DIAMETER

0.000	.976
7.450	.976
10.270	1.040
11.020	1.040
11.920	1.000
12.020	1.300

STROKE MAIN PIN DIAMETER

0.000	1.050
7.000	1.050
10.000	1.300
12.750	1.300
14.000	1.450

TABLE XVI - Continued

MOUE	SIPS	SIMOSE	SICC	JIMAIN	SITAIL	OMEGA	GEN. MASS
1	-1.23	-.09	.01	.91	-.03	15.21	0.0
2	.22	.15	-.09	-.09	-.06	10.72	0.6
3	-.21	-.13	.06	.95	-.07	20.21	4.9
4	.62	.21	-.01	.31	.95	44.92	10.1
5	.12	.06	-.01	-.00	.01	46.75	0.0
6	-.02	-.01	.05	.35	.06	47.75	5.7
7	-.14	-.06	-.06	-.97	.62	59.00	4.9
8	-.34	-.01	.01	-.01	-.16	72.45	10.5
9	.05	.15	-.06	-.07	-.04	87.96	390.7
10	.26	.05	-.1	-.02	-.01	94.31	20.0

***** INITIAL CONDITIONS *****

ZMI= -3.660 ZMI= -.953 TMEI= -.007202 ZCGI= -14.694
 XMAI= -11.113 XMOSE= -0.574 REACTN= -0.100 REACTN= -151012.

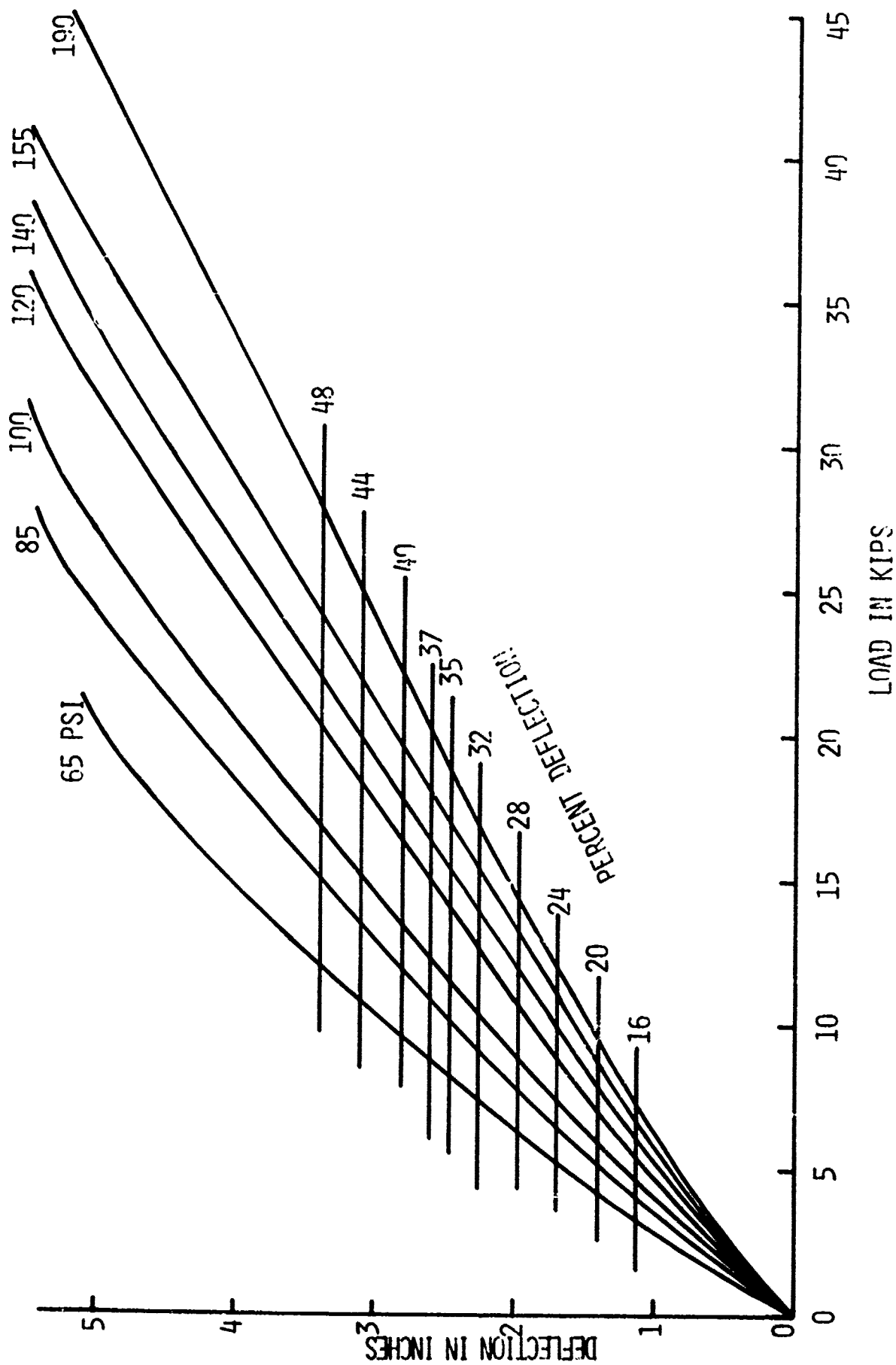


Figure 21. Class B Aircraft Nose Landing Gear Tire Deflection Curves

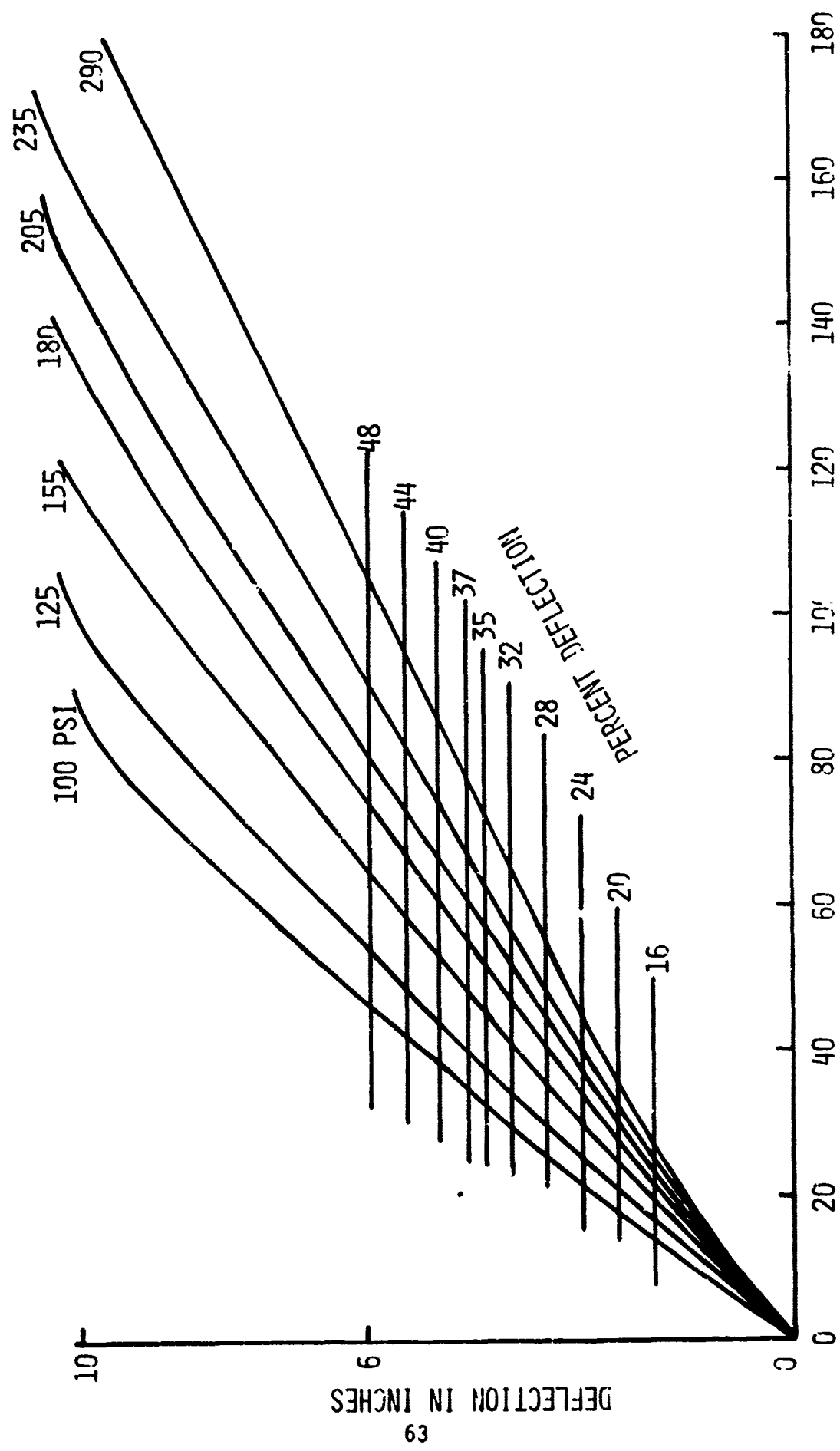


Figure 22. Class B Aircraft Main Landing Gear Tire Deflection Curves

CLASS A AIRCRAFT- 114000 POUNDS GROSS WEIGHT

WILL ROGERS INT AIRPORT

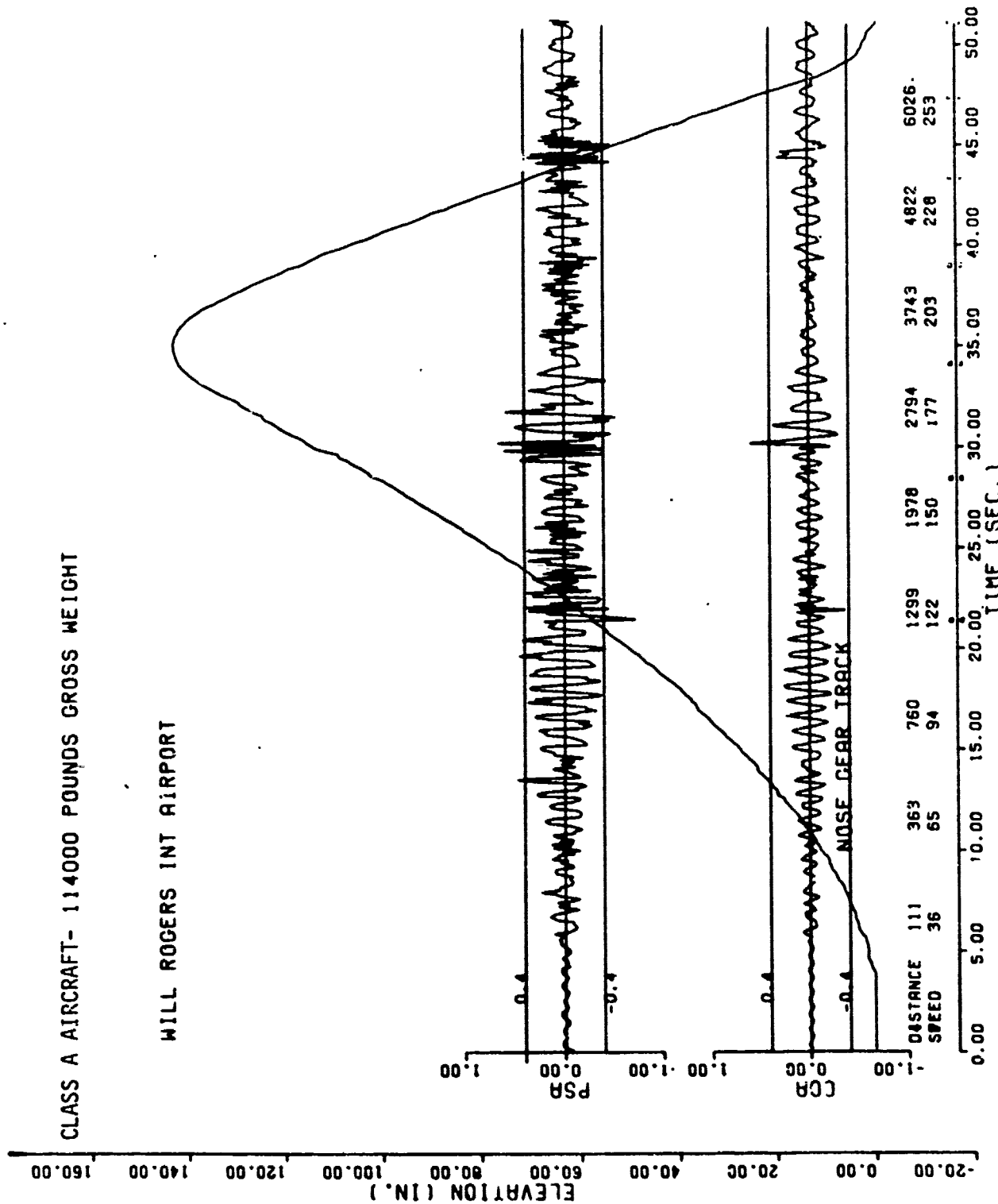


Figure 23. Plotted Results of Class A Aircraft Taking Off from the Will Rogers Profile

CLASS A AIRCRAFT 114000 POUNDS GROSS WEIGHT

DULLES INTL

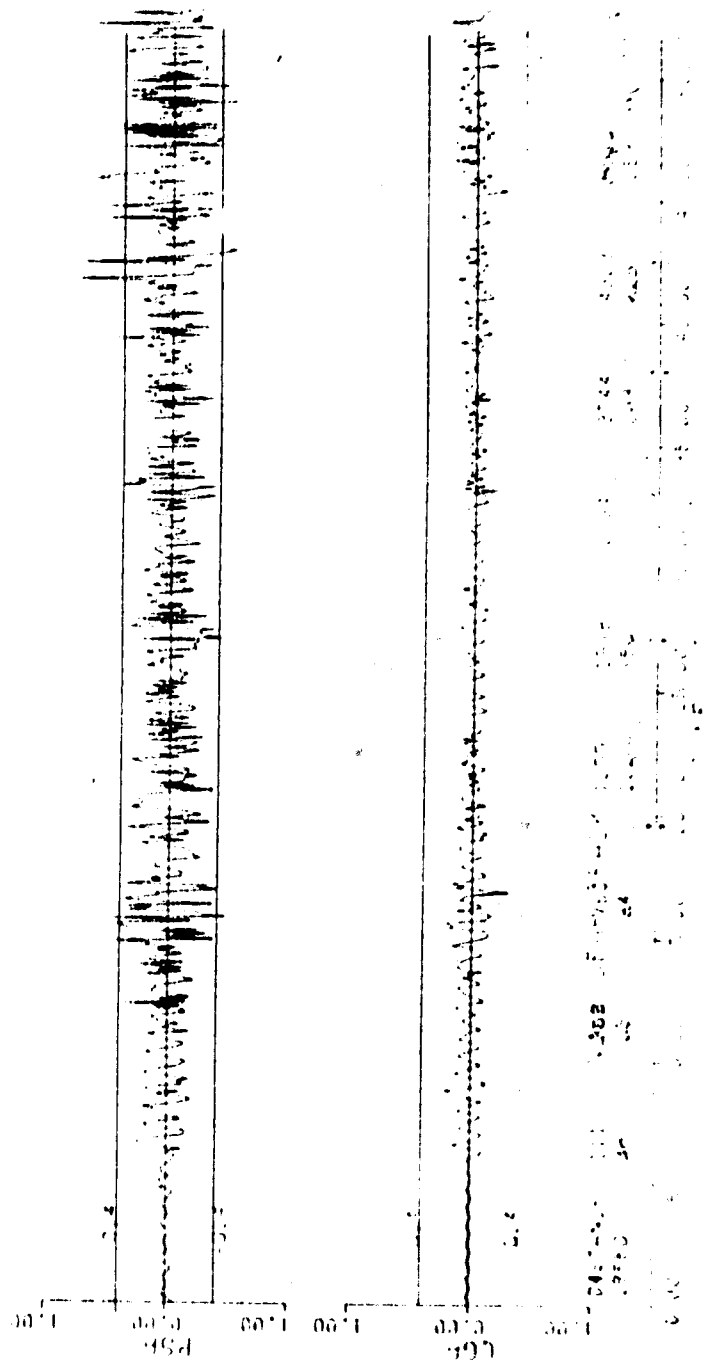


Figure 24. Plotted Results of Class A Aircraft Taking Off from the Dulles Profile

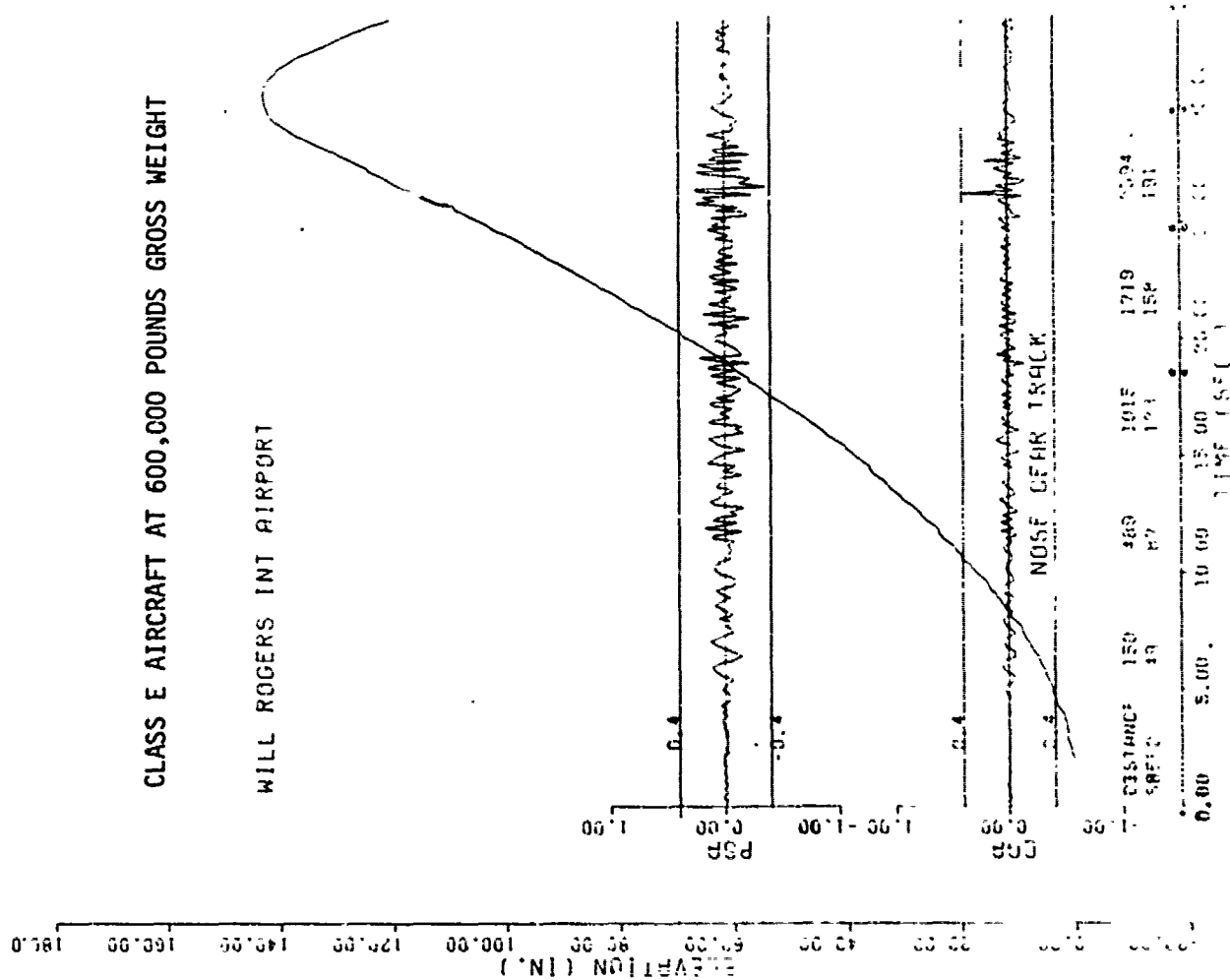


Figure 25. Plotted Results of Class E Aircraft Taking Off from the Will Rogers Profile

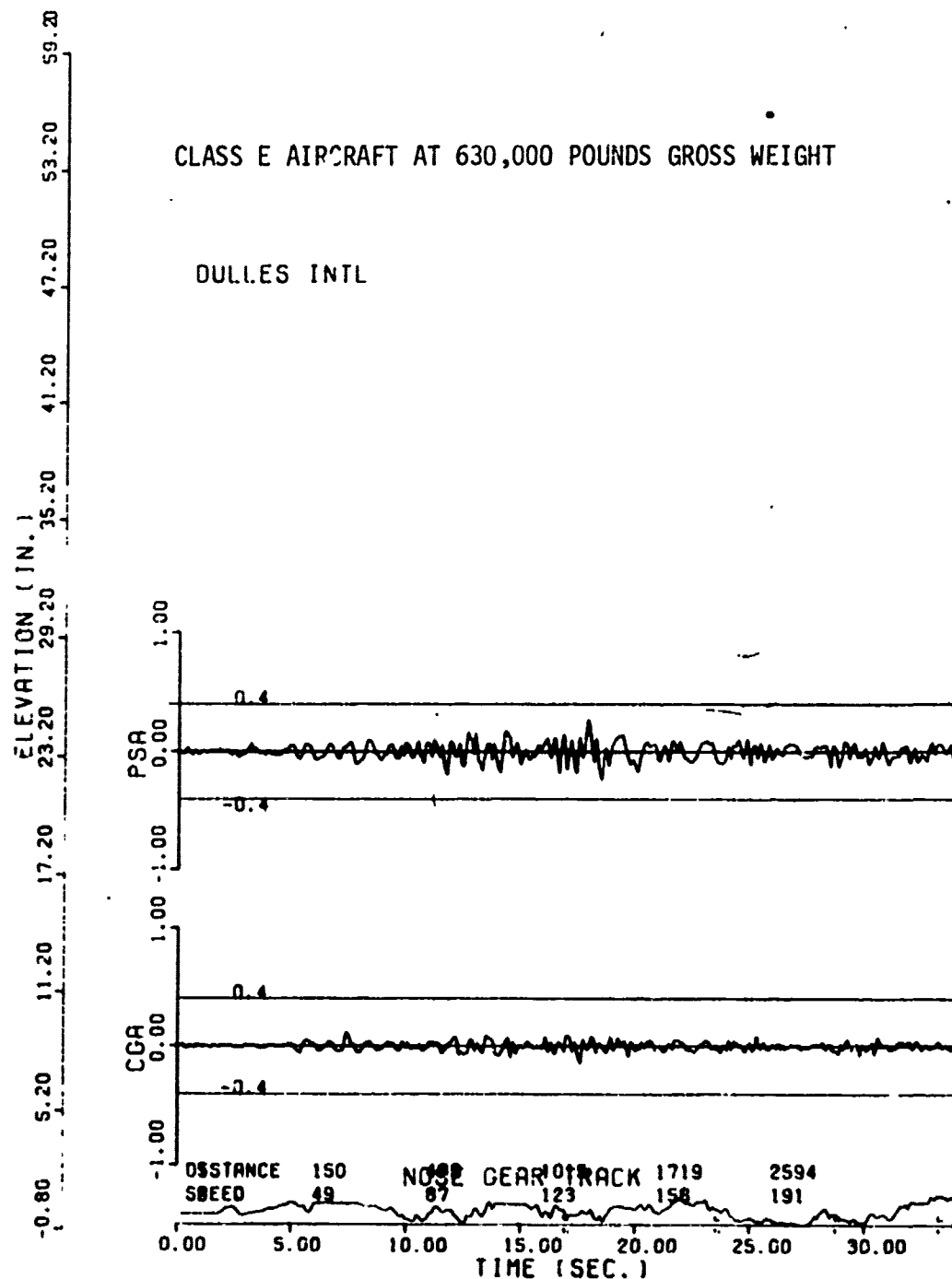


Figure 26. Plotted Results of Class E Aircraft Taking Off from the Dulles Profile

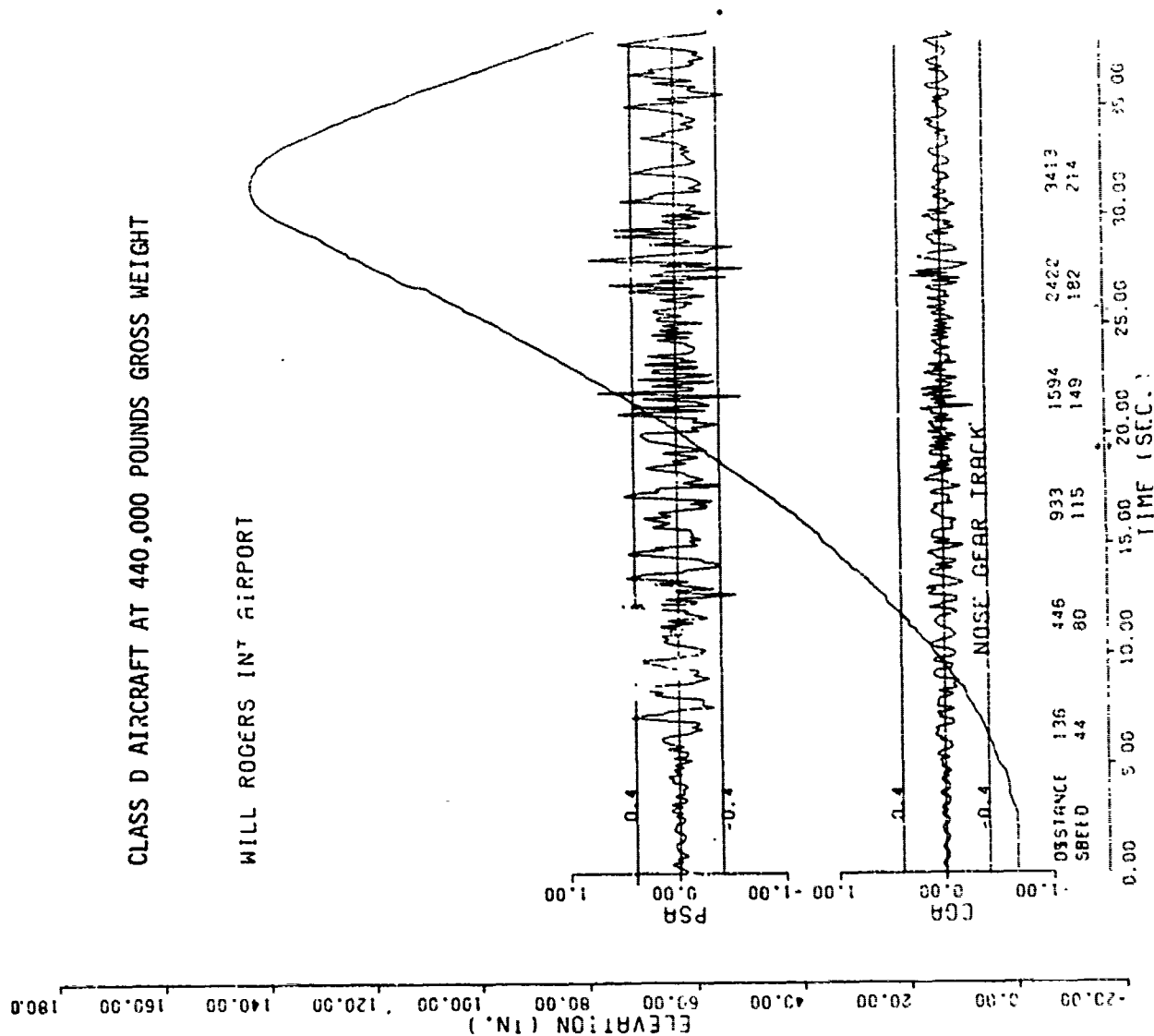


Figure 27. Plotted Results of Class D Aircraft Taking Off from the Will Rogers Profile

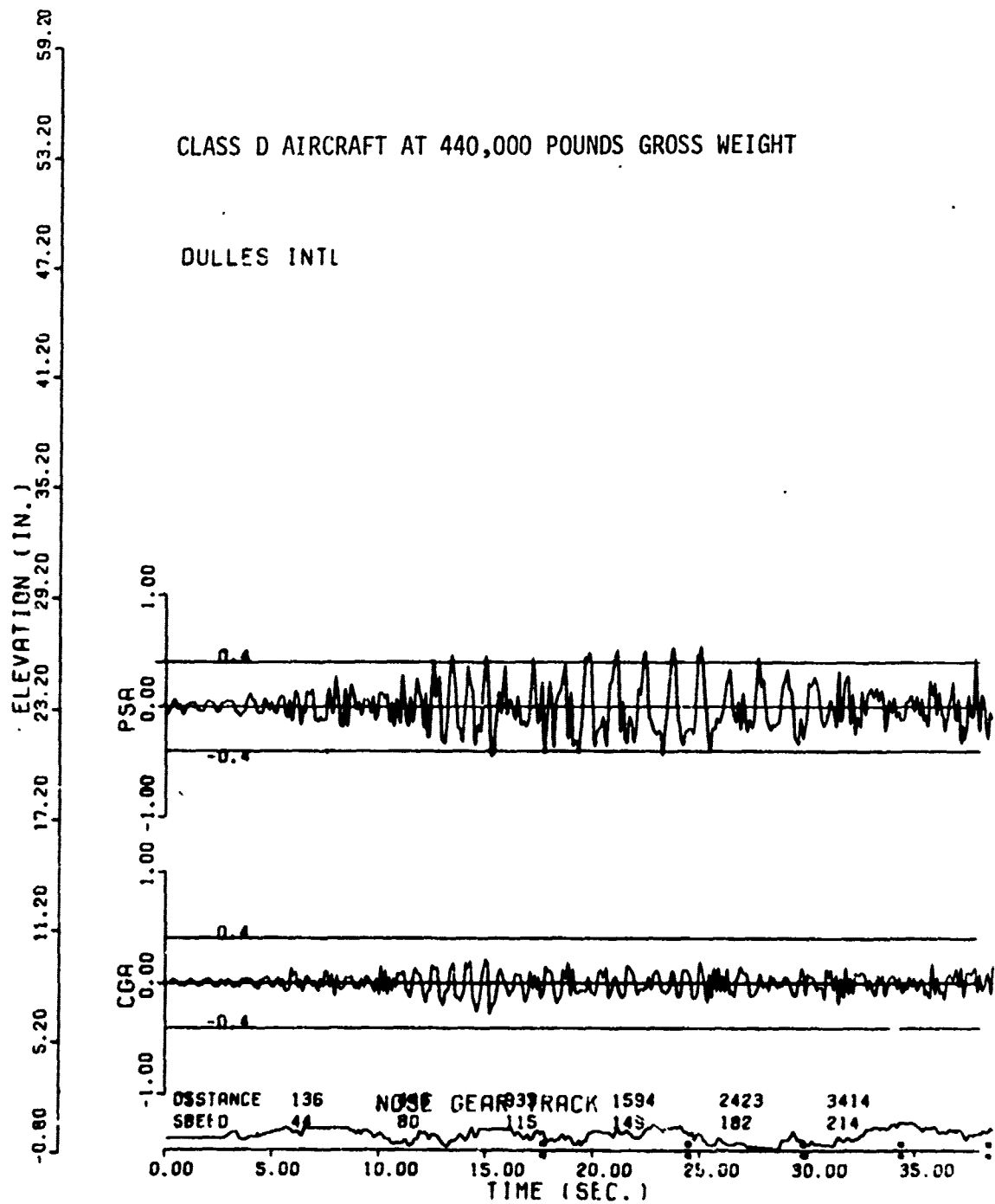


Figure 28. Plotted Results of Class D Aircraft Taking Off from the Dulles Profile

WILL ROGERS INT AIRPORT

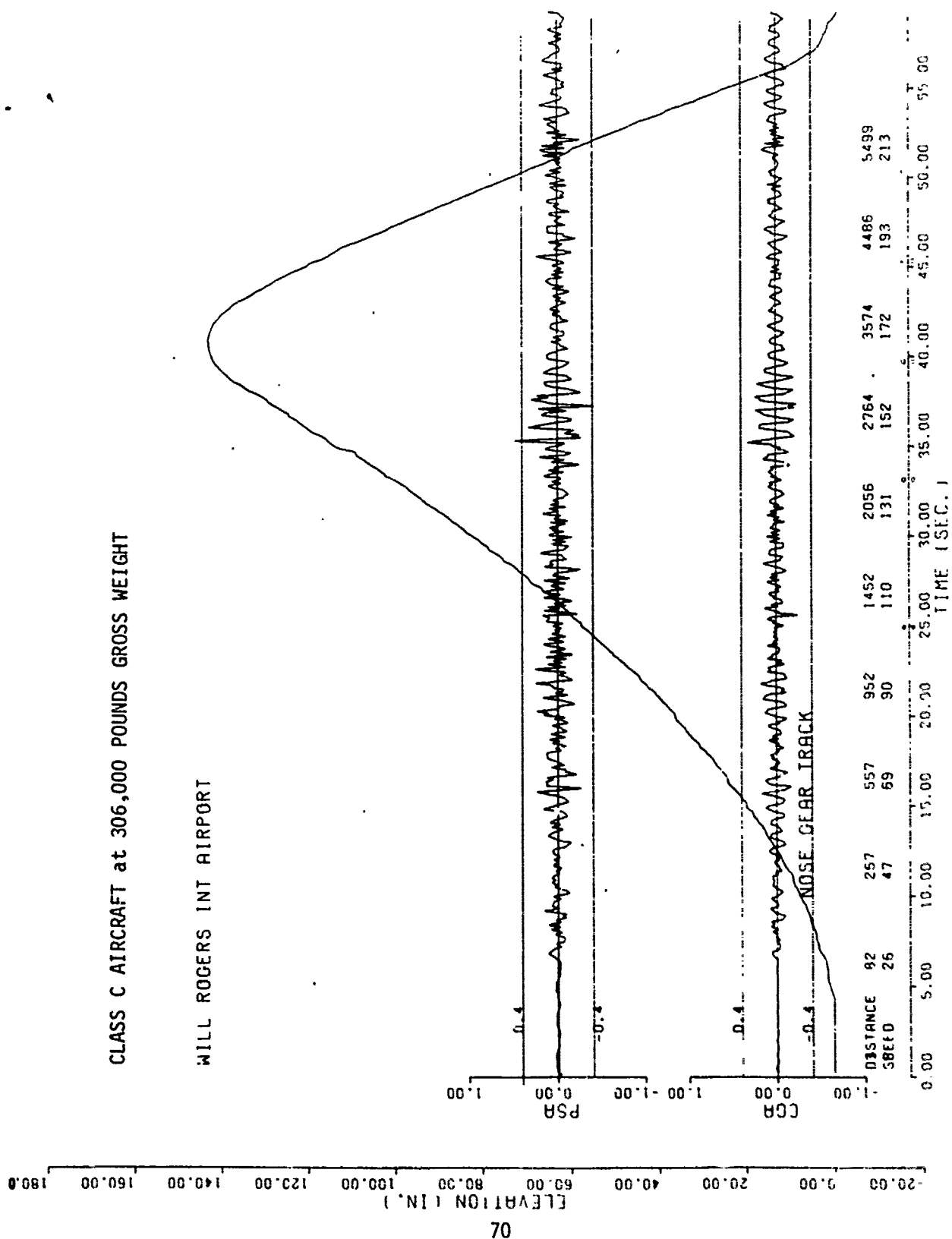


Figure 29. Plotted Results of Class C Aircraft Taking Off from the Will Rogers Profile

CLASS C AIRCRAFT AT 306,000 POUNDS GROSS WEIGHT

DULLES INTL

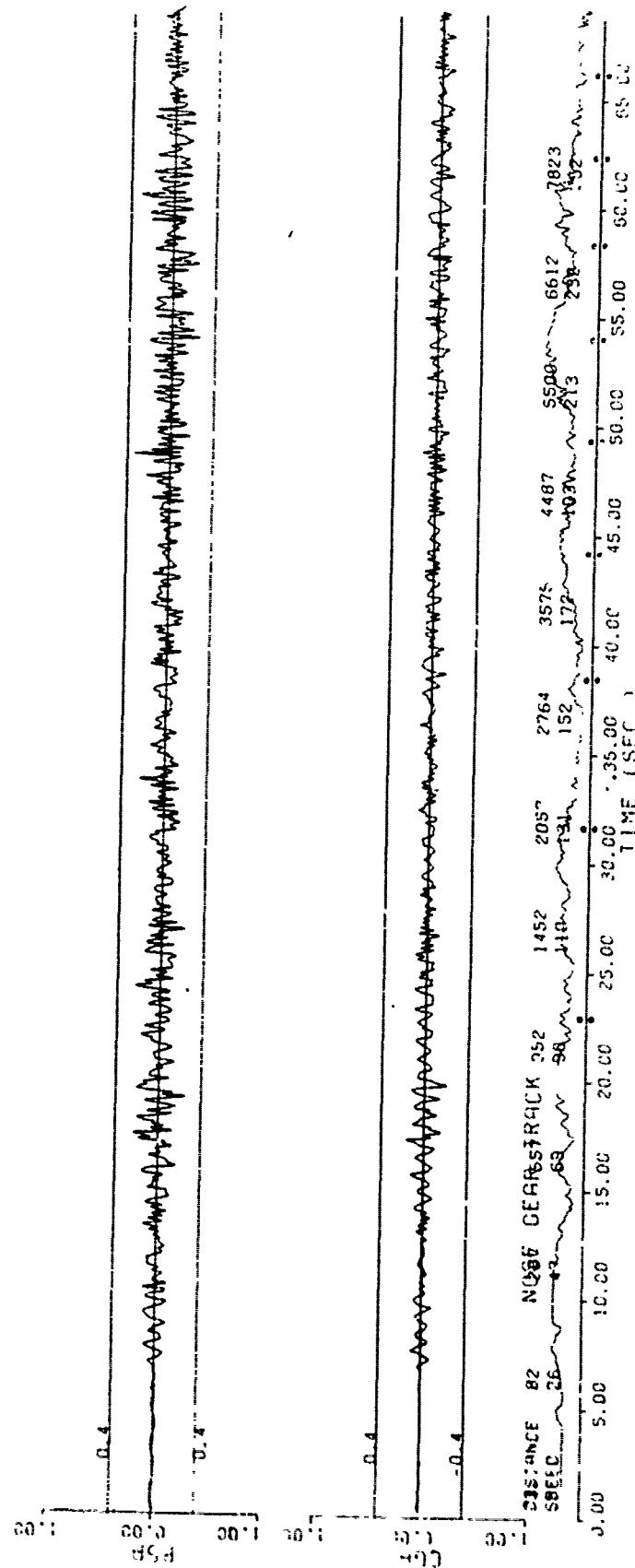


Figure 30. Plotted Results of a Class C Aircraft Taking Off from the Dulles Profile

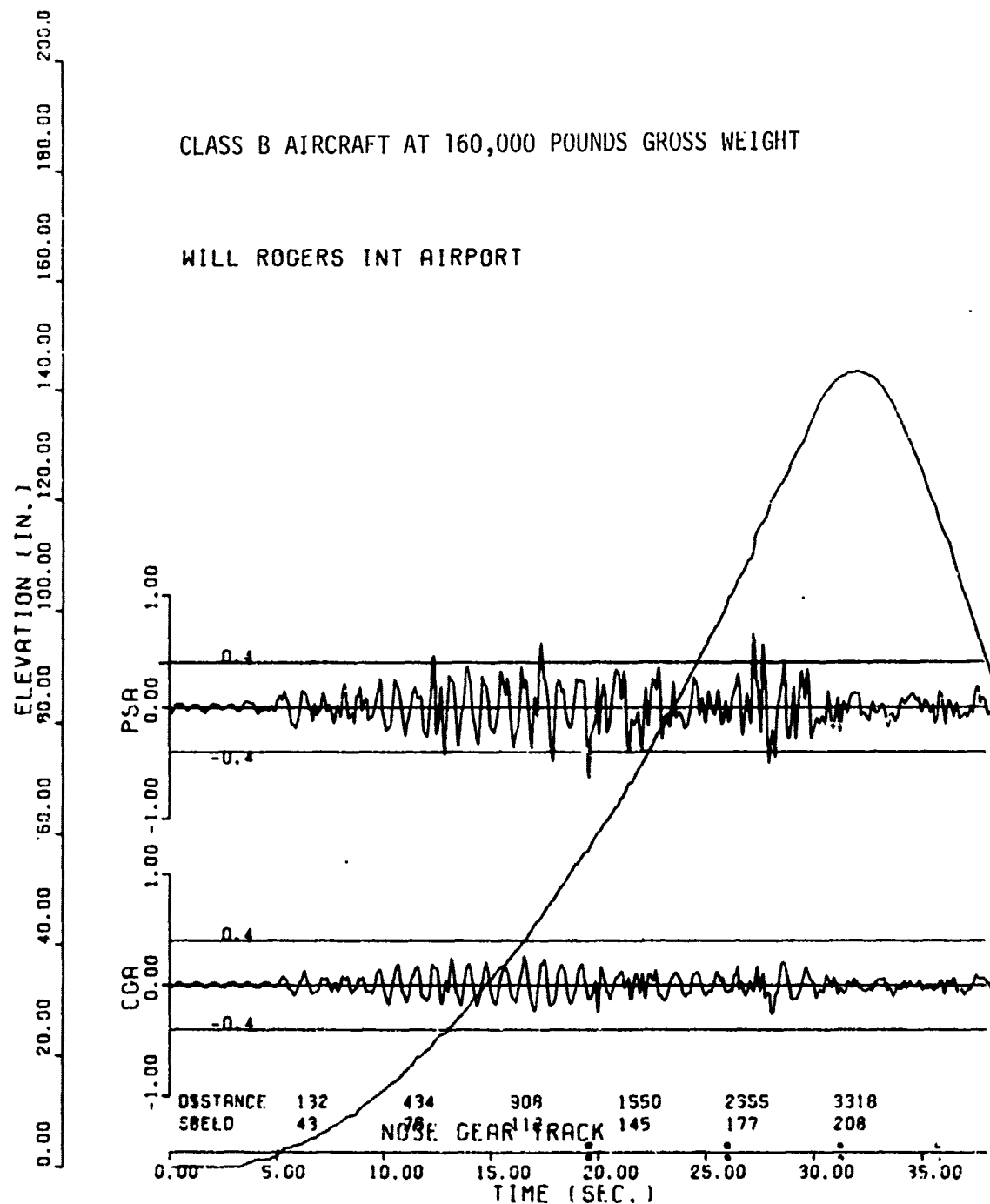


Figure 31. Plotted Results of a Class B Aircraft Taking Off from the Will Rogers Profile

Best Available Copy

CLASS B AIRCRAFT AT 160,000 POUNDS GROSS WEIGHT

DULLES INTL

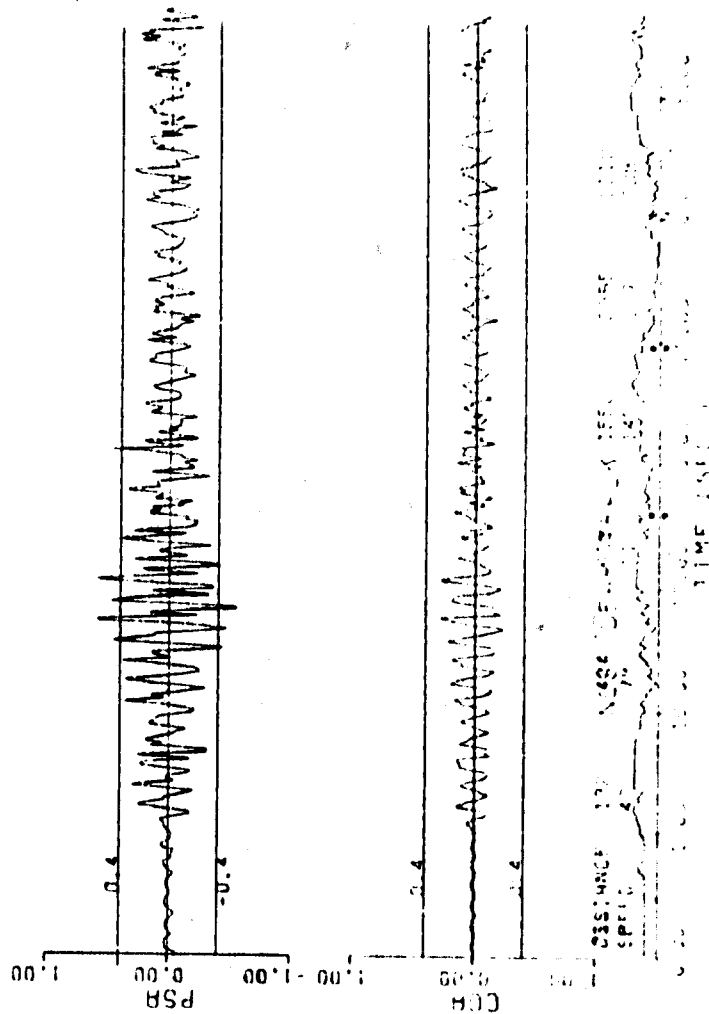


Figure 32. Plotted Results of a Class B Aircraft Taking Off from the Dulles Profile

CLASS B AIRCRAFT AT 160,000 POUNDS GROSS WEIGHT

WILL ROGERS AIRCRAFT

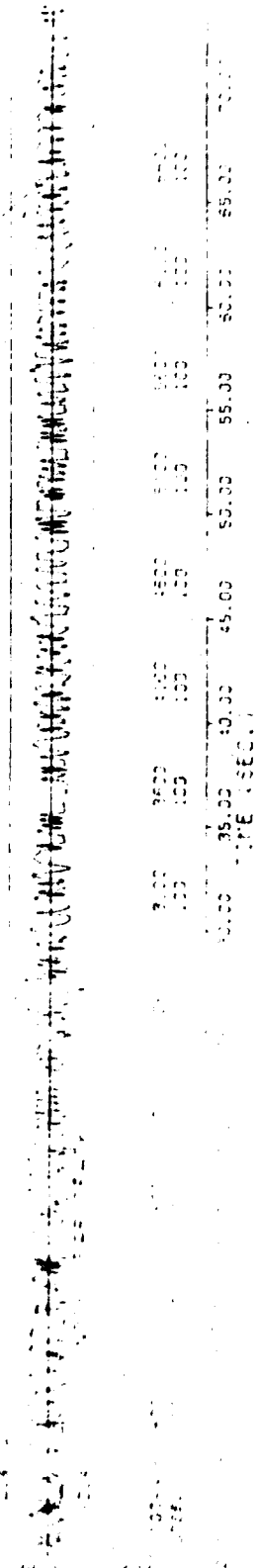
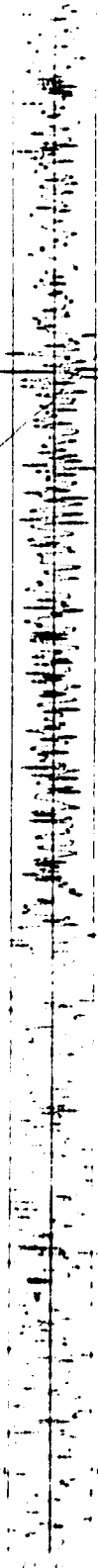


Figure 32. Plotted Results of a Class B Aircraft During Taxi over the Will Rogers profile with Strut Friction Included

Best Available Copy

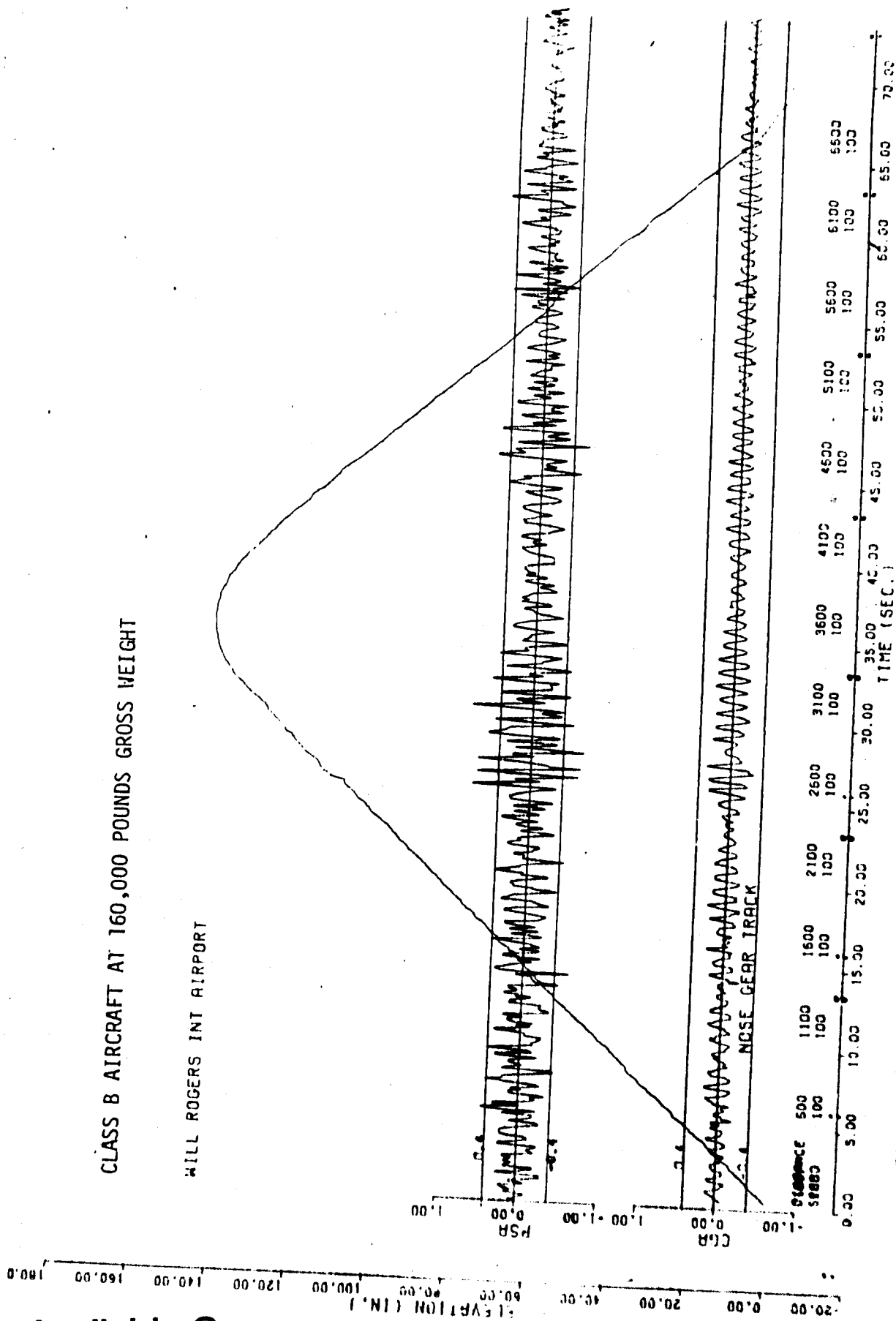


Figure 34. Plotted Results of a Class B Aircraft During Taxi over the Will Rogers Profile without Strut Friction Included

SECTION VI

CONCLUSIONS

Data have been collected and reduced to the form required by the computer program "TAXI" for simulation of five classes of commercial jet aircraft as follows:

<u>Aircraft Class</u>	<u>Gross Weight Range-Pound</u>
Class A	Less than 150,000
Class B	150,000 - 300,000
Class C	300,000 - 450,000
Class D	450,000 - 600,000
Class E	Greater than 600,000

Each of these aircraft has been successfully simulated traversing the profiles of Will Rogers International Airport in Oklahoma City, Oklahoma and Dulles International Airport in Washington DC. Results of these simulations indicate that aircraft response to runway roughness is highly dependent on aircraft parameters such as gear stiffness, gear spacing and the degree of coupling between the rigid body modes of vibration, as well as the degree of runway roughness.

The addition of the strut bearing friction forces in the simulation of Class B aircraft has a small effect on the vertical acceleration level at the pilot's station.

REFERENCES

1. Gerardi, A. G., Lohwasser, A. K., Computer Program for the Prediction of Aircraft Response to Runway Roughness, AFWL-TR-73-109, Volume I and II, Air Force Weapons Laboratory, Kirtland AFB, New Mexico, September 1973.
2. Chance Vought Corporation, A Rational Method for Prediction A Lighting Gear Dynamic Loads, ASD-TDR-62-555, Aeronautical Systems Division, Wright-Patterson AFB, Ohio, December 1963.

APPENDIX A

COMPUTER LISTING FOR THE GENERAL COMPUTER PROGRAM CALLED "TAXI"

```

PROGRAM TAXI(INPUT,OUTPUT,TAPES=INPUT,TAPES=OUTPUT,PLOT,TAPE2,
1 TAPE3)
.....
C THIS PROGRAM WILL PERFORM A SYMMETRIC
C DYNAMIC TAXI ANALYSIS ON A FLEXIBLE
C VEHICLE TRAVERSING A GIVEN RIGID RUNWAY
C PROFILE.
.....
COMMON/PLEX1/SIMIN(15),SINOS(15),SICG(15),SITAIL(15),SIPS(15)
COMMON/PLEX2/NPH,CH(15),OMEGA(15)
COMMON/PLEX3/Q(15),QO(15),QOO(15)
COMMON/X1/H,NH,MH,MCG,MH,MH,A,B,MH
COMMON/X2/PAON,VON,AM,AM,AM,AM,AM
COMMON/X3/PAON,VON,AM,AM,AM,AM,AM
COMMON/X4/SIN,SIN,SLM,SLM,ISM,ISM
COMMON/X5/CL,CD,AREA,THRUST
COMMON/X6/Z,REACTN,REACTN,DE,MTAUM
COMMON/X7/AM,BN,CH,CH,AM,AM,CH,CH
COMMON/X8/STROCH(20),PIMON(20),STROCH(20),PIMON(20),MSCH,MSCH
COMMON/X9/PSA,PSA,FTM,FTM,MAIN,INOS,VELM,VELM
COMMON/X10/ZP4,ZP4
COMMON/X11/PPM,PPM
COMMON/X12/CON,CON
DIMENSION PLANE(8),SITE(8)
DIMENSION T(12),T0(12),T00(12)
DIMENSION ELEV(7000)
DIMENSION YP(4),YPH(4),BATA(430)
DIMENSION CCACC(1300),TIME(1300),PSACC(1300),TIME1(1300)
DIMENSION PROP(1300),MARK(130)
DIMENSION SSPLOT(1300),STIME(1300),OOPLOT(1300)
REAL MCG,MH,MH,MH
PSA=0.0
CGOUT=0.0
LOR=0
MOR=0
X=0
LLL=1
LL=0
STORE1=0.
STORE2=0.
STORE3=0.
STORE4=0.
MH=0
II=0
PP=1.0
M=1
ITT=0
.....
C READ AND PRINT INPUT DATA
C .....
C M=VEHICLE WEIGHT AT CG (POUNDS)
C A=DISTANCE MAIN GEAR TO CG (INCHES)
C B=DISTANCE NOSE GEAR TO CG (INCHES)

```



```

90  FORMAT(//, 2X,12.64F7.2,2X),F10.13
C ZNI =INITIAL MAIN GEAR POSITION INCHES
WRITE(6,95)
175
95  FORMAT(//,48X,48H***** INITIAL COMITIONS *****
C ZNI =INITIAL NOSE GEAR POSITION INCHES
C ZCGI=INITIAL C.G. POSITION INCHES
C THETA=INITIAL PITCH ANGLE DEGREES
C THE ABOVE PARAMETERS ARE CALCULATED IN SUBROUTINE IC
CALL IC( ZCGI,ZNI,ZMI,THETA)
WRITE(6,105) ZMI,ZNI,THETA,ZCGI
180
105  FORMA(//,5X,4HZN=,F10.3,5X,4HMNI=,F10.3,5X,7HMETAI=,F10.6,
15X,5HZCGI=,F10.3)
REACTN=ZNI*ISM 1*SM
REACTM=ZMI*ISM 1*SM
WRITE(6,106) XMAIN,XMOSE,REACTM,REACTN
185
106  FORMAT (//,3X,4HMAIN=,F8.3,3X,4HMOSE=,F8.3,3X,4HREACTM=,F10.6,
13X,4HREACTN=,F10.6)
*****
C READ RUNWAY PROFILE DATA (LEV)
C SITE= RUNWAY PROFILE AND DIRECTION
C MPTSS=0 OF RUNWAY ELEVATION DATA POINTS
WRITE (6,111)
190
111  FORMAT(//,
DO 112 I=1,50
195
112  ELEV(I)=0.0
READ(2,113) SITE
READ(2,114) MPTSS
MPTSS=MPTSS+59
200
116  FORMAT(6)
LO=51
117  LSD = LO + 9
READ(2,118) (ELEV(I),I=LO,LSD)
118  FORMAT(10F7.3)
M10=LO
IF (LSD.GE.MPTSS) GO TO 120
LO=LO+13
GO TO 117
120  ELEV1=ELEV(51)
DO 125 I=51,M10
125  ELEV(I) = (ELEV(I)-ELEV1)*12.0
DISTAN=0.
LSD=LSD-98
SLP=(LSD-50)*2
SLP=ELEV(LSD)/SLP
DO 126 I=51,M10
126  ELEV(I)=ELEV(I)-SLP*DISTAN
DISTAN=DISTAN+2.
IVAL=(VAL+25)/25.
WRITE(6,130)
130  FORMAT(1H1,5X,0 RUNWAY PROFILE DATA NORMALIZED (SLOPE REMOVED)
150X,0FEET DOWN THE RUNWAY)
WRITE(6,131) SITE
LO1=1
135  LSD1 = LO1 + 9
LPRIM = LSD1 + 2
WRITE(6,140) (ELEV(I),I=LQ1,LSD1),LPRIN
140  FORM(13H,10F10.5,10X,10)

```

TAXI1720
TAXI1730
TAXI1740
TAXI1750
TAXI1760
TAXI1770
TAXI1780
TAXI1790
TAXI1800
TAXI1810
TAXI1820
TAXI1830
TAXI1840
TAXI1850
TAXI1860
TAXI1870
TAXI1880
TAXI1890
TAXI1900
TAXI1910
TAXI1920
TAXI1930
TAXI1940
TAXI1950
TAXI1960
TAXI1970
TAXI1980
TAXI1990
TAXI2000
TAXI2010
TAXI2020
TAXI2030
TAXI2040
TAXI2050
TAXI2060
TAXI2070
TAXI2080
TAXI2090
TAXI2100
TAXI2110
TAXI2120
TAXI2130
TAXI2140
TAXI2150
TAXI2160
TAXI2170
TAXI2180
TAXI2190
TAXI2200
TAXI2210
TAXI2220
TAXI2230
TAXI2240
TAXI2250
TAXI2260
TAXI2270
TAXI2280


```
160 TO 180
175 STORE1 = STORE2
STORE2 = CGOUT
GO TO 190
180 IF (X-TIME(NN).GT..00) GO TO 185
IF (ABS(STORE2).GT..3600) GO TO 185
GO TO 175
195 NN = NN + 1
CGACC(NN) = STORE2
PRUF(NN) = ZPN
TIME(NN) = X - 10. * DX
IF (TIME(NN).LT.0.) TIME(NN) = .01
STORE1 = STORE2
STORE2 = CGOUT
190 IF (ABS(PSA).LE.ABS(STORE1).AND.ABS(STORE1).GE.ABS(STORE2))
160 TO 295
200 STORE3 = STORE4
STORE4 = PSA
GO TO 215
205 IF (X-TIME(LL).GT..00) GO TO 210
IF (ABS(STORE4).GT..32) GO TO 210
GO TO 200
210 LL = LL + 1
PSACC(LL) = STORE4
TIME(LL) = X - 10 * DX
IF (TIME(LL).LE.0.) TIME(LL) = .001
STORE3 = STORE4
STORE4 = PSA
215 IF (ABS(T(10)-RM).LT.5.0) GO TO 220
GO TO 225
220 II = II + 1
MARK(II) = X/5.
RM = RM + 1000.
ITT = II
225 IF (HOR.LE.80.) GO TO 235
HOR = 0.
WRITE(6,155)
235 HOR = HOR + 1.
240 X = X + DX
IF (ABS(X-PP).GT..0000) GO TO 230
SSPLOT(LLL) = T(10)
STIME(LLL) = X/5.
DGPLOT(LLL) = T(10)
LLL = LLL + 1
FF = PP + 5.0
*****
230 CONTINUE
CALL TAYLOR(T,T0,T00)
IF (T(10).GE.ENDRUN) GO TO 260
IF (X-GE.300.) GO TO 263
TIMEX=TIME+DX
GDCCG=0.
CCGPS=0.
GDOTAL=0.
DO 241 I=1,NFM
QUOTAL=QUOTAL+QD0(I)*SITAIL(I)
QDCCG=QDCCG+QD0(I)*SICG(I)
240
```

TAXI2860
TAXI2870
TAXI2880
TAXI2890
TAXI2900
TAXI2910
TAXI2920
TAXI2930
TAXI2940
TAXI2950
TAXI2960
TAXI2970
TAXI2980
TAXI2990
TAXI3000
TAXI3010
TAXI3020
TAXI3030
TAXI3040
TAXI3050
TAXI3060
TAXI3070
TAXI3080
TAXI3090
TAXI3100
TAXI3110
TAXI3120
TAXI3130
TAXI3140
TAXI3150
TAXI3160
TAXI3170
TAXI3180
TAXI3190
TAXI3200
TAXI3210
TAXI3220
TAXI3230
TAXI3240
TAXI3250
TAXI3260
TAXI3270
TAXI3280
TAXI3290
TAXI3300
TAXI3310
TAXI3320
TAXI3330
TAXI3340
TAXI3350
TAXI3360
TAXI3370
TAXI3380
TAXI3390
TAXI3400
TAXI3410
TAXI3420

```

241  QDOPS=QDOPS+QDOP(I)*SIPS(I)
    TAILAC=(TOD(2)+TAILRM-TOD(0))/306. +QDOTAL/306.
    PSAM=(TOD(2)-PSARM-TOD(0))/306. +QDOPS/306.
    CGOUT=TOD(2)/306. +QDCCG/306.
    IF(TOD(10).GE.TAKOFF) GO TO 250
    IF(2.LT.4.) GO TO 245
    DZ=2-4.
    J=J+2
    IVAL=IVAL+2
    GO TO 160
245  IF(TIMEX-1.T-DEETE) GO TO 240
    DEETE=.02
    GO TO 165
250  WRITE(6,255)
255  FORMAT(5X,'THE VEHICLE WAS TAKEN OFF')
260  WRITE(6,262) ENDRUN,T(10)
262  FORMAT(3X,'END OF RUNWAY',2F10.3)
    .....
263  MCM = X
    PSMS=8.
    CGMS=8.
    DO 261 I=1,MN
    261  CGMS=CGMS+CGACC(I)*2
    DO 264 I=1,LL
    264  PSMS=PSMS+PSACC(I)*2
    PSMS=10.*SQRT(PSMS)/FLOAT(LL)
    CGMS=10.*SQRT(CGMS)/FLOAT(MN)
    WRITE(6,265) PSMS,CGMS
260  FORMAT(7X,'100 PSMS=',F10.3,10X,'100 CGMS=',F10.3)
    IF(1.PLOT.EQ.1) GO TO 265
    XLONG = FLOAT(MCM)/5.
    WRITE(6,265) MN,LL
    265  FORMAT(2I20)
    IF(MN.LE.1000.OR.LL.LE.1000) GO TO 266
    WRITE(6,267)
    267  FORMAT(3X,'THE ARRAYS CGACC OR PSACC OR PROF HAVE EXCEEDED
    1 THEIR DIMENSIONED SIZE')
    264  CALL PLOO(DATA,430)
    CALL FACTOR(2.0)
    CALL PLOT(0.0,-11.0,-3)
    CALL PLOT(3.0,-7,-3)
    TIME(MN*2) = 0.0
    TIME(MN*2) = 5.0
    TIME(1,LL*2) = 0.0
    TIME(1,LL*2) = 5.0
    CGACC(MN*2) = -1.0
    CGACC(MN*2) = 1.0
    PSACC(LL*2) = -1.0
    PSACC(LL*2) = 1.0
    PSACC(LL*2) = 1.0
    CALL SCALE(1,PROF,10.,MN,1)
    PROF(10) = PROF(MN*2) *10.
    IF(1,PROF(10).GT.10.5) GO TO 270
    PROF(MN*2) = 6.0
    IF(1,PTSS-6E.1000) GO TO 270
    DO 269 I=1,MN
    269  PROF(I)=PROF(I)*36.
    270  CALL ABSS(0.0,1.0,TIME 1SEC.),-11,XLONG,0.0,TIME IN

```

TAXI3430
 TAXI3440
 TAXI3450
 TAXI3460
 TAXI3470
 TAXI3480
 TAXI3490
 TAXI3500
 TAXI3510
 TAXI3520
 TAXI3530
 TAXI3540
 TAXI3550
 TAXI3560
 TAXI3570
 TAXI3580
 TAXI3590
 TAXI3600
 TAXI3610
 TAXI3620
 TAXI3630
 TAXI3640
 TAXI3650
 TAXI3660
 TAXI3670
 TAXI3680
 TAXI3690
 TAXI3700
 TAXI3710
 TAXI3720
 TAXI3730
 TAXI3740
 TAXI3750
 TAXI3760
 TAXI3770
 TAXI3780
 TAXI3790
 TAXI3800
 TAXI3810
 TAXI3820
 TAXI3830
 TAXI3840
 TAXI3850
 TAXI3860
 TAXI3870
 TAXI3880
 TAXI3890
 TAXI3900
 TAXI3910
 TAXI3920
 TAXI3930
 TAXI3940
 TAXI3950
 TAXI3960
 TAXI3970
 TAXI3980
 TAXI3990

```

400 1TIME(MN+2)
    XLONG = XLONG
    CALL PLOT (XLONG,1,1,3)
    CALL PLOT (XLONG,1,1,2)
    CALL SYM90L (-1.4,105,90DISTANCE,0.0,1)
    CALL SYM90L (-1.2,105,90SPEED,0.0,1)
    DO 275 I=1,XLONG
        CALL NUM90ESTIME(I,2,105,SSPLOT(I),0.0,-1)
275  CALL NUM90ESTIME(I,4,105,DDPLOT(I),0.0,-1)
        CALL PLOT (XLONG,1,5,3)
        CALL PLOT (XLONG,1,5,2)
    DO 280 I=1,IIT
280  CALL SYM90LIRMARK(I,1,245,14,0,0,1)
        CALL PLOT (XLONG,1,9,3)
        CALL PLOT (XLONG,1,9,2)
        CALL SYM90L(0,9,14,PLANE,0.0,40)
        CALL SYM90L(0,8,14,STITE,0.0,40)
        CALL SYM90L(4,7,14,10M100CGRMS,0.0,1)
        CALL SYM90L(4,6,5,14,10M100PSRMS,0.0,1)
        CALL NUM90EST(5,7,14,CGRMS,0,1)
        CALL NUM90EST(5,6,5,14,PSRMS,0,1)
    XLONG2=XLONG/2
    CALL SYM90L(XLONG2,0,5,14,11MAFFDL -FYS,0.0,11)
    CALL SYM90L(XLONG2,7,5,14,10M100PFB OHIO,0.0,10)
    CALL PLOT(0,1,5,-3)
    CALL AXIS(0,-1,3MCGA,3,2,0,70,CGACC(MN+1),CGACC(MN+2))
    CALL NUM90EST(0,4,4,105,4,0,0,1)
    CALL NUM90EST(0,5,4,105,4,0,0,1)
    CALL PLOT(0,-1,0,-3)
    CALL LIME(TIME,CGACC,MN,1,0,74)
    CALL PLOT (XLONG,3,1,3)
    CALL PLOT (0,3,1,2)
    CALL AXIS(0,-1,3MPSA,3,2,0,90,PSACC(LL+1),PSACC(LL+2))
    CALL PLOT(0,3,0,3)
    CALL PLOT(XLONG,0,2)
    CALL PLOT (XLONG,4,3)
    CALL PLOT (-1,4,2)
    CALL NUM90EST(0,5,4,105,4,0,0,1)
    CALL NUM90EST(0,4,5,105,4,0,0,1)
    CALL PLOT(0,-1,0,-3)
    CALL LIME(TIME,PSACC,LL,1,0,74)
    CALL PLOT(0,-3,0,-3)
    CALL AXIS(-1,0,0,15MELEVATION (IN,1,15,10,0,90,0,PROF(MN+1),
1PROF(MN+2))
    CALL PLOT(0,0,0,-3)
    XPROF=.25*ABS(1PROF(MN+1))/PROF(MN+2)
    CALL SYM90L (2,XPROF,14,15HMOSE GEAR TRACK,0.0,15)
    CALL LIME(TIME,PROF,MN,1,0,74)
    XSTOP=XLONG*5
    CALL PLOT (XSTOP,0,-3)
    MTIME(6,290)
    CALL PLOT
285 STOP
290 FORMAT('S01
END
455

```

TAXI400
TAXI410
TAXI420
TAXI430
TAXI440
TAXI450
TAXI460
TAXI470
TAXI480
TAXI490
TAXI500
TAXI510
TAXI520
TAXI530
TAXI540
TAXI550
TAXI560
TAXI570
TAXI580
TAXI590
TAXI600
TAXI610
TAXI620
TAXI630
TAXI640
TAXI650
TAXI660
TAXI670
TAXI680
TAXI690
TAXI700
TAXI710
TAXI720
TAXI730
TAXI740
TAXI750
TAXI760
TAXI770
TAXI780
TAXI790
TAXI800
TAXI810
TAXI820
TAXI830
TAXI840
TAXI850
TAXI860
TAXI870
TAXI880
TAXI890
TAXI900
TAXI910
TAXI920
TAXI930
TAXI940
TAXI950
TAXI960
TAXI970
TAXI980
TAXI990
TAXI1000

```

SUBROUTINE TAYLOR(TD,YDD)
COMMON/FLX1/SINAM(15),SINOS(15),SIRG(15),SIRAL(15),SIPS(15)
COMMON/FLX2/AFM,CH(15),OMEGA(15)
COMMON/FLX3/Q(15),QO(15),QOO(15)
COMMON/11/M,NM,MM,CCG,MH,MMA,B,MHI
COMMON/12/PAOM,VOP,AAH,AHM,DAH
COMMON/13/PAOM,VOM,AAH,AHM,DAH
COMMON/14/SX,SM,SLM,TSN,TSN
COMMON/15/CL,CD,AREA,THRUST
COMMON/16/7,REACTN,REACTN,DX,MTRUM
COMMON/17/AM,BN,CM,DM,AN,BN,CM,DM
COMMON/18/STROK(20),PSIDM(20),STROK(20),MSGM,MSGM
COMMON/19/FSH,FSH,FTN,FTN,XMAIN,XNOSE,VELM,VELM
COMMON/20/ZPH,ZPH,ZPH
COMMON/21/COM,SSM
DIMENSION T(12),TD(12),TDO(12)
REAL MCG,MH,MHI
Z=Z+TD(10)*DX+TD(10)*DX**2/2.
ZPH=AM+BN*Z+CM*Z**2+DM*Z**3
ZPH=AN+BN*Z+CM*Z**2+DM*Z**3
QTM=0.
QTM=0.
QTM=0.
DO 138 I=1,NPM
QTM=QTM+Q(I)*SINOS(I)
QTM=QTM+Q(I)*SINAM(I)
QTM=QTM+QO(I)*SINAM(I)
QTM=QTM+QO(I)*SINOS(I)
XMOSE = (T(12) - 0 + T(10) - T(16)) * QTM
XMAIN = (T(12) + 0 + T(10) - T(16)) * QTM
VELM = T(12) + 0 + T(10) - T(16) * QTM
VELM = T(12) - 0 + T(10) - T(16) * QTM
IF(XMAIN.GE.0.) XMAIN=-.1
IF(XNOSE.GE.0.) XNOSE=-.1
IF(VELM.GE.0.) VELM=-.1
IF(VELM.LE.0.) VELM=.1
XALK=ABS(XMAIN)
XALK=ABS(XNOSE)
XALK=ABS(XNOSE)
C NOSE AND MAIN DAMPING COEFF
CALL TLOOK(XALK,SLOPEM,YCEPM,STROK,PXDM,MSGM)
CALL TLOOK(XALK,SLOPEM,YCEPM,STROK,PXDM,MSGM)
AGM = GAN - ABS((SLOPEM*XALK*YCEPM)**2)*.78539
AGM = GAN - ABS((SLOPEM*XALK*YCEPM)**2)*.78539
CONC=.0008*(AM**2.)/12*(1.9*AHM)**2
CONC=.0008*(AM**2.)/12*(1.9*AHM)**2
C NOSE AND MAIN STRUT PNEUMATIC FORCES
SSM=(PAQ*VOM)/(1*(VOM/AAH)-XALK)
SSM=(PAQ*VOM)/(1*(VOM/AAH)-XALK)
FTN = SX + TSN + (T(14) - ZPH)
FTN = SX + TSN + (T(14) - ZPH)
IF(FTN.GT.0.) FTN=0.
IF(FTN.GT.0.) FTN=0.
FSM=SXM+SSM*COM+VELM*ABS(VELM)
FSM=SXM+SSM*COM+VELM*ABS(VELM)
VLIFT=.0015*CL*AREA*TD(10)*TDO(10)
CPAC=VLIFT*CD/CL

```

```

60      ORAGT = DBS(-.025*FTM+.025*FTM)
        IF (INTRUN.EQ.1) GO TO 125
        THRUST=DRAGA*DRAGT
125      TDD(2) = (-FSM-FSM-MCG*346.*VLIFT)/MCG
        TDD(4) = (FSM-FTM-386.*SXN*MMI)/(MM*SMXN)
        TDD(6) = (FSM-FTM-MM*346.*SXN)/(MM*SMXN)
        TDD(8) = -(FSM*A -FSM*B -DRAGT*(ISM*MM*MM))/MMI
        TDD(10) = (THRUST-DRAGA-DRAGT)/(MCG*12.)
        DO 200 I=1,NFX
200      QDD(I) = -(SIN(AM(I))*(FSM-PEACTM)*SIN(AM(I))*(FSM-REACTM)
        1+.10*OMEGA(I)*QDD(I)*CM(I)*OMEGA(I)*2*G(I)*Q(I))/CM(I)
        DO 1-31 I = 2,10,2
        T(I) = T(I) + TDD(I)*DX**2)/2.
1001  Q(I) = T(I) + TDD(I)*DX
        DO 1002 I=1,NFX
        Q(I) = Q(I)+QDD(I)*DX+(QDD(I)*DX**2)/2.
1002  QDD(I) = QDD(I)+QDD(I)*DX
        RETURN
        END
75

```

TAY 0580
TAY 0590
TAY 0600
TAY 0610
TAY 0620
TAY 0630
TAY 0640
TAY 0650
TAY 0660
TAY 0670
TAY 0680
TAY 0690
TAY 0700
TAY 0710
TAY 0720
TAY 0730
TAY 0740
TAY 0750
TAY 0760

05/13/75 17.47.54.

FTM 4.200300

SUBROUTINE TLOOK 74/74 OPT=1

SUBROUTINE TLOOK (X,SLOPE,CEPT,S,P,N)
DIMENSION S(10),P(10)

THIS IS A 2 DIMENSIONAL TABLE LOOK UP ROUTINE
WITH LINEAR INTERPOLATION

X IS THE CURRENT VALUE OF STROKE
SLOPE AND CEPT ARE CALCULATED AND RETURNED
S AND P MAKE UP THE TABLE

N IS THE NUMBER OF VALUES IN THE TABLE
DO 1 I=1,N

IF (X-GE,S(I))AND(X-LT,S(I+1))GO TO 2

CONTINUE

SLOPE=(P(I+1)-P(I))/(S(I+1)-S(I)+.01)

CEPT=P(I)-SLOPE*S(I)

RETURN

END

TL 0010
TL 0020
TL 0030
TL 0040
TL 0050
TL 0060
TL 0070
TL 0080
TL 0090
TL 0100
TL 0110
TL 0120
TL 0130
TL 0140
TL 0150
TL 0160
TL 0170

1

PAGE

05/13/75 17.07.56.

PTM 4.20P300

74/7- OPT=1

SUBROUTINE PLOOQ

SUBROUTINE PL00Q(IA-00)
CALL PLOT(0..3..-3)
RETURN
END

PLTS0010
PLTS0020
PLTS0030
PLTS0040

APPENDIX B

COMPUTER LISTING OF "TAXI" USED TO SIMULATE CLASS E AIRCRAFT


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175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999

```



```

290 ZOUT=0
291 ZNDOT=0
292 ZACOT=0
293 J=1
294 VP(1)=ZOUT
295 VP(2)=ELCV(IRVAL)
296 VP(3)=ELCV(IRVAL+1)
297 VP(4)=ELCV(IRVAL+2)
298 VPM(1)=ZNDOT
299 VPM(2)=ELCV(IRVAL)
300 VPM(3)=ELCV(IRVAL+1)
301 VPM(4)=ELCV(IRVAL+2)
302 VPR(1)=ZNDOT
303 VPR(2)=ELCV(J)
304 VPR(3)=ELCV(J+1)
305 VPR(4)=ELCV(J+2)
306 Z=0
307 CALL COEFF (VPM,AN,BN,CN,DN)
308 CALL COEFF (VPR,AL,BL,CL,DL)
309 ZOUT=BN
310 ZNDOT=BN
311 ZNDOT=BL
312 IF (MOUT.1) GO TO 2+5
313 P = M + 1
314 IF (IFLIST.EQ.1) GO TO 100
315 WRITE(6,17) XMAIN,XNOSE,FSM,FNM,FSRM ,TD(10),T(10),
316 1CGOUT ,PSA,X
317 CONTINUE
318 FORMAT(34,2(3X,F3.3),3(3X,F10.0),4(3X,F10.3),2X,F7.3)
319 T1=EXX
320 IF (IFPLDT.EQ.1) GO TO 231
321 IF (ABS(CGOUT ).LE.ABS(STORE2).AND.ABS(STORE2).GE.ABS(STORE1))
322 100 TO 100
323 STORE1 = STORE2
324 STORE2 = CGOUT
325 GO TO 190
326 IF (1X-TIME(NN).GT.00) GO TO 105
327 IF (ABS(STORE2).GT.3500) GO TO 105
328 GO TO 175
329 NA = NN + 1
330 CGACC(NN) = STORE2
331 P=CGF(NN) = ZPH
332 TIME(NN) = A - 1.0 * DK
333 IF (TIME(NN).LT.0.0) TIME(NN) = .31
334 STORE1 = STORE2
335 STORE2 = CGOUT
336 IF (ABS(PSA).LE.ABS(STORE4).AND.ABS(STORE4).GE.ABS(STORE3))
337 100 TO 235
338 STORE2 = STORE4
339 STORE4 = PSA
340 GO TO 215
341 IF (1X-TIME(LL).GT.00) GO TO 210
342 IF (ABS(STORE4).GT.32) GO TO 210
343 GO TO 200
344 LL = LL + 1

```

TAXI2080
TAXI2090
TAXI2900
TAXI2910
TAXI2920
TAXI2930
TAXI2940
TAXI2950
TAXI2960
TAXI2970
TAXI2980
TAXI2990
TAXI3000
TAXI3010
TAXI3020
TAXI3030
TAXI3040
TAXI3050
TAXI3060
TAXI3070
TAXI3080
TAXI3090
TAXI3100
TAXI3110
TAXI3120
TAXI3130
TAXI3140
TAXI3150
TAXI3160
TAXI3170
TAXI3180
TAXI3190
TAXI3200
TAXI3210
TAXI3220
TAXI3230
TAXI3240
TAXI3250
TAXI3260
TAXI3270
TAXI3280
TAXI3290
TAXI3300
TAXI3310
TAXI3320
TAXI3330
TAXI3340
TAXI3350
TAXI3360
TAXI3370
TAXI3380
TAXI3390
TAXI3400
TAXI3410
TAXI3420
TAXI3430
TAXI3440

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FTN **2*P10*

SUBROUTINE TLOOK (K,SLOPE,VECT,S,P,H)
DIMENSION S(1:P(1))

```

C
C      THIS IS A 2 DIMENSIONAL TABLE LOOK UP ROUTINE
C      WITH LINEAR INTERPOLATION
C
C      A IS THE CURRENT VALUE OF S(P,H)
C      SLOPE AND VECT ARE CALCULATED AND RETURNED
C      A AND P MAX UP THE TABLE
C      N IS THE NUMBER OF VALUES IN THE TABLE
C      GO TO 10
C
C      IF K.G.E.3(1).AND.K.L.5(1).GO TO 2
C      CONTINUE
C      SLOPE=(P(1)-P(1))/(S(1)-S(1)+.01)
C      VECT=(1)-SLOPE*(1)
C      RETURN
C
C

```

TL 0012
TL 0020
TL 0030
TL 0040
TL 0050
TL 0060
TL 0070
TL 0080
TL 0090
TL 0100
TL 0110
TL 0120
TL 0130
TL 0140
TL 0150
TL 0160
TL 0170

11.51.50.

FTN 0020130

SUBROUTINE COEFF (V, A, D, S, D)

COEFF0010
COEFF0020
COEFF0030
COEFF0040
COEFF0050
COEFF0060
COEFF0070
COEFF0080
COEFF0090
COEFF0100

SUBROUTINE COEFF (V, A, D, S, D)
DIMENSION Y(4)
DO 10 I=1,4
Y(I)=0.
10 CONTINUE
RETURN
END

5

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FTN 4.2.2.38v

7-77- 0-1-1

SUBROUTINE PLQJ3

SUBROUTINE PLQJ3(AA,2B)
(CAL) CTR(0.0,0.0)
R=1
END

PLTS0013
PLTS0020
PLTS0030
PLTS0040

APPENDIX C

COMPUTER LISTING OF SUBROUTINE TAYLOR USED TO INCLUDE
BEARING FRICTION IN THE STRUT FORCE

APPENDIX D

FORTRAN SYMBOL DEFINITIONS

This appendix contains an alphabetical listing of the Fortran variables used in the program "TAXI" categorized by the subroutine in which they are defined. In cases where a variable is defined in two or more subroutines, it is listed under the subroutine in which it is used most often. Some symbols used in the Class E Aircraft computer code are not listed. These variables are those which have been formed by adding an R to a variable name which is contained in the basic "TAXI" computer code. The R refers to the rear set of main gear.

FORTRAN SYMBOL DEFINITIONS

TAXI

<u>SYMBOL</u>	<u>DEFINITION</u>
A	Distance from CG to front main gear
AAM	Pneumatic area, main gear
AAN	Pneumatic area, nose gear
AHM	Hydraulic area, main gear
AHN	Hydraulic area, nose gear
AM	Coefficient of polynomial fit to runway profile segment, rear main gear
AN	Coefficient of polynomial fit to runway profile segment, nose gear
AREA	Aircraft wing area
B	Distance from CG to nose gear
BM	Coefficient of polynomial fit to runway profile segment, rear main gear
BN	Coefficient of polynomial fit to runway profile segment, nose gear
C	Distance from CG to rear main gear (Class E simulation only)
CD	Coefficient of drag
CGACC	Array containing CG accelerations for Calcomp plot
CGOUT	Total CG acceleration
CL	Coefficient of lift
CM	Coefficient of polynomial fit to runway profile segment, rear main gear
CN	Coefficient of polynomial fit to runway profile segment, nose gear

<u>SYMBOL</u>	<u>DEFINITION</u>
DDPLOT	Array containing aircraft distance down the runway for Calcomp plot
DISTAN	Distance down the runway used in removing overall slope from runway profile
DM	Coefficient of polynomial fit to runway profile segment, rear main gear
DN	Coefficient of polynomial fit to runway profile segment, nose gear
DX	Time step for integration
DZ	Variable which compensates for the overlap of two adjacent runway segments
ELEV	Array containing runway profile elevations
ELEVI	Elevation of first runway profile point
ENDRUN	Length of runway
GM	Array containing generalized masses for each flexible mode of vibration
HDR	Counter for printing header on printed output
I	Index variable
IFPLOT	Variable which contains decision to produce plotted output or not
IFLIST	Variable which contains decision to produce a listed output or not
II	Subscript variable for runway markers on Calcomp plot
IVAL	Integer truncation of distance between nose and rear main gear
IRVAL	Integer truncation of distance between rear main gear and front main gear (Class E simulation only)
IXLONG	Integer truncation of length of time axis on Calcomp plot
J	Subscript variable for runway profile

<u>Symbol</u>	<u>DEFINITION</u>
LD	Counting variable for runway profile input
LDI	Counting variable for runway profile output listing
LL	Subscript variable for storage of pilot station acceleration time history
LLL	Subscript variable for storage of aircraft speed and distance for Calcomp plot
LPRIN	Runway distance for runway profile listing
LSD	Counting variable for runway profile input
LSDI	Counting variable for runway profile listing
M	Counting variable for printing out output header first time
MCG	Mass of entire aircraft
MGM	Integer truncation of total simulation time
MM	Mass of unsprung portion of one main landing gear
MMI	Pitching moment of inertia about aircraft center of gravity
MN	Mass of the unsprung portion of the nose landing gear
MRM	Length of runway divided by 1000 feet
MFM	Number of flexible modes
NN	Subscript variable for CG acceleration time history
NPTSS	Number of runway profile points
NSCH	Number of slope or area changes on main strut metering pin
NSCN	Number of slope or area changes on nose strut metering pin
NTRUN	Defines run as taxi or takeoff
NIO	Index variable for normalization of runway profile
OAM	Area of orifice hole, main gear
OAN	Area of orifice hole, nose gear

<u>SYMBOL</u>	<u>DEFINITION</u>
OMEGA	Array of flexible mode frequencies
PAOM	Preload pressure of main gear strut
PAON	Preload pressure of nose gear strut
PINDM	Array containing main gear metering pin diameters for conventional aircraft and net orifice areas for aircraft with metering tubes or fluted metering pins
PINDN	Array containing nose gear metering pin diameters for conventional aircraft and net orifice areas for aircraft with metering tubes or fluted metering pins
PLANE	Aircraft being simulated
PP	Counting variable for storage of distance and speed for Calcomp plot
PROF	Runway profile time history elevations
PROF10	PROF (NN+2)X10
PSA	Pilot station acceleration
PSACC	Array containing pilot station acceleration time history
PSARM	Distance from pilot station to CG
Q	Array of non-dimensional time dependent coordinates which weight the amount of motion due to each flexible mode in the total motion of the aircraft
QD	Time derivative of Q
QDD	Time derivative of QD
QDDCG	CG acceleration due to flexible motion
QDDPS	Pilot station acceleration due to flexible motion
QDDTAL	Tail station acceleration due to flexible motion
REACTM	Static, total force at main gear
REACTN	Static, total force at nose gear
RM	Incremented variable for determining position of runway markers

<u>SYMBOL</u>	<u>DEFINITION</u>
RMARK	Array containing runway markers positions
SICG	Mode shape deflection of CG
SIMAIN	Mode shape deflection at main landing gear
SINOSE	Mode shape deflection at nose landing gear
SIPS	Mode shape deflection at pilot station
SITAIL	Mode shape deflection at tail station
SITE	Location of runway
SLM	Distance from CL of main gear axle to CG of aircraft with strut fully extended
SLN	Distance from CL of nose gear axle to CG of aircraft with strut fully extended
SLP	Overall slope of runway profile
SPEED	Initial speed of aircraft
SSPLOT	Array of velocity of aircraft for Calcomp plot
STORE1	Temporary storage space for CG accelerations
STORE2	Temporary storage space for CG accelerations
STORE3	Temporary storage space for pilot station accelerations
STORE4	Temporary storage space for pilot station accelerations
STROKM	Array of strut stroke values corresponding to metering pin values (PINDM), main gear
STROKN	Array of strut stroke values corresponding to metering pin values (PINDN), nose gear
SXM	Number of main gear struts
SXN	Number of nose gear struts
TAILAC	Acceleration at tail station
TAILRM	Distance from tail station to CG
TAKOFF	Rotation velocity of aircraft

<u>SYMBOL</u>	<u>DEFINITION</u>
THRUST	Total thrust of aircraft
TIME	Array of simulation times at which CG acceleration time history points are stored
TIMEX	Counter variable for printed output
TIME1	Array of simulation times at which pilot station time history are stored
TSM	Tire spring constant, main gear
TSN	Tire spring constant, nose gear
TYPRUN	Defines simulation as takeoff or taxi
VOM	Main gear strut fully extended volume
VON	Nose gear strut fully extended volume
W	Weight of aircraft
WM	Main gear unsprung weight
WN	Nose gear unsprung weight
X	Simulation time
XLONG	Length of time axis for Calcomp plot
XLONG2	$XLONG/2$
XPROF	Location for printing of "NOSE GEAR TRACK" on Calcomp plot
XSTOP	$XLONG+5$
YP	Array containing runway segment elevation points and slope from end of previous segment, rear main gear
YPR	Array containing runway segment elevation points and slope from end of previous segment, rear main gear (Class E simulation only)
YPN	Array containing runway segment elevation points and slope from end of previous segment, nose gear
ZRDOT	Slope of runway segment at end point, rear main gear (Class E simulation only)

<u>SYMBOL</u>	<u>DEFINITION</u>
ZNDOT	Slope of runway segment at end point, nose gear
<u>TAYLOR</u>	
AOM	Net orifice area, main gear (OAM-metering pin area)
AON	Net orifice area, nose gear (OAN-metering pin area)
*BSN	Nose landing gear minimum bearing separations
*BSM	Main landing gear minimum bearing separations
COM	Damping coefficient, main gear
CON	Damping coefficient, nose gear
DRAGA	Aerodynamic drag
DRAGT	Rolling Drag
*FFON	Nose landing gear seal friction
*FFOM	Main landing gear seal friction
*FLN	Nose landing gear lower friction force
*FLM	Main landing gear lower friction force
FSM	Total force in all main gear struts
FSN	Total force in all nose gear struts
FSTN	Net force on secondary piston, nose gear (Class E simulation only)
FST1	Net force on secondary piston, rear main gear (Class E simulation only)
FST2	Net force on secondary piston, front main gear (Class E simulation only)
FTM	Force in tires, main gear
FTN	Force in tires, nose gear
*FUN	Nose landing gear upper friction force
*FUM	Main landing gear upper friction force
*Class B simulation with Strut Friction only	

<u>SYMBOL</u>	<u>DEFINITION</u>
*OFFN	Nose landing gear axle offset
*OFFM	Main landing gear axle offset
*PHIN	Nose landing gear angle from the vertical
*PHIM	Main landing gear angle from the vertical
*PLN	Nose landing gear piston length
*PLM	Main landing gear piston length
QTDM	Total velocity due to flexible modes at main gear
QTDN	Total velocity due to flexible modes at nose gear
QTM	Total deflection due to flexible modes at main gear
QTN	Total deflection due to flexible modes at nose gear
SLOPEM	Slope of line drawn through two metering pin points, main gear
SLOPEN	Slope of line drawn through two metering pin points, nose gear
SSM	Pneumatic force, main gear
SSN	Pneumatic force, nose gear
T(2)	CG vertical displacement
T(4)	Unsprung mass vertical displacement, front main gear
T(6)	Unsprung mass vertical displacement, nose gear
T(8)	Rigid body pitch angle of aircraft
T(10)	Horizontal distance of aircraft
T(12)	Unsprung mass vertical displacement, rear main gear (Class E simulation only)
TD(2)	Time derivative of T(2)
TD(4)	Time derivative of T(4)
TD(6)	Time derivative of T(6)
TD(8)	Time derivative of T(8)
*Class B simulation with Strut Friction only	

<u>SYMBOL</u>	<u>DEFINITION</u>
TD(10)	Time derivative of T(10)
TD(12)	Time derivative of T(12) (Class E simulation only)
TDD(2)	Time derivative of TD(2)
TDD(4)	Time derivative of TD(4)
TDD(6)	Time derivative of TD(6)
TDD(8)	Time derivative of TD(8)
TDD(10)	Time derivative of TD(10)
TDD(12)	Time derivative of TD(12) (Class E simulation only)
VELM	Total strut velocity, main gear
VELN	Total strut velocity, nose gear
VLIFT	Aerodynamic lift force
XMAIN	Strut stroke, main gear
XMLK	Absolute value of XMAIN
XNLK	Absolute value of XNOSE
XNOSE	Strut stroke, nose gear
YCEPN	Y intercept of line drawn through two metering pin points, nose gear
Z	Distance of aircraft from beginning of a 4 ft runway segment
ZPM	Runway elevation, rear main gear
ZPMR	Runway elevation, front main gear (Class E simulation only)
ZPN	Runway elevation, nose gear
<u>IC</u>	
RM	Static reaction force at main gear
RMIT	Static reaction force at rear main gear (Class E simulation only)
RM2T	Static reaction force at front main gear (Class E simulation only)

<u>SYMBOL</u>	<u>DEFINITION</u>
RN	Static reaction force at nose gear
RSM	$RM - WM$
RSN	$RN - WN$
THETA I	Rigid body initial pitch angle
XRMAIN	Test variable for rigid body initial conditions (Class E simulation only)
ZCGI	Initial CG vertical displacement
ZMI	Initial tire deflection, main gear
ZNI	Initial tire deflection, nose gear
<u>COEFF</u>	
A	Coefficient of polynomial fit to runway profile segment
B	Coefficient of polynomial fit to runway profile segment
C	Coefficient of polynomial fit to runway profile segment
D	Coefficient of polynomial fit to runway profile segment
Y	Runway profile elevation value
<u>TLOOK</u>	
I	Index variable
N	Number of values in metering pin - stroke table
P	Metering pin diameter or net orifice area for aircraft with metering tubes or fluted metering pins
S	Strut stroke in metering pin table
SLOPE	Slope of line drawn between two metering pin points
YCEPT	Y intercept of line drawn between two metering pin points

APPENDIX E

TYPICAL WIDE BODIED TRI-JET TRANSPORT DATA AND SIMULATIONS

This appendix contains data obtained late in the study which represents a "TYPICAL" Wide Bodied Tri-Jet Transport and may be used to simulate Class C and D aircraft of this type. This appendix also contains takeoff simulations over the Will Rogers and Dulles Profiles.

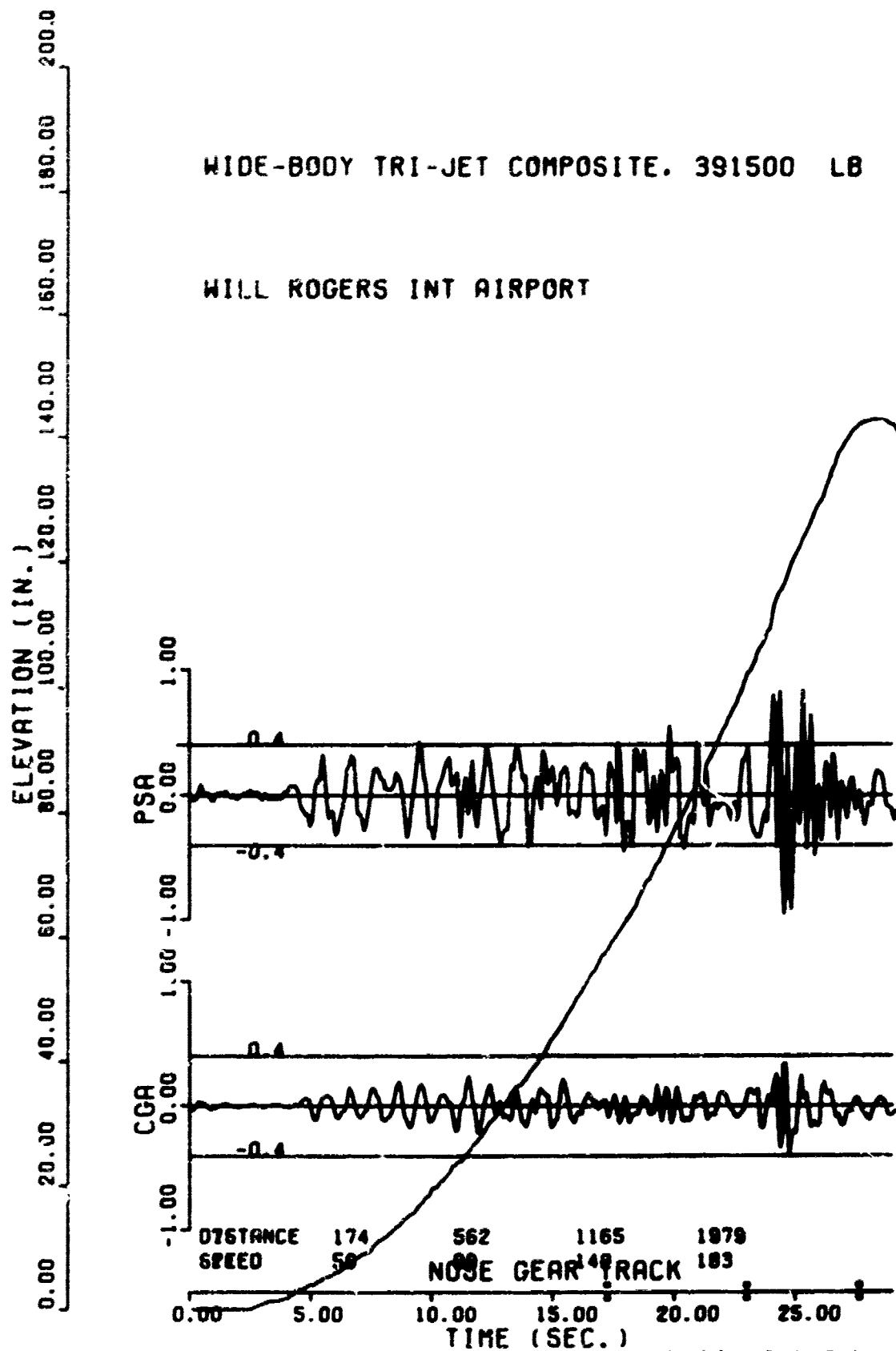


Figure 35. Plotted Results of a "Typical" Wide Body Tri-Jet transport Taking Off from the Dulles Profile

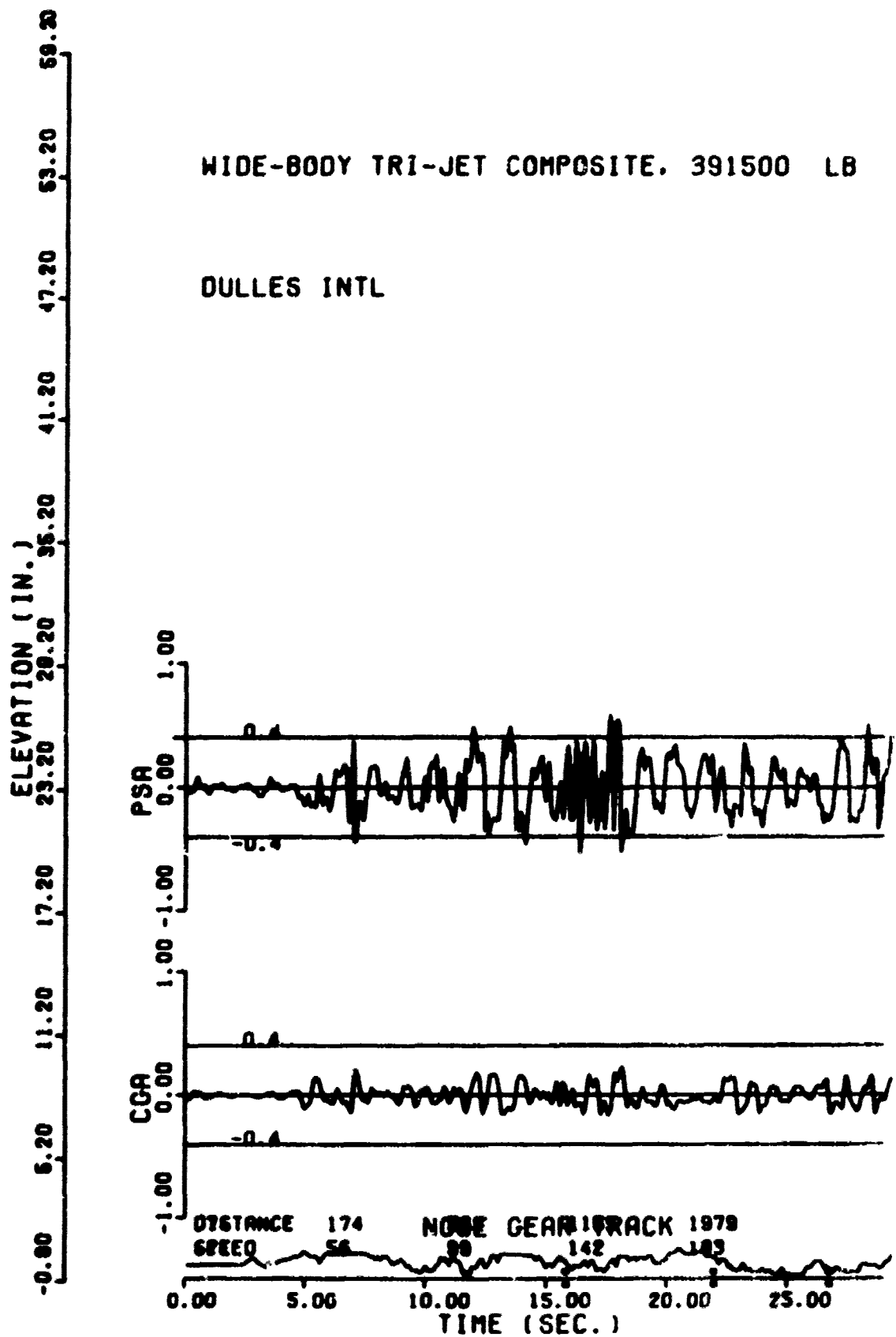


Figure 36. Plotted Results of a "Typical" Wide Body Tri-Jet Transport Taking Off from the Dulles Profile

TABLE XVII. List of Data Used to Simulate the Wide-Body Tri-Jet Composite

***** INPUT DATA *****

***** GENERAL AIRCRAFT DATA *****

WIDE-BODY TRI-JET COMPOSITE, 331500 LBS.

W=	331500.0	WM=	5000.00	AW=	590.00	A=	69.000	B=	797.000	MMI=	190000000.
SW=	2.0	SN=	1.0	SM=	183.0	SL=	173.0	PSARM=	1035.0	TAILRM=	508.0
WAM=	100.00	WAW=	84.00	WAW=	300.00	WAW=	2600.00	WAW=	2.03	TSM=	55000.00
WAW=	33.00	WAW=	25.40	WAW=	151.50	WAW=	537.30	WAW=	.57	TSN=	20000.00
CL=	.220	CD=	.070	AREA=	3500.00	SPEED=	2.5	TAPOUT=	119000.	TAKOFF=	249.00

STROKE NOSE PIN DIAMETER

3.000	0.000
12.000	.550
17.500	.750
50.000	.750

STROKE MAIN PIN DIAMETER

3.000	0.000
15.000	1.200
25.000	1.200
50.000	1.200

TABLE XVII - Continued

MODE	SIPS	SIMOSE	SIDS	SIGMIM	SIFAIL	OMEGA	SEV. MASS
1	-17	-23	-50	-23	-93	7.63	2000.0
2	-86	-59	-09	-07	-13	12.93	2000.0
3	2.52	1.58	-23	-63	50	13.10	2000.0
4	2.13	1.10	-1.01	1.23	88	10.19	2000.0
5	.53	.17	-47	-13	-19	22.37	2000.0
6	-1.54	-.54	.96	-03	53	25.19	2000.0
7	.39	.10	-.35	.89	-.30	27.34	2000.0
8	-1.24	-.62	.41	.19	-.72	29.17	2000.0
9	1.93	.50	.11	.63	1.33	35.95	2000.0
10	-.72	-.13	.14	1.61	-1.25	39.26	2000.0
11	1.47	.13	-.54	.19	.60	39.96	2000.0
12	2.73	-.04	.17	.67	.55	47.73	2000.0
13	.62	0.00	-.27	1.52	-.19	52.27	2000.0
14	-3.13	.74	-1.22	-1.00	1.53	61.90	2000.0
15	.94	-.13	.94	-1.35	-1.24	71.36	2000.0

***** INITIAL CONDITIONS *****

ZMI= -3.276 ZNI= -1.537 F4ETAI= -.010302 ZCMI= -24.787
 KQMI= -22.210 KQSE= -13.139 REACMI= -31137. REACSE= -160363.