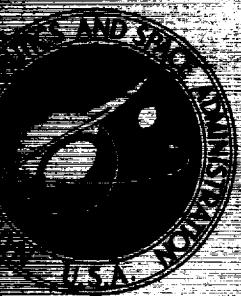


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NASA CR-2144

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AIRCRAFT HANDLING QUALITIES DATA

by Robert K. Heffley and Wayne F. Jewell

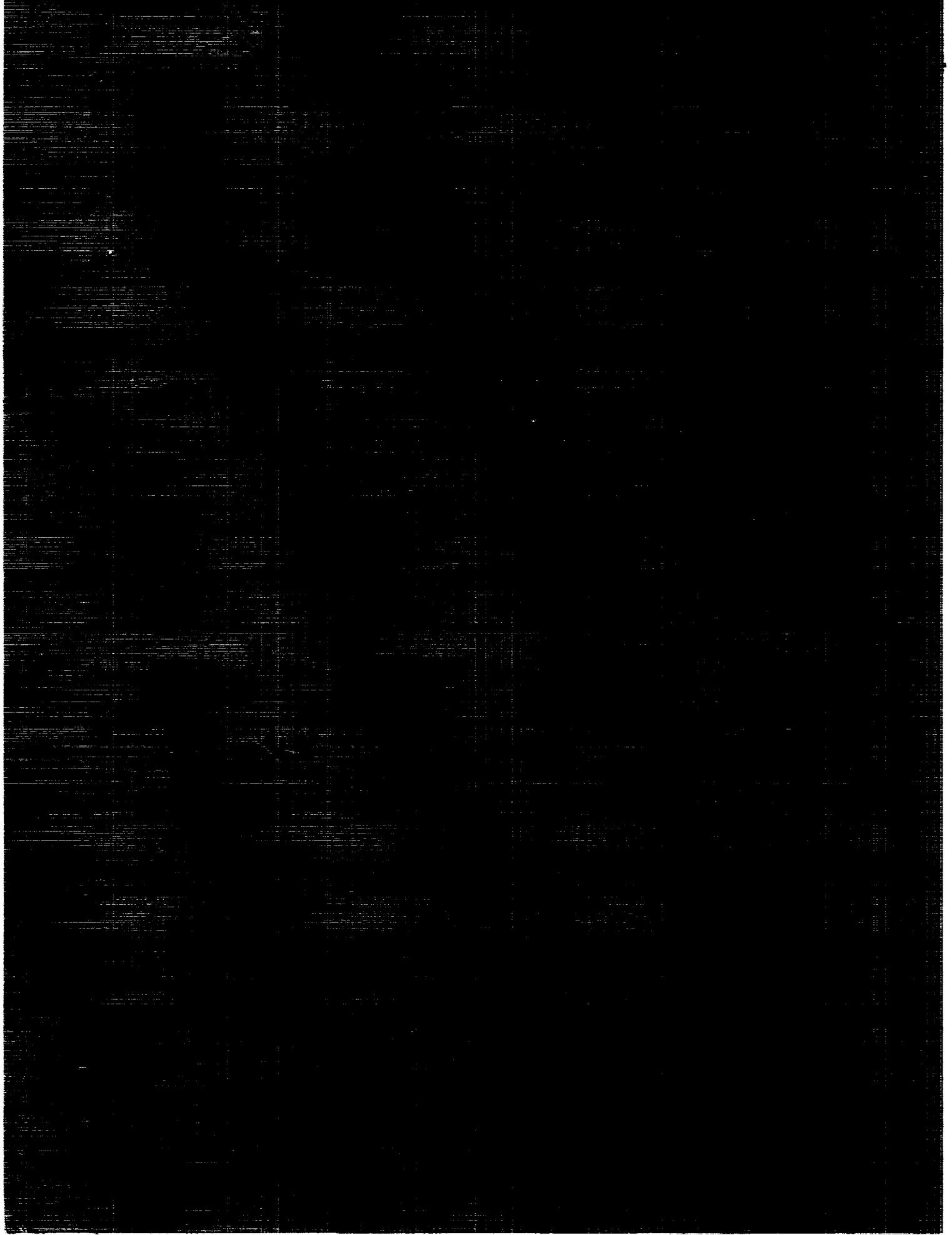
prepared by

SYSTEMS TECHNOLOGY, INC.

Hawthorne, Calif. 90250

for Flight Research Center

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16. Abstract Available information on weight and inertia, aerodynamic derivatives, control characteristics, and stability augmentation systems is documented for 10 representative contemporary airplanes. Data sources are given for each airplane. Flight envelopes are presented and dimensional derivatives, transfer functions for control inputs, and several selected handling qualities parameters have been computed and are tabulated for 10 different flight conditions including the power approach configuration. The airplanes documented are the NT-33A, F-104A, F-4C, X-15, HL-10, Jetstar, CV-880M, B-747, C-5A, and XB-70A.			
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TABLE OF CONTENTS

	<u>Page</u>
I. INTRODUCTION	1
II. NT-33A	5
III. F-104A	32
IV. F-4C	61
V. X-15	108
VI. HL-10	137
VII. LOCKHEED JETSTAR	166
VIII. CONVAIR 880M	193
IX. BOEING 747	210
X. C-5A	243
XI. XB-70A	273
APPENDIX A. AXIS SYSTEMS, SYMBOLS, COMPUTER MNEMONICS, AND DERIVATIVE DEFINITIONS	A-1
APPENDIX B. TRANSFORMATION OF STABILITY AXIS DERIVATIVES TO BODY AXIS	B-1
APPENDIX C. EQUATIONS OF MOTION AND TRANSFER FUNCTIONS	C-1

SECTION I

INTRODUCTION

The purpose of this document is to provide handling qualities investigators with readily usable data on several representative contemporary aircraft. Included are those data required to obtain transfer functions relating the aircraft's response to control inputs. An analytical description of the aircraft's stability augmentor is also given.

For those aircraft for which complete information was available, the following summarizes the contents and presentation:

1. Flight conditions for which computations are made including:
 - a. Configurations (e.g., fuel load, flaps, gear, etc.)
 - b. Mach/altitude combinations
2. General arrangement
3. Control system description
4. Stability augmentation description
5. Tabulations and/or plots of non-dimensional stability derivatives for trimmed flight
6. Dimensional, mass, and flight condition parameters
7. Dimensional stability derivatives
8. Transfer functions for control inputs
9. Selected handling qualities parameters
10. Data sources

A page number cross index is presented in Table I-1.

The intention has been to make this report completely self-consistent insofar as symbols, nomenclature, definitions, etc. The system used is described in three appendices. Appendix A covers axis systems, symbols and notation, and definitions of nondimensional and dimensional stability derivatives. Appendix B gives the axis system transformations for the derivatives. Appendix C includes the aircraft equations of motion and transfer functions used herein.

TABLE I-1
PAGE NUMBER CROSS INDEX

	NT-72A	F-104A	74C	X-15	HL-10	Jetstar	CV-880N	B-747	C-5A	XB-70A
BACKGROUND	6	33	62	109	136	157	194	211	214	274
FLIGHT CONDITIONS	7	34	63	110	139	168	195	212	215	275
GENERAL ARRANGEMENT	8	35	64	111	140	159	196	213	216	276
CONTROL SYSTEM	9	36	65	112	141	170	197	214	217	277
STABILITY AUGMENTATION SYSTEM	-	-	69	113	142	-	-	215	-	278
TRIMMED NON-DIMENSIONAL DERIVATIVES	10	37	70	114	143	171	198	215	218	279
DIMENSIONAL MASS AND FLIGHT CONDITION PARAMETERS	22	49	82	125	152	183	200	229	261	292
LONGITUDINAL TRANSFER FUNCTION FACTORS	23	50	83	126	153	184	201	230	262	293
● SAS off										
- Bobweight loop open										
● Pitch axis control	24	51	84	127	154	185	202	231	263	294
● Thrust	25	52	85	-	-	186	203	232	264	295
- Bobweight loop closed										
● Pitch axis control	-	53	86	-	-	-	-	-	255	295
● Thrust	-	54	88	-	-	-	-	-	256	297
● SAS on										
- Bobweight loop open										
● Pitch axis control	-	-	90	127	155	-	-	-	-	299
● Thrust	-	-	92	-	-	-	-	-	-	301
- Bobweight loop closed										
● Pitch axis control	-	-	94	-	-	-	-	-	-	303
● Thrust	-	-	96	-	-	-	-	-	-	305
LONGITUDINAL HANDLING QUALITIES FACTORS	26	55	98	129	156	187	204	233	267	307
LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES	27	56	99	130	157	188	205	234	268	308
LATERAL-DIRECTIONAL TRANSFER FUNCTION FACTORS										
● SAS off										
- Roll axis control	28	57	100	131	158	189	206	235	269	309
- Yaw axis control	29	58	101	132	159	190	207	236	270	310
● SAS on										
- Roll axis control	-	-	102	133	160	-	-	257	-	311
- Yaw axis control	-	-	104	134	162	-	-	239	-	313
LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS	30	59	106	135	164	191	208	241	271	315
DATA SOURCES	31	60	107	136	165	192	209	242	272	316

The aircraft considered in this report span a wide range of sizes, speeds, and uses. In each case, transfer functions and handling qualities parameters were computed for flight conditions which were selected to cover the flight regimes of interest. A nominal configuration (generally cruise) was picked for all up and away flight conditions. For this nominal configuration, plots of trimmed non-dimensional aerodynamic force and moment coefficients are presented. Also, in most cases, a power approach case is presented along with a tabulation of aerodynamic coefficients. The coefficients are based on rigid wind tunnel data, estimated flexible data, or flight test results, depending upon availability. This is indicated by the words "rigid," "flexible," and "flight" on each aero data plot. Also, the axis system is indicated by "stability" for a body-fixed stability axis system or "body" for a body-fixed system aligned with the F.R.L. (Further clarification of axis systems used is given in Appendix A.) Descriptions of control systems and stability augmentation systems are given along with transfer functions. Where a longitudinal control system has a significant effect on the equations of motion (as with a bobweight) the stick-free transfer functions and handling qualities are given.

Transfer functions are always given for body axis motion quantities. Handling qualities parameters are also given in the body axis. All acceleration transfer functions (a_z' and a_y') are for the pilot's position. Thrust transfer functions do not include any engine response characteristics.

A substantial portion of this report is in the form of computer printout. The mnemonics used in this printout are defined in Appendix A.

The handling qualities parameters given in this report represent only a small fraction of those developed over the years. The majority presented here are used in past and present versions of MIL-F-8785. Although only SAS-off values are shown, the definitions given in Appendix A are general and could be used in conjunction with the SAS-on transfer functions to yield SAS-on handling qualities parameters.

While complete coverage of each aircraft including only the "latest" and "best" data would be desirable, the major criterion used was that the data be accessible to the author. This is why only isolated flight conditions are given for some aircraft, and also why, as those people more intimately familiar

with each particular aircraft will recognize, the data presented may represent an early estimate in the design process and perhaps the "nominal configuration" is one which never left the drawing board. The data have been reviewed and, although not all those presented indicate unquestionable trends, those data known to be based on only early "guesstimates" or showing unreasonable trends have been deleted. In some cases data were estimated by the author. As to how well the data can be expected to match the flying aircraft, it is assumed that those for whom this document is intended know well the difficulties of obtaining derivatives from flight test data. Every attempt has been made to insure reliable translation, interpretation, and transcription of the data from their source documents.

The manufacturers of the aircraft described herein can not be held accountable for the information presented, nor would they be bound to concur in any conclusions with respect to their aircraft which might be derived from its use.

SECTION II

NT-33A

NT-33A BACKGROUND

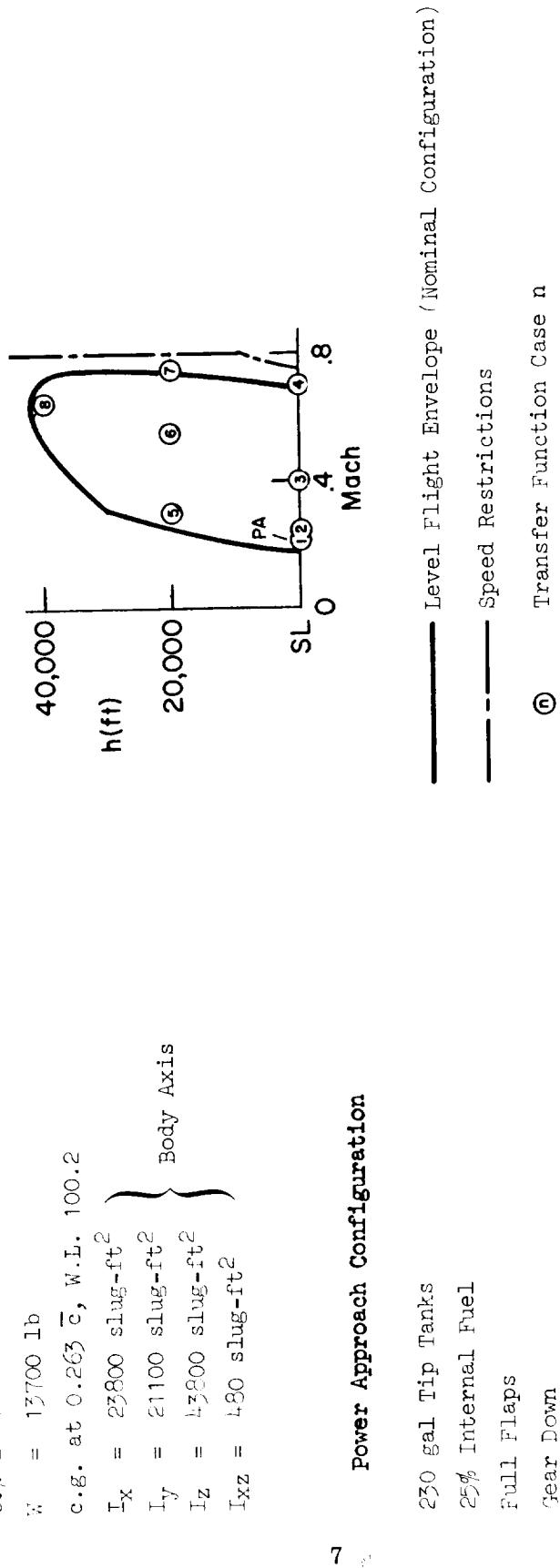
"The NT-33A variable stability airplane (Serial No. 51-4120) is an extensively modified T-33 jet trainer. The elevator, aileron and rudder controls in the front cockpit are disconnected from their respective control surfaces and have been connected to separate servomechanisms that make up an 'artificial feel' system. In addition, the elevator, aileron and rudder control surfaces have been connected to individual servos which can be driven by a number of different inputs. These servos receive their electrical inputs from the artificial feel system (pilot's commands, position or force), attitude and rate gyros, accelerometers, dynamic pressure, a vane and β probe. This arrangement, through a response-feedback system, allows the normal T-33 derivatives to be augmented to the extent that the handling qualities of many existing airplanes, future airplanes or hypothetical research configurations, can be simulated. The original T-33 nose section has been replaced with the larger nose of an F-94 to provide the volume required for the electronic components of the response-feedback system and the recording equipment."*

Transfer functions are given for only the primary surfaces and engine thrust although the NT-33A also has other control surfaces and a range of control crossfeed and feedback combinations.

Aerodynamic data, for the most part, was taken from AFFDL-TR-70-71. However, longitudinal data for the high lift configuration was obtained from LAL 127 and Mach number derivatives from NACA-RM-7116.

Nominal Configuration

230 gal Tip Tanks
60% Internal Fuel

$$\begin{aligned} W &= 13700 \text{ lb} \\ \text{c.g. at } 0.263 \bar{c}, \text{W.L. } 100.2 \\ I_x &= 23800 \text{ slug}\cdot\text{ft}^2 \\ I_y &= 21100 \text{ slug}\cdot\text{ft}^2 \\ I_z &= 17800 \text{ slug}\cdot\text{ft}^2 \\ I_{xz} &= 480 \text{ slug}\cdot\text{ft}^2 \end{aligned}$$
Flight Envelope**Power Approach Configuration**

230 gal Tip Tanks
25% Internal Fuel
Full Flaps
Gear Down

$$\begin{aligned} W &= 11800 \text{ lb} \\ \text{c.g. at } 0.260 \bar{c}, \text{W.L. } 100 \\ I_x &= 12700 \text{ slug}\cdot\text{ft}^2 \\ I_y &= 20700 \text{ slug}\cdot\text{ft}^2 \\ I_z &= 32000 \text{ slug}\cdot\text{ft}^2 \\ I_{xz} &= 480 \text{ slug}\cdot\text{ft}^2 \end{aligned}$$

Figure II-1. NT-3A Flight Conditions

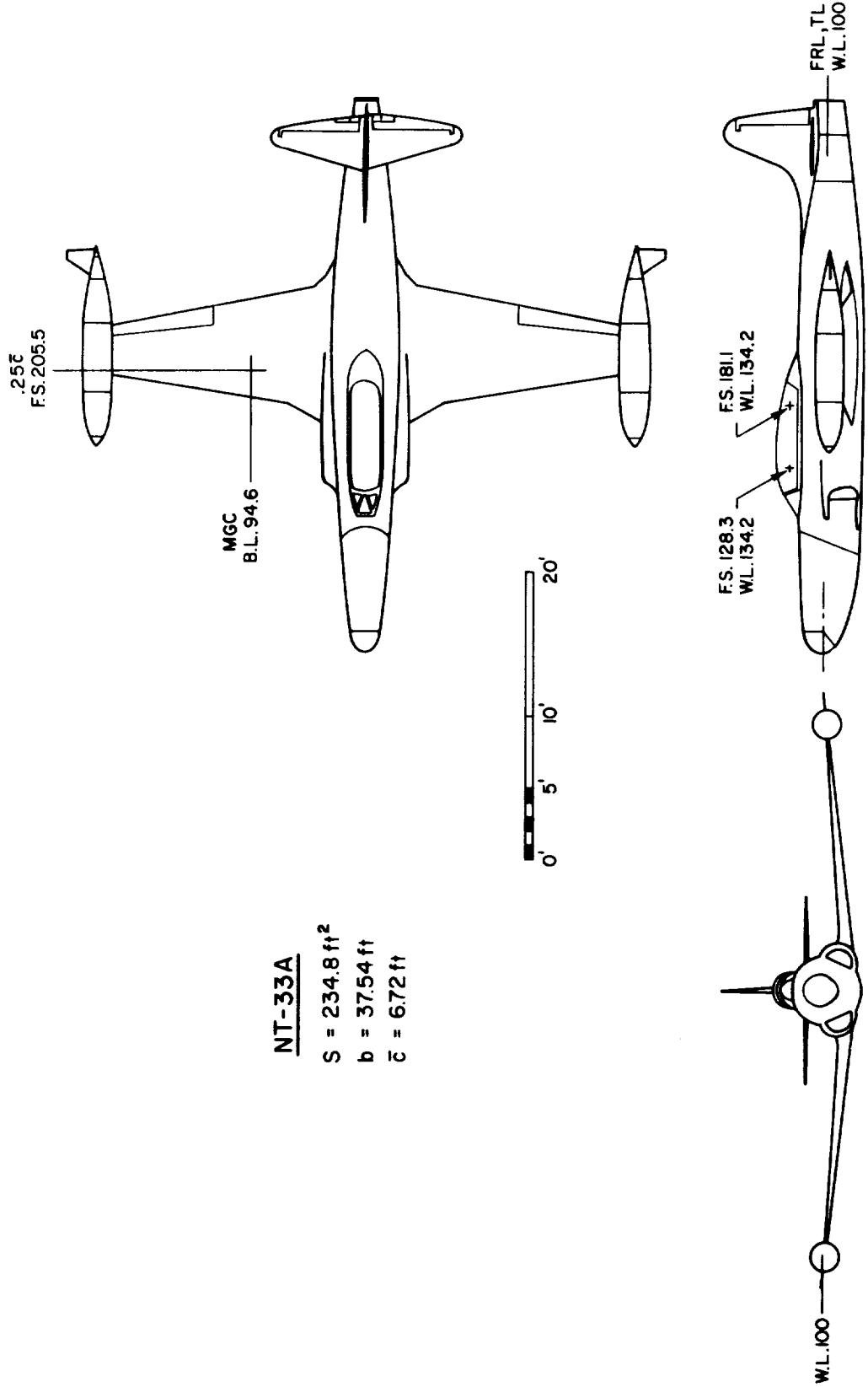
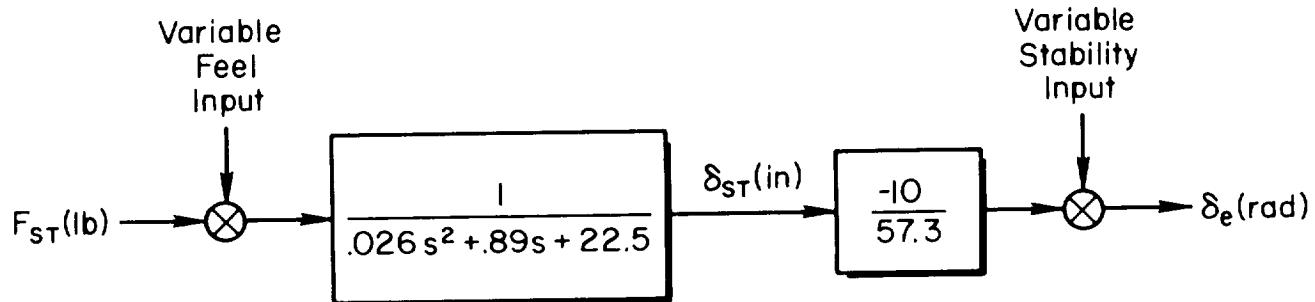


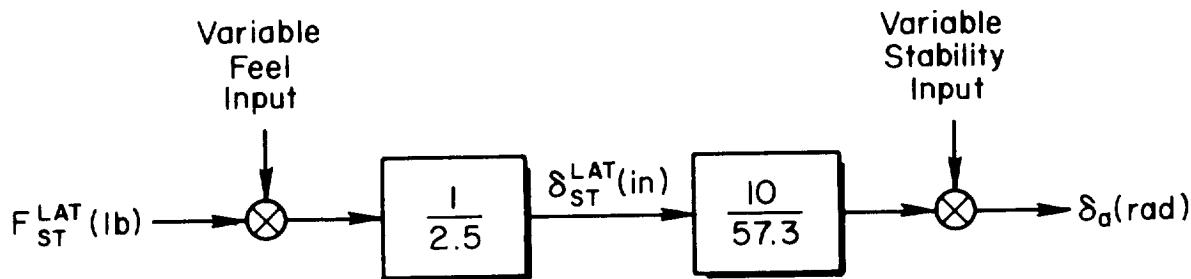
Figure II-2. NT-33 A General Arrangement

NT-33A

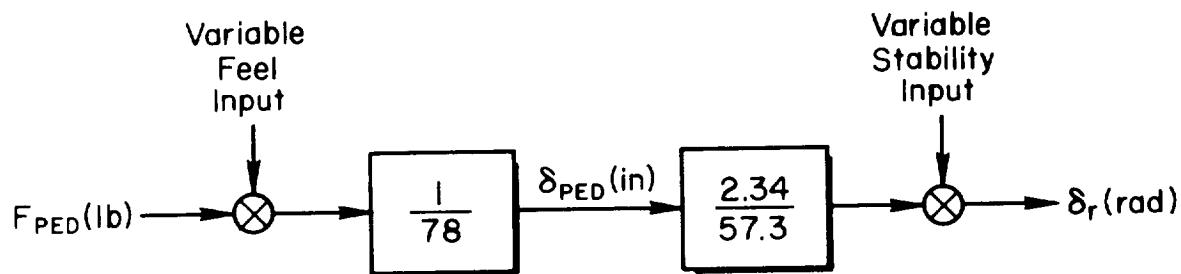
PITCH AXIS



ROLL AXIS



YAW AXIS



Feel system parameter values shown correspond to the "Front Seat Engage" mode (normal NT-33)

Figure III-3. NT-33A Control System

TABLE II-1

NT-33A

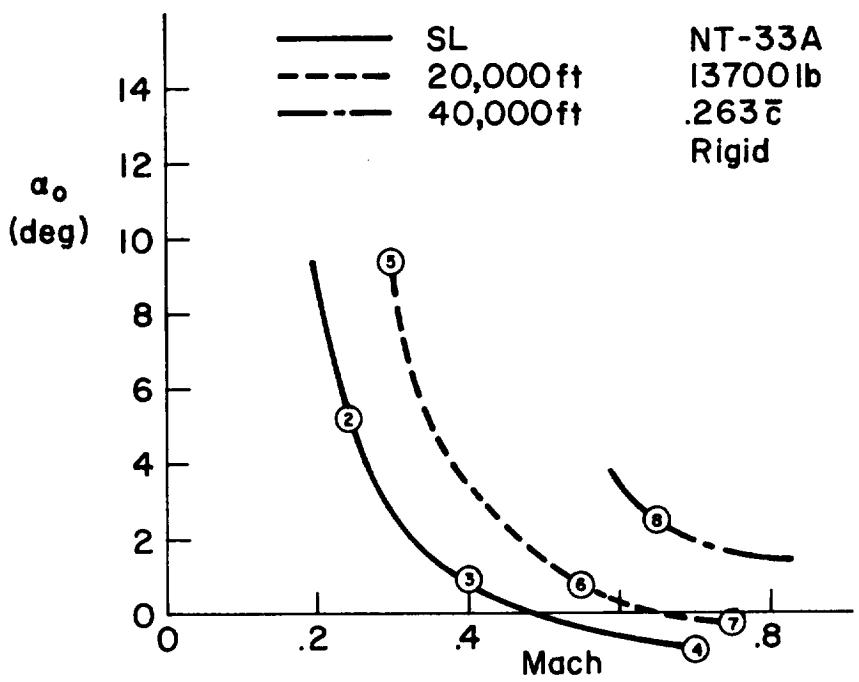
Power Approach Non-Dimensional Stability Derivatives

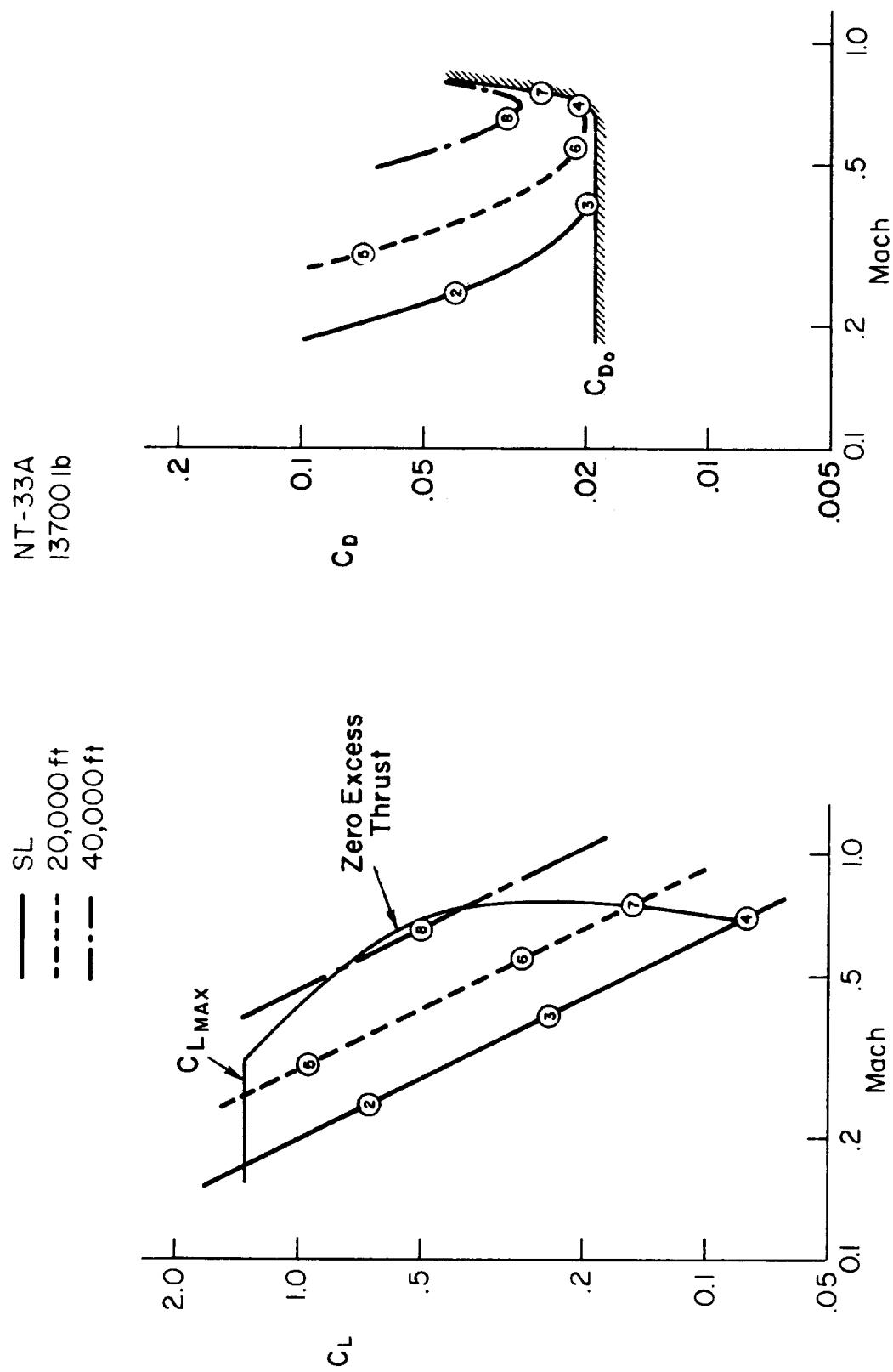
h = sea level

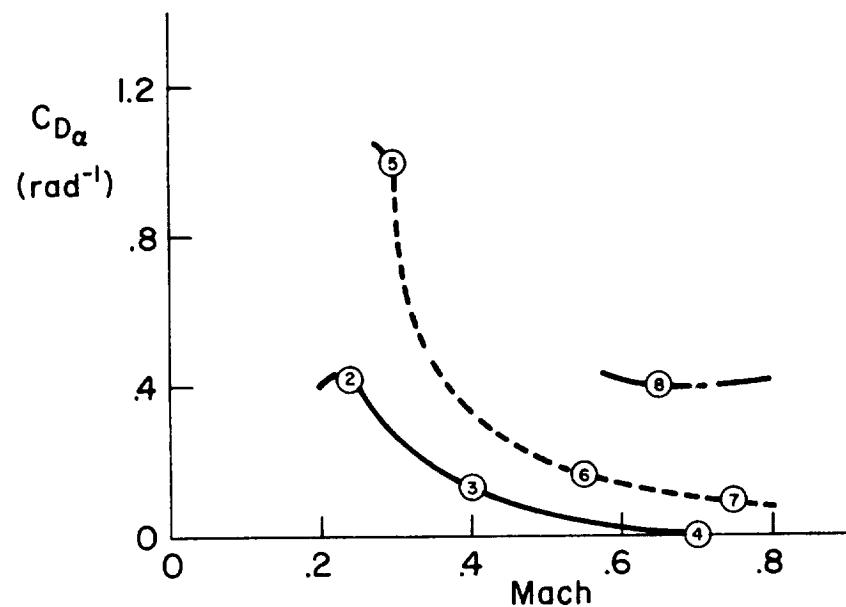
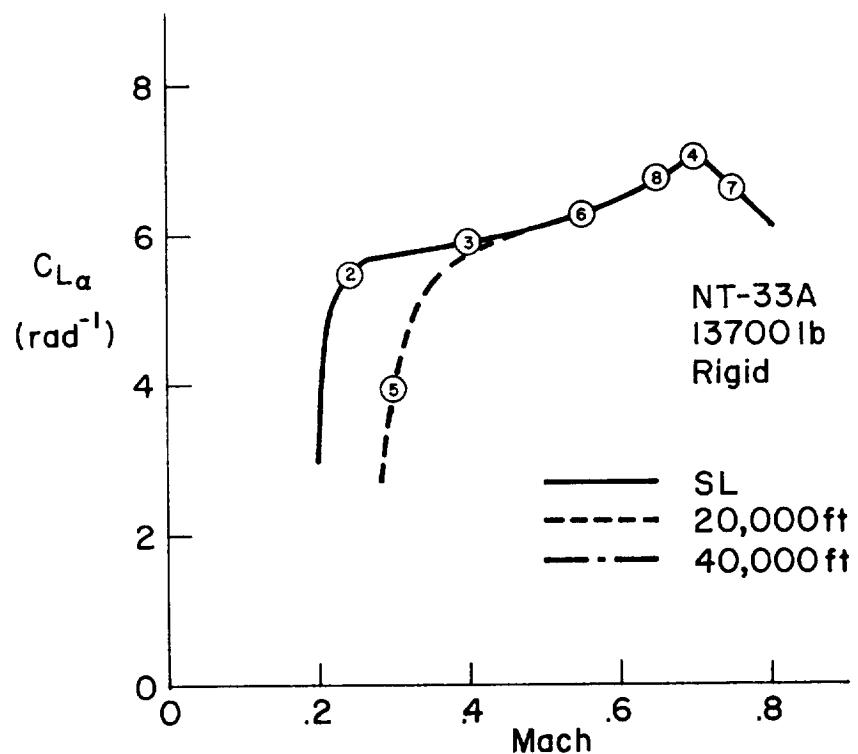
$$V_{T_0} = 228 \text{ ft/sec} = 135 \text{ kt}$$

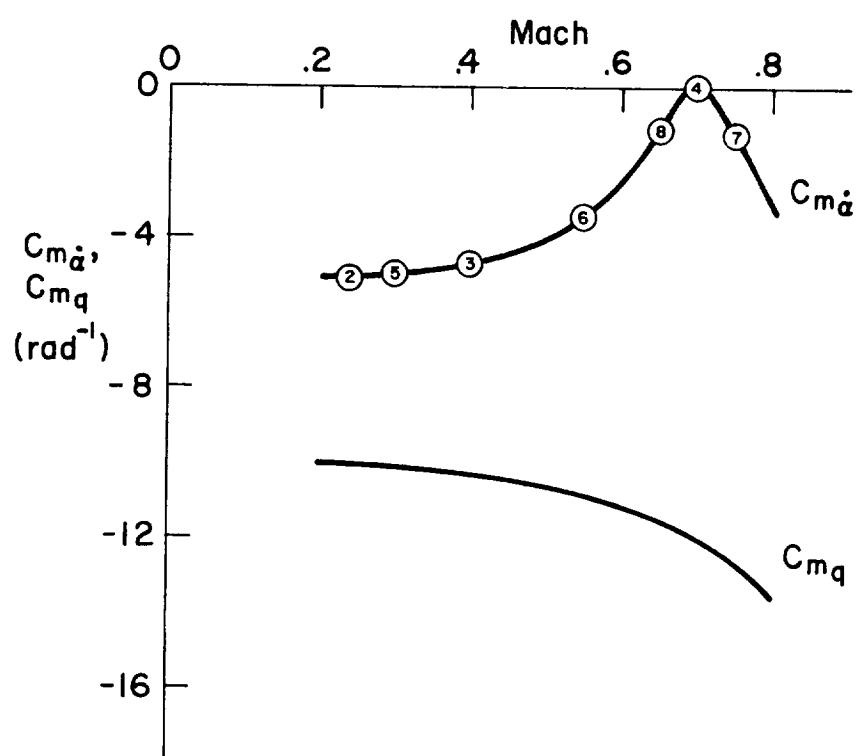
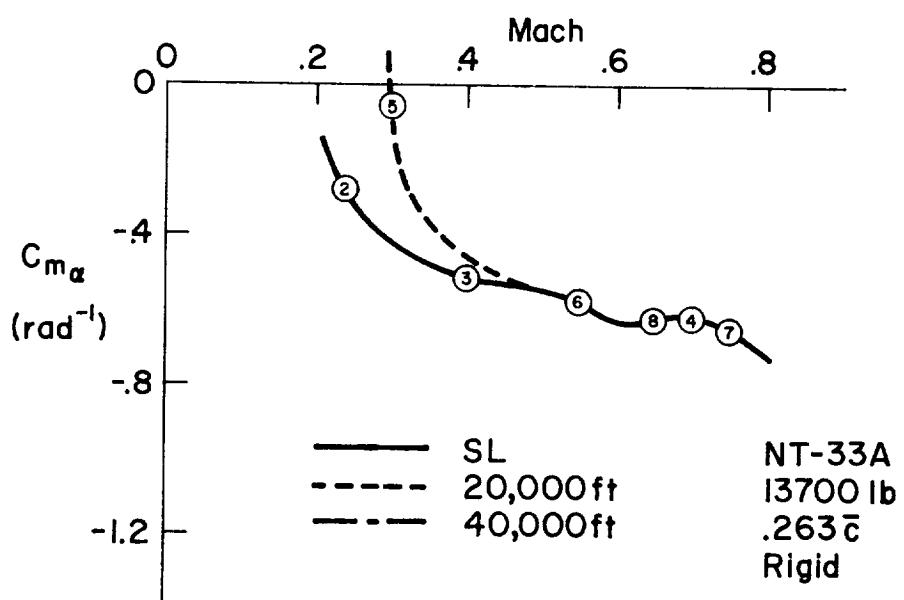
$$\alpha_0 = 2.2^\circ$$

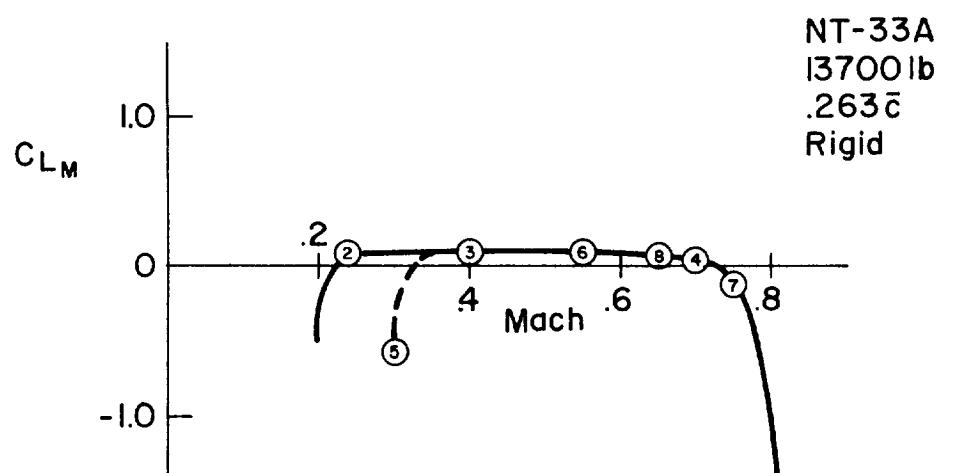
Longitudinal	Lateral-Directional (Stability Axis)
$C_L = .813$	$C_{y\beta} = -.72/\text{rad}$
$C_D = .135$	$C_{n\beta} = .049/\text{rad}$
$C_{L\alpha} = 5.22/\text{rad}$	$C_{\ell\beta} = -.127/\text{rad}$
$C_{D\alpha} = .54/\text{rad}$	$C_{\ell_p} = -.57/\text{rad}$
$C_{m\alpha} = -.401/\text{rad}$	$C_{n_p} = -.045/\text{rad}$
$C_{m_q} = -10/\text{rad}$	$C_{\ell_r} = .20/\text{rad}$
$C_{m\dot{\alpha}} = -5/\text{rad}$	$C_{n_r} = -.16/\text{rad}$
$C_{L\delta_e} = .34/\text{rad}$	$C_{n_{\delta_a}} = -.009/\text{rad}$
$C_{m\delta_e} = -.89/\text{rad}$	$C_{\ell_{\delta_a}} = .14/\text{rad}$
	$C_{y_{\delta_r}} = .17/\text{rad}$
	$C_{n_{\delta_r}} = -.073/\text{rad}$
	$C_{\ell_{\delta_r}} = -.002/\text{rad}$



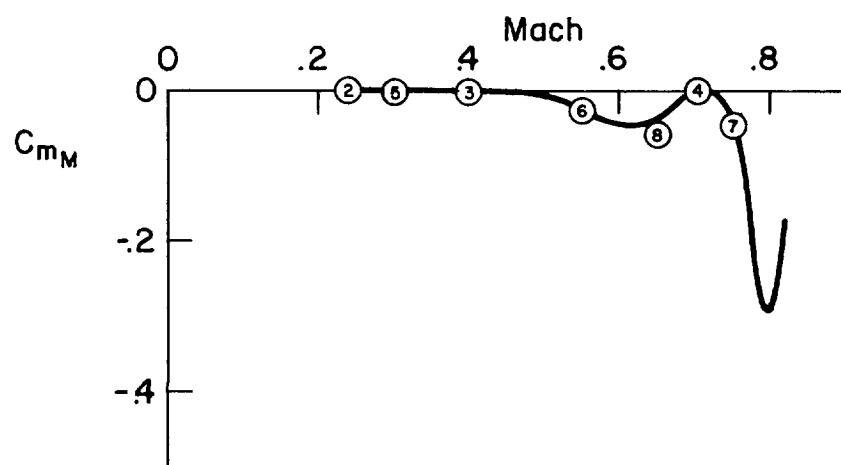
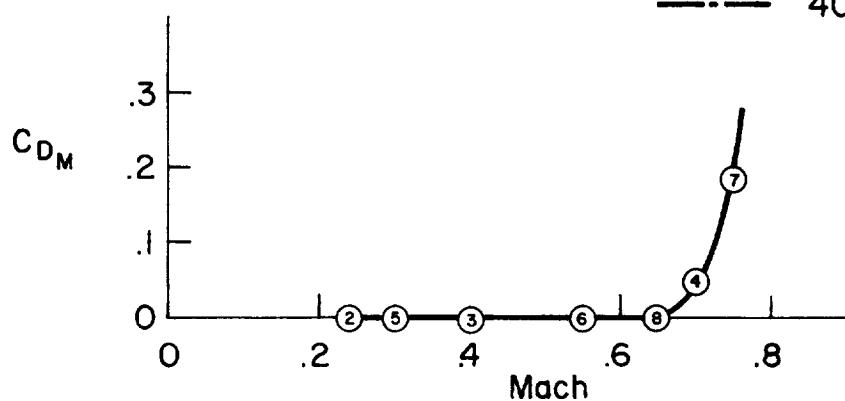


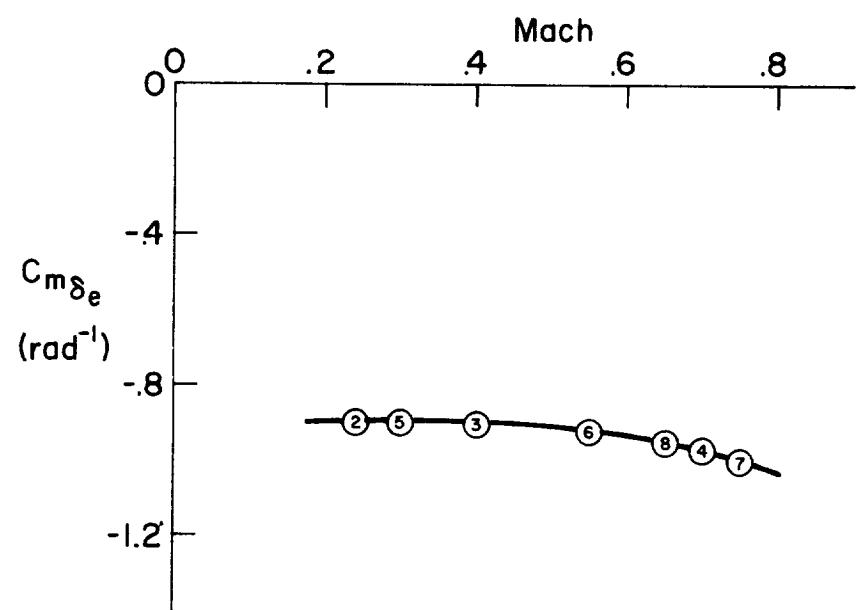
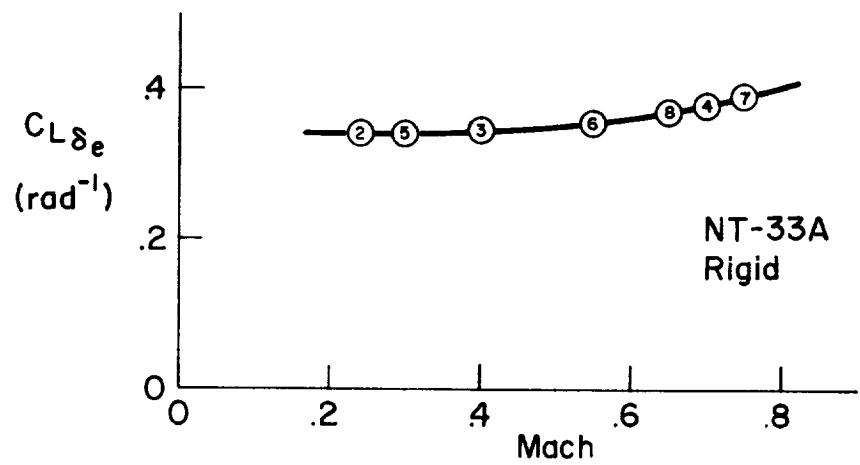


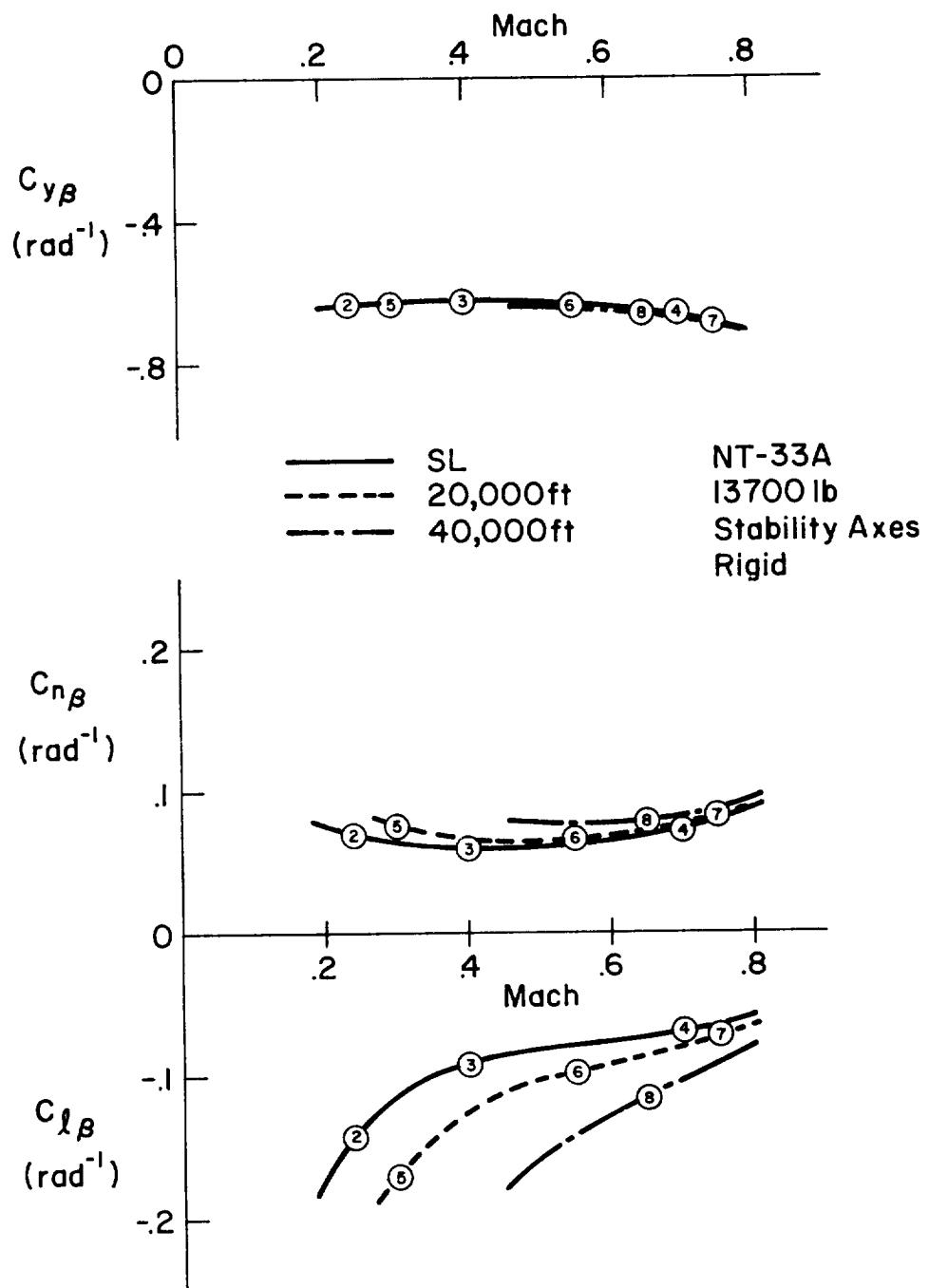


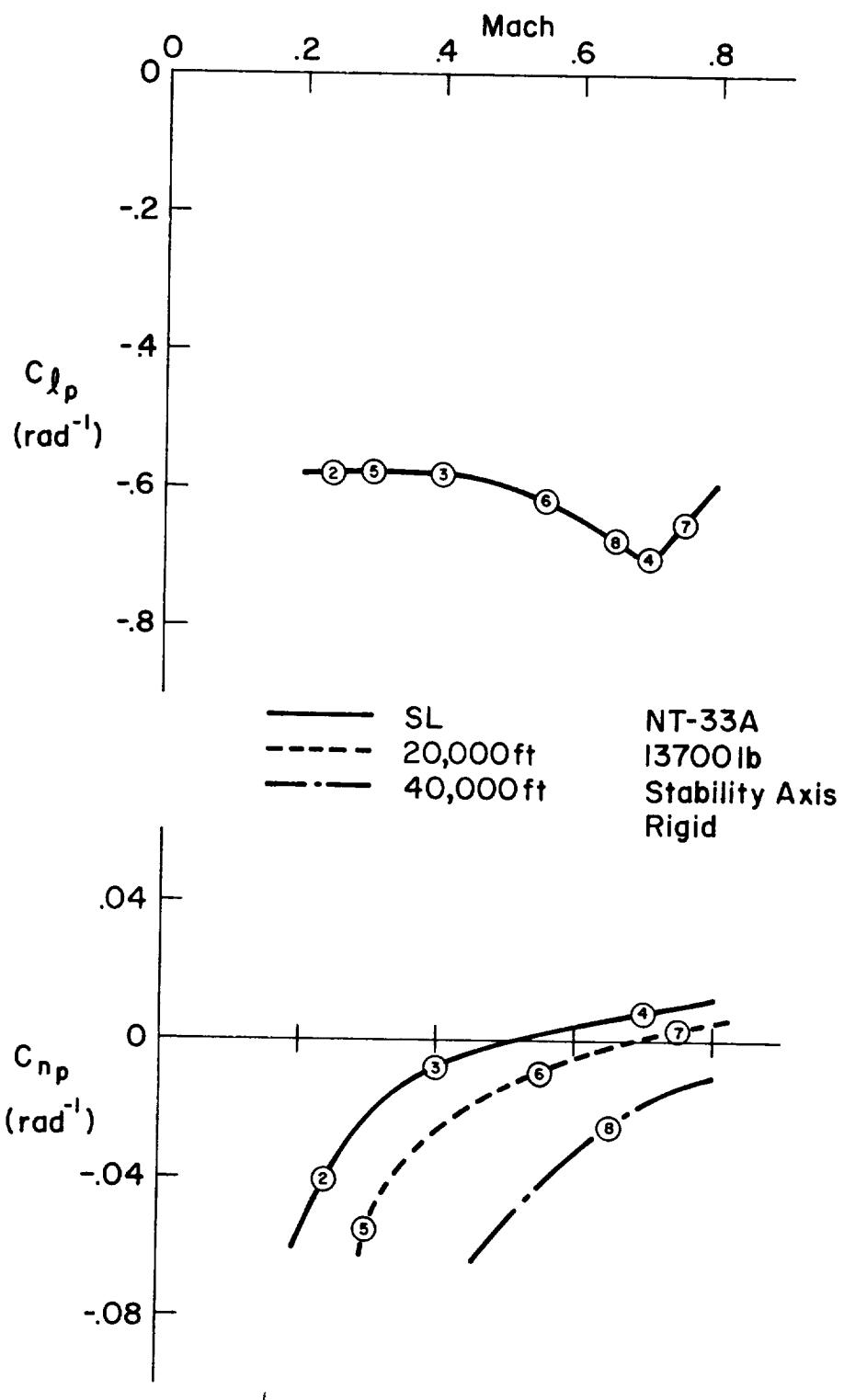


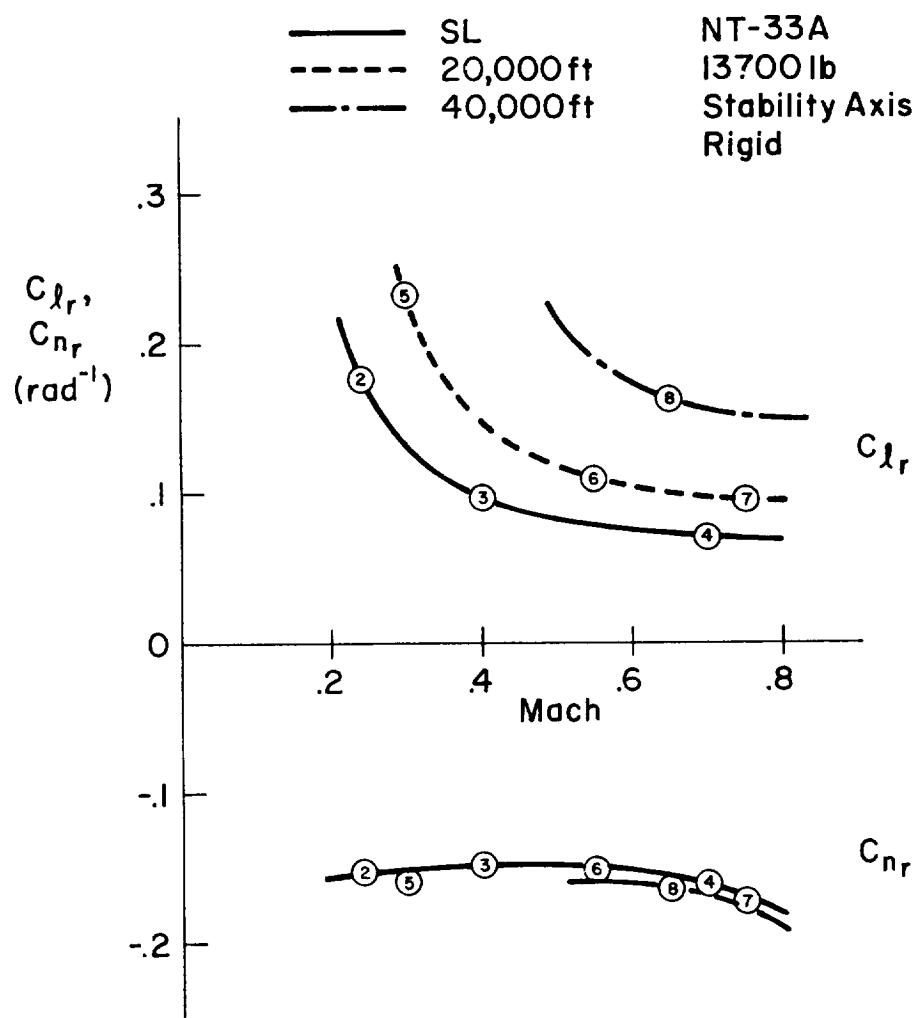
— SL
- - - 20,000ft
— 40,000ft

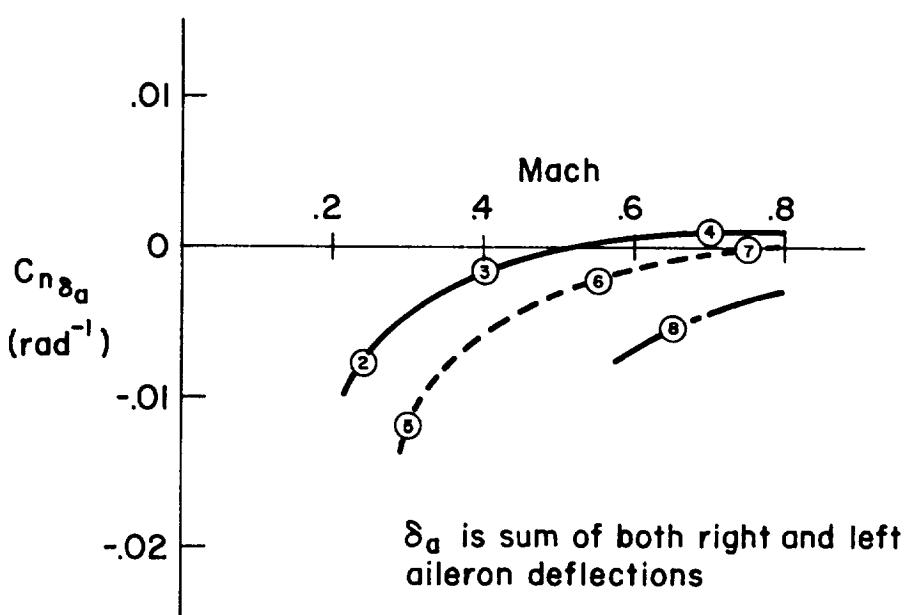
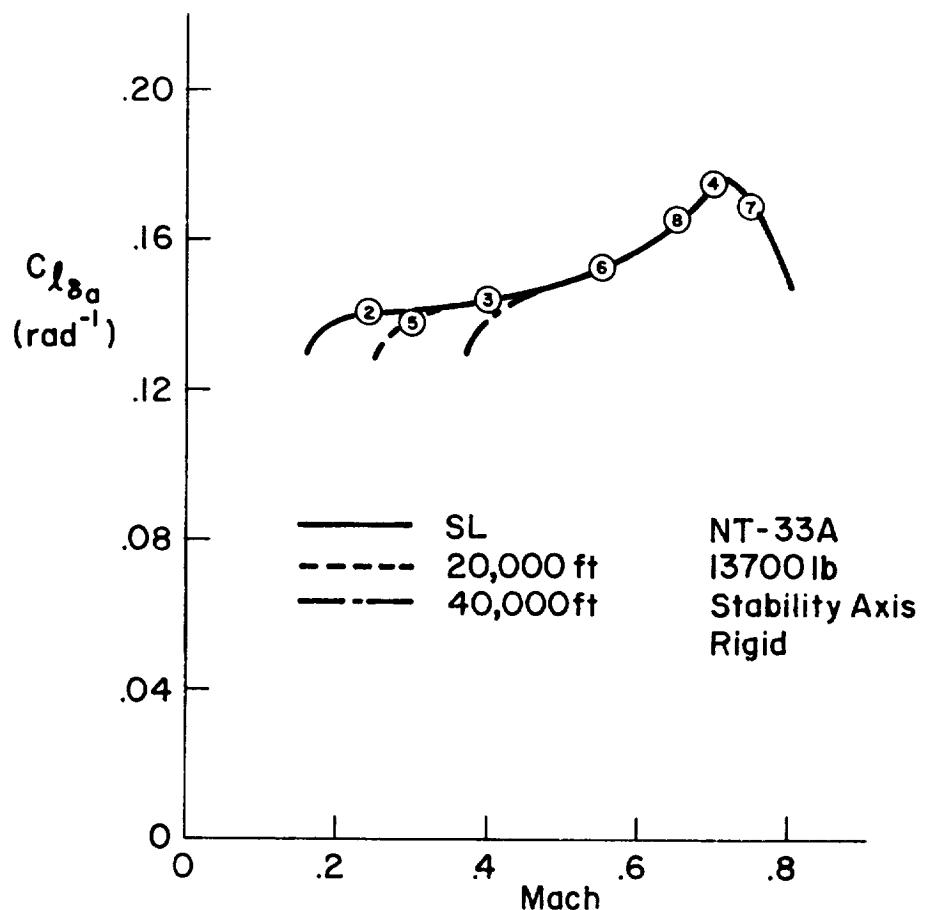












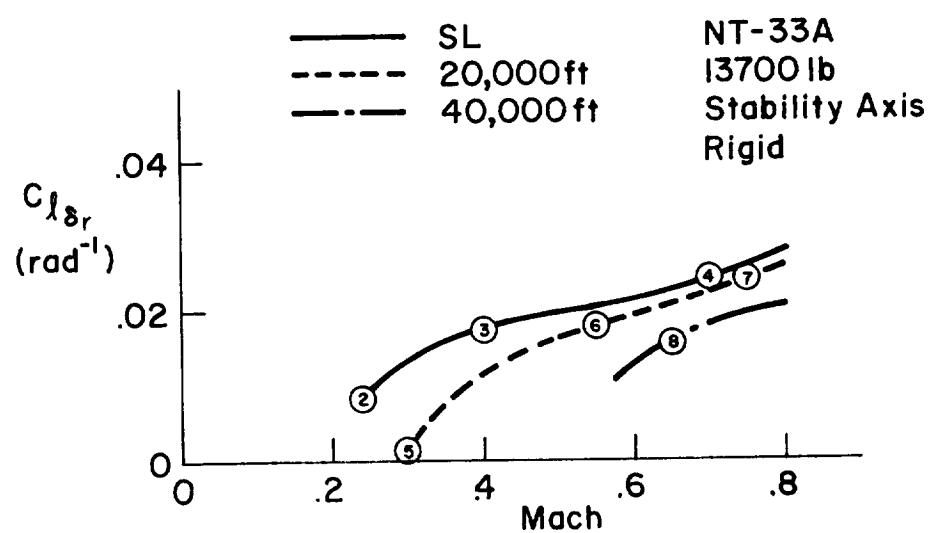
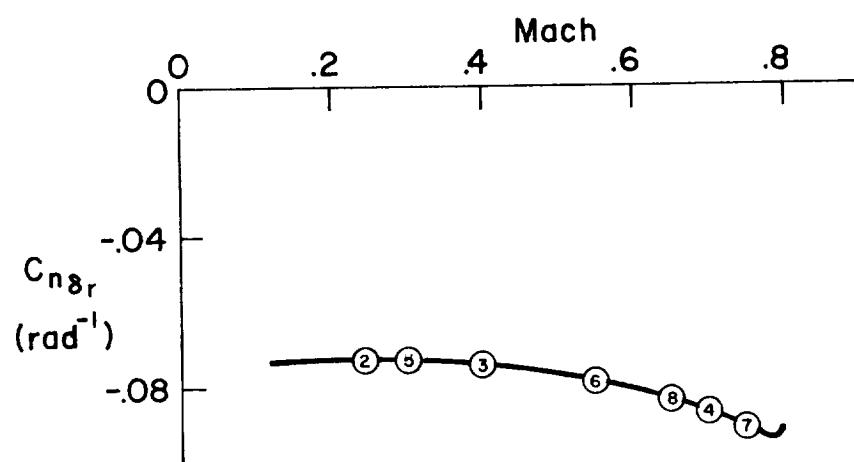
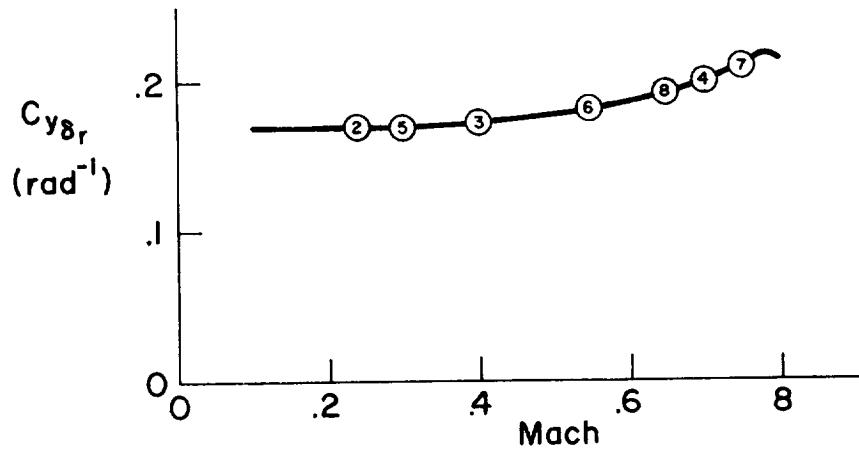


TABLE III-2
NT-33A DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

S = 234.8 sq ft, b = 37.54 ft, \bar{c} = 6.72 ft

F/C #	1	2	3	4	5	6	7	8
H(FT)	SL	SL	SL	SL	20 K	20 K	20 K	40 K
M(-)	.204	.242	.400	.700	.300	.550	.750	.650
VTC(FPS)	228.	270.	447.	782.	311.	570.	778.	629.
VTO(KTAS)	135.	160.	265.	463.	184.	338.	461.	373.
VTO(KCAS)	135.	160.	265.	463.	135.	252.	348.	193.
W(LBS)	11800.	13700.	13700.	13700.	13700.	13700.	13700.	13700.
C.G.(%GC)	.260	.263	.262	.263	.263	.263	.263	.263
I X (SLUG-FT SG)	12700.	23801.	23801.	23801.	23801.	23801.	23801.	23801.
I Y (SLUG-FT SG)	20700.	21101.	21101.	21101.	21101.	21101.	21101.	21101.
I Z (SLUG-FT SG)	32001.	43802.	43802.	43802.	43802.	43802.	43802.	43802.
I X2(SLUG-FT SG)	480.	480.	480.	480.	480.	480.	480.	480.
EPSILCN(DEG)	-1.42	-1.37	-1.37	-1.37	-1.37	-1.37	-1.37	-1.37
Q(PSF)	61.7	86.7	237.	726.	61.3	206.	383.	117.
QC(PSF)	62.3	87.9	247.	819.	62.7	222.	440.	129.
ALPHA(DEG)	2.20	5.20	.900	-.900	.540	.800	-.300	2.50
GAMMA(DEG)	C.	C.	0.	C.	0.	0.	0.	0.
LXP(FT)	6.51	6.53	6.53	6.53	6.53	6.53	6.53	6.53
LZP(FT)	-2.85	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84
I TH(DEG)	0.	C.	C.	C.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	C.	0.	0.	0.	0.
LTH(FT)	0.	.0200	.0200	.0200	.0200	.0200	.0200	.0200

TABLE III-3

NT-33A LONGITUDINAL DIMENSIONAL DERIVATIVES

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K
Y	.204	.242	.400	.700	.300	.550	.750	.650
XU *	-.0391	-.00484	-.0104	-.0415	.00477	-.00735	-.0511	-.00355
ZU *	-.248	-.153	-.128	-.162	-.114	-.107	-.0703	-.0766
RYU *	.000318	.000603	.000263	-.000760	.000114	-.000183	-.00151	-.000183
XW	.0815	.131	.0562	-.0211	.0657	.0391	.00986	.0391
ZW	-.936	-.991	-.73	-.355	-.451	-.125	-.180	-.696
RW	-.00827	.00669	-.0206	-.0431	-.000728	-.0157	-.0239	-.00861
ZHD	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.00152	-.00149	-.00140	0.	-.000785	-.000541	-.000207	-.887E-4
RQ	-.694	-.806	-.137	-.280	-.500	-.981	-.156	-.535
XDE	.516	1.47	.620	-.265	1.88	.500	-.432	.996
ZDE	-13.4	-16.2	-44.4	-152.	-11.3	-40.9	-82.4	-23.8
MDE	-4.19	-5.83	-16.0	-52.7	-4.13	-14.2	-28.7	-8.28
XDTH	.00273	.00235	.00235	.00235	.00235	.00235	.00235	.00235
ZDTH	0.	0.	0.	0.	0.	0.	0.	0.
MDTH	0.	.948E-6	.948E-6	.948E-6	.948E-6	.948E-6	.948E-6	.948E-6

TABLE II-4

NT-33A ELEVATOR TRANSFER FUNCTION FACTORS

Bare Airframe

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H	.204	.242	.400	.700	.300	.550	.750	.650
N								
DENOMINATOR								
Z(DET)1	.0948	C199	.0546	.351	.00782	.0522	(-.0217)	.0315
W(DET)1	.172	.141	.0932	.0561	.0977	.0678	(.0717)	.0543
Z(DET)2	.622	.680	.548	.484	.887	.398	.380	.268
W(DET)2	1.59	1.62	3.41	6.61	.674	3.19	4.63	2.40
NUMERATORS								
N(U /DE)								
A(U)	.516	1.47	.620	-2.65	1.88	.500	-.432	.996
1/T(U)	6.80	96.5	177.	2.84	112.	.222.	2.15	.228.
Z(L)	.673	.369	.484	(-3.03)	.631	.560	(-6.16)	.545
W(U)	1.87	1.14	2.80	(249.)	.537	2.23	(280.)	.889
N(W /DE)								
A(W)	-13.4	-16.2	-44.4	-152.	-11.3	-40.9	-82.4	-23.8
1/T(W)	71.7	97.8	162.	273.	112.	199.	272.	220.
Z(W)	.115	.0290	.0584	.245	-.0137	.0519	.488	.0373
W(W)	.186	.135	.0955	.0805	.109	.0774	.0522	.0623
N(THE/DE)								
A(THE)	-4.17	-5.81	-15.9	-52.7	-4.12	-14.2	-28.6	-8.28
1/T(THE)1	.0627	.0258	.0147	.0406	.0123	.0108	.0515	.00794
1/T(THE)2	.890	.955	1.68	3.47	.433	1.20	1.73	.667
N(HD /DE)								
A(HD)	13.4	16.2	44.4	152.	11.5	40.9	82.4	23.8
1/T(HD)1	.0174	-.00440	.00796	.0394	-.0326	.00499	.0501	-.000124
1/T(HD)2	-7.48	-9.06	-15.4	-29.3	-6.54	-14.8	-20.8	-11.8
1/T(HD)3	8.55	10.3	17.4	32.1	7.33	16.1	22.5	12.4
N(AZP/DE)								
A(AZP)	13.7	21.7	59.3	192.	15.5	51.5	105.	30.3
1/T(AZP)1	-.0116	.0145	-.00172	.00967	.00549	-.00134	.00224	.00414
1/T(AZP)2	.0288	-.0191	.00967	.0387	-.0385	.00633	.0499	-.00428
Z(AZP)1	.0507	.0482	.051C	.C734	.0209	.0416	.0454	.0343
W(AZP)1	7.92	8.32	14.2	27.3	5.92	13.7	19.2	10.7
+	+	+	+	+	+	+	+	+

TABLE II-5

NT-35A THRUST TRANSFER FUNCTION FACTORS

Bare Airframe

(Body Axis System)

F/C *	1	2	3	4	5	6	7	8
H	SL .204	SL .242	SL .400	SL .700	20 K .300	20 K .550	20 K .750	40 K .650
M								
DENOMINATOR								
Z(DET)1	.0948	.0199	.0546	.351	-C0782	.0522	(-.0217)	.0315
W(DET)1	.172	.141	.0922	.0561	C977	.0678	(.0717)	.0543
Z(DET)2	.622	.680	.548	.484	.887	.398	.380	.268
W(DET)2	1.59	1.62	3.41	6.61	.674	3.19	4.63	2.40
NUMERATORS								
N(U /DTI)	.00273	.00235	.00235	.00235	.00235	.00235	.00235	.00235
A(L)	-.00403	-.0124	-.00284	-.00057C	-.0214	-.00229	-.000903	-.00366
1/T(U)1	.621	.680	.548	.484	.883	.398	.381	.266
Z(U)1								
W(L)1	1.59	1.62	3.41	6.61	.676	3.19	4.63	2.40
N(W /DTI)								
A(W)	-.000639	-.180E-4	.000143	.00036C	.000116	.000297	.000570	.000421
1/T(W)1	.0398	.0C629	-.C335	-.CC167	-.0415	-.00713	-.00521	-.00815
1/T(W)12	.421	-.517	-.746	-.674	-.425	-.164	-.523	-.854
N(THE/DTI)								
A(THE)	.159 E-6	.127E-5	.954E-6	.948E-6	.125E-5	.963E-6	.945E-6	.957E-6
Z(THE)1	{ 5.44}	{ 7.29	{ 521	{ 26E	{ 819	{ 252	{ 899	{ 117
W(THE)1	{ 7.38}	{ 1.74	{ 2.73	{ 3.2E	{ 506	{ 1.89	{ 2.77	{ 1.15
N(HD /DTI)								
A(HD)	.000105	.000213	.369E-4	.369E-4	.000384	.328E-4	.123E-4	.000102
1/T(HD)1	7.38	1.96	6.51	10.5	.242	3.23	-1.24	.849
Z(HD)1	.379	.612	.727	.795	.817	.816	{ 7.45)	.365
W(HD)1	1.37	1.57	3.70	4.42	1.01	4.29	{ 16.1)	3.00
N(AZP/DTI)								
A(AZP)	-.104E-5	-.827E-5	-.649E-5	-.619E-5	-.818E-5	-.629E-5	-.617E-5	-.625E-5
1/T(AZP)1	-.00542	-.0109	-.00112	-.00112	.CC064E	-.C173	-.000790	-.00224
1/T(AZP)2	6.63	4.38	4.6	2.91	.351	3.6.8	-1.04	2.60
Z(AZP)1	.389	.632	.685	{ 8.44)	{ 1.06)	.730	.768	.701
W(AZP)1	1.46	1.69	3.38	{ 51.8)	{ 32.2)	2.90	16.9	2.20
	+	+	+	+	+	+	+	+

TABLE III-6
MT-33A LONGITUDINAL HANDLING QUALITIES PARAMETERS
 Bare Airframe
 (Body Axis System)

F/C #	1	2	3	4	5	6	7	8
H								
S _L	S _L	S _L	S _L	20 K	20 K	20 K	40 K	
r	.204	.242	.400	.700	.300	.550	.750	.650
STICK FIXED								
D(G)/D(U) (DEG/KT)	-.0526	.0131	-.0240	-.118	.0977	-.0150	-.151	.000330
NLA (G/RAC)	6.37	8.05	23.0	83.2	4.26	21.2	41.6	13.1
DE/G (DEG/G)	5.39	3.14	1.79	.565	1.46	1.92	1.02	3.05
CAP (RAD/SEC/SEC/G)	.392	.319	.497	.515	.105	.475	.512	.441
PHUGOID(2) (SEC)	--	--	--	--	.908.	--	(32.0)	--
1/C(1/10)	2.17	2.53	1.79	1.51	5.25	1.19	1.12	.758
+	+	+	+	+	+	+	+	+

TABLE III-7
NT-33A LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>h</i>	1	2	3	4	5	6	7	8	*						
<i>M</i>	.242	.400	.700	.300	.550	.750	.650								
<i>YV</i>	-.125	-.111	-.181	-.338	-.0696	-.128	-.185								
<i>YB</i>	-28.4	-30.1	-81.0	-264.	-21.6	-72.7	-14.								
<i>LB</i>	-5.49	-4.72	-8.02	-18.0	-4.06	-7.42	-9.89								
<i>NB</i>	.667	.940	2.71	10.6	.540	2.60	6.24	1.68							
<i>LP</i>	-2.03	-1.32	-2.15	-4.51	-.820	-1.56	-2.23	-877							
<i>NP</i>	-.116	-.112	-.0512	.0118	-.103	-.0383	-.0141	-0.428							
<i>LR</i>	.641	.305	.320	.495	.214	.256	.328	.179							
<i>NR</i>	-.207	-.173	-.291	-.561	-.104	-.204	-.318	-.110							
<i>Y*CA</i>	0.	0.	0.	0.	0.	0.	0.	0.							
<i>L*CA</i>	6.C1	4.53	12.6	47.0	3.14	11.7	24.0	7.13							
<i>N*CA</i>	.0286	.134	.165	.260	.164	.121	.195	.118							
<i>Y*CR</i>	.0295	.0301	.0503	.102	.0185	.0363	.0571	.0195							
<i>L*CR</i>	-.0125	.443	1.57	5.89	.287	1.39	3.20	.808							
<i>N*DR</i>	-1.24	-1.25	-3.50	-12.6	-.883	-3.21	-6.99	-1.92							
	+	+	+	+	+	+	+	+							

TABLE III-8

NT-3A ATTERRON TRANSFER FUNCTION FACTORS
Bare Airframe
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8
H	.204	.242	.4CC	.7CC	.300	.550	.750	.650
M								
DENOMINATOR								
1/T(DET)1	*0318	*C185	*0143	*00465	*0129	*00932	00333	*00483
1/T(DET)2	2.20	1.47	2.24	4.57	*966	1.66	2.29	.979
Z(DET)1	*C609	*0435	*102	.127	*C0638	*0647	*0868	*0251
W(DET)1	1.13	1.26	1.75	3.28	1.16	1.70	2.52	1.41
NUMERATOR								
N(B/DA)								
A(B)	*202	*278	.0333	-.999	*351	*0619	-.320	*193
1/T(B)1	*.116	*.103	.214	-.946	*.0616	*144	*.330	*0692
1/T(B)2	7.48	3.30	37.8	1.15	1.56	22.6	-3.01	3.05
N(P/DA)								
A(P)	*6.01	*4.53	12.6	*47.C	*3.14	*11.7	24.0	7.13
1/T(P)1	-.00522	-.0106	-.00111	*000636	-.0169	-.000781	*.00215	-.00222
Z(P)1	*.200	*.145	*.141	*.136	*.116	*.102	*.0999	*.0687
W(P)1	*.849	1.05	1.65	3.30	*.868	1.64	2.53	1.33
N(R/DA)								
A(R)	*.0286	*134	*165	*260	*164	*121	*195	*118
1/T(R)1	*.885	*.786	*1.75	10.4	*485	*1.60	*3.86	*828
Z(R)1	{-1.06}	-.673	-.559	-.621	-.450	-.597	-.553	*482
W(R)1	{-22.01}	2.35	2.98	2.77	1.74	3.02	2.89	2.56
N(PHI/DA)								
A(PHI)	6.01	4.55	12.6	47.C	3.17	11.7	24.0	7.14
Z(PHI)1	*195	*136	*141	*136	*0995	*1.02	*0999	*0673
W(PHI)1	*.848	1.05	1.65	3.30	*.874	1.64	2.53	1.33
N(AYP/DA)								
A(AYP)	17.3	12.7	37.C	135.	6.99	34.0	69.4	21.0
1/T(AYP)1	*122	*110	*204	-.356	*0666	*141	*236	*0730
1/T(AYP)2	-1.24	-1.07	-.806	*481	-.587	-.660	-.395	-.604
Z(AYP)1	*437	*407	*269	*121	*460	*226	*126	*236
W(AYP)1	1.38	1.33	1.89	3.53	1.05	1.77	2.66	1.37

MT-33A RUDDER TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)											
+ F/C #		1	2	3	4	5	6	7	8	+	+
H	SL	SL	SL	SL	SL	20 K	20 K	20 K	40 K		
M	.204	.242	.400	.700	.300	.550	.750	.750	.650		
DENOMINATOR											
1/T (DET) 1	.0318	.0185	.0143	.00469	.0129	.00932	.00333	.0C483			
1/T (DET) 2	2.2C	1.47	2.24	4.57	.966	1.66	2.29	.979			
Z (DET) 1	.06C9	.C435	.103	.127	.00638	.0647	.0868	.C251			
W (DET) 1	1.13	1.26	1.75	3.28	1.16	1.70	2.52	1.41			
NUMERATORS											
N(9 /DR)	.0255	.C301	.0503	.102	.0185	.0363	.0571	.0195			
A(B)	-.0454	-.C312	-.C0728	-.00146	-.0377	-.00664	-.00313	-.0C955			
1/T (B) 1	2.05	1.36	2.19	4.57	.836	1.60	2.26	.502			
1/T (B) 2	42.3	42.9	70.2	122.	49.8	89.2	123.	100.			
N(P /DR)											
A(P)	-.0125	.443	1.57	5.89	.287	1.39	3.20	.808			
1/T (P) 1	-.00533	-.C107	-.00112	-.00641	-.0170	-.00785	.000215	-.00223			
1/T (P) 2	8.06	3.12	3.67	5.07	3.10	3.60	3.74	.3.05			
1/T (P) 3	69.0	-4.00	-4.17	-5.54	-3.83	-4.05	-4.13	-3.42			
N(M R /DR)											
A(R)	-1.24	-1.25	-3.50	-12.6	-.883	-3.21	-6.99	-1.92			
1/T (R) 1	2.12	1.35	2.23	4.58	.730	1.66	2.31	.547			
Z(R) 1	.0159	.C724	.0912	.259	*123	*0170	*0822	-.0C220			
W(R) 1	.605	.620	.469	.343	.737	.463	.355	.486			
N(PHI/DR)											
A(PHI)	-.0602	.329	1.51	6.09	.140	1.35	3.23	.724			
1/T (PHI) 1	{ .822}	3.35	3.70	5.06	3.90	3.63	3.74	.3.16			
1/T (PHI) 2	{ 10.8)	-5.06	-4.30	-5.36	-6.38	-4.15	-4.10	-3.68			
N(AYP/DR)											
A(AYP)	-1.40	1.22	4.08	14.8	.799	3.68	7.80	2.03			
1/T (AYP) 1	-.0563	-.C519	-.0140	-.00362	-.0602	-.0120	-.00564	-.0154			
1/T (AYP) 2	1.36	.880	1.78	4.37	.471	1.25	2.00	.643			
1/T (AYP) 3	{ .201)	5.29	7.29	11.4	5.13	7.24	9.38	.5.98			
1/T (AYP) 4	{ 5.62)	-6.80	-9.12	-15.2	-6.23	-8.58	-11.2	-6.90			
	+	+	+	+	+	+	+	+	+	+	+

TABLE III-10
NT-33A LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS
 Bare Airframe
 (BODY AXIS SYSTEM)

	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
F/C #	1	2	3	4	5	6	7	8	
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	
M	.204	.242	.400	.700	.300	.550	.750	.650	
DR PERIOD (SEC)	5.57	4.97	3.61	1.93	5.43	3.71	2.50	4.45	
L/C (1/2)	.553	.395	.941	1.16	.0578	.588	.790	.228	
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--	
P(1)	2.34	2.41	5.18	10.4	2.11	6.29	10.5	5.69	
P(2)	.418	1.22	4.79	10.3	.659	6.04	10.3	5.56	
P(3)	2.00	2.41	5.16	10.4	2.46	6.61	10.4	6.71	
P(2)/P(1)	.179	.505	.924	.983	.313	.961	.981	.977	
P(USC)/P(AV)	.677	.329	.0384	.00752	.552	.0328	.00677	.0542	
W(PHI)/W(D)	.751	.829	.966	1.01	.755	.970	1.00	.942	
DEL-B-MAX	1.01	.701	.326	.104	.781	.322	.141	.459	
PHI TO BETA, PHASE	-297.	-313.	-313.	48.7	-322.	-320.	38.2	-328.	
PHI TO BETA	2.14	2.07	1.73	1.06	2.44	1.95	1.22	2.16	
PHI TO VEE	.539	.438	.223	.0778	.616	.269	.124	.395	
+	+	+	+	+	+	+	+	+	

NT-33A DATA SOURCES

Hall, G. Warren, and Ronald W. Huber, System Description and Performance Data for the USAF/CAL Variable Stability T-33 Airplane, Air Force Flight Dynamics Laboratory Rept. No. AFFDL TR-70-71, Aug. 1970

Tests of a 1/5 Scale Wind Tunnel Model of the TP-80C Trainer, Lockheed Aerodynamics Laboratory Rept. No. LAL 127, Jan. 23, 1948

Cleary, Joseph W., and Lyle J. Gray, High Speed Wind-Tunnel Tests of a Model Pursuit Airplane and Correlation with Flight-Test Results, NACA-RM-7116, Jan. 21, 1948

Statler, Irving C., et al, The Development and Evaluation of the CAL/Air Force Dynamic Wind Tunnel Testing System; Part 1 — Description and Dynamic Tests of an F-80 Model, AFFDL-TR-66-153, Feb. 1967

Flight Manual, USAF Series T-33A Aircraft, T. O. 1T-33A-1.

SECTION III

F-104A

F-104A BACKGROUND

The F-104A is a single place, lightweight, supersonic air superiority fighter powered by a single turbojet engine with afterburner. The wing has a full span leading edge flap. Trailing edge flaps have a blowing-type boundary layer control system. Control is provided by conventional ailerons and rudder and an all-movable stabilizer. Pitch, roll, and yaw dampers are incorporated, however their effect is not shown here. Pitch and roll controls are fully irreversible while the yaw control is a cable-actuated rudder without boost. A bobweight is used in the longitudinal feel system. Its position is assumed to be at the pilot's location.

The primary source of data was LR 10794. Drag information was obtained from LR-12873.

The nominal configuration used here is the combat loading for the F-104A based on actual weight and balance data. The PA configuration is a typical loading at flight manual approach speeds.

Nominal Configuration

Clean, 750 Rounds Ammunition

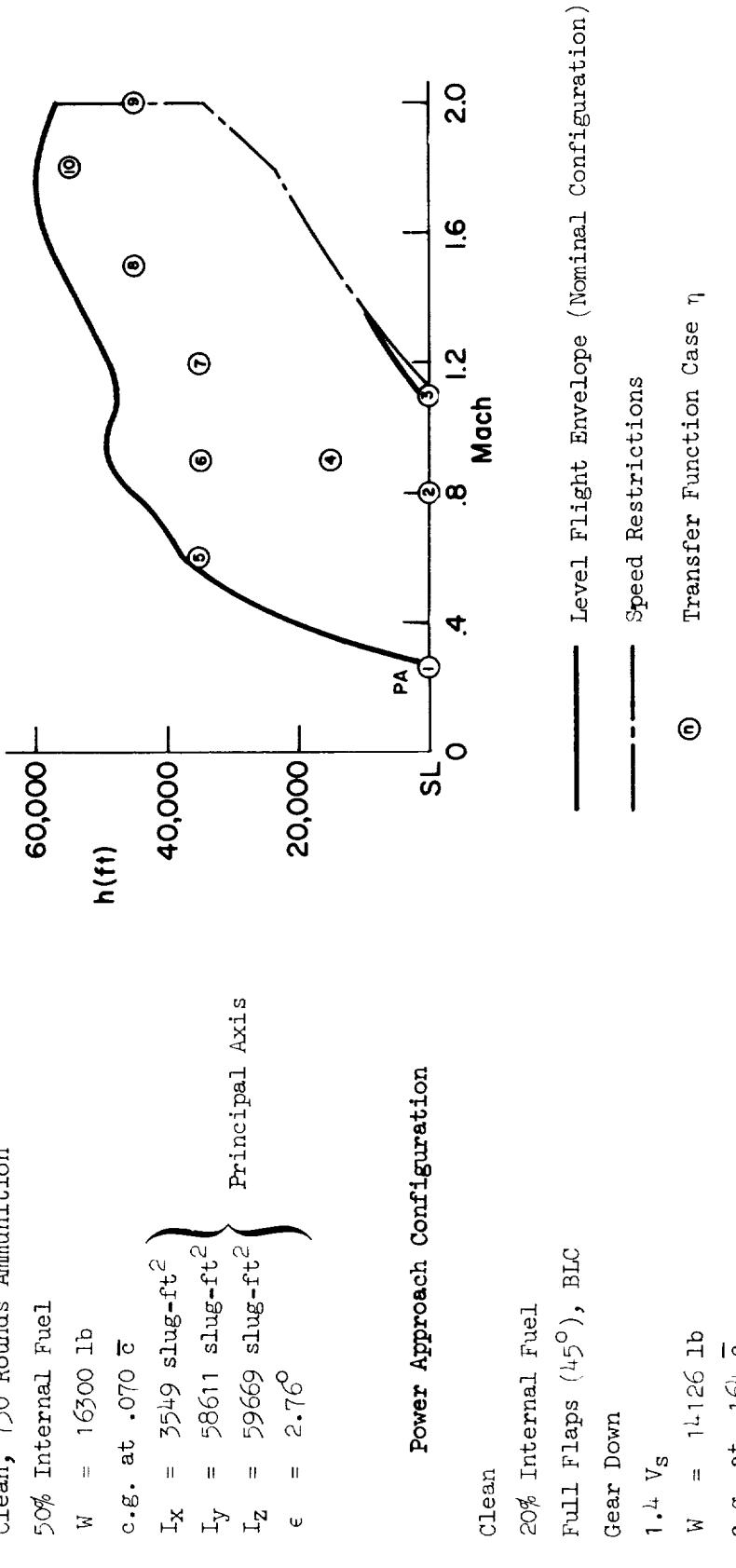
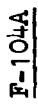
50% Internal Fuel
W = 16300 lb

$$\left. \begin{array}{l} c.g. \text{ at } .070 \bar{c} \\ I_x = 3549 \text{ slug-ft}^2 \\ I_y = 58611 \text{ slug-ft}^2 \\ I_z = 59669 \text{ slug-ft}^2 \\ \epsilon = 2.76^\circ \end{array} \right\}$$

iii

$$W = 16300 \text{ lb}$$

$$\left. \begin{array}{l} c.g. \text{ at } .070 \bar{c} \\ I_x = 3549 \text{ slug-ft}^2 \\ I_y = 58611 \text{ slug-ft}^2 \\ I_z = 59669 \text{ slug-ft}^2 \\ \epsilon = 2.76^\circ \end{array} \right\}$$



$$\left. \begin{array}{l} I_x = 3450 \text{ slug}\cdot\text{ft}^2 \\ I_y = 55800 \text{ slug}\cdot\text{ft}^2 \\ I_z = 56800 \text{ slug}\cdot\text{ft}^2 \\ \epsilon = 2.86^\circ \end{array} \right\} \text{Principal Axis}$$

Figure III-1. F-104A Flight Conditions

F-104A

$S = 196.1 \text{ ft}^2$
 $b = 21.94 \text{ ft}$
 $\bar{c} = 9.55 \text{ ft}$

.25 \bar{c}
F.S. 472.5

MGC
B.L. 55.8

0' 5' 10' 20'

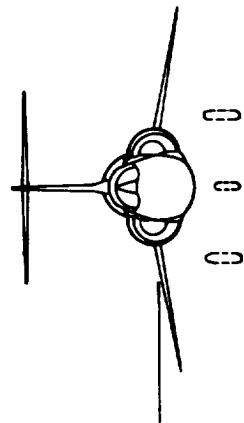
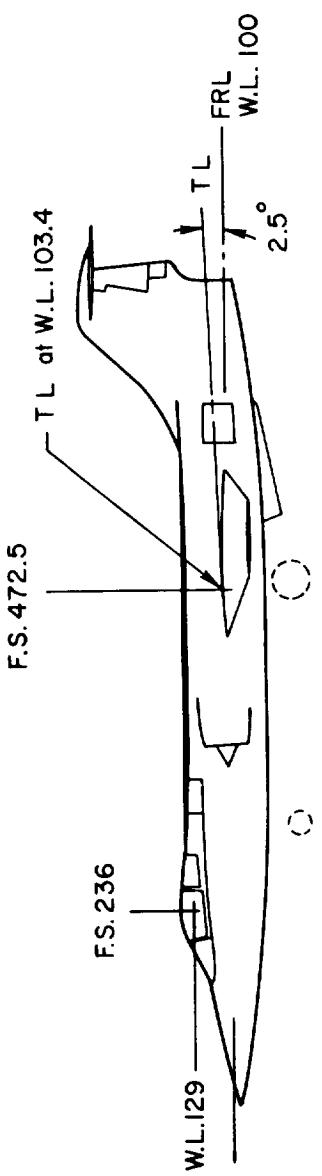
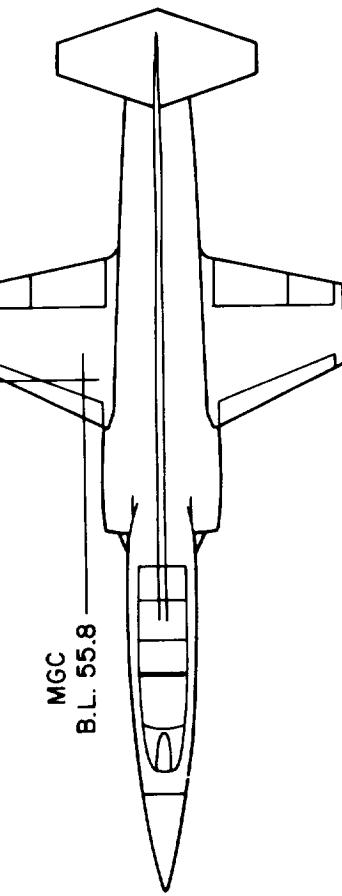
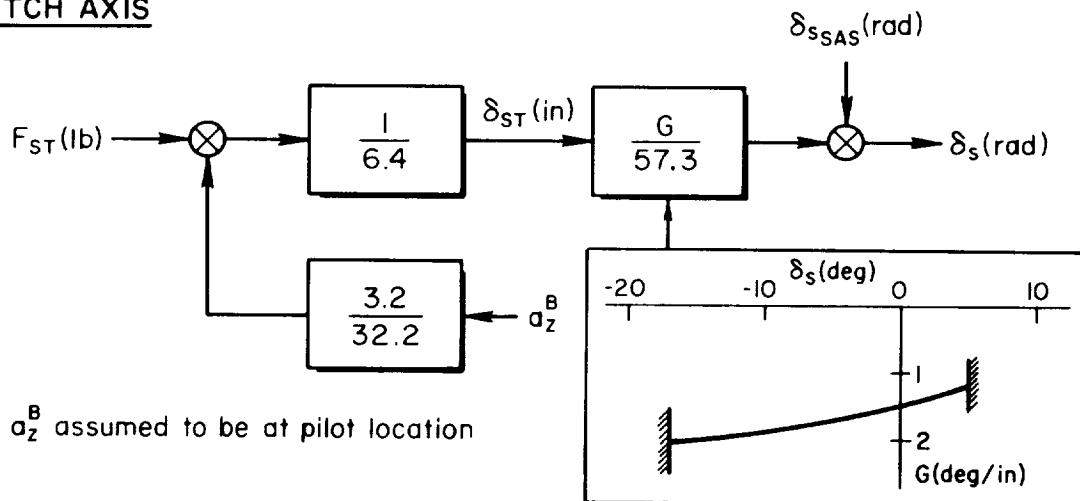


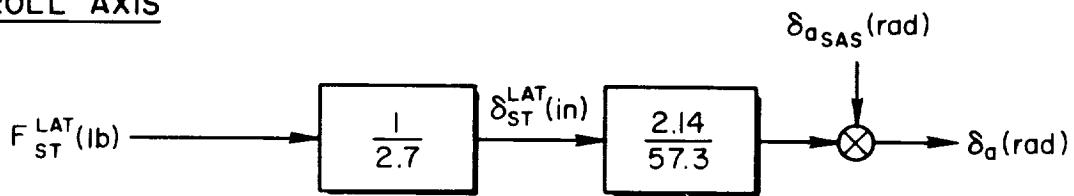
Figure III-2. F-104A General Arrangement

F-104A

PITCH AXIS



ROLL AXIS



YAW AXIS

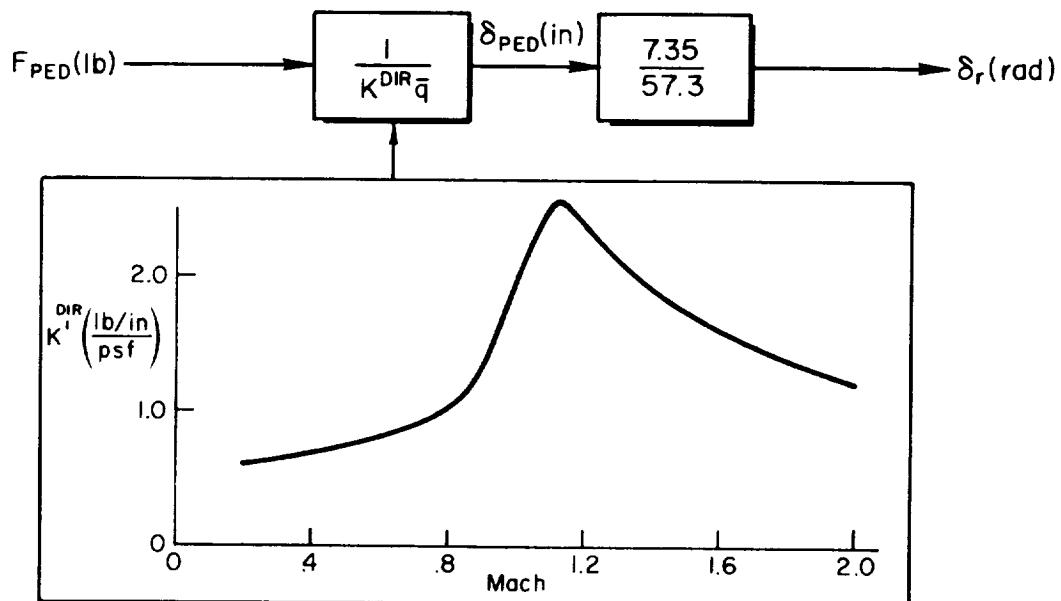


Figure III-3. F-104A Control System

TABLE III-1

F-104A

Power Approach Non-Dimensional Stability Derivatives

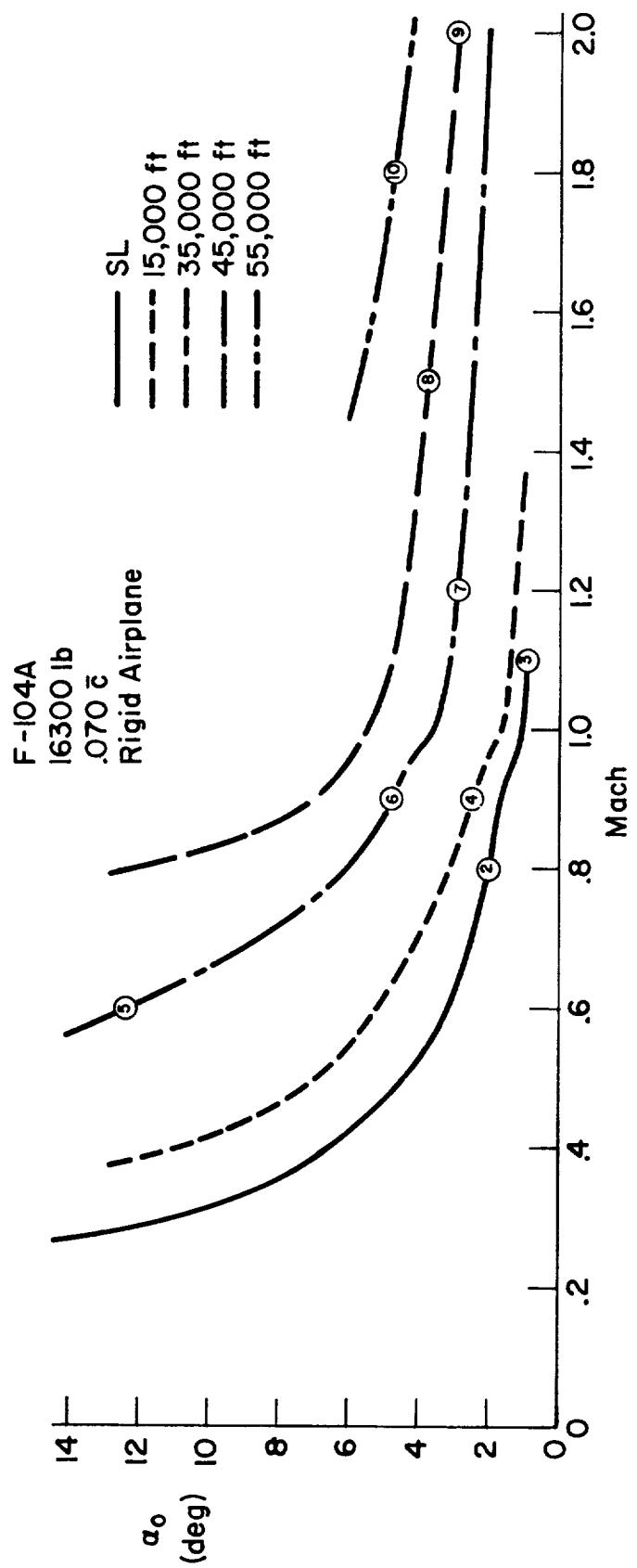
h = sea level

v_{T_0} = 287 ft/sec = 170 kt

α_0 = 2.3°

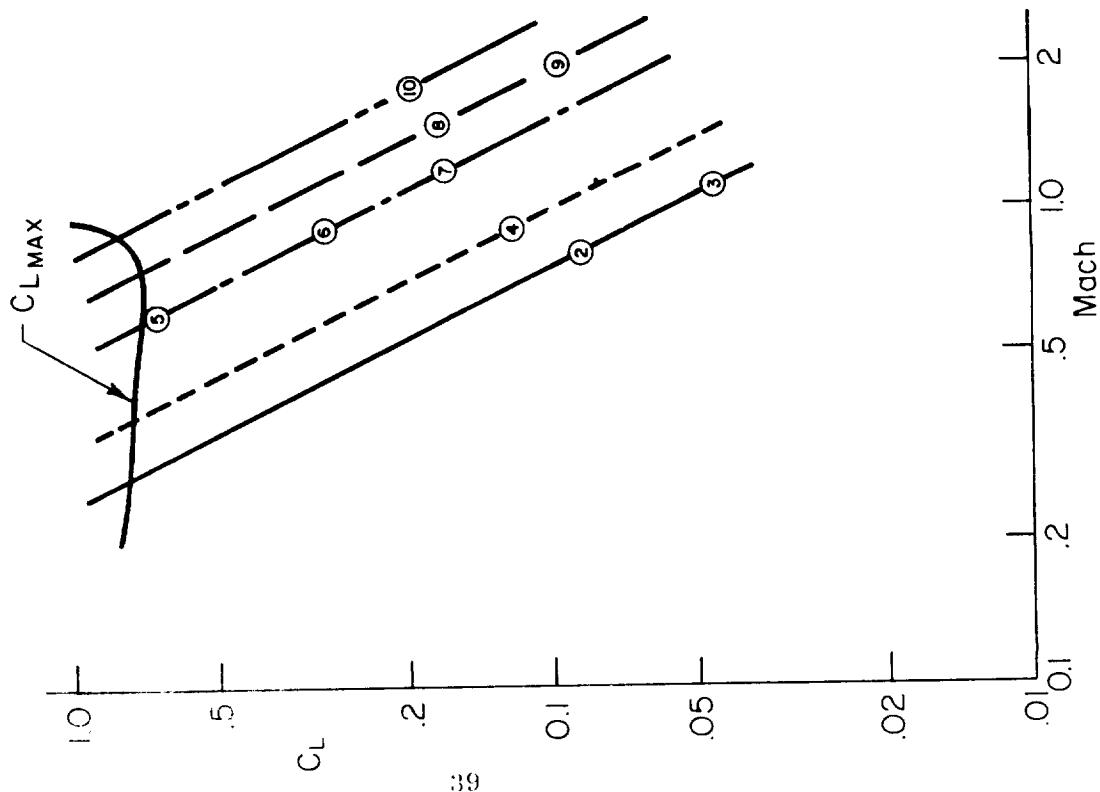
δ_s = -7.1°

Longitudinal	Lateral-Directional (Stability Axis)
$C_L = .735$	$C_{y\beta} = -1.17/\text{rad}$
$C_D = .263$	$C_{n\beta} = .50/\text{rad}$
$C_{L\alpha} = 3.44/\text{rad}$	$C_{\ell\beta} = -.175/\text{rad}$
$C_{D\alpha} = .45/\text{rad}$	$C_{\ell p} = -.285/\text{rad}$
$C_{m\alpha} = -.64/\text{rad}$	$C_{n p} = -.14/\text{rad}$
$C_{m\dot{\alpha}} = -1.6/\text{rad}$	$C_{\ell r} = .265/\text{rad}$
$C_{mq} = -5.8/\text{rad}$	$C_{n r} = -.75/\text{rad}$
$C_{L\delta_s} = .68/\text{rad}$	$C_{n\delta_a} = .0042/\text{rad}$
$C_{m\delta_s} = -1.46/\text{rad}$	$C_{\ell\delta_a} = .039/\text{rad}$
	$C_{y\delta_r} = .208/\text{rad}$
	$C_{\ell\delta_r} = .045/\text{rad}$
	$C_{n\delta_r} = -.16/\text{rad}$
	$C_{y\delta_d} = .0325/\text{rad}$
	$C_{n\delta_d} = -.025/\text{rad}$
	$C_{\ell\delta_d} = -.0044/\text{rad}$

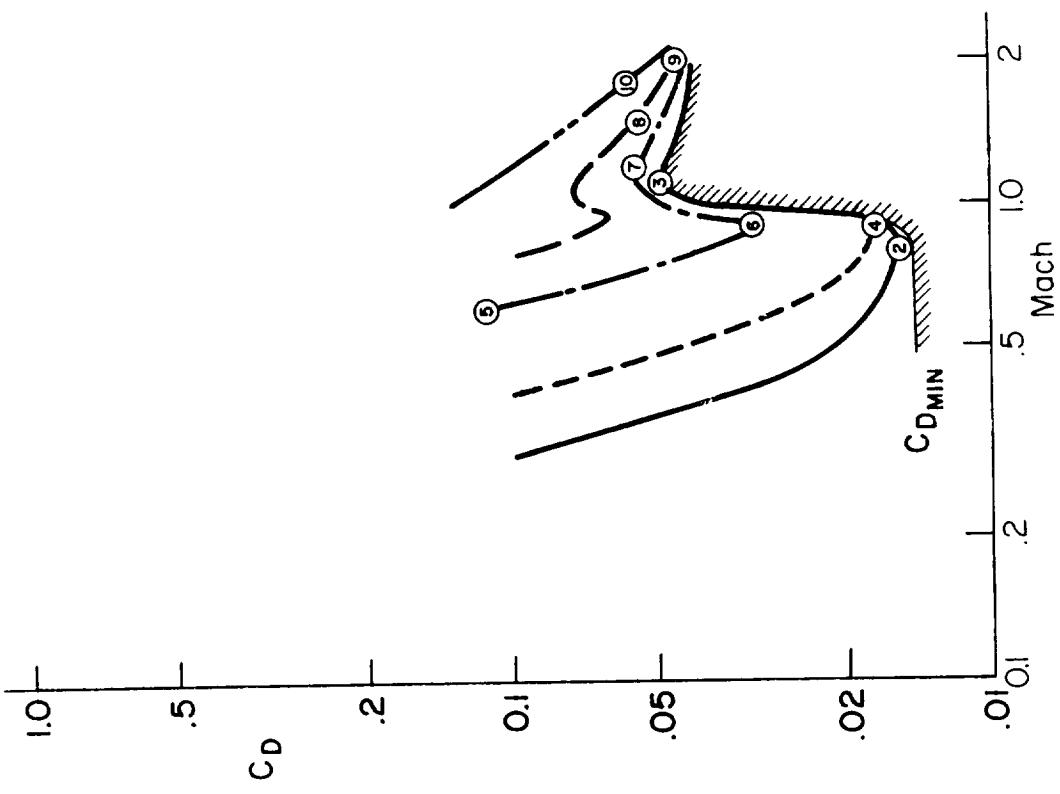


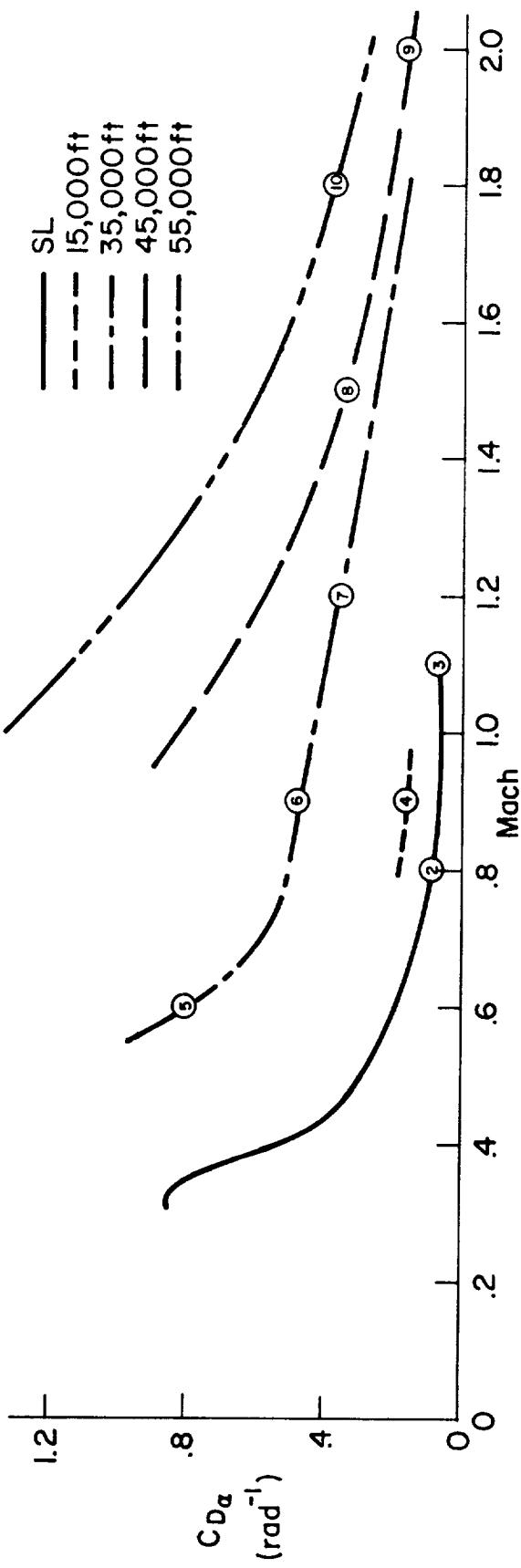
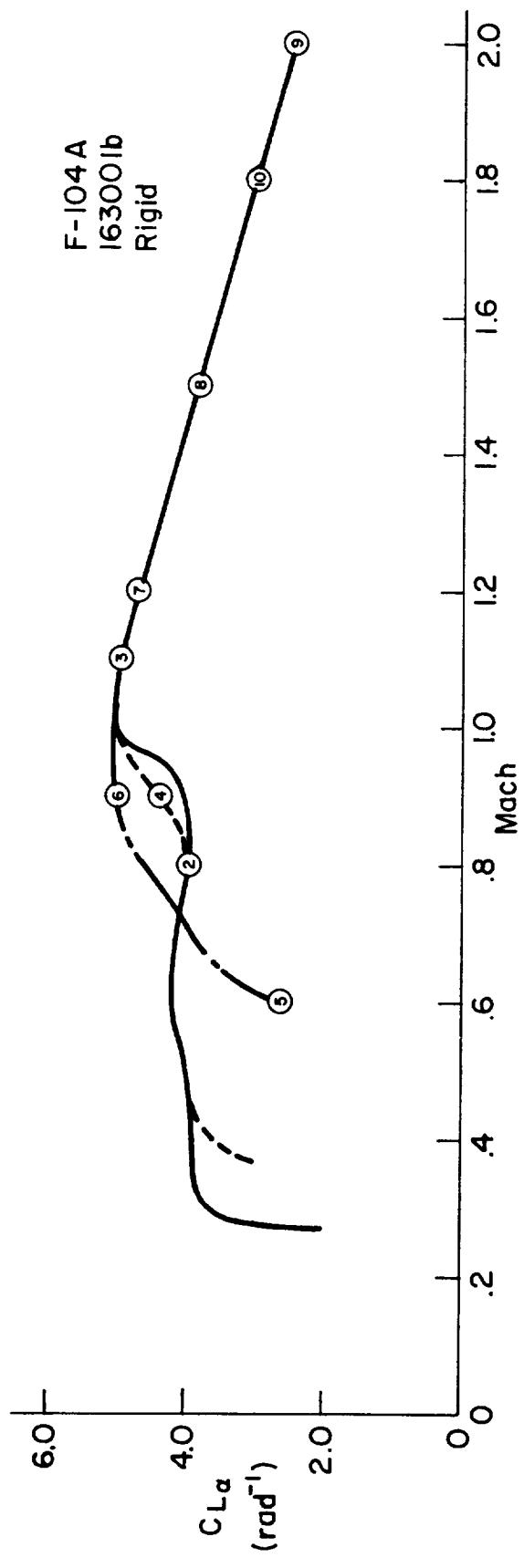
SL
 - - - 15,000ft
 - - - 35,000ft
 - - - 45,000ft
 - - - 55,000ft

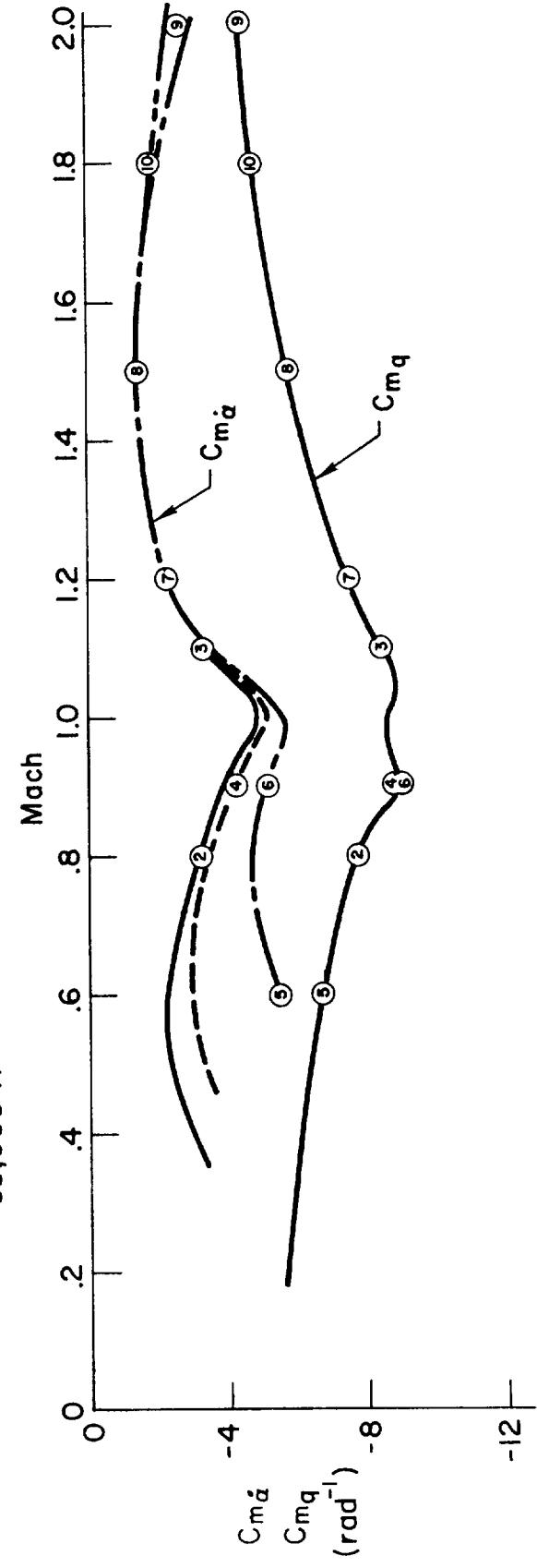
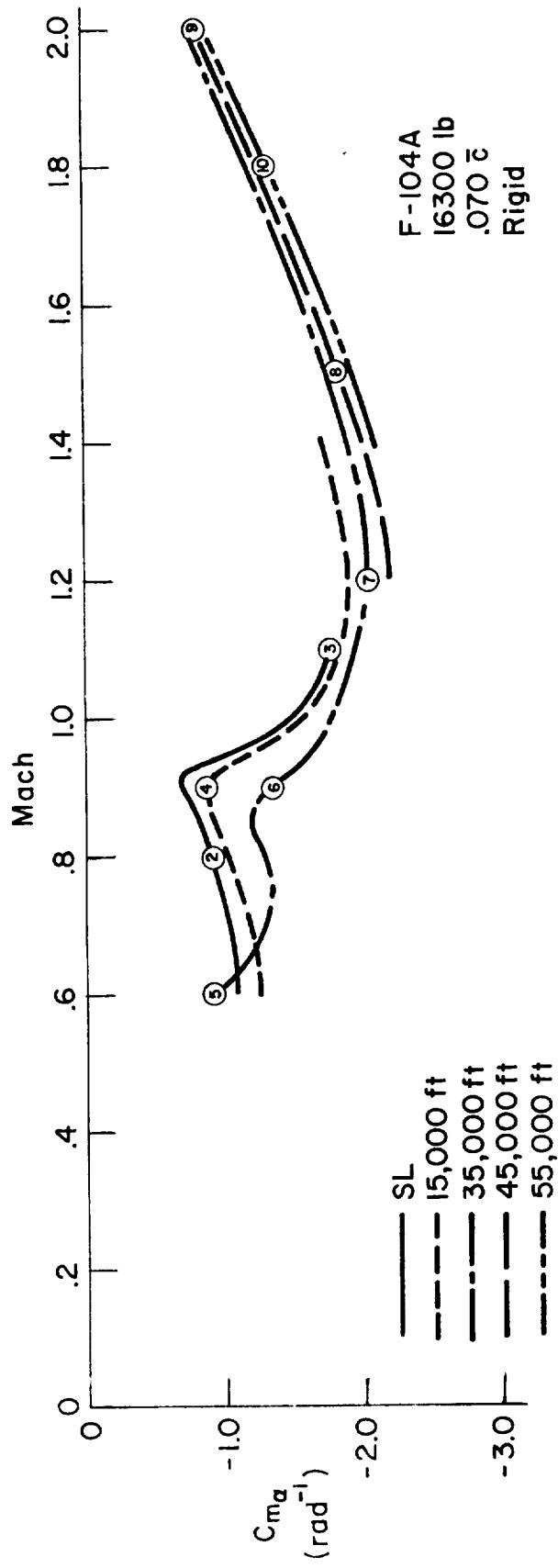
F-104A
16300lb

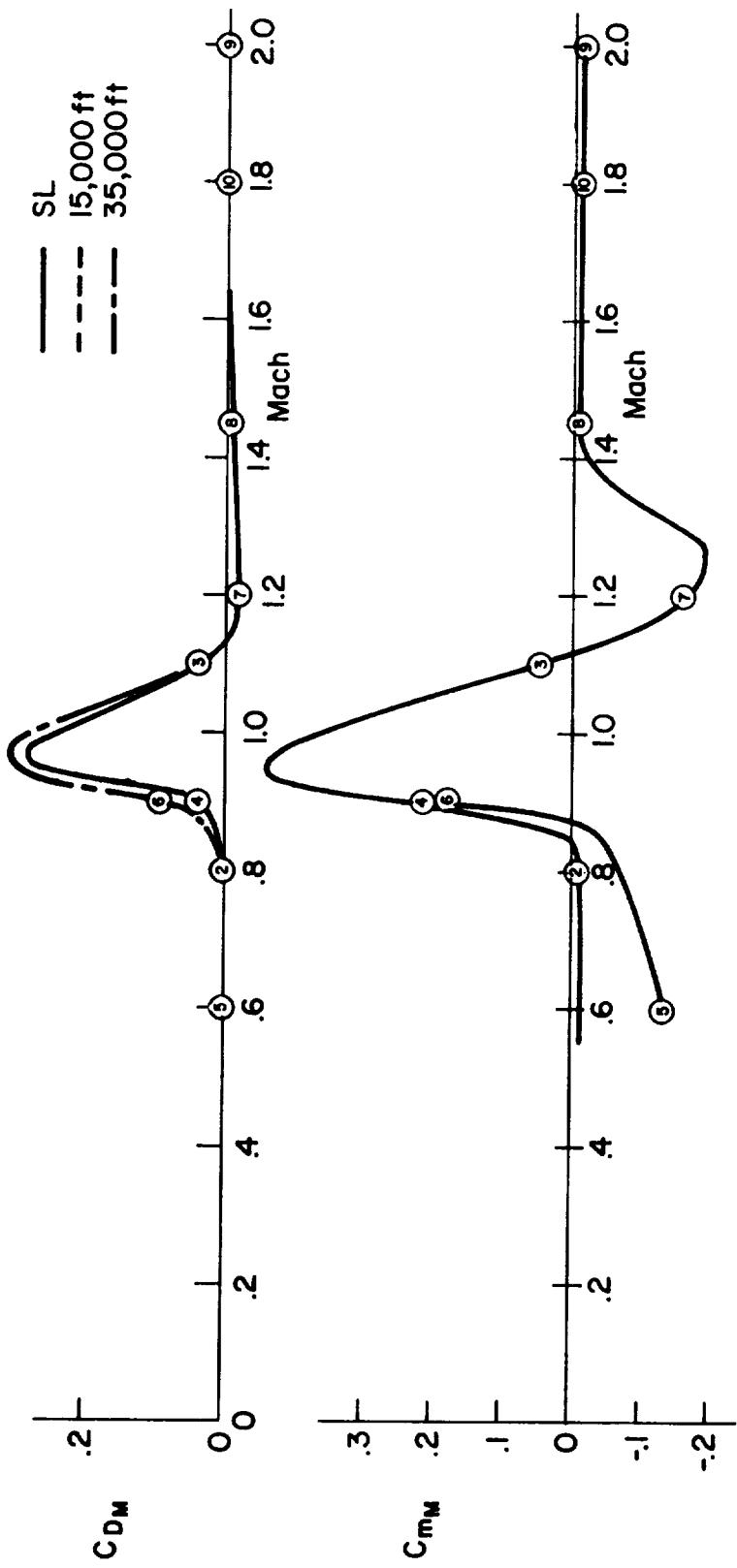
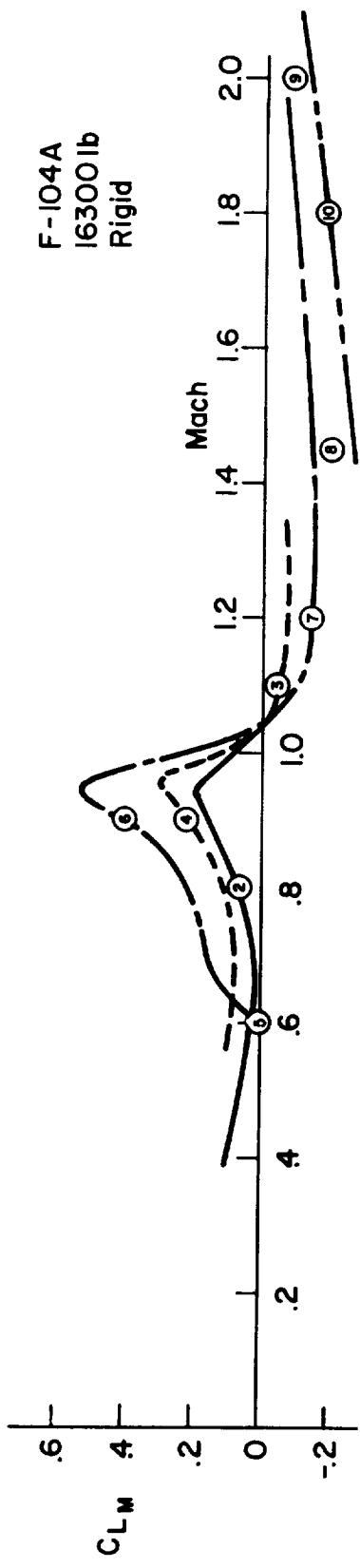


39

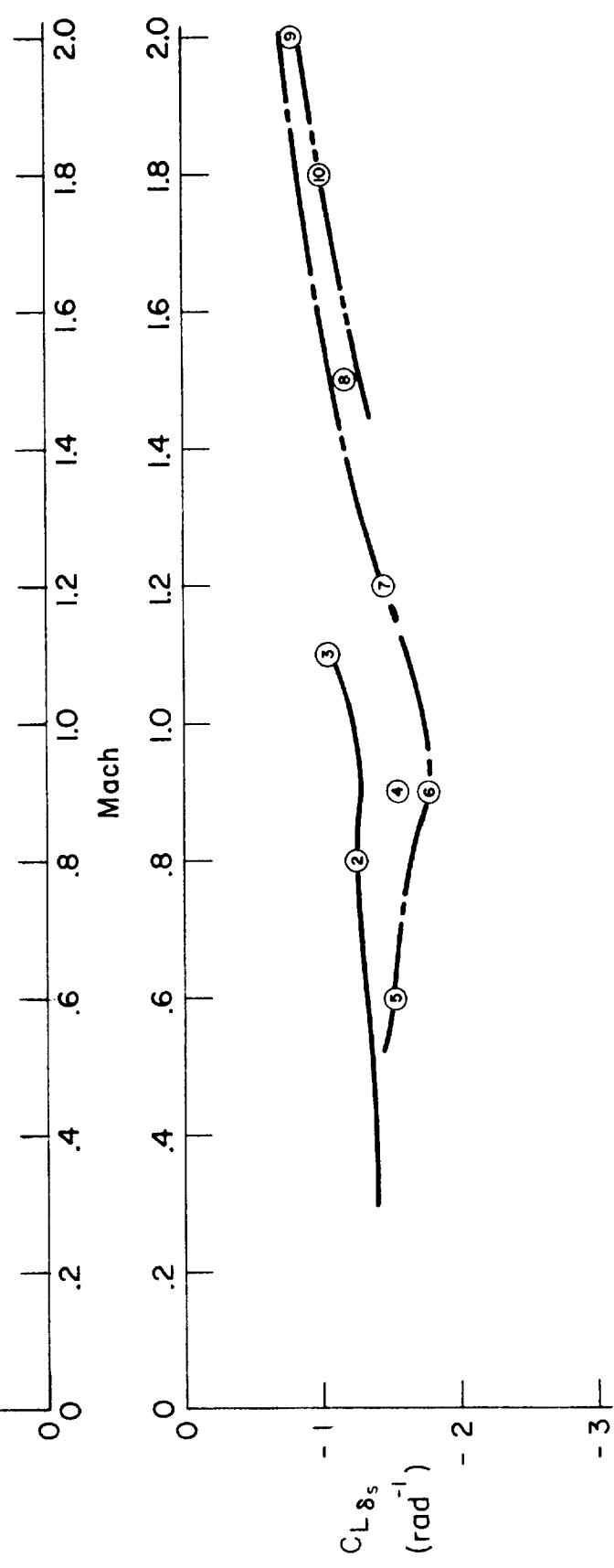
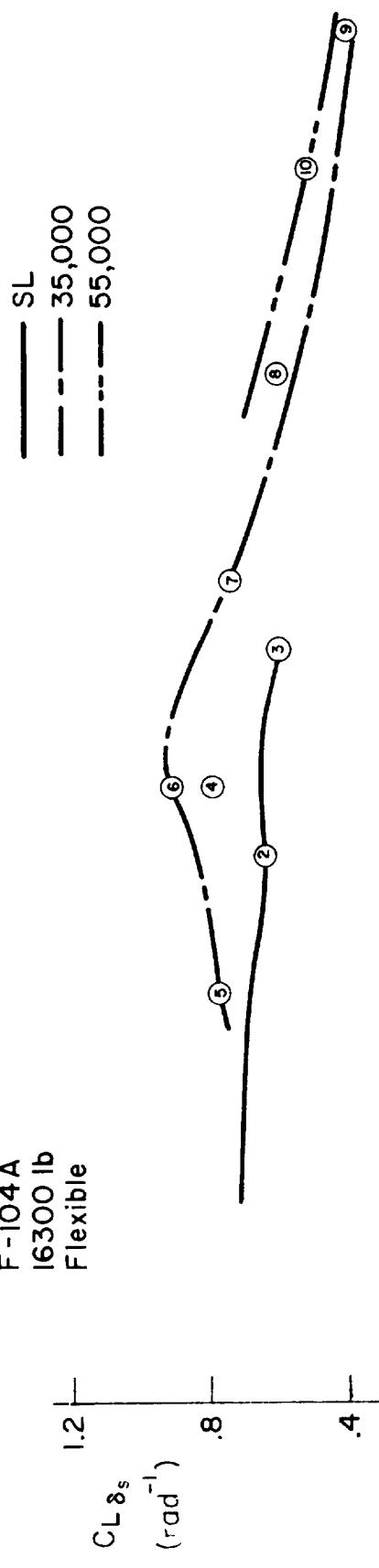


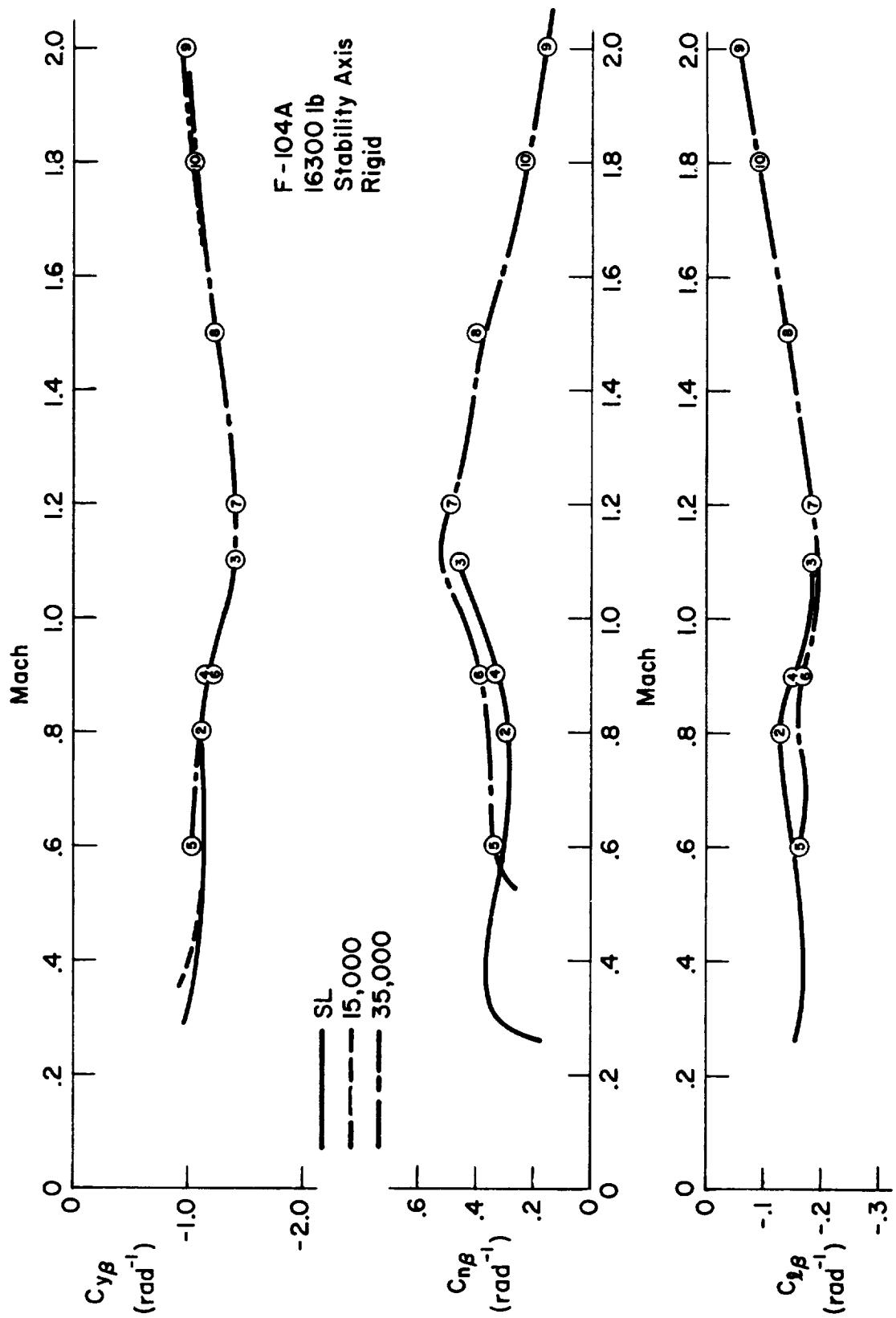


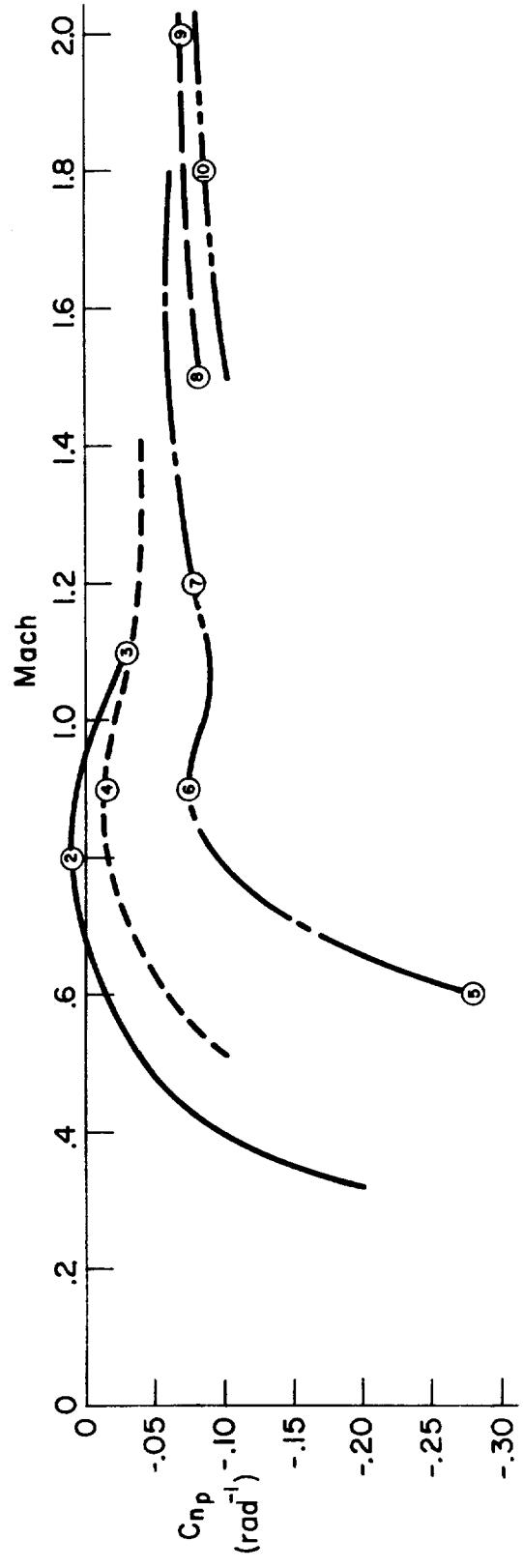
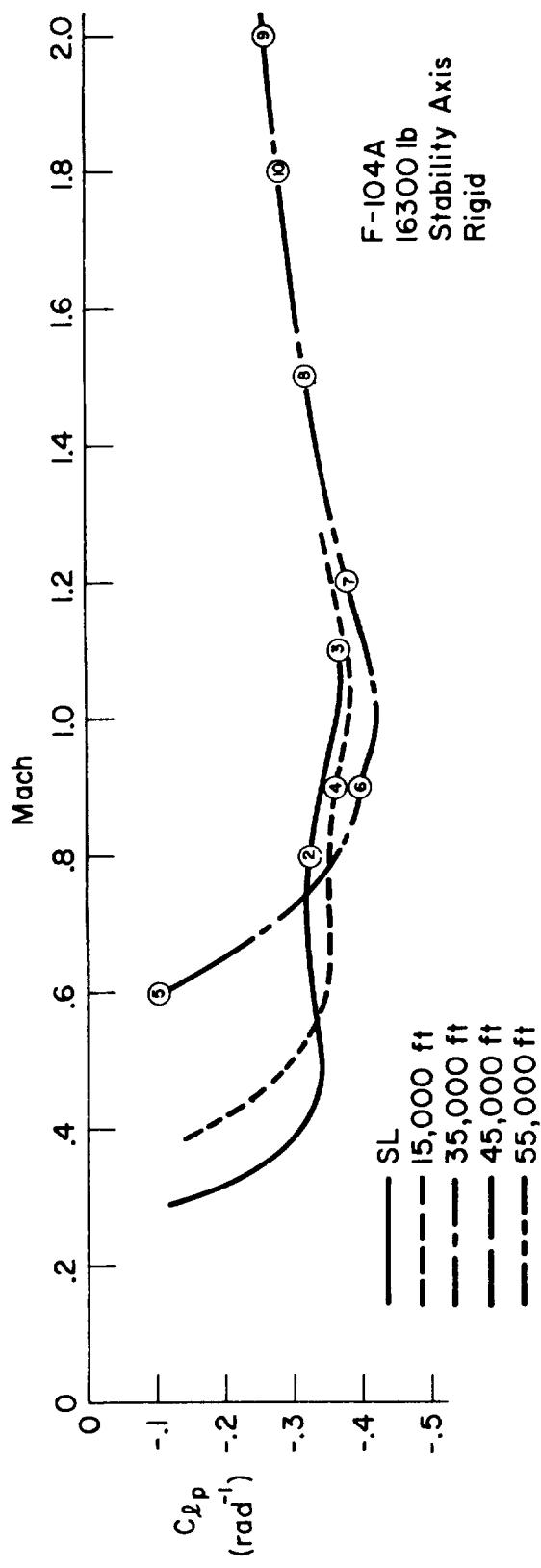


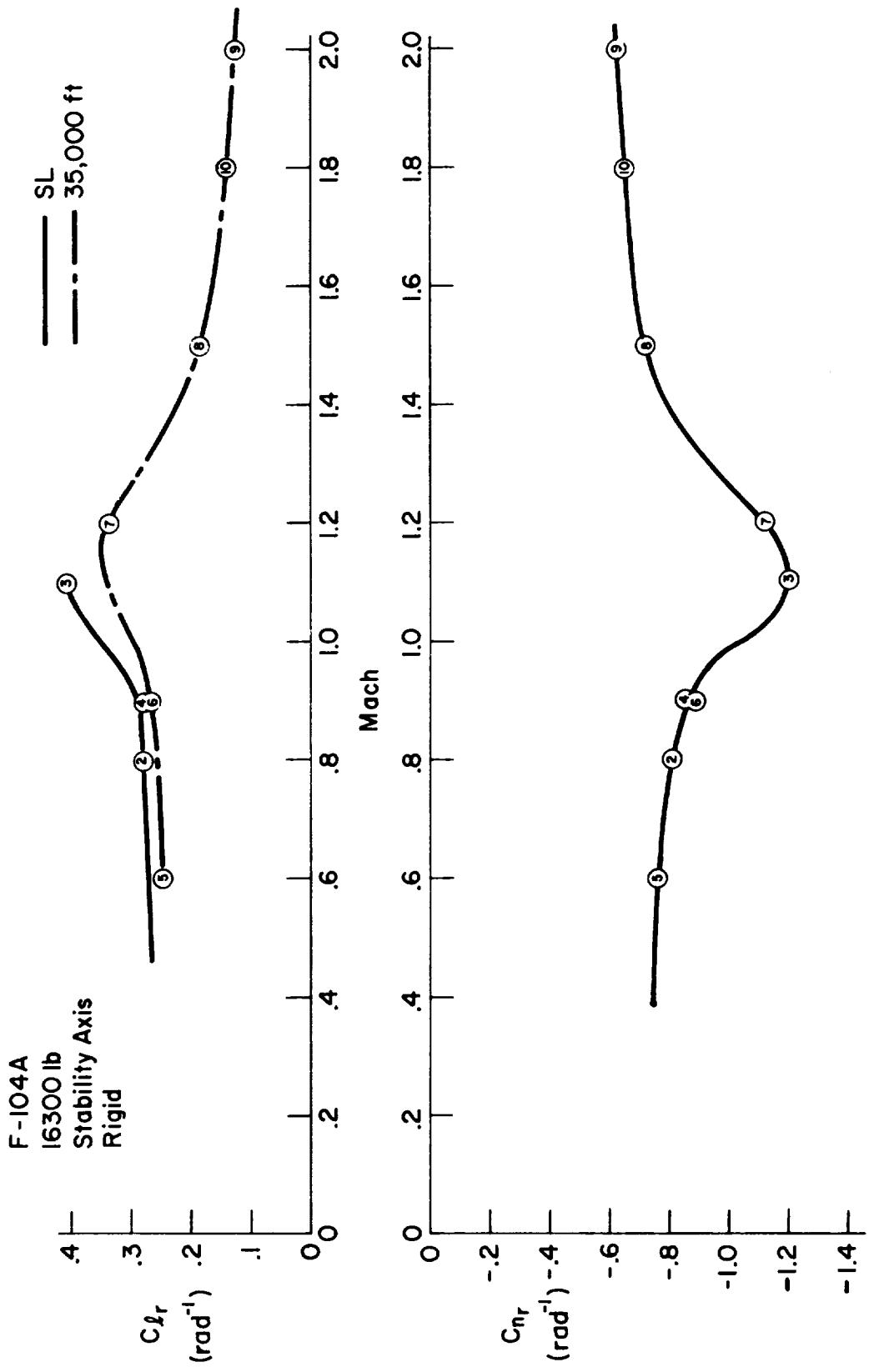


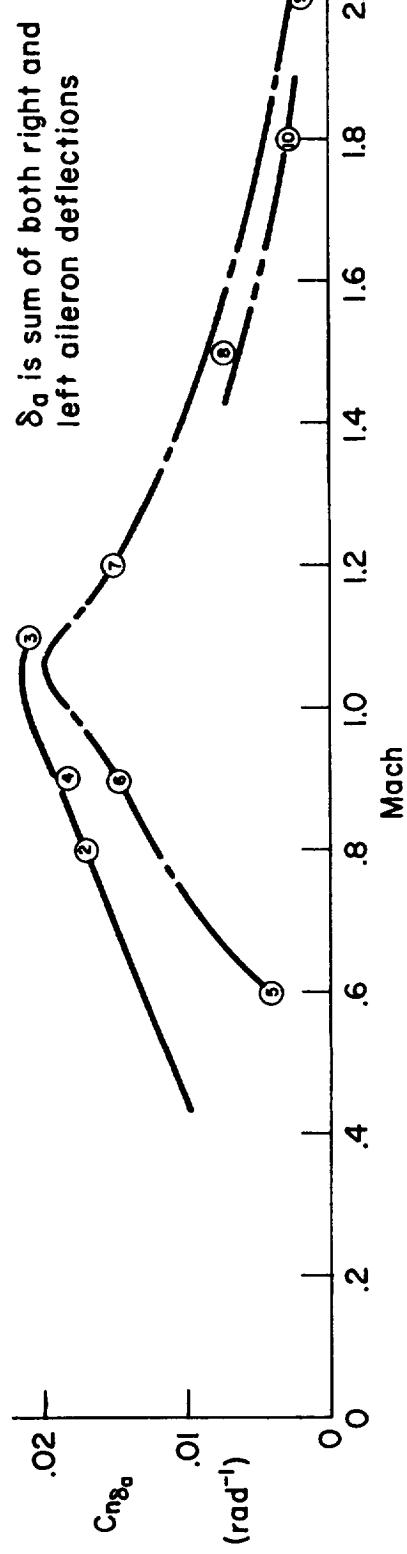
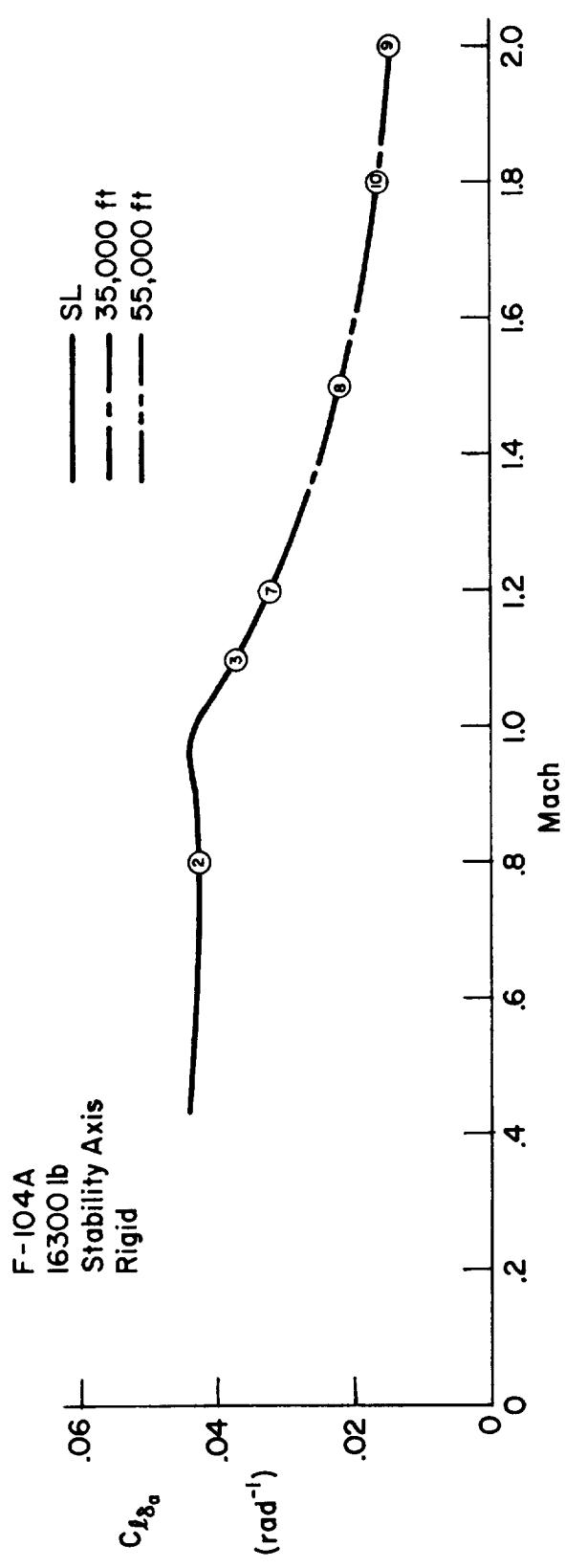
F-104A
16300 lb
Flexible











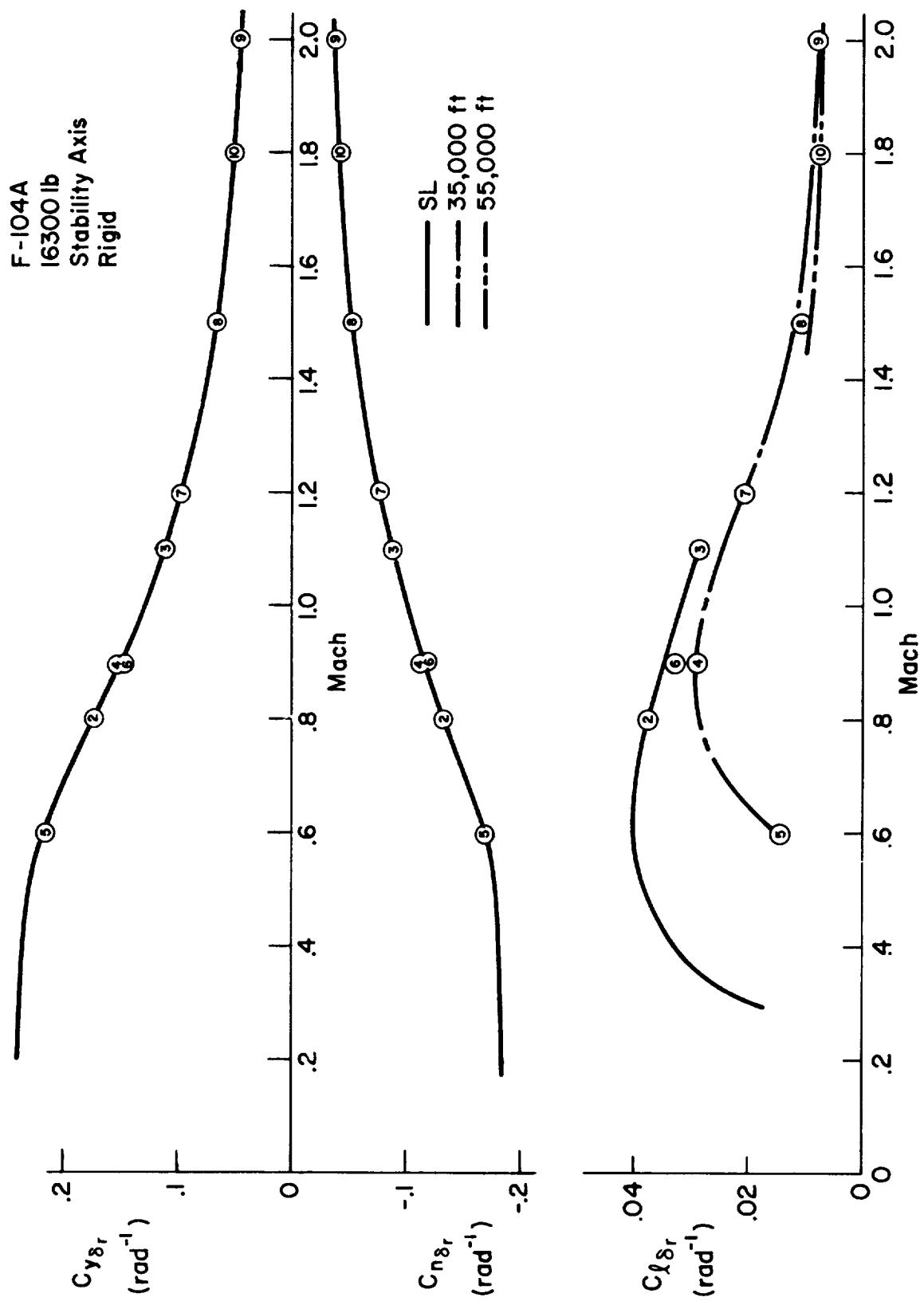


TABLE III-2

F-104A DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

$s = 196.1 \text{ sq ft}$, $b = 21.94 \text{ ft}$, $\bar{c} = 9.55 \text{ ft}$

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	15 K	35 K	35 K	45 K	45 K	45 K	55 K	
M(-)	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
VTO(FPS)	287.	853.	1228.	952.	584.	876.	1167.	1452.	1936.	1742.
VTO(KTAS)	170.	529.	728.	564.	346.	519.	692.	860.	1147.	1032.
VTO(KCAS)	170.	529.	728.	465.	199.	311.	432.	445.	591.	433.
W(LBS)	14126.	16300.	16300.	16300.	16300.	16300.	16300.	16300.	16300.	16300.
C.G. (MGC)	.164	.0700	.0700	.0700	.0700	.0700	.0700	.0700	.0700	.0700
I X (SLLG-F1 SC)	3582.	3679.	3679.	3679.	3679.	3679.	3679.	3679.	3679.	3679.
I Y (SLLG-F1 SC)	55802.	58612.	58612.	58612.	58613.	58613.	58613.	58613.	58613.	58613.
I Z (SLLG-F1 SC)	56669.	59541.	59541.	59541.	59541.	59541.	59541.	59541.	59541.	59541.
I XZ(SLLG-F1 SC)	2658.	2699.	2699.	2699.	2699.	2699.	2699.	2699.	2699.	2699.
EPSILCN(DEG)	-2.86	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76	-2.76
Q(PSF)	97.8	948.	1792.	677.	126.	263.	503.	489.	869.	436.
QC(PSF)	99.5	1109.	2397.	826.	138.	345.	703.	749.	1440.	706.
ALPHA(DEG)	2.30	2.00	1.00	4.80	12.4	2.50	3.00	3.80	3.00	4.80
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	19.0	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
L2P(FT)	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40
I TH(DEG)	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
X1(DEG)	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50	-2.50
L TH(FT)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	+	+	+	+	+	+	+	+	+	+

(BODY AXIS SYSTEM)

F-104A STABILIZER TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Open

TABLE III-4

(BODY AXIS SYSTEM)									
F/C #		+		+		+		+	
H	M	SL	SL	SL	K	35 K	35 K	45 K	55 K
		.257	.800	1.10	.900	.600	.900	1.20	1.50
								2.00	1.80
DENOMINATOR									
Z(CET)1		*23.8	*122	*76.7	*12.1	*08.44	*14.3	(-.0299)	*71.6
W(CET)1		*15.2	*50.4	*0523	*11.1	*07.09	*08.39	(-.0389)	(*0156)
Z(CET)2		*32.4	*31.5	*26.3	*28.8	*16.3	*18.5	*12.5	*0967
W(CET)2		1.51	5.41	10.3	4.54	1.91	3.53	5.78	*06.3
								5.39	4.26
NUMERATORS									
N(U/DS)		1.19	8.07	7.27	17.6	8.05	4.35	7.55	7.52
A(U)		43.8	147.	186.	153.	93.9	143.	189.	7.04
1/T(U)	1	74.0	*43.8	*632	*41.2	*69.0	*96.9	*54.6	2.36.
Z(U)	1	1.25	1.23	1.85	1.65	*23.0	*68.1	*57.1	320.
W(U)	1							*35.9	*95.7
									.344
									.226
N(W/DS)		-29.7	-231.	-416.	-209.	-36.6	-99.6	-144.	-113.
A(W)		46.6	148.	-000664	153.	94.1	-0190	-0174	-134.
1/T(W)	1	{ 256)	{ 158)	{ 0791	{ 178)	{ 0315)	{ 123)	{ 0266	-0103
1/T(W)	2	{ 150)	{ 0367)	{ 188.	{ 0437)	{ 0608)	{ 0625)	{ 236.	*0245
1/T(W)	3								320.
									282.
N(THE/DS)		-4.79	-37.7	-62.8	-33.5	-6.02	-16.3	-23.3	-18.4
A(THE)		*104	*128	*0789	*0178	*0117	*0127	*0134	*0118
1/T(THE)	1	*496	1.47	2.29	1.09	.195	.550	.620	*386.
1/T(THE)	2								*373.
									.233
N(HC/DS)									
A(HD)		29.7	231.	416.	210.	37.5	99.7	144.	114.
1/T(HC)	1	*05C4	*C106	*0784	*0132	-0198	*0399	*0129	*0116
1/T(HC)	2	-4.65	-13.8	-19.4	-12.2	-3.99	-8.48	-10.5	-9.36
1/T(HC)	3	5.12	15.5	21.9	13.6	4.41	9.18	11.1	9.72
									11.2
									8.22
N(AZP/DS)									
A(AZP)		61.2	452.	720.	396.	72.3	195.	278.	220.
1/T(AZP)	1	-0.0775	-.0C135	-.000458	-.00311	*0051	-.00297	-.00135	-.000839
1/T(AZP)	2	*0575	*C120	*0789	*0162	-.0262	*00690	*0142	*C128
Z(AZP)	1	*087	*C631	*0678	*0498	*0210	*0390	*0291	*0161
W(AZP)	1	3.41	C.5	15.7	9.35	3.01	6.32	7.79	*0209
									*0192
									*0174
									*0192
									5.83

T-104A THRUST TRANSFER FUNCTION FACTORS
SAS Off — Bowweight Loop Open
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	\$L	\$L	\$L	15 K	35 K	35 K	45 K	45 K	55 K	
H	.257	.800	1.1C	.9CC	.600	.900	1.2C	1.5C	2.0C	1.80
DEACTIVATOR										
Z(DET)1	.239	.123	.767	.122	.0853	.143	(-.0299)	.716	(-.00333)	.604
K(DET)1	.152	.C504	.0523	.111	.0708	.0839	(.0389)	.00834	(.0156)	.0895
Z(DET)2	.324	.215	.263	.289	.165	.185	.125	.0810	.0968	.0643
K(DET)2	1.51	5.41	10.3	4.54	1.91	3.53	5.78	5.39	4.73	4.26
INTEGRATORS										
N(U/DTH)										
A(U)	.00228	.00197	.00197	.00197	.00197	.00197	.00197	.00197	.00197	
1/T(U)	.000361	.000293	.000652	-.0012E	-.00947	.119E-8	-.000238	-.000501	-.00144	.000740
Z(U)	.323	.316	.263	.293	.170	.187	.124	.0811	.0968	.0645
K(U)	1.51	5.42	10.2	4.5C	1.90	3.52	5.79	5.39	4.73	4.26
N(A/DTH)										
A(H)	.994E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4
1/T(H)	.00157	.C00334	.000679	-.0013E	-.C0993	.471E-9	-.000242	-.000501	-.00144	.000740
Z(H)	(-.118)	.117	.134	.06C5	-.0529	-.107	(-.67)	.0816	.101	.0645
K(H)	(-.09)	3.91	10.7	11.5	3.21	6.70	(5.68)	6.43	4.52	5.65
N(THE/DTH)										
A(THE)	-2.42E-8	-.000E-8	-.300E-7	.380E-7	.103E-6	.355E-14	.223E-8	.222E-8	.152E-8	.313E-8
1/T(THE)1	24.0	-4.54	13.6	1.49	1.14	1.60	.538	.194	.0481	.144
1/T(THE)2	-6.4.1	100.	-42.5	273.	9.78	.949E+9	-1972.	33C.	-55.5	218.
N(HD/DTH)										
A(HD)	-7.95E-5	-.172E-4	-.517E-4	.792E-4	.00339	.146E-10	.172E-4	.448E-4	.172E-4	.792E-4
1/T(HD)1	-6.4.1	-10.0	-3.51	5.83	.543	.163E+8	-2.94	.151	-.0205	.119
Z(HD)1	.139	.149	.248	-.124	.135	.0769	.453	.0424	.116	.0356
K(HD)1	1.45	4.85	10.8	5.65	1.90	4.46	7.39	.38	4.75	4.26
N(AZP/DTH)										
A(AZP)	.994E-4	.863E-4	.866E-4	.854E-4	.642E-4	.861E-4	.861E-4	.861E-4	.861E-4	.861E-4
1/T(AZP)1	-.00451	-.00126	-.000436	-.00284	-.0122	-.00161	-.00145	-.00150	-.00167	.00157
1/T(AZP)2	-4.79	-1.63	-2.25	-5.05	-1.96	-3.65	.982	-.0763	.0066	-.1C7
Z(AZP)1	.194	.265	.255	.328	.168	.105	.0805	.0868	.0547	.0738
K(AZP)1	1.50	5.38	10.4	5.83	1.99	3.87	5.71	5.40	4.72	4.27

TABLE III-6
F-104A STICK FORCE TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Closed
(BODY AXIS SYSTEM)

F/C #	+										+									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	45 K	55 K
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80										
DENOMINATOR																				
Z(DET)1	*249	*151	*990	*127	*0717	*134	{-*0266}	*776	{-*000450}	*644										
W(DET)1	*142	*0387	*0401	*0851	*0683	*0749	{*.0363}	*0765	{*.0157}	*0832										
Z(DET)2	*303	*239	*199	*218	*156	*164	*113	*C754	*0838	*0602										
W(DET)2	1.55	6.31	11.3	5.35	1.95	3.76	5.91	5.45	5.02	4.33										
NUMERATORS																				
N(W/FST)	A(W)	-0.00565	-0.265	-0.0213	-0.0591	-0.0317	-0.0161	-0.0268	-0.0275	-0.0252										
	1/T(W)1	4.3 .8	1.47.	1.86.	1.53.	93.9	143.	189.	236.	320.										
	Z(W)1	74 C	438	632	412	690	989	946	946	797										
	W(W)1	1.25	1.23	1.85	.665	.230	.681	.571	.359	.344										
N(W/FST)	A(W)	*141	*760	1.22	*704	*144	*369	*512	*414	*480										
	1/T(W)1	4.6 .6	1.48.	-0.00664	153.	94.1	149.	-0.0190	*0174	-0.0103										
	Z(W)2	{ .256}	{ -158)	{ .0791	{ *178)	{ .0315)	{ *123)	{ .0300	*0266	*0245										
	W(W)3	{ .150)	{ -.0367)	{ 1.88.	{ .0437)	{ .0608)	{ .0625)	{ .189.	236.	320.										
N(THE/FST)	A(THE)	*0227	*124	*184	*113	*0237	*0602	*0829	*0674	*0794										
	1/T(THE)1	*104	C128	*0789	*0178	*0117	*0127	*0134	*0118	*0155										
	1/T(THE)2	*496	1.47	2.29	1.09	.195	.550	.620	.386	.373										
N(HC/FST)	A(HC)	-141	-761	-1.22	-707	-148	-369	-513	-415	-481										
	1/T(HC)1	*0504	C106	*0784	*0132	-0.0198	*00399	*0129	*0116	*0153										
	Z(HC)2	-4.6 9	-13.8	-19.4	-12.2	-3.9 c	-8.48	-10.5	-9.36	-10.7										
	W(HC)3	5.12	15.5	21.9	13.6	4.41	9.18	11.1	9.72	11.2										
N(AZP/FST)	A(AZP)	*290	-1.49	-2.11	-1.34	-265	-720	-988	-805	-956										
	1/T(AZP)1	-0.0775	-0.0135	-0.00458	-0.00311	-0.00551	-0.00297	-0.00136	-0.00135	-0.000339										
	Z(AZP)2	*0575	*C120	*0789	*0162	-0.0262	*00690	*0142	*0128	*0101										
	W(AZP)1	*0887	*C631	*0678	*0498	*0210	*0386	*0390	*0291	*0161										
	Z(AZP)3	3.41	1.C.5	15.7	9.35	3.01	6.32	7.79	6.86	7.74										

TABLE III-7
F-104A THRUST TRANSFER FUNCTION FACTORS
 SAS Off — Bobweight Loop Closed
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	S _L .257	S _L .800	S _L 1.1C	15 K .9CC	35 K .600	35 K .900	35 K 1.2C	45 K 1.5C	45 K 2.0C	55 K 1.8C
DENOMINATOR										
Z(DET)1	.249	.151	.99C	*127	*0725	*134	(*0266)	*777	(*000450)	*644
X(CET)1	.142	*C387	*0401	*0851	*0683	*0749	(*0363)	*0775	(*0157)	*0832
Z(DET)2	.3C3	.239	.199	.218	.158	*164	*113	*0755	*082K	*0602
K(DET)2	1.59	6.31	11.3	5.35	1.95	3.76	5.91	5.45	5.02	*.33
NUMERATORS										
I(U /DTM)										
A(U)	*0.0228	*0.0197	*0.00197	*0.00197	*0.00197	*0.00197	*0.00197	*0.00197	*0.00197	
i/T(U)1	-0.000293	-0.000339	*0.00203	-0.00193	-0.00197	-0.00228	-0.00043	-0.000624	-0.000308	-0.000831
Z(U)1	*30.2	*238	*19.8	*216	*158	*164	*111	*0730	*0804	*0566
k(U)1	1.59	6.31	11.3	5.33	1.94	3.76	5.92	5.45	5.02	*.33
54										
I(U /DTM)										
A(h)	*0.00101	*.926E-4	*.966E-4	*.921E-4	*.873E-4	*.893E-4	*.905E-4	*.896E-4	*.902E-4	*.889E-4
1/T(W)1	-0.0C555	*0.0585	*0.0065C	-0.00115	-0.00935	*0.0074C	*.519E-4	-0.00608	-0.000310	-0.000809
Z(h)1	{ 50.5 }	{ 24.4 }	{ 4.20 }	{ 5.66 }	{ 1.64 }	{ 3.36 }	{ -1.53 }	{ 814 }	{ 1.60 }	*.846
w(w)1	{ -4.19 }	{ 1C.5 }	{ 17.8 }	{ 5.43 }	{ 2.78 }	{ 5.18 }	{ 11.6 }	{ 6.32 }	{ 13.8 }	5.57
55										
N(THE /DTM)										
A(THE)	*2.21E-6	*105E-5	*156E-5	*593E-6	*201E-6	*515E-6	*711E-6	*578E-6	*681E-6	*450E-6
1/T(THE)1	{ -53.1 }	{ -429 }	{ C874 }	{ 2.82 }	{ 2.82 }	{ 669 }	{ .565 }	{ .532 }	{ 142 }	-0.204
1/T(THE)2	{ -4.03 }	{ 1.86 }	{ 2.82 }	{ 4.52 }	{ 1.92 }	{ 3.08 }	{ 3.08 }	{ 5.44 }	{ 1.46 }	.256
N(HD /DTM)										
A(HD)	-*9.34E-5	-*2.37E-4	-*6.22E-4	*732E-4	*C00338	*316E-5	*128E-4	*4.12E-4	*131E-4	*765E-4
1/T(HD)1	-5.6.4	-11.4	-4.52	3.78	.495	-79.8	-1.87	*106	-0.0763	*.0640
Z(HD)1	*15.9	*480	*362	*0712	*142	*215	*315	*0372	*070q	*.0331
k(HD)1	1.41	3.48	7.37	6.62	1.95	4.12	10.0	6.23	8.41	4.67
56										
N(AZP /DTM)										
A(AZP)	*.965E-4	*7.25E-4	*6.84E-4	*7.01E-4	*8.19E-4	*7.01E-4	*7.99E-4	*7.92E-4	*7.79E-4	*8.07E-4
1/T(AZP)1	-0.03451	-0.0C126	-0.000458	-0.CC284	-0.0122	-0.00161	-0.001458	-0.00150	-0.00067	-0.00157
1/T(AZP)2	-4.79	-1.63	-2.24	-4.95	-1.95	-3.64	-0.763	-0.0466	-0.1C7	
Z(AZP)1	*19.3	*261	*25.3	*325	*168	*194	*0.875	*0.870	*0.943	*.0741
k(AZP)1	1.49	5.23	9.98	5.72	1.98	3.83	5.61	5.32	4.64	4.23

TABLE III-8
F-104A LONGITUDINAL HANDLING QUALITIES PARAMETERS
 SAS Off
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K	55 K
R	.257	.600	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
STICK FIXED										
D(G)/D(U) (DEC/KT)	- .152	- .0319	- .236	- .0397	.0594	- .0120	- .0388	- .0343	- .0440	- .0305
NZA (G/RAD)	4.64	40.2	86.3	32.C	3.62	14.9	22.4	17.4	22.3	12.5
DE/2 (DEG/G)	5.83	1.09	1.10	1.07	.936	2.92	3.66	5.17	2.57	5.92
CAP (RAD/SEC/SEC/G)	.487	.719	1.21	.623	.983	.829	1.40	1.66	.996	1.44
PHC,CIO(2) (SEC)	--	--	--	--	--	--	(23.2)	--	(20.80 .)	--
{ TJK(K2) }										
1/C(1/10)	.933	.907	.744	.623	.455	.515	.343	.222	.265	.176
STICK FREE										
FSI/KT (LB/KT)	- .223	- .0171	- .0254	- .0875	- .189	- .126	.0345	- .00351	.000317	- .00563
FSI/C (LB/C)	23.9	7.86	7.90	7.76	43.1	15.7	19.8	25.3	14.2	28.5

F-104A LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	55 K	
H	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
VV	-1.78	-4.52	-7.91	-3.28	-0.868	-1.49	-0.234	-0.160	-0.170	-0.102
VB	-51.1	-404.	-971.	-312.	-50.7	-130.	-273.	-233.	-330.	-177.
LB	-20.9	-146.	-363.	-134.	-32.3	-58.1	-115.	-87.8	-64.3	-52.2
NB	2.68	13.6	42.7	9.91	1.06	4.98	11.9	9.79	6.92	4.62
LP	-1.38	-4.64	-7.12	-3.63	-3.74	-1.77	-2.27	-1.46	-1.59	-0.962
NP	-0.993	-1.88	-3.41	-1.50	-0.406	-0.043	-0.117	-0.0604	-0.0901	-0.0544
LR	1.16	3.67	7.17	2.66	1.02	1.08	1.88	.822	.689	.469
NR	-1.57	-4.98	-1.06	-3.50	-0.809	-1.69	-0.292	-0.152	-0.188	-0.106
Y*CA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
L*CA	4.76	49.6	81.5	34.7	6.35	14.8	19.4	12.9	15.8	8.38
N*CA	.266	3.51	6.50	2.64	.407	1.01	1.49	.902	.890	.517
Y*CR	.0217	.0719	.0621	.0413	.0179	.0188	.0159	.00847	.00782	.00485
L*CR	5.35	41.5	57.6	27.6	6.66	11.2	13.1	7.17	8.68	5.04
N*DR	-9.23	-7.07	-8.72	-4.49	-1.18	-1.91	-2.09	-1.52	-1.78	-1.01
	+	+	+	+	+	+	+	+	+	+

TABLE III-10
F-104A AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	55 K	
M	.257	.800	1.10	.900	.600	.900	1.20	1.50	2.00	1.80
DENOMINATOR										
1/T(DET)1	-0.00594	0.0711	0.0044	0.00849	0.0172	0.00849	0.0570	0.0368	0.0588	0.0602
1/T(DET)2	1.86	4.82	7.86	3.08	4.46	2.04	2.41	1.50	1.72	.941
Z(CET)1	-0.0345	0.849	0.732	1.36	0.138	0.0590	0.453	0.339	0.331	0.373
W(DET)1	2.10	4.51	7.53	4.50	2.84	2.85	4.29	3.97	3.25	3.00
NUMERATORS										
N(B/DA)	-0.0749	-1.78	-5.08	.275	.966	-36.9	-468	-0.432	-0.0631	.187
A(B)	.170	-308	-229	-447	.0864	31.7	.596	.295	.127	.111
1/T(B)	-9.28	2.48	3.00	-5.36	.586	-1.13	.843	-4.74	-7.43	1.01
N(P/DA)	-4.76	-0.0124	81.5	34.7	6.35	14.8	-0.0144	12.9	15.8	8.38
A(P)	-0.0446	.103	.123	-0.00450	-0.00282	-0.0121	-0.00160	-0.0147	-0.00868	.00155
1/T(P)	1.97	4.93	8.54	.142	.0983	.0699	.0656	.0737	.0466	.0426
Z(P)				4.49	4.49	1.76	3.00	4.55	3.99	2.80
W(P)										
N(R/DA)										
A(R)	.266	3.51	6.50	2.64	.407	1.01	1.49	.902	.890	.517
1/T(R)	1.48	1.08	1.61	.405	.249	.804	.528	.334	.316	.220
Z(R)	-372	202	.265	.169	-.0646	-.0633	.0591	.0170	-.0252	-.00604
W(R)	2.28	3.35	3.83	4.69	3.25	2.44	3.75	3.89	3.14	3.27
N(PHI/DA)										
A(PHI)	4.77	45.7	81.7	34.9	6.44	14.8	19.5	13.0	15.8	8.43
Z(PHI)	1.01	123	.142	.0987	.0639	.0655	.0737	.0464	.0610	.0423
W(PHI)	1.97	4.92	8.53	4.49	1.78	3.00	4.55	3.99	3.25	2.80
N(AYP/DA)										
A(AYP)	16.5	183.	313.	131.	22.6	53.8	73.6	47.3	53.9	29.5
1/T(AYP)	-278	-176	-169	-154	111	-146	-144	-114	116	.0988
Z(AYP)	34.3	721	.961	.105	-.290	.250	.301	.164	-.289	-.167
W(AYP)	0.370	112	128	.104	.0760	.0574	.0695	.0444	.0758	.0520
	1.96	4.87	8.16	4.49	1.85	2.96	4.48	3.98	3.29	2.76

TABLE III-11

P-104A RUDDER TRANSFER FUNCTION FACTORS
SAS Off
(BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10		
M	SL .257	SL .800	SL 1.10	15 K .900	35 K .600	35 K .900	35 K 1.20	45 K 1.50	45 K 2.00	55 K 1.80		
DENOMINATOR												
1/T (DET) 1	-0.00594	.0711	.004C4	.00849	.0172	.00849	.00570	.00368	.00588	.00602		
1/T (DET) 2	1.86	4.82	7.86	3.08	.446	2.04	2.41	1.50	1.72	*.941		
Z(CET) 1	-0.0345	.0849	.0732	.136	.0138	.00590	.0453	.0339	.0331	.0373		
W(CET) 1	2.10	4.51	7.53	4.50	2.84	2.85	4.29	3.97	3.25	3.00		
NUMERATORS												
N(B /DR)												
A(B)	.0317	*C719	.0621	.0413	.0179	.0188	.0159	.00847	.00782	.00485		
1/T (B) 1	-0.0139	-0.0574	-0.0100	-0.00640	-0.0439	-0.0267	-0.0171	-0.00256	-0.00069	-0.000579		
1/T (B) 2	2.16	4.94	8.64	3.11	.391	2.02	2.40	1.48	1.69	*.938		
1/T (B) 3	35.3	119.	156.	165.	144.	128.	175.	235.	285.	294.		
N(P /DR)												
A(P)	5.35	41.5	57.6	27.6	6.66	11.2	13.1	7.17	8.68	5.04		
1/T (P) 1	-0.0447	-.0C125	-0.00454	-0.00283	-0.0121	-0.0160	-0.0144	-0.0147	-0.000872	-0.00155		
1/T (P) 2	-.960	-3.32	-3.33	-3.42	2.09	-2.19	-2.49	-2.95	-2.42	-2.37		
1/T (P) 3	.976	3.40	3.70	3.47	-2.18	2.23	2.58	2.98	2.58	2.44		
N(R /DR)												
A(R)	-.923	-7.07	-8.72	-4.49	-1.18	-1.91	-2.09	-1.52	-1.78	-1.01		
1/T (R) 1	2.01	5.41	9.26	.498	.254	1.95	2.27	.397	.477	.236		
Z(R) 1	.0299	.493	.627	.966	.0889	.320	.635	.508	.820	.358		
W(R) 1	.548	.662	.478	2.22	2.36	.736	.699	1.52	1.03	1.51		
N(Phi/DR)												
A(Phi)	5.32	41.2	57.4	27.2	6.40	11.2	13.0	7.07	8.58	4.95		
1/T (Phi) 1	.972	-3.36	-3.35	3.47	2.16	-2.21	-2.52	-2.99	-2.45	-2.42		
1/T (Phi) 2	-.974	3.39	3.69	-3.49	-2.30	2.23	2.58	3.00	2.58	2.46		
N(AYP/DR)												
A(AYP)	4.40	35.8	56.7	24.3	5.13	8.79	12.2	2.04	3.63	2.30		
1/T (AYP) 1	-.0277	-.C129	-.00460	-.0144	-.0582	-.0100	-.00748	-.00671	-.000431	-.00323		
1/T (AYP) 2	-.666	-1.6	-22.9	2.25	.209	1.46	2.00	.897	1.40	*.622		
1/T (AYP) 3	{ .611}	{ .787}	{ .612}	4.85	5.75	3.03	3.74	8.86	8.88	8.20		
1/T (AYP) 4	{ 1.43}	{ 4.07}	{ 6.05}	-16.5	-8.08	-10.3	-11.4	-25.9	-20.6	-15.0		

TABLE III-12

F-104A LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS
 SAS Off
 (BODY AXIS SYSTEM)

	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
F/C #	1	2	3	4	5	6	7	8
H	SL	SL	SL	15 K	35 K	35 K	45 K	45 K
M	.257	.600	1.10	.900	.600	.900	1.20	1.50
DR PERIOD (SEC)	3.00	1.40	.836	1.41	2.22	2.21	1.47	1.59
1/C(1/2)	--	.773	.665	1.24	.125	.0535	.411	.308
SPIRAL (2) (SEC)	1167.	--	--	--	--	--	--	--
P(1)	2.47	13.2	15.0	11.1	2.60	8.04	8.72	8.51
P(2)	1.66	11.2	11.7	10.8	1.37	7.12	8.42	8.48
P(3)	2.86	12.8	14.5	11.0	4.89	8.44	9.31	8.61
P(2)/P(1)	.671	.847	.783	.973	.525	.885	.966	.997
P(OSC)/P(AV)	.232	.C751	.114	.0111	.466	.0732	.0340	.00450
W(PHI)/W(D)	.940	1.09	1.13	.999	.629	1.05	1.06	1.01
DEL-B-MAX	.170	.C908	.0873	.0302	.261	.0954	.0456	.0129
PHI TO BETA, PHASE	-318.	44.3	44.9	390.	-353.	33.6	26.4	18.2
PHI TO BETA	3.94	5.31	4.92	5.59	3.98	6.12	5.64	5.28
PHI TO VE	.787	.341	.230	.424	.701	.719	.497	.472
	+	+	+	+	+	+	+	+

F-104A DATA SOURCES

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No. LR 10794, 12 Dec. 1955

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bility and Control Derivatives of a Supersonic Airplane with a
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Apr. 1959

Performance, F-104D, Lockheed Rept. No. LR-12873, 1 May 1958

Flight Manual, F-104A and F-104B USAF Series Aircraft, T. O. 1F-104A-1,
15 Dec. 1961

Technical Manual, Flight Controls, USAF Series F-104A and F-104C
Aircraft, T. O. 1F-104A-2-8, 15 Mar. 1960

SECTION IV

F-4C

F-4C BACKGROUND

The F-4C is an Air Force tactical fighter whose primary mission is all-weather air-to-air missile combat. Lateral control is achieved by ailerons in combination with spoilers on a swept wing. A swept stabilator provides longitudinal stability and control. Directional stability and control is accomplished through a conventional fin-rudder combination. Landing speed is reduced by full span leading edge flaps and inboard plain trailing edge flaps in conjunction with blowing-type boundary layer control (BLC). Boundary layer control is automatically induced when full flap deflection occurs.

Features distinguishing the USAF F-4C from its Navy counterpart, the F-4B, are:

- Lack of drooped ailerons with flaps down resulting in higher landing speeds.
- Dual flight controls resulting in slightly increased control system inertia.
- Wing bumps to house larger main gear wheels resulting in a slight drag increase.

Data included here was obtained primarily from MAC Report No. 9842. Special emphasis is placed on the longitudinal control system because of its relative complexity when compared to other aircraft. Figure IV-4 has been added to help illustrate this system. Also, care has been taken to retain some of the control system nomenclature used by the manufacturer, e.g., q_B and P_{BF} (see Fig. IV-5).

The Stability Augmentation block diagrams are shown in Fig. IV-7. The roll SAS described is not included in lateral directional SAS on transfer functions since it is faded out with the lateral control stick out of neutral position.

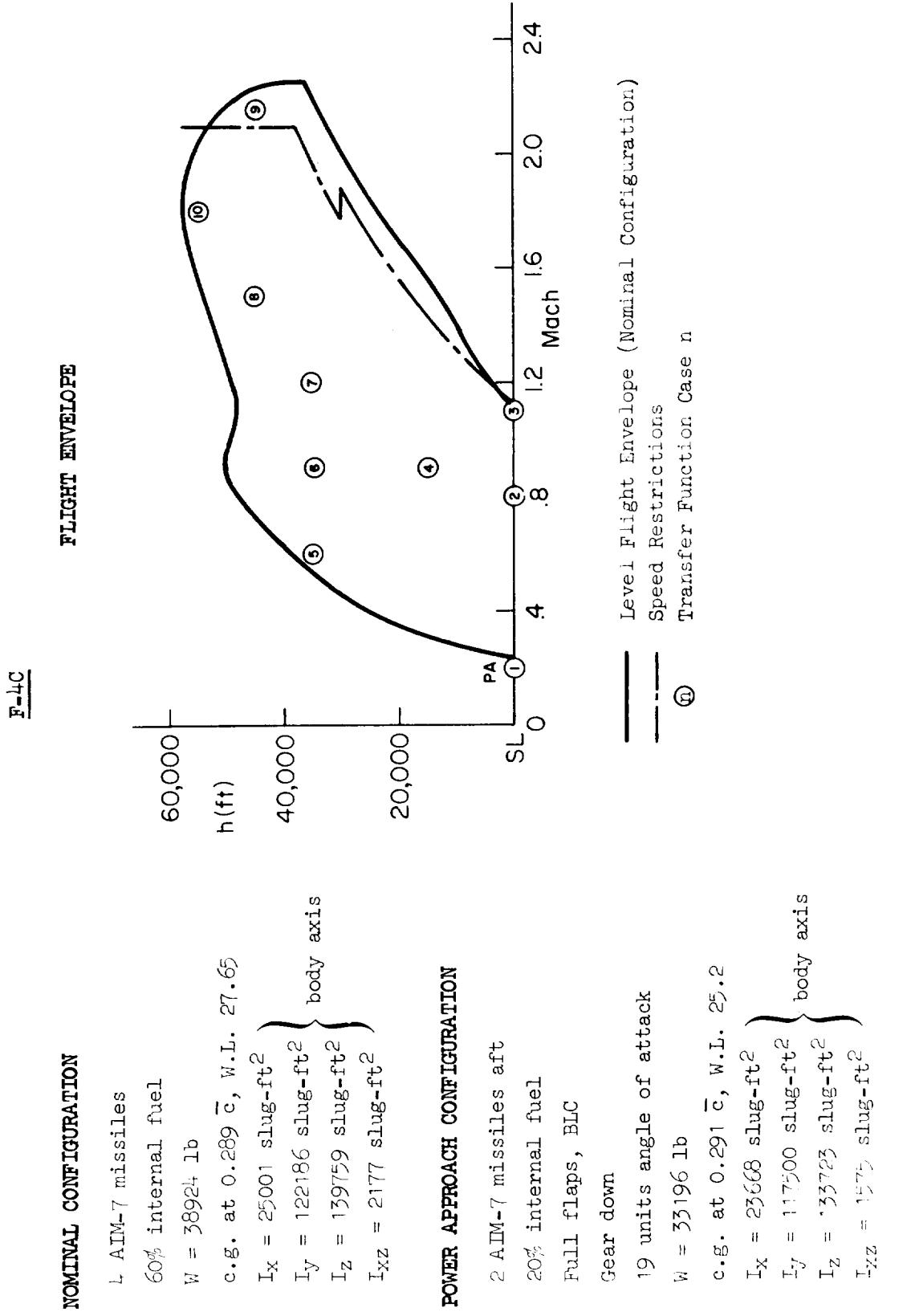


Figure IV-1. Flight Conditions

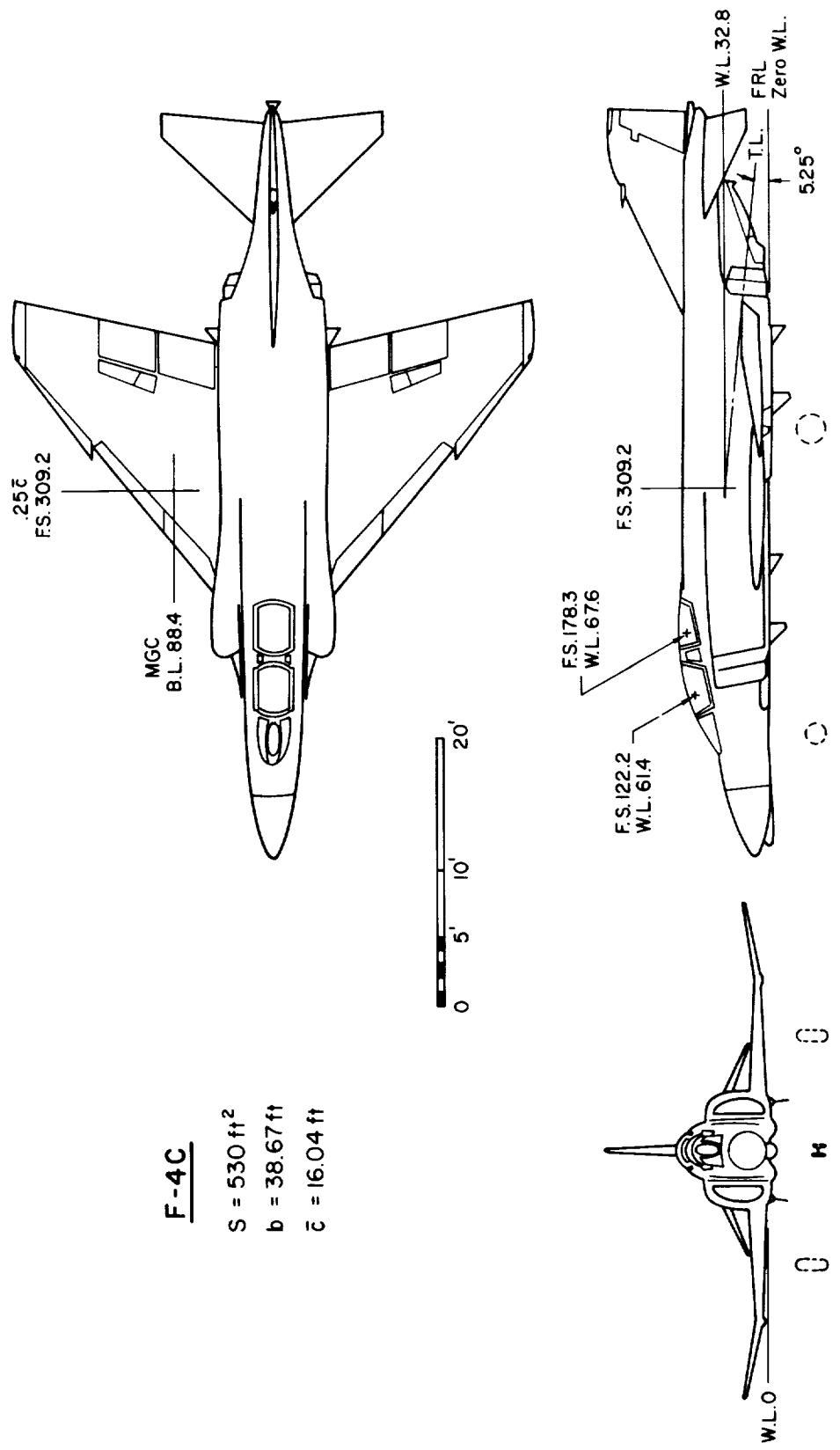
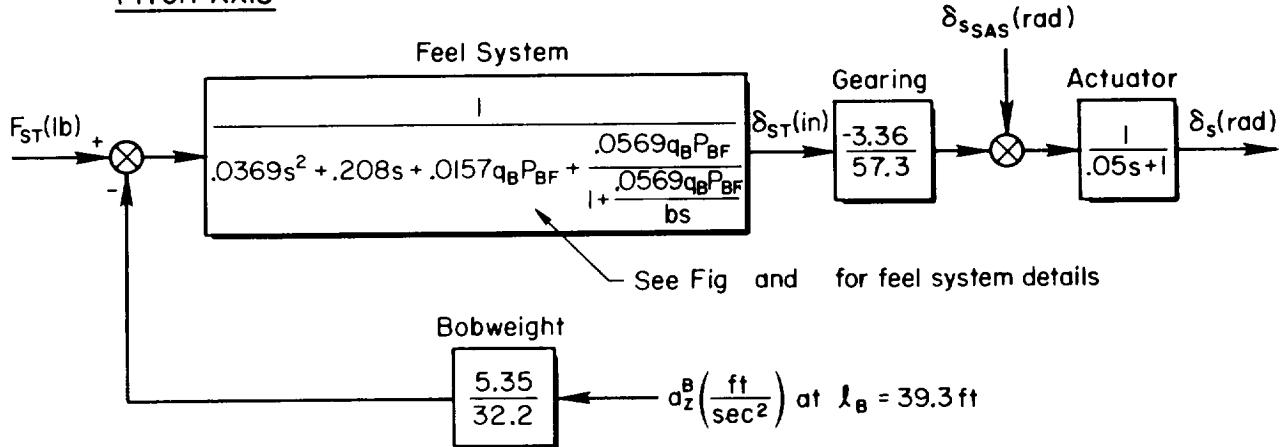


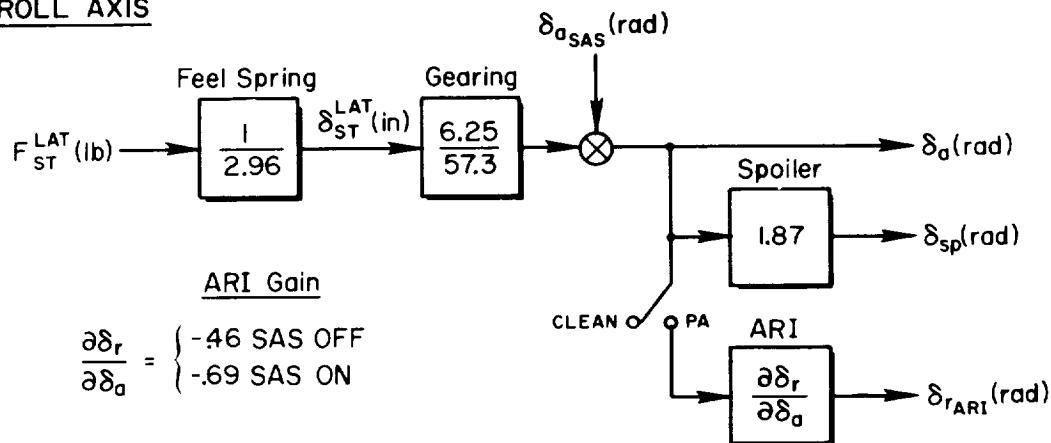
Figure IV-2. F-4C General Arrangement

F-4C

PITCH AXIS



ROLL AXIS



YAW AXIS

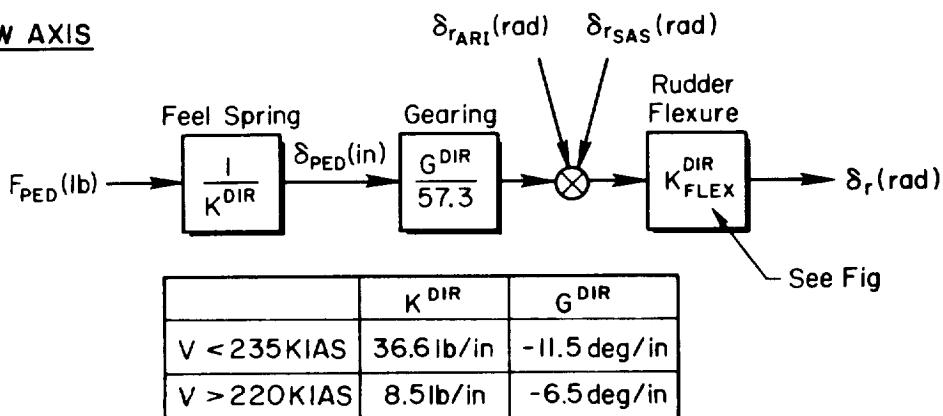
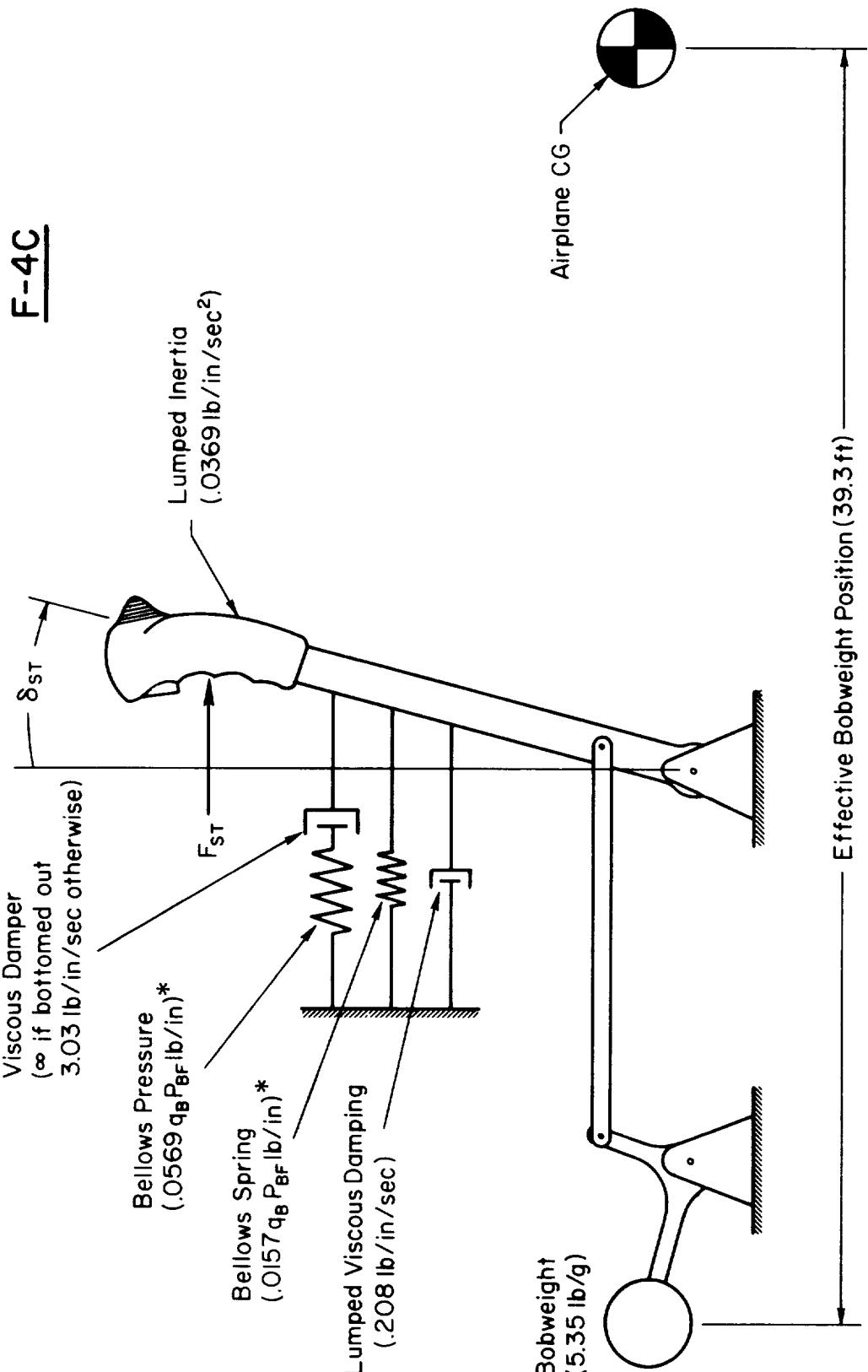


Figure IV-3. F-4C Control System



* The product $q_B P_{BF}$ is determined by the mach, q , and δ_s combination at a particular flight condition. See Fig. IV-5 for nominal configuration values

Figure IV-4. F-4C Feel System Schematic

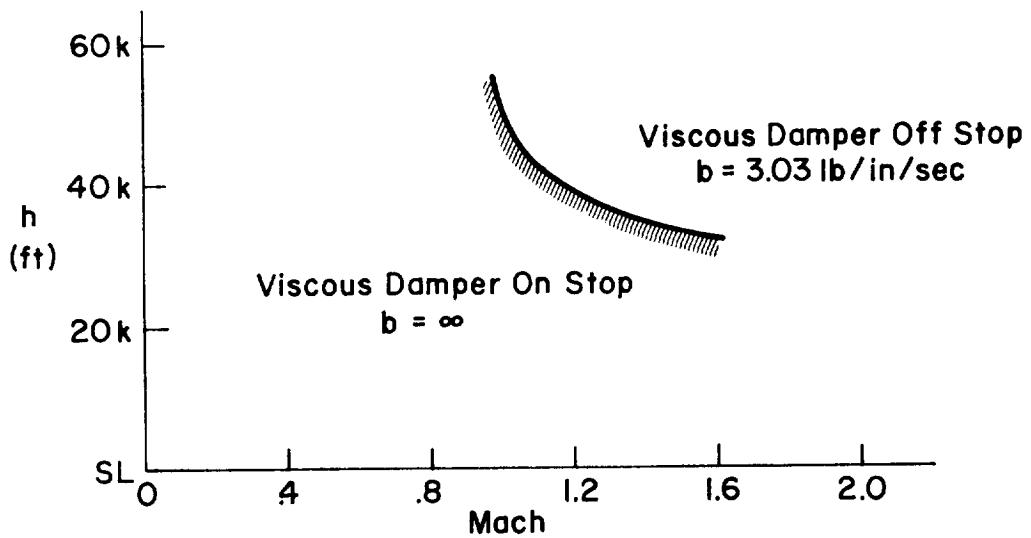
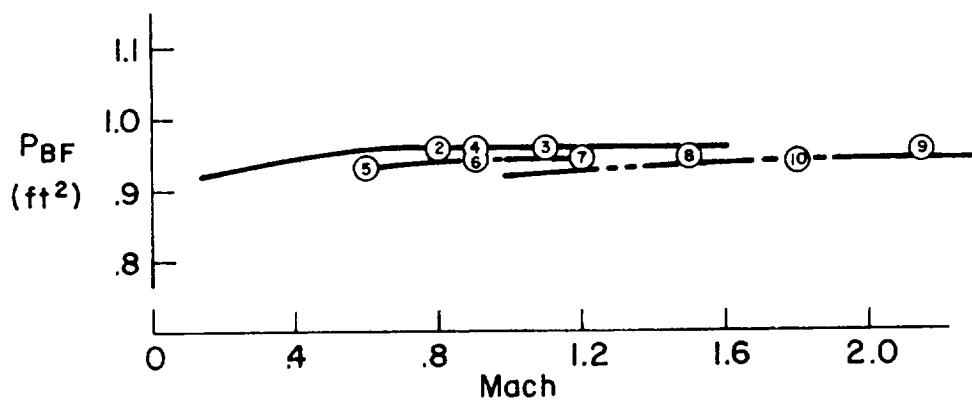
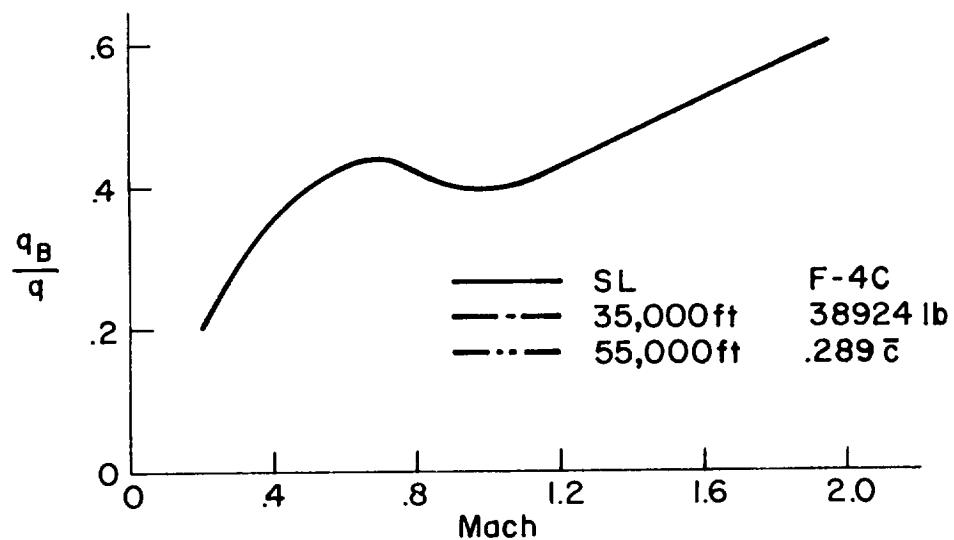


Figure IV-5. F-4C Feel System Parameters

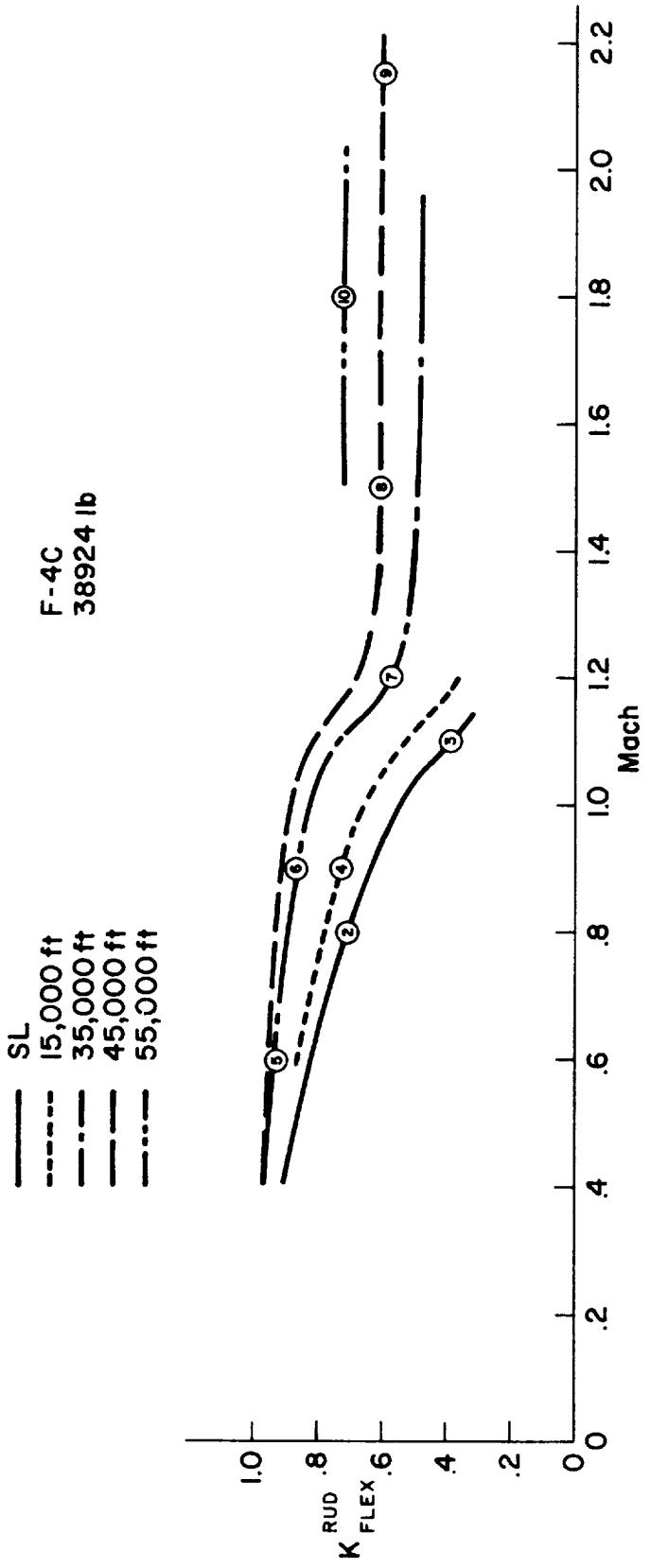
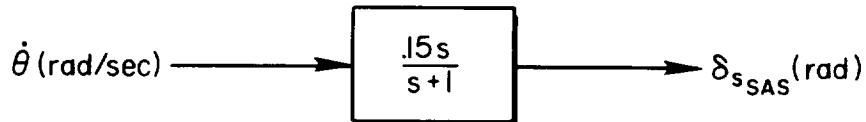


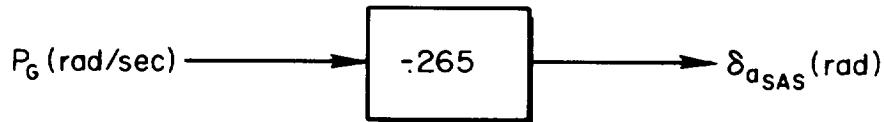
Figure IV-6. F-4C Rudder Flexure Coefficient

F-4C

PITCH SAS



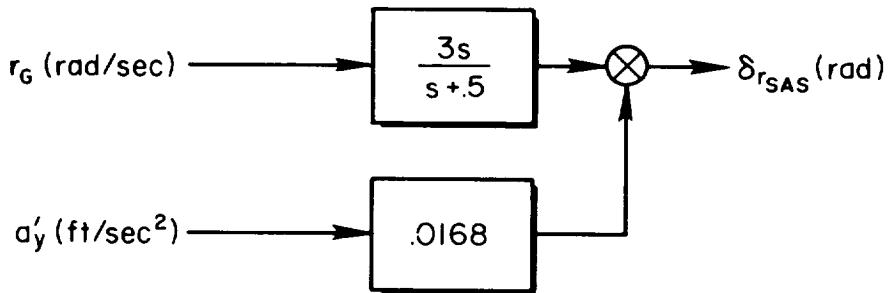
ROLL SAS



$P_G = P$ (Roll rate gyro assumed aligned with FRL)

Note: Roll SAS faded out with lateral control out of neutral

YAW SAS



$$r_G = r \cos(-1.5^\circ) + p \sin(-1.5^\circ)$$

$$a'_y = a_y + 9.9\dot{r} - .39\dot{p}$$

Yaw rate gyro inclined 1.5° below FRL and lateral accelerometer at F.S. 198.0 and W.L. 23.0

Figure IV-7. F-4C Stability Augmentation

TABLE IV-1

F-4C**Power Approach Non-Dimensional Stability Derivatives**

h = sea level

V_{T_0} = 230 ft/sec = 136 kt

α_0 = 11.7°

δ_s = -9.1°

Longitudinal**Lateral-Directional
(Stability Axis)**

$$C_L = .915$$

$$C_{y\beta} = -.655/\text{rad}$$

$$C_D = .242$$

$$C_{n\beta} = .199/\text{rad}$$

$$C_{L\alpha} = 2.8/\text{rad}$$

$$C_{\ell\beta} = -.156/\text{rad}$$

$$C_{D\alpha} = .555/\text{rad}$$

$$C_{\ell p} = -.272/\text{rad}$$

$$C_{m\alpha} = -.098/\text{rad}$$

$$C_{n_p} = -.013/\text{rad}$$

$$C_{m\dot{\alpha}} = -.95/\text{rad}$$

$$C_{\ell r} = .205/\text{rad}$$

$$C_{m_q} = -2.0/\text{rad}$$

$$C_{n_r} = -.320/\text{rad}$$

$$C_{L\delta_s} = .24/\text{rad}$$

$$C_{y\delta_a} = -.0355/\text{rad}$$

$$C_{m\delta_s} = -.322/\text{rad}$$

$$C_{n\delta_a} = -.0041/\text{rad}$$

$$C_{D\delta_s} = -.14/\text{rad}$$

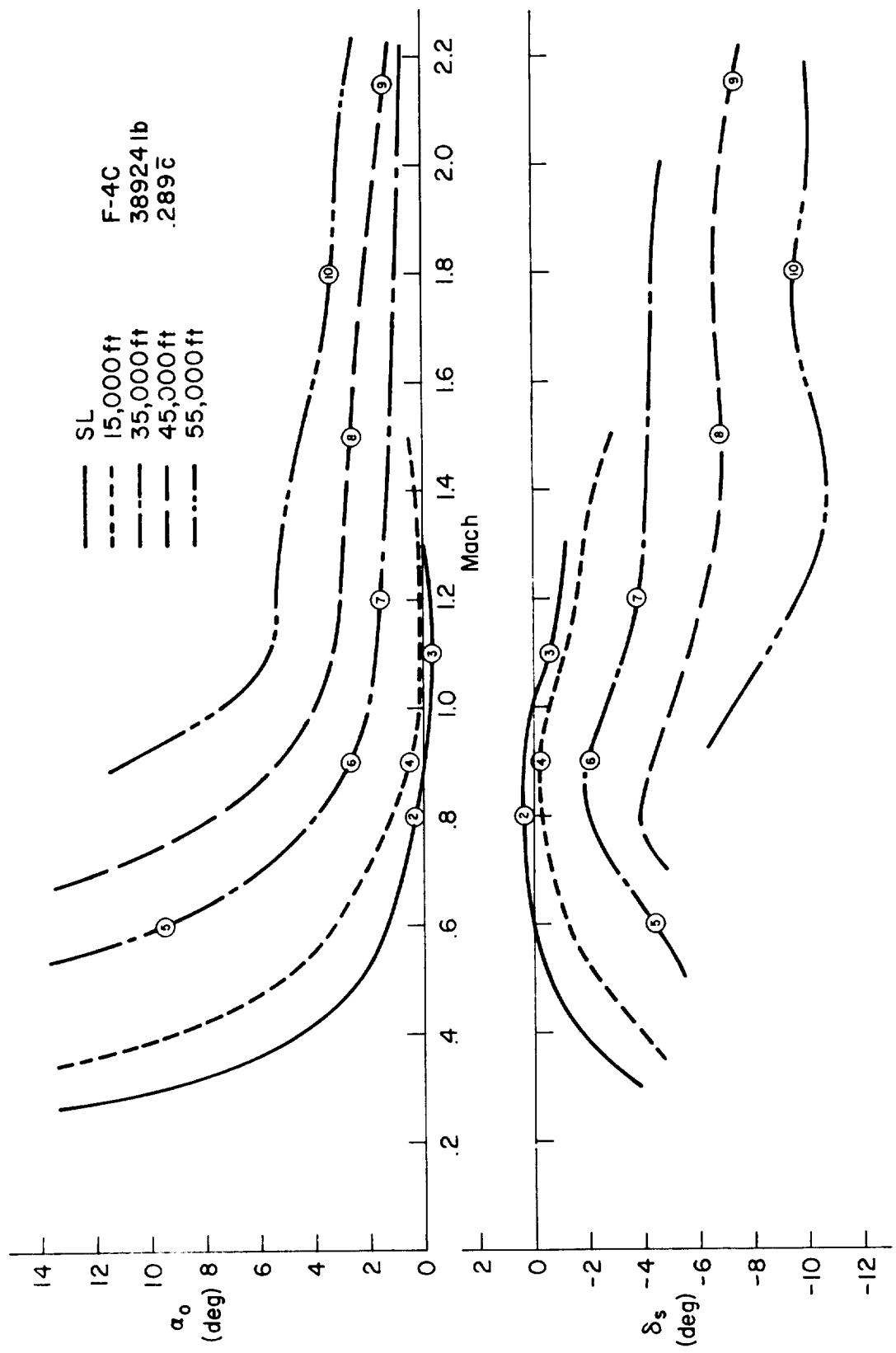
$$C_{\ell\delta_a} = .057/\text{rad}$$

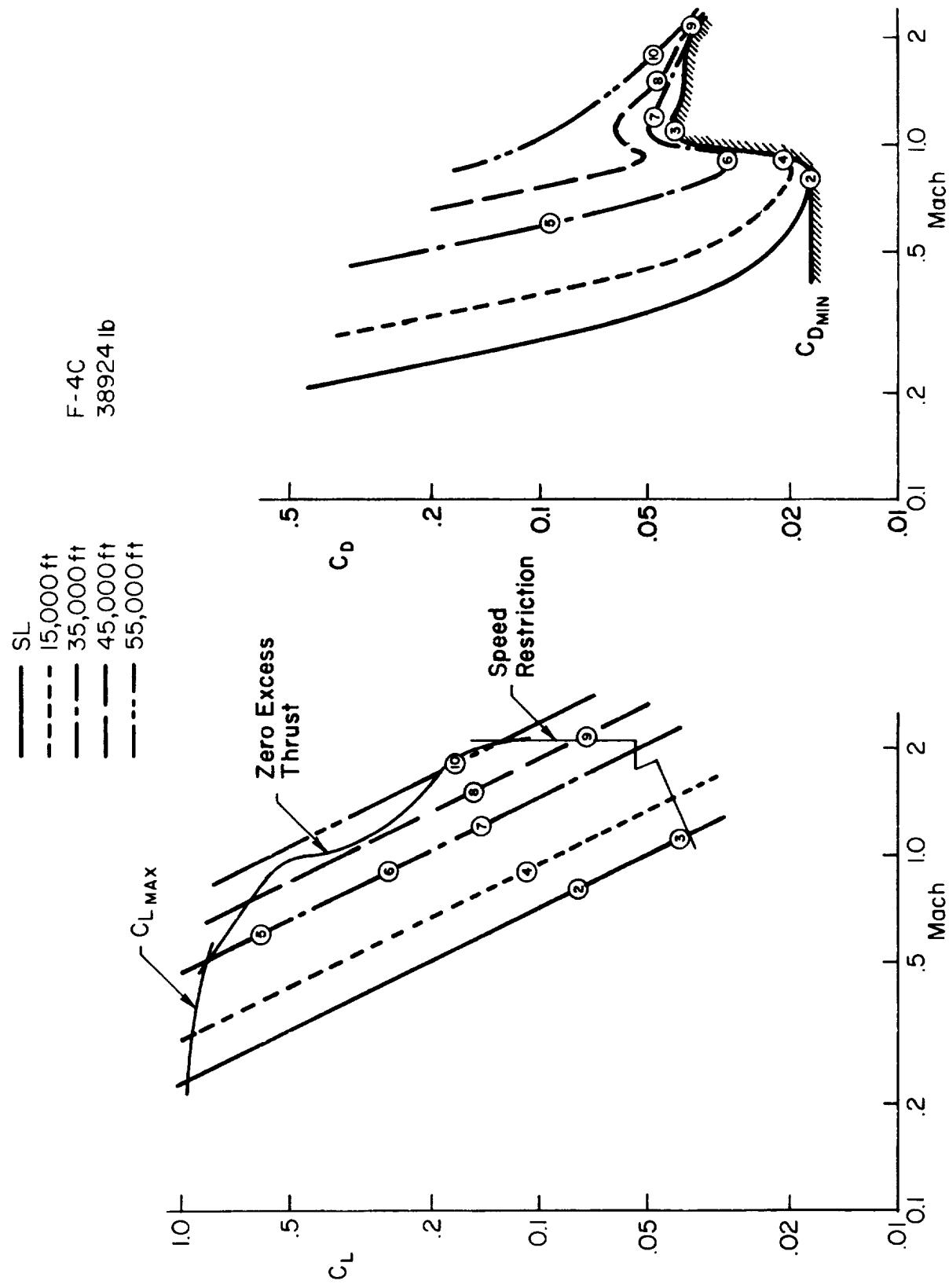
Spoiler
Effects
Included

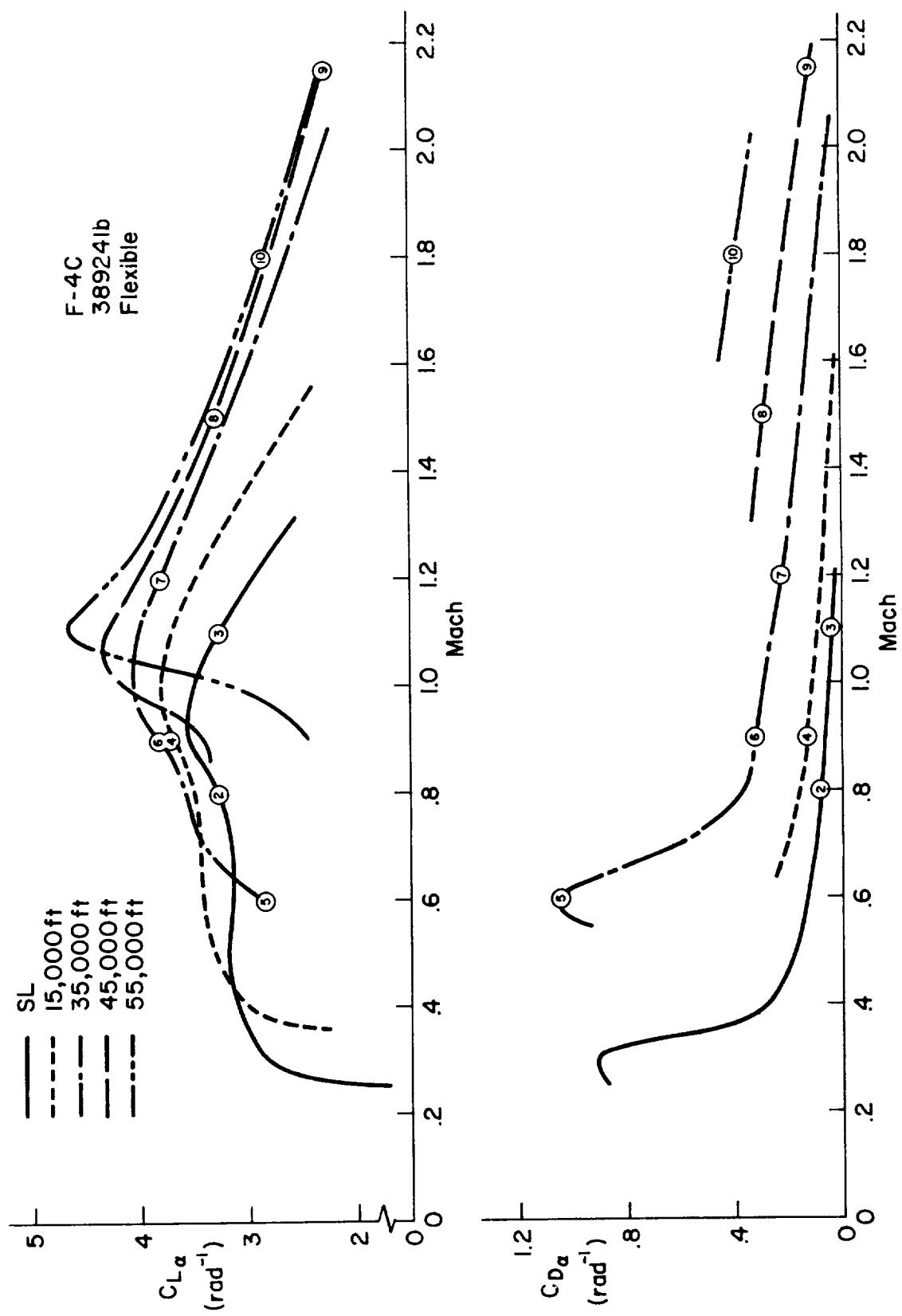
$$C_{y\delta_r} = .124/\text{rad}$$

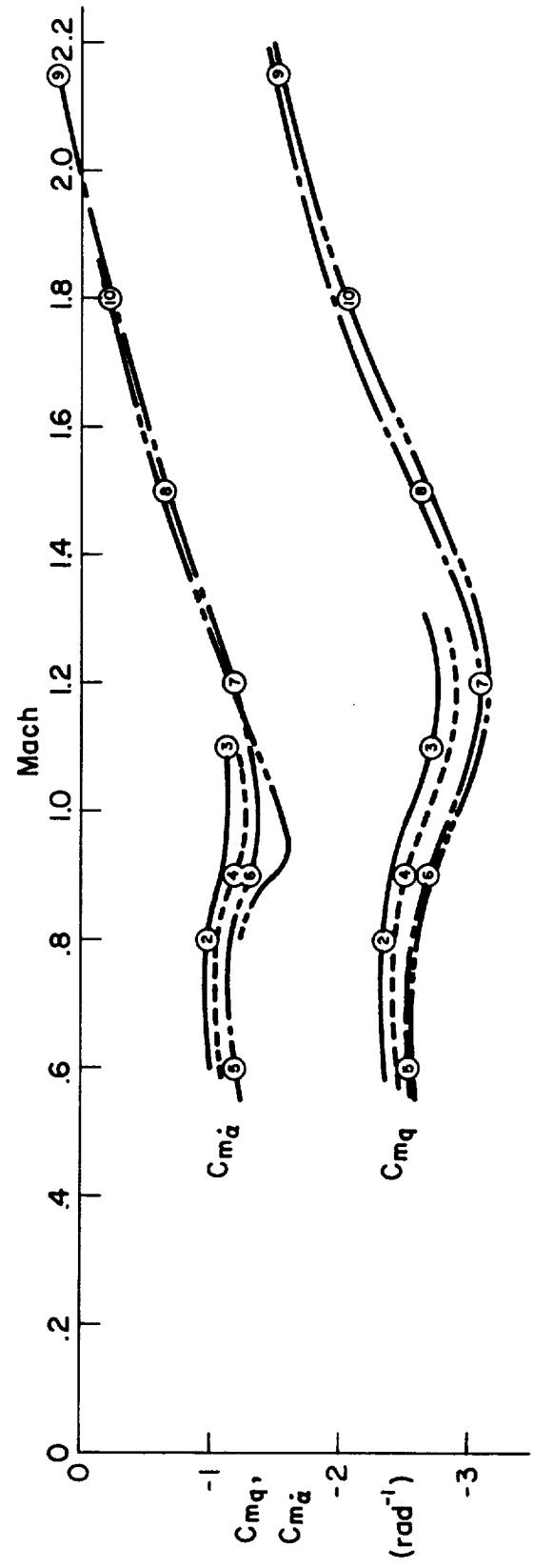
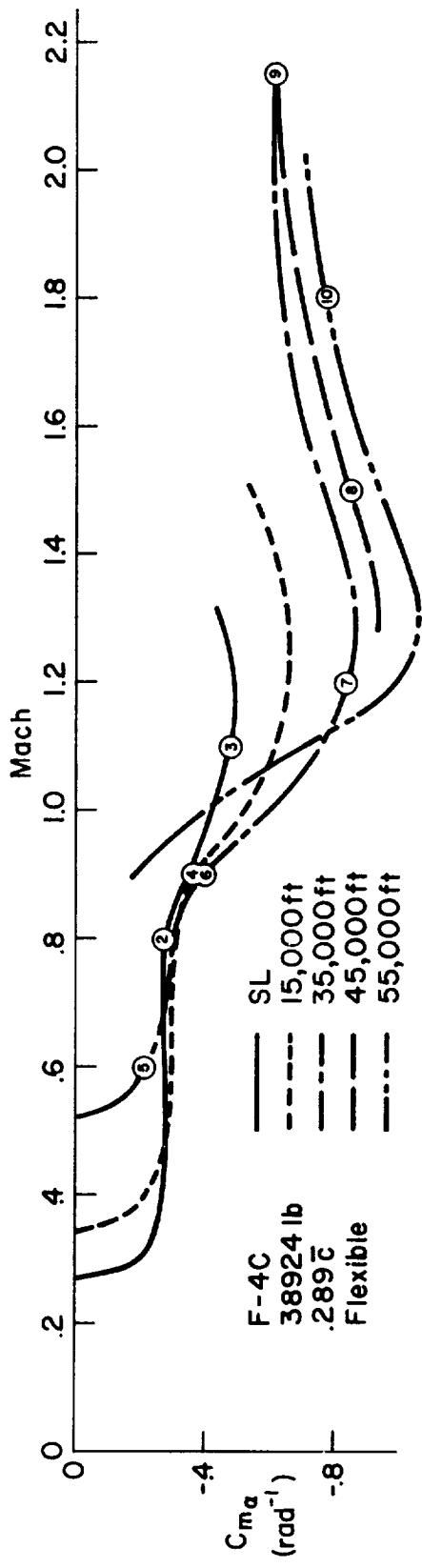
$$C_{n\delta_r} = -.072/\text{rad}$$

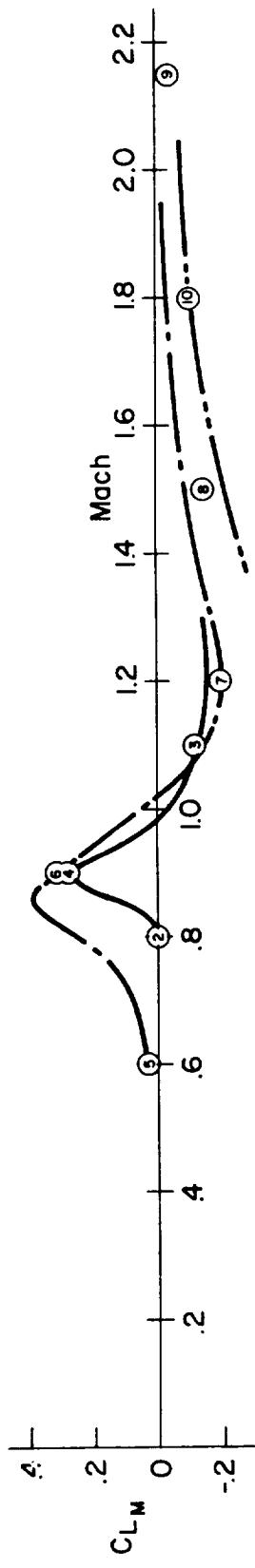
$$C_{\ell\delta_r} = -.0009/\text{rad}$$



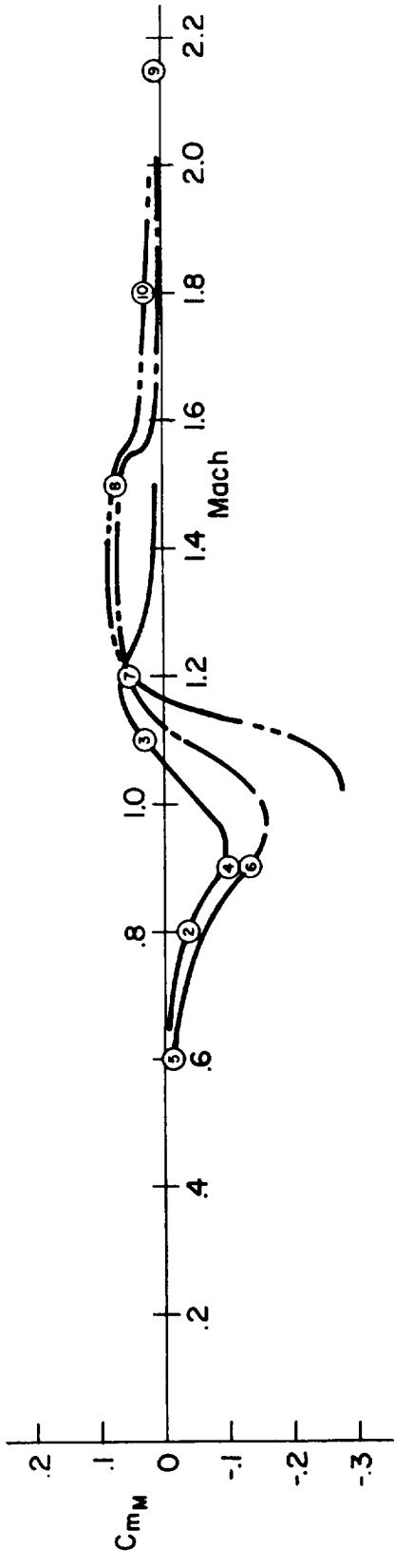
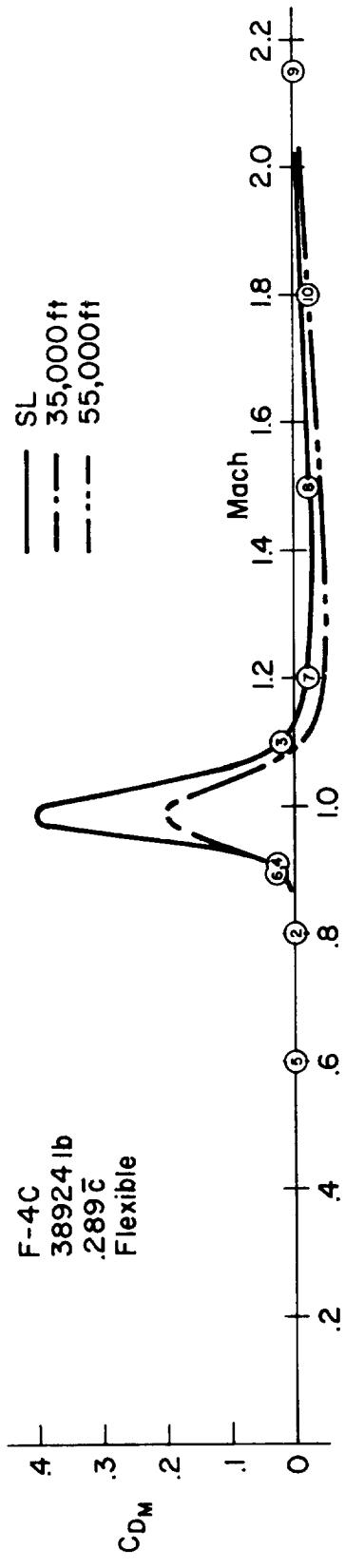


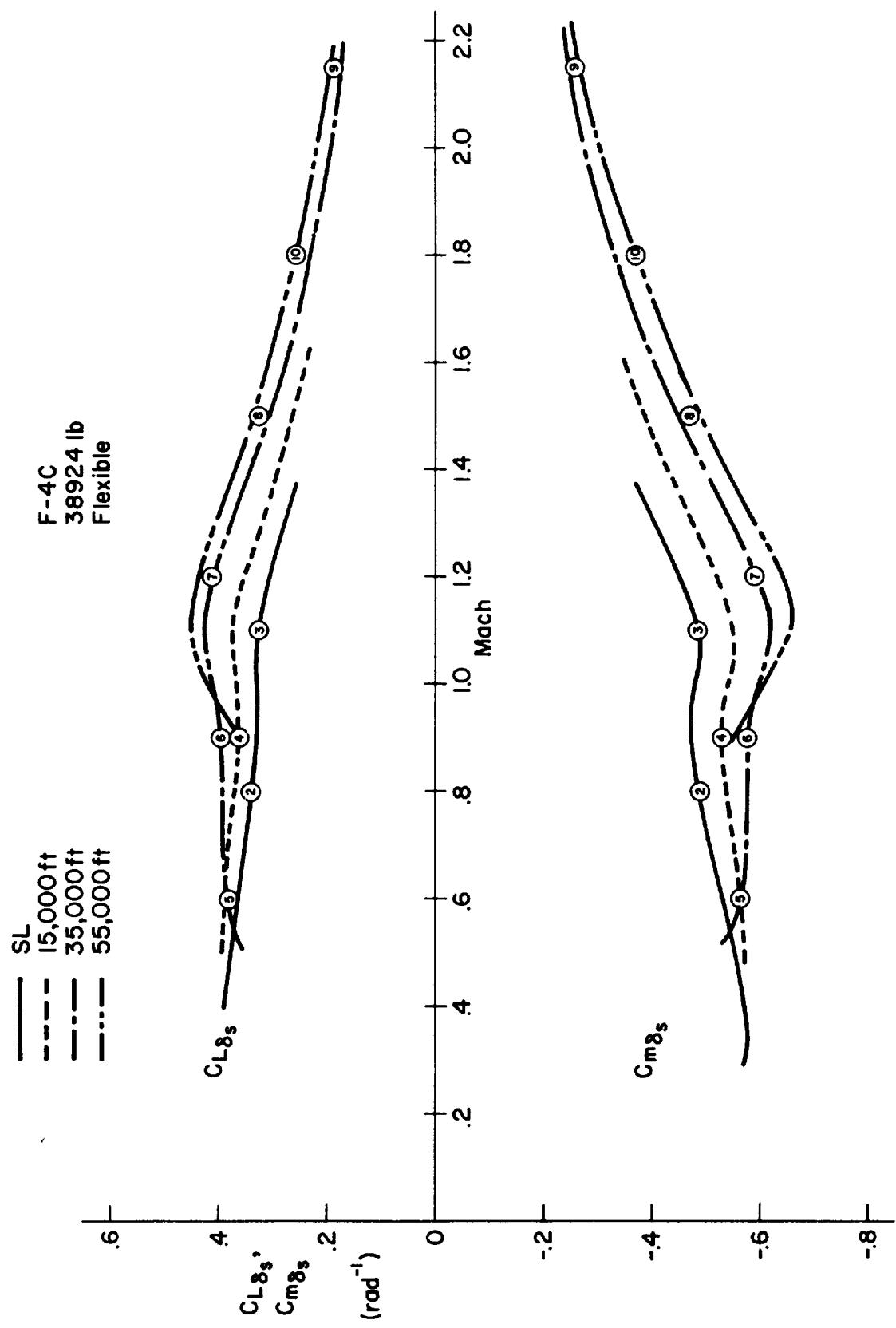


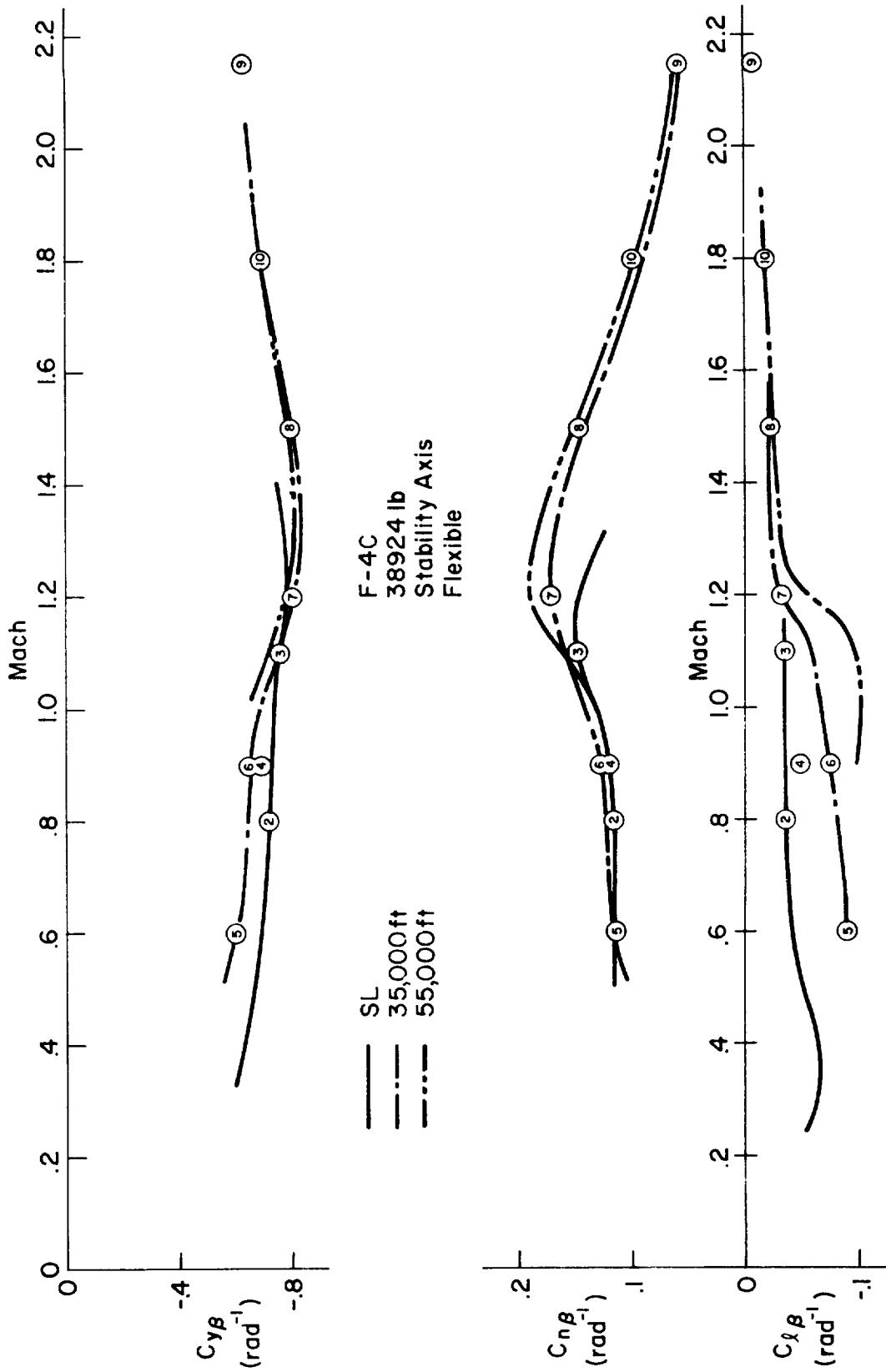


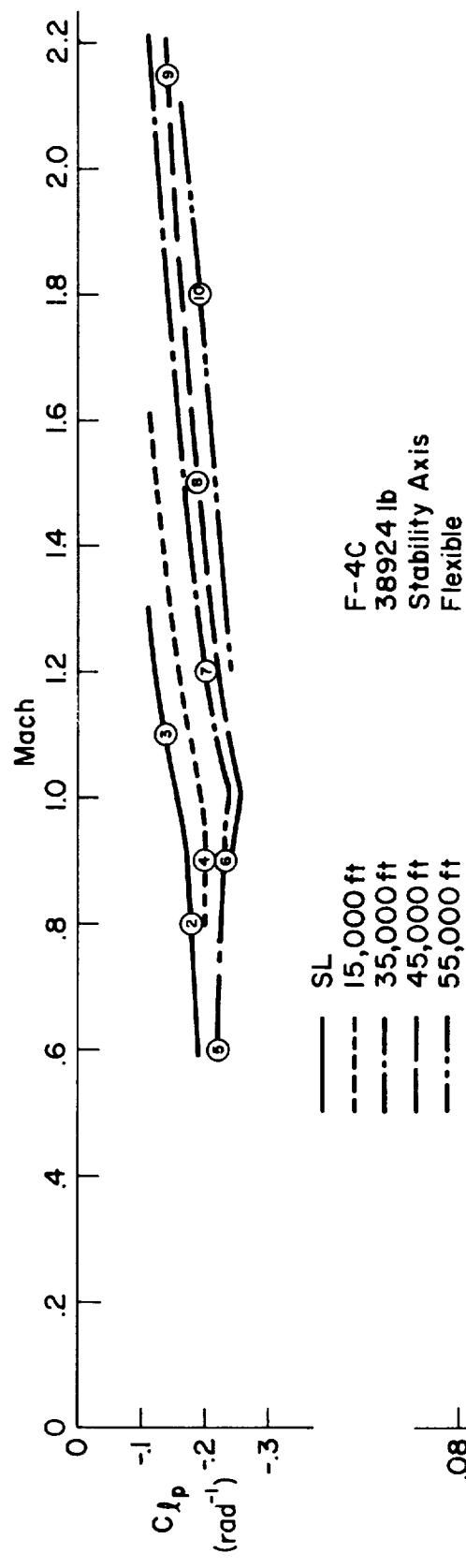


F-4C
38924 lb
.289 $\frac{c}{S}$
Flexible

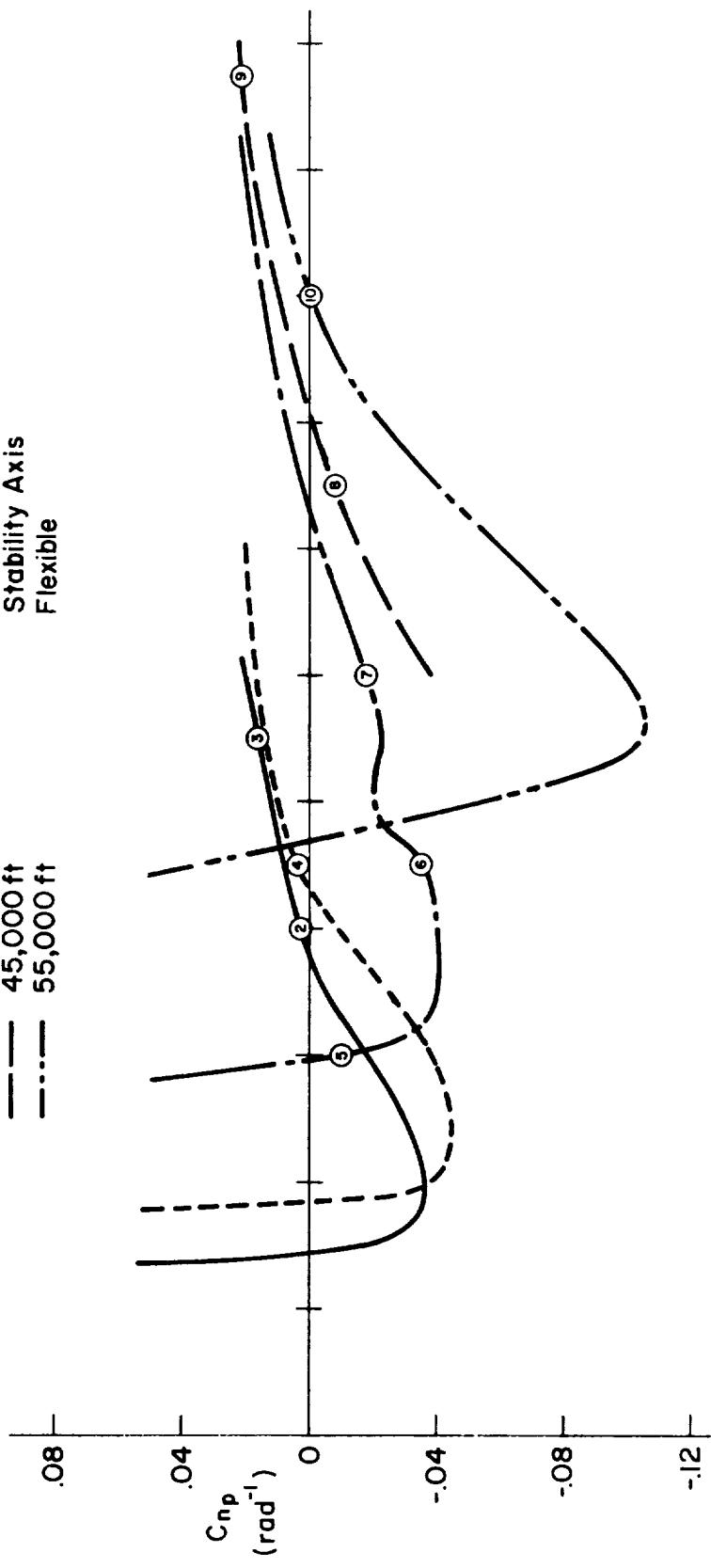


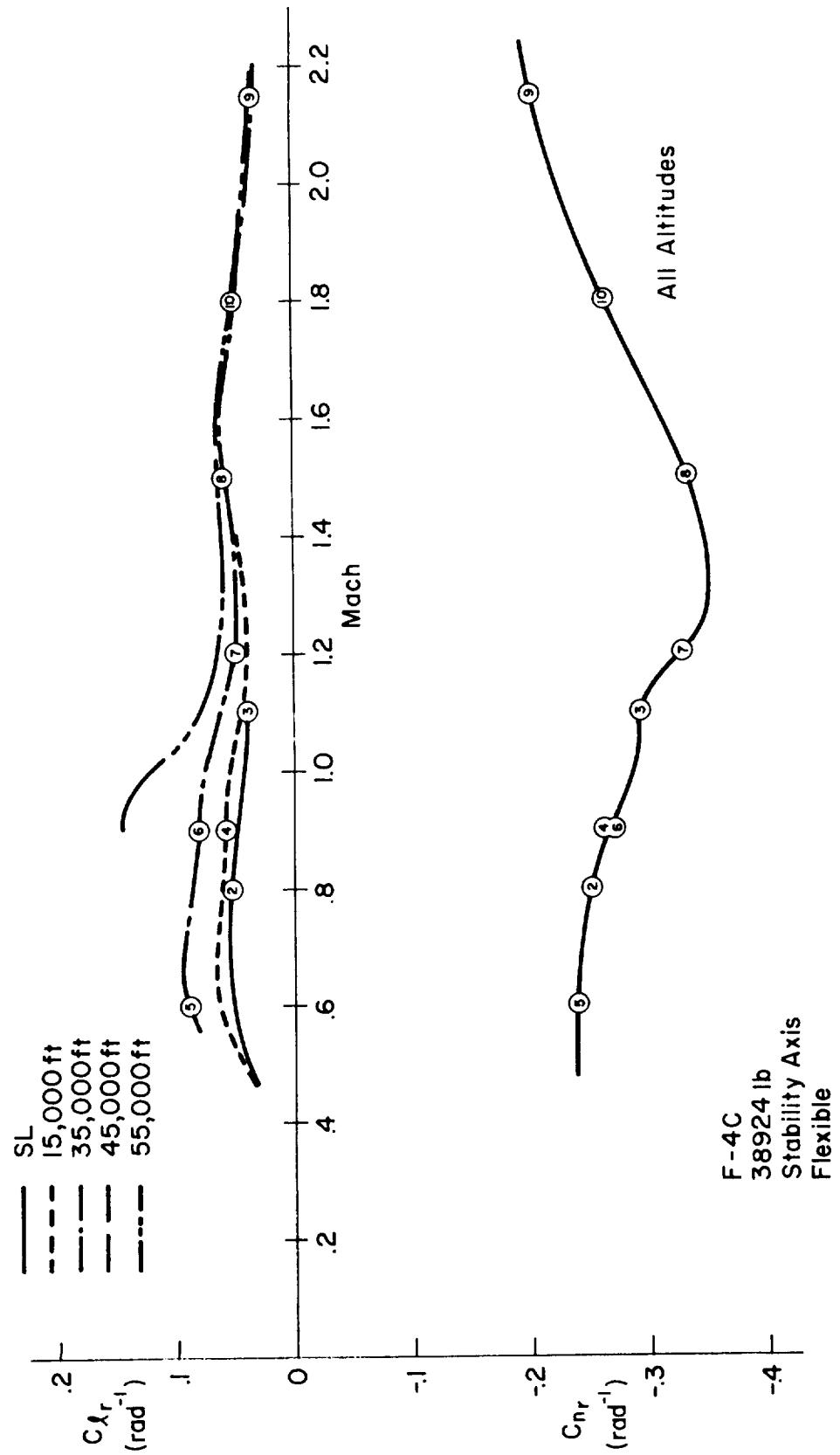


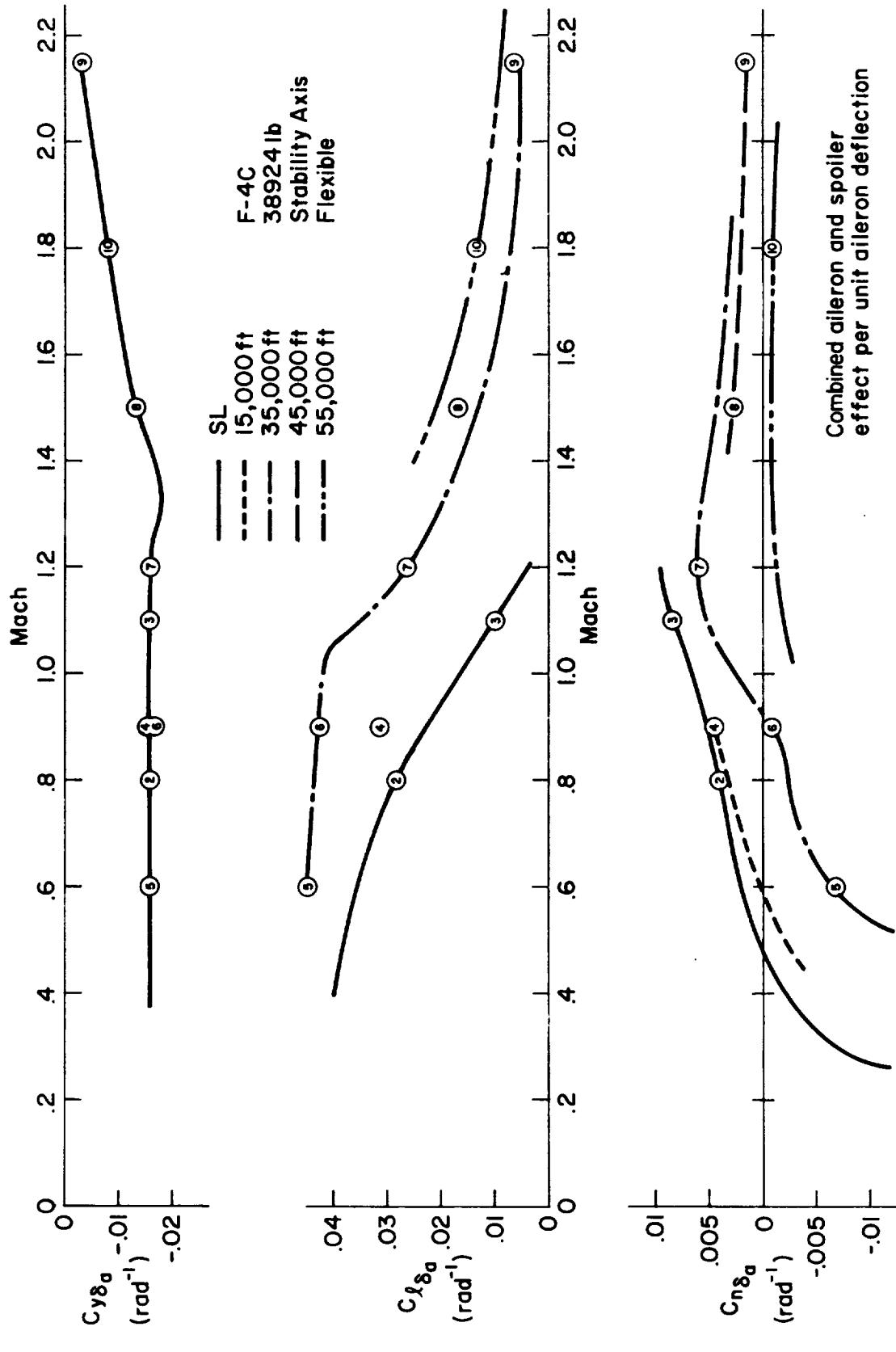




F-4C
 38924 lb
 Stability Axis
 Flexible







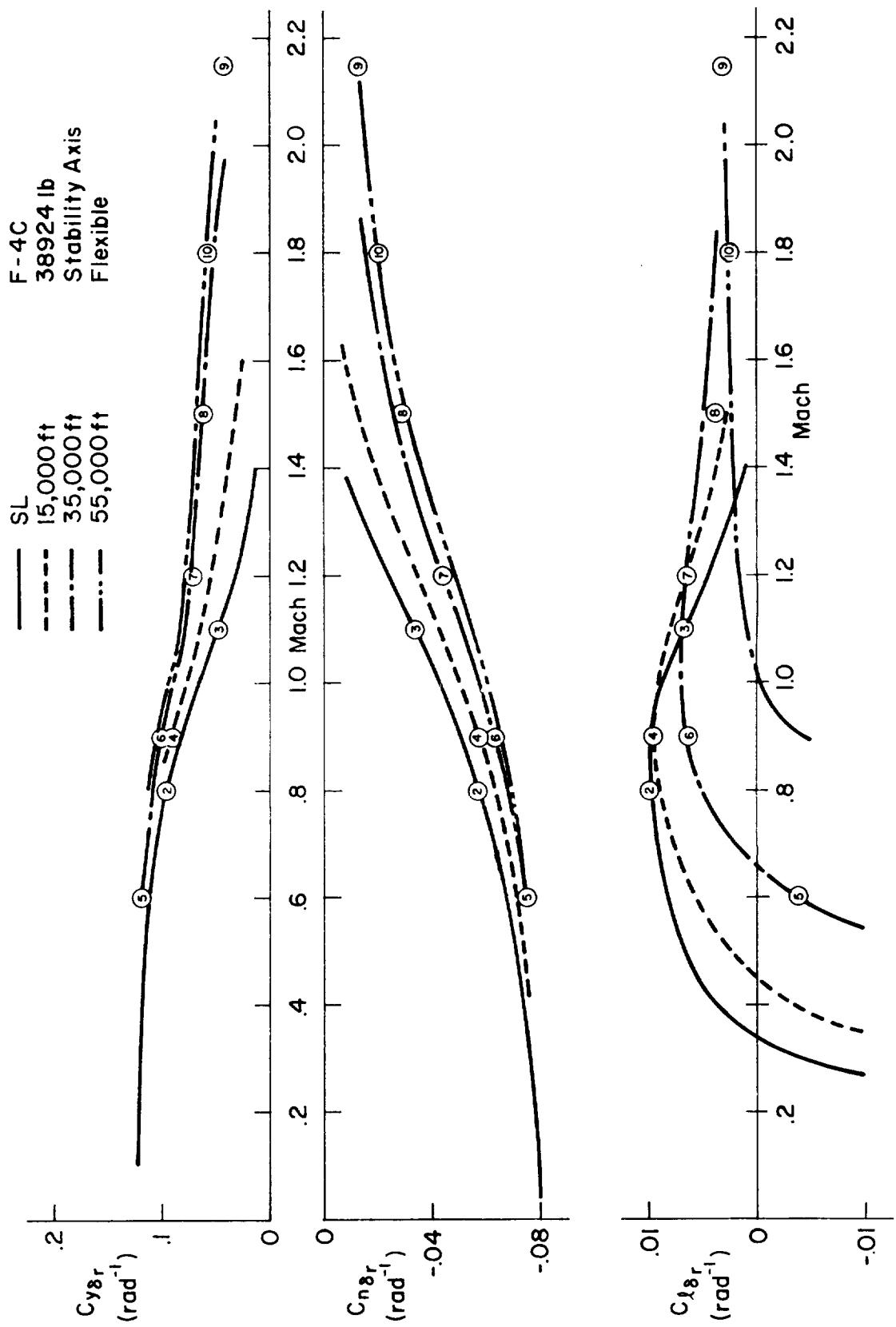


TABLE IV-2
F-4C DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

F/C #	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +	+ + + + +
H(FT)	1	2	3	4	5	6	7
M(-)	.206	.800	1.10	.900	.600	.900	1.20
VTO(FPS)	230.	893.	1228.	952.	584.	876.	1167.
VTO(KIAS)	136.	529.	728.	564.	346.	519.	692.
VTO(KCAS)	136.	529.	728.	465.	199.	311.	432.
W(LBS)	33197.	38925.	38925.	38925.	38925.	38925.	38925.
C.G. (VGC)	.291	.289	.289	.299	.289	.289	.289
I X (SLUG-FT SC)	23669.	25002.	25002.	25002.	25002.	25002.	25002.
I Y (SLUG-FT SC)	117506.	122193.	122193.	122193.	122193.	122193.	122193.
I Z (SLUG-FT SC)	133730.	139767.	139767.	139767.	139767.	139767.	139767.
I XZ(SLUG-FT SC)	1575.	2177.	2177.	2177.	2177.	2177.	2177.
EPSILON(DEG)	-0.020	-1.09	-1.09	-1.09	-1.09	-1.09	-1.09
Q(PSF)	62.6	948.	1792.	677.	126.	283.	503.
QC(PSF)	63.3	1109.	2397.	825.	138.	345.	703.
ALPHA(DEG)	11.7	.300	-.300	.500	.940	2.60	1.60
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	16.3	16.2	16.2	16.2	16.2	16.2	16.2
L2P(FT)	-3.02	-2.81	-2.81	-2.31	-2.81	-2.81	-2.81
LTH(DEG)	5.25	5.25	5.25	5.25	5.25	5.25	5.25
X1(DEG)	5.25	5.25	5.25	5.25	5.25	5.25	5.25
LTH(FT)	-0.570	-.370	-.370	-.370	-.370	-.370	-.370
	+	+	+	+	+	+	+

TABLE IV-3
F-4C LONGITUDINAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

	+ F/C *	+ H	+ M	+ XU *	+ ZU *	+ MU *	+ XW	+ ZW	+ ZQ	+ MW	+ ZWD	+ ZQ	+ MWC	+ MC	+ XDS	+ MDS	+ ZDT	+ MDT	+ MDTH
	1	2	3	4	5	6	7	8	9	10									
F/C *																			
H	.51	.51	.51	.15 K	.35 K	.35 K	.35 K	.45 K	.45 K	.55 K									
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80									
XU *	-.0417	-.0159	-.0677	-.0203	.000719	-.00796	-.0135	-.00679	-.0158	-.00528									
ZU *	-.177	-.0645	.0226	-.134	-.0689	-.0876	.0155	.0110	-.00092	.000474									
MU *	.000743	-.00161	.00325	-.00425	.000511	-.00239	.00232	.00341	.00128	.00175									
XW	.130	.00705	-.0107	.0071	.00458	.0158	.00576	.00146	.00387	-.00501									
ZW	-.452	-1.54	-2.11	-1.16	-2.96	-.547	-.727	-.604	-.604	-.310									
ZQ	-.00182	-.0199	-.0488	-.0175	-.00326	-.00911	-.0248	-.0198	-.01205	-.0133									
MWC	-.00305	-.00271	-.00326	-.00210	-.00104	-.00116	-.00106	-.000358	.977E-4	-.604E-4									
ZWD	-2.48	-8.20	-8.72	-6.00	-1.84	-2.89	-4.09	-2.24	-1.27	-1.14									
MWC	-.000642	-.000663	-.000729	-.000480	-.000244	-.000267	-.000247	-.840E-4	.259E-4	-.150E-4									
MC	-.317	-1.36	-2.20	-.953	-.307	-.487	-.745	-.488	-.488	-.286									
XDS	5.98	.739	-1.32	.952	3.42	2.25	2.52	3.21	2.00%	2.86									
MDS	-6.65	-141.	-251.	-107.	-20.7	-49.6	-90.4	-70.6	-82.6	-49.6									
XDT	-1.46	-32.3	-61.1	-25.0	-4.90	-11.4	-20.7	-16.0	-16.0	-11.2									
MDT	.000905	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823	.000823									
ZDT	-.887E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4	-.756E-4									
MDTH	-.485E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5	-.303E-5									

TABLE IV-4
F-4C STABILIZER TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Open

(BODY AXIS SYSTEM)									
F/C *		+		+		+		+	
H	H	1	2	3	4	5	6	7	8
		\$L	\$L	1.10	.9CC	.60C	.900	1.20	1.50
		.206	.800						
DENOMINATOR									
Z(DET)1	.102	(-.0378)	.639	(-.C612)	.0928	(-.0446)	.191	.156	.384
H(DET)1	.191	(-.0516)	.0542	(-.0741)	.0774	(-.0456)	.0450	.0402	.0220
Z(DET)2	.607	.393	.324	.308	.259	.224	.162	.102	.0645
H(DET)2	.757	4.44	7.95	4.24	1.41	2.85	5.43	5.39	6.52
NUMERATORS									
N(L/DS)	5.97	737	-1.31	.930	3.42	2.25	2.52	3.20	2.04
A(LU)	11.4	1.94	1.49	1.25	1.36.	201.	266.	.310	4.00
1/T(LU)	1	5.35	-6.31	3.44	(.980)	(.787)	(.965)	.641	.143
Z(W)	12	{ .452)	304.	218.	(.307)	(.643)	(.783)	3.28.	.584
H(W)	13	{ .561)	197.						3.92.
N(W/DS)									
A(H)	-6.62	-141.	-250.	-107.	-20.6	-49.5	-90.3	-70.6	-83.6
1/T(W)	11	49.3	204.	-0.032C	222.	137.	202.	328.	400.
Z(W)	1	.151	.176	(-0711)	.165	.0121	.0964	.852	.731
H(H)	1	.156	.0456	{ .299.)	.0627	.0532	.00729	.00911	.0114
N(THE/DS)									
A(THE)	-1.45	-32.2	-60.9	-24.5	-4.90	-11.4	-20.6	-16.0	-16.1
1/T(THE)	1	.0162	.0678	.02CE	-.000498	.0106	.0131	.00608	.0157
1/T(THE)2	.379	1.46	1.90	1.08	.282	.505	.618	.407	.388
N(HD/DS)									
A(HD)	7.70	141.	250.	107.	20.9	49.6	90.3	70.6	83.6
1/T(HD)	11	.0146	.0680	.0169	-.0245	.00335	.0123	.00689	.0151
1/T(HD)	12	-4.21	17.0	-23.8	15.3	5.96	9.99	12.7	-12.4
1/T(HD)	13	4.27	-17.5	23.9	-15.7	-6.05	-10.2	-11.5	-12.5
N(AZP/DS)									
A(AZP)	17.0	382.	737.	298.	58.7	135.	244.	188.	177.
1/T(AZP)	1	-.0514	-.000207	.000137	-.000356	-.000194	-.000287	-.000776	-.000385
1/T(AZP)	2	.0543	.0148	.0675	.0172	-.0243	.00618	.0131	.00590
Z(AZP)	1	.121	.104	.0917	.C876	.0620	.0625	.0586	.0400
H(AZP)	1	2.80	1C.5	13.9	9.3C	3.61	6.09	7.81	7.07

TABLE IV-5
F-4C THRUST TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Open
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	S _L .206	S _L .800	S _L 1.1C	.9CC	1.5 K .600	35 K .900	35 K 1.20	45 K 1.50	45 K 2.15	55 K 1.80
DE Nominator										
Z(DE T)1	*102	(-.0378)	.639	(-.0612)	.0928	(-.0446)	.191	.156	.384	.175
W(DE T)1	*191	(-.0516)	.0542	(-.0741)	.0774	(-.0456)	.0450	.0402	.0220	.0274
Z(DE T)2	*607	*393	.224	.308	.259	*224	*162	*102	*0645	*0.650
W(DE T)2	*757	4.44	7.99	4.24	1.41	2.85	5.43	5.39	6.54	4.84
Numerators										
N(U /DTH)										
A(U)1	*000865	*000823	.000823	*000823	.000823	*000823	*000823	*000823	*000823	*000823
1/T(U)1	-109	.00607	.00176	.00435	.00376	.00295	-.000327	-.000327	-.000327	-.00113
Z(U)1	*694	*393	*322	*305	*371	*244	*173	*125	*0788	*104
W(U)1										
N(W /DTH)										
A(W)1	-878E-4	-754E-4	-754E-4	-755E-4	-755E-4	-755E-4	-755E-4	-755E-4	-755E-4	-755E-4
1/T(W)1	14.3	.00167	-.00175	.0005C3	24.0	-.000110	-.00300	-.00281	-.0193	-.00279
Z(W)2	(-123)	*458	*788	1.18	(-.807)	*658	*756	*897	*327	*461
1/T(W)3	{ 1.161)	37.0	51.7	35.1	{ .C746)	35.6	47.9	59.2	82.0	70.3
N(THE/DTH)										
A(THE)1	-4.67E-5	-2.98E-5	-2.98E-5	-2.98E-5	-3.00E-5	-3.00E-5	-3.02E-5	-3.03E-5	-3.03E-5	-3.03E-5
1/T(THE)1	-192	*283	-1.21	.517	-289	*178	*450	*321	*282	*215
1/T(THE)2	*480	1.23	1.28	1.38	.358	*800	-1.13	-1.24	-630	-700
N(HD /DTH)										
A(HD)1										
1/T(HD)1	*0.9	.341	-1.86	1.45	*681	2.53	1.43	1.08	.655	
Z(HD)1	-552	(-6.91)	(-4.80)	(-4.11)	-367	(-1.86)	-293	-122	-0.978	-0.393
W(HD)1	*516	{ 6.88)	{ 8.90)	{ 5.67)	.793	{ 2.62)	2.68	3.31	2.29	3.15
N(AZP/DTH)										
A(AZP)										
1/T(AZP)1										
1/T(AZP)2	16.5	*332	-2.06	.956	-.050256	-.000768	-.00168	-.000768	-.000377	*0.0106
Z(AZP)1	-984	(-8.60)	(-6.63)	(-7.34)	(-1.59)	(-4.60)	*451	6.65	3.61	3.30
W(AZP)1	*815	{ 11.8)	{ 15.3)	{ 1C.2)	{ 5.35)	{ 6.67)	-536	-316	-294	-275

F-4C STICK FORCE TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Closed

(BODY AXIS SYSTEM)									
F/C #		+		+		+		+	
H	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	55 K
H	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15
DENOMINATOR									
1/T(DET)1	20.8	-0.0271	26.6	-.0445	22.0	-.0335	24.5	1.49	3.10
1/T(DET)2		-.0412		-.0585		-.0343		2.32	1.35
Z(DET)1	.146	(25.3)	.760	(25.C)	-.0455	(23.5)	.205	.159	2.22
H(DET)1	.0881		.0454		.0540		.0389	.021	.169
Z(DET)2	.271	*.277	*.263	*.215	*.166	*.155	*.148	*.138	.0218
H(DET)2	1.15	4.91	7.90	4.6C	1.67	3.09	5.12	5.07	.102
Z(DET)3	.427	*.0192	*.0C0438	*.0253	*.167	*.0751	*.0302	*.1C9	.102
H(DET)3	6.01	25.1	38.9	24.6	11.4	16.5	22.1	*.174	.137
								34.5	22.5
NUMERATORS									
N(W /FST)									
A(U)	-190.	-23.4	41.7	-29.6	-109.	-71.5	-80.2	-102.	-64.9
1/T(U)1	1.14	1.95	1.49	1.25	1.36.	201.	266.	*.310	-90.9
1/T(U)2	(.452)	5.35	-6.31	3.44	(.980)	(.787)	(.965)	*.641	11.1
1/T(U)3	{ .561)		197.	304.	(.307)	(.643)	(.783)	*.641	.143
1/T(U)4								(.278)	.584
								(.406)	.4.42
									394.
N(W /FST)									
A(W)	210.	4476.	7961.	1388.	656.	1573.	2869.	2242.	1575.
1/T(W)1	49.3	2C4.	-.00320	222.	137.	202.	267.	4.22	4.42
1/T(W)2			*.0711					3.28	394.
Z(W)1	.151	*.176	(299.)	*.165	*.0121	*.0964	*.852	*.290	*.731
H(W)1	*.156	*.C456		.0627	*.0627	*.0532	*.00729	*.0911	*.0114
N(THE /FST)									
A(THE)	4.6.2	1C24.	1936.	792.	156.	363.	656.	508.	511.
1/T(THE)1	*.104	*.C162	*.678	*.02CE	-.00498	*.0106	*.0131	*.0609	*.0157
1/T(THE)2	*.379	1.46	1.90	1.08	*.282	*.505	*.618	*.407	*.388
1/T(THE)3								*.422	11.1
N(HD /FST)									
A(HD)	-4476.	-7961.	-2388.	-665.	-1575.	-2870.	-2245.	-2657.	-1579.
1/T(HD)1	.0416	*.0680	*.0165	-.0245	*.00335	*.0123	*.00489	*.0C307	*.0C151
1/T(HD)2	-.21	17.0	-23.8	15.3	*.96	12.7	*.422	11.1	4.42
1/T(HD)3	4.27	-17.5	23.9	-15.7	-6.05	-10.2	-12.9	11.5	-10.1
1/T(HD)4								-11.5	12.5

TABLE IV-6 (Concluded)

N(AZP/FSI)					
A(AZP)	-5.40	-12129.	-23420.	-5456.	-1867.
1/T(AZP)1	-0.0514	-0.000207	.000137	-.CC0356	-.C00194
1/T(AZP)2	.0543	.0143	.C679	.C172	-.0243
1/T(AZP)3					.00618
Z(AZP)1	12.1	*104	*0917	*C876	*0620
W(AZP)1	2.80	1C.5	13.5	9.3C	3.61
					6.09
	+	+	+	+	+
					+
					+

TABLE IV-7

F-4C THRUST TRANSFER FUNCTION FACTORS

SAS Off — Bowweight Loop Closed

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	55 K	55 K
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.50
DENOMINATOR										
1/T(DET)1	20.8	-.0271	26.6	-.0445	22.0	-.0335	24.5	1.49	3.10	1.35
1/T(DET)2		+.0412		+.0585		+.0343		23.2	21.1	22.2
Z(DET)1	*146	(25.3)	*76.0	(25.C)	-.0455	(23.5)	*205	*159	*431	*169
W(DET)1	*.0881		*.0454		*.0540		*.0289	*.0291	*.0192	*.0218
Z(DET)2	*.271		*.277		*.263		*.166	*.148	*.138	*.102
H(DET)2	*1.15		*4.91		*7.90		*4.66	*3.09	*5.12	*102
Z(DET)3	*.427		*.0192		*.00438		*.0252	*.167	*.109	*.137
W(DET)3	6.01		25.1		39.9		24.6	11.4	22.4	22.5
NUMERATORS										
N(w /DTH)										
A(w)	*.000965	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823
1/T(w)1		*.00561	*.00339	*.00128	*.00241	-.00271	*.000946	-.000438	-.000999	-.000410
1/T(w)2			20.8	25.3	26.6	25.0	22.0	23.5	24.5	24.5
1/T(w)3										
Z(w)1			*.318	*.277	*.262	*.220	*.247	*.172	*.158	*.117
W(w)1				*1.19	*4.92	*7.91	*4.62	*1.71	*3.11	*1.38
Z(w)2				*.432	*.0192	*.00420	*.0254	*.169	*.0755	*.0305
W(w)2				6.02	25.1	38.9	24.6	11.4	16.5	22.1
N(w /DTH)										
A(w)										
1/T(w)1										
1/T(w)2										
1/T(w)3										
1/T(w)4										
1/T(w)5										
Z(w)1										
W(w)1										
N(w /DTH)										
A(w)										
1/T(w)1										
1/T(w)2										
1/T(w)3										
1/T(w)4										
Z(w)1										
W(w)1										

TABLE IV-7 (Concluded)

N(HD /DTH)	.000282	.797E-4	.711E-4	.826E-4	.000209	.000113	.985E-4	.000113	.957E-4	.000123
A(HD)	1.12	.349	-1.84	1.10	.734	-1.33	1.94	.527	.785	.363
1/T(HD)1	20.8	-4.32	-4.26	-3.53	22.0	23.4	24.4	2.15	3.39	1.57
1/T(HD)2		5.45	7.06	4.38				23.1	21.1	22.2
1/T(HD)3		(25.1)	(26.5)	(24.5)	- .0241	.941	- .245	- .0579	- .0494	.00928
Z(HD)1	-.0630					.906	1.30	2.53	3.11	3.00
W(HD)1		.484				.169	.0800	.0351	.114	.141
Z(HD)2		.435	.0241	.00513	.0308				.177	
W(HD)2	5.91	29.0	38.7	24.4	11.3	16.3	21.9	22.4	34.5	22.5
N(AZP/DTH)										
A(AZP)	-.120E-4	-.272E-4	-.272E-4	-.270E-4	-.272E-4	-.269E-4	-.268E-4	-.267E-4	-.265E-4	-.266E-4
1/T(AZP)1	-.0214	-.000189	.000137	-.CC0256	-.CC0872	-.00168	-.000758	-.00100	-.000377	-.00106
1/T(AZP)2	7.89	-.231	-.213	.991	2.78	.448	4.63	.867	1.94	.895
1/T(AZP)3	24.9	-7.43	-5.54	-6.19	23.1	-3.74	27.0	4.83	5.12	3.53
1/T(AZP)4		8.15	9.66	7.01		4.62		25.1	2.19	23.5
Z(AZP)1	-.847	(28.4)	(31.7)	(27.7)	- .969	(25.2)	- .532	- .281	- .258	- .235
W(AZP)1		.709			1.02	2.81	3.06	3.01	2.60	
Z(AZP)2		.622	-.00375	-.0192	.CC028C	.0481	.00588	.0768	.157	.108
W(AZP)2	7.20	25.9	35.9	25.4	12.1	17.2	23.2	23.3	34.6	23.0
	+	+	+	+	+	+	+	+	+	+

TABLE IV-8
F-4C STABILIZER TRANSFER FUNCTION FACTORS
SAS On — Bobweight Loop Open
(BODY AXIS SYSTEM)

F/C #	H	M	+											
			1	2	3	4	5	6	7	8	9	10		
DENOMINATOR														
1/T(DET)1	1.24	-0.0375	.858	-0.0607	1.44	-0.0447	1.05	.883	1.04	.924				
1/T(DET)2	1.98	.0520	6.40	.0746	19.2	-.0454	16.1	1.06	2.34	1.06				
1/T(DET)3		.0741		.574		1.18		1.72	1.74	18.1				
Z(DET)1		.0868	(4.44)	.632	(14.2)	.0890	(17.9)	.189	.155	.384	.175			
W(DET)1	.189			.0542		.0775		.0450	.0402	.0220	.0274			
Z1(DET)2	.672	.940		.620	.824	.464	.568	.477	.339	.250	.247			
W(DET)2	.690	1.02		.513	5.10	1.20	2.77	5.90	5.64	6.88	4.93			
Z1(DET)3	.584	.103		.0767	.125	.287	.194	.141	.210	.208	.209			
W(DET)3	4.83	27.4		37.1	22.6	5.82	14.5	20.0	21.4	34.5	21.9			
NUMERATORS														
N(L /DS)														
A(L)	5.97	.737	-1.31	.930	3.42	2.25	2.52	3.20	2.04	2.86				
1/T(U)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
1/T(U)	1.1													
1/T(U)	1.1													
1/T(U)	1.2													
1/T(U)	1.3													
1/T(U)	1.3													
1/T(U)	1.4													
{ .452 }														
1/T(U)	1.4													
{ .561 }														
1/T(U)	1.5													
1/T(U)	1.6													
Z(U)	1													
W(U)	1													
N(W /DS)														
A(W)	-6.62	-141.	-250.	-107.	-20.6	-49.5	-90.3	-70.6	-83.6	-49.6				
1/T(W)	1.00		-.00320	1.00	1.00	1.00	1.00	1.00	.883	1.00	.924			
1/T(W)	1.1													
1/T(W)	1.2													
1/T(W)	1.3													
1/T(W)	1.3													
Z(W)	1.4													
Z(W)	1													
W(W)	1													
N(H /DS)														
A(H)														
1/T(H)	1.1													
1/T(H)	1.2													
1/T(H)	1.3													
1/T(H)	1.3													
Z(H)	1													
Z(H)	1													
Z(H)	2													
W(H)	12													

TABLE IV-8 (Concluded)

N(THE /DS)	-1.45	-32.2	-60.9	-24.5	-4.90	-11.4	-20.6	-16.0	-16.1
A(THE)	* 10.4	.0162	.0678	.0218	-.00098	* C1C6	.0131	.00608	.0157
1/T(THE)1	1.379	1.00	1.00	1.00	* 282	* 505	* 618	* 407	-.00460
1/T(THE)2	1.00	1.46	1.90	1.08	1.00	1.00	1.00	* 388	* 260
1/T(THE)3	20.0	20.0	2C.0	2C.0	20.0	20.0	20.0	* 883	* 924
1/T(THE)4	1.584	* 103	.0760	.125	* 287	* 194	* 141	1.00	1.00
1/T(THE)5	4.83	27.4	37.1	22.6	9.82	14.5	20.0	20.0	20.0
Z(THE)1								* 210	* 208
K(THE)1								* 210	* 209
								34.5	21.9
 N(HD /DS)									
A(HD)	7.70	141.	250.	107.	20.9	49.6	90.3	70.6	83.6
1/T(HD)1	.00726	* 0146	.0680	* 0165	-.0245	* 00335	* 0123	* 00489	* 0151
1/T(HD)2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	* 883	* 00307
1/T(HD)3	-4.21	17.0	20.0	15.3	5.96	9.99	12.7	1.00	* 924
1/T(HD)4	4.27	-17.5	-23.8	-15.7	-6.05	-10.2	-12.9	1.00	2.34
1/T(HD)5	20.0	20.0	23.9	20.0	20.0	20.0	20.0	-10.1	-10.1
1/T(HD)6	1.584	* 103	.0760	.125	* 287	* 194	* 141	20.0	20.0
Z(HD)1	4.83	27.4	37.1	22.6	9.82	14.5	20.0	* 210	* 208
K(HD)1								34.5	21.9
 N(AZP /DS)									
A(AZP)	17.0	-382.	737.	-298.	58.7	135.	244.	186.	177.
1/T(AZP)1	-.0514	-.000207	.000137	-.000356	-.000194	-.00267	-.000776	-.00104	132.
1/T(AZP)2	* 0543	* 0148	.0675	.0172	-.0243	* 00618	* 0131	* C0590	-.00385
1/T(AZP)3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	* 683	* 00419
1/T(AZP)4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	1.00	* 924
1/T(AZP)5	1.121	* 104	.0917	* 0876	* 0620	* 0625	* 0586	20.0	20.0
Z(AZP)1	2.80	1C.5	13.9	9.3C	3.61	6.09	7.81	7.07	* 0280
Z(AZP)2	* 584	* 103	.0760	* 125	* 287	* 194	* 141	* 210	* 0294
K(AZP)2	4.83	27.4	37.1	22.6	9.82	14.5	20.0	21.4	* 056
	+	+	+	+	+	+	+	+	+

TABLE IV-9
F-4C THRUST TRANSFER FUNCTION FACTORS
SAS On — Bobweight Loop Open
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10	+		+	
											+	+	+	+
H	.206	.800	1.10	.9CC	.600	.900	1.20	1.50	2.15	1.80				
M														
DENOMINATOR														
1/T(DET)1	1.24	-0.0375	.858	-0.0607	1.44	.0447	1.05	.883	1.04	.924				
1/T(DET)2	19.8	.0520	6.40	.0746	19.2	-.0454	16.1	1.06	2.34	1.05				
1/T(DET)3														
Z(DET)1														
W(DET)1														
Z(DET)2														
W(DET)2														
Z(DET)3														
W(DET)3														
N(U/DTH)														
A(U)														
1/T(U)1														
1/T(U)2														
1/T(U)3														
1/T(U)4														
Z(U)1														
W(U)1														
Z(U)2														
W(U)2														
N(W/DTH)														
A(W)														
1/T(W)1														
1/T(W)2														
1/T(W)3														
1/T(W)4														
1/T(W)5														
1/T(W)6														
Z(W)1														
W(W)1														

TABLE IV-9 (Concluded)

N(THE / DTH)	- .467 E-5	- .298 E-5	- .298 E-5	- .299 E-5	- .298 E-5	- .300 E-5	- .300 E-5	- .302 E-5	- .303 E-5	- .303 E-5
A(THE)	- .192	.283	1.00	.517	.289	.178	.450	.321	.282	.215
1/T(THE) 1	.480	1.00	-1.21	1.00	.358	.800	1.00	.883	-.630	-.700
1/T(THE) 2	1.00	1.23	1.28	1.36	1.00	1.00	-1.13	1.00	.924	1.00
1/T(THE) 3	20.0	20.0	20.0	20.0	20.0	20.0	20.0	-1.24	2.34	1.00
1/T(THE) 4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1/T(THE) 5	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Z(THE) 1	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
Z(THE) 2	4.83	27.4	37.1	22.6	.82	14.5	20.0	21.4	34.5	21.9
N(HD / DTH)										
A(HD)	.000282	.797 E-4	.711 E-4	.826 E-4	.00209	.000113	.985 E-4	.000113	.957 E-4	.000123
1/T(HD) 1	.998	.331	.938	.775	.840	.614	.897	.851	.785	.598
1/T(HD) 2	2.06	.572	(-.942)	1.26	2.25	.907	5.34	.883	2.14	.924
1/T(HD) 3	1.98	-3.83	(2.51)	-3.27	19.2	-1.52	16.4	2.73	2.34	1.44
1/T(HD) 4	- .523	.946	.825	(13.7)	11.2	4.30	(18.1)	-1.48	1.74	1.76
Z(HD) 1	.497	1.37	16.4	- .311	.710	.710	.109	.109	.160	.183
W(HD) 1	.584	.103	.0760	.125	.287	.194	.141	.210	.208	.209
Z(HD) 2	4.83	27.4	37.1	22.6	.82	14.5	20.0	21.4	34.5	21.9
N(AZP / DTH)										
A(AZP)	- .120 E-4	- .272 E-4	- .272 E-4	- .272 E-4	- .272 E-4	- .268 E-4	- .268 E-4	- .267 E-4	- .266 E-4	- .266 E-4
1/T(AZP) 1	- .0214	- .00189	.000137	- .00256	- .00872	- .00168	- .000758	- .00100	- .000377	- .00106
1/T(AZP) 2	1.04	.324	.940	.766	.994	.426	.928	.883	.906	.902
1/T(AZP) 3	.568	.124	1.24	7.36	1.00	.933	2.34	.924	2.30	1.33
Z(AZP) 1	- .922	(-5.98)	- .880	(-5.22)	(17.5)	(-3.55)	- .392	- .177	- .115	- .115
W(AZP) 1	.780	.276	.651	.808	- .945	.951	2.44	2.75	2.47	2.30
Z(AZP) 2	.584	.770	.651	.808	- .945	.814	.873	.897	.996	1.12
W(AZF) 2	4.83	15.0	24.2	17.4	1.03	13.5	15.5	13.6	12.4	11.2
Z(AZF) 3	.975	.103	.0760	.125	.287	.194	.141	.210	.208	.209
W(AZF) 3	18.6	27.4	37.1	22.6	.82	14.5	20.0	21.4	34.5	21.9
+ + + + + + + + + +										

TABLE IV-10
F-4C STICK FORCE TRANSFER FUNCTION FACTORS
SAS On — Boweight Loop Closed
(BODY AXIS SYSTEM)

F/C #	H	SL	SL	+		+		+		+		+		
				1	2	3	4	5	6	7	8	9	10	
DENOMINATOR														
1/T(DET)1	1.05	- .0270	.902	- .0443	1.14	- .0335	1.04	.990	1.02	.951				
1/T(DET)2	20.6	.0413	17.9	.055	21.4	.0344	22.2	1.68	3.34	1.50				
1/T(DET)3		.924		.988		1.07					21.1	18.5	20.7	
Z(DET)1	.143	(21.2)	.755	(22.1)	- .0469	(22.2)	.204	.159	.431					
W(DET)1	.0880		.0454		.0540		.0389	.0291	.0192					
Z(DET)2	.313		.627		.504		.362	.357	.337					
W(DET)2	1.12		.627		.294									
A(Ce)1	5.53		1C.1		4.87		1.56	3.03	5.22					
Z(DET)3	.431		.0181		.00197		.0781	.0316	.0106					
W(DET)3	6.06		29.4		39.2		11.5	16.7	22.4					
H(DET)3														
NUMERATORS														
H(U /FST)														
A(U)	-190.	-23.4	41.7	-29.6	-109.	-71.5	-80.2	-102.	-64.9	-90.9				
1/T(U)1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.310	1.00	.143				
1/T(U)2	1.14	1.94	1.49	1.25	1.36	201.	266.	.641	11.1	.584				
1/T(U)3	(.452)	5.35	-6.31	3.44	(.980)	(.787)	(.965)	1.00	400.	1.00				
1/T(U)4	(.561)	197.	304.	218.	(.307)	(.643)	(.783)	4.22	(.978)	4.42				
1/T(U)5														
N(U /FST)														
A(h)	210.	4476.	7961.	3388.	656.	1573.	2869.	2242.	2656.	1576.				
1/T(h)1	1.00	1.00	- .00320	1.00	1.00	1.00	1.00	1.00	1.00	1.00				
1/T(h)2	49.3	204.	.0711	222.	137.	202.	267.	4.22	11.1	4.42				
1/T(h)3				1.00							328.	400.	394.	
Z(h)1	151	* 176	(299.)	* 165	* 0121	* 0964	* 852	* 290						
W(h)1	.156	.0456		.0627	.0532	.00729	.00911	.0106						

TABLE IV-10 (Concluded)

N(THE /FST)	4.6.2	1024.	1936.	752.	- .0206	.00498	156.	363.	656.	508.	511.	357.
A(HD),	* 10.4	.0162	.0678	.0206	- .00498	.0106	.0131	.00608	.0157	.00460		
1/T(THE)1	* 37.9	1.00	1.00	1.00	* 28.2	.505	.618	* 407	* 388	* 260		
1/T(THE)2		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1/T(THE)3		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1/T(THE)4								4.22	11.1	4.42		
N(HD /FST)												
A(HD),	- 245.	- 4476.	- 7961.	- 3388.	- 665.	- 1575.	- 2870.	- 2245.	- 2657.	- 1579.		
1/T(HC)1	.00726	.0146	.0680	.0165	-.0245	.00335	.0123	.00489	.0151	.00307		
1/T(HD)2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1/T(HD)3	* 21	17.0	- 23.8	15.3	5.96	9.99	12.7	4.22	11.1	4.42		
1/T(HD)4	4.27	- 17.5	23.9	- 15.7	- 6.05	- 10.2	- 12.9	1.15	- 12.4	- 10.1		
1/T(HD)5								12.5	12.5	10.1		
N(AZP /FST)												
A(AZP)	- 5.40	- 12129.	- 23430.	- 9456.	- 1867.	- 4306.	- 7765.	- 5989.	- 5624.	- 4209.		
1/T(AZP)1	- .0514	-.000207	.000137	-.000356	-.00194	-.00287	-.000776	-.00104	-.000385	-.00117		
1/T(AZP)2	.0543	* 0148	.0679	* 0172	-.0243	.00618	* 0131	.00590	* 0154	.00419		
1/T(AZP)3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
1/T(AZP)4								4.22	11.1	4.42		
Z(AZP)1	* 121	* 104	* 0917	* 0876	* 0620	* 0625	* 0585	* 0400	* 0294	* 0280		
W(AZP)1	2.80	1C.5	13.9	9.3C	3.61	6.09	7.81	7.07	8.56	6.19		
	+	+	+	+	+	+	+	+	+	+	+	

TABLE IV-11
F-4C THRUST TRANSFER FUNCTION FACTORS
SAS On — Bowweight Loop Closed
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	15 K •CC	35 K •600	35 K •900	35 K •120	45 K •150	45 K •215	55 K •180
M	.206	.800	1.10							
DENOMINATOR										
1/T(DET)1	1.05	-.0270	.902	-.0443	1.14	-.0335	1.04	.990	1.02	.991
1/T(DET)2	20.6	.0413	17.5	.0590	21.4	.0344	22.2	1.68	3.34	1.50
1/T(DET)3		.924		.928		1.07		21.1	18.5	20.7
Z(DET)1	*14.3	(21.2)	*755	(22.1)	-.0469	(22.2)	.204	.159	.431	.168
W(DET)1	*.0880		.0454		.0540		.0389	.0291	.0192	.0218
Z(DET)2	*31.3	*627	*657	*5C4	*294	*342	*357	*337	*289	*263
W(DET)2	1.12	5.53	10.1	4.87	1.56	3.03	5.22	4.98	6.46	4.56
Z(DET)3	*.0181	-*.0C157	.0256	*.170	*.0781	*.0315	*.106	*.173	*.135	
W(DET)3	*43.1		29.4	39.2	24.5	11.5	16.7	22.4	34.5	22.6
NUMERATORS										
N(W /DTH)										
A(U)	*.000965	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823	*.000823
1/T(U)1	*.0C561	*.0C340	*.00128	*.0271	*.00271	*.000946	*.000438	*.000946	*.000410	*.000410
1/T(U)2	1.05	*924	*902	*988	1.15	1.07	1.04	*990	1.02	.991
1/T(U)3	20.6	21.2	17.5	22.1	21.4	22.2	22.2	1.69	3.35	1.51
1/T(U)4									21.1	18.5
Z(U)1	*359	*627	*655	*5C5	*375	*359	*367	*360	*305	*303
W(U)1	1.15	5.54	10.1	4.85	1.60	3.06	5.22	4.97	6.46	4.55
Z(U)2	*43.6	*0181	-*.00200	*C256	*172	*0786	*0319	*1C7	*173	*135
W(U)2	6.07	25.4	39.2	24.5	11.5	16.7	22.4	22.6	34.5	22.6
N(W /DTH)										
A(W)1	-.878E-4	-.754E-4	-.754E-4	-.755E-4	-.755E-4	-.755E-4	-.755E-4	-.756E-4	-.756E-4	-.756E-4
1/T(W)1	*.0248	*.0C116	-.00173	*.CCC299	.998	-.000597	*.003C4	-.000293	-.00215	-.00306
1/T(W)2	*38.1	*49.2	-.625	*892	20.2	.719	-.578	-.532	-.221	-.276
1/T(W)3	1.03	*962	*927	1.32	24.4	1.00	*.974	1.01	*.988	1.01
1/T(W)4	13.1	26.2	27.2	24.3	(*974)	22.2	23.2	1.17	2.90	1.19
1/T(W)5	20.9	33.6	48.0	37.4	(.C509)	35.0	47.0	22.2	21.1	21.5
1/T(W)6									83.6	83.6
Z(W)1	*522	*C483	*0261	*C63C	*21.7	*124	*0751	*151	*188	*167
W(W)1	5.25	25.0	38.8	24.3	10.9	16.0	21.5	22.2	34.7	22.4

TABLE IV-11 (Concluded)

N(THE/DTH)	-4.67E-5	-2.93E-5	-2.98E-5	-2.99E-5	-2.98E-5	-3.00E-5	-3.00E-5	-3.02E-5	-3.03E-5
A(THE)	-9.23	.250	1.00	.391	-.185	.127	.420	.273	.199
1/T(THE)1	*901	1.00	-1.10	1.00	*444	*865	-.949	*266	-.516
1/T(THE)2	1.00	1.11	1.13	1.43	1.00	1.00	1.00	1.00	1.00
1/T(THE)3	20.3	23.2	23.8	23.1	21.2	22.2	22.8	21.9	21.3
1/T(THE)4									1.24
1/T(THE)5									2.95
Z(THE)1	*78	*0457	*0246	*0556	*197	*110	*0640	*146	*189
w(THE)1	5.04	28.4	38.0	23.8	10.7	15.7	21.1	21.9	34.5
									22.2
N(HD/DTH)									
A(HD)	*00282	*757E-4	*711E-4	*826E-4	*000209	*000113	*985E-4	*957E-4	*001123
1/T(HD)1	*993	.234	*935	*791	.655	-1.13	.834	.520	.361
1/T(HD)2	1.22	*971	(-.941)	1.29	1.46	2.60	3.36	*694	*983
1/T(HD)3	20.6	-3.45	(2.40)	-2.88	21.4	22.2	22.3	3.27	1.31
1/T(HD)4	8.39			6.37	(6.37)			4.51	2.14
Z(HD)1	*6437	(21.4)	*983	(22.2)	*C387	*97	*116	21.2	20.3
w(HD)1	*463		16.4		.798	*868	*034	*140	*1PC
Z(HD)2	*438	*0229	*CC284	*C3C5	*172	*0822	*056	2.66	2.68
w(HD)2	5.95	29.2	38.9	38.4	11.4	16.5	22.1	*176	*139
								22.5	34.5
N(AZP/DTH)									
A(AZP)	-1.20E-4	-2.22E-4	-2.72E-4	-2.70E-4	-2.69E-4	-2.68E-4	-2.67E-4	-2.65E-4	-2.64E-4
1/T(AZP)1	-*0214	-*000189	*000137	-*000256	-*000287	-*000768	-*00100	-*000277	-*00106
1/T(AZP)2	1.04	*324	*540	*764	*994	*424	*928	*858	*860
1/T(AZP)3	8.98	*568	(-666)	1.23	4.54	1.00	9.01	*947	*950
1/T(AZP)4	23.3	-5.34	(2.65)	-4.56	21.7	-3.01	21.1	9.71	(-142)
Z(AZP)5	-800	*956	*842	(16.4)	-881	(22.1)	*416	-1.196	1.12
w(AZP)1	*682	18.0	22.8		*941	*230	*2.48	*958	-1.150
Z(AZP)2	*652	-*0C329	-*C197	*00452	*163	*0586	*0158	*140	2.08
w(AZP)2	7.11	30.5	4C.8	26.1	12.4	17.7	23.9	*153	*105
	*	*	*	*	*	*	*	*	23.3

TABLE IV-12
F-4C LONGITUDINAL HANDLING QUALITIES PARAMETERS
 SAS Off
 (BODY AXIS SYSTEM)

	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
F/C #	1	2	3	4	5	6	7	8	9	10	
H	SL	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K	
P	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80	
D(G)/D(U) (DEG/KT)	- .0221	- .0440	- .205	- .0506	.0737	- .0101	- .0370	- .0147	- .0453	- .00923	
NZA (G/RAD)	3.11	40.5	72.6	32.1	5.06	13.8	22.4	18.3	25.1	14.1	
DE/G (DEG/G)	6.94	.867	.827	1.25	4.54	2.99	3.64	5.65	6.08	8.44	
CAP (RAD/SEC/SEC/G)	.176	.488	.880	.562	.368	.595	1.31	1.58	1.70	1.66	
PHCGOIC(2) (SEC)	--	(18.4)	--	(11.3)	--	(15.2)	--	--	--	--	
i/C(1/10)	2.08	1.17	.935	.883	.731	.626	.447	.279	.176	.178	
Bobweight Loop Closed											
FSI/KT (LB/KT)	- .0191	.0203	- .0736	.0511	- .0279	.0199	- .0613	--	--	--	
FSI/G (LB/G)	7.13	12.5	17.9	12.6	1C.2	12.2	21.3	--	--	--	

TABLE IV-15
F-4C LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10									
S	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	45 K	55 K									
R	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80									
VV	-.0918	-.335	-.466	-.215	-.0566	-.0921	-.151	-.118	-.133	-.0768									
VB	-.21.1	-299.	-597.	-205.	-33.1	-80.6	-176.	-171.	-277.	-134.									
LB	-.10.4	-26.3	-47.0	-27.4	-10.7	-18.3	-14.1	-11.7	-8.67	-8.66									
NB	1.44	15.6	38.2	11.5	1.66	4.97	12.3	9.90	8.37	5.18									
LP	-1.43	-2.04	-3.11	-2.27	-7.99	-1.24	-1.28	-1.00	-1.08	-7.67									
NP	-.0260	-0.372	.0184	-.0260	-.0179	-.0504	-.0378	-.0170	.0153	-.00013									
L	.929	.817	.802	.632	.300	.395	.318	.323	.217	.198									
NR	-.215	-.739	-1.20	-.520	-.134	-.238	-.397	-.309	-.273	-.181									
Y*UA	-.00130	-.00744	-.0102	-.00499	-.00151	-.00227	-.00302	-.00199	-.00169	-.000320									
L'DA	2.74	22.2	15.0	17.5	4.70	0.00	10.9	6.78	5.35	4.67									
N'CA	.416	.923	2.45	.747	.0887	.195	.657	.376	.357	.0567									
Y*DR	.0174	.0442	.0307	.0261	.0113	.0142	.0132	.00988	.00847	.00614									
L'DR	.699	7.32	9.26	5.07	.768	1.95	2.09	1.95	2.57	1.21									
N*DR	-.670	-7.80	-8.80	-5.50	-1.36	-2.61	-3.10	-2.03	-1.86	-1.31									
	+	+	+	+	+	+	+	+	+	+									

TABLE IV-14

F-4C AILERON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	S _L	S _L	SL	15 K .9CC	35 K .600	35 K .900	45 K 1.20	45 K 1.50	45 K 2.15	55 K 1.80
M	.206	.800	1.10							
DENOMINATOR										
1/T(DET) ₁	.0147	.00469	.00568	.00348	.0173	.00969	.00187	-.000179	-.00058	.000226
1/T(DET) ₂	1.15	3.10	3.13	2.33	.650	1.33	1.40	.996	1.06	.743
Z(DET) ₁	.156	.125	.134	.0972	.0881	.0491	.0727	.0670	.0731	.0535
W(DET) ₁	1.82	4.01	6.21	3.45	1.83	2.43	3.57	3.23	2.93	2.58
NUMERATORS										
N(B/DA)										
A(B)	-.0130	-.00744	-.0102	-.00455	-.0151	-.00227	-.00302	-.00199	-.00169	-.000329
1/T(B)	-10.4	-.425	-.664	-.407	.121	.127	.487	-.760	-.0660	.156
Z(B)	{ 297)	1.77	3.06	1.35	.433	2.70	.704	.930	1.60	.479
W(B)	{ 1.05)	111.	249.	121.	450.	-115.	121.	35.1	134.	-644.
N(P/DA)										
A(P)	2.74	22.2	15.0	17.5	4.70	0.00	10.9	6.78	5.35	4.67
1/T(P)	-.0285	-.000186	.000125	-.000252	-.00908	-.00166	-.000766	-.00100	-.000376	-.00106
Z(P)	.152	.136	.135	.105	.0767	.0742	.0788	.0691	.0706	.0522
W(P)	1.74	4.11	6.82	3.57	1.36	2.31	3.63	3.25	3.00	2.51
N(R/DA)										
A(R)	41.6	.923	2.45	7.47	.0887	.195	.567	.376	.357	.0567
1/T(R)	74.6	3.08	4.05	2.35	.331	.733	.964	.494	.711	.320
Z(R)	{ 145	-.169	-.200	-.146	-.0560	-.275	-.0224	.0457	.203	-.0241
W(R)	{ 1.91	2.16	1.34	2.05	4.03	3.69	2.48	2.92	1.71	5.46
N(PHI/DA)										
A(PHI)	2.82	22.2	15.0	17.5	4.71	10.0	10.9	6.80	5.35	4.67
2(PHI)	.150	.136	.135	.109	.0722	.0735	.0788	.0691	.0700	.0518
W(PHI)	1.74	4.11	6.82	3.57	1.38	2.31	3.63	3.25	3.00	2.51
N(AYP/DA)										
A(AYP)	12.0	70.7	69.3	56.6	13.8	29.3	38.0	22.3	17.3	13.5
1/T(AYP)	-.234	-.211	-.0885	-.243	.125	.119	-.199	.184	-.0738	*104
Z(AYP)	*373	.496	1.27	*393	-.400	-.390	*230	-.195	*485	-.257
W(AYP)	{ 149	.114	.0935	.0950	.149	.0765	.0710	*0665	*0230	*0766
	1.77	4.14	6.40	3.57	1.32	2.34	3.58	3.26	3.08	2.42
	+	+	+	+	+	+	+	+	+	+

TABLE IV-15
F-4C RUDDER TRANSFER FUNCTION FACTORS

SAS Off											
(BODY AXIS SYSTEM)											
F/C #	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10	
N	.206	.800	.SL	.SL	.15 K	.35 K	.35 K	.45 K	.45 K	.55 K	
					.90 C	.600	.900	1.20	1.50	2.15	1.80
DENOMINATOR											
1/T(DET)1	.0147	.00469	.00566	.CG848	.0173	.0C969	.00187	-.000179	.000558	.000226	
1/T(DET)2	1.15	3.10	3.12	2.32	.650	1.33	1.40	.996	1.06	.748	
Z(DET)1	*156	*125	*134	*C912	*C881	*0491	*0727	*0670	*0731	*0535	
W(DET)1	1.82	4.01	6.21	3.45	1.83	2.43	3.57	3.23	2.93	2.58	
NUMERATORS											
N(B /DR)											
A(B)	.0174	-.0911	-.0C161	.03C7	.0281	.0113	.0142	-.00775	.00300	.000300	.00614
1/T(B)1		1.26	3.09	.00396	-.CC55	-.0240	-.0075	.00165	.00190	.00179	
1/T(B)2				3.13	2.3C	.750	1.26	1.40	*.996	1.05	*.752
1/T(B)3		4.64	178.	286.	2C1.	130.	191.	248.	215.	222.	225.
N(P /DR)											
A(P)	.699	-.C00188	-.C00254	.000140	-.000254	.00911	.00167	-.000771	-.00100	-.000376	.00614
1/T(P)1		2.53	-3.52	-2.16	4.27	3.91	4.26	1.58	1.51	1.79	
1/T(P)2			3.57	2.92	-4.36	-4.40	-4.59	1.73	1.54	(1.45)	-1.79
1/T(P)3											
N(R /DR)											
A(R)	-.670	-7.80	-8.80	-5.5E	-1.36	-2.61	-3.19	-2.03	-1.86	-1.31	
1/T(R)1		3.10	3.13	2.33	.366	1.11	1.40	.964	1.172	*.632	
Z(R)1		*257	*297	*671	*113	*201	*169	*258	*277	(* .237)	*.326
W(R)1			1.15	.269	.238	.496	1.21	.694	.225	(* .237)	*.264
N(PHI /DR)											
A(PHI)	*56.1	7.28	9.30	5.02	.542	1.83	2.90	1.86	2.52	1.13	
1/T(PHI)1	2.67	-3.54	-2.15	4.2E	4.51	4.35	-1.63	1.55	(* .692)	1.83	
1/T(PHI)2	-4.10	3.57	2.92	-4.42	-5.57	-4.79	1.74	-1.58	(* 1.46)	-1.88	
N(AYP /DR)											
A(AYP)	-4.79	-.66.5	-.79.0	-.49.4	-13.3	-24.4	-27.8	-13.1	-4.05	-7.18	
1/T(AYP)1	-.102	-.0C390	.00330	-.CC55	-.0320	-.0152	-.000507	-.00267	.00246	-.00300	
1/T(AYP)2		*604	3.00	3.15	1.93	*368	1.37	1.360	1.11	*.691	
Z(AYP)1		*356	*102	*0552	*11E	*130	*128	*0544	*0402	*.4C8	
W(AYP)1		2.71	5.19	6.92	4.54	2.68	3.29	3.75	4.12	8.48	4.18
+	+	+	+	+	+	+	+	+	+	+	+

TABLE IV-16
F-4C AILERON TRANSFER FUNCTION FACTORS
SAS On
(BODY AXIS SYSTEM)

F/C #	+										+									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
H	SL	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	55 K	-	-	-	-	-	-	-	-	-	-
M	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.87	-	-	-	-	-	-	-	-	-	-
DENOMINATOR																				
1/T(DET)1	*.00233	-.000122	.00468	.C0114	.C0289	.00176	.00129	-.000595	.00116	-.000318	-	-	-	-	-	-	-	-	-	-
1/T(DET)2	*.905	*.852	*.534	2.72	.453	1.38	.645	*.617	*.530	*.624	-	-	-	-	-	-	-	-	-	-
1/T(DET)3	2.03	1.58	3.15	8.01	3.62	5.31	1.28	*.992	1.11	*.803	-	-	-	-	-	-	-	-	-	-
Z(DET)1	*.393	(3.20)	*.657	*.763	*.332	*.508	*.752	*.608	*.572	*.592	-	-	-	-	-	-	-	-	-	-
W(DET)1	1.52	(9.95)	6.68	1.05	1.36	1.01	3.38	2.15	3.24	2.48	-	-	-	-	-	-	-	-	-	-
NUMERATORS																				
N(B / DA)																				
A(B)	-.0160	-.00965	-.00937	-.00665	-.00181	-.00294	-.00315	-.00216	-.00187	-.000461	-	-	-	-	-	-	-	-	-	-
1/T(B)1	.0939	*.C124	.C828	.0150	.0136	.0128	.0299	*.0354	*.0453	*.0223	-	-	-	-	-	-	-	-	-	-
1/T(B)2	.887	-1.04	-1.154	-1.14	*.398	1.62	-1.68	1.10	-3.09	*.591	-	-	-	-	-	-	-	-	-	-
1/T(B)3	-6.92	7.03	4.91	5.78	4.15	1.03	2.24	*.27	2.13	2.79	-	-	-	-	-	-	-	-	-	-
1/T(B)4	8.52	128.	246.	137.	-254.	-48.9	129.	55.1	143.	-393.	-	-	-	-	-	-	-	-	-	-
N(P / DA)																				
A(P)	2.64	21.8	15.2	17.3	4.68	9.90	10.9	6.75	5.29	4.64	-	-	-	-	-	-	-	-	-	-
1/T(P)1	-.0285	-.000187	.000136	-.000294	-.CC908	-.00166	-.000757	-.00100	-.000277	-.000106	-	-	-	-	-	-	-	-	-	-
1/T(P)2	1.09	*.592	*.513	*.710	2.61	5.33	.602	*.594	*.578	*.536	-	-	-	-	-	-	-	-	-	-
Z(P)1	*.867	(2.16)	*.675	(1.49)	*.543	*.764	*.766	*.626	*.590	*.598	-	-	-	-	-	-	-	-	-	-
W(P)2	1.29	(1C.2)	7.33	(8.16)	*.549	.772	3.48	3.19	3.35	2.42	-	-	-	-	-	-	-	-	-	-
N(R / DA)																				
A(R)	*.547	1.31	2.21	*.558	*.125	*.320	*.699	*.411	*.395	*.3850	-	-	-	-	-	-	-	-	-	-
1/T(R)1	*.471	*.481	*.495	*.468	*.302	*.417	*.456	*.400	*.423	*.300	-	-	-	-	-	-	-	-	-	-
1/T(R)2	*.904	7.04	5.26	5.87	*.719	3.08	1.84	*.755	1.36	*.623	-	-	-	-	-	-	-	-	-	-
Z(R)1	*.226	-.0496	-.220	-.C272	*.467	*.417	*.271	*.305	*.295	*.414	-	-	-	-	-	-	-	-	-	-
W(R)2	1.69	1.52	1.38	1.38	*.21	1.68	1.93	2.69	1.53	4.47	-	-	-	-	-	-	-	-	-	-

TABLE IV-16 (Concluded)

N(PH1 / DA)																				
A(PH1)	2.76	21.9	15.2	17.4	4.70	9.92	10.9	6.77	5.30	4.65										
1/T(PH1) 1	1.07	.592	.513	.710	3.59	5.33	.602	.594	.578	.635										
Z(PH1) 1	.841	(2.16)	.675	(1.49)	.539	.763	.766	.625	.590	.596										
K(PH1) 1	1.30	(16.2)	7.34	(8.15)	.556	.772	3.48	3.16	3.34	2.42										
N(AYP / DA)																				
E(AYP)	13.2	74.1	67.1	58.5	14.1	30.4	38.3	22.5	17.4	13.5										
1/T(AYP) 1	* 14.9	* 0.293	* 11.1	* 0.254	* 0.208	* 0.0212	* 0.486	* 0.580	* 0.790	* 0.371										
1/T(AYP) 2	- * 37.0	- * 57.9	- * 17.4	- * 51.5	- * 50.8	- * 67.5	- * 39.6	- * 37.2	- * 17.4	- * 47.6										
i/T(AYP) 3	* 92.5	* 9.30	2.56	7.52	- * 88.0	5.02	1.17	* 75.9	1.14	* 61.5										
Z(AYP) 1	* 61.0	* 6.41	.475	* 63.2	(1.31)	* 77.0	* 67.3	* 57.3	* 47.0	* 64.1										
K(AYP) 1	1.64	2.32	6.00	1.94	(3.16)	1.18	3.33	3.28	3.47	2.63										
	*	*	*	*	*	*	*	*	*	*										

TABLE IV-17
F-4C RUDDER TRANSFER FUNCTION FACTORS
 SAS On
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	15 K	35 K	35 K	35 K	45 K	45 K	55 K	55 K
M	.206	.800	.110	.9CC	.600	.900	1.20	1.50	2.15	1.80
DEA(MINATOR										
1/T(DET)1	.00233	-.000122	.00468	.00114	.00289	.00176	.00129	-.000595	.00114	-.000318
1/T(DET)2	.905	.852	.534	.272	.453	1.38	.645	.617	.539	.624
1/T(DET)3	2.03	1.58	3.15	8.01	3.62	5.31	1.38	.992	1.11	.803
Z(DET)1	39.3	{ 3.20)	.657	.762	.332	.508	.752	.608	.572	.562
W(DET)1	1.52	{ 9.95)	6.68	1.05	1.36	1.01.	3.38	3.15	3.24	2.48
NUMERATORS										
N(B /DR)										
A(B)	.0166	-.0298	.0229	.0204	.0102	.0117	.0113	.00926	.00854	.00594
1/T(B)1	-.0911	-.00161	.00396	-.00256	-.0240	-.00775	.000201	-.00165	.00190	-.00179
1/T(B)2	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
1/T(B)3	1.26	3.09	3.13	2.30	.750	1.26	1.40	.906	1.05	.752
1/T(B)4	4.64	178.	286.	201.	130.	191.	248.	215.	222.	225.
N(P /DR)										
A(P)	.669	4.93	6.91	3.69	.690	1.62	2.57	1.83	2.53	1.17
1/T(P)1	-.0287	-.000198	.000140	-.000254	-.00911	-.00167	-.000771	-.00100	-.000376	-.00105
1/T(P)2	.500	.500	.500	.500	.500	.500	.500	.500	.500	.500
1/T(P)3	2.53	-3.52	-2.16	4.27	3.91	4.26	-1.58	-1.51	(.0758)	1.79
1/T(P)4	-3.34	3.57	2.92	-4.38	-4.40	-4.59	1.73	1.54	(1.45)	-1.79

TABLE IX-17 (Concluded)

N($\kappa_{\text{A}(\text{R})}$)	-•.641	-5.26	-6.57	-4.06	-1.22	-2.17	-2.73	-1.91	-1.84	-1.27
$1/\Gamma(\kappa_{\text{A}(\text{R})})^1$	•500	•500	•500	•500	•366	•500	•500	•500	•172	•360
$1/\Gamma(\kappa_{\text{A}(\text{R})})^2$.917	3.10	3.13	2.33	.500	1.11	1.46	.904	23.7	632
$1/\Gamma(\kappa_{\text{A}(\text{R})})^3$.257	.297	.671	.113	.201	.169	.258	.277	(•.500)	•326
$\kappa_{\text{A}(\text{R})}^1$	1.15	.269	.236	.496	1.21	.694	.225	.226	(1.09)	•294
 N($\rho_{\text{PHI}/\text{C}^{\infty}}$)										
$\text{A}(\text{PHI})$	•536	4.91	6.95	3.65	•487	1.52	2.49	1.74	2.49	1.10
$1/\Gamma(\text{PHI})^1$	•500	•500	•500	•500	•500	•500	•500	•500	•500	•500
$1/\Gamma(\text{PHI})^2$	2.67	-2.54	-2.15	4.28	4.51	4.35	-1.63	1.55	(•.692)	1.33
$1/\Gamma(\text{PHI})^3$	-4.10	3.57	2.92	-4.42	-5.57	-4.79	1.74	-1.58	(1.46)	-1.88
 N($\text{AYP}/\text{C}^{\infty}$)										
$\text{A}(\text{AYP})$	-4.58	-44.8	-59.0	-36.0	-12.0	-20.3	-23.8	-12.3	-4.88	-5.95
$1/\Gamma(\text{AYP})^1$	-•.102	-•.0390	-•.00330	-•.00365	-•.0320	-•.0152	-•.00357	-•.00267	•.0246	-•.00306
$1/\Gamma(\text{AYP})^2$	•500	•500	•500	•363	•500	•500	•500	•500	•500	•500
$1/\Gamma(\text{AYP})^3$	•604	3.00	3.15	1.93	.500	.766	1.37	.960	1.11	•691
$\text{z}(\text{AYP})^1$	•356	•102	•C552	•118	•130	•0544	•0502	•0400	•0403	•0403
$\kappa(\text{AYP})^1$	2.71	5.19	6.92	4.54	2.66	3.29	3.75	4.12	4.18	
+ + + + + + + + + +										

TABLE IX-18

F-4C LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

	(BODY AXIS SYSTEM)											
	SAS Off					SAS On						
	+	+	+	+	+	+	+	+	+	+	+	+
F/C #	1	2	3	4	5	6	7	8	9	10		
H	SL	SL	SL	15 K	35 K	35 K	45 K	45 K	45 K	55 K		
N	.206	.800	1.10	.900	.600	.900	1.20	1.50	2.15	1.80		
DR PERIOD (SEC)	3.49	1.58	1.02	1.82	3.45	2.59	1.76	1.95	2.15	2.44		
1/C(1/2)	1.43	1.15	1.22	.885	.802	.446	.661	.609	.665	.485		
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--	3868.	--	--	--
P(1)	1.90	7.39	5.51	7.75	2.52	6.80	7.93	6.83	5.22	5.79		
P(2)	--	7.33	5.42	7.55	2.12	6.28	7.90	6.83	5.21	5.75		
P(3)	--	7.52	5.81	7.98	4.00	6.63	7.98	6.85	5.28	5.85		
P(2)/P(1)	--	.992	.984	.938	.844	.924	.996	.000	.937	.993		
P(OSC)/P(AV)	--	.00847	.02117	.0125	.211	.0335	.00355	.000659	.00415	.00588		
W(PHI)/W(D)	.955	1.03	1.10	1.33	.753	.951	1.02	1.01	1.02	.972		
DEL-B-MAX	.0738	.0664	.106	.0757	.338	.145	.0521	.0157	.0559	.0562		
PHI TC BETA, PHASE	29.1	32.4	18.7	28.4	16.4	-335.	18.2	15.5	16.0	-346.		
PHI TC BETA	2.63	1.39	1.16	2.30	2.98	2.79	1.03	1.05	.948	1.21		
PHI TC VE	.657	.0891	.0539	.152	.526	.327	.0910	.0940	.0591	.115		
+	+	+	+	+	+	+	+	+	+	+		

F-4C DATA SOURCES

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SECTION V

X-15

X-15 BACKGROUND

The X-15 is a single-place, rocket-powered airplane designed for flight at hypersonic speeds and extreme altitudes. The airplane is carried aloft under the right wing of a B-52 and is launched at an altitude of about 45,000 ft and a Mach number of about 0.80. After launch, the X-15 performs a powered flight mission, followed by a deceleration glide prior to vectoring for a landing. With this operational technique, the airplane is capable of attaining a Mach number of 6 and can be flown to and recovered from an altitude in excess of 300,000 feet.

Flights to high altitudes have been made with all three of the X-15 airplanes in two configurations: the basic and the ventral off. The basic configuration is considered here.

Aerodynamic control is provided through conventional aerodynamic surfaces, with vertical surfaces used for yaw control and the horizontal tail for both pitch and roll control. All of the aerodynamic control surfaces are actuated by irreversible hydraulic systems. Control force is provided by bungee for pilot feel. A conventional center stick is used for pitch and roll control, and rudder pedals are used for yaw control; however, a side-located stick is provided for control of pitch and roll in high-acceleration environments at the option of the pilot. Most of the X-15 missions have been made with the side stick, although the pilots used the center stick on their first flights. Only the center stick control is shown here.

The augmentation system shown in this report consists of angular rate feedback loops about all three axes. In addition to the normal $p \rightarrow \delta_a$ roll SAS loop, there is an $r \rightarrow \delta_a$ feedback known as the YAR loop. The gains for each SAS loop are manually set by the pilot. The SAS-on transfer functions given for this airplane assume maximum gain settings for each loop. This may not have been realistic for actual flights.

The flight conditions considered for this airplane are all for straight and level trimmed flight. This is definitely unrealistic for this airplane; however, the intent here is to show general speed and altitude variation effects.

X-15

Nominal Configuration

Zero Fuel
Lower Ventral On
Speed Brakes Retracted

$W = 15560 \text{ lb}$
 $c.g. \text{ at } .22 \bar{c}$
 $I_x = 3650 \text{ slug}\cdot\text{ft}^2$
 $I_y = 80000 \text{ slug}\cdot\text{ft}^2$
 $I_z = 82000 \text{ slug}\cdot\text{ft}^2$
 $I_{xz} = -30 \text{ slug}\cdot\text{ft}^2$

Flight Envelope

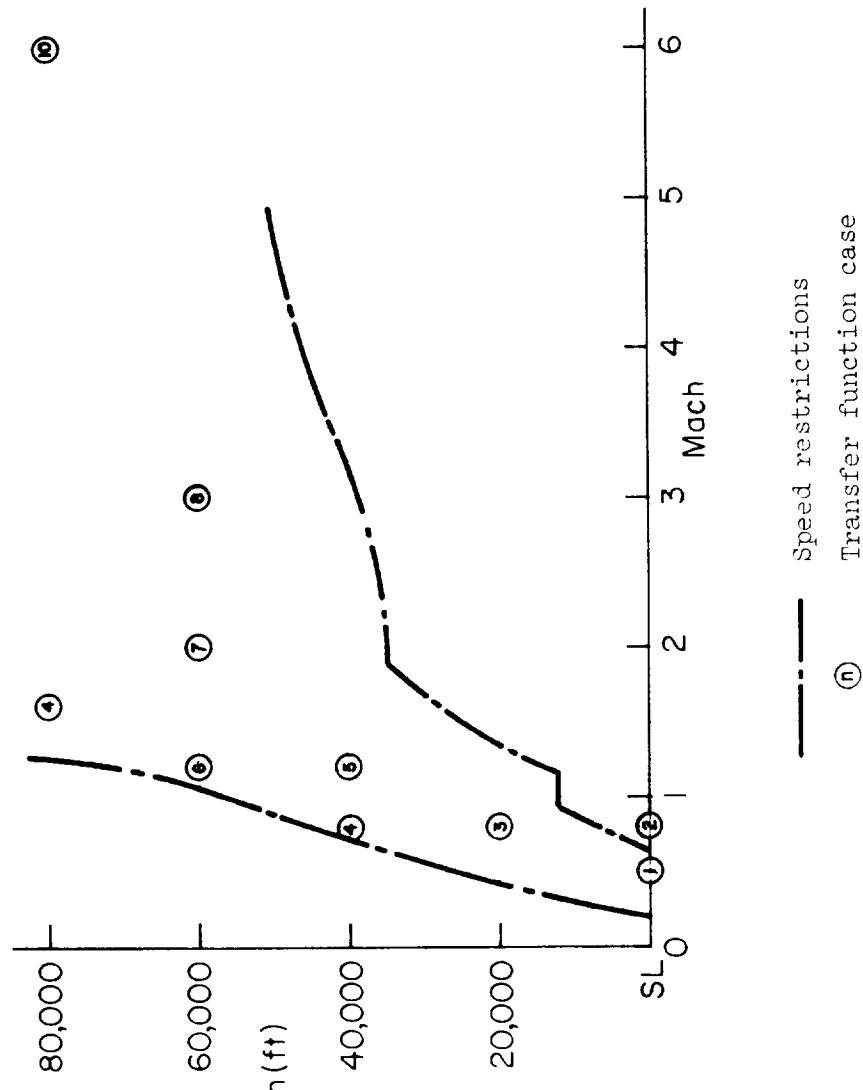


Figure V-1. X-15 Flight Conditions

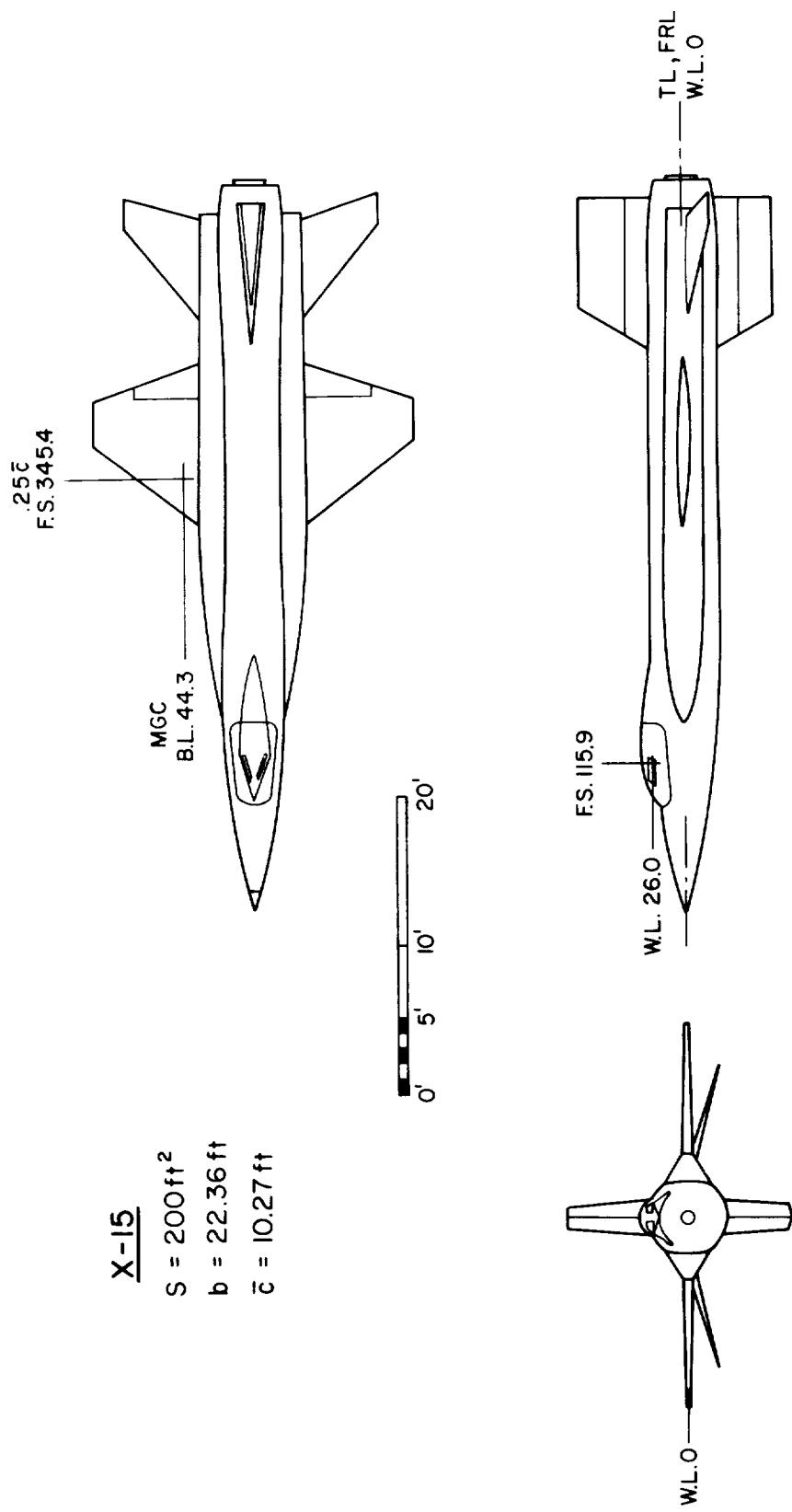
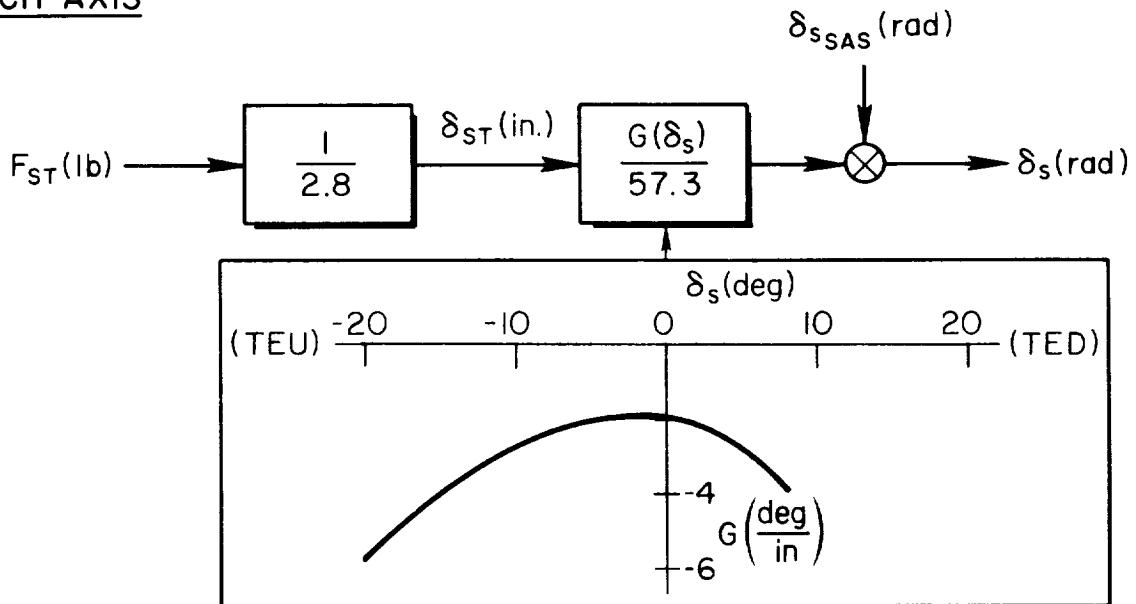


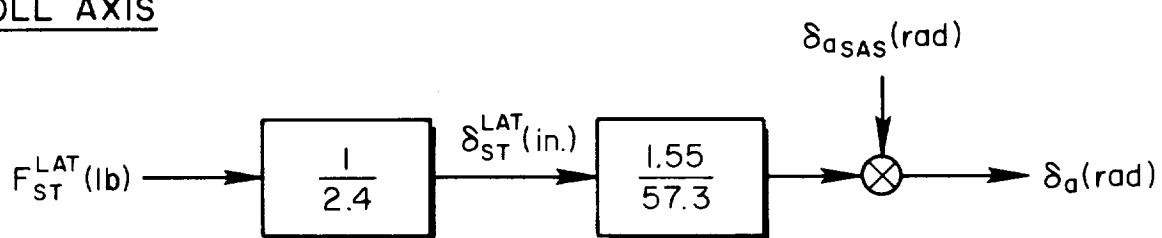
Figure V-2. X-15 General Arrangement

X-15

PITCH AXIS



ROLL AXIS



YAW AXIS

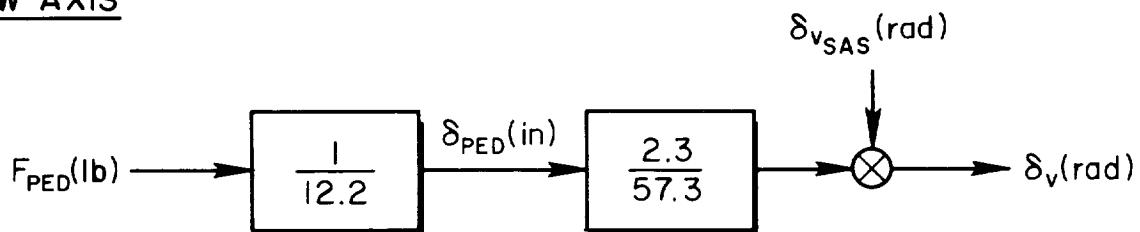
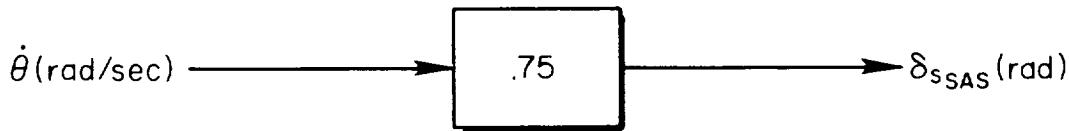


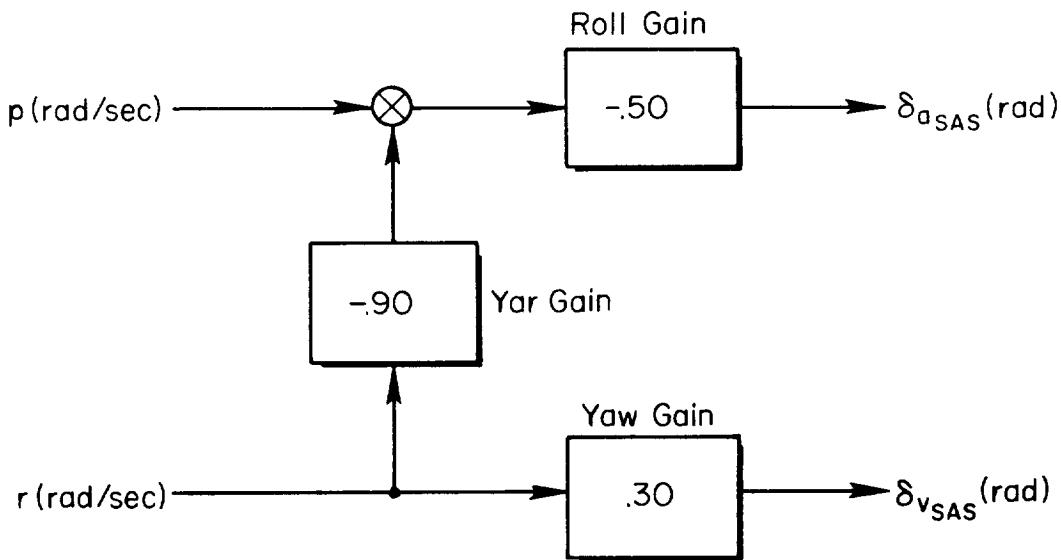
Figure V-3. X-15 Control System

X-15

PITCH SAS



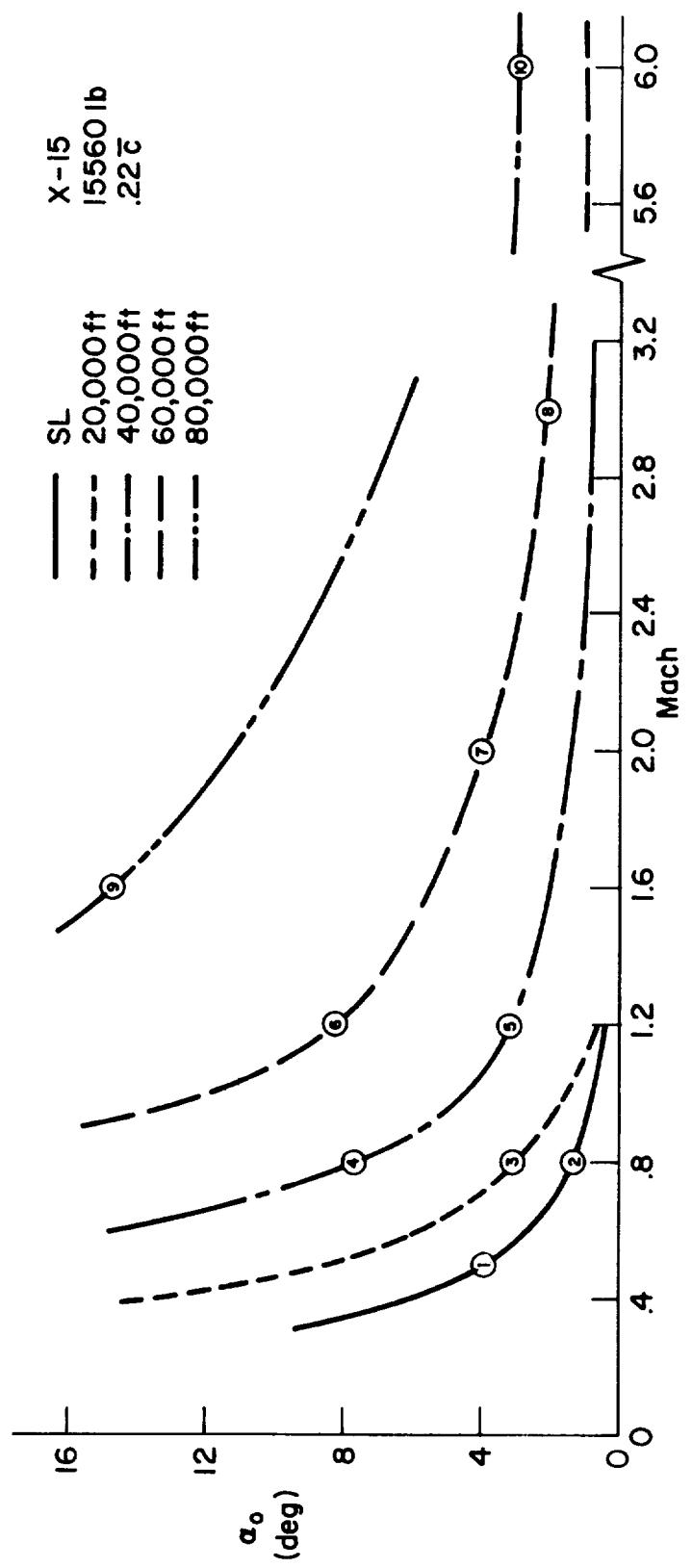
ROLL - YAW - YAR SAS

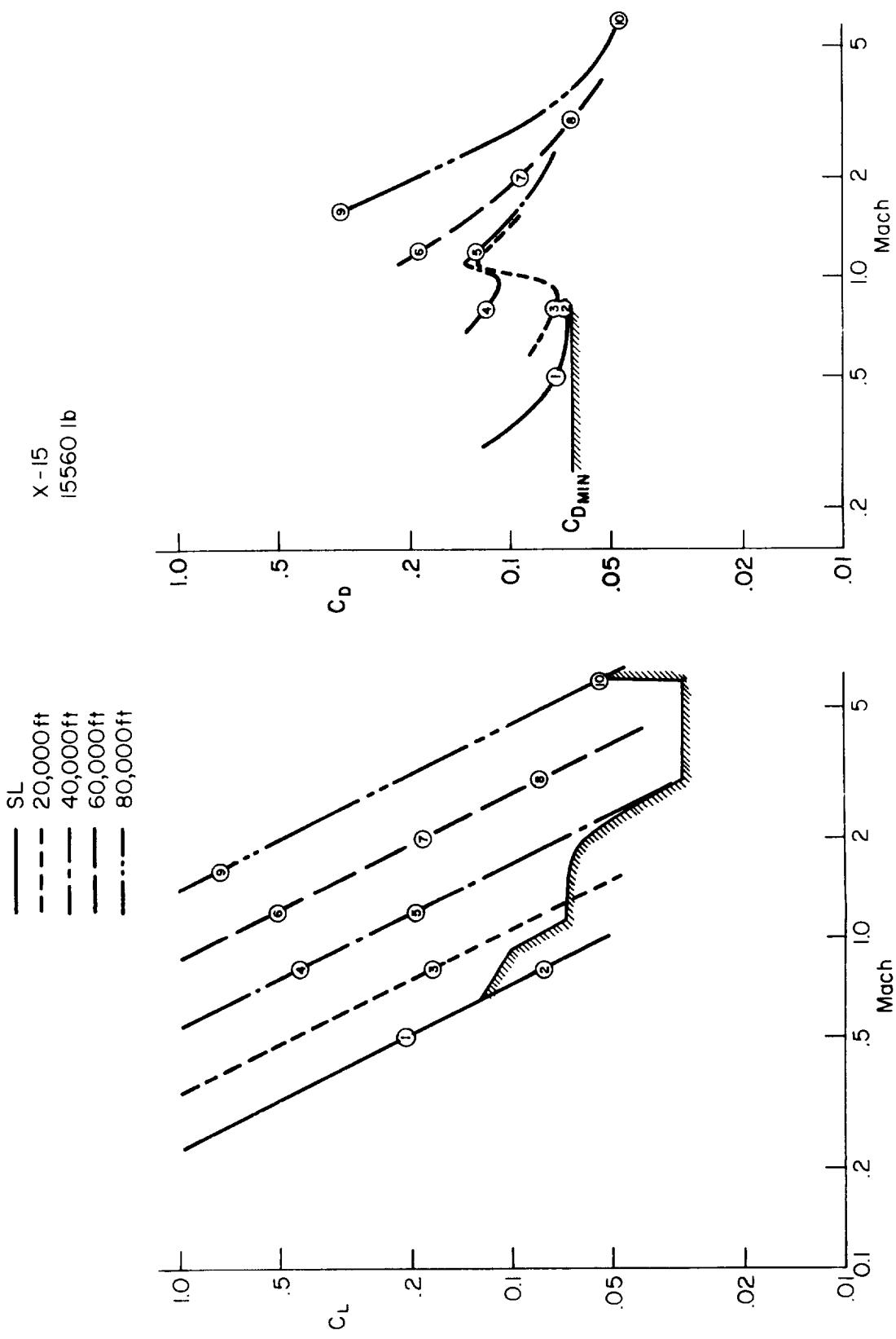


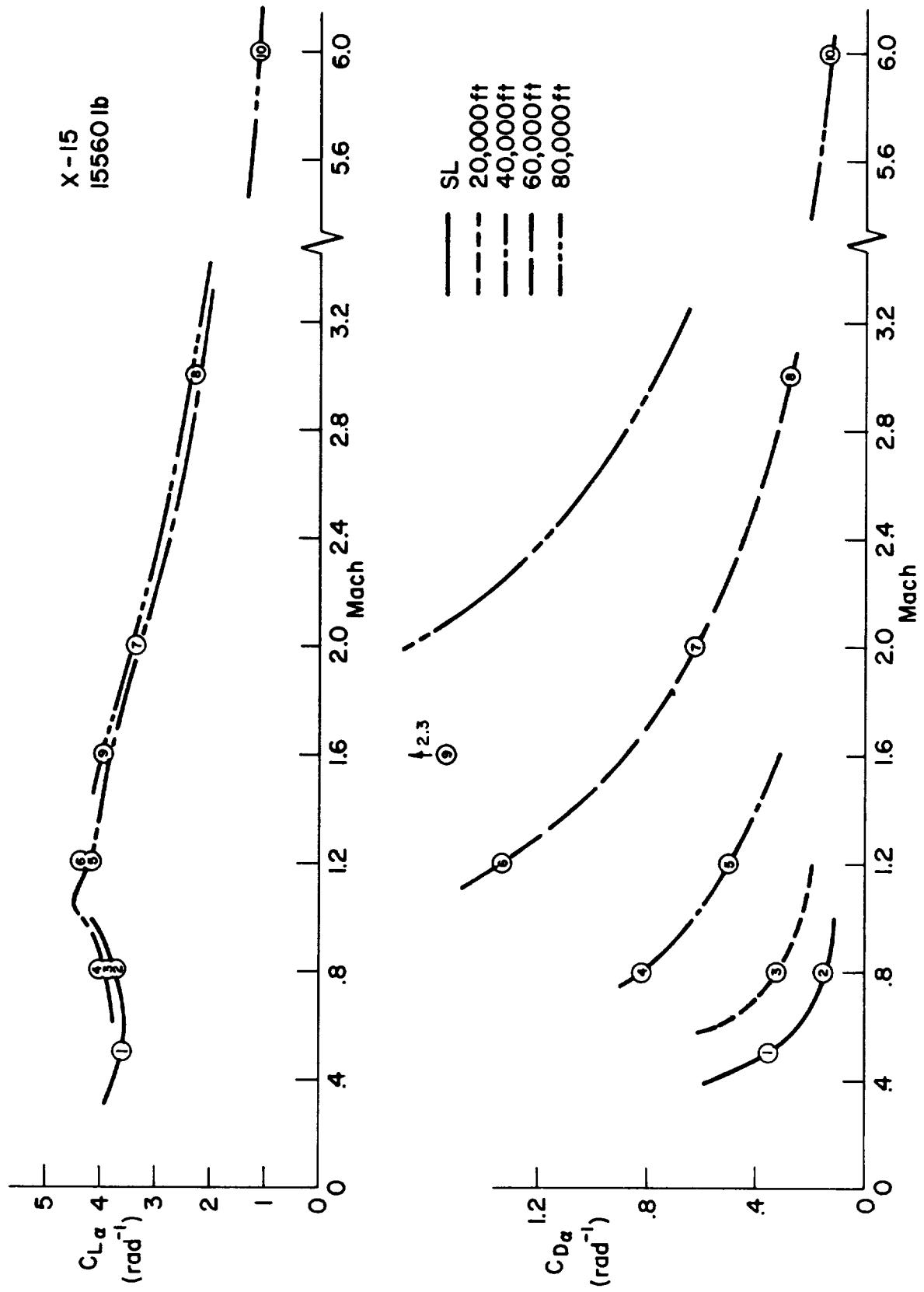
Note:

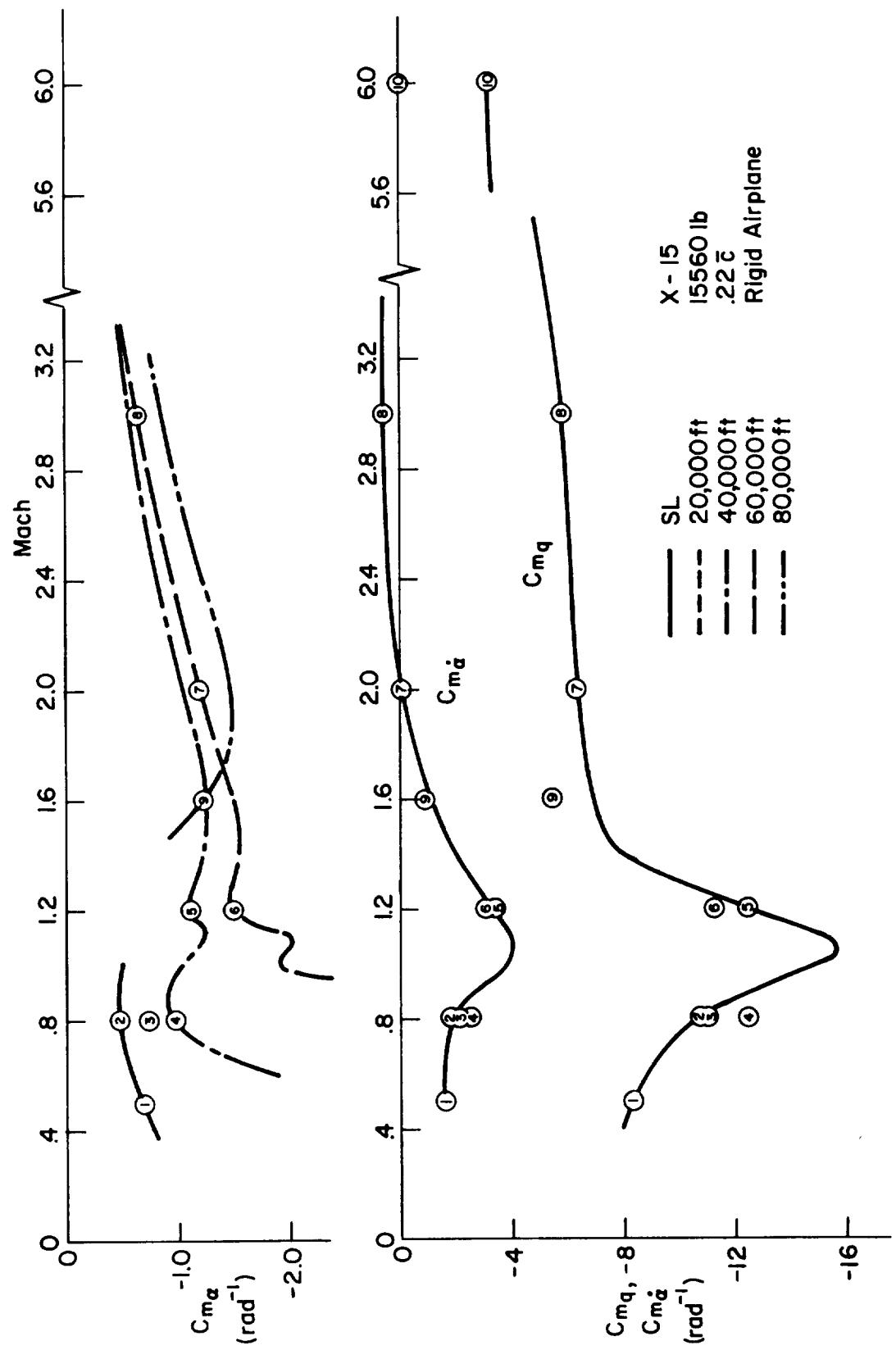
Gains variable in 10% increments of the maximum values which are shown above.
(e.g. roll gains selectable are .05,.10,.15,.20,.25,.30,.35,.40,.45, and .50)

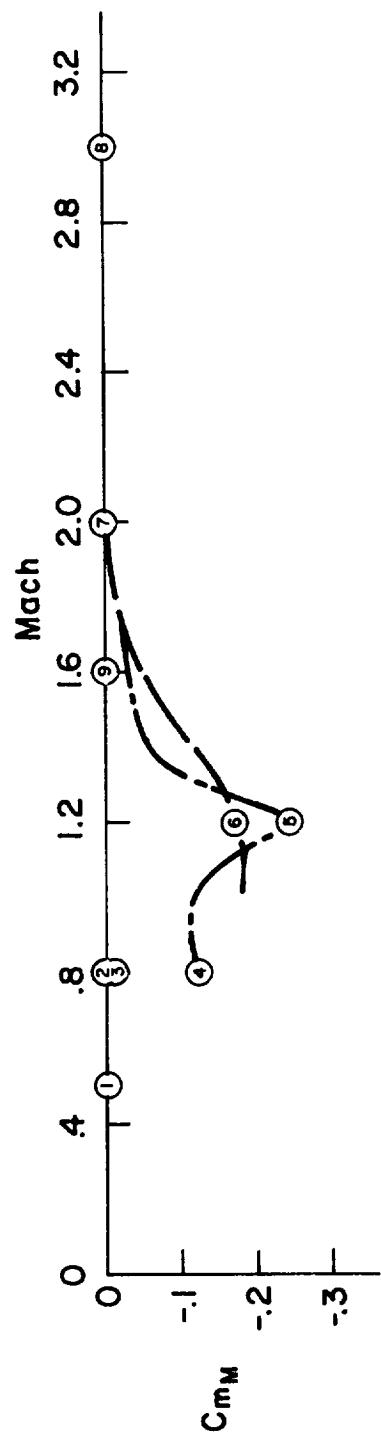
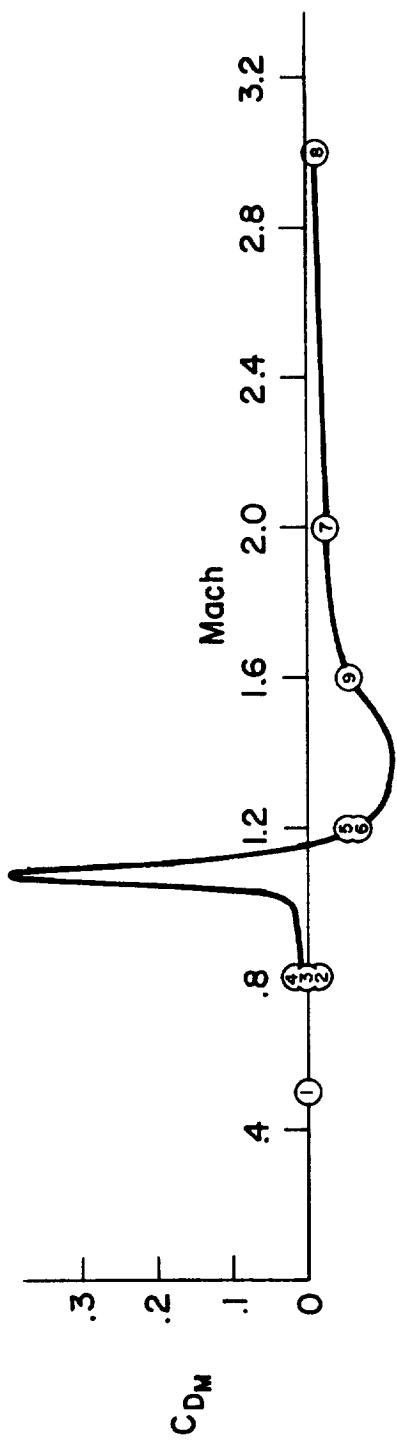
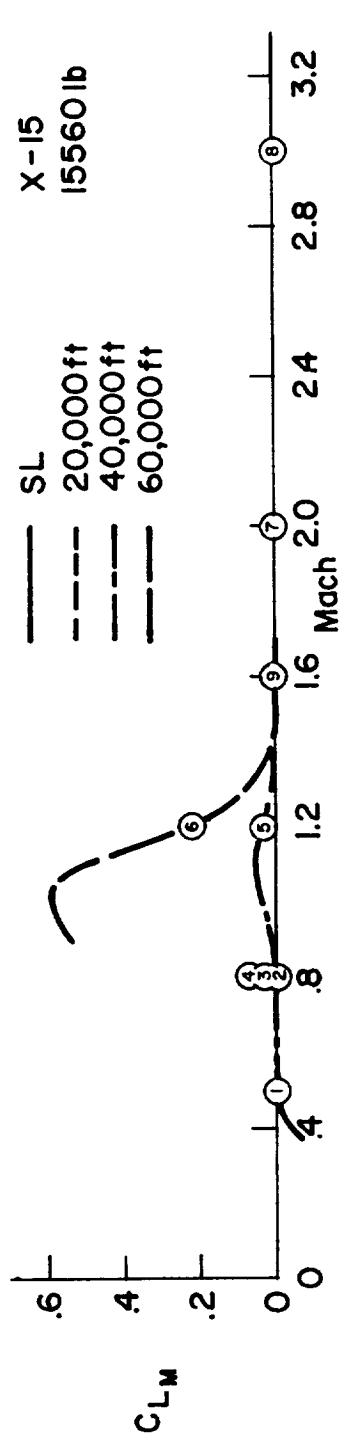
Figure V-4. X-15 Stability Augmentation

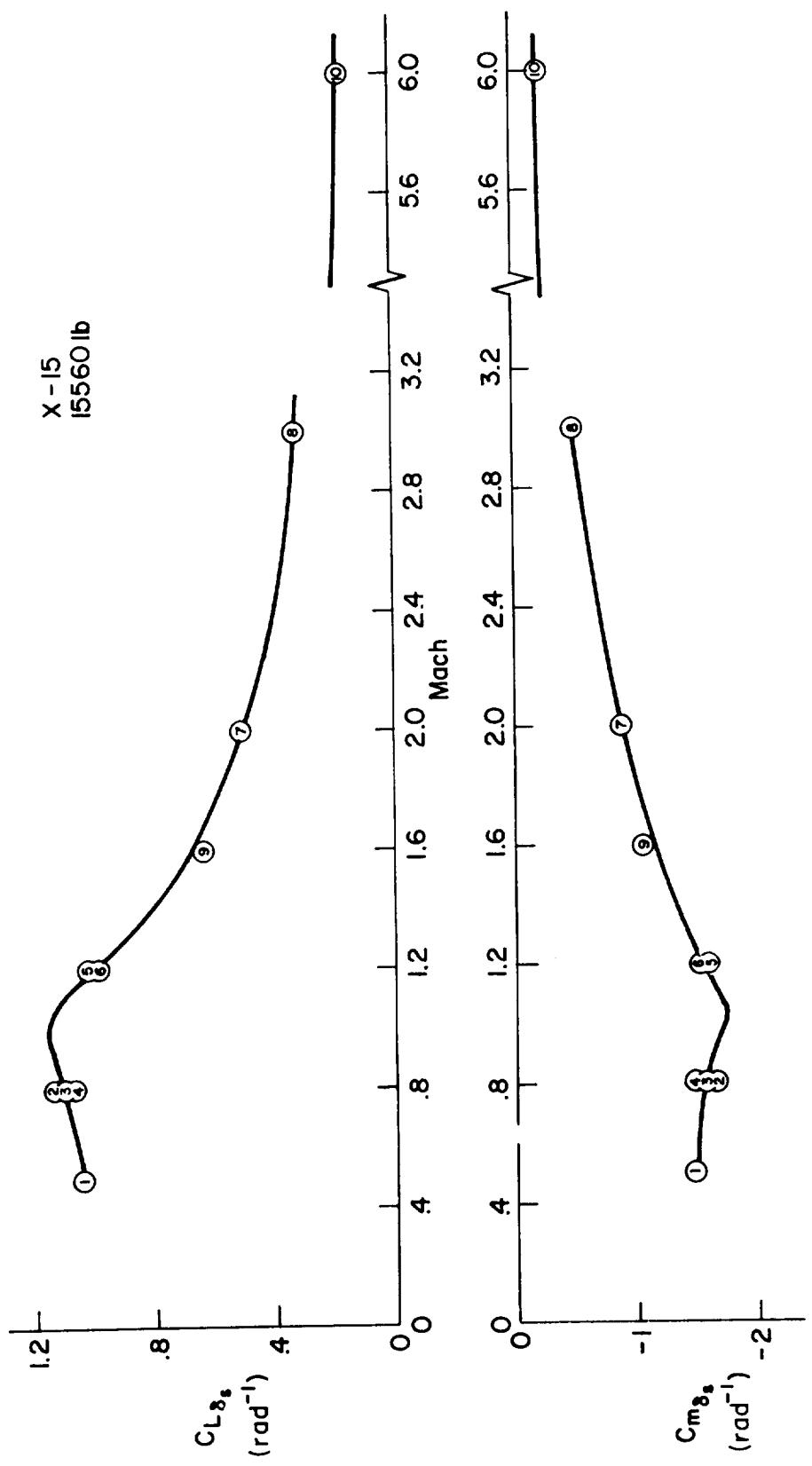


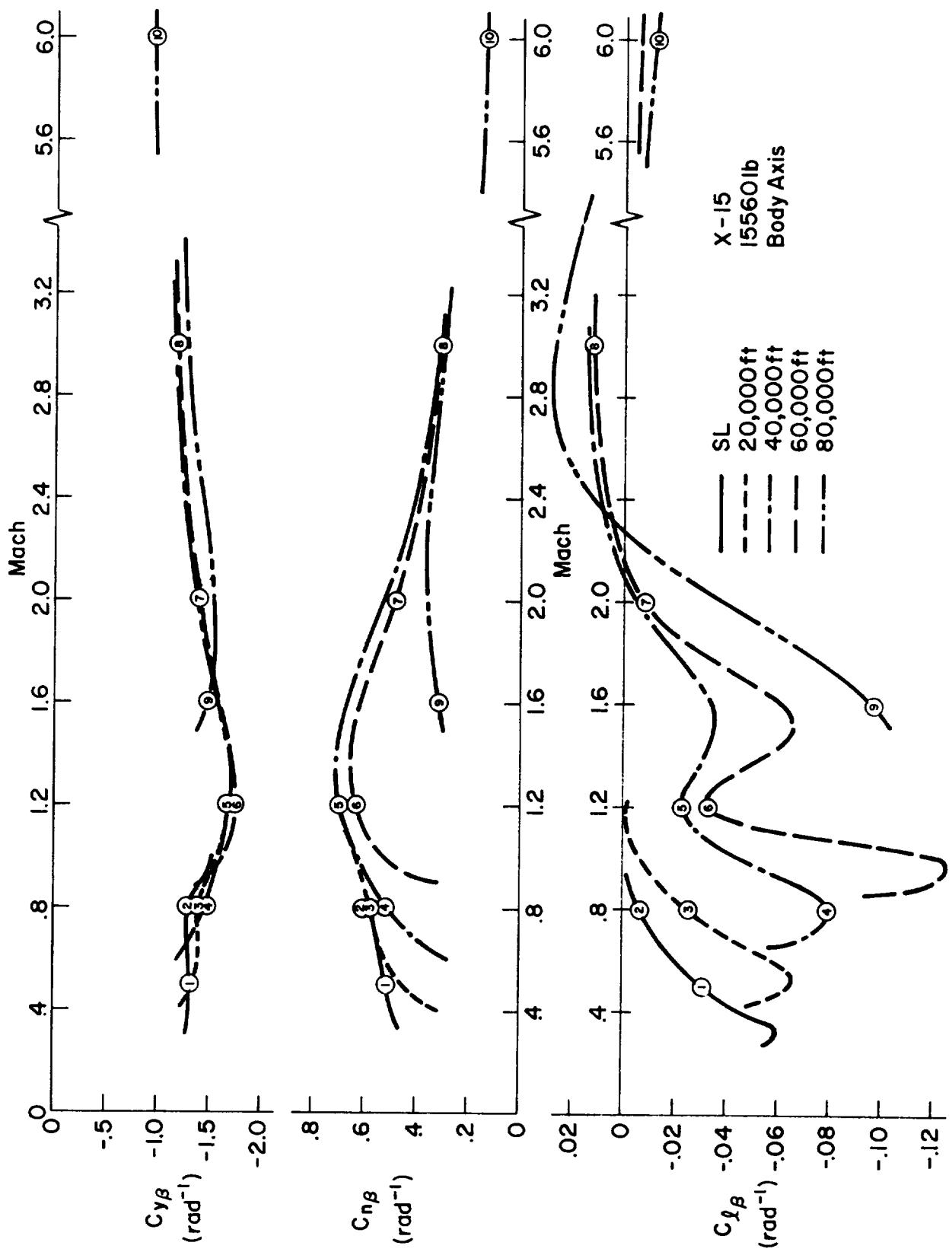


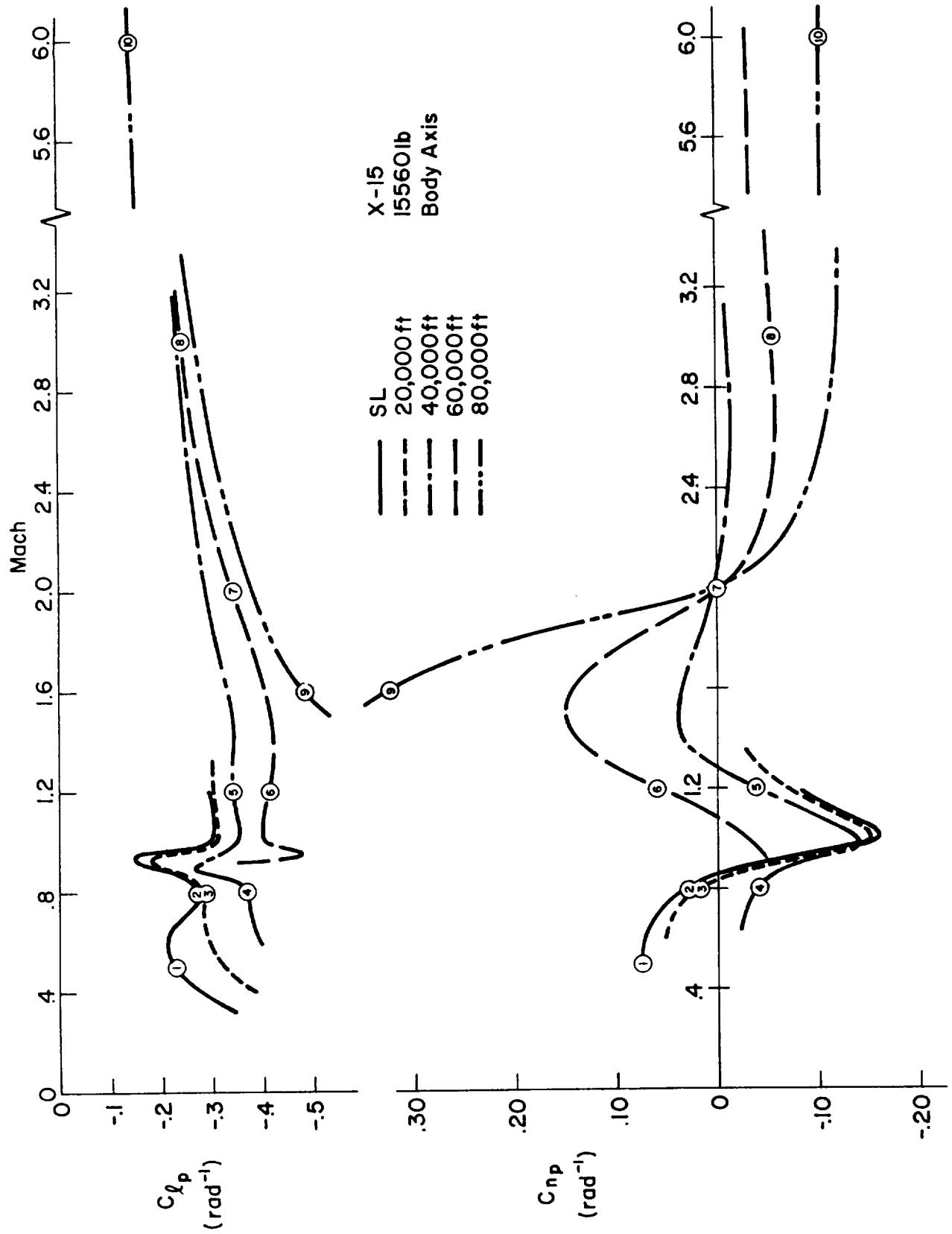


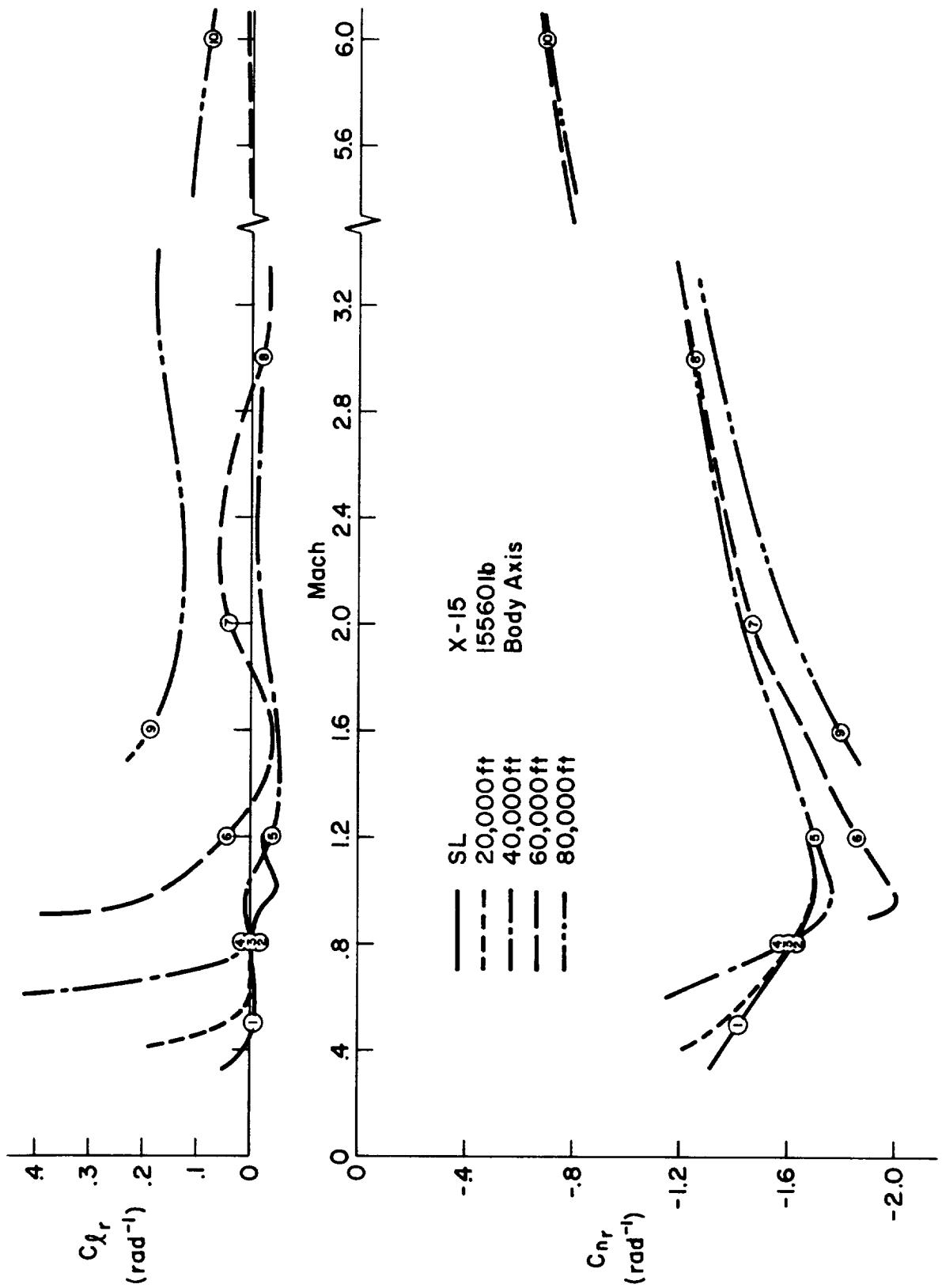


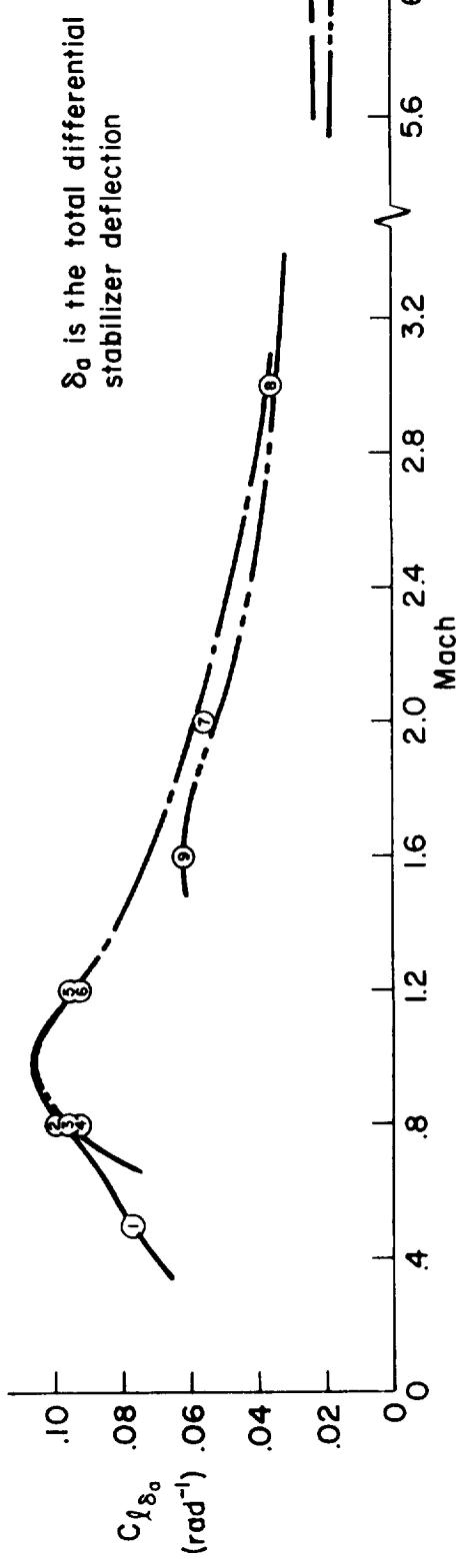
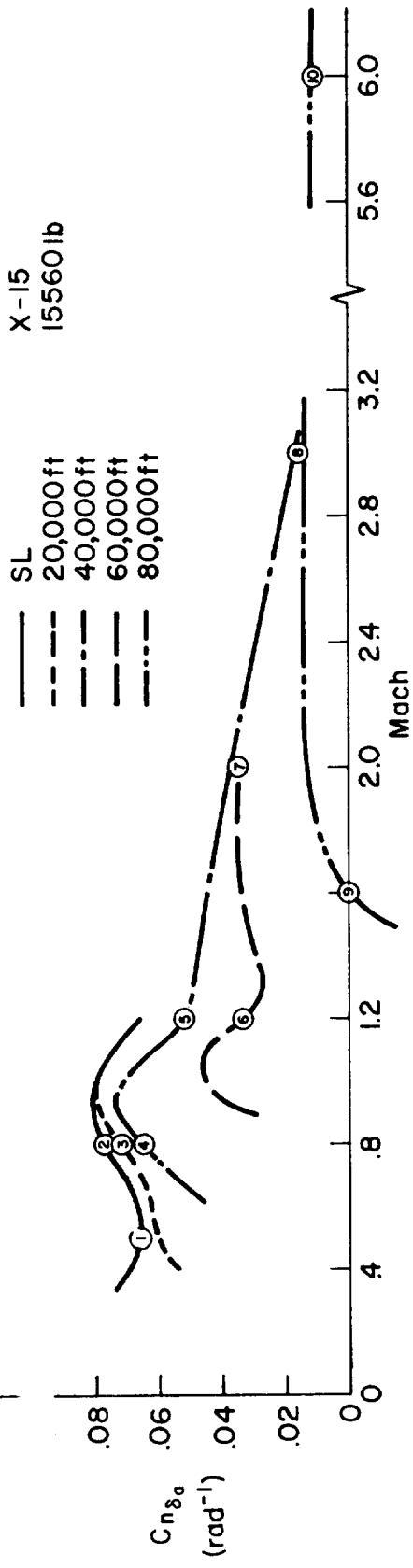
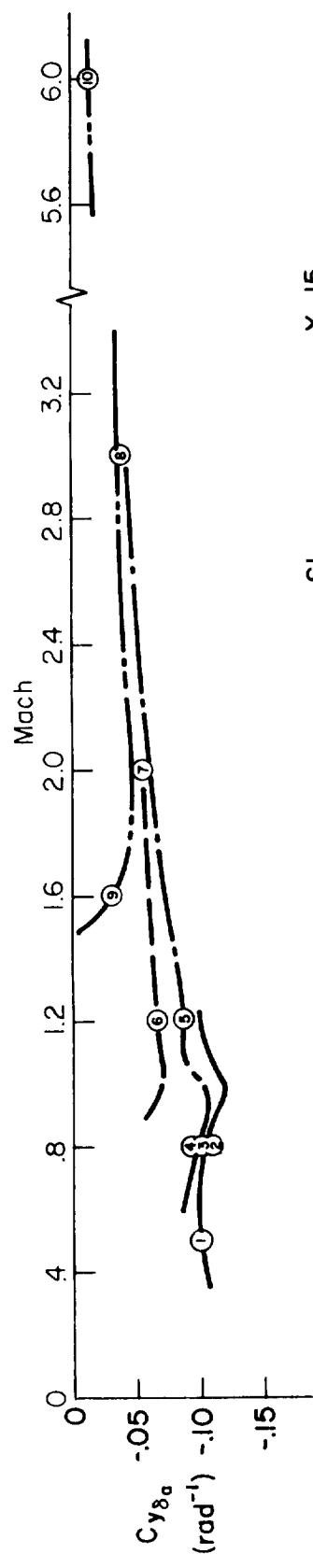












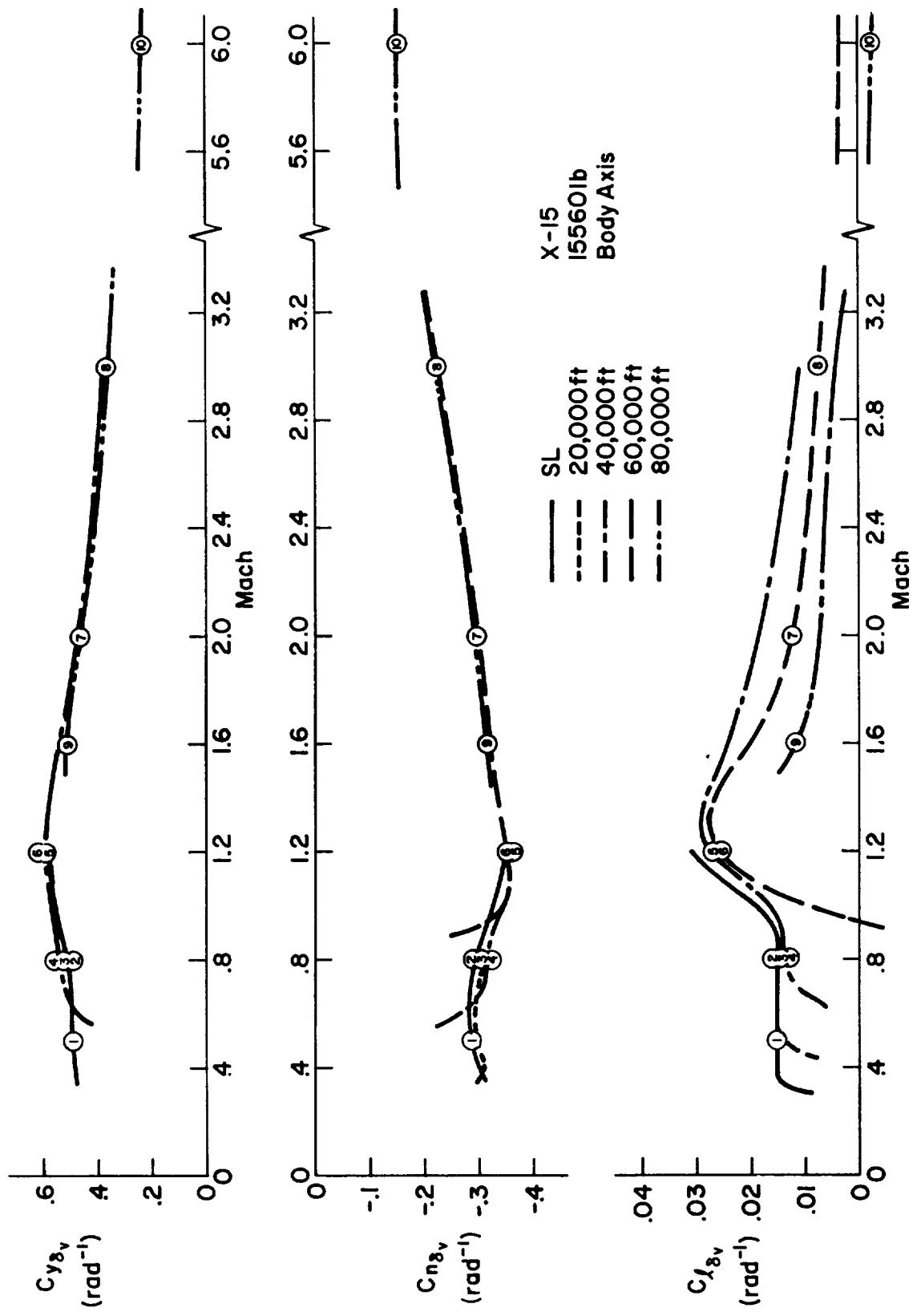


TABLE V-1

X-15 DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

$S = 200 \text{ sq ft}$, $b = 22.36 \text{ ft}$, $\bar{c} = 10.27 \text{ ft}$

	/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K	80 K
M(-)	• 500.	• 800.	• 800.	• 800.	1.20	1.20	2.00	3.00	1.60	6.00	6.00
VTO(FPS)	558.	893.	830.	774.	1161.	1161.	1936.	2904.	1564.	5855.	5855.
VTO(KTAS)	331.	529.	492.	459.	688.	688.	1147.	1720.	927.	3475.	3475.
VTO(KCAS)	331.	529.	373.	243.	388.	247.	432.	630.	218.	764.	764.
W(LBS)	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.	15560.
C.G.(MGC)	• 220	• 220	• 220	• 220	• 220	• 220	• 220	• 220	• 220	• 220	• 220
I X (SLUG-FT SQ)	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.	3650.
I Y (SLUG-FT SQ)	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.	80003.
I Z (SLUG-FT SQ)	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.	82003.
I XZ(SLUG-FT SQ)	590.	590.	590.	590.	590.	590.	590.	590.	590.	590.	590.
EPSILON(DEG)	-• 431	-• 431	-• 431	-• 431	-• 431	-• 431	-• 431	-• 431	-• 431	-• 431	-• 431
Q(PSF)	370.	948.	436.	177.	397.	153.	424.	954.	106.	1489.	1489.
QC(PSF)	394.	1109.	510.	207.	555.	213.	703.	1675.	166.	2707.	2707.
ALPHA(DEG)	4.00	1.30	3.00	7.70	3.20	8.30	4.00	2.20	14.7	3.00	3.00
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
LZP(FT)	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20	-2.20
I TH(DEG)	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.
L TH(FT)	0.	C.	0.	0.	C.	C.	C.	C.	C.	0.	0.
	+	+	+	+	+	+	+	+	+	+	+

TABLE V-2

X-15 LONGITUDINAL DIMENSIONAL DERIVATIVES
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	60 K	60 K	60 K	80 K	80 K	
M	.500	.800	.800	.800	1.20	2.00	3.00	1.60	6.00	
XU *	-0.0339	-0.0601	-0.0292	-0.0134	-0.0216	-0.00516	-0.00871	-0.0101	-0.00111	-0.00916
ZU *	-0.0471	-0.0253	-0.0335	-0.0323	-0.0281	-0.0348	-0.0117	-0.0196	-0.0113	-0.00551
RU *	.00C808	.000278	.000279	.000188	-0.00199	.495E-4	.000471	.000210	.000529	.430E-4
XW *	.0269	.00105	.0111	.0149	-0.00810	-0.00893	-0.0190	-0.0148	-0.0127	-0.00215
ZW	-1.01	-1.66	-0.845	-0.398	-0.602	-0.261	-0.311	-0.323	-0.132	-0.121
XW	-0.0116	-0.0123	-0.00945	-0.00559	-0.00979	-0.00511	-0.00673	-0.00548	-0.00202	-0.000820
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	C.
ZC	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MC()	-0.000250	-0.000282	-0.000150	-0.923E-4	-0.000124	-0.472E-4	0.	.894E-5	-0.607E-5	C.
MQ	-0.735	-1.53	-0.755	-0.376	-0.559	-0.194	-0.182	-0.251	-0.0482	-0.107
XDS	11.2	9.78	10.4	10.8	9.27	9.21	6.24	4.85	7.11	5.64
ZDS	-16.0.	-431.	-198.	-79.6	-166.	-63.1	-89.2	-126.	-27.1	-108.
MDS	-13.8	-37.7	-17.4	-7.03	-15.5	-5.96	-9.80	-12.2	-2.85	-8.79
	+	+	+	+	+	+	+	+	+	+

C

X-15 STABILIZER TRANSFER FUNCTION FACTORS
SAS Off
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	S _L	S _L	20 K	40 K	60 K	60 K	60 K	60 K	60 K	60 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
DENOMINATOR										
Z(DET)1	*24.7	*71.6	*33.8	*17.3	(*-C469)	*108	*264	*366	*262	*626
W(DET)1	*0773	*0424	*0452	*0419	(*-.0552)	*0317	*0232	*0158	*0294	*0788
Z(DET)2	*351	*467	*296	*200	*194	*104	*0675	*0683	*0429	*518
W(DET)2	2.68	3.67	2.91	2.11	2.40	2.43	3.62	4.00	1.81	2.20
NUMERATORS										
N(U /DS)										
A(U)	11.2	9.78	10.4	10.8	\$2.27	9.21	6.24	4.85	7.11	5.64
1/T(U)1	47.8	1.22	72.6	67.8	*247	*0926	*0705	*0840	*0386	*0548
W(U)2	(*84.9)	1.98	(*92.6)	(*92.6)	*996	*420	*741	*013	*221	*212
1/T(U)3	(*85.3)	78.1	(*739)	(*321)	109.	109.	212.	292.	150.	479.
N(W /DS)										
A(W)	-160.	-421.	-198.	-79.6	-156.	-63.1	-89.2	-126.	-27.1	-108.
1/T(W)1	4.8*6	79.7	73.3	68.1	109.	109.	212.	282.	159.	470.
Z(W)1	*29.9	*96.7	*394	*166	*876	*100	*261	*431	-0.363	*30.
W(W)1	*0555	*0310	*0367	*C367	*0124	*0309	*0160	*0117	*0184	*00552
N(THE/DS)										
A(THE)	-13.7	-37.6	-17.3	-7.02	-15.5	-5.96	-9.80	-12.3	-2.85	-8.79
1/T(THE)1	*034.4	*0600	*0293	*C138	*0226	*00688	*00919	-0.0270	*0098	*0098
1/T(THE)2	*881	1.52	.738	*334	*498	*210	*251	*267	*116	*111
N(HD /DS)										
A(HD)	161.	431.	198	80.3	166.	63.8	89.4	126.	20.0	108.
1/T(HD)1	*0270	*0586	*0256	*C0435	*0209	*00561	*00482	*0833	*0121	*00849
1/T(HD)2	-6.03	-10.0	-6.87	-4.46	-6.98	-4.47	-7.13	*8.52	-3.00	-7.21
1/T(HD)3	6.92	11.8	7.75	4.93	7.62	4.74	7.32	8.75	3.99	7.32
N(AZP/DS)										
A(AZP)	98.0	276.	128.	52.4	125.	48.9	95.0	104.	26.6	57.7
1/T(AZP)1	*00446	-.000827	-.00217	-.00711	-.00157	*00116	-.00134	-.00155	-.000297	
1/T(AZP)2	*0312	*C593	*0276	*011C	*0223	-.0089	*0083	*00873	*00100	*00872
Z(AZP)1	*0540	*0411	*0266	*0141	*0135	*0149	*0224	*0166	*0210	*00597
W(AZF)1	8.28	13.6	9.10	5.83	8.44	5.37	7.00	*0.53	*4.21	*0.94

TABLE V-4

X-15 STABILIZER TRANSFER FUNCTION FACTORS

SAS On

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL .500	SL .800	20 K .800	40 K .800	60 K 1.20	60 K 2.00	60 K 3.00	80 K 3.00	80 K 1.60	80 K 6.00
M										
DENOMINATOR										
1/T(DET)1	1.53	.00833	1.35	1.29	-.0350	(.0957)	3.26	2.58	(.242)	.946
1/T(DET)2	10.7	.0517	13.4	4.82	.0491	(.0295)	4.58	7.16	(.0285)	5.88
Z(DET)1	.338	{ 1.89	*.474	.188	{ 1.53	*.951	*.262	*.278	*.622	*.670
W(DET)1	.0514	{ 29.7	.0309	.0355	{ 11.4	2.52	.0218	.0147	.0187	.00734
NUMERATOR										
N(U/DS)										
A(U)	11.2	9.78	10.4	10.8	.927	9.21	6.24	4.85	7.11	.564
1/T(U)	47.8	1.22	72.6	67.8	.247	.0926	.0795	.0840	.0386	.0548
1/T(U)	{ 84.9	1.99	{ .928	{ .926	.996	.420	.741	.213	.221	*.212
1/T(U)	{ 85.3	78.1	{ .739	{ .321	1C9.	1.09.	212.	282.	1.59.	.479.
N(W/DS)										
A(W)	-160.	-431.	-198.	-166.	-63.1	-89.2	-126.	-27.1	-108.	
1/T(W)	48.6	75.7	73.3	68.1	109.	109.	212.	150.	479.	
Z(W)	*.299	*.967	*.394	*.166	*.876	*.100.	*.261	*.431	*.0363	*.830
W(W)	*.0555	*.0310	*.0367	*.0367	*.0124	*.0309	*.0160	*.0117	*.0184	.00552
N(THE/DS)										
A(THE)	-13.7	-37.6	-17.3	-7.02	-15.5	-5.96	-9.80	-12.3	-2.85	.879
1/T(THE)	*.0344	*.0600	*.0253	*.0138	*.0226	*.00218	*.00618	*.00919	*.00270	*.00899
1/T(THE)	*.881	1.52	*.738	*.334	*.498	*.210	*.251	*.267	*.116	*.111
N(HD/DS)										
A(HD)	161.	431.	198.	80.3	166.	63.8	89.4	126.	28.0	108.
1/T(HD)	*.0270	*.0536	*.0256	*.00439	*.0209	*.00661	*.00482	*.00833	*.0121	*.07849
1/T(HD)	-6.03	-10.0	-6.87	-4.46	-6.08	-4.47	-7.13	-8.52	-3.90	-7.21
1/T(HD)	6.92	11.8	7.75	4.93	7.69	4.74	7.32	8.75	3.39	7.32
N(AZP/DS)										
A(AZP)	98.0	276.	128.	52.4	125.	48.9	95.0	104.	26.6	57.7
1/T(AZP)	-0.0446	-.000827	-.00217	-.00711	-.00157	*.00116	-.00134	-.000451	-.00155	-.000297
1/T(AZP)	*.0312	*.0593	*.0276	*.0110	*.0223	-.00789	*.00605	*.00873	*.0100	*.00872
Z(AZP)	*.0440	*.0411	*.0286	*.0141	*.0135	*.0148	*.0224	*.0166	*.0210	*.005597
W(AZP)	8.28	13.6	9.10	5.83	5.32	7.04	9.53	4.21	9.94	

TABLE V-5
X-15 LONGITUDINAL HANDLING QUALITIES PARAMETERS
 SAS Off
 (Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	80 K	80 K
R	*500	*800	.800	.800	.800	1.20	1.20	2.00	3.00	6.00
STICK FIXED										
D(G)/D(U) (DEG/KT)	-*.0812	-.176	-.0769	-.0132	-.0629	.0198	-.0145	-.0250	.0362	-.0255
NZA (G/RAD)	15.0	41.2	18.8	7.92	17.8	7.37	15.0	24.0	5.32	20.2
DE/G (DEG/G)	1.96	.487	1.47	4.54	2.41	7.71	5.10	3.11	11.5	1.55
CAP (RAD/SEC/SEC/G)	*471	*320	*445	*556	*652	*801	*872	*666	*574	*238
PHUGIC(2) (SEC)	--	--	--	--	(14.8)	--	--	--	--	--
{ TUCK(2) }										
1/C(1/10)	1.02	1.44	.846	.557	.539	.267	.185	.187	.132	.141
	+	+	+	+	+	+	+	+	+	+

X-15 LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
 TABLE V-6
 (BODY AXIS SYSTEM)

F/C *	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	60 K	60 K	60 K	80 K	80 K	80 K
M	.500	.800	.800	.800	1.20	2.00	3.00	1.60	6.00	
YV	-3.571	-3.04	-1.37	-0.241	-0.0951	-0.127	-0.163	-0.0414	-0.0997	
YB	-1.90.	-510.	-252.	-106.	-279.	-110.	-246.	-474.	-64.8	-5.85.
L ^B	-12.4	-1.96	-11.7	-16.3	-8.76	-5.33	-2.36	16.6	-12.3	-20.1
NB ^B	10.4	31.0	13.7	4.89	15.1	5.21	11.1	15.7	1.76	11.2
LP ^B	-2.54	-3.93	-2.09	-1.16	-1.60	-0.738	-1.02	-1.08	-0.448	-0.507
NP ^B	.0129	-0.0384	-0.00862	-0.0139	-0.0198	-0.000563	-0.00735	-0.0188	.0C998	-0.0195
LR ^B	-1.84	-1.70	-0.0830	-0.0353	-0.245	.0570	.103	.131	.164	.261
NR ^B	-5.76	-1.05	-5.13	-2.19	-3.56	-0.149	-0.16	-0.251	-0.0727	-0.106
Y*SA	-0.0274	-0.0461	-0.0217	-0.00895	-0.0120	-0.00353	-0.00493	-0.00542	-0.000840	-0.00157
L ^B DA	35.2	11.3.	52.2	21.1	46.5	17.8	28.7	42.3	8.05	33.0
N ^B DA	1.59	4.85	2.09	.778	1.46	.403	.993	1.08	.C579	1.13
Y*D ^V	.137	.224	.113	.0509	.0821	.0326	.0426	.0563	.0143	.C241
L ^B D ^V	5.87	15.0	6.60	2.55	11.9	4.21	5.38	6.88	1.20	-6.54
N ^B D ^V	-5.81	-14.9	-7.09	-2.97	-7.50	-2.88	-6.90	-11.7	-1.81	-12.2
	+	+	+	+	+	+	+	+	+	+

TABLE V-7
X-15 ATTERRON TRANSFER FUNCTION FACTORS
SAS Off
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	S _L .500	S _L .800	20 K .800	40 K .800	60 K 1.20	60 K 1.20	60 K 2.00	60 K 3.00	60 K 1.60	60 K 6.00
M										
DENOMINATOR										
1/T(DET)1	.00149	.00132	.00734	.0176	.00608	.000447	.00215	.00185	.00863	-.000937
1/T(DET)2	2.46	3.93	2.06	.991	1.59	.679	1.01	1.09	.207	.503
Z(DET)1	*14.8	*14.4	*11.0	*0957	*0754	*0623	*0503	*C524	*0792	*.302
W(DET)1	5.63	3.96	3.80	2.64	2.43	3.35	3.89	2.19	3.50	3.50
NUMERATORS										
N(B/DA)	-.0274	-.0461	-.00896	-.0120	-.00353	-.00498	-.00543	-.00840	-.001157	
A(B)	-.27.3	-.347	-.229.	-.53.2	-.615.	-.202.	-.98.7	-.2366.	*.0479	
1/T(B)1	(-.560)	5.43	(-.306)	(-.705)	(-.551)	(-.734)	(-.121)	(-.665)	*.727	
1/T(B)2										
1/T(B)3	(1.25)	4.9.2	(1.35)	(.306)	(.634)	(.185)	(.308)	(.466)	(.0700)	-.380.
N(P/DA)										
A(P)	35.2	113.	52.2	21.1	46.5	17.8	28.7	42.3	8.25	33.0
1/T(P)1	-.00396	-.0003	-.00201	-.0055	-.00403	-.00116	-.000425	-.00530	-.001287	
Z(P)	*14.0	*14.3	*10.9	*0783	*0544	*0490	*0523	*0456	*.0314	
W(P)	3.34	5.63	3.78	2.34	2.93	2.30	3.34	2.92	1.34	3.45
N(R/DA)										
A(R)	1.59	4.85	2.09	.778	1.46	*403	*993	1.08	*.0579	1.13
1/T(R)1	*89.5	1.95	.770	.310	.501	*190	*239	*289	*.0786	*.105
Z(R)	.267	.279	*150	*C615	*0559	*0493	*0677	*0152	*.110	-.0111
W(R)	3.96	3.67	4.22	4.45	5.20	5.83	4.74	4.78	8.07	4.27
N(phi/DA)										
A(phi)	35.3	114.	52.3	21.2	46.6	17.9	28.8	42.3	8.27	33.1
1/T(phi)1	*14.1	*14.4	*10.9	*0772	*0753	*0534	*0490	*0522	*0434	*.0312
Z(phi)	3.34	5.63	3.78	2.36	3.93	2.32	3.35	3.92	1.38	3.45
N(AYP/DA)										
A(AYP)	91.9	300.	136.	54.1	116.	42.7	72.2	97.6	17.5	84.7
1/T(AYP)1	-.287	-.344	-.235	*196	*219	*157	*107	*131	*.383	
1/T(AYP)2	*60.6	*69.6	*40.8	-.376	-.325	-.296	-.192	-.360	-1.41	-.396
Z(AYP)1	*15.4	*13.8	*11.4	*11.8	*0823	*0997	*0591	*.920	*.20	*.777
W(AYP)1	3.33	5.52	3.79	2.31	3.95	2.19	3.27	3.80	1.50	3.08

X-15 VERTICAL STABILIZER TRANSFER FUNCTION FACTORS
 TABLE V-8
 SAS Off
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL .500	SL .800	2C K .800	4C K .8CC	40 K 1.20	60 K 1.20	60 K 2.00	60 K 3.00	80 K 1.60	80 K 6.00
DENUMINATOR										
1/T(DET)1	*0149	*00132	*00734	*0176	*00608	-0.00447	-0.00216	-0.00185	.00863	-0.00987
1/T(DET)2	2.46	3.93	2.06	.591	1.59	.679	1.01	1.09	*207	.503
Z(DET)1	*14.8	*14.4	*11.0	*C957	*0754	*0623	*0503	*C524	*C7C2	*0302
W(DET)1	3.36	5.63	3.80	2.64	3.96	2.43	3.35	3.89	2.10	3.50
NUMERATORS										
N(B /DV)										
A(B)	*137	*224	*113	*0509	*0821	*0326	*0425	*0503	*0143	*0241
1/T(B)1	*0128	*0101	*00807	*CC215	*0117	*00181	*000352	*CC37	*0110	*00393
1/T(B)2	2.45	3.90	2.05	1.1C	1.56	.656	.989	1.08	*346	*495
1/T(B)3	4.59	6.1	6.2	64.7	59.8	106.	171.	237.	144.	492.
N(P /DV)										
A(P)	5.87	15.0	6.60	2.55	11.9	*4.21	*5.38	*6.88	1.20	*6.54
1/T(P)1	*C0417	-0.00802	-0.00193	*CC561	*C0154	-0.00402	-0.0015	-0.00425	*00040	-0.000287
Z(P)1	(-.988)	*16.2	*31.9	(-3.7C)	*111	*0673	*0304	*0572	(3.00)	*055C
h(P)1	(1.82)	5.45	1.11	(3.78)	3.11	1.24	2.84	6.42	(4.17)	6.98
N(R /DV)										
A(R)	-F.81	-14.9	-7.09	-2.97	-7.50	-2.88	-6.90	-11.7	-1.81	-12.2
1/T(R)1	2.40	*.510	-.112	*365	*352	*157	*190	*255	*0750	*106
Z(R)1	*356	(* 513)	(* 179)	*367	(* -612)	(* -393)	(* -417)	(* -691)	*116	*201
w(R)1	*.208	(* 4.04)	(* 2.12)	1.17	(1.96)	(1.01)	(1.31)	(1.63)	1.68	1.16
N(PHI /DV)										
A(PHI)	5.46	14.7	6.23	2.15	11.5	3.79	4.90	6.44	*724	-7.18
1/T(PHI)1	(-1.10)	*155	*271	(* 4.04)	*103	*0361	*0135	*0530	(* 4.00)	*0563
Z(PHI)1	(* 1.79)	5.51	1.14	(* -4.19)	3.17	1.32	2.98	6.85	(-5.77)	6.67
N(AYP /DV)										
A(AYP)	-19.8	-46.9	-24.9	-16.7	-19.4	-7.07	-35.5	-58.0	-9.07	-103.
1/T(AYP)1	.00785	*0492	*0100	-.0278	*0238	*00545	*00169	*CC518	-.0208	-.00486
Z(AYP)2	2.60	6.05	2.27	*62C	2.69	.787	1.17	1.42	*215	*418
w(AYP)1	*.0739	-*.498	-0.937	*0724	-.0524	*0224	-.00935	*0362	*0430	*00863
	4.28	4.47	4.37	4.51	4.70	4.16	4.44	6.47	4.25	7.75
	*	*	*	*	*	*	*	*	*	*

TABLE V-9
X-15 ALTERNATOR TRANSFER FUNCTION FACTORS
 SAS On
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H _N	\$L .500	\$L .800	20 K .800	4C K .800	40 K 1.20	60 K 1.20	60 K 2.30	60 K 3.00	80 K 1.60	80 K 6.00
DENOMINATOR										
1/T(DET)1	-.0464	-.0323	-.0343	-.0315	-.0277	-.0312	-.0173	-.0131	-.00528	-.00250
1/T(DET)2	1.9.3	58.2	27.1	11.1	24.0	9.30	14.8	21.6	3.50	16.4
Z(DET)1	41.9	.556	.408	.322	.300	.298	.385	.518	.507	.564
W(DET)1	3.37	5.75	3.81	2.33	3.93	2.21	3.32	3.44	1.51	3.52
NUMERATORS										
N(P/DA)										
A(P)	-.0274	-.0461	-.0217	-.0096	-.0120	-.00353	-.00498	-.00543	-.000240	-.00157
1/T(P)1	-3.3.3	3.02	1.14	.362	.557	.210	.273	.293	.0867	.162
1/T(P)2	1.854	-3.23	6.23	1.32	5.26	1.12	3.94	10.4	.580	.107
1/T(P)3	(2.31)	51.9	-35.6	-230.	-99.1	-617.	-207.	-108.	-2266.	-392.
N(R/DA)										
A(R)	35.2	113.	52.2	21.1	46.5	17.8	28.7	42.3	.0.05	33.0
1/T(R)1	-.00388	-.000790	-.00198	-.00154	-.00152	-.00400	-.0015	-.000416	-.00534	-.000281
2(R)1	*410	*553	*397	*273	*374	*248	*365	*500	*24.8	*54.7
W(R)1	3.37	5.67	3.81	2.35	2.95	2.31	3.36	2.96	1.35	3.49
N(PH/DA)										
A(PH)	1.59	4.85	2.09	778	1.46	403	993	1.08	.0579	1.13
1/T(PH)1	.895	1.95	.770	.310	.501	.190	.239	.289	.0786	.105
2(PH)1	2.67	*279	*150	*C615	*C559	*0493	*0677	*0152	*10	*0111
W(PH)1	3.96	3.67	4.22	4.45	5.20	5.83	4.74	4.78	8.07	4.27
N(AYP/DA)										
A(AYP)	35.3	114.	52.3	21.2	46.6	17.9	28.8	42.3	8.07	33.1
1/T(AYP)1	*409	*553	*397	*270	*373	*245	*264	*500	*235	*54.6
2(AYP)1	3.37	5.67	3.81	2.36	3.96	2.33	3.35	3.06	1.30	3.49
N(AYP/UA)										
A(AYP)	91.9	300.	136.	54.1	116.	42.7	72.2	97.6	17.5	94.7
1/T(AYP)1	-.635	-.533	.488	.235	.312	.164	.208	.228	*C826	*.0067
1/T(AYP)2	.668	.820	-.578	-.670	-.656	-.672	-.744	-.1.21	-.1.65	-.1.95
Z(AYP)1	*412	*522	*289	*234	*374	*342	*390	*523	*827	*597
W(AYP)1	3.46	5.58	3.90	2.46	4.10	2.38	3.52	4.35	1.30	4.38

X-15 VERTICAL STABILIZER TRANSFER FUNCTION FACTORS

TABLE V-10

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	+	+	3	4	+	+	5	6	+	+	7	8	+	+	9	+	+	10
H	SL	SL	.	20 K	.800	40 K	1.20	K	60 K	2.00	K	60 K	3.00	K	80 K	1.60	K	80 K	6.00	
M	.500	.800	.	.800	.	.800	.	K	1.20	K	1.20	K	2.00	K	3.00	K	1.60	K	6.00	
DENOMINATOR																				
$1/T(\text{DET})_1$	-0.0464	-0.328	-0.0343	-0.0315	-0.0277	-0.0312	-0.0173	-0.0131	-0.00528	-0.00350	-0.00528	-0.00350	-0.00528	-0.00528	-0.00528	-0.00528	-0.00528	-0.00528		
$1/T(\text{DET})_2$	19.3	56.2	27.1	11.1	24.0	9.30	14.8	21.6	3.58	16.4	3.58	16.4	3.58	16.4	3.58	16.4	3.58	16.4		
$Z(\text{DET})_1$.419	.556	.408	.322	.390	.298	.385	.518	.507	.564	.507	.564	.507	.564	.507	.564	.507	.564		
$W(\text{DET})_1$	3.37	5.75	3.81	2.33	3.93	2.21	3.32	3.94	3.32	3.94	3.32	3.94	3.32	3.94	3.32	3.94	3.32	3.94		
NUMERATORS																				
$N(D_V/D_V)$																				
$A(3)$.137	.224	.0348	.0505	.0821	.0326	.0426	.0503	.0143	.0241	.0241	.0241	.0241	.0241	.0241	.0241	.0241	.0241	.0241	
$1/T(B)_1$	-0.0492	-0.306	-0.0348	-0.0423	-0.0250	-0.0300	-0.0160	-0.0101	-0.0286	-0.00544	-0.00544	-0.00544	-0.00544	-0.00544	-0.00544	-0.00544	-0.00544	-0.00544	-0.00544	
$1/T(R)_2$	17.5	56.9	25.6	9.37	22.1	7.11	14.0	21.2	2.99	16.4	2.99	16.4	2.99	16.4	2.99	16.4	2.99	16.4		
$1/T(R)_3$	49.0	73.6	69.1	67.2	103.	109.	172.	239.	146.	492.	146.	492.	146.	492.	146.	492.	146.	492.	146.	
$N(P/D_V)$																				
$A(P)_1$	5.67	15.0	6.60	2.55	11.9	4.21	5.38	6.88	1.20	6.54	1.20	6.54	1.20	6.54	1.20	6.54	1.20	6.54	1.20	
$1/T(P)_1$	-0.00206	-0.0100	.00252	-.00536	-.00173	-.00474	-.00133	-.00458	-.00534	-.000275	-.000275	-.000275	-.000275	-.000275	-.000275	-.000275	-.000275	-.000275	-.000275	
$1/T(P)_2$.230	-.469	.0371	1.17	-.691	-.250	-.427	-.1.33	2.09	1.95	2.09	1.95	2.09	1.95	2.09	1.95	2.09	1.95	2.09	
$1/T(P)_3$	-15.8	-50.6	-25.5	-12.5	-12.4	-5.26	-16.4	-30.6	-7.86	26.1	-7.86	26.1	-7.86	26.1	-7.86	26.1	-7.86	26.1	-7.86	
$N(R/D_V)$																				
$A(R)_1$	-5.81	-14.9	-7.09	-2.97	-7.50	-2.88	-6.90	-11.7	-11.7	-12.2	-12.2	-12.2	-12.2	-12.2	-12.2	-12.2	-12.2	-12.2	-12.2	
$1/T(R)_1$	20.9	-0.885	-.0147	11.9	-.107	-.0770	-.0670	-.0898	-.0898	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	
$Z(R)_1$.811	(.819)	(.0987)	-.448	(.151)	(.0810)	(.0983)	(.141)	(.141)	.857	.857	.857	.857	.857	.857	.857	.857	.857	.857	
$W(R)_1$.0719	(63.1)	(29.2)	.204	(26.1)	(9.98)	(15.8)	(22.6)	(3.74)	.0927	.0927	.0927	.0927	.0927	.0927	.0927	.0927	.0927	.0927	
$N(\text{PHI}/D_V)$																				
$A(\text{PHI})_1$	5.46	14.7	6.23	2.15	11.5	3.79	4.90	6.44	7.24	-7.18	-7.18	-7.18	-7.18	-7.18	-7.18	-7.18	-7.18	-7.18	-7.18	
$1/T(\text{PHI})_1$.219	-.455	.0423	1.06	-.639	-.211	-.391	-.1.26	2.01	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	
$1/T(\text{PHI})_2$	-18.5	-53.2	-28.7	-16.8	-13.9	-7.03	-19.7	-34.5	-14.5	25.2	-14.5	25.2	-14.5	25.2	-14.5	25.2	-14.5	25.2	-14.5	
$N(\text{AYP}/D_V)$																				
$A(\text{AYP})_1$	-19.8	-46.9	-24.9	-10.7	-19.4	-7.07	-35.5	-58.0	-9.07	-103*	-103*	-103*	-103*	-103*	-103*	-103*	-103*	-103*	-103*	
$1/T(\text{AYP})_1$	-0.0508	-0.0269	-.0351	-.0465	-.0243	-.0298	-.0159	-.0094	-.0298	-0.0547	-0.0547	-0.0547	-0.0547	-0.0547	-0.0547	-0.0547	-0.0547	-0.0547	-0.0547	
$1/T(\text{AYP})_2$	44.9	02.4	24.2	80.4	30.0	26.7	36.1	4.86	4.86	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	
$Z(\text{AYP})_1$	-0.0560	-0.206	-.0680	-.1119	-.0320	-.0670	-.0106	.492	.492	.0515	.0515	.0515	.0515	.0515	.0515	.0515	.0515	.0515	.0515	
$W(\text{AYP})_1$	2.62	3.61	3.01	2.19	3.26	2.24	3.51	5.79	5.79	2.5C										

TABLE V-11

X-15 LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS
(BODY AXIS SYSTEM)

	SAS Off									
	(BODY AXIS SYSTEM)									
	+	+	+	+	+	+	+	+	+	+
F/C *	1	2	3	4	5	6	7	8	9	10
H	SL	SL	20 K	40 K	60 K	60 K	60 K	80 K	80 K	80 K
M	.500	.800	.800	.800	1.20	1.20	2.00	3.00	1.60	6.00
DR PERIOD (SEC)	1.89	1.13	1.67	2.39	1.59	2.59	1.88	1.62	2.88	1.79
I/C(1/2)	1.36	1.32	1.01	.871	.685	.566	.456	.476	.720	.274
SPIRAL (2) (SEC)	--	--	--	--	--	1550.	321.	375.	--	702.
P(1)	13.6	28.8	24.5	15.8	28.2	23.0	--	39.5	3.99	--
P(2)	--	--	--	14.7	--	22.5	--	--	2.96	--
P(3)	--	--	--	15.6	--	23.0	--	--	8.59	--
P(2)/P(1)	--	--	--	.929	--	.982	--	--	.742	--
P(DSC)/P(AV)	--	--	--	.0326	--	.0101	--	--	.360	--
W(PHI)/W(D)	.993	1.00	.997	.894	.994	.954	.998	1.01	.631	.985
DEL-B-MAX	.0324	.132	.0384	.398	.100	.543	.153	.0631	.685	.104
PHI TO BETA, PHASE	22.3	-3.41	17.5	14.2	9.05	13.9	30.0	191.	3.58	7.48
PHI TO BETA	.888	.0391	.699	2.14	.484	.755	.144	1.11	2.46	1.58
PHI TO VE	.0911	.00251	.0662	.318	.0480	.121	.0139	.0709	.472	.0809
	+	+	+	+	+	+	+	+	+	+

X-15 DATA SOURCES

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SECTION VI

HL-10

HL-10 BACKGROUND

The HL-10 is one of a number of lifting body research vehicles. The airplane is typically launched from a B-52 at 0.8 Mach and 45,000 feet. In numerous glide and powered flights the HL-10 has been flown in excess of 1.8 Mach and 90,000 feet.

Following problems involving the loss of roll-control effectiveness, the leading edge of the tip fins was modified. This became known as the Mod II configuration. The information contained here is for the Mod II HL-10.

Pitch and roll control is obtained by elevons and yaw control by a conventional rudder. A subsonic or a transonic configuration is selected using combinations of speed brakes, elevon flaps, and tip fin flaps. These combinations are specified in Fig. VI-1.

The stability augmentation system consists of angular rate feedback loops about all three axes.

The flight conditions shown correspond to actual flight test points.

Nominal Configuration

Zero fuel (burnout)

Gear up

Transonic or subsonic configuration
depending upon flight condition

$$W = 6466 \text{ lb}$$

$$\text{c.g. at } .517 \bar{c}, \text{ W.L. } 94.4$$

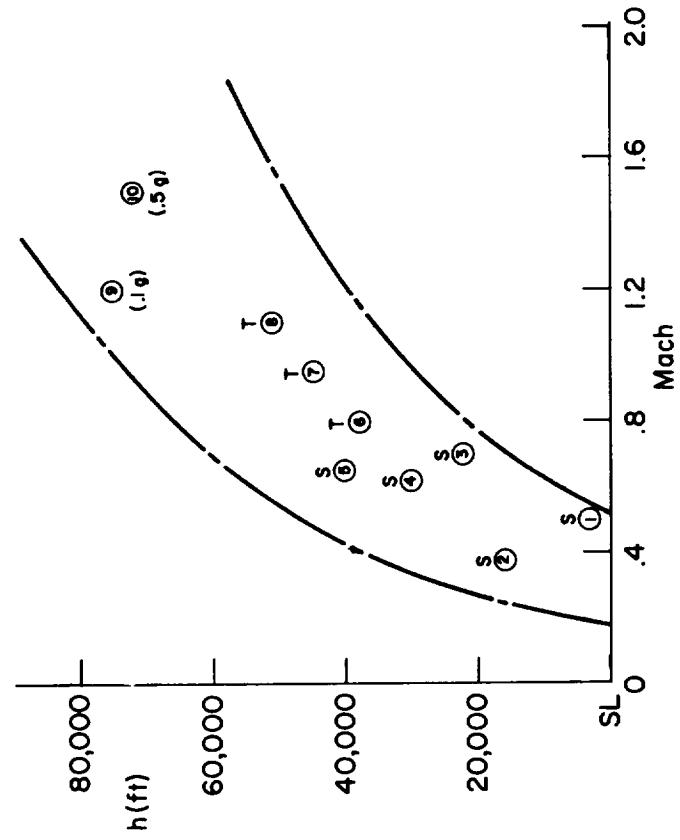
$$I_x = 1353 \text{ slug-ft}^2$$

$$I_y = 6413 \text{ slug-ft}^2$$

$$I_z = 7407 \text{ slug-ft}^2$$

$$I_{xz} = 399 \text{ slug-ft}^2$$

Body Axis

Flight Envelope

Nominal Envelope Extremes

Transfer Function Case n
(S ≈ Subsonic, T ≈ Transonic)**Note:**

Configuration	Speed Brakes	Elevon Flaps	Tip-Fin Flaps
Subsonic	Zero	Zero	Zero
Transonic	8°	30°	30.5°/32.5°

Figure VI-1. HL-10 Flight Conditions

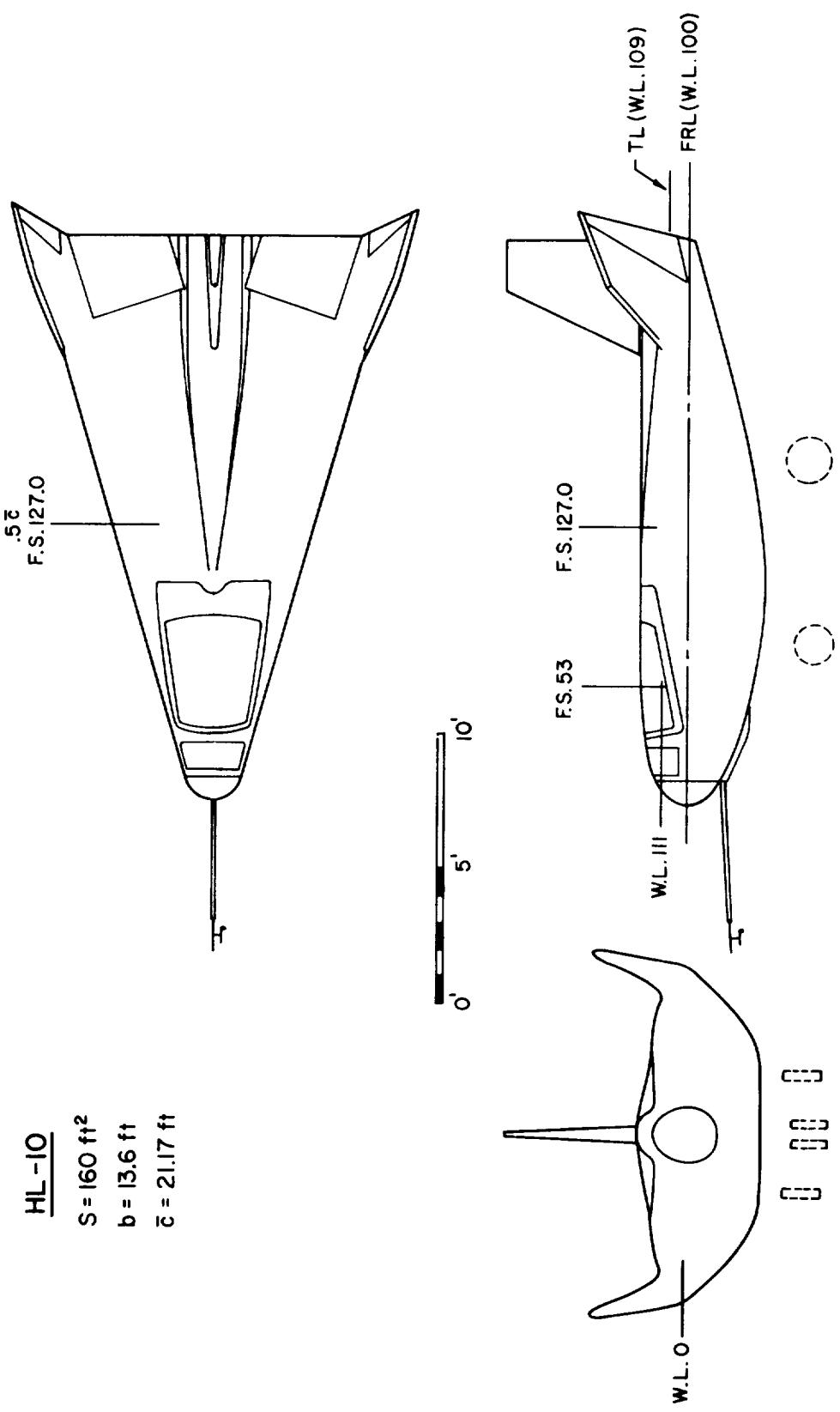
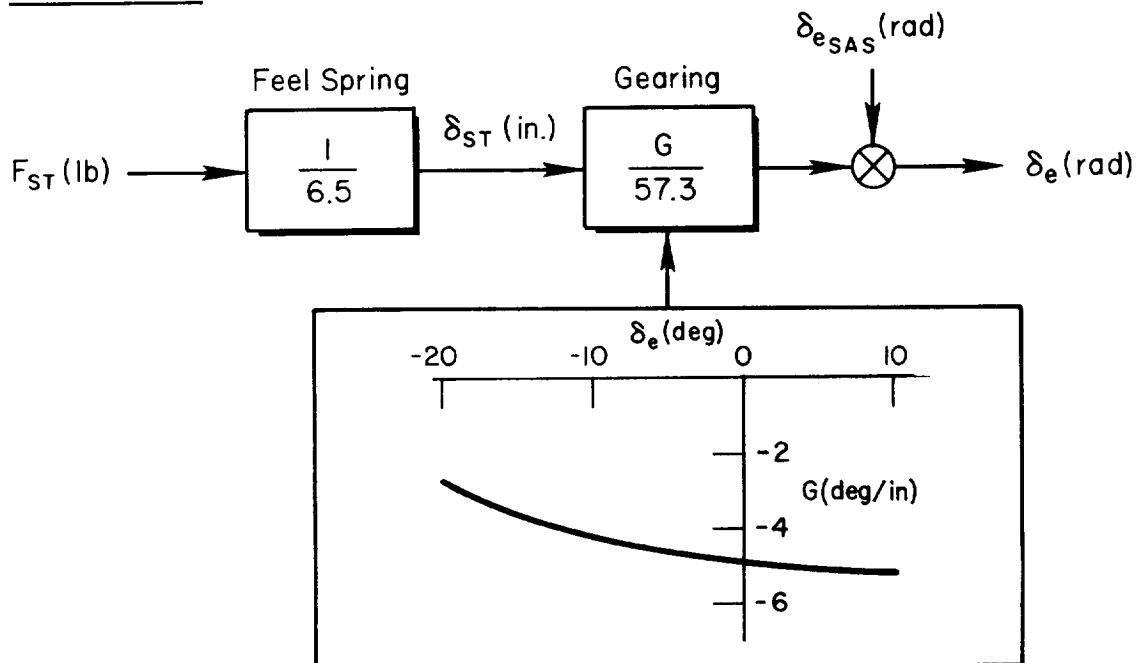


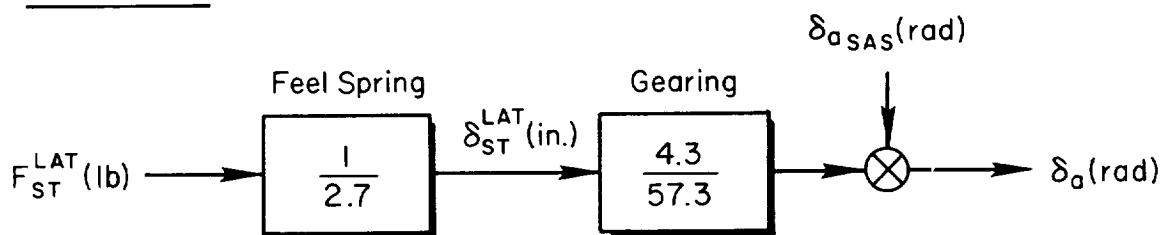
Figure VI-2. HL-10 General Arrangement

HL-10

PITCH AXIS



ROLL AXIS



YAW AXIS

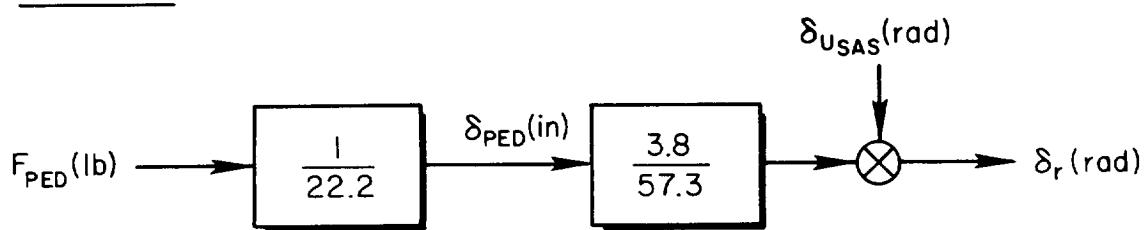
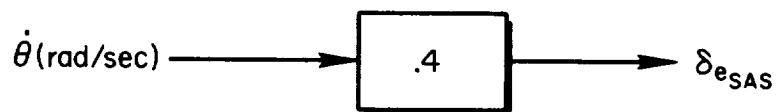


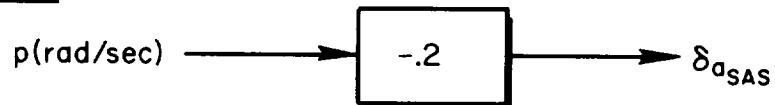
Figure VI-3. HL-10 Control System

HL-10

PITCH SAS



ROLL SAS



YAW SAS

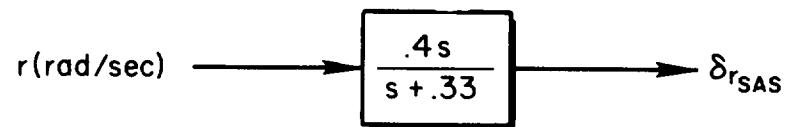
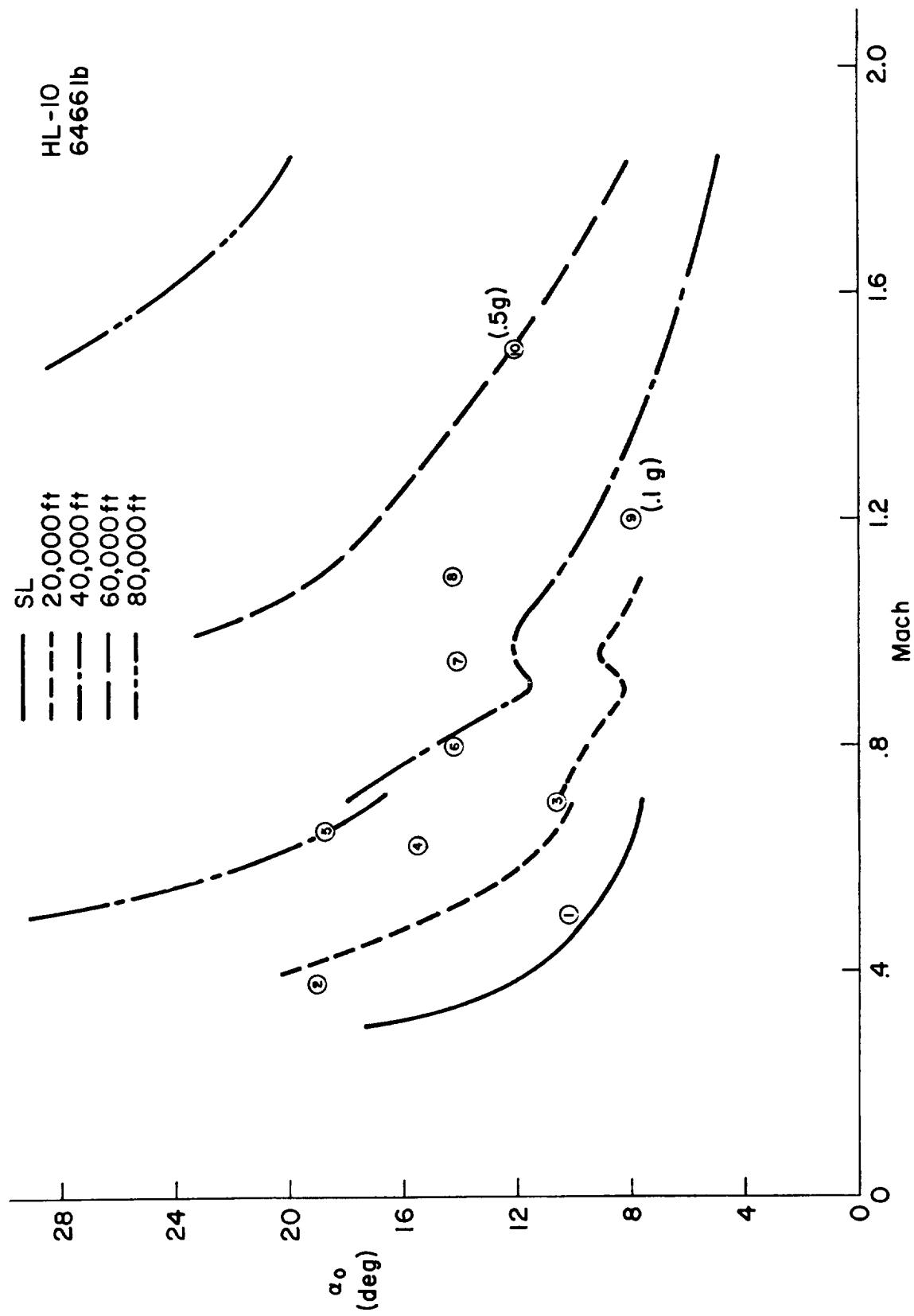
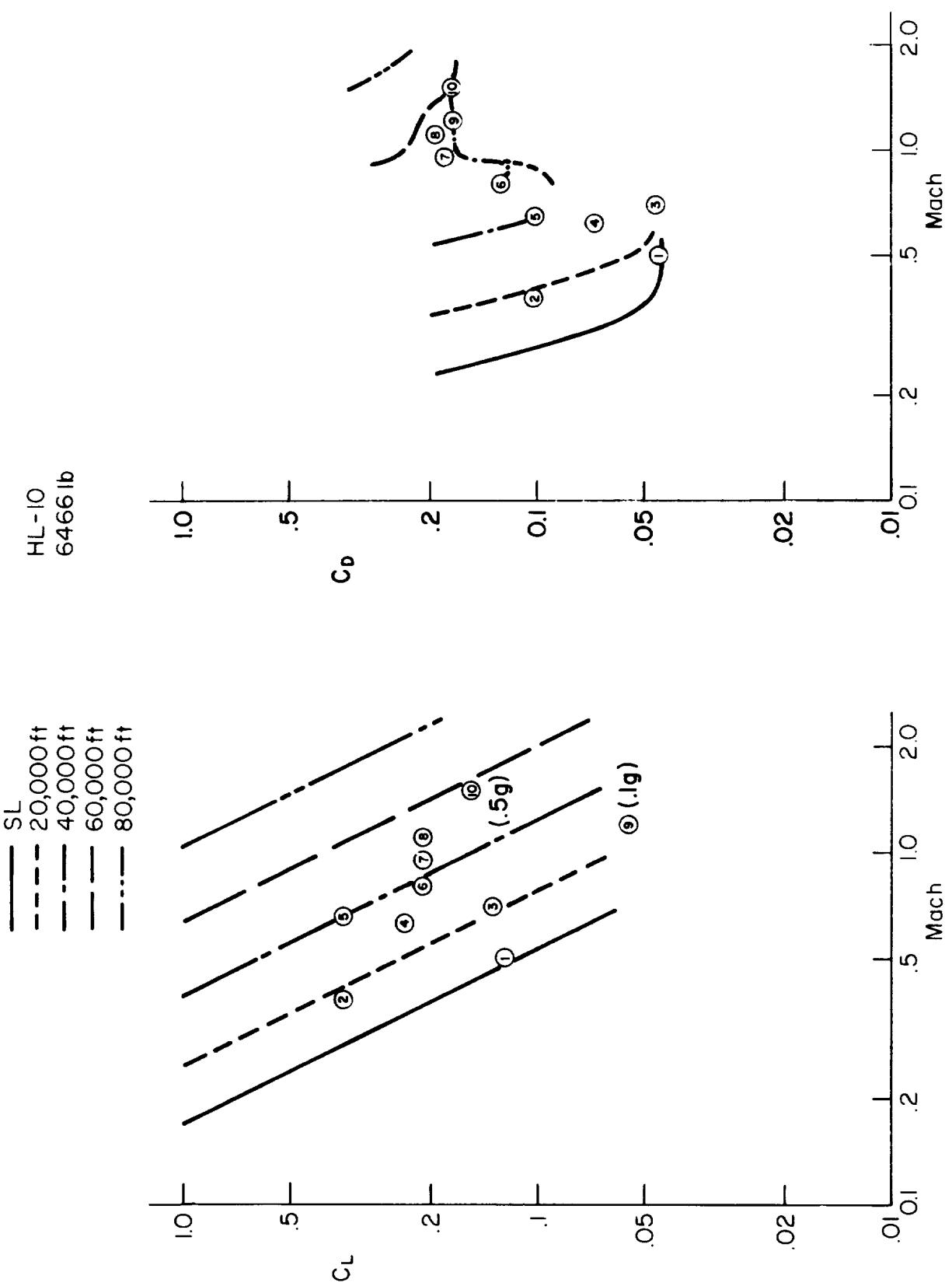
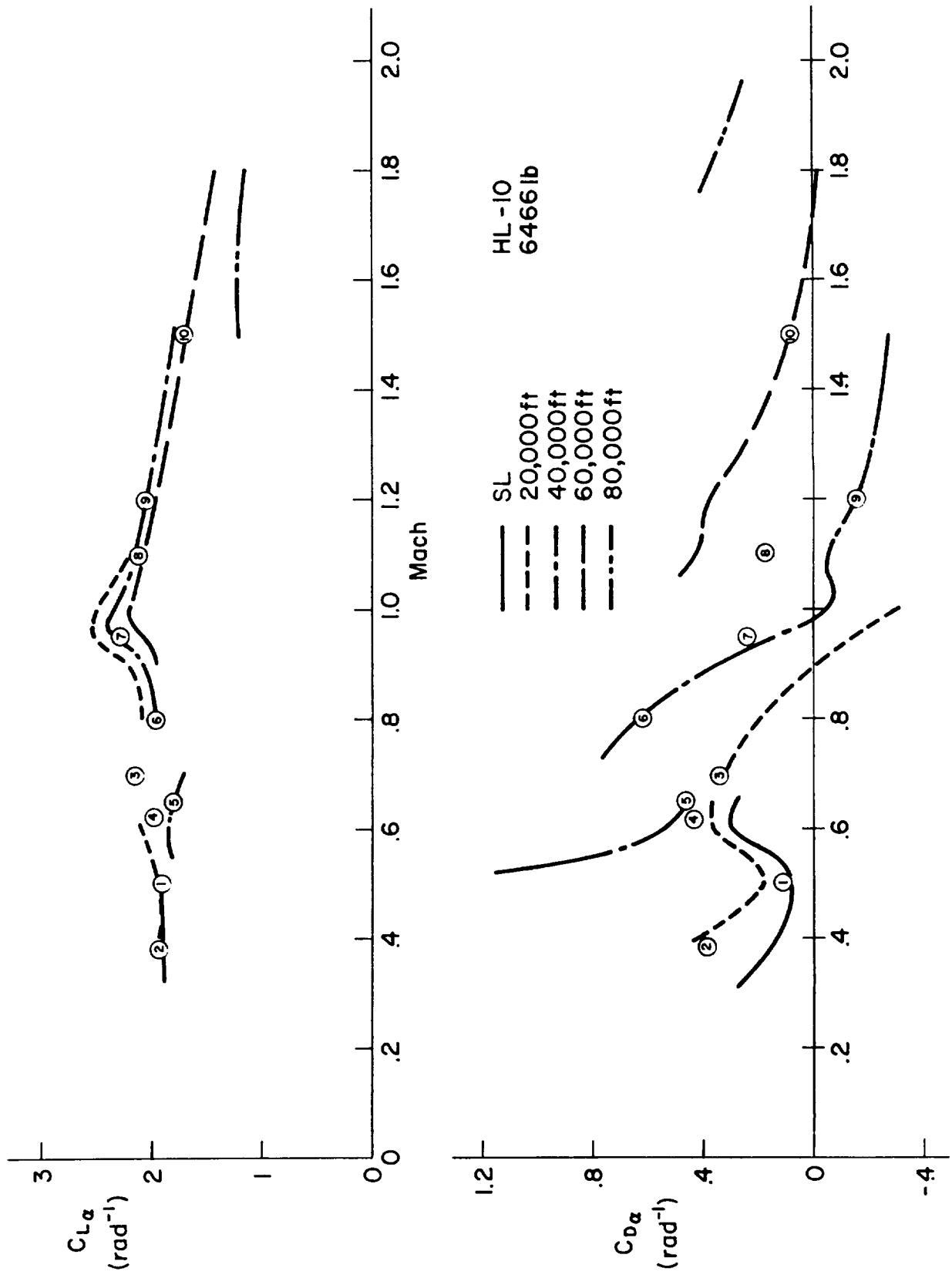
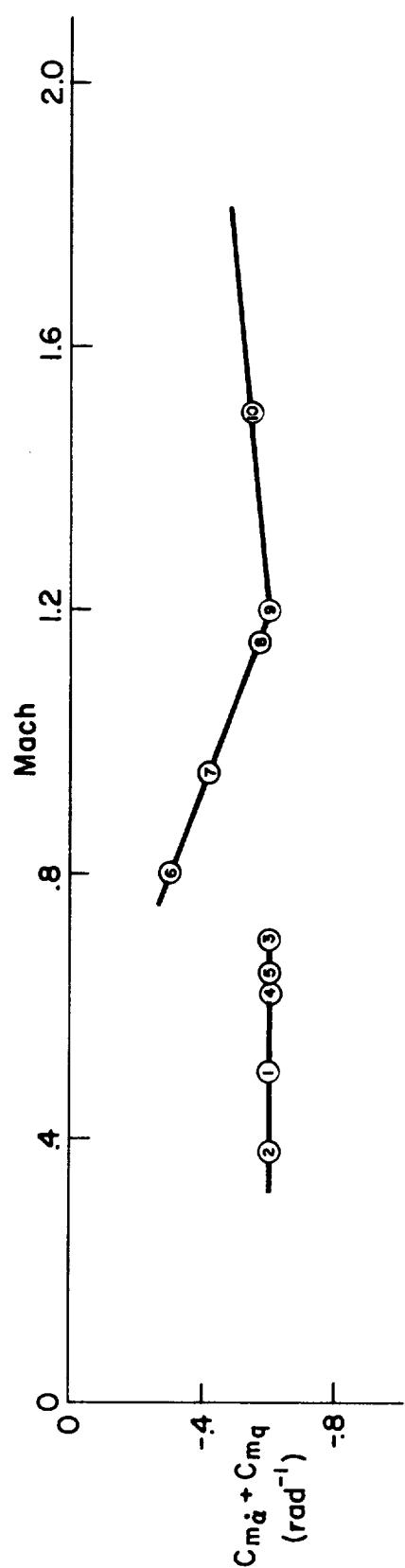
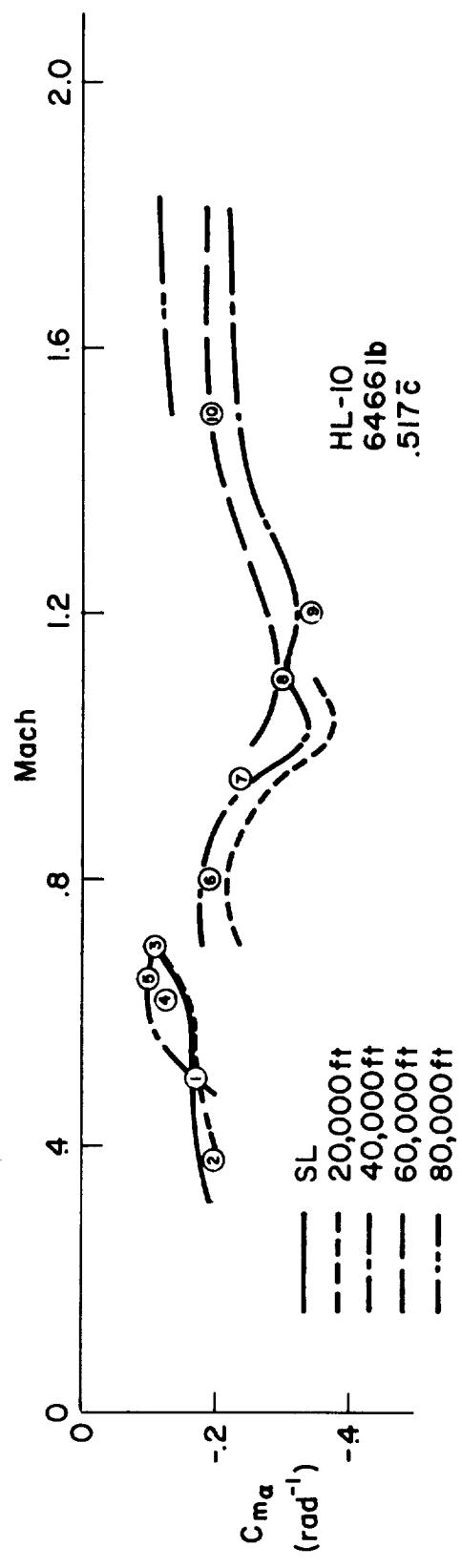


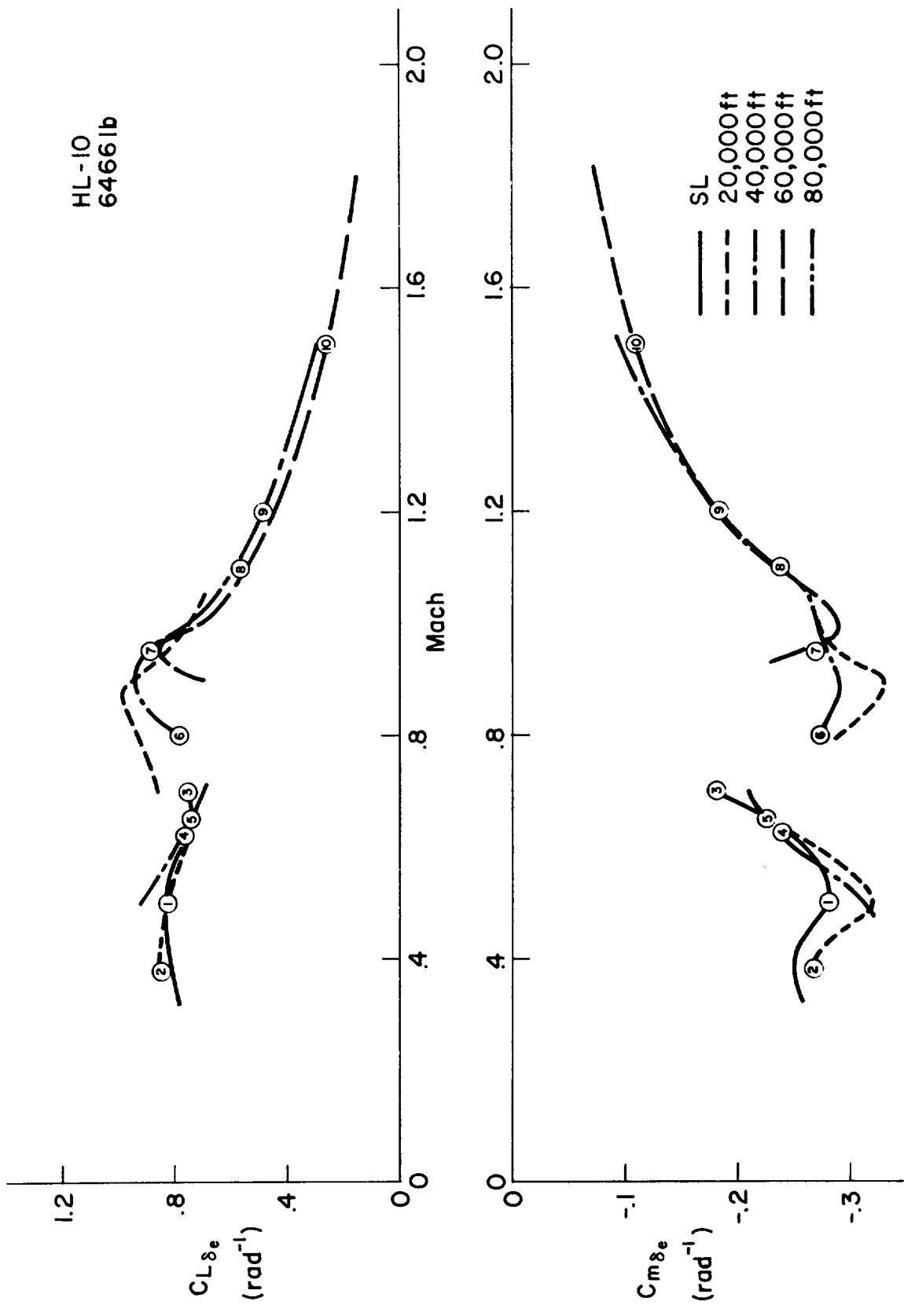
Figure VI-4. HL-10 Stability Augmentation

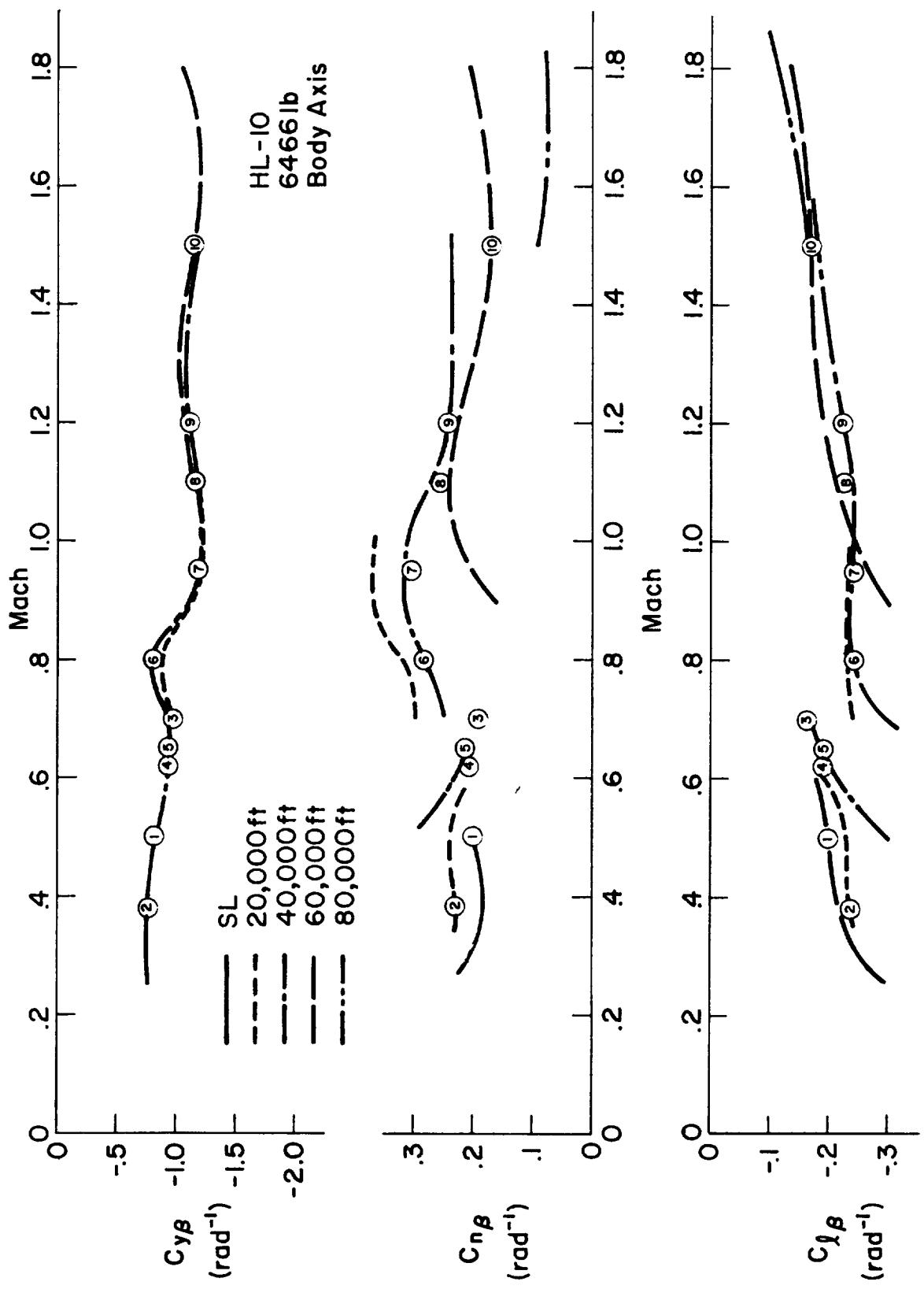


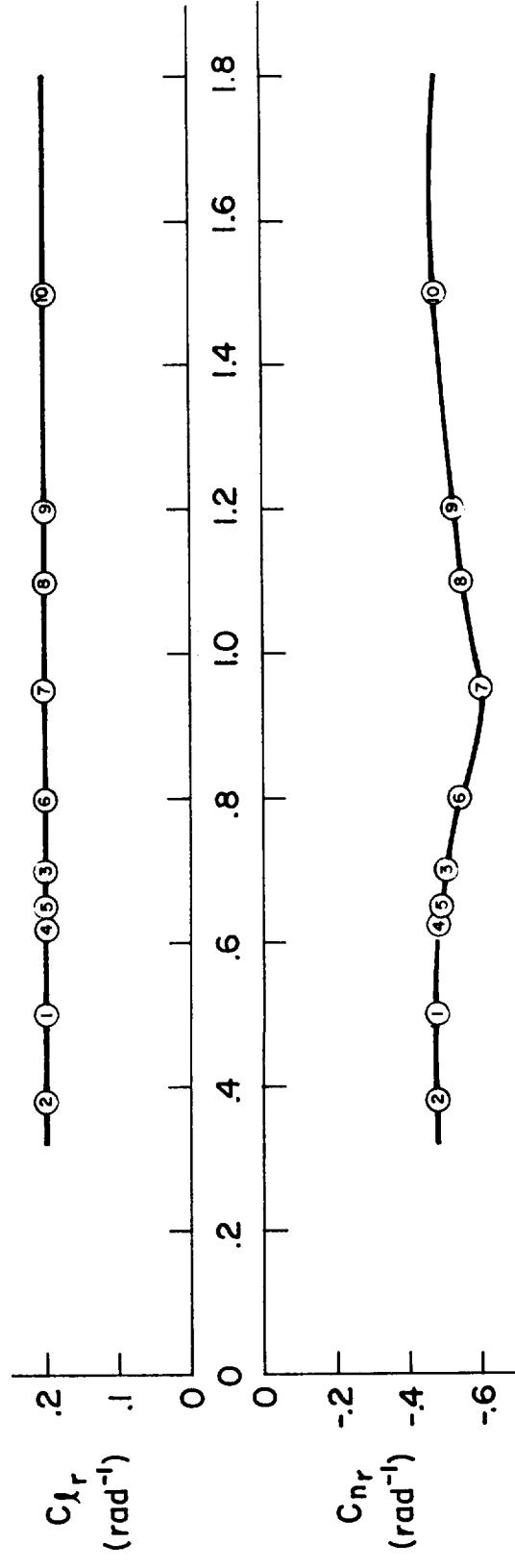
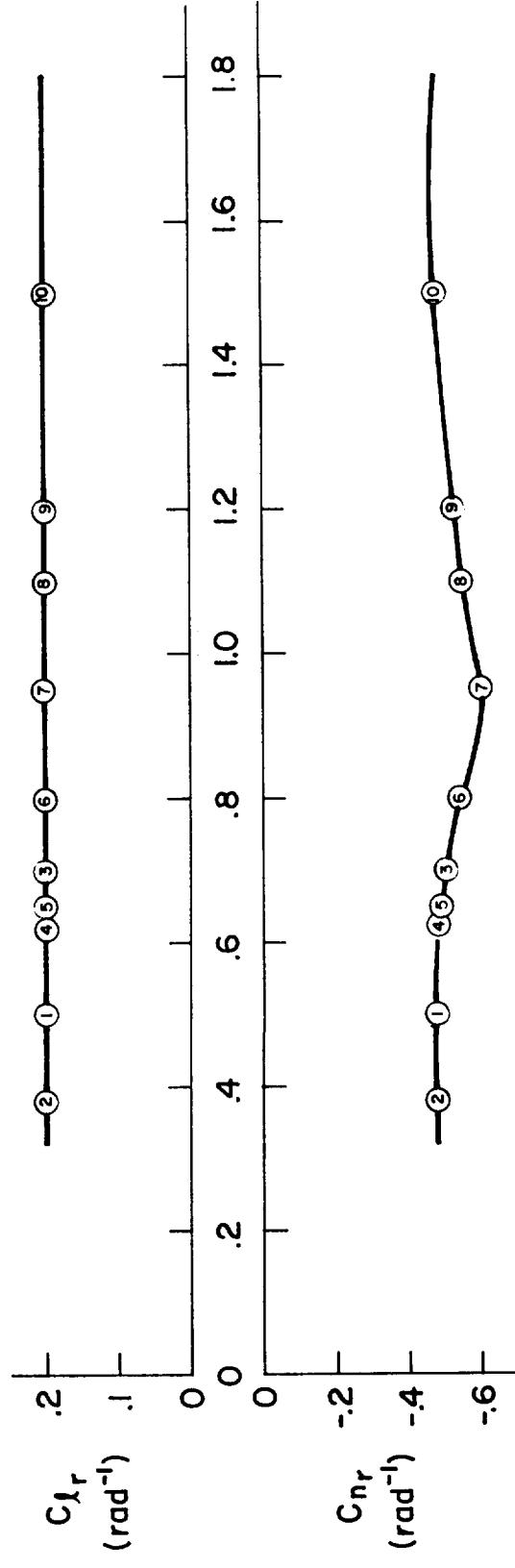
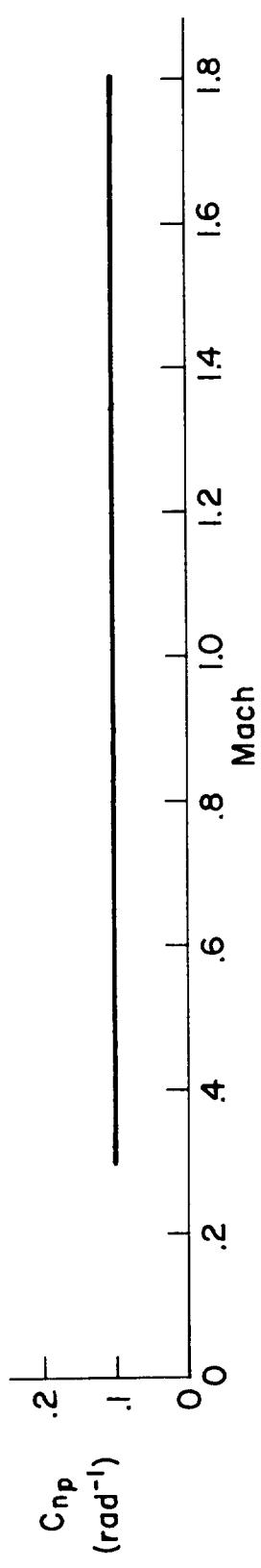
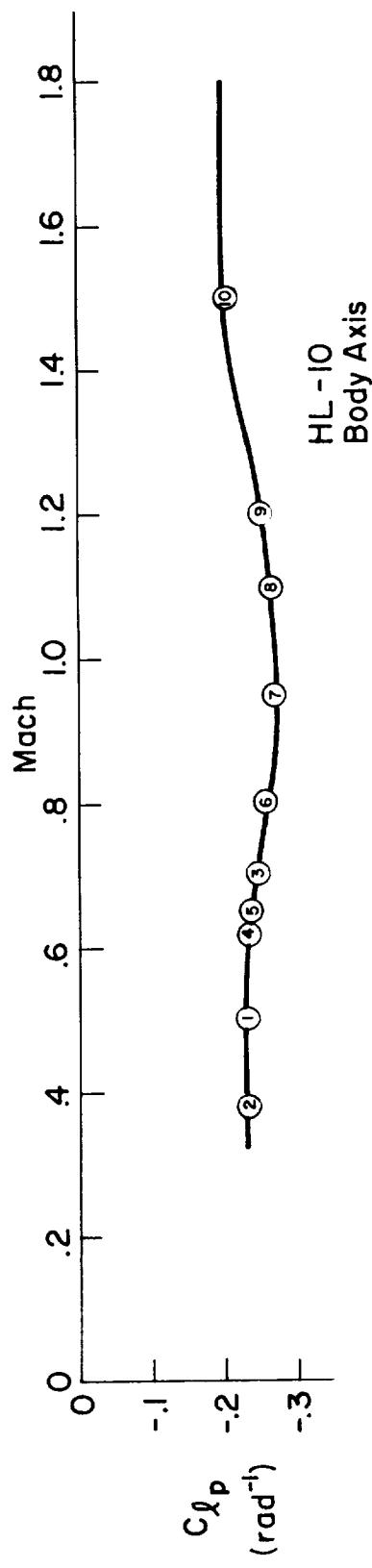


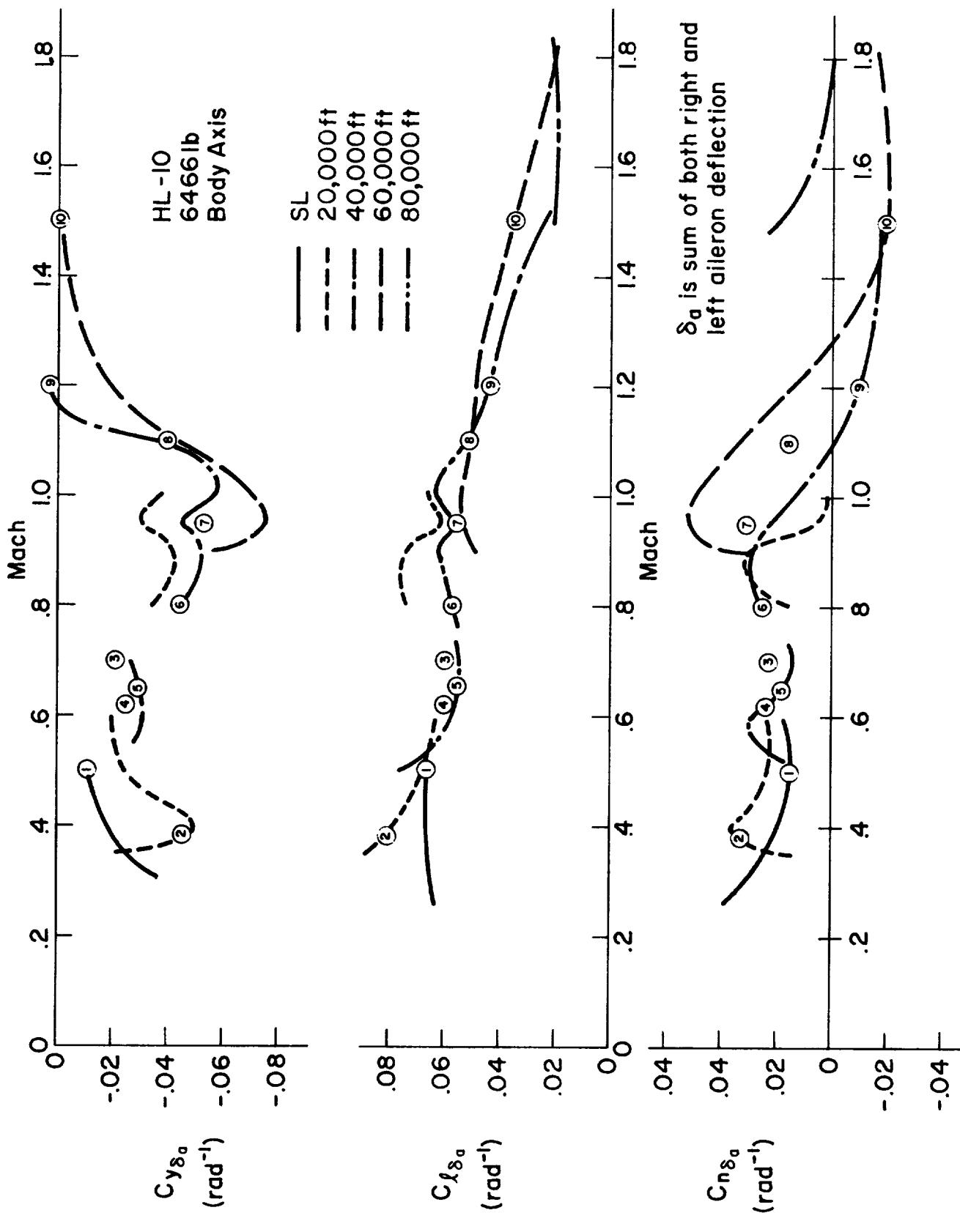












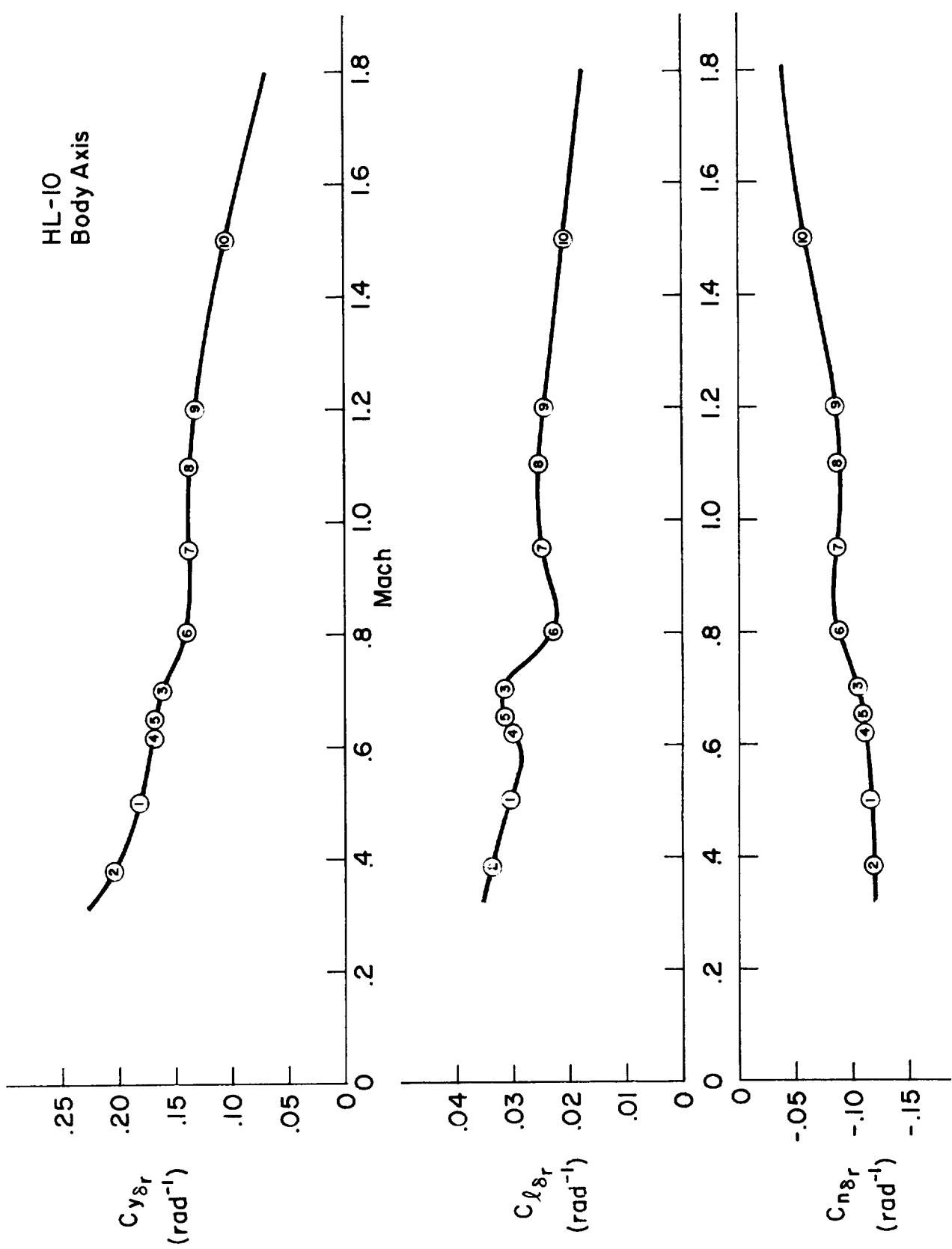


TABLE VI-1

HL-10 DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

$s = 160.0 \text{ sq ft}$, $b = 13.60 \text{ ft}$, $\bar{c} = 21.17 \text{ ft}$

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M(-)	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
VTO(FPS)	552.	400.	720.	617.	629.	774.	920.	1064.	1160.	1458.
VTO(KTAS)	327.	237.	427.	365.	373.	459.	545.	631.	692.	864.
VTO(KCAS)	313.	187.	311.	231.	193.	254.	263.	273.	175.	244.
W(LBS)	6466.	6466.	6466.	6466.	6466.	6466.	6466.	6466.	6466.	6466.
C.G.(MGC)	.517	.517	.517	.517	.517	.517	.517	.517	.517	.517
I _X (SLUG-FT SQ)	1353.	1353.	1353.	1353.	1353.	1353.	1353.	1353.	1353.	1353.
I _Y (SLUG-FT SQ)	6413.	6413.	6413.	6413.	6413.	6413.	6413.	6413.	6413.	6413.
I _Z (SLUG-FT SC)	7407.	7407.	7407.	7407.	7407.	7407.	7407.	7407.	7407.	7407.
I _{XZ} (SLUG-FT SQ)	399.	399.	399.	399.	399.	399.	399.	399.	399.	399.
EPSILON(DEG)	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75
Q(PSF)	329.	116.	307.	169.	117.	197.	196.	197.	75.3	136.
QC(PSF)	351.	120.	346.	186.	129.	228.	244.	264.	105.	208.
ALPHA(DEG)	10.2	19.0	10.6	15.5	18.8	14.2	14.1	14.2	8.00	12.0
GAMMA(DEG)	-32.0	-14.0	-26.0	-26.0	-23.0	-25.0	-26.0	-35.0	-15.0	14.0
LXP(FT)	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
LZP(FT)	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40	-1.40
ITH(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
XI(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20
	+	+	+	+	+	+	+	+	+	+

TABLE VI-2
HL-10 LONGITUDINAL DIMENSIONAL DERIVATIVES
 (Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.550	.800	.950	1.10	1.20	1.50
XU *	-.0509	-.0401	-.0260	-.0227	-.0191	-.0325	-.0648	-.0597	-.0200	-.0273
ZU *	.0383	-.0122	.0417	.0175	-.0143	.0128	.0182	.00842	.00754	.000742
MU *	.00463	.00596	.00225	.00217	.00136	.00400	.00479	.00478	.00130	.00258
XW	.164	.140	.0637	.0777	.0727	.0148	.0851	.0763	.0242	.0293
ZW	-.916	-.481	-.742	-.459	-.291	-.432	-.417	-.334	-.111	-.137
MW	-.0305	-.0166	-.0141	-.0132	-.00548	-.0139	-.0148	-.0162	-.02663	-.00493
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MQ	-.662	-.321	-.472	-.305	-.205	-.139	-.165	-.199	-.0714	-.0945
XDE	38.1	25.6	33.7	27.7	22.1	29.6	33.5	21.6	4.01	5.84
ZDE	-212.	-74.2	-180.	-98.7	-65.0	-117.	-132.	-85.3	-26.5	-27.5
MDE	-28.0	-9.51	-16.8	-12.3	-7.97	-16.2	-16.1	-14.2	-4.23	-4.53
	+	+	+	+	+	+	+	+	+	+

TABLE VI-3

ML-10 ELEVATOR TRANSFER FUNCTION FACTORS

SAS Off

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
H	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DE NUMINATOR										
Z(DET)1	*46.9	*28.3	*40.3	*363	*333	*526	*618	*697	*609	*362
W(DET)1	*0760	*117	*0581	*0632	*0651	*0676	*0636	*0531	*0209	*0345
Z(DET)2	*186	*145	*184	*145	*125	*0794	*0751	*0610	*0316	*0418
W(DET)2	4.19	2.68	3.25	2.56	1.89	3.35	3.79	4.25	2.81	2.80
NUMERATORS										
N(W/DE)										
A(W)	38.1	25.6	33.7	27.7	22.1	29.6	33.5	21.6	4.01	*5.84
1/T(W)1	72.3	48.6	66.1	73.7	73.0	*138	108.	172.	172.	235.
Z(W)1	*34.6	*53.6	*862	*399	*601	(*402)	*539	*467	*602	*467
W(W)1	*44.0	*298	*369	*265	*196	(*104.)	*199	*158	*112	*106
N(W/DE)										
A(W)	-212.	-74.2	-180.	-98.7	-65.0	-117.	-133.	-85.3	-28.5	-27.5
1/T(W)1	*0158	*48.8	-.C12C	*00853	73.2	104.	108.	*0320	*0566	*0557
1/T(W)2	*0500	(*267)	*0422	*0191	(*369)	(*629)	(*991)	*0366	*0164	*0115
1/T(W)3	72.5	(* .0690)	66.4	74.6	(* .0378)	(* .0296)	(* .0341)	172.	172.	235.
N(TH/DE)										
A(TH)	-28.0	-9.51	-16.8	-12.3	-7.97	-16.2	-16.1	-14.2	-4.23	-4.53
1/T(TH)1	*0440	*0423	*0204	*0178	*0218	*0246	*0592	*0583	*0193	*0282
1/T(TH)2	*686	*334	*594	*378	*239	*332	*289	*231	*0661	*103
N(HD/DE)										
A(HD)	182.	76.2	165.	92.0	63.2	109.	123.	72.0	27.8	27.2
1/T(HD)1	*0650	*0207	*0325	*0265	*0199	*0292	*0632	*0647	*0215	*0167
1/T(HD)2	-6.69	-3.83	-6.16	-5.22	-4.07	-5.93	-5.50	-6.18	-3.31	-4.97
1/T(HD)3	7.34	4.18	6.60	5.51	4.28	6.06	5.67	6.37	3.38	5.07
N(AZP/DE)										
A(AZP)	-29.6	-12.4	-71.1	-18.5	-13.3	-11.5	-28.7	7.01	-1.00	1.08
1/T(AZP)1	*0218	*0105	*0107	*0098	*00613	*00918	*0782	*0117	*00350	*0108
1/T(AZP)2	*0445	*0301	*0229	*0175	*0142	*0218	*0571	*0552	*0186	*0256
Z(AZP)1	(-18.5)	(-9.66)	(-9.84)	(-12.2)	(-5.18)	(17.8)	(11.0)	(1.042	(-17.9)	*00687
W(AZP)1	(19.0)	(9.95)	(10.1)	(-12.3)	(-5.26)	(-19.4)	(-12.2)	(-22.0)	(18.1)	(18.4)

TABLE VI-14

HI-10 ELEVATOR TRANSFER FUNCTION FACTORS

SAS On

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K .500	16 K .380	22 K .700	30 K .620	40 K .650	38 K .800	45 K .950	51 K 1.10	75 K 1.20	72 K 1.50
DE NCMINATOR	{ 2.42 (1.03)	*267 -109	{ 2.86 (5.06)	*342 -0561	*315 -0594	*503 -0625	*629 -0650	*705 -0672	*610 -0514	*263 -0207
Z(DET)1	{ 1.03 (1.49)	*792 -792	{ 391 -391	*986 -883	*896 -969	*883 -969	*872 -901	*706 -639	*610 -231	*341 -2.83
W(DET)2	{ 0.36 (0.97)	*2.90 -0.497		2.88 -0.497	2.07 -1.96	3.63 -1.04	4.01 -1.12	4.39 -1.15	2.83 -1.12	2.83 -1.12
NUMERATORS										
N(U/DE)	38.1	25.6	33.7	27.7	22.1	29.6	33.5	21.6	4.24	5.24
A(U)	72.3	48.6	66.1	73.7	73.0	138	108.	172.	235.	235.
1/T(W)1	*346	*53.6	*862	*699	*601	{ 4.02 -1.96	*539 -1.96	*467 -1.96	*447 -1.96	*447 -1.96
Z(U)1	*440	*365	*298	*265						
1/T(W)2										
1/T(W)3										
N(W/DE)										
A(W)	-212.	-74.2	-180.	-98.7	-65.0	-117.	-133.	-85.3	-28.5	-27.5
1/T(W)1	*0158	*48.8	-CL2C { 267	*C0853 *0422	*C191 *369	{ 1C4. -629	{ 108. -91	*0520 *0366	*00596 *0164	*00571 *0115
1/T(W)2	*0500									
1/T(W)3	72.5	{ 0.6901	66.4	74.6	{ .03781	{ .02961	{ .03411	172.	172.	235.
N(THE/DE)										
A(THE)	-28.0	-9.51	-16.8	-12.3	-7.97	-16.2	-16.1	-14.2	-4.23	-4.23
1/T(THE)1	*0440	*0423	*0204	*0178	*0218	*0246	*0599	*0583	*0193	*0202
1/T(THE)2	*686	*234	*594	*378	*239	*332	*289	*231	*0561	*193
1/T(THE)3										
N(HD/DE)										
A(HD)	182.	76.2	165.	92.0	63.2	109.	123.	72.0	27.8	27.2
1/T(HD)1	*0650	*0207	*0325	*026;	*0199	*0292	*0632	*0647	*0215	*0167
1/T(HD)2	-6.69	-3.83	-6.16	-5.22	-4.07	-5.93	-5.50	-6.18	-3.31	-4.97
1/T(HD)3	7.34	4.18	6.60	5.51	4.28	6.06	5.67	6.37	3.38	5.07
N(AZP/DE)										
A(AZP)	-29.6	-12.4	-71.1	-18.5	-13.3	-11.5	-28.7	7.01	-1.00	1.08
1/T(AZP)1	*0218	-0.0105	*0107	*00983	*00613	*00918	*00782	*0117	*00250	*0108
1/T(AZP)2	*0645	*0301	*0225	*0173	*0142	*0218	*0571	*0552	*0186	*0256
Z(AZP)1	{ -18.5	{ -9.66	{ 12.2	{ -5.18	{ 17.8	{ 11.0	{ 11.0	{ 11.0	{ -17.0	{ -17.0
W(AZP)1	{ 19.0	{ 9.95	{ 10.1	{ -12.31	{ 5.26	{ -19.4	{ -12.2	{ 22.0	{ 18.1	{ 18.4

TABLE VI-5
HL-10 LONGITUDINAL HANDLING QUALITIES PARAMETERS
 SAS Off
 (Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
P	.500	.280	.700	.620	.650	.800	.950	1.10	1.20	1.50
STICK FIXED										
D(G) / D(U) (DEG/KT)	- .121	- .00405	- .0433	- .0134	.000279	- .0386	- .160	- .174	- .0449	- .0695
NZA (G/RAD)	11.5	4.11	12.9	6.94	4.54	7.72	8.14	7.58	2.39	4.76
DF/G (DEG/G)	3.03	9.36	2.70	4.14	5.26	4.80	5.81	8.92	43.5	18.7
CAP (RAD/SEC/SEC/G)	1.48	1.55	.791	.892	.731	1.36	1.63	2.21	3.21	1.48
PHUGOID(2) (SEC)	--	--	--	--	--	--	--	--	--	--
(TUCK(2))										
I/C(1/10)	.516	.400	.510	.399	.343	.217	.206	.167	.0861	.114
	+	+	+	+	+	+	+	+	+	+

TABLE VI-6

HL-10 LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
 (BODY AXES SYSTEM)

F/C #	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7	+ 8	+ 9	+ 10
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	*.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
YY	-.354	-.173	-.322	-.203	-.140	-.160	-.204	-.173	-.0564	-.0851
YB	-218.	-69.3	-232.	-125.	-88.2	-124.	-187.	-184.	-66.0	-124.
LB*	-102.	-43.1	-75.1	-49.5	-34.0	-71.4	-71.5	-69.7	-25.5	-34.5
NB*	13.9	5.51	13.1	7.79	5.53	12.4	14.0	11.0	3.94	4.91
LP*	-1.49	-.723	-1.13	-.686	-.473	-.710	-.627	-.524	-.175	-.201
NP*	*.0390	.0189	.0240	.0179	.0115	.0119	.00882	.00877	.00344	.00774
LR*	1.16	.561	.820	.532	.357	.477	.397	.351	.123	.180
NK*	-.458	-.248	-.382	-.235	-.162	-.245	-.234	-.185	-.0616	-.0795
Y*DA	-.00523	-.0104	-.00679	-.00547	-.00428	-.00899	-.00900	-.00590	.000154	0.
L'DA	36.C	15.5	30.7	17.0	10.7	18.5	18.2	16.7	5.23	7.52
N'DA	3.39	1.96	3.73	2.11	1.19	2.43	2.76	1.83	.0603	-.392
Y*DR	*.0665	.0473	.0553	.0372	.0251	.0280	.0233	.0202	.00677	.00777
L'DR	13.0	5.12	13.0	6.61	4.87	5.82	6.53	6.50	2.45	3.94
N'DR	-.10.6	-3.81	-8.77	-.5.12	-.3.51	-.4.65	-.4.60	-.4.87	-1.75	-2.18

TABLE VI-7
III-10 ATTENON TRANSFER FUNCTION FACTORS
SAS Off
(BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10			
M	.03 K .500	16 K .380	22 K .700	30 K .620	40 K .650	38 K .800	45 K .950	51 K 1.10	75 K 1.20	72 K 1.50			
DENOMINATOR													
1/T(DET)1	.0868	C796	.0509	.0548	.0440	.0434	.0367	.0375	.0249	.0201			
1/T(DET)2	.812	.383	.683	.375	.265	.417	.389	.298	.171	.124			
Z(DET)1	.132	C777	.107	.0762	.0579	.0602	.0574	.0518	.0179	.0320			
W(DET)1	5.64	4.39	5.17	4.55	4.02	5.44	5.57	5.27	2.73	3.46			
NUMERATORS													
A(D/DA)													
A(B)	-.00523	-C104	-.00679	-.00547	-.00428	-.00899	-.00900	-.00590	-.000154	1.95			
1/T(B)	-578.	-3C7.	-291.	-451.	-539.	-243.	-193.	-394.	.0874				
Z(B)	.172	.546	.415	.337	.587	.182	.0638	.318	(.152)	.973			
W(B)	.587	.358	.541	.313	.216	.315	.313	.201	(43.9.)	.0726			
V(P/DA)													
A(P)	36.0	15.5	30.7	17.0	10.7	18.5	18.2	16.7	5.23	7.52			
1/T(P)	.0218	-C0737	.0120	.00983	.00395	.00602	.00743	.0111	.00339	-.00987			
Z(P)	.103	C817	.0862	.0695	.0591	.0537	.0535	.0481	.0282	.0473			
W(P)	4.63	3.23	4.69	3.67	2.98	4.60	4.92	4.26	2.05	1.75			
V(R/DA)													
A(R)	3.39	1.96	3.73	2.11	1.19	2.43	2.76	1.83	.0603	-.392			
1/T(R)	.305	.247	.234	.192	.158	.167	.141	.115	.197	.0955			
Z(R)	(.148)	(.0725)	(.120)	(.0750)	(.0519)	(.0586)	(.0556)	(.0484)	(.0440)	-.50			
1/T(R)	(6.65)	(5.31)	(5.81)	(5.47)	(5.19)	(6.39)	(6.31)	(6.47)	(7.14)	3.54			
V(PHI/DA)													
A(PHI)	34.6	15.7	29.7	16.6	10.6	18.1	17.6	16.0	5.22	7.33			
Z(PHI)	.102	C807	.0853	.0702	.0598	.0541	.0538	.0487	.0291	.0419			
W(PHI)	4.74	3.26	4.64	3.62	2.95	4.54	4.87	4.13	2.02	1.86			
V(AYP/DA)													
A(AYP)													
1/T(AYP)1	69.5	3C.3	62.3	34.1	20.0	34.8	35.1	29.0	7.89	7.98			
1/T(AYP)2	-.293	.271	-.234	-.286	.200	.198	.207	.178	.0838	.0628			
1/T(AYP)3	.565	-.387	.506	-.320	-.498	-.216	-.228	-.332	-.617	.114			
1/T(AYP)4	(.123)	(.126)	(.0933)	(.111)	(.167)	(.0679)	(.0687)	(.0963)	(.283)	4.71			
	(4.45)	(3.10)	(4.33)	(3.22)	(4.62)	(4.62)	(4.62)	(3.34)	(1.19)	4.73			

TABLE VI-8
HL-10 RUDDER TRANSFER FUNCTION FACTORS
SAS Off

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
1/T (DET) 1	.0868	.C796	.0509	.0548	.0440	.0434	.0367	.0375	.0249	.0201
1/T (DET) 2	.812	.383	.683	.375	.265	.417	.389	.298	.171	.124
Z (DET) 1	.132	.C777	.107	.0762	.0579	.0602	.0574	.0518	.0179	.0320
W (DET) 1	5.64	4.39	5.17	4.55	4.02	5.44	5.57	5.27	2.73	3.46
NUMERATORS										
N(B /DR)										
A(B)	*.0865	*.C473	.0553	.0372	-.0251	.0280	.0233	.0202	.00677	.00777
1/T (B) 1	*.00111	-.C315	*.00183	-.00794	-.0105	-.00222	*.00348	*.00498	-.00203	-.0116
1/T (B) 2	*.1.17	*.527	*.881	*.506	*.343	*.544	*.480	*.396	*.175	*.161
1/T (B) 3	1.48.	1.12.	2.00.	1.81.	1.95.	2.13.	2.61.	3.13.	3.06.	3.80.
N(P /DR)										
A(P)	13.0	5.12	13.0	6.67	4.87	5.82	6.53	6.50	2.45	3.94
1/T (P) 1	*.0219	-.0C739	*.0120	.00985	*.00395	*.00802	*.00743	*.0111	*.0039	*.00989
1/T (P) 2	7.91	4.83	6.01	5.27	4.17	6.42	5.90	6.26	3.73	3.72
1/T (P) 3	-8.66	-5.22	-6.19	-5.53	-4.30	-6.75	-6.00	-6.39	-3.78	3.73
N(R /DR)										
A(R)	-10.6	-3.81	-8.77	-5.12	-3.51	-4.65	-4.60	-4.87	-1.75	-2.18
1/T (R) 1	*.306	*.247	*.234	*.192	*.159	*.167	*.141	*.115	*.196	*.0955
Z(R) 1	*.183	*.C816	*.172	*.0952	*.0685	*.0830	*.0855	*.0713	*.00461	*.0345
W(R) 1	3.68	3.40	3.20	3.24	2.91	3.70	3.55	2.67	1.67	2.31
N(PHI/DR)										
A(PHI)	17.3	4.79	15.4	7.61	5.13	6.71	7.50	8.34	2.67	2.88
1/T (PHI) 1	6.86	5.04	-5.42	4.86	4.03	5.90	-5.40	-5.28	3.56	4.53
1/T (PHI) 2	-6.98	-5.52	5.48	-4.98	-4.12	-6.07	5.41	5.33	-3.58	-4.63
N(AYP/DR)										
A(AYP)	-3.07	1.32	*.978	-.991	-.182	-.445	*.609	-1.02	-.0193	2.69
1/T (AYP) 1	-.0430	-.123	-.0195	-.0404	-.0393	-.0557	-.0218	-.0131	-.0143	-.0207
1/T (AYP) 2	*.681	*.300	*.613	*.330	*.235	*.260	*.297	*.248	*.132	*.129
1/T (AYP) 3	{ 1.170	1.7.2	{ 43.8	{ .125)	{ 187)	{ 139)	{ 39.9	{ .0789	{ .196)	{ 11.8
1/T (AYP) 4	{ 33.9	-20.6	{ -63.9	{ 31.5)	{ 51.9)	{ 43.9)	{ 48.1	{ 36.5)	{ 92.8)	{ 12.1

TABLE VI-9
HL-10 ATTERRON TRANSFER FUNCTION FACTORS
SAS On
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	+	+	+	+
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K			
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50			
DENOMINATOR													
1/T(DET)1	.00751	.00201	.00626	.00491	.00328	.00533	.00555	.00620	.00269	-.000773			
1/T(DET)2	.323	.275	.269	.224	.187	.214	.197	.156	.232	.120			
1/T(DET)3	2.55	14.8	2.10	19.9	13.6	17.7	17.0	18.7	6.75	8.54			
Z(DET)1	{ 7.48 }	{ 638 }	{ 7.01 }	{ 70.9 }	{ 533 }	{ 673 }	{ 706 }	{ 608 }	{ 439 }	{ 445 }			
W(DET)1	{ 42.0 }	{ 3.75 }	{ 34.0 }	{ 3.63 }	{ 3.22 }	{ 4.37 }	{ 4.40 }	{ 4.22 }	{ 1.91 }	{ 2.53 }			
NUMERATORS													
V(B / DA)													
A(B)	-.00523	-.0104	-.00679	-.00547	-.00428	-.00899	-.00900	-.00590	-.000154	1.93			
1/T(B)1	.00374	.00600	.00352	.00391	.00399	.00442	.00408	.00295	.00277	.0072			
1/T(B)2	.304	.245	.232	.190	.157	.164	.138	.113	.196	.0951			
1/T(B)3	69.8	25.1	76.0	37.5	23.0	37.7	44.7	35.9	8.10	6.75			
i/T(B)4	-830.	-352.	-453.	-531.	-576.	-292.	-248.	-435.	4349.				
V(P / DA)													
A(P)	36.0	15.5	30.7	17.0	10.7	18.5	18.2	16.7	5.23	7.52			
1/T(P)1	.0225	-.00735	.0122	.00989	.00395	.00803	.00744	.0111	.00339	-.00981			
1/T(P)2	48.0	41.8	23.9	16.3	21.4	.561	22.1	6.93	7.93				
Z(P)1	.886	.755	.880	.790	.742	{ .914 }	{ .645 }	.891	.693	.640			
W(P)1	.394	.438	.414	.430	.424	.570	{ 22.0 }	.519	.447	.357			
V(R / DA)													
A(R)	3.39	1.96	3.73	2.11	1.19	2.43	2.76	1.83	.0603	-.392			
1/T(R)1	.305	.247	.234	.192	.158	.167	.141	.115	.197	.0955			
1/T(R)2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330			
1/T(R)3	{ 1.148 }	{ 0.725 }	{ .120 }	{ .0750 }	{ .0519 }	{ .0586 }	{ .0556 }	{ .0484 }	{ .0240 }	-3.50			
1/T(R)4	{ 6.65 }	{ 5.31 }	{ 5.81 }	{ 5.47 }	{ 5.19 }	{ 6.39 }	{ 6.31 }	{ 6.47 }	{ 7.14 }	3.54			

TABLE VI-9 Continued

J(PHI/DA)															
A(PHI)	34.6	15.7	29.7	16.6	10.6	18.1	17.6	16.0	5.22	7.33					
1/T(PHI)1	4.9.9	17.8	43.2	24.5	16.4	22.0	22.8	23.2	6.95	8.09					
Z(PHI)1	.885	.757	.879	.786	.739	.901	.985	.867	.691	.651					
W(PHI)1	.386	.443	.406	.420	.419	.556	.585	.493	.443	.375					
J(AYP/DA)															
A(AYP)	69.5	30.3	62.3	34.1	20.0	34.8	35.1	29.0	7.89	7.98					
1/T(AYP)1	.01653	.0147	.00553	.00662	.00649	.0116	.00774	.00468	.00393	.00318					
1/T(AYP)2	.304	.246	.232	.190	.157	.165	.138	.114	.200	.0957					
1/T(AYP)3	-3.16	-2.01	-3.47	-2.97	-2.90	-2.22	-3.24	-3.90	-1.84	4.25					
1/T(AYP)4	4.19	3.00	4.68	4.20	4.17	3.90	5.65	5.84	2.56	-4.58					
1/T(AYP)5	42.3	15.3	35.3	19.8	13.3	17.6	17.0	18.0	6.54	8.91					
	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

TABLE VI-10

HL-10 RUDDER TRANSFER FUNCTION FACTORS
SAS On
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K	16 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DENOMINATOR										
1/T (DET) 1	.00751	.0C201	.00626	.00491	.00328	.00533	.00555	.00620	.00269	-.000773
1/T (DET) 2	.323	.275	.269	.224	.187	.214	.197	.156	.232	.120
1/T (DET) 3	2.55	14.8	2.10	19.9	13.6	17.7	17.0	18.7	6.75	8.54
Z (DET) 1	(7.48)	638	(7.01)	709	533	673	706	608	439	*445
W (DET) 1	(42.0)	3.75	(34.0)	3.63	3.22	4.37	4.40	4.22	1.91	2.53
NUMERATORS										
V(B /DR)										
A(B)	.0865	.0473	.0553	.0372	.0251	.0280	.0233	.0202	.00677	.00777
1/T(B) 1	.0188	-.C117	.0107	.00724	.00150	.00658	.00693	.0103	.00251	-.0102
1/T(B) 2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(B) 3	7.68	2.96	6.52	3.37	2.00	3.80	3.72	3.24	1.06	1.14
1/T(B) 4	149.	113.	200.	182.	196.	214.	262.	314.	306.	380.
V(P /DR)										
A(P)	13.0	5.12	13.0	6.67	4.87	5.82	6.53	6.50	2.45	3.94
1/T(P) 1	.0219	-.0C739	.0120	.00985	.00395	.00802	.00743	.0111	.00339	-.00089
1/T(P) 2	.330	.330	.330	.330	.330	.330	.330	.330	.330	.330
1/T(P) 3	7.91	4.83	6.01	5.27	4.17	6.42	5.90	6.26	3.73	-3.72
1/T(P) 4	-8.66	-5.22	-6.19	-5.53	-4.30	-6.75	-6.00	-6.39	-3.78	3.73
N(R /DR)										
A(R)	-10.6	-3.81	-8.77	-5.12	-3.51	-4.65	-4.60	-4.87	-1.75	-2.18
1/T(R) 1	321	263	238	198	162	173	142	115	.210	*.0961
1/T(R) 2	.330	.330	.330	.330	.330	.330	.330	.330	.330	*.330
Z(R) 1	(1.90)	.631	(1.47)	.713	.497	.677	.710	.592	.330	*.330
W(R) 1	(7.52)	3.30	(6.88)	3.20	2.88	3.64	3.54	3.68	1.61	2.00

TABLE VI-10 Continued

N(PHI/DR)								
A(PHI)	17.3	4.79	15.4	7.61	5.13	6.71	7.50	8.34
1/T(PHI)1	.330	.330	.330	.330	.330	.330	.330	.330
1/T(PHI)2	-6.02	4.92	-4.86	-4.73	-4.06	-5.79	-5.11	-4.86
1/T(PHI)3	7.87	-5.65	6.06	5.11	4.09	6.18	5.70	5.76
V(AYP/DR)								
A(AYP)	-3.07	1.32	.978	-.991	-.182	-.445	.609	-1.02
1/T(AYP)1	.0104	-.0400	.00743	.00105	-.00468	-.00313	.00350	.00814
1/T(AYP)2	.330	.330	.330	.330	.330	.330	.330	.330
1/T(AYP)3	6.26	1.20	-1.93.	2.08	1.23	1.61	2.41	2.11
1/T(AYP)4	11.1	9.30	(.954)	(.935)	24.6	20.4	17.3	17.3
1/T(AYP)5	61.0	-34.1	(7.71)	(29.6)	103.	84.9	-99.3	(35.2)
	+	+	+	+	+	+	+	+

TABLE VI-11

F/C #	1	2	3	4	5	6	7	8	9	10
H	.03 K	1.6 K	22 K	30 K	40 K	38 K	45 K	51 K	75 K	72 K
M	.500	.380	.700	.620	.650	.800	.950	1.10	1.20	1.50
DR PERIOD (SEC)	1.12	1.44	1.22	1.38	1.56	1.16	1.13	1.19	2.30	1.82
1/C(1/2)	1.20	.706	.974	.693	.526	.547	.521	.470	.162	.290
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--	--	--
P(1)	25.8	11.1	31.2	21.5	9.65	--	--	--	7.43	2.44
P(2)	25.8	11.0	31.1	21.5	9.65	--	--	--	7.27	.860
P(3)	26.3	13.7	--	--	13.0	--	--	--	10.2	4.95
P(2)/P(1)	.000	.988	.997	.998	.000	--	--	--	.979	.353
P(OSC)/P(AV)	.00471	.6619	--	--	.0800	--	--	--	.0967	.622
W(PHI)/W(D)	.042	.743	.898	.795	.733	.836	.873	.784	.744	.537
DEL-B-MAX	.120	.290	.115	.201	.257	.123	.0928	.146	.179	.309
PHI TO BETA, PHASE	1.21	1.54	1.53	.799	.873	1.29	.497	.153	-358.	.202
PHI TO BETA	3.38	2.21	2.94	2.45	2.12	2.49	2.40	2.66	3.48	2.68
PHI TO VE	.368	.406	.332	.373	.389	.353	.339	.374	.793	.455

HL-10 DATA SOURCES

1. Ladson, Charles L., and Acquilla S. Hill, Aerodynamics of a Model of the HL-10 Flight Test Vehicle at Mach 0.35 to 1.80, NASA TN D-6018, Feb. 1971
2. Pyle, Jon S., Lift and Drag Characteristics of the HL-10 Lifting Body during Subsonic Gliding Flight, NASA TN D-6263, Mar. 1971
3. Ware, George M., Full Scale Wind Tunnel Investigation of the Aerodynamic Characteristics of the HL-10 Manned Lifting Entry Vehicle, NASA TMX-1160, Oct. 1965.

SECTION VII
LOCKHEED JETSTAR

JETSTAR BACKGROUND

The Jetstar is a four engine utility transport. Controls consist of conventional ailerons, elevators, and rudder. Ailerons and elevators are mechanically actuated with hydraulic boost. The rudder is mechanically activated but assisted by a servo tab.

The primary source of aerodynamic data was NASA CR-544. Power approach aerodynamics were estimated using CR-544 and flight test data from FTC-TDR-62-24C-140. The control system description was based solely on flight test data from the latter reference.

JETSTAR

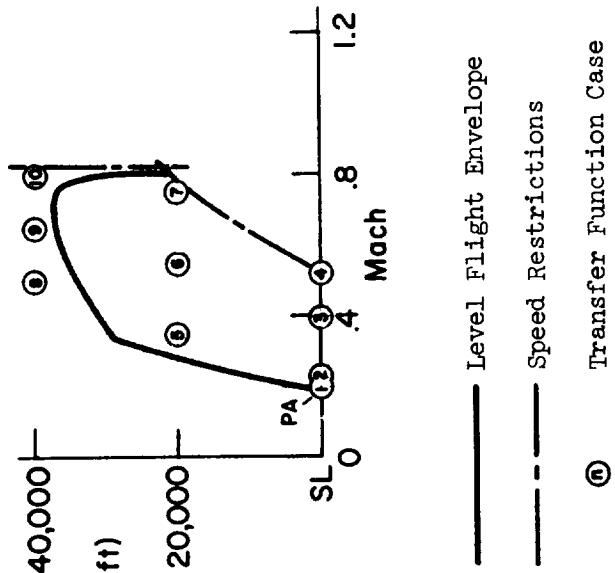
Nominal Configuration

Slipper Tanks Installed

Heavy Gross Weight

$$\begin{aligned} W &= 38204 \text{ lb} \\ \text{c.g. at } 0.25 \bar{c}, \text{W.L. } 94.2 \\ I_x &= 118773 \text{ slug}\cdot\text{ft}^2 \\ I_y &= 135869 \text{ slug}\cdot\text{ft}^2 \\ I_z &= 243504 \text{ slug}\cdot\text{ft}^2 \\ I_{xz} &= 5061 \text{ slug}\cdot\text{ft}^2 \end{aligned}$$

Flight Envelope



Power Approach Configuration

Slipper Tanks Installed

Light Gross Weight

Gear Down

40% Flaps

1.4 V_s

$$\begin{aligned} W &= 23904 \text{ lb} \\ \text{c.g. at } 0.25 \bar{c}, \text{W.L. } 94.2 \\ I_x &= 42273 \text{ slug}\cdot\text{ft}^2 \\ I_y &= 126099 \text{ slug}\cdot\text{ft}^2 \\ I_z &= 160104 \text{ slug}\cdot\text{ft}^2 \\ I_{xz} &= 5470 \text{ slug}\cdot\text{ft}^2 \end{aligned}$$

Figure VII-1. Jetstar Flight Conditions

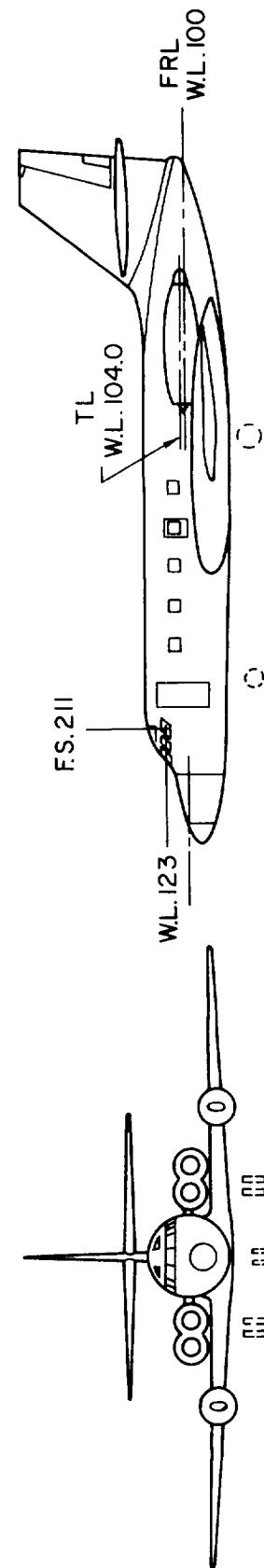
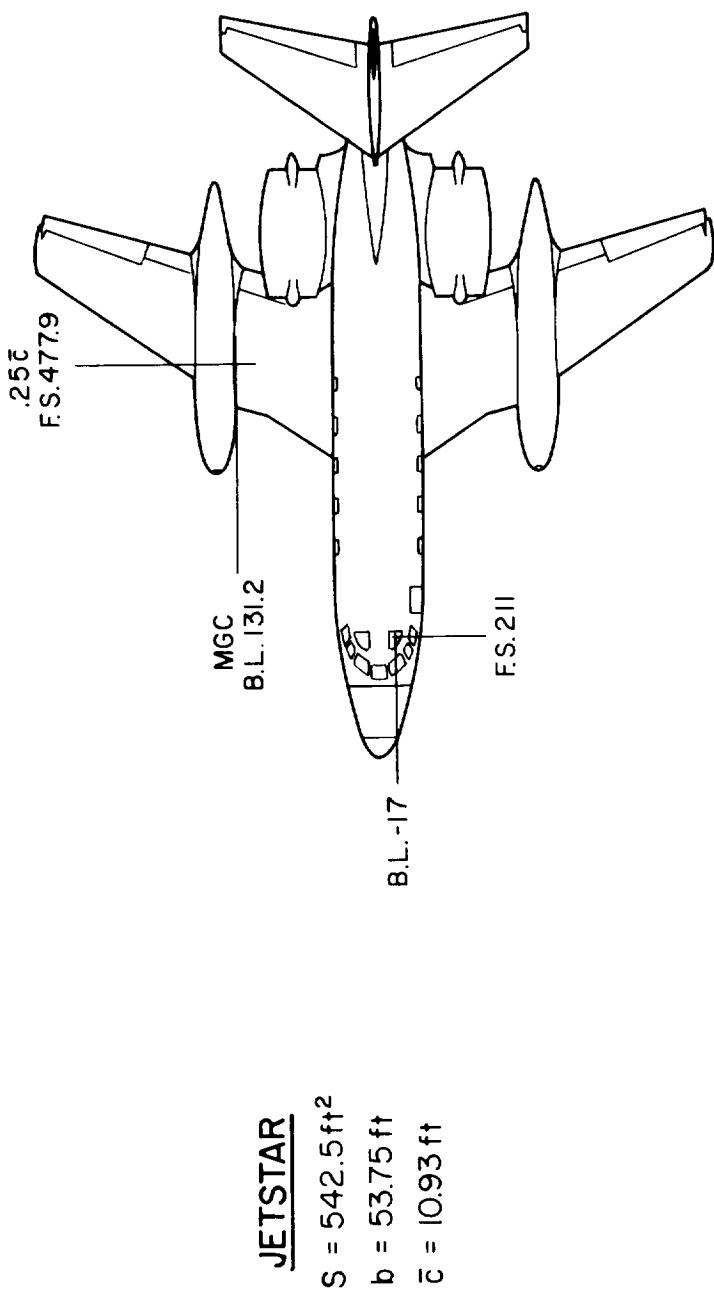
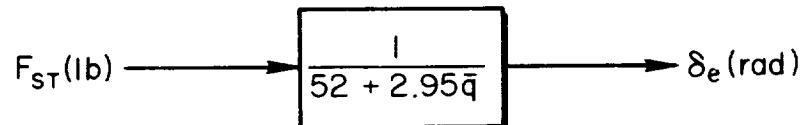


Figure VII-2. Jetstar General Arrangement

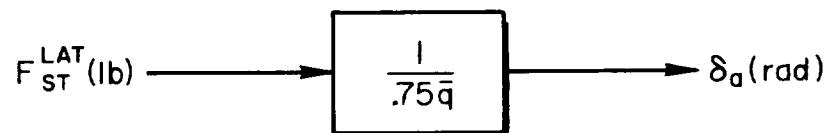
JETSTAR

PITCH AXIS



Note: Angle of attack effects on elevator hinge moment are neglected

ROLL AXIS



YAW AXIS

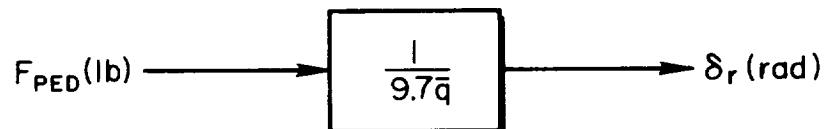


Figure VII-3. Jetstar Control System

TABLE VII-1

JETSTAR

Power Approach Non-Dimensional Stability Derivatives

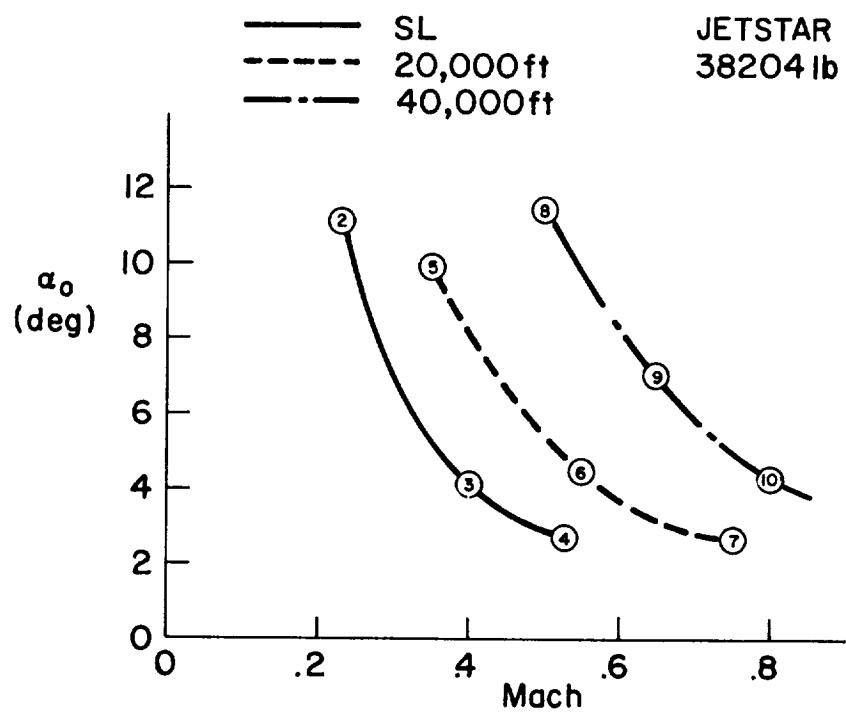
h = sea level

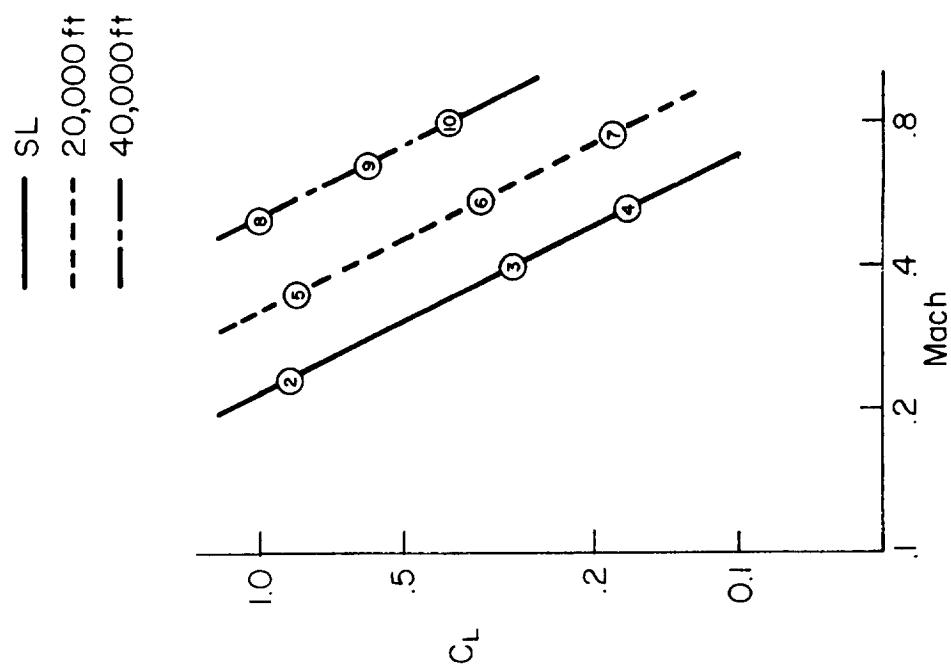
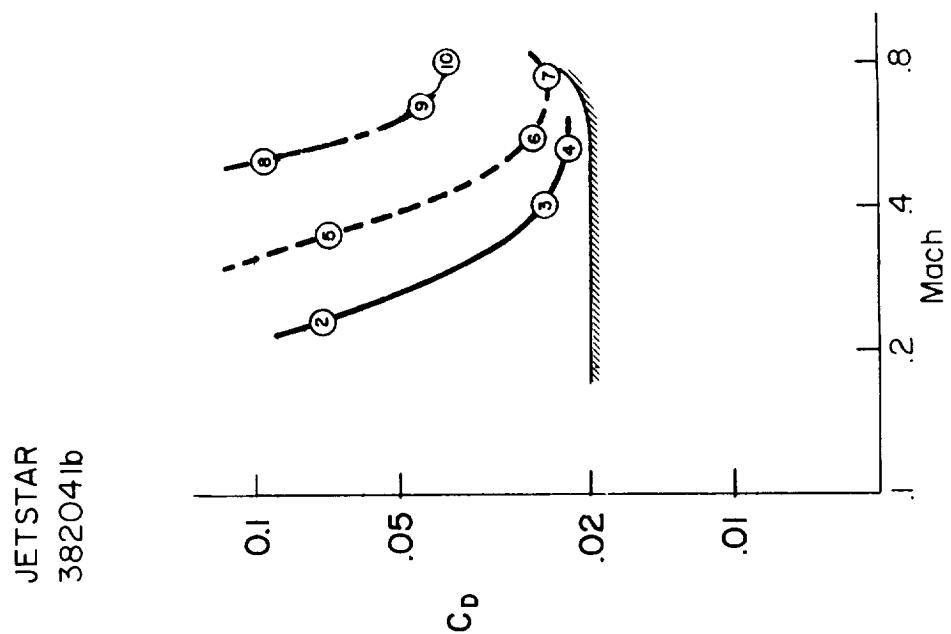
V_{TO} = 224 ft/sec = 132.5 kt

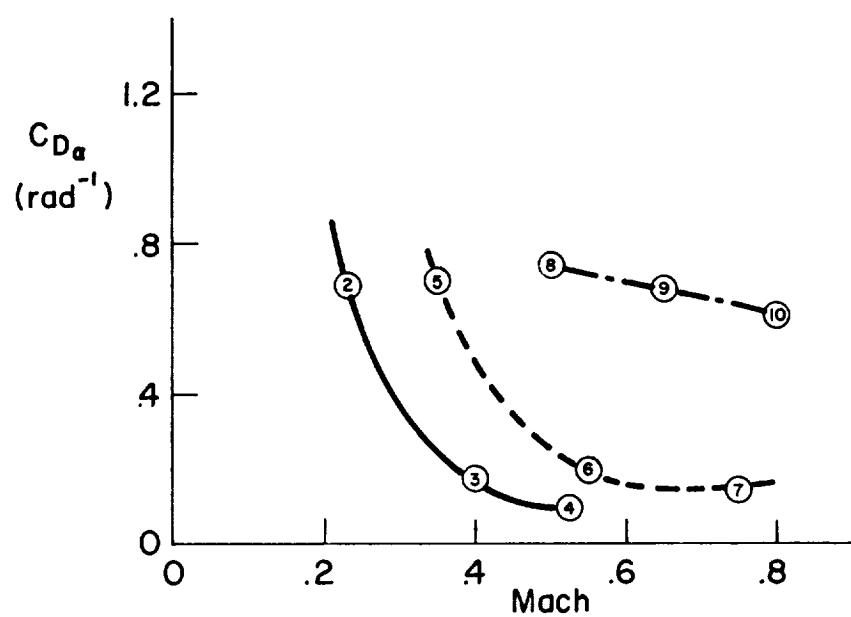
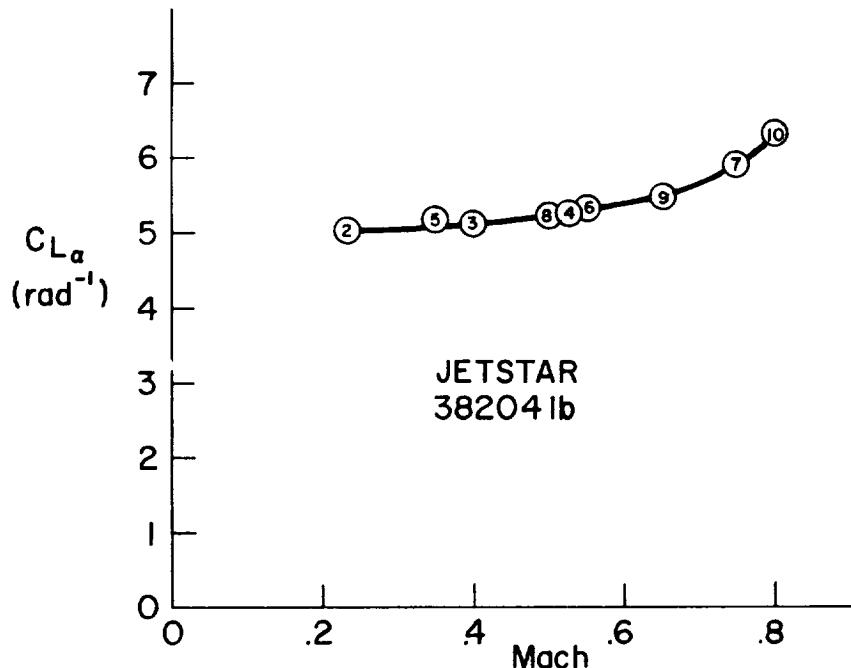
α_0 = 6.5°

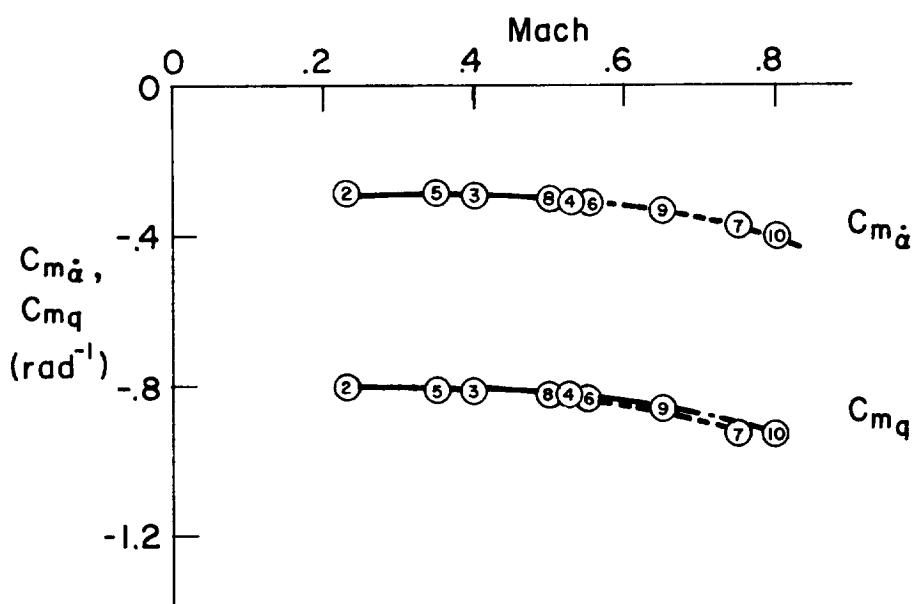
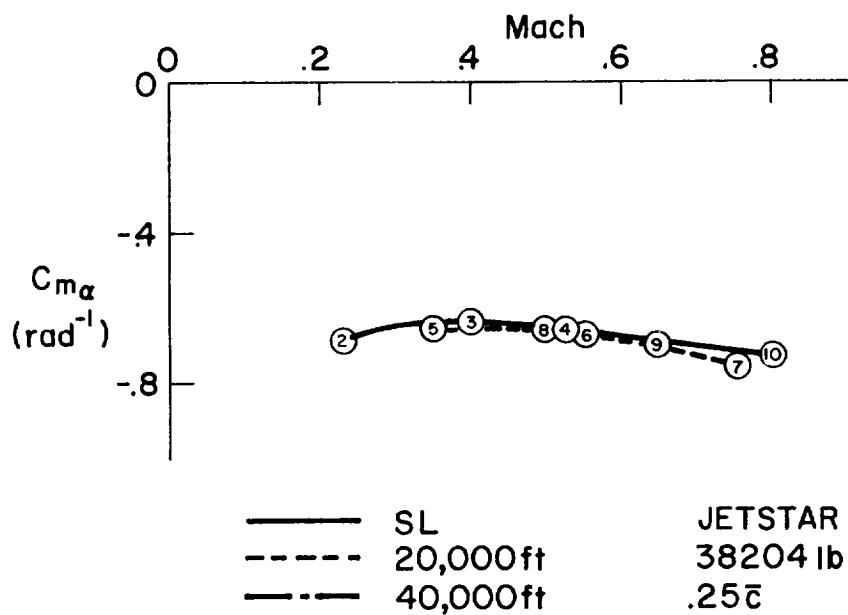
Longitudinal	Lateral-Directional (Body Axis)
--------------	------------------------------------

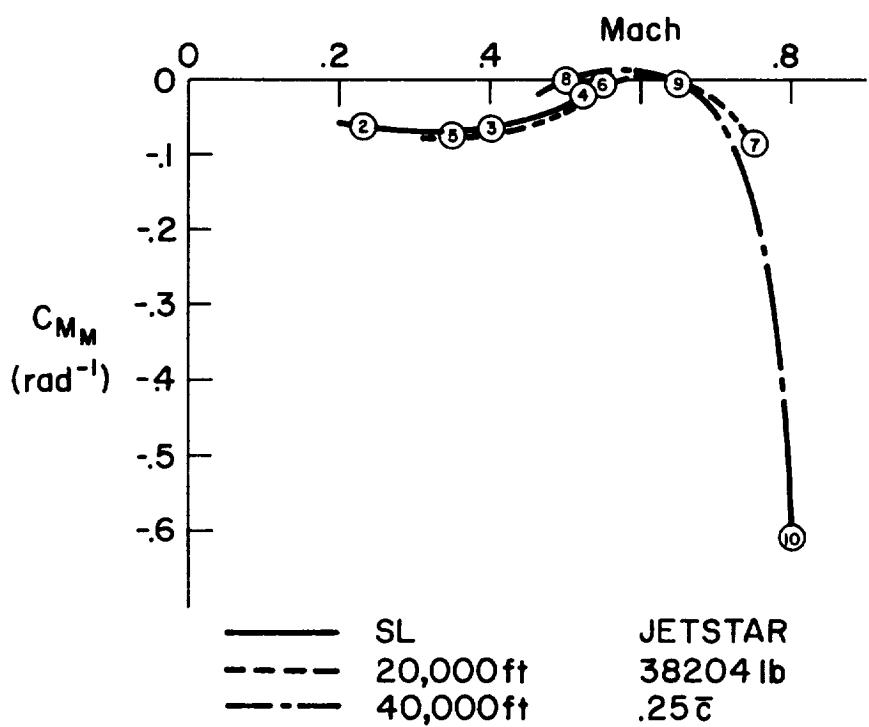
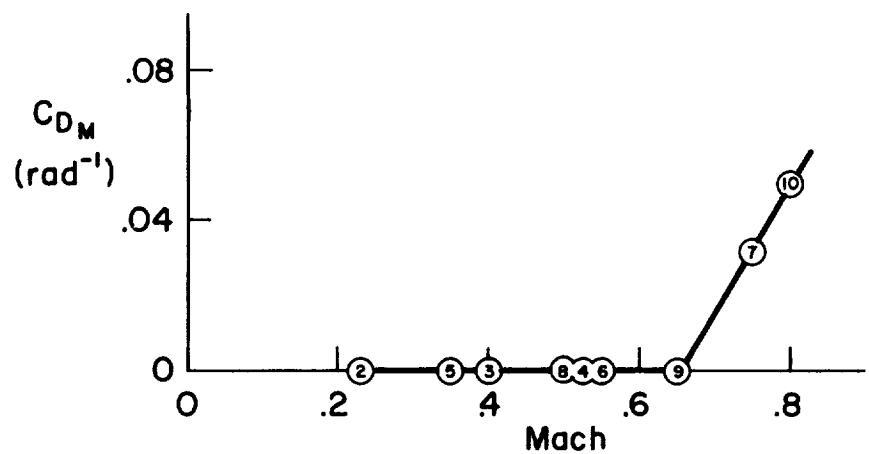
$C_L = .737$	$C_{y\beta} = -.72/\text{rad}$
$C_D = .095$	$C_{n\beta} = .137/\text{rad}$
$C_{L\alpha} = 5.0/\text{rad}$	$C_{\ell\beta} = -.103/\text{rad}$
$C_{D\alpha} = .75/\text{rad}$	$C_{\ell p} = -.37/\text{rad}$
$C_{m\alpha} = -.80/\text{rad}$	$C_{n_p} = -.14/\text{rad}$
$C_{m\dot{\alpha}} = -3.0/\text{rad}$	$C_{\ell r} = .11/\text{rad}$
$C_{m_q} = -8.0/\text{rad}$	$C_{n_r} = -.16/\text{rad}$
$C_{L\delta_e} = .4/\text{rad}$	$C_{n_{\delta_a}} = -.0075/\text{rad}$
$C_{m_{\delta_e}} = -.81/\text{rad}$	$C_{\ell_{\delta_a}} = .054/\text{rad}$
	$C_{y_{\delta_r}} = .175/\text{rad}$
	$C_{n_{\delta_r}} = -.063/\text{rad}$
	$C_{\ell_{\delta_r}} = .029/\text{rad}$

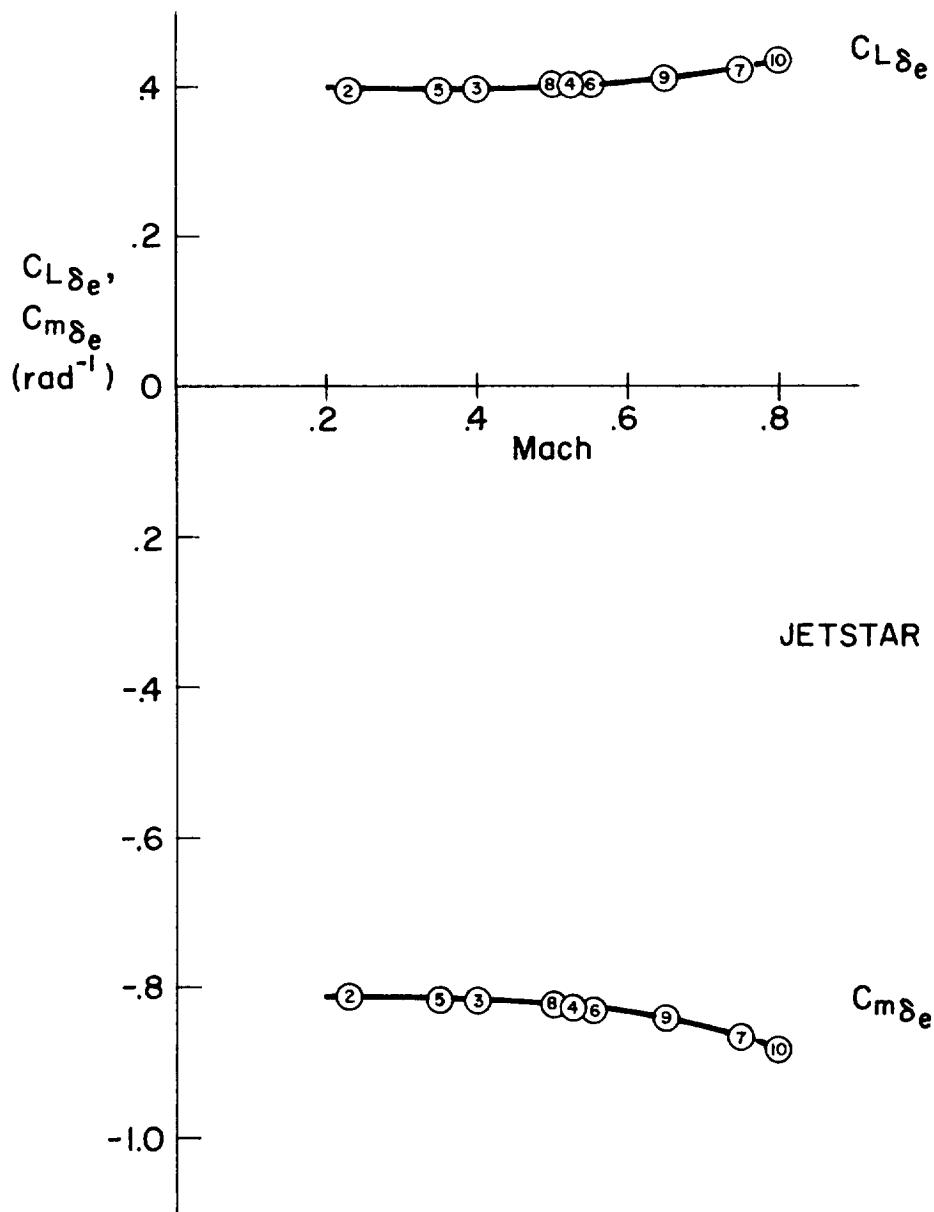


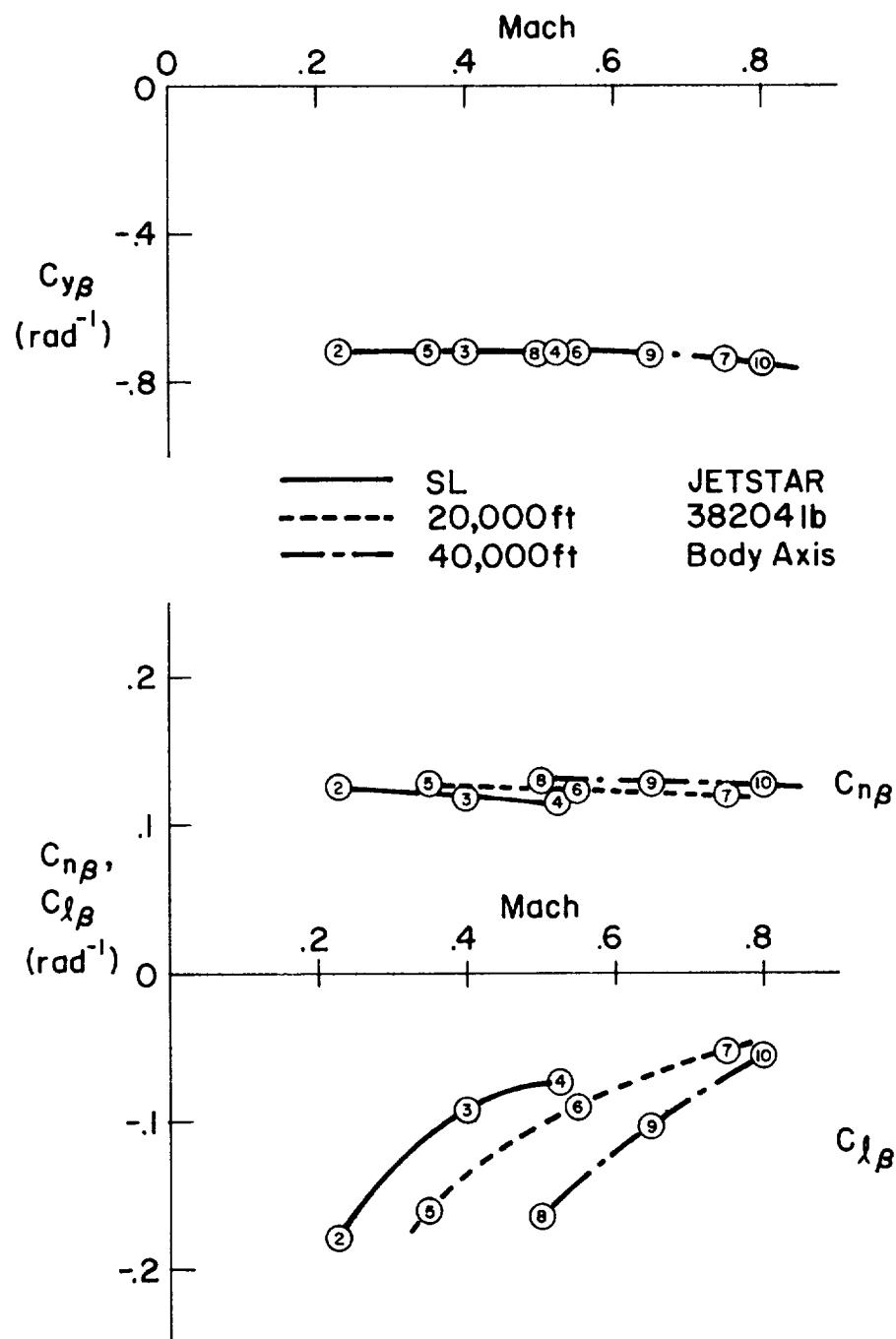


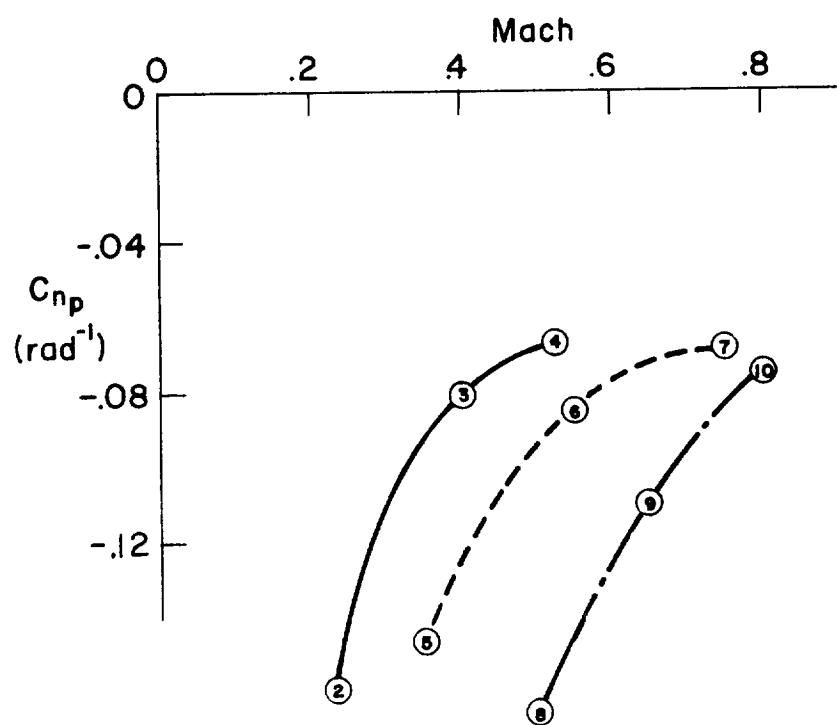
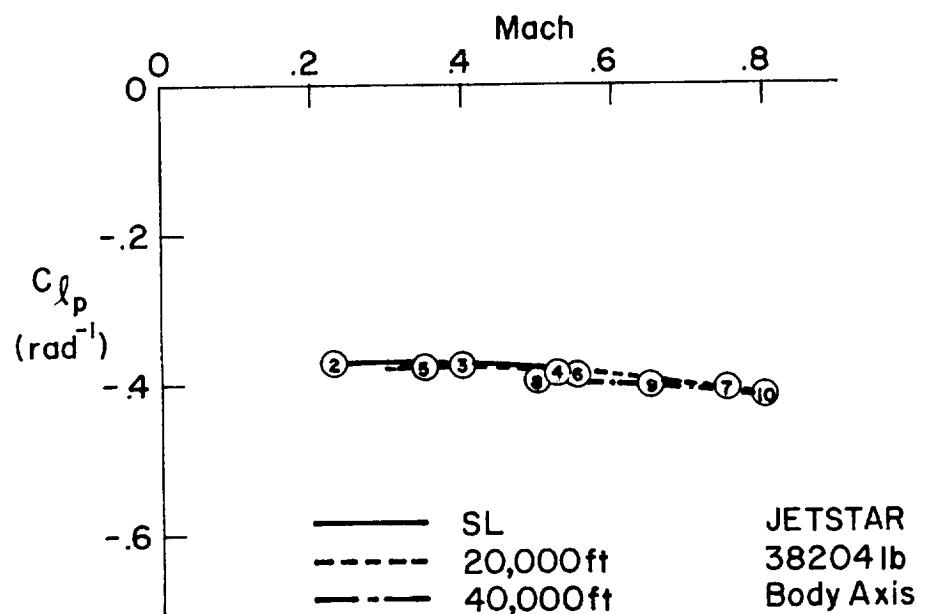


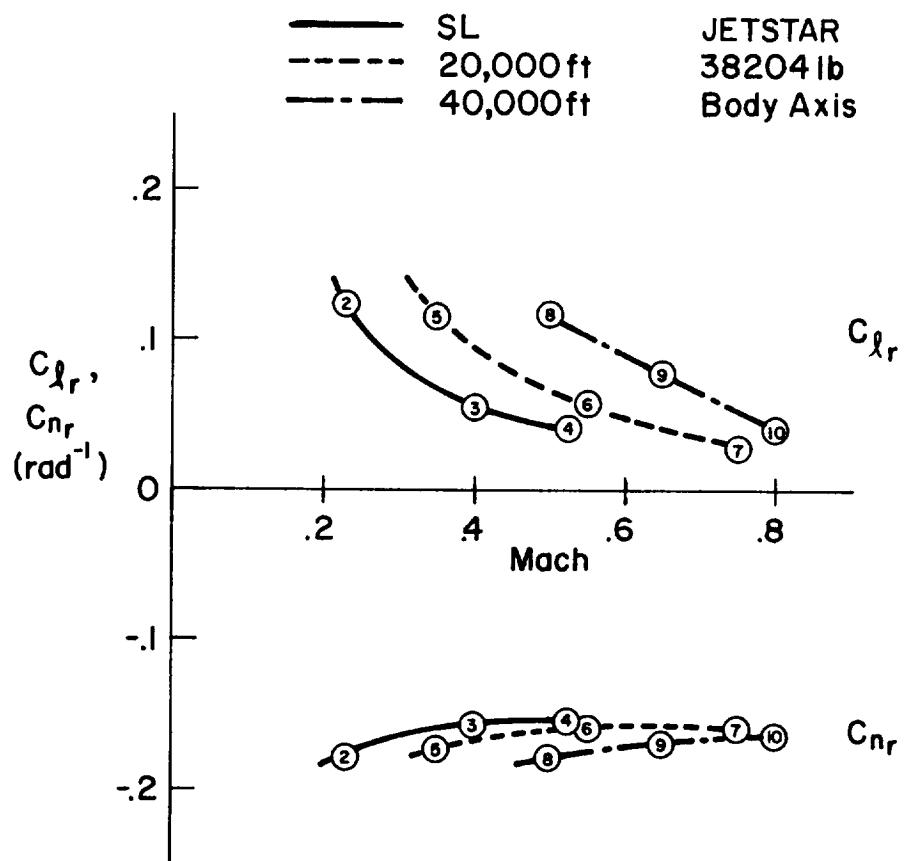


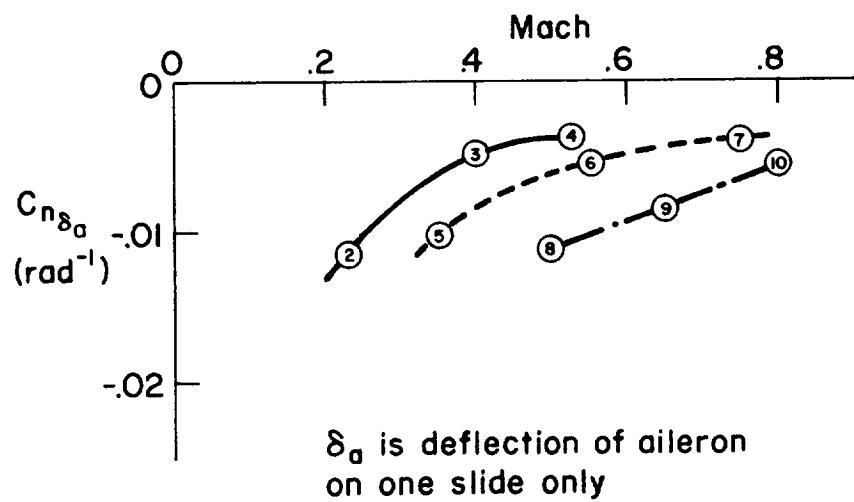
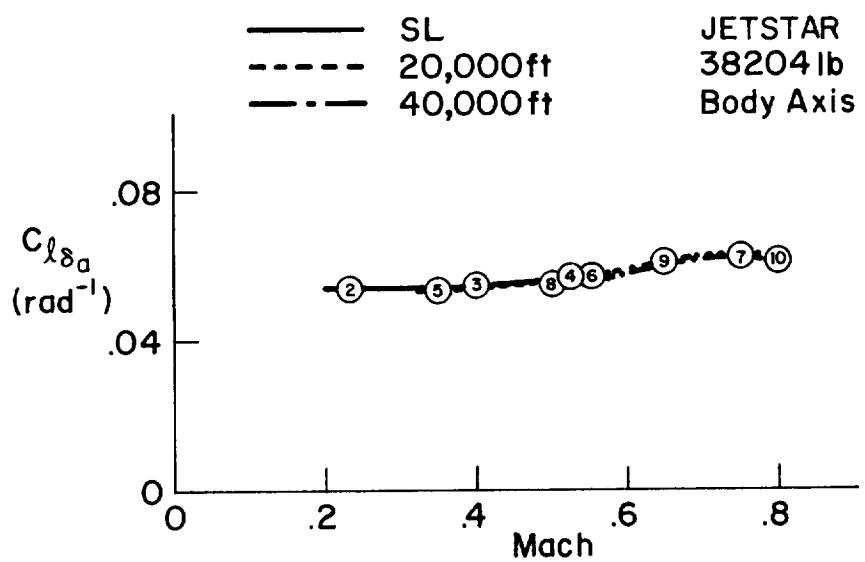












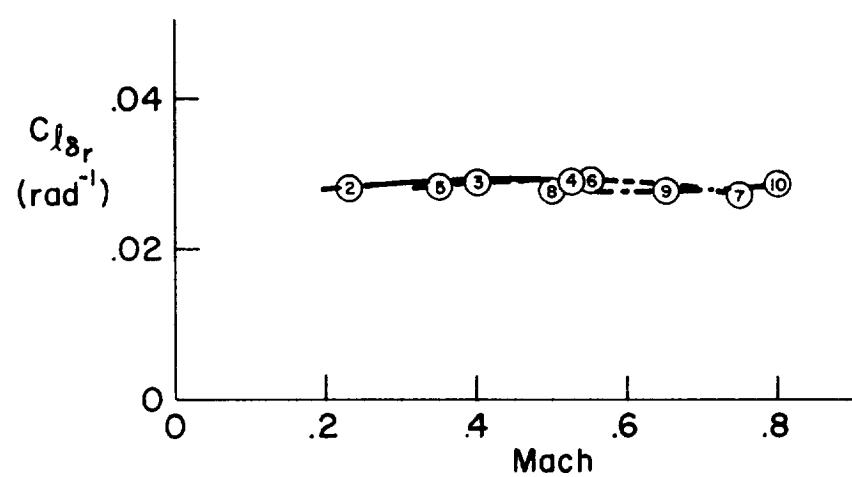
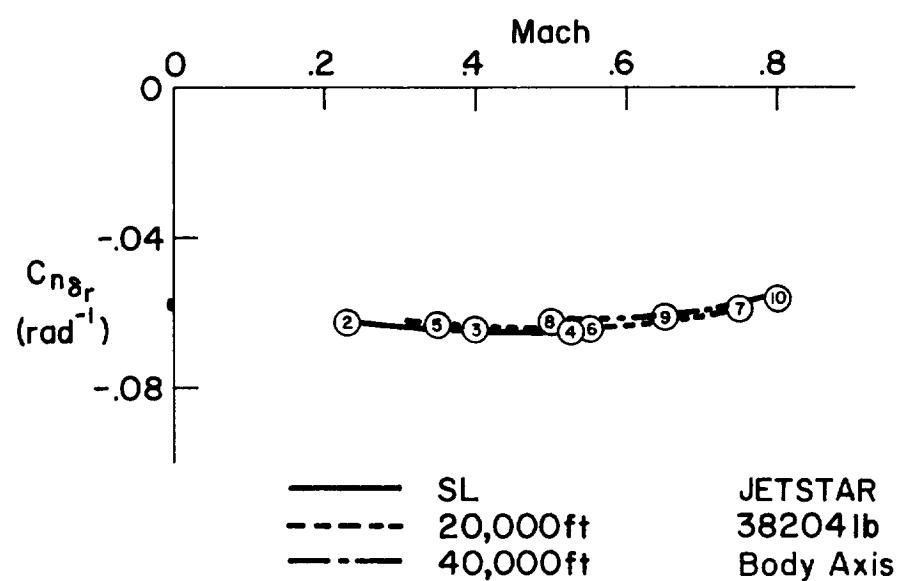
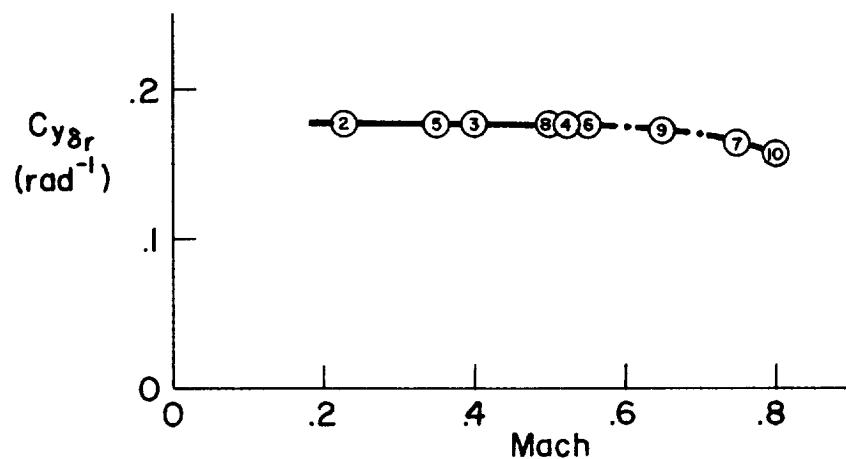


TABLE VII-2

JETSTAR DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
N(-)	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
VTO(FPS)	224.	257.	447.	586.	363.	570.	778.	484.	620.	774.
VTO(KTAS)	133.	152.	265.	347.	215.	338.	461.	287.	372.	459.
VTO(KCAS)	132.	152.	265.	347.	158.	252.	348.	146.	103.	243.
W(LBS)	23905.	38205.	38205.	38205.	38205.	38205.	38205.	38205.	38205.	38205.
C.G.(MGC)	.250	.250	.250	.250	.250	.250	.250	.250	.250	.250
I _X (SLUG-FT SQ)	42275.	118779.	118779.	118779.	118779.	118779.	118779.	118779.	118779.	118779.
I _Y (SLUG-FT SQ)	126106.	135876.	135876.	135876.	135876.	135876.	135876.	135876.	135876.	135876.
I _Z (SLUG-FT SQ)	160113.	243518.	243518.	243518.	243518.	243518.	243518.	243518.	243518.	243518.
I _{XZ} (SLUG-FT SQ)	5470.	5061.	5061.	5061.	5061.	5061.	5061.	5061.	5061.	5061.
EPSILON(DEG)	-2.65	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32	-2.32
Q(PSF)	59.4	78.4	237.	408.	83.5	206.	383.	69.0	117.	177.
QC(PSF)	60.0	79.4	247.	437.	86.0	222.	440.	73.4	120.	207.
ALPHA(DEG)	6.50	11.2	4.00	2.70	9.90	4.50	2.60	11.4	7.00	4.20
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2	22.2
LZP(FT)	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40	-2.40
I _{TH} (DEG)	0.	C.	0.	0.	0.	0.	0.	C.	C.	0.
X ₁ (DEG)	0.	0.	0.	C.	0.	0.	0.	C.	0.	0.
L _{TH} (FT)	-.820	-.820	-.820	-.820	-.820	-.820	-.820	-.820	-.820	-.820

TABLE VII-3
JETSTAR LONGITUDINAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K	40 K
P	.200	.400	.525	.350	.550	.750	.500	.650	.800	
XU *	-0.0166	-0.00456	-0.0102	-0.0136	-0.00324	-0.00697	-0.0157	-0.00353	-0.00168	-0.211E-5
ZU *	-0.175	-0.103	-0.0593	-0.0335	-0.0804	-0.0436	-0.0212	-0.0614	-0.0406	-0.0348
PYU *	.00131	.00175	.000549	.000177	.00102	.000815	.0002472	.0000902	.000747	.00425
XW	.108	.164	.118	.103	.111	.0918	.0689	.0858	.0498	.0266
ZW	-1.01	-0.723	-1.24	-1.65	-0.565	-0.881	-1.33	-0.354	-0.475	-0.654
HW	-0.00991	-0.00902	-0.0146	-0.0201	-0.00665	-0.0107	-0.0154	-0.00401	-0.00561	-0.00760
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-0.000910	-0.000834	-0.000848	-0.000306	-0.000447	-0.000482	-0.000574	-0.000207	-0.000237	-0.000280
NQ	-0.546	-0.582	-1.03	-1.33	-0.439	-0.724	-1.09	-0.279	-0.380	-0.506
XDE	1.97	2.78	3.02	3.51	2.62	2.96	3.34	2.49	2.66	2.54
ZDE	-17.2	-14.0	-43.2	-74.3	-15.0	-37.5	-73.5	-12.4	-21.7	-34.6
HDE	-2.26	-2.80	-8.38	-14.6	-2.95	-7.47	-14.5	-2.47	-4.27	-6.72
XDT	.00135	.000842	.000842	.000342	.000842	.000842	.000842	.000842	.000842	.000842
ZDT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PDT	-0.650E-5	-0.604E-5								
	+	+	+	+	+	+	+	+	+	+

TABLE VII-4
JETSTAR ELEVATOR TRANSFER FUNCTION FACTORS
Bare Airframe
(BODY AXIS SYSTEM)

$F/C \#$	1	2	3	4	5	6	7	8	9	10
H	S_L .200	S_L .230	S_L .400	S_L .525	S_L .350	S_L .550	S_L .750	S_L .500	S_L .650	S_L .800
DE/N(1/T(DET)1)	{ .0521)	{ .0293)	{ .0626)	{ .102)	{ .0386)	{ .0498)	{ .0195	{ .0600)	{ .0492)	.102
1/T(DET)2	{ .188)	{ .160)	{ .0797)	{ .0644)	{ .115)	{ .0751)	{ .0339	{ .0937)	{ .0709)	-.134
Z(DET)1	.528	.456	.475	.477	.355	.362	.382	.252	.259	.249
k(DET)1	1.66	1.66	2.75	3.75	1.64	2.60	3.77	1.44	1.03	2.45
NUMERATORS										
N(U/DE)	1.97	2.78	3.02	3.51	2.62	2.96	3.34	2.49	2.66	2.54
A(U)	28.5	50.2	86.4	115.	70.1	113.	154.	94.7	123.	151.
1/T(U)1	*59.0	*38.4	*258	*252	*41.0	*274	*235	*378	*558	*727
Z(U)1	1.11	.670	1.10	1.35	.529	.773	1.07	.340	.434	.506
N(W/DE)										
A(W)	-17.2	-14.0	-43.2	-74.5	-15.0	-37.5	-72.5	-12.4	-21.7	-34.6
1/T(W)1	29.7	50.9	87.4	116.	70.7	114.	155.	95.1	124.	152.
Z(W)1	*0612	*00143	*0704	*146	*0105	*0581	*270	*0191	*00430	*0104
k(W)1	.161	.118	.0662	.0427	.0867	.0515	.0273	.0659	.0476	.0237
N(THE/DE)										
A(THE)	-2.25	-2.79	-8.34	-14.5	-2.94	-7.45	-14.5	-2.47	-4.27	-6.77
1/T(THE)1	*0360	*0297	*0160	*0155	*0199	*0118	*0158	*0198	*01589	*01210
1/T(THE)2	.919	.653	1.17	1.57	.515	.824	1.25	.317	.443	.626
N(HD/DE)										
A(HD)	17.4	14.3	43.3	74.6	15.3	37.7	73.5	12.6	21.8	34.7
1/T(HD)1	-.00931	-.0168	*00715	*0118	-.0104	-.00405	*00751	-.00553	-.00182	
1/T(HD)2	-.4777	-.536	-.936	-.12.5	-.573	-.917	-.13.1	-.524	-.710	-.936
1/T(HD)3	5.57	6.19	10.8	14.4	6.36	10.2	14.7	5.74	7.64	10.1
N(AZP/DE)										
A(AZP)	32.7	47.9	142.	248.	50.3	128.	249.	42.4	75.1	116.
1/T(AZP)1	*0198	*0196	-.00611	-.00277	*0129	-.00549	-.0195	*0126	*01390	*01177
1/T(AZP)2	-.0297	-.0372	*0132	*0145	-.0237	*00951	*0162	-.0207	-.00952	-.00361
Z(AZP)1	*140	*106	*0999	*10C	*0790	*0746	*0777	*0550	*0533	*0565
k(AZP)1	3.76	3.11	5.54	7.33	*2.29	5.23	7.54	2.98	4.02	5.32

JETSTAR THRUST TRANSFER FUNCTION FACTORS
Bare Airframe
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
DENOMINATOR										
1/T(DET)1	{ .0521)	{ .0293)	{ .0626)	{ .102)	{ .0386)	{ .0498)	{ .0195)	{ .0600)	{ .0492)	*102
1/T(DET)2	{ -.188)	{ -.160)	{ -.0797)	{ -.0644)	{ -.115)	{ .0751)	{ .0339)	{ .0327)	{ .0709)	-.134
Z(DET)1	*52.8	*456	*475	*477	*355	*362	*382	*252	*256	*289
W(DET)1	1.66	1.66	2.79	3.75	1.64	2.60	3.77	1.64	1.95	2.45
NUMERATORS										
N(W /DTH)	A(W)	.00135	.000842	.000842	.000842	.000842	.000842	.000842	.000842	*000842
1/T(W)1	1/T(W)1	.0430	.0409	.0327	.0251	.0348	.0261	.0199	.0273	.0225
Z(W)1	W(W)1	*54.6	*54.7	*50.8	*49.9	*47.4	*41.7	*41.1	*38.7	*34.7
W(W)1	1.68	1.67	2.80	3.75	1.66	2.61	3.78	1.46	1.08	2.55
N(W /DTH)	A(h)	-.00165	-.00157	-.00272	-.00354	-.00220	-.00345	-.00469	-.00370	-.00468
1/T(W)1	1/T(W)2	{ -.440)	{ -.752)	{ -.354)	{ -.905)	{ -.648)	{ -.922)	{ -.776)	{ -.958)	-.00668
1/T(W)2		{ .135)	{ .160)	{ .0676)	{ .C436)	{ .0594)	{ .0541)	{ .1752)	{ .0521)	.555
N(THE /DTH)	A(THE)	-.636 E-5	-.590 E-5	-.599 E-5	-.600 E-5	-.597 E-5	-.600 E-5	-.601 E-5	-.601 E-5	-.602 E-5
1/T(THE)1	1/T(THE)2	-.502	-.357	-.150	-.135	-.226	-.167	.0450	-.178	*438
1/T(THE)2		1.22	.822	1.32	1.70	.646	.937	1.37	.4C8	.522
N(HD /DTH)	A(HD)	-0.00152	.000164	.587E-4	.397E-4	.000145	.661E-4	.382E-4	.000166	.000103
1/T(HD)1	1/T(HD)2	4.70	3.32	-.203	-.159	-.611	-.224	.0482	-.454	*610
1/T(HD)2	1/T(HD)3	{ -.615)	{ -.672)	-5.24	-9.48	-1.16	-4.95	-10.7	-1.18	-2.90
1/T(HD)3		{ .114)	{ .951)	8.94	13.5	2.40	7.61	13.9	2.67	-6.06
N(AZP/DTH)	A(AZP)	*000141	*000131	-.000133	*000133	*000133	*000133	*000133	*000133	*000134
1/T(AZP)1	1/T(AZP)2	-.0235	-.0235	-.00492	-.00257	-.0147	-.00437	-.0191	-.0126	-.01307
1/T(AZP)2	Z(AZP)1	-.809	-.483	-.167	-.141	-.292	-.183	.0457	-.233	*542
Z(AZP)1	W(AZP)1	-.0231	*0565	*0980	*115	*0370	*0725	*0307	*0163	*0408
W(AZP)1	2.81	2.70	4.93	6.55	2.91	4.71	6.82	2.66	3.62	4.70

TABLE VII-6
JETSTAR LONGITUDINAL HANDLING QUALITIES PARAMETERS
 Bare Airframe
 (BODY AXIS SYSTEM)

	F/C *	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
R	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800	
STICK FIXED											
D(G)/D(U) (DEG/KT)	.0278	.0502	-.0215	-.0354	.0310	-.0122	-.0429	.0225	.0166	.00544	
NZA (G/RAD)	6.32	5.24	16.0	28.0	5.86	14.5	30.0	4.90	8.64	15.0	
DE/G (DEG/G)	10.8	3.29	1.94	8.64	3.53	1.85	9.43	5.70	3.49		
CAP (RAD/SEC/SEC/G)	.425	.506	.478	.492	.444	.459	.468	.406	.425	.413	
PHIGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	(35.4)	--	--	--	(5.17)	
I/C(1/10)	1.70	1.40	1.47	1.48	1.04	1.06	1.13	.711	.731	.825	
	+	+	+	+	+	+	+	+	+	+	

TABLE VII-7

JETSTAR LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
H	1 2 3	4 5 6	7 8 9	10				
H	SL SL SL	SL SL SL	20 K 20 K 20 K	40 K 40 K 40 K				
H	.220 .230	.400 .525	.350 .550	.750 .500	.650 .800			
YV	-.140 -.100	-.175 -.229	-.0756	-.1119	-.167	-.0469	-.0618	-.0781
YB	-.31 .2	-.25 .8	-.78 .0	-.134 .*	-.27 .5	-.67 .8	-.130 .*	-.22 .7
L _B *	-4 .C5	-3 .42	-5 .27	-7 .28	-3 .23	-4 .43	-4 .93	-2 .75
NB*	1 .34	1 .10	3 .30	5 .47	1 .21	2 .99	5 .63	1 .02
LP*	-1 .65	-.752	-1 .30	-1 .75	-.582	-.935	-1 .34	-.380
NP*	-.245	-.173	-.164	-.187	-.121	-.119	-.137	-.0840
LR*	.517	.234	.181	.170	.169	.124	.0868	.105
NR*	-.190	-.172	-.261	-.333	-.125	-.178	-.252	-.0804
Y*CA	0 .	0 .	0 .	0 .	0 .	0 .	0 .	0 .
L*CA	2 .21	1 .04	3 .14	5 .71	1 .10	2 .88	5 .83	.929
N*CA	-.00557	-.0864	-.0767	-.0524	-.0770	-.0759	-.0624	-.0716
Y*CR	.0340	.0244	.0424	.0557	.0184	.0289	.0371	.0114
L*CR	1 .11	.533	1 .61	2 .77	.568	1 .40	2 .43	.444
N*CR	-.644	-.580	-.1 .81	-.3 .12	-.618	-.1 .55	-.2 .66	-.511
	+	+	+	+	+	+	+	+

TABLE VII-8
JETSTAR ALITRON TRANSFER FUNCTION FACTORS
 Bare Airframe
 (BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10					
M	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800					
DENOMINATOR															
1/T(DET)1	-0.0112	.00318	.00535	.00467	.000351	.00242	.00186	-.000800	-.000248	-.000201					
1/T(DET)2	1.95	.558	1.45	1.39	.741	1.04	1.42	.499	.576	.680					
2(DET)1	.632	.229	.729	.056	.0147	.0499	.0690	.0352	.0267	.0453					
N(CET)1	1.45	1.39	1.97	2.47	1.37	1.86	2.45	1.26	1.46	1.69					
NUMERATORS															
N(B/DA)															
A(B)	.256	.280	.295	.321	.266	.302	.327	.254	.291	.265					
1/T(B)	.0566	.0350	.0626	.055	.0286	.0440	.0502	.0175	.0268	.0353					
1/T(B)	3.51	1.35	2.96	4.79	1.07	1.99	3.59	.676	.920	1.31					
N(P/DA)															
A(P)	2.21	1.04	3.14	5.71	1.10	2.88	5.83	.929	1.71	2.64					
1/T(P)	-0.0160	-0.0242	-0.0697	-0.0255	-0.013	-0.0441	-0.0187	-.0133	-.00626	-.00304					
Z(P)	.149	.153	.122	.120	.103	.0876	.0885	.0744	.0643	.0619					
W(P)	1.17	.907	1.79	2.34	.992	1.70	2.37	.891	1.27	1.61					
N(R/DA)															
A(R)	-.00557	-.0864	-.0767	-.0524	-.0770	-.0759	-.0624	-.0716	-.0831	-.0720					
1/T(R)	.673	.443	.717	.807	.404	.570	.700	.290	.369	.490					
1/T(R)	-1.13	-.823	-1.46	-1.72	-1.02	-1.62	-1.98	-.1.04	-.1.44	-.1.79					
1/T(R)	99.9	3.30	8.92	23.2	3.00	6.64	15.6	2.26	3.19	4.52					
N(PHI/DA)															
A(PHI)	2.21	1.02	3.13	5.71	1.09	2.87	5.83	.914	1.70	2.64					
Z(PHI)	.129	.112	.116	.118	.0798	.0827	.0866	.0531	.0566	.0589					
W(PHI)	1.17	.226	1.80	2.34	1.01	1.71	2.37	.914	1.28	1.62					
N(AYP/DA)															
A(AYP)	5.19	.566	5.83	12.5	.938	5.23	12.6	.639	2.27	4.74					
1/T(AYP)	.08C4	.0443	.0776	.0767	.0378	.0557	.0594	.0233	.0361	.0467					
1/T(AYP)	-2.34	-.937	-2.44	-2.23	-4.36	-1.87	-1.67	-3.97	-1.85	-1.20					
Z(AYP)	.0867	.221	.135	.209	.111	.100	.277	.137	.0988	.1.67					
W(AYP)	1.28	1.22	1.97	2.51	1.20	1.81	2.47	1.07	1.36						
+	+	+	+	+	+	+	+	+	+	+					

JETSTAR RUDDER TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10		
H	.SL .200	.SL .230	.SL .400	.SL .525	.20 K .350	.20 K .550	.20 K .750	.40 K .500	.40 K .650	.40 K .800		
DEINCINATOR												
I/T(DET)1	-0.0112	.00318	.00535	.00467	.000351	.00242	.00186	-.000600	-.000248	-.000201		
I/T(DET)2	1.95	.558	1.45	1.89	.741	1.04	1.42	.495	.576	.680		
Z(DET)1	.C229	.0729	.0856	.0147	.0499	.0690	.0352	.0267	.0453			
W(DET)1	1.45	1.39	1.97	2.47	1.37	1.86	2.45	1.26	1.46	1.69		
NUMERATORS												
N(B/DR)												
A(B)	-.0340	.0244	-.0424	.0557	-.0184	.0289	.0371	-.0114	-.0144	.0162		
I/T(B)	-.0255	-.C312	-.00240	.000986	-.0201	-.00232	.00211	-.C164	-.00599	.00100		
Z(T(B)	2.13	.670	1.43	1.90	.668	1.02	1.45	.434	.548	.698		
W(T(B)	22.5	21.7	45.4	58.5	38.5	57.4	74.6	51.7	64.2	77.1		
N(P/DR)												
A(P)	1.11	.533	1.61	2.77	.568	1.40	2.43	.444	.766	1.21		
I/T(P)	-.0161	-.C246	-.00502	-.00259	-.0154	-.00444	-.00177	-.0134	-.00627	-.00303		
Z(P)	1.1	.974	1.55	1.58	1.47	1.34	2.52	1.43	1.19	.0848		
W(P)	1.1	(-1.05)	(-1.67)	(-1.67)	(-1.77)	(-1.55)	(-1.42)	(-1.48)	(-1.20)	.695		
N(R/DR)												
A(R)	-.644	-.580	-1.81	-3.12	-.618	-1.55	-2.66	-.511	-.836	-1.16		
I/T(R)	2.25	.803	1.42	1.90	.604	1.01	.0455	.363	.506	-.156		
Z(T(R)	1.17	.134	.181	.287	.116	.161	.131	.0582	.120	.186		
W(T(R)	1.3	(.333)	(.607)	(.344)	(.264)	(.553)	(.310)	(.579)	(.365)	.717		
N(PH1/DR)												
A(PH1)	1.03	.418	1.48	2.63	.460	1.28	2.31	.341	.663	1.12		
Z(PH1)	.932	(1.65)	(1.68)	(-1.64)	(1.57)	(1.43)	(-1.47)	(1.58)	(1.26)	.0464		
W(PH1)	(-1.26)	(-2.09)	(-1.72)	(-1.72)	(-1.76)	(-1.85)	(-1.47)	(-1.81)	(-1.34)	.721		
N(AYP/DR)												
A(AYP)	-4.05	-5.33	-17.4	-30.0	-5.68	-14.6	-24.3	-4.77	-7.66	-10.3		
I/T(AYP)	-.04C7	-.C666	-.00942	-.00202	-.0408	-.00693	-.00234	-.0317	-.0118	.00207		
I/T(AYP)	3.95	.550	1.37	1.92	.453	.951	1.56	.269	.457	.765		
Z(AYP)	2.33	.243	.111	.0878	.173	.0953	.0472	.126	.0872	.0394		
W(AYP)	1.20	1.57	2.20	2.83	1.59	2.07	2.68	1.50	1.67	1.87		
+	+	+	+	+	+	+	+	+	+	+	+	+

JETSTAR LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS
 TABLE VII-10
 Bare Airframe
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
N	.200	.230	.400	.525	.350	.550	.750	.500	.650	.800
DR PERIOD (SEC)	4.34	4.51	3.20	2.55	4.60	3.39	2.57	4.97	4.29	3.72
1/C(1/2)	.757	.208	.652	.778	.134	.453	.627	.0319	.242	.411
SPIRAL (2) (SEC)	62.1	--	--	--	--	--	--	866.	2795.	3443.
P(1)	.865	.594	1.60	2.45	.756	1.89	3.87	.753	1.53	3.47
P(2)	.464	.631	1.51	2.04	.352	1.88	3.73	.365	1.53	3.36
P(3)	.904	.709	1.88	2.78	1.03	2.40	3.84	1.17	2.31	3.53
P(2)/P(1)	.537	.106	.943	.996	.466	.999	.962	.510	.996	.970
P(GSC)/P(AV)	.311	.823	.0705	.0342	.434	.0639	.0173	.428	.114	.0200
W(PHI)/W(D)	.804	.664	.912	.949	.740	.919	.970	.724	.874	.955
DEL-B-MAX	.381	.368	.251	.207	.356	.262	.203	.374	.339	.261
PHI TO BETA, PHASE	57.9	-327.	31.8	31.8	-333.	26.0	25.7	-340.	19.7	20.0
PHI TO BETA	1.22	1.48	1.13	.983	1.50	1.11	.708	1.53	1.21	.693
PHI TO VE	.314	.330	.145	.0961	.325	.153	.0714	.365	.222	.103

JETSTAR DATA SOURCES

Myers, Russell H., Jr., and Carl S. Cross, Jetstar Flight Evaluation,
Air Force Flight Test Center Rept No. FTC-TDR-62-24C-140, Feb. 1963

Clark, Daniel C., and John Kroll, General Purpose Airborne Simulator—
Conceptual Design Report, NASA CR-544, Aug. 1966

Flight Manual, USAF Series C-140A, C-140B, and VC-140B Aircraft,
T. O. 1C-140A-1

Jetstar Handbook of Operating and Maintenance Instructions for USAF
Models C-140A and VC-140B Aircraft, T. O. 1C-140A-2

SECTION VIII

CONVAIR 880M

CONVAIR 880M BACKGROUND

The Convair 880M is a medium-size four engine jet transport. Longitudinal and directional control consists of servo tab deflected elevators and rudder. Lateral control consists of servo tab deflected ailerons plus hydraulic actuated spoilers.

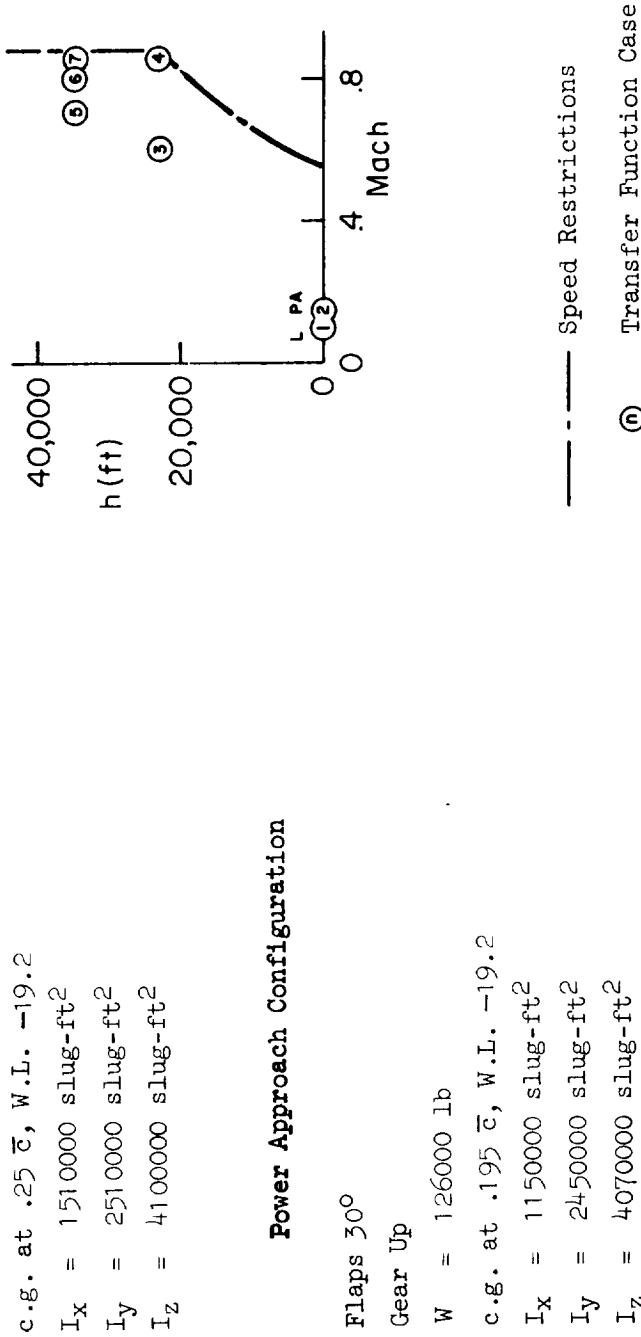
Elevator, aileron, and rudder transfer functions are in terms of respective primary surface deflections with tab losses included. Although the control system diagram shows a lag in the spoiler actuator, none was used in computing transfer functions.

CV-880M

Nominal Configuration

$W = 155000 \text{ lb}$
 c.g. at .25 \bar{c} , W.L. -19.2
 $I_x = 1510000 \text{ slug}\cdot\text{ft}^2$
 $I_y = 2510000 \text{ slug}\cdot\text{ft}^2$
 $I_z = 4100000 \text{ slug}\cdot\text{ft}^2$

Flight Envelope



Landing Configuration

Same as Power Approach except:

Flaps 50°
 Speed Brakes 8°
 Gear Down

Figure VIII-1. Convair 880M Flight Conditions

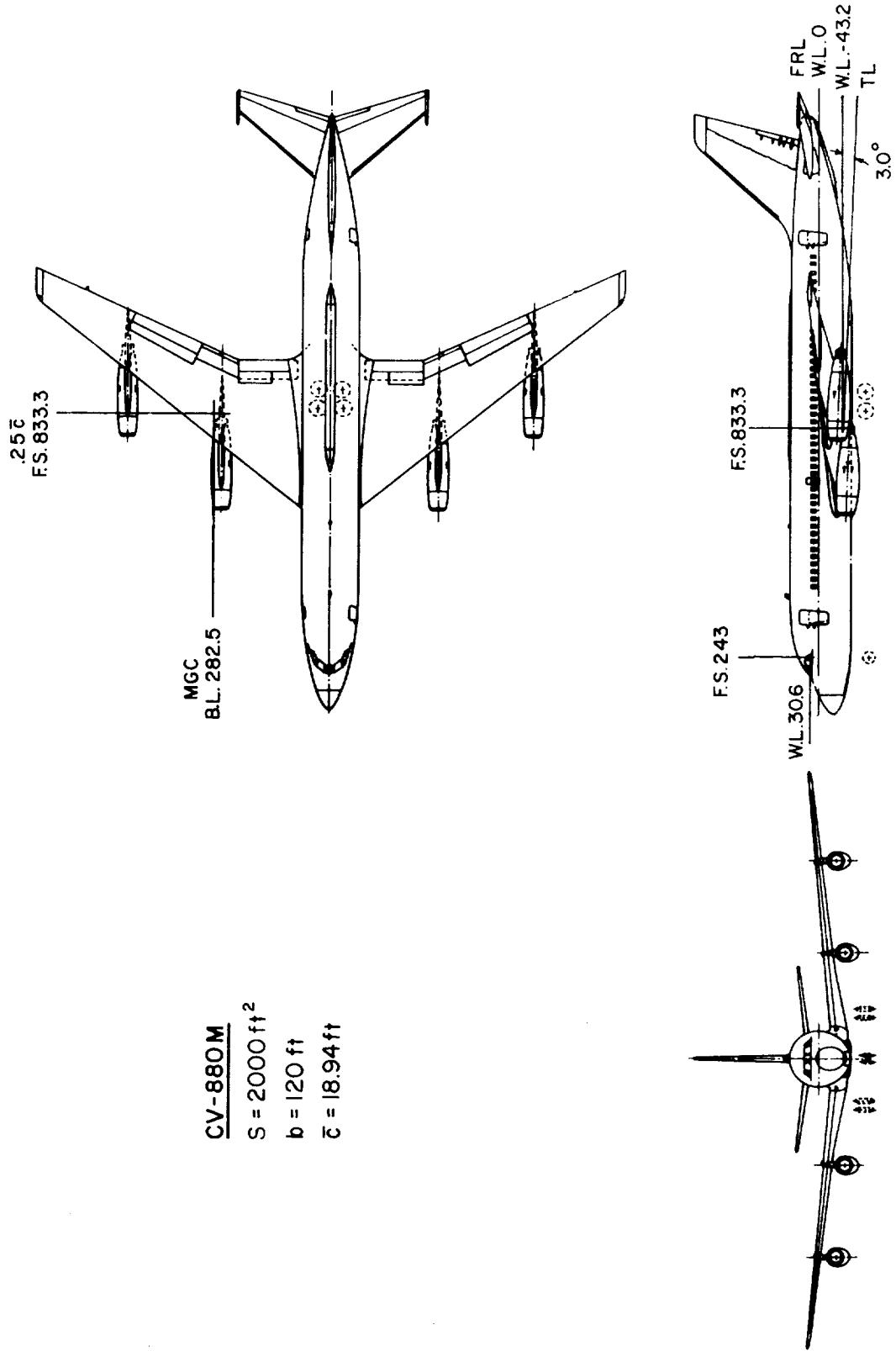
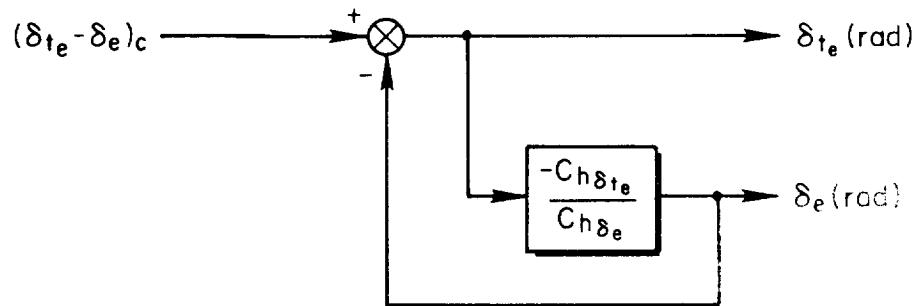


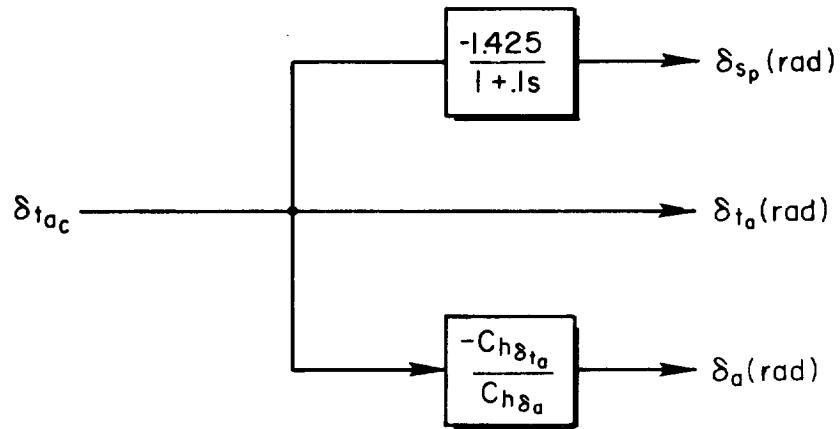
Figure VIII-2. Convair 880M General Arrangement

CV-880M

PITCH AXIS



ROLL AXIS



YAW AXIS

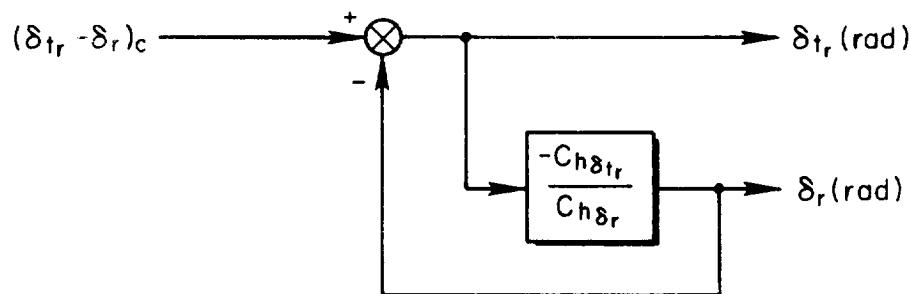


Figure VIII-3. CV-880M Control System

TABLE VIII-1

CV-880M**Longitudinal Non-Dimensional Stability Derivatives**

Flight Condition	1	2	3	4	5	6	7
Configuration	L	PA					
Speed	134 KTAS	165 KTAS	.6M	.86M	.7M	.8M	.86M
Altitude	SL	SL	23K	23K	35K	35K	35K
α_0 (Deg)	5.2	4.3	5.3	2.8	8.3	4.7	4.0
C_L	1.03	0.68	0.36	0.175	0.454	0.347	0.301
C_D	0.154	0.080	0.022	0.019	0.025	0.024	0.023
$C_{L\alpha}$ (1/rad)	4.66	4.52	4.28	4.41	4.62	4.8	4.9
$C_{D\alpha}$ (1/rad)	0.43	0.27	0.14	0.07	0.18	0.15	0.13
$C_{m\alpha}$ (1/rad)	-0.381	-0.903	-0.522	-0.572	-0.568	-0.65	-0.74
$C_{L\dot{\alpha}}$ (1/rad)	2.7	2.7	2.44	2.5	2.75	2.75	2.9
C_{Lq} (1/rad)	7.92	7.72	6.76	6.37	7.51	7.5	7.62
$C_{m\dot{\alpha}}$ (1/rad)	-4.17	-4.13	-4.16	-4.66	-4.4	-4.5	-4.6
C_{mq} (1/rad)	-12.2	-12.1	-11.5	-11.8	-12.	-12.	-12.
$C_{L\delta_e}$ (1/rad)	0.22	0.213	0.193	0.141	0.203	0.190	0.180
$C_{m\delta_e}$ (1/rad)	-0.657	-0.637	-0.586	-0.438	-0.618	-0.57	-0.532
$C_{h\delta_e}$ (1/rad)	-0.326	-0.328	-0.336	-0.278	-0.342	-0.31	-0.285
$C_{L\delta_{te}}$ (1/rad)	0.055	0.0532	0.0482	0.0352	0.0508	0.047	0.0450
$C_{m\delta_{te}}$ (1/rad)	-0.164	-0.159	-0.146	-0.11	-0.155	-0.14	-0.134
$C_{h\delta_{te}}$ (1/rad)	-0.287	-0.285	-0.297	-0.343	-0.312	-0.335	-0.352

TABLE VIII-2
CV-880M
Lateral-Directional Non-Dimensional Derivatives
(Stability Axis System)

Flight Condition	1	2	3	4	5	6	7
Configuration	L	PA					
Speed	134 KTAS	165 KTAS	.6M	.86M	.7M	.8M	.86M
Altitude	SL	SL	23K	23K	35K	35K	35K
$C_{y\beta}$ (1/rad)	-1.015	-0.877	-0.788	-0.815	-0.807	-0.8125	-0.842
$C_{\ell\beta}$ (1/rad)	-0.239	-0.196	-0.163	-0.145	-0.181	-0.177	-0.179
$C_{n\beta}$ (1/rad)	0.145	0.139	0.128	0.122	0.129	0.129	0.133
C_{ℓ_p} (1/rad)	-0.395	-0.381	-0.329	-0.243	-0.341	-0.312	-0.294
C_{n_p} (1/rad)	-0.087	-0.049	-0.0173	-0.0031	-0.023	-0.011	-0.0054
C_{ℓ_r} (1/rad)	0.309	0.198	0.146	0.088	0.180	0.153	0.146
C_{n_r} (1/rad)	-0.218	-0.185	-0.163	-0.189	-0.166	-0.165	-0.165
$C_{y\delta_a}$ (1/rad)	0	0	0.0019	0.0745	0.0044	0.00775	0.00975
$C_{\ell\delta_a}$ (1/rad)	-0.0487	-0.0384	-0.0466	-0.0452	-0.0479	-0.0497	-0.0479
$C_{n\delta_a}$ (1/rad)	0.01862	0.0172	0.00746	0.01061	0.007	0.00803	0.00975
$C_{h\delta_a}$ (1/rad)	-0.607	-0.481	-0.236	-0.258	-0.2233	-0.2005	-0.258
$C_{y\delta_{ta}}$ (1/rad)	0	0	0	0	0	0	0
$C_{\ell\delta_{ta}}$ (1/rad)	-0.0072	-0.0056	-0.0068	-0.0068	-0.0071	-0.0075	-0.0071
$C_{n\delta_{ta}}$ (1/rad)	0	0	0	0	0	0	0
$C_{h\delta_{ta}}$ (1/rad)	-0.249	-0.227	-0.215	-0.2125	-0.226	-0.235	-0.213
$C_{y\delta_s}$ (1/rad)	-0.078	-0.0315	-0.0189	-0.0175	-0.0189	-0.0189	-0.0175
$C_{\ell\delta_s}$ (1/rad)	0.0805	0.0405	0.029	0.0281	0.0324	0.0329	0.0339
$C_{n\delta_s}$ (1/rad)	0.0258	0.0129	0.01146	0.0109	0.00975	0.01004	0.00917
$C_{y\delta_r}$ (1/rad)	0.223	0.2155	0.1904	0.1394	0.199	0.184	0.1685
$C_{\ell\delta_r}$ (1/rad)	0.0207	0.0226	0.0176	0.0183	0.0165	0.0187	0.0193
$C_{n\delta_r}$ (1/rad)	-0.0935	-0.0958	-0.0845	-0.0534	-0.0848	-0.0756	-0.0644
$C_{h\delta_r}$ (1/rad)	-0.2140	-0.2125	-0.1626	-0.1844	-0.1345	-0.1491	-0.1924
$C_{y\delta_{tr}}$ (1/rad)	0.0493	0.0467	0.0374	0.0215	0.0404	0.0355	0.0316
$C_{\ell\delta_{tr}}$ (1/rad)	0.0021	0.0027	0.0016	0.0018	0.0014	0.0019	0.0020
$C_{n\delta_{tr}}$ (1/rad)	-0.020	-0.019	-0.015	-0.0077	-0.016	-0.0134	-0.011
$C_{h\delta_{tr}}$ (1/rad)	-0.255	-0.253	-0.267	-0.254	-0.27	-0.267	-0.265

TABLE VIII-3

CV-880M DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

	*	*	*	*	*	*	*	*	*	*	*	*	*
F/C #	1	2	3	4	5	6	7						
H (FT)	SL	SL	23 K	23 K	35 K	35 K	35 K						
M (-)	.203	.249	.600	.860	.700	.800	.860						
VTO(FPS)	226.	278.	615.	881.	681.	779.	837.						
VTO(KTAS)	134.	165.	364.	522.	404.	461.	496.						
VTO(KCAS)	134.	165.	259.	381.	235.	272.	295.						
W(LBS)	126007.	126007.	155008.	155008.	155008.	155008.	155008.						
C.G.(MGC)	.195	.195	.250	.250	.250	.250	.250						
I X (SLUG-FT SC)	.115E+7	.115E+7	.151E+7	.151E+7	.151E+7	.151E+7	.151E+7						
I Y (SLUG-FT SQ)	.245E+7	.245E+7	.251E+7	.251E+7	.251E+7	.251E+7	.251E+7						
I Z (SLUG-FT SC)	.359E+7	.359E+7	.410E+7	.410E+7	.410E+7	.410E+7	.410E+7						
I XZ(SLUG-FT SQ)	0.	0.	0.	0.	0.	0.	0.						
EPSILCN(DEG)	0.	0.	0.	0.	0.	0.	0.						
Q(PSF)	60.8	92.2	216.	444.	171.	224.	259.						
QC(PSF)	61.4	93.6	236.	532.	193.	262.	310.						
ALPHA(DEG)	5.20	4.32	5.30	2.80	6.30	4.65	4.04						
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.						
LXP(FT)	48.1	48.1	49.1	49.1	49.1	49.1	49.1						
LZP(FT)	-4.15	-4.15	-4.15	-4.15	-4.15	-4.15	-4.15						
I TH(DEG)	3.00	3.00	3.00	3.00	3.00	3.00	3.00						
XI(DEG)	3.00	3.00	3.00	3.00	3.00	3.00	3.00						
LTH(FT)	2.00	2.00	2.00	2.00	2.00	2.00	2.00						
	*	*	*	*	*	*	*						

TABLE VIII-4

CV-88QM LONGITUDINAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
K	.203	.249	.600	.860	.700	.800	.860
XU *	-.0292	-.0192	-.00501	-.00764	-.00799	-.00468	-.00512
ZU *	-.226	-.173	-.0473	-.0283	-.000148	-.0364	-.0330
MU *	.894E-5	.000262	.000221	.000182	.000325	.000207	.000221
XW	.140	.127	.0899	.0669	.0929	.0699	.0652
ZW	-.674	-.785	-.629	-.927	-.501	-.577	-.632
MW	-.00159	-.00461	-.00276	-.00434	-.00245	-.00281	-.00344
ZWD	-.0154	-.0154	-.00544	-.00561	-.00391	-.00396	-.00419
ZQ	-10.2	-12.3	-9.26	-12.6	-7.26	-8.42	-9.21
MWD	-.000723	-.000717	-.000338	-.000380	-.000235	-.000237	-.000242
MQ	-.481	-.585	-.578	-.850	-.431	-.493	-.520
XDE	.450	.539	1.14	1.01	1.52	1.10	1.09
ZDE	-4.95	-7.13	-12.3	-20.6	-10.4	-13.5	-15.4
MDE	-.443	-.647	-1.37	-2.34	-1.17	-1.49	-1.65
XDTM	.000255	.000255	.000207	.000207	.000207	.000207	.000207
ZDTM	-.134E-4	-.134E-4	-.109E-4	-.109E-4	-.109E-4	-.109E-4	-.109E-4
MDTM	.816E-6	.816E-6	.797E-6	.797E-6	.797E-6	.797E-6	.797E-6
	+	+	+	+	+	+	+

TABLE VIII-5
CV-880M ELEVATOR DIMENSIONAL DERIVATIVES

Bare Airframe									
(BODY AXIS SYSTEM)									
<i>F/C</i>	<i>H</i>	<i>S_L</i>	<i>S_L</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>
1	2	3	4	5	6	7			
<i>H</i>	<i>S_L</i>	<i>S_L</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>			
<i>H</i>	<i>S_L</i>	<i>S_L</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>	<i>S_K</i>			
<i>DENOMINATOR</i>									
<i>Z(DET)1</i>	•120	•0628	•0361	•0815	•0351	•0443	•0513		
<i>W(DET)1</i>	•131	•137	•0659	•0452	•0528	•0538	•0504		
<i>Z(DET)2</i>	•793	•599	•494	•492	•400	•399	•381		
<i>W(DET)2</i>	•818	1.29	1.42	2.13	1.37	1.56	1.78		
<i>NUMERATORS</i>									
<i>N(U /DE)</i>									
<i>A(h)</i>	•443	•531	1.14	1.00	1.51	1.09	1.08		
<i>L/T(U)1</i>	18.1	23.1	67.2	58.5	74.9	84.3	88.2		
<i>Z(U)1</i>	•245	•304	•192	•187	•236	•212	•209		
<i>W(h)1</i>	1.08	1.11	•593	•822	•401	•535	•577		
<i>N(W /DE)</i>									
<i>A(h)</i>	-4.87	-7.03	-12.3	-20.5	-10.4	-13.5	-15.4		
<i>L/T(W)1</i>	19.7	24.7	67.7	59.2	75.3	84.9	88.7		
<i>Z(W)1</i>	•0965	•0783	•0429	•105	•0554	•0533	•0641		
<i>W(h)1</i>	•180	•143	•0508	•0329	•0961	•0397	•0366		
<i>N(THE /DE)</i>									
<i>A(THE)</i>	-439	-642	-1.37	-2.33	-1.17	-1.48	-1.64		
<i>L/T(THE)1</i>	•0841	•0505	•0121	•0977	•0815	•00932	•00876		
<i>L/T(THE)2</i>	•597	•697	•596	•884	•477	•545	•595		
<i>N(HD /DE)</i>									
<i>A(HD)</i>	4.89	7.05	12.3	20.5	10.5	13.5	15.4		
<i>L/T(HD)1</i>	•0161	•0124	•00289	•0075	•0101	•00304	•00377		
<i>L/T(HD)2</i>	3.34	3.94	6.11	9.02	5.78	6.56	7.00		
<i>L/T(HD)3</i>	-3.89	-4.65	-6.72	-9.82	-6.30	-7.15	-7.63		
<i>N(AZP/DE)</i>									
<i>A(AZP)</i>	16.3	23.9	54.9	93.5	46.9	59.3	65.3		
<i>L/T(AZP)1</i>	-0.0250	-0.0154	-0.00636	-0.00222	-0.0703	-0.00428	-0.00334		
<i>L/T(AZP)2</i>	•0405	•0277	•00921	•00798	•00730	•00710	•00710		
<i>Z(AZP)1</i>	•260	•250	•145	•143	•125	•124	•125		
<i>W(AZP)1</i>	1.97	2.32	3.02	4.4C	2.83	3.26	3.54		

TABLE VIII-6
CV-880M THRUST DIMENSIONAL DERIVATIVES
Bare Airframe
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	.5L	.5L	.23 K	.23 K	.35 K	.35 K	.35 K
V	.203	.249	.600	.860	.700	.800	.860
DE/NOMINATOR							
Z(DET)1	*120	*.628	*.0361	*.0815	*.0351	*.0443	*.0513
H(DET)1	*131	*.137	*.0659	*.0452	*.0528	*.0538	*.0504
Z(DET)2	*793	*.599	*.494	*.492	*.400	*.399	*.381
H(DET)2	*818	*.129	1.42	2.13	1.37	1.56	1.78
NUMERATORS							
N(L /DTH)	*.00255	*.000255	*.0002C7	*.0002C7	*.000207	*.000207	
A(L)	-*.104	-*.0586	-*.0453	-*.0284	-*.0438	-*.0348	
1/T(W)1	*776	*.590	*.435	*.461	*.281	*.335	*.328
Z(W)1	*.858	*.130	1.42	2.13	1.34	1.55	1.77
N(W /DTH)							
A(h)	-*.128E-4	-*.129E-4	-*.107E-4	-*.107E-4	-*.1C7E-4	-*.108E-4	
1/T(W)1	-8.64	-12.9	-43.6	-62.9	-60.9	-55.8	
Z(W)1	-*.400	-*.0568	*.590	*.811	(*C937)	.750	*.899
H(W)1	*.228	*.158	*.0456	*.0295	(*49.5)	.0350	*.0317
N(THE/DTH)							
A(THE)	*.842E-6	*.829E-6	*.807E-6	*.805E-6	*.806E-6	*.803E-6	
1/T(THE)1	{ .955}	{ .838}	{ .130	{ .0388	{ .0850	{ .111	*.113
1/T(THE)2	{ .398}	{ .580)	{ .598	{ .943	{ .536	{ .559	*.625
N(HD /DTH)							
A(HD)	*.359E-4	*.320E-4	*.298E-4	*.209E-4	*.405E-4	*.275E-4	*.253E-4
1/T(HD)1	*137	*.210	*.0973	*.0776	*.0668	*.0865	*.0906
Z(HD)1	*.658	*.501	*.249	*.21C	*.187	*.197	*.188
H(HD)1	*2.15	*2.70	*3.52	*5.96	*2.92	*3.92	*4.44
N(AZP/DTH)							
A(AZP)	-*.533E-4	-*.532E-4	-*.503E-4	-*.503E-4	-*.503E-4	-*.502E-4	-*.502E-4
1/T(AZP)1	-*.0155	-*.00919	-*.00455	-*.00455	-*.00455	-*.00344	-*.00276
1/T(AZP)2	*163	*.353	*.113	*.0845	*.0845	*.091	*.102
Z(AZE)1	*.599	*.416	*.201	*.185	*.145	*.165	*.162
H(AZP)1	1.70	1.99	2.56	3.72	2.39	2.76	3.01
+ + + + + + + +							

TABLE VIII-7
CV-880M LONGITUDINAL HANDLING QUALITIES PARAMETERS

Bare Airframe (BODY AXIS SYSTEM)							
F/C #	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
H	SL	SL	23 K	23 K	35 K	35 K	35 K
P	.203	.249	.600	.860	.700	.800	.860
STICK FIXED							
D(G)/D(U) (DEG/KT)	-.0488	-.0376	-.00873	-.02033	-.00306	-.00918	-.0114
NZA (G/RAD)	4.69	6.47	11.6	24.4	10.1	13.3	15.6
DE/G (DEG/G)	18.8	23.5	7.36	4.60	5.03	7.09	7.11
CAP (RAD/SEC/SEC/G)	.144	.264	.176	.187	.184	.184	.204
PHUGOID(2) (SEC) (TUCK(2))	--	--	--	--	--	--	--
1/C(1/10)	3.55	2.04	1.55	1.55	1.19	1.19	1.13
+ + + + + + + +	+ + + + + + + +	+ + + + + + + +	+ + + + + + + +	+ + + + + + + +	+ + + + + + + +	+ + + + + + + +	+ + + + + + + +

TABLE VIII-8

CV-880M LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K
P	.203	.249	.600	.860	.700	.800	.860
YV	-.139	-.148	-.115	-.170	-.0842	-.0969	-.108
YB	-31.5	-41.3	-70.7	-15C.	-57.4	-75.5	-90.4
LB	-3.19	-3.96	-5.98	-10.6	-5.38	-6.64	-7.72
NB	.499	.763	1.42	2.98	1.02	1.50	1.82
LP	-1.39	-1.62	-1.14	-1.15	-.863	-.884	-.893
NP	-.113	-.0857	-.0416	-.01C5	-.0453	-.0240	-.0165
LR	.980	.756	.434	.4C5	.364	.384	.401
NR	-.215	-.232	-.188	-.327	-.130	-.156	-.159
Y*DA	-.0371	-.0161	-.00458	-.00774	-.00303	-.00364	-.00512
L'DA	3.84	2.81	2.85	6.CC	2.30	2.93	4.00
N'DA	.401	.202	.220	.321	.192	.142	.195
Y*DR	.0250	.0298	.0245	.0259	.0187	.0196	.0187
L'DR	.335	.507	.806	1.36	.563	.824	.892
N'DR	-.327	-.480	-.926	-1.22	-.747	-.870	-.829
	+	+	+	+	+	+	+

TABLE VIII-9
CV-880M AILERON TRANSFER FUNCTION FACTORS
Bare Airframe
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7
H	S _L	S _L	23 K	23 K	35 K	35 K	35 K
M	.203	.249	.500	.86C	.700	.800	.860
DENOMINATOR							
1/T(DET)1	.00912	.0123	.0C785	.0184	.00553	.00790	.00837
1/T(DET)2	1.50	1.69	1.12	1.17	.792	.871	.875
Z(DET)1	-119	136	112	132	.105	.0903	.0931
W(DET)1	1.02	1.11	1.41	1.8E	1.33	1.43	1.54
NUMERATORS							
N(B/DA)	-.0371	-.0161	-.0045E	-.00774	-.00303	-.00364	-.00512
A(B)	.316	.215	-.817	-.126	.294	.253	-.171
1/T(B)	{-2.74}	{-3.87}	{.981}	{1.6E}	{4.23}	{86.8}	.987
Z(B)	{5.42}	{4.78}	{.952}	{4.71}	{-46.9}	{-26.6}	
W(B)							
N(P/DA)							
A(P)	2.84	2.81	2.85	6.0C	2.30	2.93	4.00
1/T(P)	-.0122	-.0C835	-.00475	-.00176	-.00682	-.00333	-.00269
Z(P)	.266	.223	.127	.141	.107	.105	.104
W(P)	.938	1.05	1.39	1.9C	1.21	1.35	1.49
N(R/DA)							
A(R)	.401	.202	.230	.321	.192	.142	.195
1/T(R)	.951	1.05	.576	.786	.325	.504	.549
Z(R)	-.251	-.211	.0451	.0865	.0193	.0167	.0190
W(R)	1.09	1.26	1.4E	1.76	1.59	1.75	1.77
N(PHI/DA)							
A(PHI)	3.87	2.82	2.87	6.01	2.33	2.94	4.01
Z(PHI)	.261	.219	.126	.141	.104	.104	.103
W(PHI)	.934	1.04	1.39	1.9C	1.22	1.35	1.49
N(AYP/DA)							
A(AYP)	26.8	16.9	20.2	33.6	16.9	16.3	21.9
1/T(AYP)1	-.360	.352	-.210	-.272	.180	.196	.223
1/T(AYP)2	-.596	-.561	.292	.363	-.214	-.269	-.244
Z(AYP)1	.159	.152	.118	.133	.108	.105	.104
W(AYP)1	.987	1.09	1.40	1.9C	1.26	1.38	1.51

TABLE VIII-10

CV-880M RUDDER TRANSFER FUNCTION FACTORS

Bare Airframe

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	*
H	S _L .203	S _L .249	23 K .600	22 K .860	35 K .700	35 K .800	35 K .860	
H	.00912	.0123	.00789	.0184	.00553	.00790	.00837	
H	1.50	1.69	1.12	1.17	.792	.871	.875	
H	1.19	1.36	1.12	1.32	.105	.0903	.0931	
H	1.02	1.11	1.41	1.88	1.33	1.43	1.54	
NUMERATOR CR S								
N(B /DR)	*0250	*0298	*0245	*0259	*0187	*0196	*0187	
A(B)	-.0753	-.0398	-.0164	-.0255	-.0205	-.0136	-.0115	
1/T(B)1	1.53	1.71	1.12	1.17	.819	.871	.880	
1/T(B)2	12	17.5	41.0	45.5	44.1	47.9	47.9	
1/T(B)3	14.4							
N(P /DR)								
A(P)	*335	*507	*806	*1.36	*563	*824	*892	
1/T(P)1	-.0123	-.00846	-.00481	-.00177	-.00685	-.00334	-.00270	
1/T(P)2	1.29	1.50	2.16	2.53	2.26	2.21	2.20	
1/T(P)3	-2.12	-2.06	-2.54	-2.60	-2.70	-2.51	-2.45	
N(R /DR)								
A(R)	-.327	-.480	-.926	-1.22	-.747	-.870	-.829	
1/T(R)1	1.53	1.71	.974	1.05	.444	.721	.751	
Z(R)1	.0813	.114	.275	.221	.367	.228	.209	
H(R)1	.498	.462	.504	.495	.698	.547	.543	
N(PHI /DR)								
A(PHI)	*305	*471	*720	1.30	*454	*753	*834	
1/T(PHI)1	1.28	1.49	2.22	2.56	2.42	2.26	2.24	
1/T(PHI)2	-2.36	-2.24	-2.79	-2.65	-3.20	-2.70	-2.59	
N(AYP/DR)								
A(AYP)	-8.68	-12.7	-27.1	-31.4	-21.6	-24.1	-21.4	
1/T(AYP)1	-.0930	-.0555	-.0270	-.0161	-.0303	-.0238	-.0226	
1/T(AYP)2	1.63	1.78	.859	.556	.516	.634	.654	
Z(AYP)1	*227	*204	*184	*103	*184	*146	*134	
H(AYP)1	1.03	1.12	1.57	2.24	1.63	1.70	1.85	
*	+	+	+	+	+	+	+	

TABLE VIII-11
CV-880M LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS
 Bare Airframe
 (BODY AXIS SYSTEM)

	F/C #	1	2	3	4	5	6	7
H	SL	SL	23 K	23 K	35 K	35 K	35 K	35 K
r	.203	.249	.600	.860	.700	.800	.860	
DR PERIOD (SEC)	6.20	5.69	4.49	3.37	4.75	4.41	4.10	
1/C(1/2)	1.08	1.24	1.02	1.21	.956	.822	.848	
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--
P(1)	2.52	1.56	2.36	4.85	2.37	2.95	4.11	
P(2)	1.57	1.19	--	4.85	2.12	2.72	3.92	
P(3)	2.12	1.38	--	4.85	2.21	2.79	3.95	
P(2)/P(1)	.624	.764	--	1.00	.893	.924	.953	
P(OSC)/P(AV)	.192	.105	--	.107E-4	.0395	.0263	.0143	
W(PHI)/W(D)	.915	.937	.984	1.01	.914	.947	.967	
DEL-B-MAX	.669	.272	.0578	.0237	.140	.105	.0839	
PHI TO BETA, PHASE	-302.	-304.	34.1	23.1	-333.	-333.	24.9	
PHI TC BETA	1.96	1.94	2.45	2.68	2.64	2.85	2.90	
PHI TC VE	.497	.400	.329	.251	.398	.376	.357	
+	+	+	+	+	+	+	+	+

CV-880M DATA SOURCES

McNeill, Walter E., Calculated and Flight Measured Handling-Qualities Factors of Three Subsonic Jet Transports, NASA TN D-4832, Nov. 1968.

Brooks, Peter W., The World's Airliners, London, Putnam, 1962.

SECTION IX

BOEING 747

BOEING 747 BACKGROUND

The Boeing 747 is a very large four-fanjet intercontinental transport designed to operate from existing international airports. To obtain the necessary low speed characteristics the wing has triple-slotted trailing flaps and Krueger type leading edge flaps. The Krueger flaps outboard of the inboard nacelle are variable cambered and slotted while the inboard Krueger flaps are standard unslotted. Longitudinal control is obtained through four elevator segments and a movable stabilizer. The lateral control employs five spoiler panels, an inboard aileron between the inboard and outboard flaps, and an outboard aileron which operates with flaps down only on each wing. The five spoiler panels on each wing also operate symmetrically as speedbrakes in conjunction with the most inboard sixth spoiler panel. Directional control is obtained from two rudder segments.

Information for this aircraft was obtained solely from a 747 simulator description (Boeing D6-30643).

Nominal Configuration

Load to Max Zero Fuel Weight

TOGW less 40% Fuel

$$W = 636,600 \text{ lb}$$

c.g. at 0.25 \bar{c}

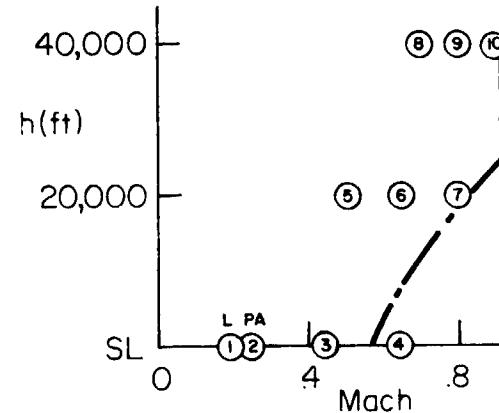
$$I_x = 18.2 \times 10^6 \text{ slug-ft}^2$$

$$I_y = 33.1 \times 10^6 \text{ slug-ft}^2$$

$$I_z = 49.7 \times 10^6 \text{ slug-ft}^2$$

$$I_{xz} = 0.97 \times 10^6 \text{ slug-ft}^2$$

Body Axis



212

Power Approach Configuration

Max Landing Weight

20° Flaps

Gear Up

1.4 V_s

$$W = 564,000 \text{ lb}$$

c.g. at 0.25 \bar{c}

$$I_x = 13.7 \times 10^6 \text{ slug-ft}^2$$

$$I_y = 30.5 \times 10^6 \text{ slug-ft}^2$$

$$I_z = 43.1 \times 10^6 \text{ slug-ft}^2$$

$$I_{xz} = 0.825 \times 10^6 \text{ slug-ft}^2$$

Body Axis

⑩

Landing Configuration

Same as Power Approach except:

30° Flaps

Gear Down

1.2 V_s

Figure IX-1. B-747 Flight Conditions

213

B-747

$$S = 5500 \text{ ft}^2$$

$$b = 195.68 \text{ ft}$$

$$\bar{c} = 27.31 \text{ ft}$$

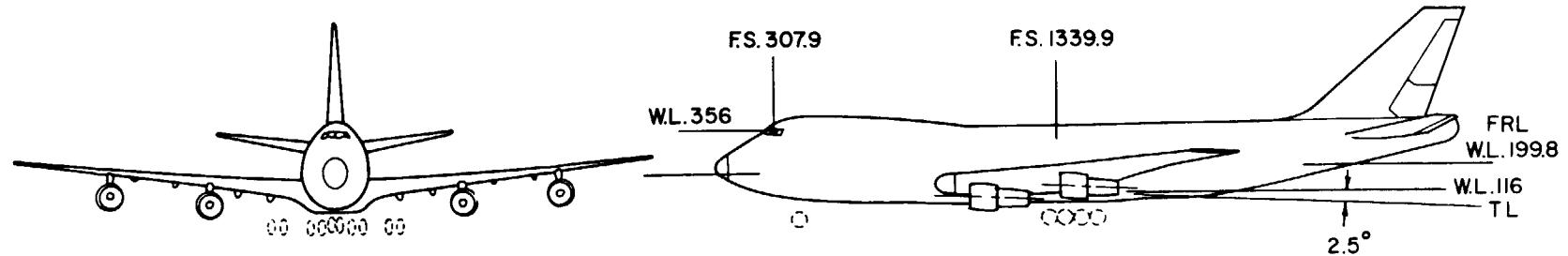
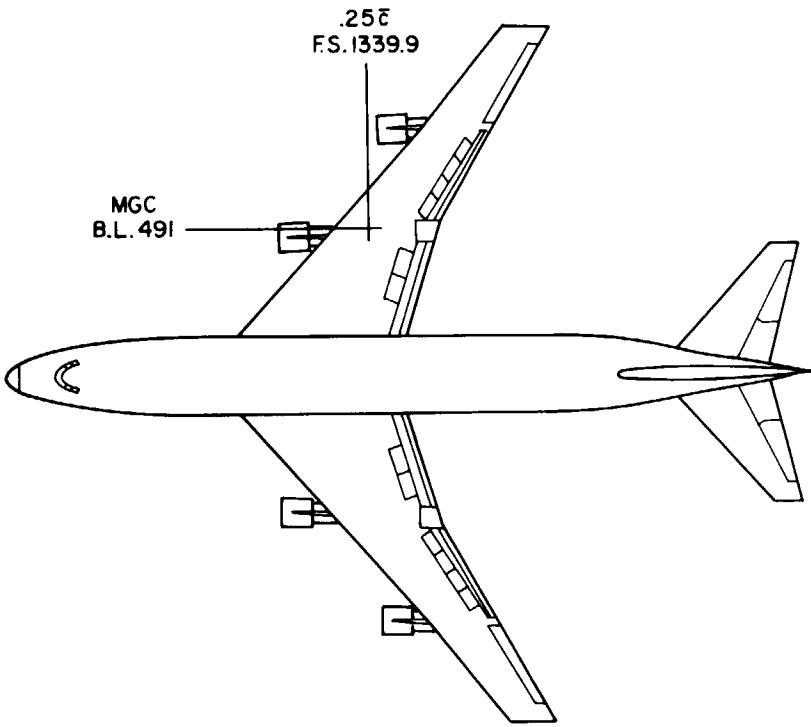
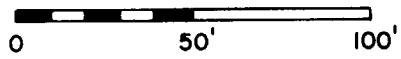
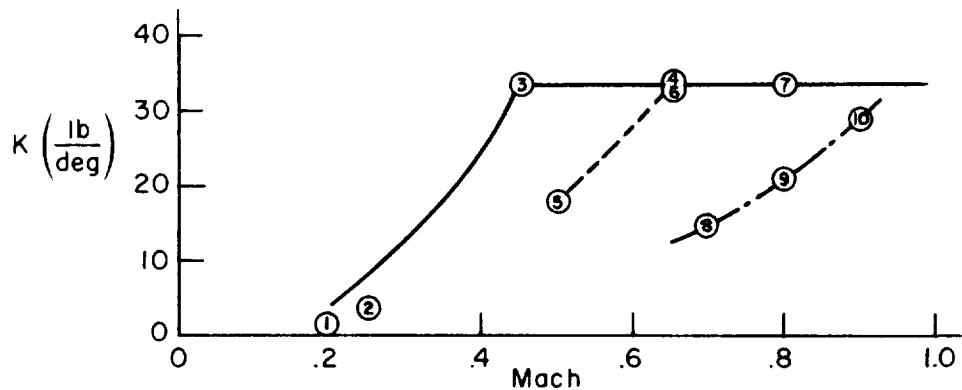
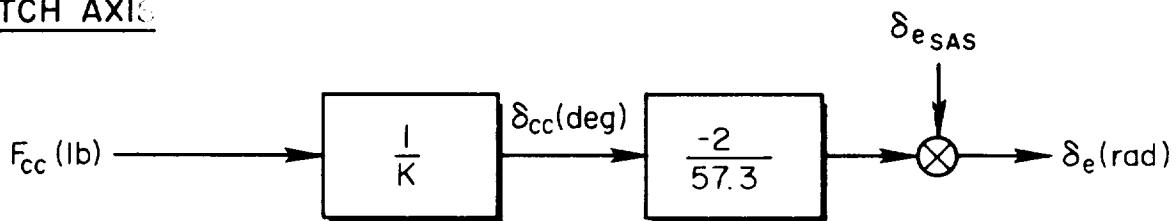


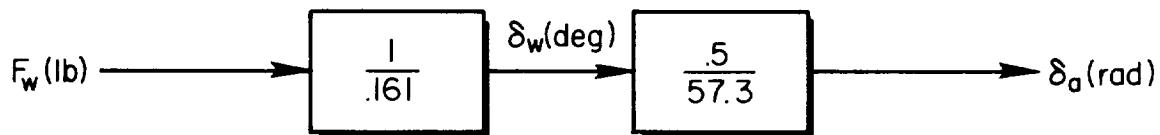
Figure IX-2. B-747 General Arrangement

B-747

PITCH AXIS



ROLL AXIS



YAW AXIS

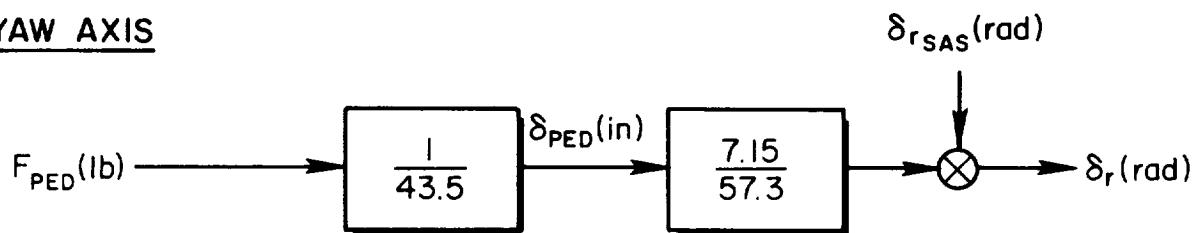
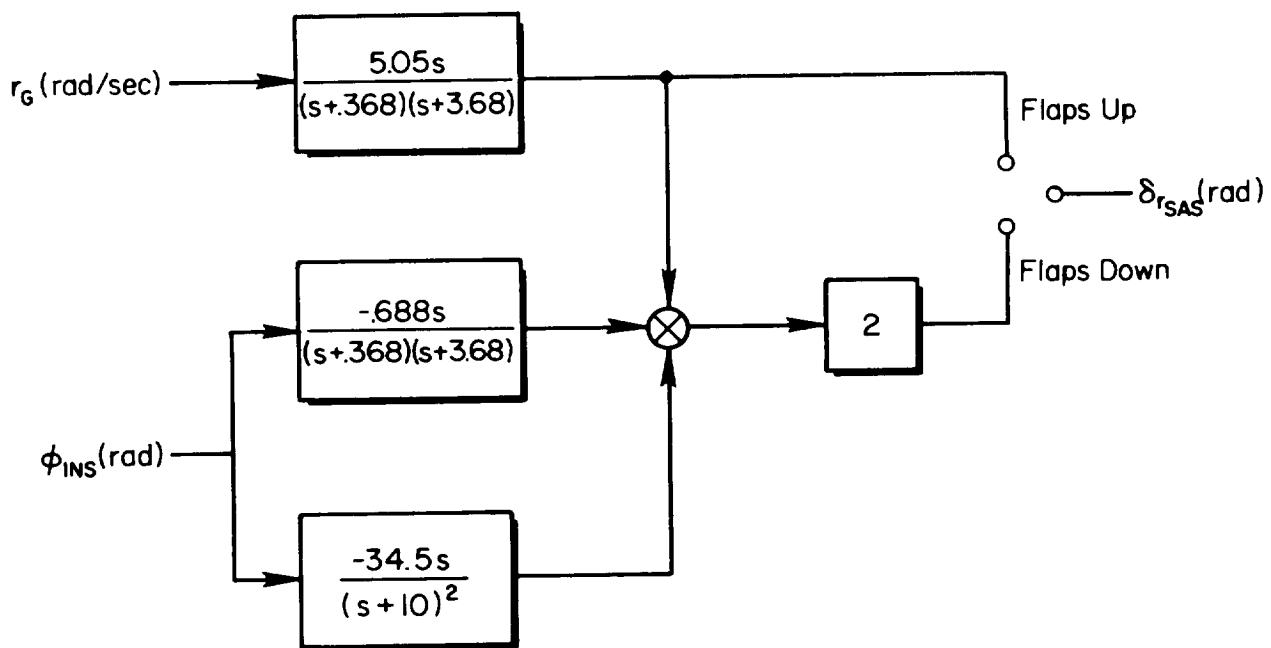


Figure E-5. B-747 Control System

B-747

YAW SAS



$$r = r$$

$$\phi_{INS} = \int p \, dt$$

(Gyro and INS Aligned with FRL)

Figure IX-4. B-747 SAS

TABLE IX-1

B-747

Landing Configuration Non-Dimensional Derivatives

h = sea level

 $V_{T_0} = 131 \text{ KTAS}$ $\alpha_0 = 8.5^\circ$ $\delta_s = -6.3^\circ$

Longitudinal

 $C_L = 1.76$ $C_D = .263$ $C_{L\alpha} = 5.67/\text{rad}$ $C_{D\alpha} = 1.13/\text{rad}$ $C_{m\alpha} = -1.45/\text{rad}$ $C_{L\dot{\alpha}} = -6.7/\text{rad}$ $C_{m\dot{\alpha}} = -3.3/\text{rad}$ $C_{Lq} = 5.65/\text{rad}$ $C_{mq} = -21.4/\text{rad}$ $C_{LM} = -1.1$ $C_{mM} = .36$ $C_{L\delta_e} = .356/\text{rad}$ $C_{m\delta_e} = -1.40/\text{rad}$

Lateral-Directional

 $C_{y\beta} = -1.08/\text{rad}$ $C_{\ell\beta} = -.281/\text{rad}$ $C_{n\beta} = .184/\text{rad}$ $C_{\ell p} = -.502/\text{rad}$ $C_{np} = -.222/\text{rad}$ $C_{\ell r} = .195/\text{rad}$ $C_{nr} = -.36/\text{rad}$ $C_{\ell\delta_a} = .0530/\text{rad}$ $C_{n\delta_a} = .0083/\text{rad}$ $C_{y\delta_r} = .179/\text{rad}$ $C_{\ell\delta_r} = 0$ $C_{n\delta_r} = -.112/\text{rad}$

δ_a = total deflection of right inboard aileron plus left inboard aileron with the effect of outboard ailerons included

TABLE IX-2

B-747

**Power Approach Configuration
Non-Dimensional Derivatives**

h = sea level

V_{T_0} = 165 KTAS

α_0 = 5.7°

δ_s = -2.1°

Longitudinal

$$C_L = 1.11$$

$$C_D = .102$$

$$C_{L\alpha} = 5.70/\text{rad}$$

$$C_{D\alpha} = .66/\text{rad}$$

$$C_{m\alpha} = -1.26/\text{rad}$$

$$C_{L\dot{\alpha}} = -6.7/\text{rad}$$

$$C_{m\dot{\alpha}} = -3.2/\text{rad}$$

$$C_{Lq} = 5.4/\text{rad}$$

$$C_{mq} = -20.8/\text{rad}$$

$$C_{LM} = -.81$$

$$C_{mM} = .27$$

$$C_{L\delta_e} = .338/\text{rad}$$

$$C_{m\delta_e} = -1.34/\text{rad}$$

Lateral-Directional

$$C_{y\beta} = -.96/\text{rad}$$

$$C_{\ell\beta} = -.221/\text{rad}$$

$$C_{n\beta} = .150/\text{rad}$$

$$C_{\ell_p} = -.45/\text{rad}$$

$$C_{n_p} = -.121/\text{rad}$$

$$C_{\ell_r} = .101/\text{rad}$$

$$C_{n_r} = -.30/\text{rad}$$

$$C_{\ell\delta_a} = .0461/\text{rad}$$

$$C_{n\delta_a} = .0064/\text{rad}$$

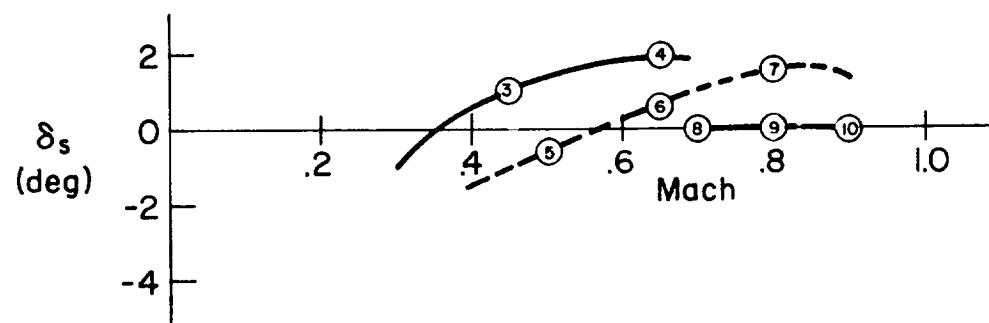
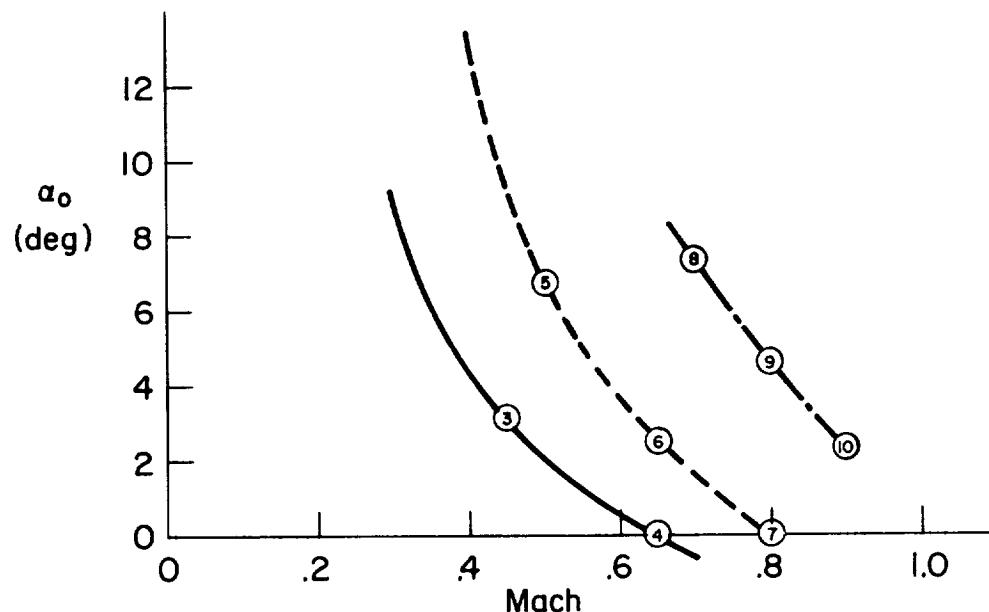
$$C_{y\delta_r} = .175/\text{rad}$$

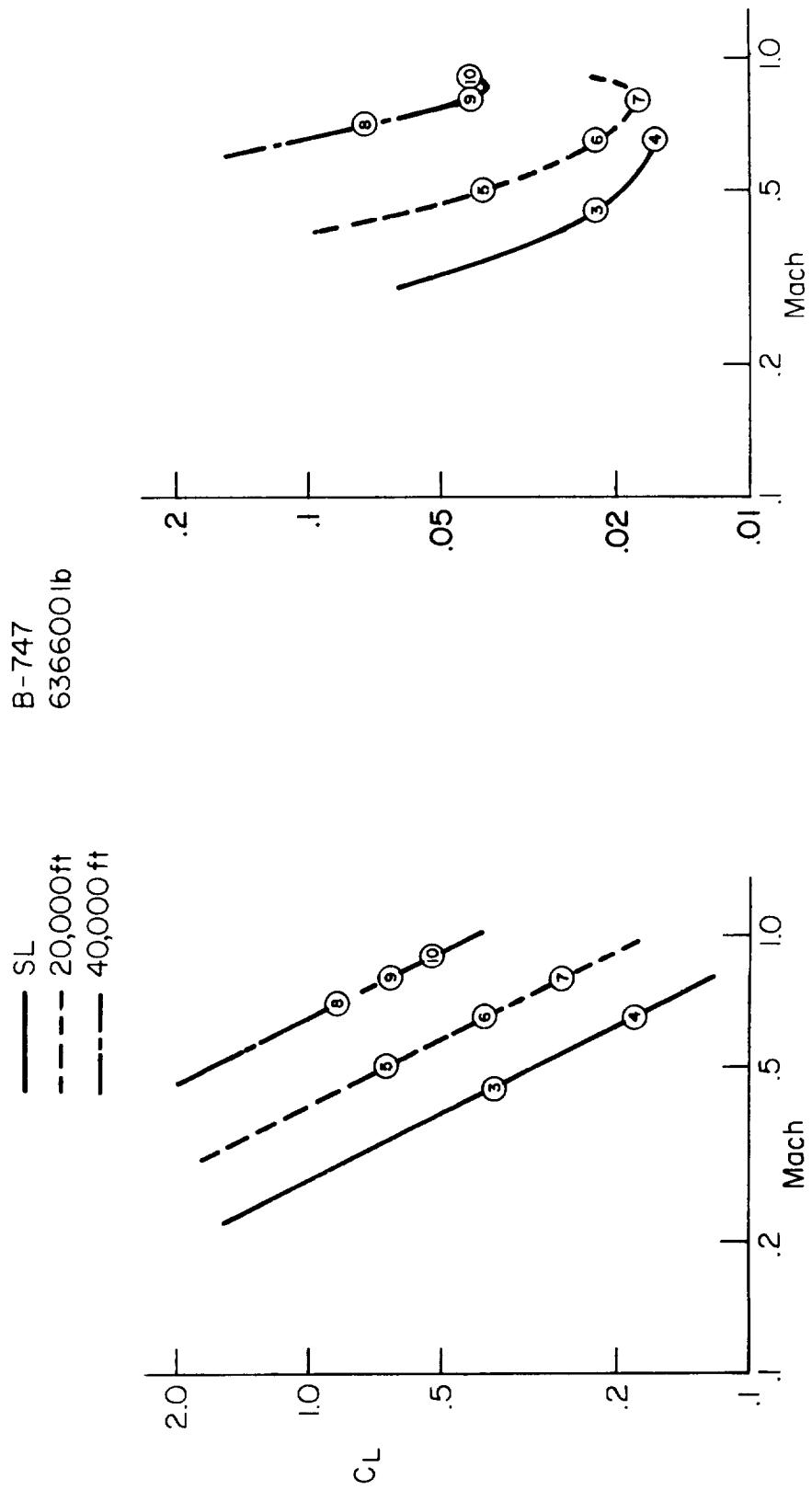
$$C_{\ell\delta_r} = .007/\text{rad}$$

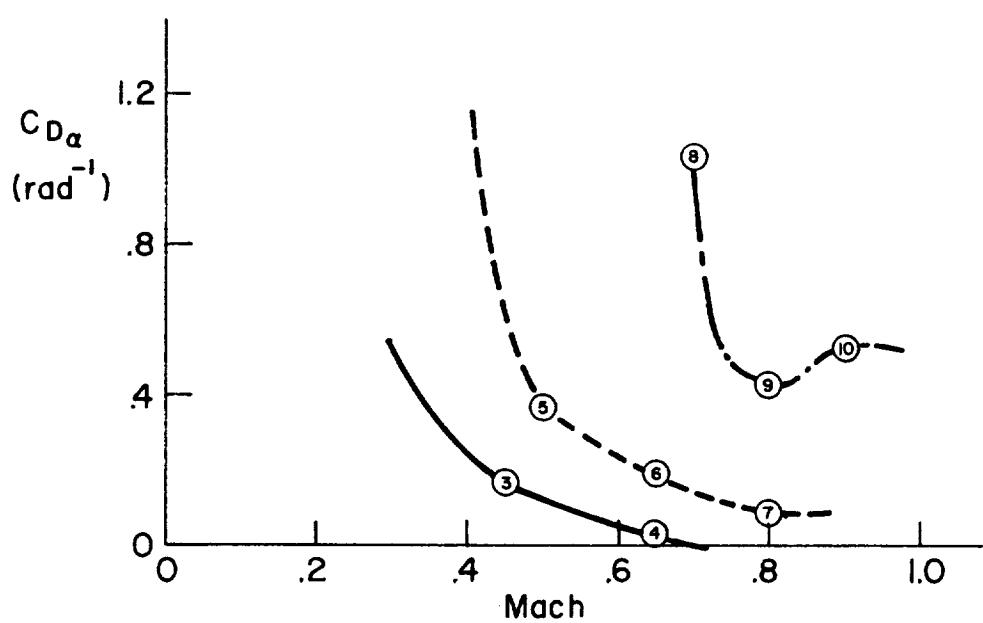
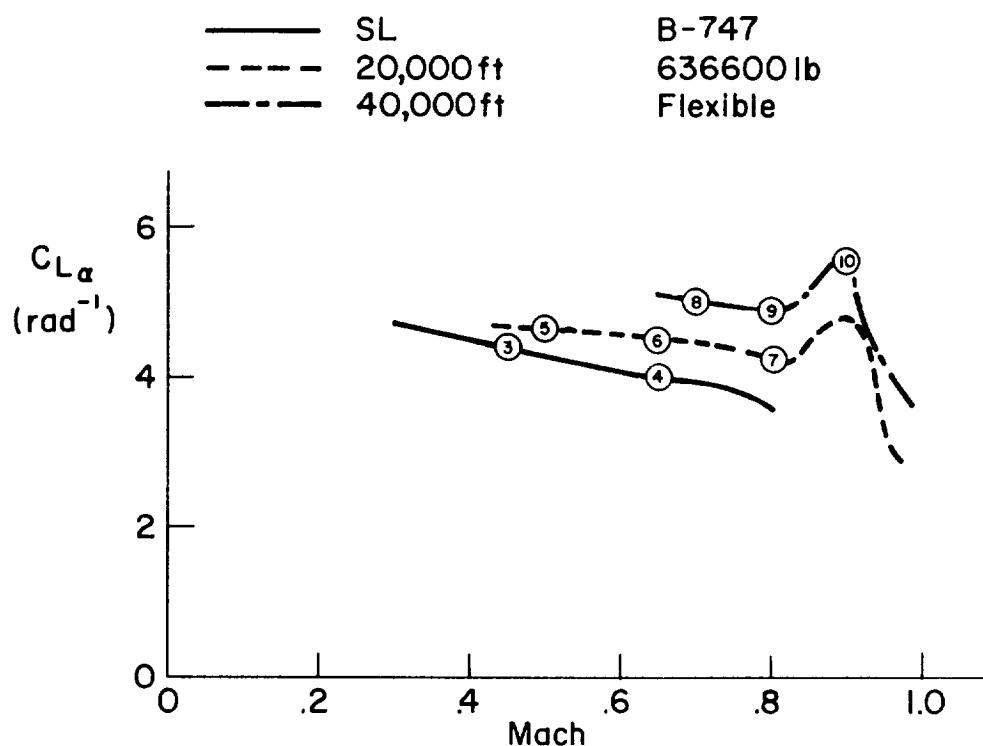
$$C_{n\delta_r} = -.109/\text{rad}$$

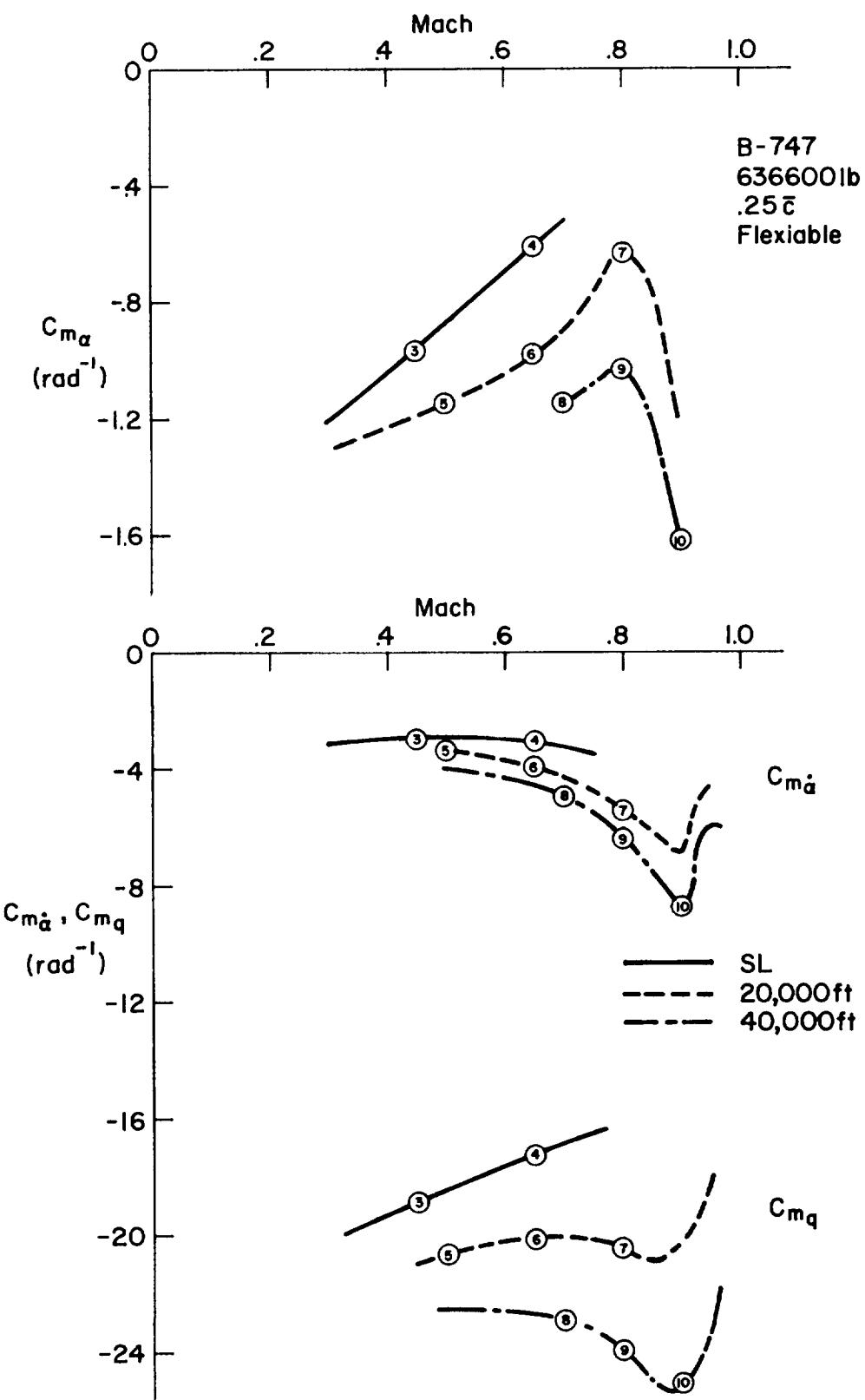
δ_a = total deflection of right inboard aileron plus left inboard aileron with the effect of outboard ailerons included

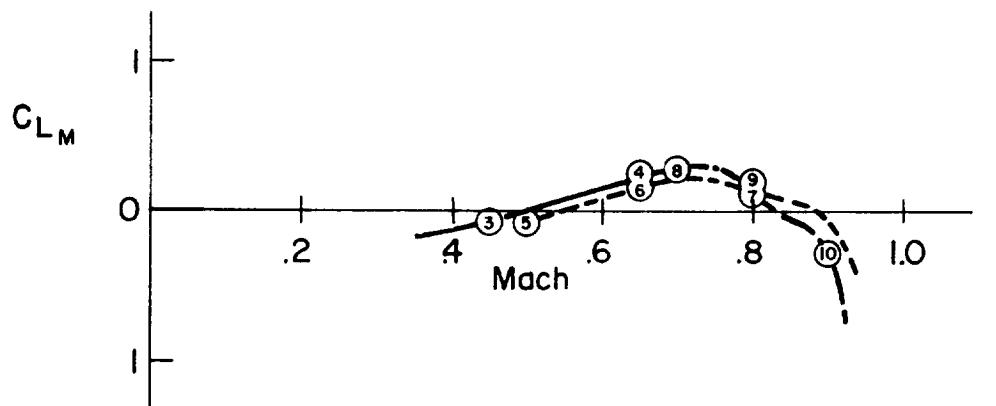
— SL B-747
 - - - 20,000 ft 636600 lb
 - - - 40,000 ft .25 \bar{c}
 - - - Flexible





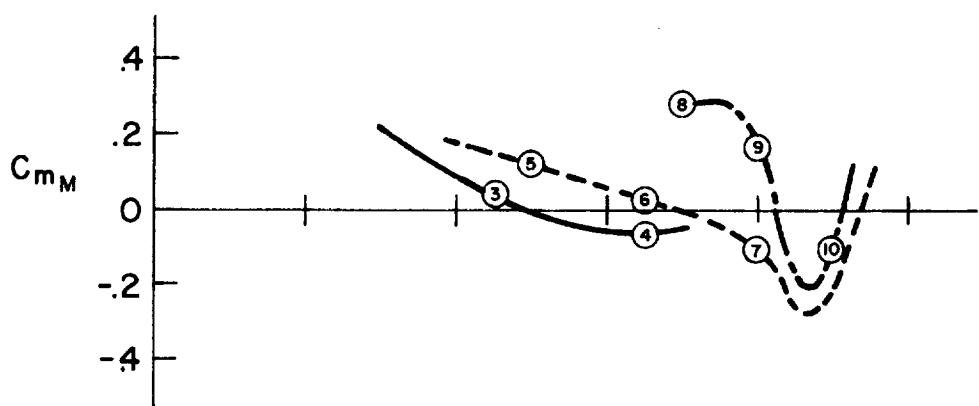
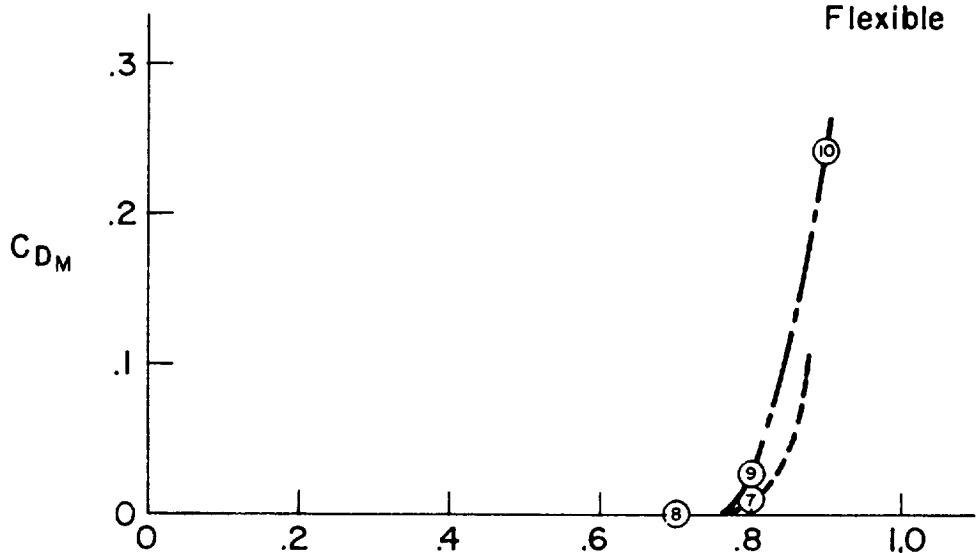






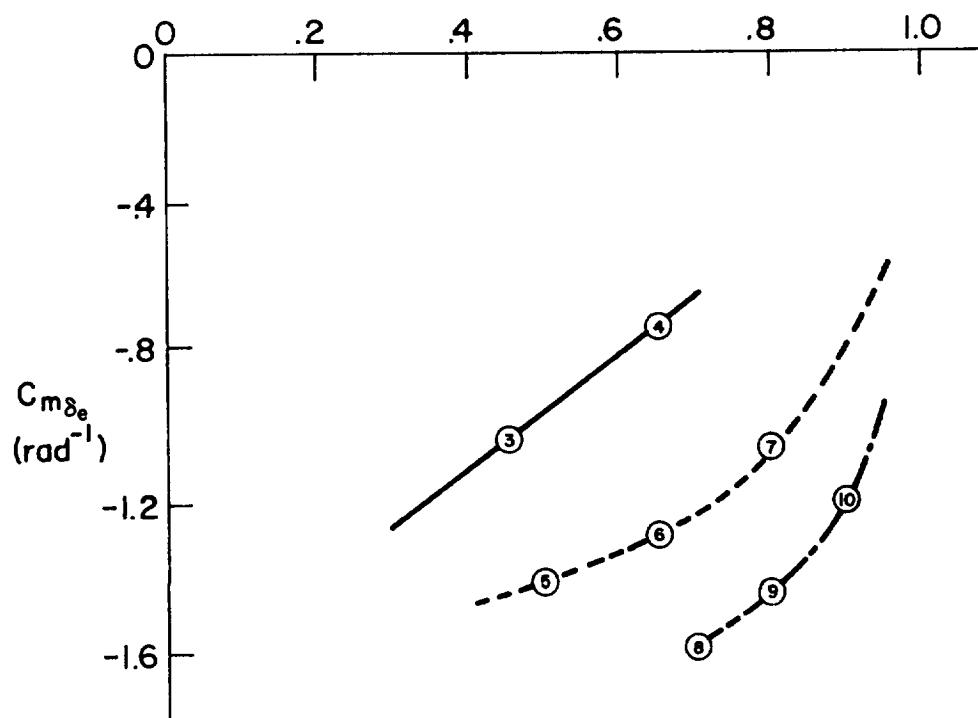
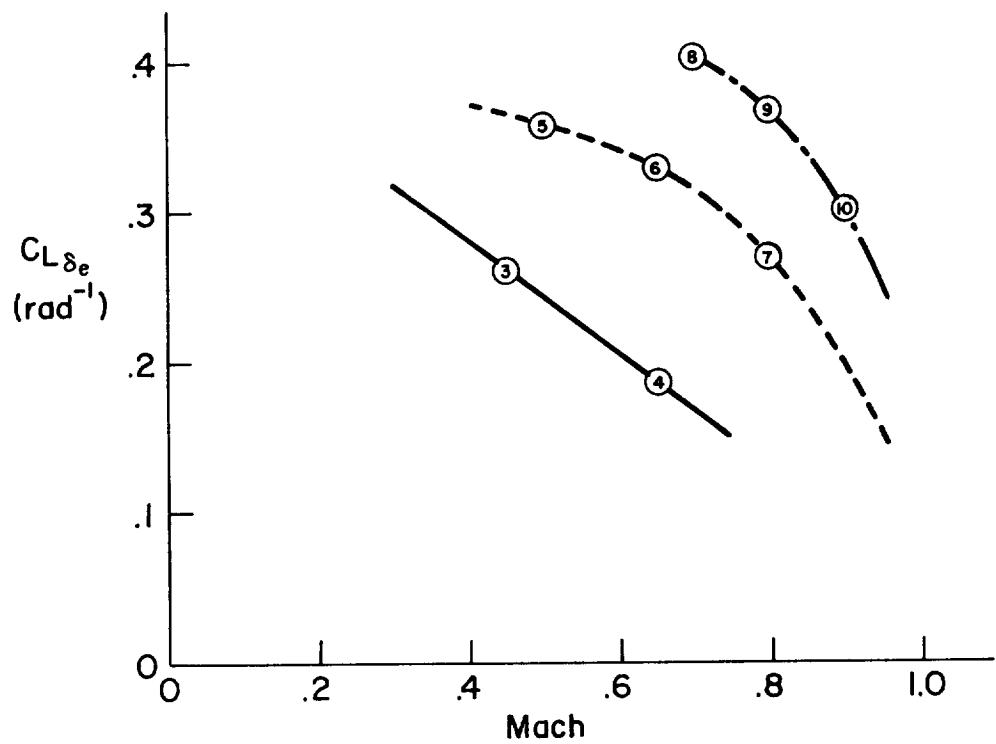
— SL
 - - - 20,000 ft
 - · - 40,000 ft

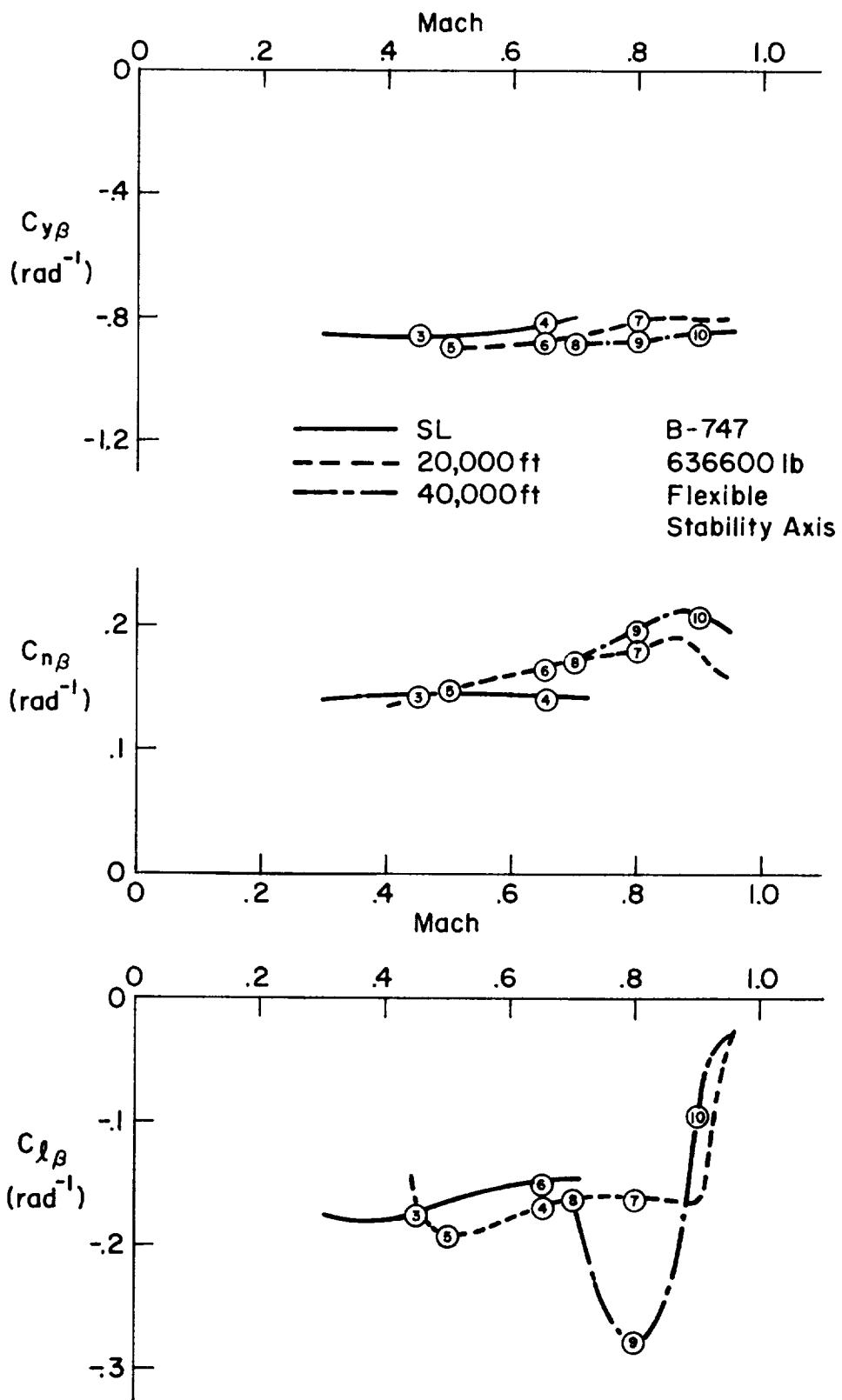
B-747
 636600 lb
 $.25 \bar{c}$
 Flexible



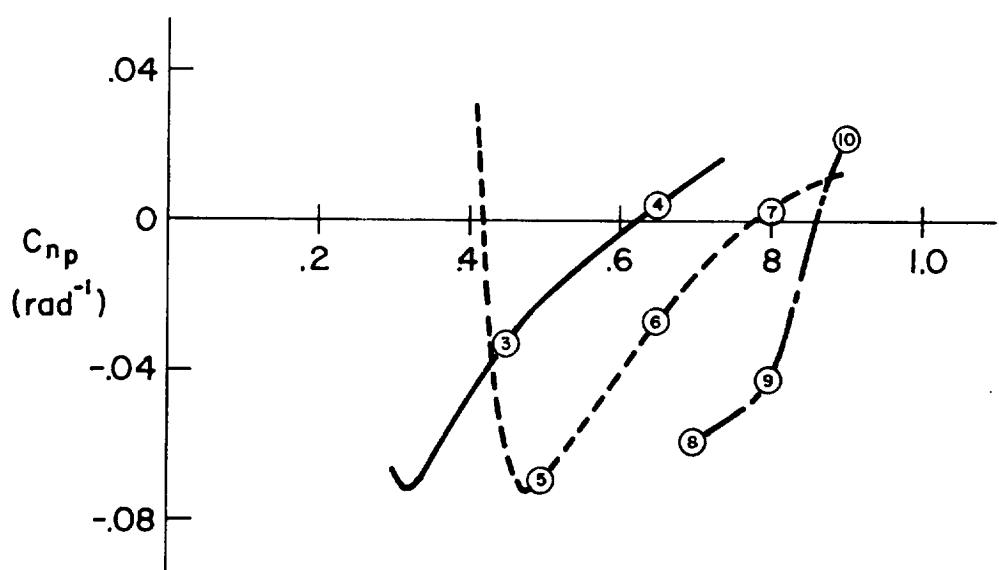
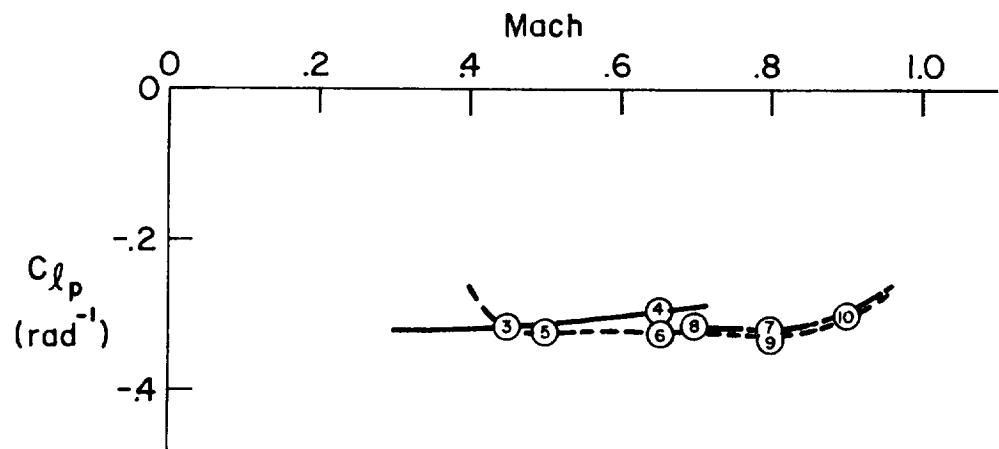
B-747

—	SL
- - -	20,000 ft
— — —	40,000 ft

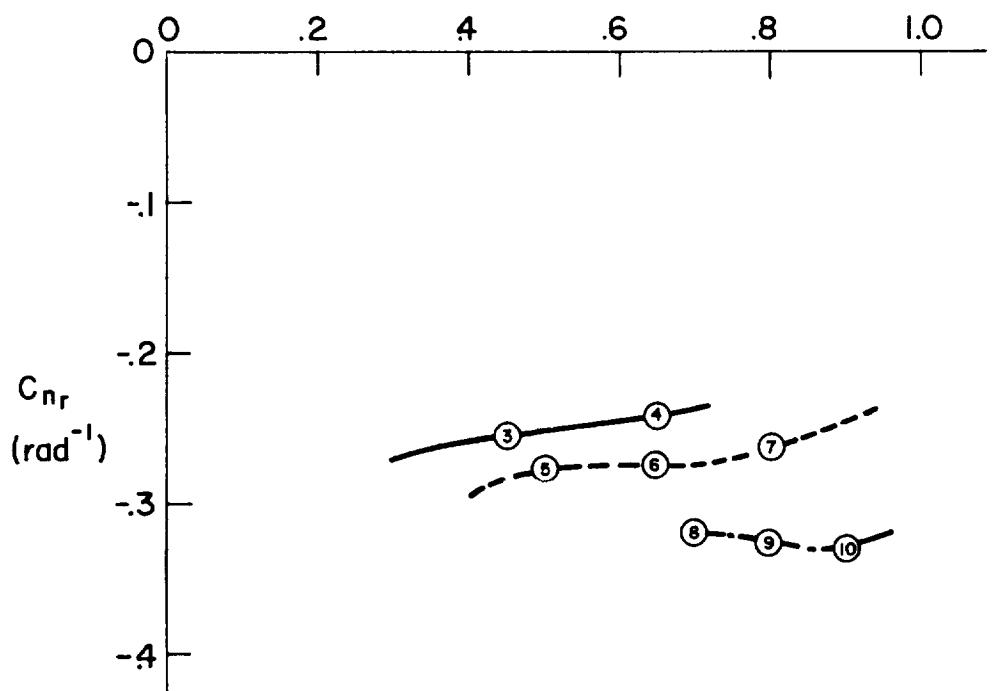
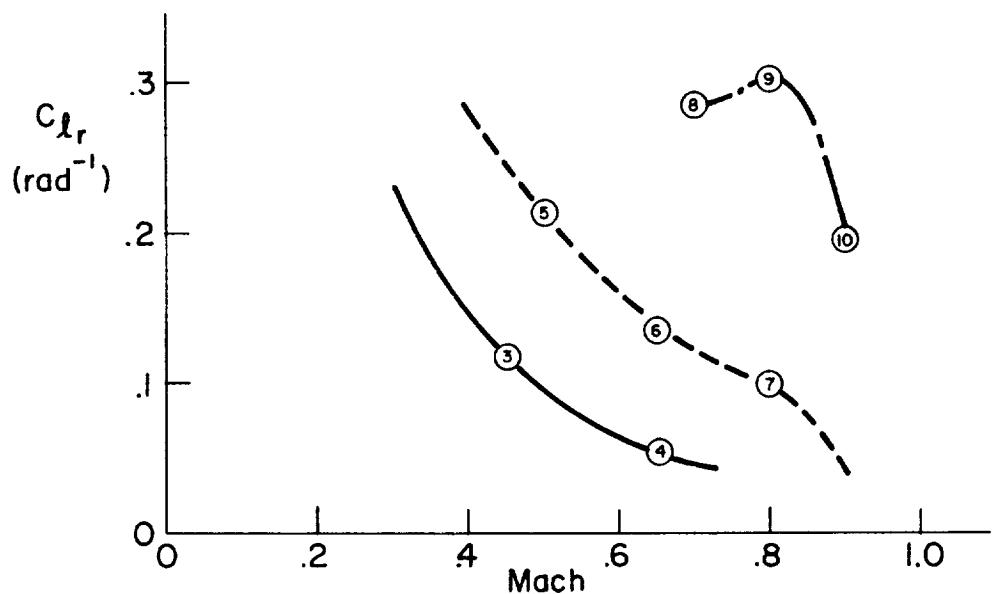


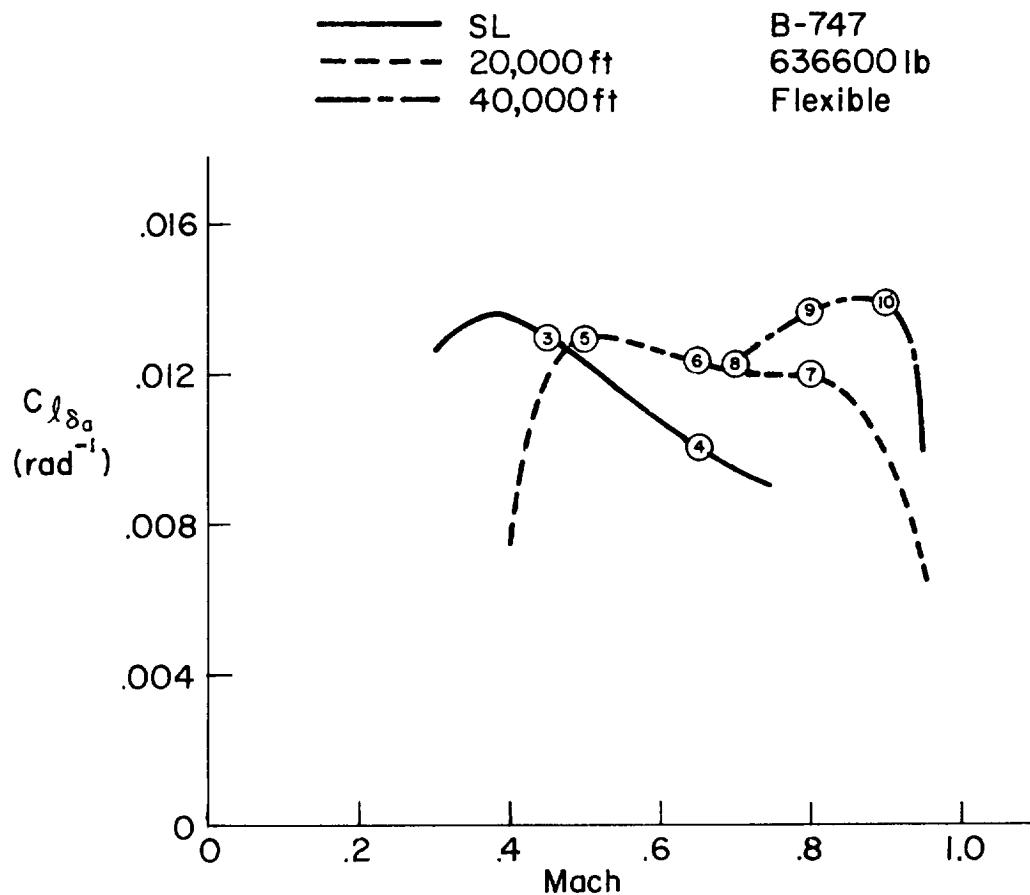


— SL B-747
 - - - 20,000ft 636600 lb
 - - - 40,000ft Stability Axis
 Flexible



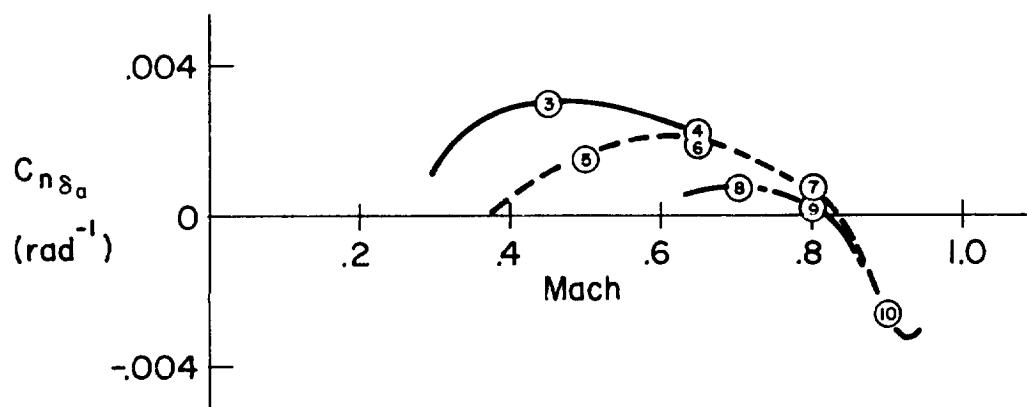
— SL B-747
 - - - 20,000ft 636600lb
 - - - 40,000ft Stability Axis
 Flexible





Note:

- Because spoilers operate around a dead band their effect is neglected here
- δ_a is the total differential deflection of right and left inboard ailerons



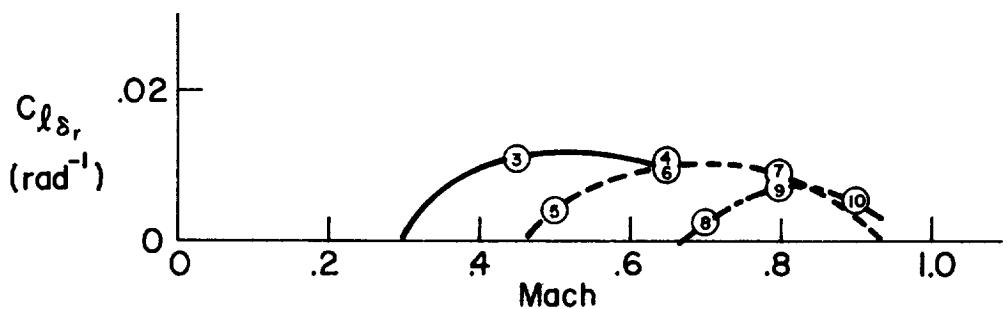
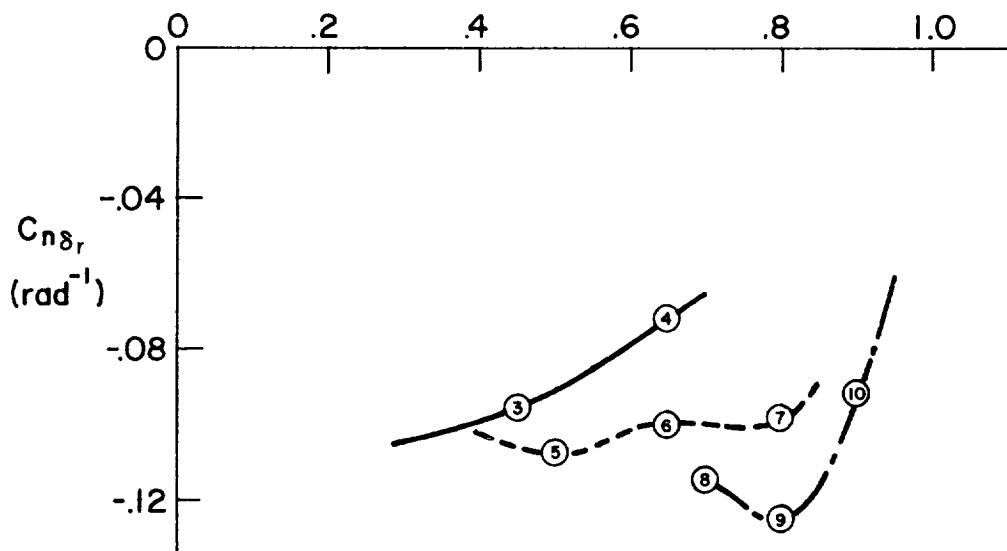
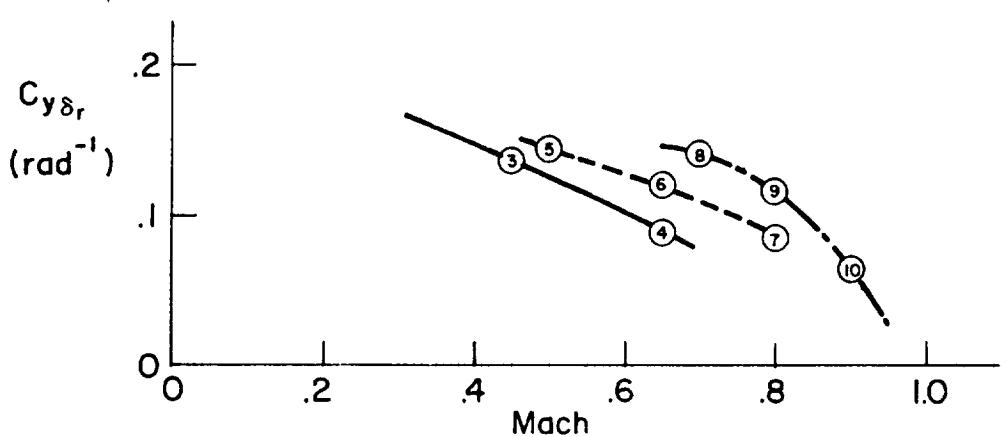
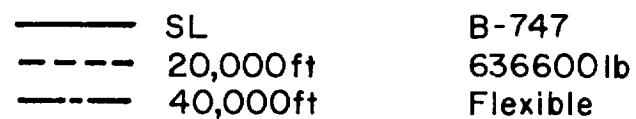


TABLE IX-3

B-747 DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

S = 5500 sq ft, b = 195.68 ft, \bar{c} = 27.31 ft

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K	40 K
M(-)	.128	.249	.450	.650	.500	.650	.800	.700	.800	.900
VTO(FPS)	221.	278.	502.	726.	518.	674.	830.	678.	774.	871.
VTO(TAS)	131.	165.	298.	430.	307.	399.	492.	402.	459.	516.
VTO(KCAS)	131.	165.	298.	430.	228.	299.	373.	210.	243.	278.
W(LBS)	564032.	636636.	636636.	636636.	636636.	636636.	636636.	636636.	636636.	636636.
C.G.(MGC)	.250	.250	.250	.250	.250	.250	.250	.250	.250	.250
IX(SLUG-FT SQ)	.142E+8	.142E+8	.182E+8							
IY(SLUG-FT SQ)	.323E+8	.323E+8	.331E+8							
IZ(SLUG-FT SQ)	.454E+8	.454E+8	.497E+8							
IXZ(SLUG-FT SQ)	870050.	970056.	970056.	970056.	970056.	970056.	970056.	970056.	970056.	970056.
EPOSILCNS(DEC)	-1.60	-1.60	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76
Q(PSF)	58.1	92.2	300.	626.	170.	288.	436.	135.	177.	224.
QC(PSF)	58.7	93.6	315.	695.	181.	320.	510.	153.	207.	273.
ALPHA(DEC)	8.50	5.70	3.10	0.	6.80	2.50	0.	7.30	4.60	2.40
GAMMA(DEC)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0	86.0
LZP(FT)	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
LTH(DEC)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
XI(DEC)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
LTH(FT)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	*	*	*	*	*	*	*	*	*	*

TABLE IX-4

B-747 LONGITUDINAL DIMENSIONAL DERIVATIVES
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K	40 K
R	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
XU *	-.0209	-.0108	-.00499	-.00777	-.00247	-.00280	-.00563	-.00187	-.00276	-.0200
ZU *	-.202	-.150	-.0807	-.126	-.0679	-.0832	-.0941	-.0696	-.0650	-.0424
MU *	.000117	.000181	.000146	-.000199	.000247	.885E-4	-.000222	.00259	.000193	.523E-4
XW	.122	.106	.0743	.0345	.0782	.0482	.0253	.0263	.0389	.0159
ZW	-.512	-.613	-.736	-.963	-.433	-.539	-.624	-.292	-.317	-.401
MW	-.001177	-.00193	-.00262	-.00239	-.00170	-.00190	-.00153	-.00101	-.00105	-.00190
ZWD	.0334	.0338	.0297	.0253	.0157	.0156	.0144	.00704	.00556	.00614
ZG	-6.22	-7.58	-10.4	-12.8	-6.39	-8.09	-9.99	-4.32	-5.16	-6.71
MWD	-.000246	-.000240	-.000221	-.000228	-.000125	-.000155	-.000212	-.905E-4	-.000116	-.000160
RQ	-.357	-.437	-.699	-.925	-.421	-.535	-.659	-.284	-.330	-.401
XDE	.959	.971	1.18	0.	2.02	1.15	0.	1.93	1.44	.781
ZDE	-6.42	-9.73	-21.8	-32.4	-16.9	-26.4	-32.7	-15.1	-17.9	-18.6
MDE	-.378	-.574	-1.40	-2.07	-1.09	-1.69	-2.09	-.970	-1.16	-1.22
XD TH	.570E-4	.570E-4	.5C5E-4	.505E-4						
ZD TH	-.249E-5	-.249E-5	-.220E-5							
MD TH	.310E-6	.310E-6	.302E-6							
	+	+	+	+	+	+	+	+	+	+

TABLE IX-5
B-747 ELEVATOR TRANSFER FUNCTION FACTORS
Bare Airframe
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	\$L	\$L	\$L	\$L	\$L	20 K	20 K	40 K	40 K	.900
H	.108	.249	.450	.650	.500	.650	.800	.800	.800	.900
DE NUMINATOR										
Z(DE T)1	.0417	.0228	.0319	.011C	.0241	.0264	.323	.0636	.0489	.304
H(DE T)1	.152	.127	.0753	.0363	.0823	.0653	.00984	.0781	.0673	.0311
Z(DE T)2	.616	.629	.575	.637	.446	.473	.567	.357	.387	.351
H(DE T)2	.771	.910	.137	1.63	1.04	1.26	1.30	.870	.964	1.35
NUMERATORS										
N(U/DE)	.993	1.01	1.22	-1.15	2.05	1.17	-873	1.95	1.45	.785
A(U)	1.19	15.2	21.1	3.71	32.7	42.0	1.83	42.8	49.6	56.0
1/T(U)	1	1	1	(-14.9)	.306	.335	(-25.5)	.705	.434	.783
Z(U)	1	1	1	1	.469	.758		.323	.392	.578
H(U)	1	1	1	1						
N(W/DE)	-6.65	-10.1	-22.5	-33.3	-17.2	-26.8	-33.2	-15.2	-18.0	-18.7
A(W)	1.29	16.4	32.3	46.6	33.2	43.0	52.7	43.2	50.1	56.9
1/T(W)	1	1	1	1	.0401	.0238	.0338	.0537	.00781	.260
Z(W)	1	1	1	1	.0514	.0518	.0635	.0593	.00593	.0387
H(W)	1	1	1	1	.171	.133	.0728			
N(THE/DE)	-377	-572	-1.40	-2.07	-1.09	-1.68	-2.07	-1.98	-1.16	-1.21
A(THE)	.0801	.0396	.0136	.0124	.0158	.0107	.0105	.00419	.0113	.0217
1/T(THE)1					.952	.400	.511	.606	.272	.373
1/T(THE)2										
N(HD/DE)	6.72	10.1	22.5	33.3	17.3	26.8	33.2	15.3	18.1	16.8
A(HD)	-0.0118	-.0045	.0024C	.0064C	-.0030C2	.000530	.0054	-.0151	-.00166	.0161
1/T(HD)1	-2.17	-2.75	-4.21	-5.75	-3.35	-4.29	-5.15	-3.19	-3.64	-4.36
1/T(HD)2					5.31	7.43	5.09	6.13	4.08	4.82
1/T(HD)3										
N(ALP/DE)	25.7	39.1	97.7	144.	76.3	118.	145.	68.1	81.7	85.7
A(ALP)	.0339	.0189	-.00577	0.	.00927	-.0045	0.	.00154	.00532	-.00188
1/T(ALP)1										
1/T(ALP)2										
Z(ALP)1										
H(ALP)1										

TABLE IX-6
B-747 TERRIST TRANSFER FUNCTION FACTORS
Bare Airframe
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	.40 K
H	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
DENOMINATOR										
Z(DET)1	.0417	.0228	.0319	.110	.0241	.0264	.323	.0636	.0489	.304
W(DET)1	.152	.127	.0753	.0368	.0823	.0653	.00984	.0781	.0673	.0311
Z(DET)2	.616	.629	.575	.637	.446	.473	.567	.357	.387	.351
W(DET)2	.771	.910	1.37	1.63	1.04	1.26	1.30	.879	.964	1.35
NUMERATORS										
N(W /DTH)	A(W)	.571E-4	.505E-4	.5C5E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4	.505E-4
	1/T(W)1	-.173	-.0823	-.070C	-.0943	-.0715	-.0713	-.114	-.0803	-.0502
	2(W)1	.592	.605	.54C	.323	.433	.586	.159	.251	.301
	W(W)1	.784	.928	1.37	1.67	1.00	1.25	1.32	.740	.908
										1.29
N(W /DTH)	A(W)	-.287E-5	-.277E-5	-.226E-5	-.227E-5	-.234E-5	-.227E-5	-.224E-5	-.227E-5	-.223E-5
	1/T(W)1	-.194	-.276	-.62.6	-.93.8	-.65.1	-.87.5	-.109.	-.88.1	-.102.
	Z(W)1	-.0347	.0126	.0785	-.355	.286	.0642	-.360	.360	.320
	W(W)1	.189	.139	.0726	.0715	.0627	.0637	.0621	.0551	.0551
N(THE/DTH)	A(THE)	.312E-6	.303E-6							
	1/T(THE)1	(.876)	.197	.089E	.032E	.115	.0808	.0125	.110	.0932
	1/T(THE)2	(.340)	.504	.721	.955	.383	.500	.603	.233	.270
N(HD /DTH)	A(HD)	.113 E-4	.842E-5	.508E-5	.227E-5	.830E-5	.448E-5	.224E-5	.866E-5	.629E-5
	1/T(HD)1	.118	.102	.0686	.0243	.0739	.0601	.00572	.0652	.0626
	Z(HD)1	.433	.330	.170	.139	.176	.158	.158	.161	.153
	W(HD)1	1.97	2.74	4.98	10.C	3.06	5.18	8.60	2.75	3.58
N(AZP/DTH)	A(AZP)	-.297E-4	-.296E-4	-.284E-4	-.283E-4	-.284E-4	-.283E-4	-.283E-4	-.283E-4	-.283E-4
	1/T(AZP)1	-.0276	-.0137	-.00376	C	-.00231	0.	-.00689	-.00372	-.00169
	1/T(AZP)2	.155	.122	.0751	.0243	.0884	.0641	.00577	.0761	.0401
	Z(AZP)1	.362	.202	.203	.195	.164	.160	.161	.135	.128
	W(AZP)1	1.16	1.42	2.06	2.84	1.58	2.03	2.42	1.46	1.65

TABLE IX-7

B-747 LONGITUDINAL HANDLING QUALITIES PARAMETERS

Bare Airframe

(Body Axis System)

F/C *	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K	40 K
P	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
STICK FIXED										
D(G)/D(Y) (DEG/KT)	.0349	.0123	-.00726	-.0154	.00900	-.00166	-.0137	.0452	.00494	-.0486
NZA (G/RAD)	3.27	5.00	10.8	20.8	6.50	10.7	15.4	5.76	7.22	10.1
DE/G (DEG/G)	25.9	15.7	6.80	3.43	8.45	4.95	2.98	7.75	6.25	8.45
CAP (RAD/SEC/SEC/G)	.170	.157	.166	.124	.160	.145	.108	.131	.127	.179
PHUGOID(2) (SEC)	--	--	--	--	--	--	--	--	--	--
{ TUG(K(Z)) }										
1/C(1/10)	2.13	2.21	1.92	2.26	1.36	1.46	1.88	1.04	1.14	1.02
	+	+	+	+	+	+	+	+	+	+

B-747 LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
 TABLE IX-8
 (BODY AXIS SYSTEM)

	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
F/C *	1	2	3	4	5	6	7	8	9	10									
H	SL	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K									
M	-158	.249	.450	.650	.500	.650	.800	.700	.800	.900									
YY	-.0890	-.0997	-.143	-.197	-.0822	-.104	-.120	-.0488	-.0558	-.0606									
YB	-19.7	-27.8	-71.7	-143.	-42.6	-70.4	-99.4	-33.1	-43.2	-52.8									
LB*	-1.33	-1.63	-3.19	-5.45	-2.05	-2.96	-4.12	-1.45	-3.05	-1.32									
NB*	.168	.247	.810	1.82	.419	.923	1.62	.404	.598	.971									
LP*	-.975	-1.10	-1.12	-1.47	-6.52	-.804	-.974	-.404	-.465	-.459									
NP*	-.146	-.125	-.0706	-.0214	-.0701	-.0531	-.0157	-.0366	-.0316	.00284									
LR*	.327	.198	.379	.256	.376	.317	.292	.312	.388	.280									
NR*	-.217	-.229	-.246	-.344	-.140	-.193	-.232	-.0963	-.115	-.141									
Y*CA	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.									
L*CA	.227	.318	.229	.372	.128	.210	.310	.0964	.143	.186									
N*CA	.0264	.0300	.0285	.0371	.0177	.0199	.0127	.00875	.00775	-.00611									
Y*CR	.0148	.0182	.0226	.0213	.0131	.0142	.0124	.00777	.00729	.00464									
L*CR	.0636	.110	.254	.318	.148	.211	.183	.115	.153	.100									
N*CR	-.151	-.233	-.614	-.970	-.391	-.616	-.922	-.331	-.475	-.442									
	+	+	+	+	+	+	+	+	+	+									

B-747 AILERON TRANSFER FUNCTION FACTORS
SAS Off
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL .198	SL .249	SL .450	SL .650	20 K .550	20 K .650	20 K .800	40 K .700	40 K .800	40 K .900
N($\eta_{MIN4/TCR}$)	.0427	.0465	.0194	.0203	.00903	.0108	.0103	-.00234	.00730	-.00777
1/T(DET)1	.1.11	.1.23	.1.56	.745	.913	1.06	.462	.562	.478	.0929
1/T(DET)2	.107	.126	.153	.0693	.0823	.0981	.0568	.0349	.141	.173
Z(DET)1	.0878	.1.06	.1.40	.863	1.07	1.31	.788	.947	.0529	.0405
W(CET)1	.735	.746							.762	1.11
N($\eta_{MATICRS}$)										
N(η_B/DA)	.00740	.0171	-.0161	-.0371	-.00243	-.0107	-.0127	.00358	.00373	.0139
A(B)	.154	.176	.448	.168	.174	.230	.333	.0981	.0995	.103
1/T(B)1									2.17	.628
1/T(B)2	.71C	.7.1C	-.605	.981	-.3.62	-.910	-.694	1.61		
N(η_P/DA)										
N($\eta_A(R)$)										
1/T(P)1	.227	.318	.229	.372	.128	.210	.310	.0964	.143	.186
1/T(P)2	-.0199	-.0108	-.00335	0.	-.00722	-.00205	0.	-.00601	-.00331	-.00154
Z(P)1	.308	.274	.197	.181	.166	.149	.135	.122	.111	.100
W(P)1	.591	.653	1.12	1.56	.846	1.11	1.35	.734	.877	.967
N(η_R/DA)										
N($\eta_A(R)$)										
1/T(R)1	.0254	.0300	.0285	.0371	.0177	.0199	.0127	.00875	.00775	-.00611
1/T(R)2	.499	.593	.849	.6.8	.442	.718	1.46	.330	.435	-.1.22
Z(R)1	-.482	-.395	-.0874	-.142	-.128	-.201	-.347	-.153	-.217	.893
W(R)1	.895	.507	.855	.791	.842	.920	1.08	.919	1.16	.925
N(η_{PHI}/DA)										
A(PHI)										
1(Z PHI)1	.231	.321	.230	.372	.130	.211	.310	.0975	.143	.186
Z(PHI)1	.284	.264	.196	.181	.162	.148	.135	.117	.109	.0991
W(PHI)1	.586	.650	1.12	1.56	.844	1.11	1.25	.735	.878	.968
N(η_{AYP}/DA)										
A(AYP)										
1/T(AYP)1	4.54	5.76	4.74	6.91	2.82	4.19	1.72	2.10	1.34	
1/T(AYP)2	.257	.279	-.143	-.0950	-.151	-.137	-.126	-.134	-.135	-.166
Z(AYP)1	-.331	-.313	.406	.626	.216	.264	.334	.141	.149	.173
W(AYP)1	.0459	.121	.145	.146	.100	.0983	.0955	.0731	.0529	.0405
	.643	.705	1.07	1.42	.847	1.07	1.29	.762	.907	
+	+	+	+	+	+	+	+	+	+	+

TABLE IX-10
B-747 RUDDER TRANSFER FUNCTION FACTORS
 SAS Off
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.SL	.SL	.SL	.SL	.20 K	.20 K	.20 K	.20 K	.40 K	.40 K
M	.158	.249	.450	.650	.500	.650	.800	.700	.800	.900
DECCELERATOR										
1/T (DET) 1	.0427	.0465	.0194	.0203	.00903	.0108	.0103	.C0234	.00730	.00777
1/T (DET) 2	1.11	1.23	1.23	1.56	.745	.913	1.06	.462	.562	.478
Z(DET) 1	.0876	.107	.126	.153	.0693	.0623	.0981	.0568	.0349	.0929
W(DET) 1	.735	.746	1.06	1.40	.863	1.07	1.31	.788	.947	1.02
NUMERATORS										
N(S / D _R)										
A(P)	.0148	.C182	.0226	.0213	.0131	.0142	.0124	.00777	.00729	.00464
1/T(B)	-.0533	-.C192	-.0482	-.0420	-.0359	-.0162	-.00957	-.0366	-.0329	-.0208
1/T(B)	1.05	1.17	1.16	1.50	.665	.630	.995	.411	.478	.471
1/T(B)	11.C	13.6	28.0	45.8	31.0	44.0	74.4	44.3	66.8	96.3
Y(P / D _R)										
A(P)	.0636	.110	.254	.318	.148	.211	.183	.115	.153	.100
1/T(P)	-.0209	-.C113	-.C0340	0.	-.00728	-.00206	0.	-.00601	-.00532	-.00153
1/T(P)	1.42	1.64	2.28	3.58	1.83	2.41	3.75	1.57	2.65	1.74
1/T(P)	13	-2.18	-1.99	-4.18	-2.77	-3.24	-5.15	-2.41	-3.63	-2.83
N(R / D _R)										
A(R)	-.151	-.233	-.614	-.970	-.391	-.616	-.922	-.321	-.475	-.442
1/T(R)	1.05	1.17	1.16	1.58	.621	.865	1.11	.393	.492	.524
Z(R)	.0790	.C895	.130	.0796	.144	.0522	-.0468	.0769	.0245	.0283
W(R)	11	.416	.284	.397	.434	.382	.364	.397	.488	.278
N(P H _I / D _R)										
A(PH _I)	.0410	.C867	.221	.318	.101	.185	.0727	.115	.0815	
1/T(PH _I)	1.48	1.69	2.35	3.58	2.01	2.50	3.75	1.79	2.69	1.83
1/T(PH _I)	12	-3.31	-2.48	-3.47	-3.74	-3.58	-3.15	-3.40	-4.44	-3.20
N(A Y P / D _R)										
A(AYP)	-.9.12	-.13.9	-.38.9	-.64.7	-.25.3	-.41.3	-.67.1	-.22.1	-.33.7	-.33.0
1/T(AYP)	-.0646	-.C386	-.C268	-.0103	-.0573	-.0210	-.0126	-.0530	-.0284	-.0206
1/T(AYP)	1	1.07	.973	1.32	.491	.069	.848	.312	.334	.427
Z(AYP)	2	.958	.128	.191	.137	.193	.147	.116	.136	.135
Z(AYP)	1	.247	.208	.111	1.45	.984	1.10	1.22	.860	1.05
W(AYP)	1	.668	.740							.573
	+	+	+	+	+	+	+	+	+	+

TABLE IX-11

B-747 AILERON TRANSFER FUNCTION FACTORS
SAS On

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.SL	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K
M	.198	.249	.45C	.65C	.500	.650	.800	.700	.800	.900
DENOMINATOR										
1/T(DET1)	.0770	.198	.0148	.016C	.00698	.00843	.00801	-.00185	.00514	-.00687
1/T(DET2)	.471	.858	.804	.163	.495	.696	1.28	.386	.467	2.83
1/T(DET3)	1.20	1.53	(.524)	(.795)	1.09	1.67	(.685)	.808	1.16	(.973)
1/T(DET4)	3.10	2.50	(.900)	(.791)	2.91	1.90	(.748)	3.07	2.68	(.540)
1/T(DET5)	9.26	9.03	(.978)	(.692)	(.267)	(.477)	(.729)	(.234)	(.255)	(.412)
1/T(DET6)	10.7	1C.9	(1.94)	(2.28)	(.794)	(.908)	(2.10)	(.716)	(.828)	(.961)
Z(DET1)	.472	.849	.287	.576						
V(DET1)										
NUMERATORS										
N(8 /DA)										
A(P)	.00740	.00171	-.0161	-.0371	-.00243	-.0107	-.0127	.00358	.00373	.0130
1/T(B) 1	1.1	13.0	.0905	.101	.0706	.0613	.0535	.0479	.0413	
1/T(B) 2	1.37	39.4	.841	.381	.465	.708	.117	.464	.464	3.27
Z(B) 1	.790	.150	(-1.21)	(1.79)	(4.90)	(-1.57)	(1.58)	.783	.754	.906
N(B) 1	.289	.444	(3.97)	(3.25)	(-5.32)	(4.03)	(3.17)	3.47	3.00	.806
Z(B) 2	.901	.849	3.69	2.88						
N(B) 12										
R(P /DA)										
A(P)		.227	.313	.372	.128	.210	.310	.0664	.143	.143
1/T(P) 1	-.0198	-.C107	-.00335	0.	-.00721	-.0004	0.	-.00600	-.00331	-.00154
1/T(P) 2	.863	1.48	.613	.466	.619	.611	.621	.612	.706	.525
1/T(P) 3	3.04	2.43	1.80	1.28	2.86	2.07	.907	3.04	2.67	2.84
1/T(P) 4	9.99	9.99	{ .837)	{ .610)	{ .577)	{ .690)	{ .690)	{ .456)	{ .581)	{ .475)
1/T(P) 5	10.0	10.0	(1.24)	(2.35)	(.741)	(1.15)	(2.00)	(.626)	(.743)	(.921)
Z(P) 1	.594	.616	.426	.402						
N(P) 1										
M(P /DA)										
A(R)		.0264	.0285	.0371	.0177	.0199	.0127	.00875	.00775	.00611
1/T(R) 1	3.96	12.6	.368	.368	.368	.368	.363	.330	.368	.368
1/T(R) 2	6.22	(.573)	.849	1.68	4.42	718	1.46	.362	.435	-1.22
1/T(R) 3	12.7	(.251)	3.68	3.68	3.68	3.68	3.63	3.68	3.68	3.68
Z(R) 1	.773	.634	-.0874	-.142	-.129	-.201	-.367	-.153	-.217	.873
N(R) 1	.410	1.49	.855	.701	.842	.920	1.02	.010	1.16	.025
Z(R) 2	.C977	.952								
N(R) 12	1.02	4.22								

TABLE IX-11 (Concluded)

N(PH1 / DA)									
A(PH1)	.231	.321	.230	.372	.130	.211	.310	.0975	.143
1/T(PH1)1	.638	1.46	.616	.466	.615	.612	.621	.606	.526
1/T(PH1)2	3.06	2.45	1.83	1.28	2.87	2.09	.907	3.05	2.68
1/T(PH1)3	9.59	10.59	{ .834}	{ .610	{ .563	{ .736	{ .690	{ .445	{ .574
1/T(PH1)4	10.4	10.4	{ 1.22)	{ 2.35)	{ .739)	{ 1.14)	{ 2.09)	{ .629)	{ .744)
Z(PH1)1	.585	.620							
W(PH1)1	.428	.402							
N(AYP / DA)									
A(AYP)	4.54	5.76	4.74	6.91	2.80	3.82	4.19	1.72	2.10
1/T(AYP)1	-24.9	-0.175	.147	.145	.118	.103	.0823	.0835	.0700
1/T(AYP)2	3.35	2.87	-0.212	-.151	-.217	-.226	-.226	-.202	-.227
1/T(AYP)3	7.90	7.16	.821	{ .464)	.495	.694	{ .524)	.440	.518
1/T(AYP)4	11.7	12.2	2.94	{ 1.40)	3.30	2.94	{ 1.26)	3.32	3.08
Z(AYP)1	.794	.483	.425	.949	.348	.391	.932	.336	.382
W(AYP)1	.360	.379	1.09	1.96	.870	1.11	1.78	.775	.942
Z(AYP)2	.502	.857							
W(AYP)2	.723	1.02							
	+	+	+	+	+	+	+	+	+

TABLE IX-12

B-747 RUDDER TRANSFER FUNCTION FACTORS

SAS On

		(Body Axis System)									
F/C #		1	2	3	4	5	6	7	8	9	10
H	S _L	.249	S _L	S _L	S _L	20 K	20 K	20 K	40 K	40 K	40 K
M						.500	.650	.800	.700	.800	.900
DE M CMINATOR											
1/T(DET)1	.0770	.198	.0148	.016C	.00688	.00843	.00801	-.00185	.00514	-.00687	
1/T(DET)2	.471	.858	.804	1.63	.495	.696	1.28	.386	.467	2.83	
1/T(DET)3	1.20	1.53	(.524)	(.795)	1.09	1.67	(.685)	.808	1.10	(.973)	
1/T(DET)4	3.10	2.50	(.900)	(.791)	2.91	1.90	(.748)	3.07	2.68	(.540)	
1/T(DET)5	9.26	9.03	(.978)	(.692)	(.267)	(.477)	(.729)	(.234)	(.432)	(.432)	
1/T(DET)6	10.7	10.9	(1.94)	(2.26)	(.754)	(.908)	(2.10)	(.716)	(.838)	(.961)	
Z(DET)1											
Z(DET)1	.472	.849									
K(DET)1											
K(DET)1	.576	.287									
NUMERATORS N(P /DR)											
A(E)	.0148	.0182	.0226	.0042C	.0213	.0131	.0142	.0124	.00777	.00464	
1/T(B)	-0.0503	-0.0192	-0.0182	-0.042C	-0.0359	-0.0162	-0.00957	-0.0366	-0.032a	-0.0208	
1/T(B)	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
1/T(B)											
N(P /DR)											
A(P)	.0636	.110	.254	.318	.148	.211	.183	.115	.153	.100	
1/T(P)	-0.0209	-0.0113	-0.0034C	0.	-0.00206	0.	-0.00601	-0.00332	-0.00153	-0.00332	
1/T(P)	1	2	3	4	5	6	7	8	9	10	
1/T(P)											
1/T(P)											
1/T(P)											
1/T(P)											
1/T(P)											
1/T(P)											
1/T(P)											
Z(P)	1	2	3	4	5	6	7	8	9	10	
Z(P)											
K(P)	1	2	3	4	5	6	7	8	9	10	
K(P)											

TABLE IX-12 (Continued)

N(PHI /DR)							
A(PHI)	.0410	.0867	.221	.318	.101	.185	.0727
1/T(PHI)1	*.368	*.368	*.368	*.368	*.368	*.368	*.368
1/T(PHI)2	1.48	1.69	2.35	3.58	2.01	2.50	2.69
1/T(PHI)3	-3.31	-2.48	-3.47	3.68	-3.68	-3.58	1.83
1/T(PHI)4	3.68	3.68	3.68	-4.18	-3.74	3.68	-3.30
1/T(PHI)5	0.00	{ 1.00 }				-5.15	-4.44
1/T(PHI)6	10.0	{ 10.0 }				3.68	3.68
N(AYP/DR)							
A(AYP)	-9.12	-13.9	-38.9	-64.7	-25.3	-41.3	-22.1
1/T(AYP)1	-.0646	-.0386	-.0268	-.0103	-.0373	-.0126	-.0330
1/T(AYP)2	*.368	*.368	*.368	*.368	*.368	*.368	-.0294
1/T(AYP)3	*.958	1.07	*.973	1.32	*.491	*.669	*.312
1/T(AYP)4	3.68	3.68	3.68	3.68	3.68	3.68	*.368
Z(AYP)1	*24.7	*20.8	*19.1	*13.7	*19.3	*14.7	*1.35
k(AYP)1	*.668	.740	1.11	1.45	.984	1.10	1.22
Z(AYP)2	1.00	1.00					.860
k(AYP)2	10.0	10.0					1.05
+							

TABLE IX-13

B-747 LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off

(Body Axis System)

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K	40 K
M	.198	.249	.450	.650	.500	.650	.800	.700	.800	.900
DR PERIOD (SEC)	8.59	8.47	5.98	4.53	7.30	5.87	4.83	7.99	6.64	6.19
I/C(1/2)	.799	.978	1.16	1.41	.630	.749	.894	.516	.317	.846
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	296.	--	89.2
P(1)	.178	.235	.211	.304	.162	.241	.302	.156	.188	.363
P(2)	.0285	.0867	.171	.253	.134	.215	.287	.153	.175	.359
P(3)	.111	.148	.182	.268	.155	.233	.299	.187	.221	.381
P(2)/P(1)	.160	.369	.811	.832	.832	.891	.949	.979	.935	.990
P(DSC)/P(AV)	.671	.377	.0691	.0618	.0819	.0494	.0238	.0560	.0755	.0174
W(PHI)/W(D)	.797	.871	1.05	1.11	.978	1.03	1.03	.933	.927	.950
DEL-B-MAX	.161	.136	.00830	.0178	.0219	.00936	.00425	.0301	.0234	.0316
PHI TO BETA, PHASE	-304.	-306.	43.0	37.0	-322.	35.4	32.5	-331.	-332.	-333.
PHI TO BETA	1.54	1.69	2.07	2.07	2.26	2.12	2.03	2.09	3.07	1.19
PHI TO VE	.399	.349	.236	.163	.343	.247	.192	.355	.456	.156
	+	+	+	+	+	+	+	+	+	+

B-747 DATA SOURCES

Hanke, C. Rodney and Donald R. Nordwall, The Simulation of a Large Jet Transport Aircraft, Boeing Rept. No. D6-30643, Vols. I and II, Sept. 1970.

SECTION X

C-5A

C-5A BACKGROUND

The C-5A is a very large military logistics transport powered by four turbofan engines. Longitudinal control consists of elevators in four sections with an all-movable stabilizer for trim, roll control employs ailerons and spoilers, and yaw control a conventional rudder. All control surfaces are irreversible.

A bobweight is used in the longitudinal feel system. The effective bobweight position is assumed to be at the pilot.

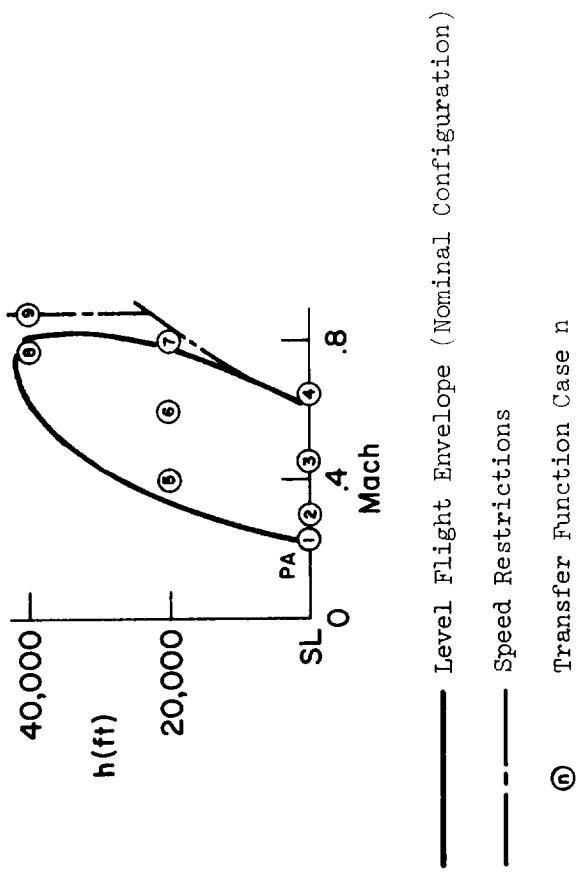
The C-5A employs stability augmentation about all axes. A description of the SAS is not included here.

C-5A

Nominal Configuration

220,000 lb Cargo
 TOGW less 40% Fuel
 $W = 654,362 \text{ lb}$
 c.g. at $0.30 \bar{c}$, W.L. 265
 $I_x = 27.8 \times 10^6 \text{ slug-ft}^2$
 $I_y = 31.8 \times 10^6 \text{ slug-ft}^2$
 $I_z = 56.2 \times 10^6 \text{ slug-ft}^2$
 $I_{xz} = 2.46 \times 10^6 \text{ slug-ft}^2$

Flight Envelope



Power Approach Configuration

220,000 lb Cargo
 TOGW less 80% Fuel
 30° Flaps
 Gear Down
 1.4 V_s
 $W = 580,723 \text{ lb}$
 c.g. at $0.30 \bar{c}$, W.L. 265
 $I_x = 19.1 \times 10^6 \text{ slug-ft}^2$
 $I_y = 31.3 \times 10^6 \text{ slug-ft}^2$
 $I_z = 47.0 \times 10^6 \text{ slug-ft}^2$
 $I_{xz} = 2.5 \times 10^6 \text{ slug-ft}^2$

Figure X-1. C-5A Flight Conditions

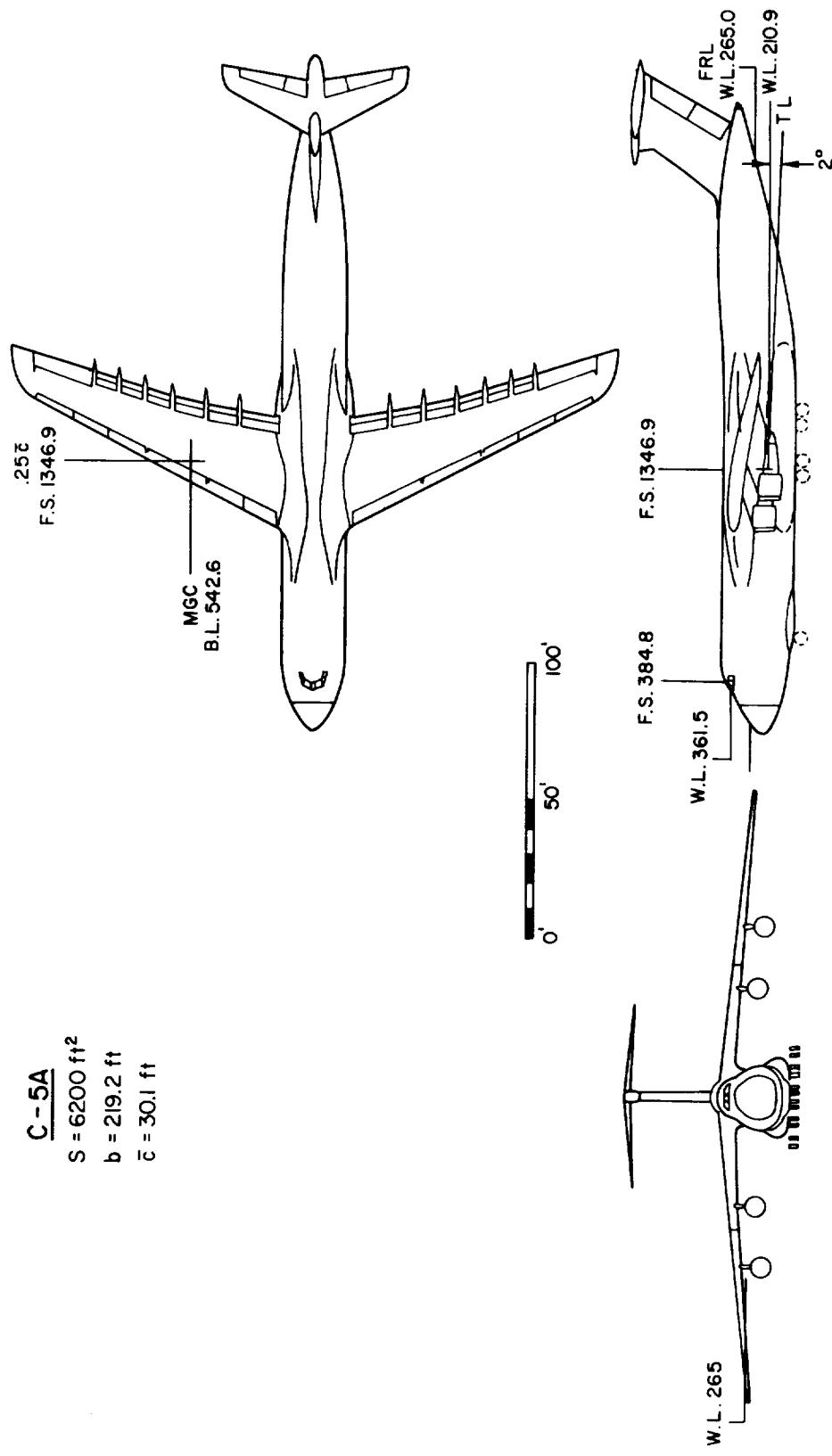
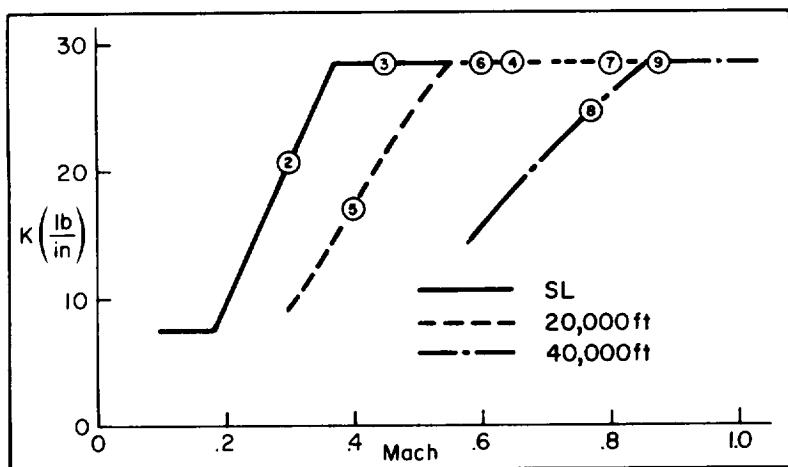
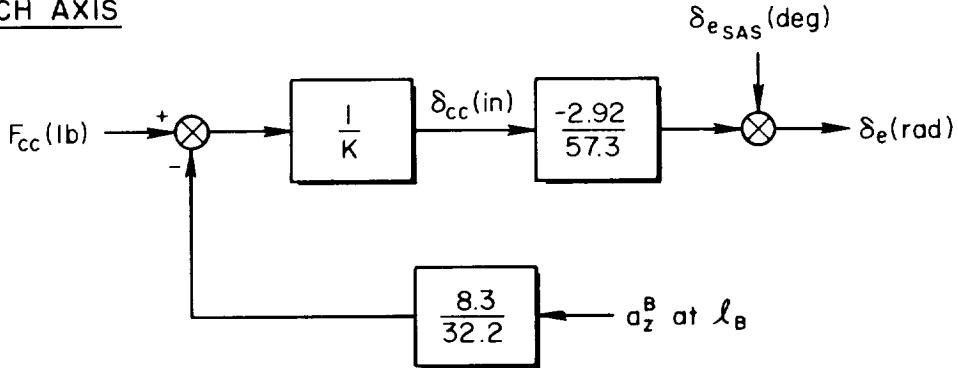


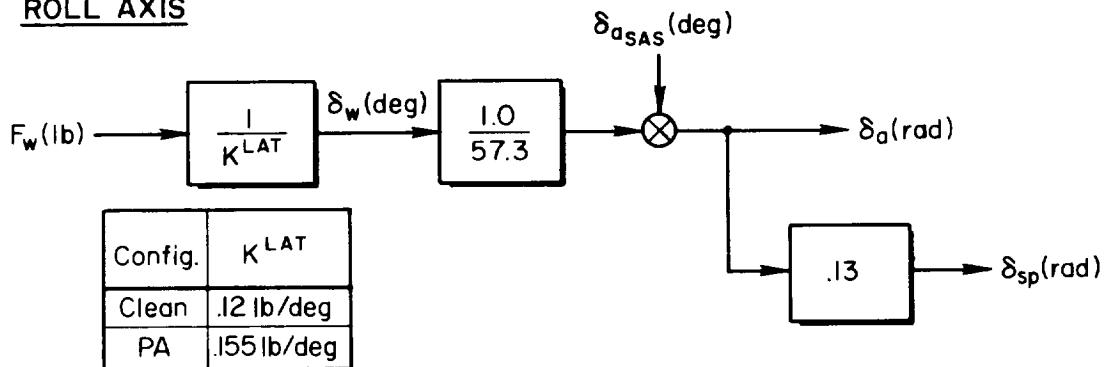
Figure X-2. C-5A General Arrangement

C-5A

PITCH AXIS



ROLL AXIS



YAW AXIS

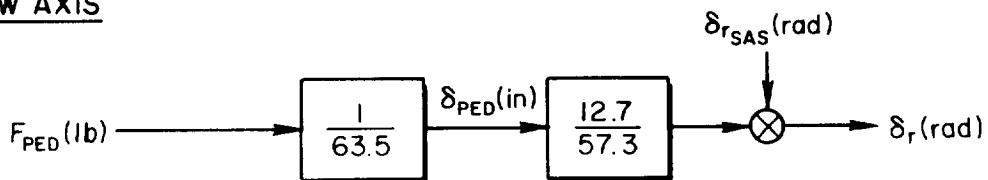


Figure X-3. C-5A Control System

TABLE X-1

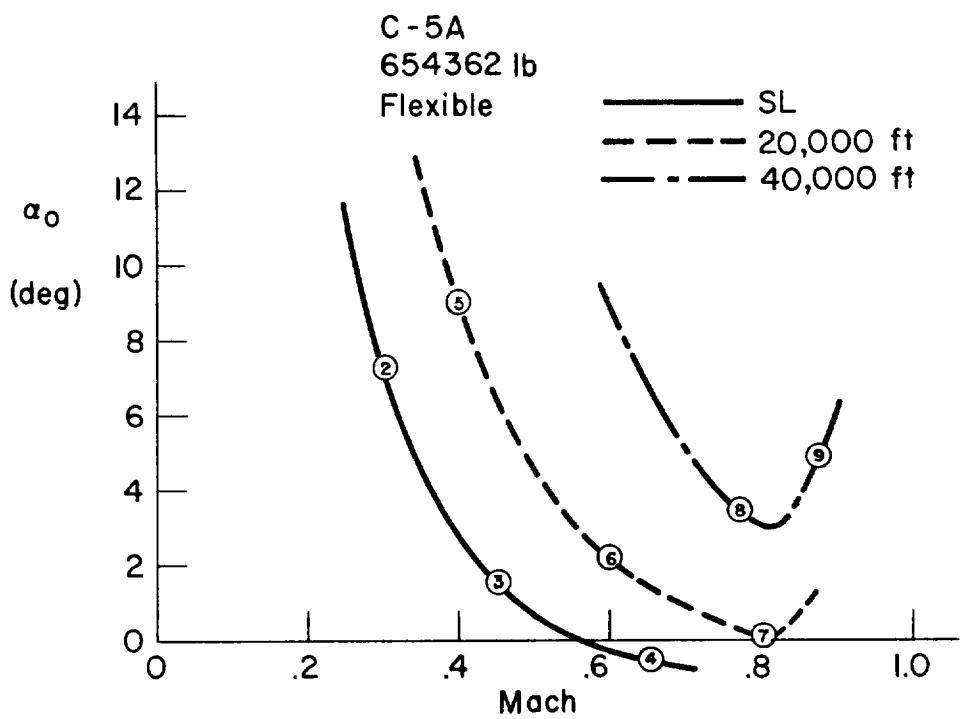
C-5A**Power Approach Non-Dimensional Derivatives**

h = sea level

V_{T_0} = 247 ft/sec = 146 kt

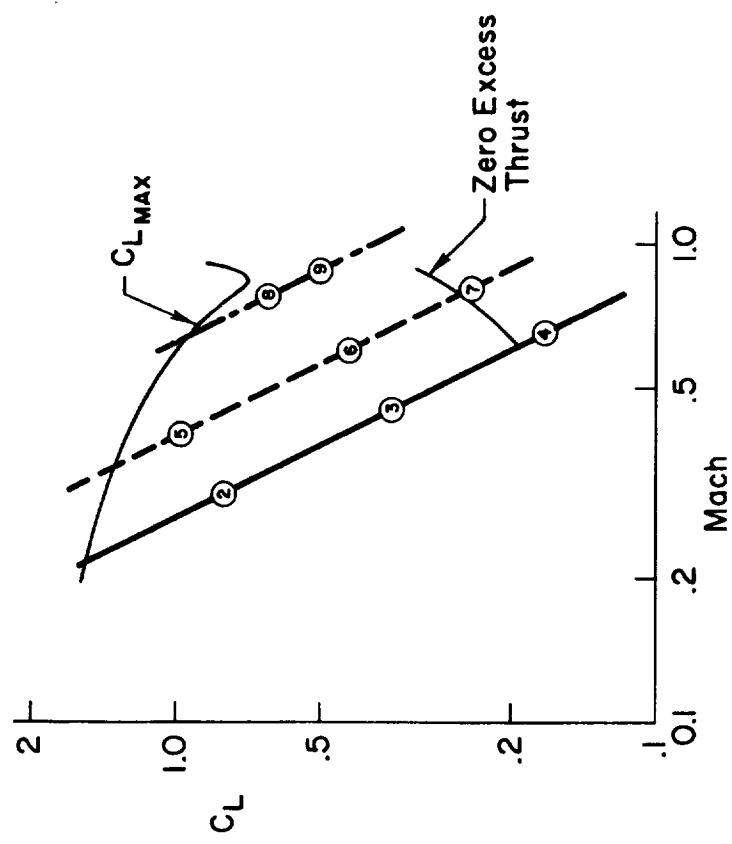
α_0 = 2.7°

Longitudinal	Lateral-Directional (Stability Axis)	} Spoiler Effects Included
C_L = 1.29	$C_{y\beta}$ = -.77/rad	
C_D = .145	$C_{n\beta}$ = .075/rad	
$C_{L\alpha}$ = 6.08/rad	$C_{\ell\beta}$ = -.123/rad	
$C_{D\alpha}$ = .622/rad	$C_{\ell p}$ = -.458/rad	
$C_{m\alpha}$ = -.827/rad	C_{n_p} = -.098/rad	
$C_{m\dot{\alpha}}$ = -8.3/rad	$C_{\ell r}$ = .290/rad	
C_{m_q} = -23.2/rad	C_{n_r} = -.293/rad	
$C_{L\delta_e}$ = .385/rad	$C_{y\delta_a}$ = -.0044/rad	
$C_{m\delta_e}$ = -1.6/rad	$C_{n\delta_a}$ = .0091/rad	
	$C_{\ell\delta_a}$ = .089/rad	
	$C_{y\delta_r}$ = .211/rad	
	$C_{n\delta_r}$ = -.106/rad	
	$C_{\ell\delta_r}$ = .0209/rad	

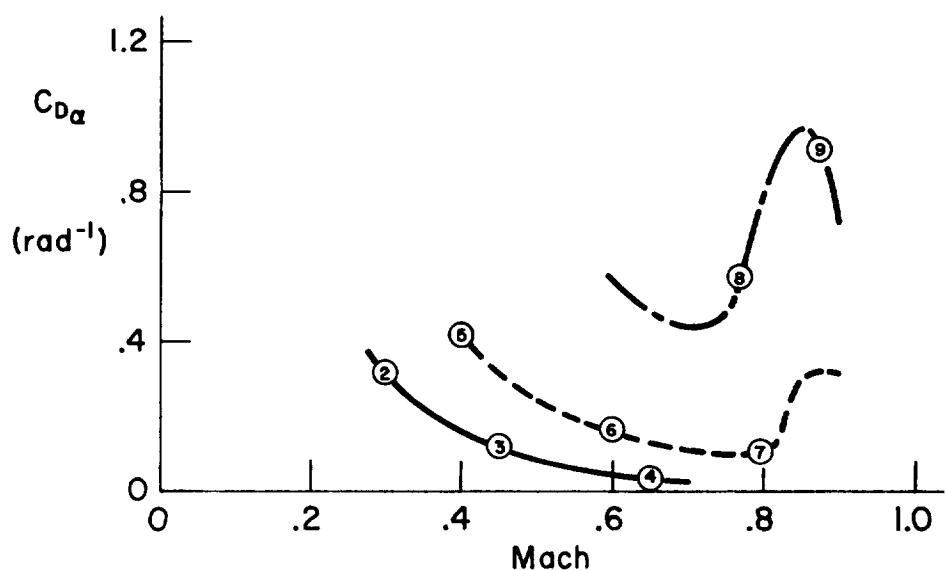
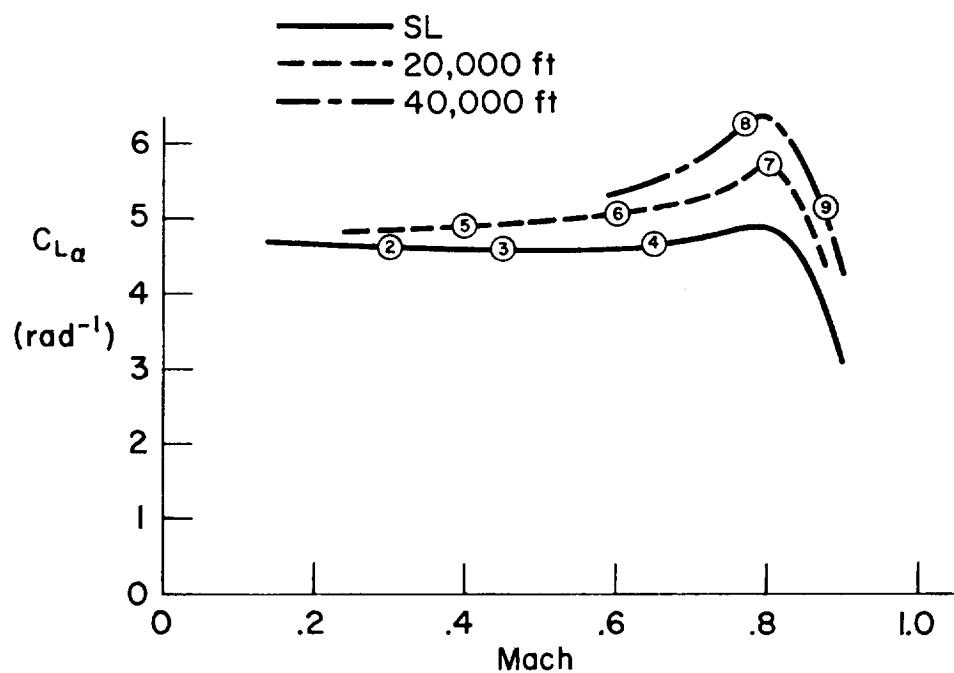


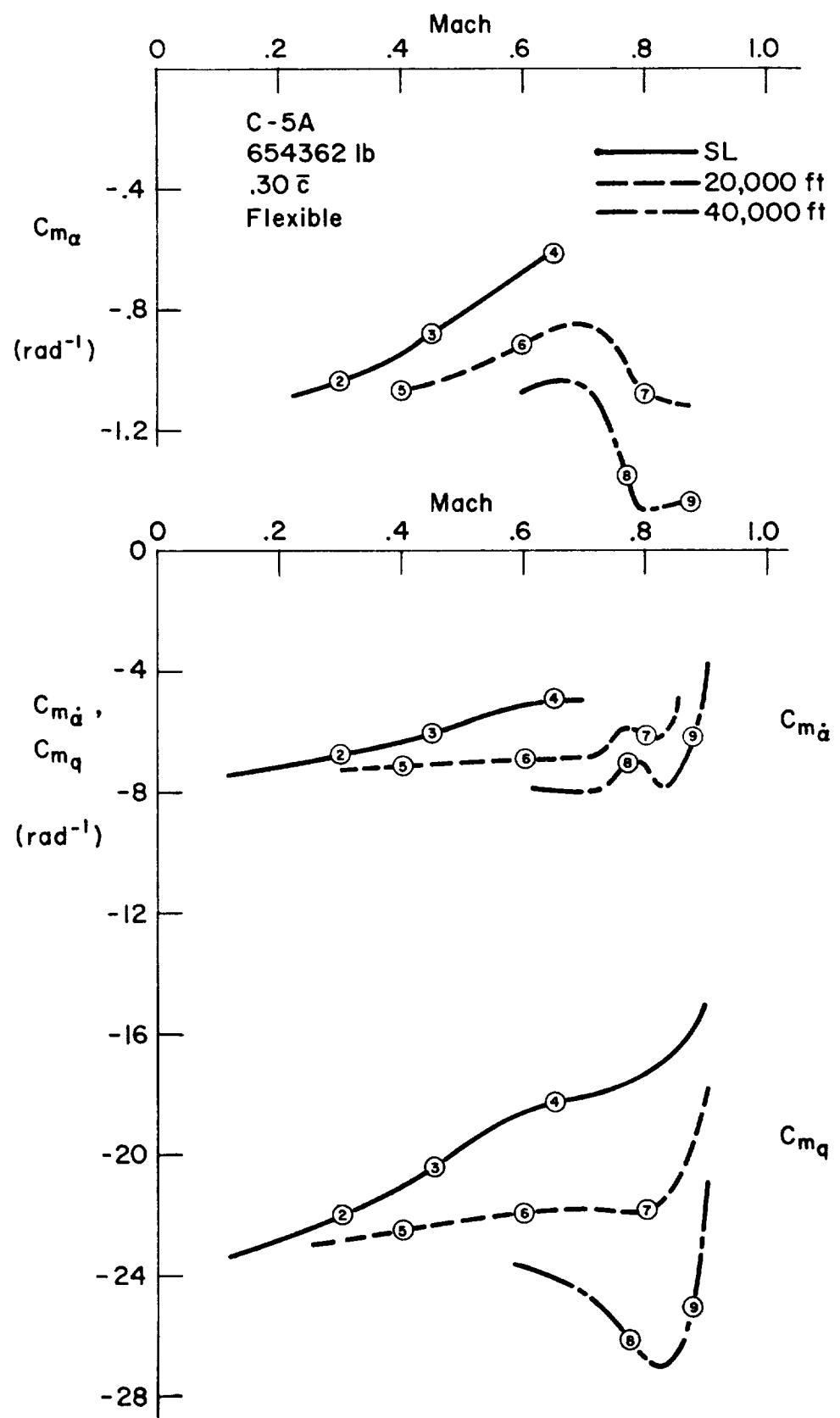
C-5A
654362 lb

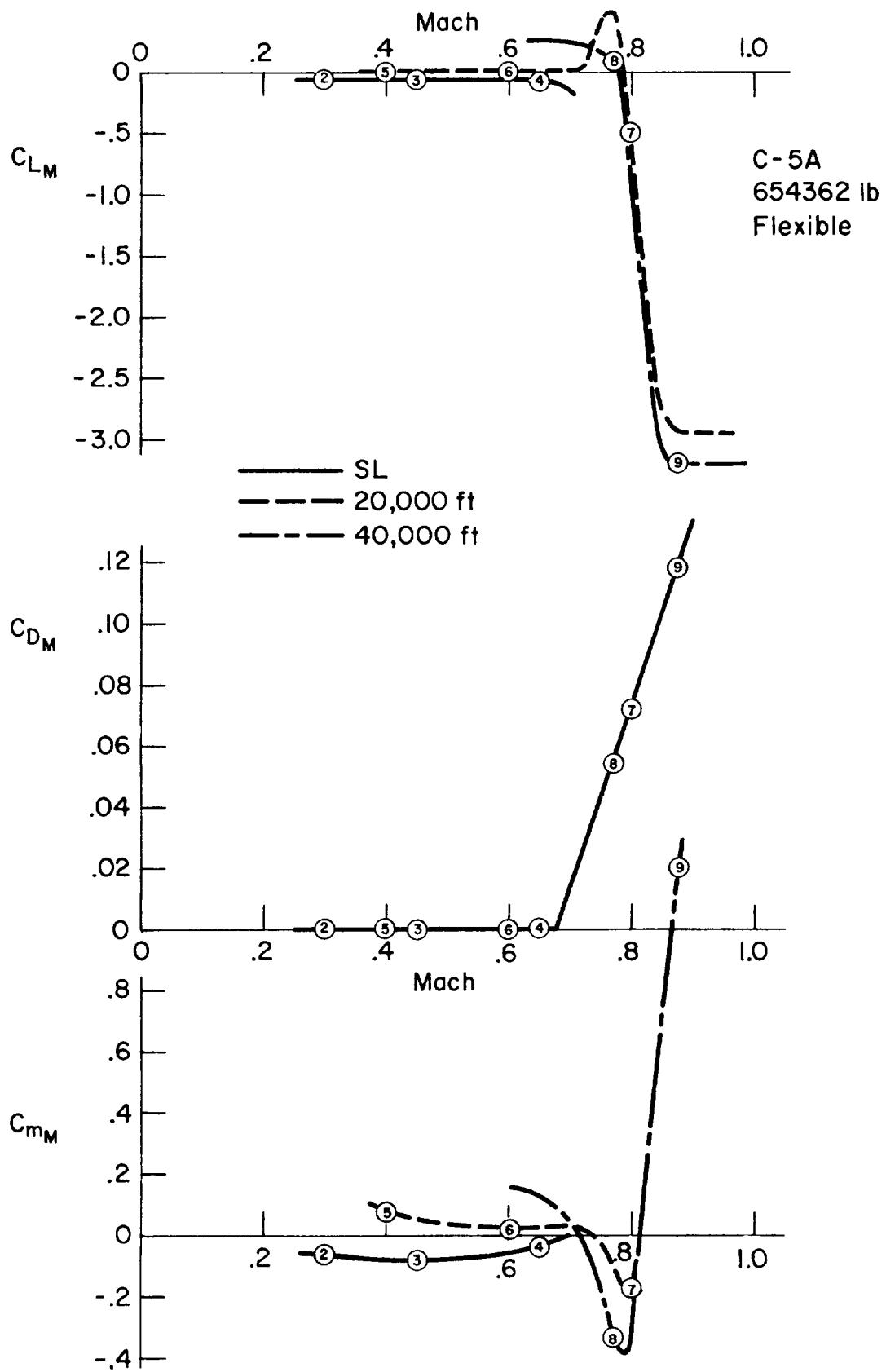
— SL
- - - 20,000 ft
- - - 40,000 ft

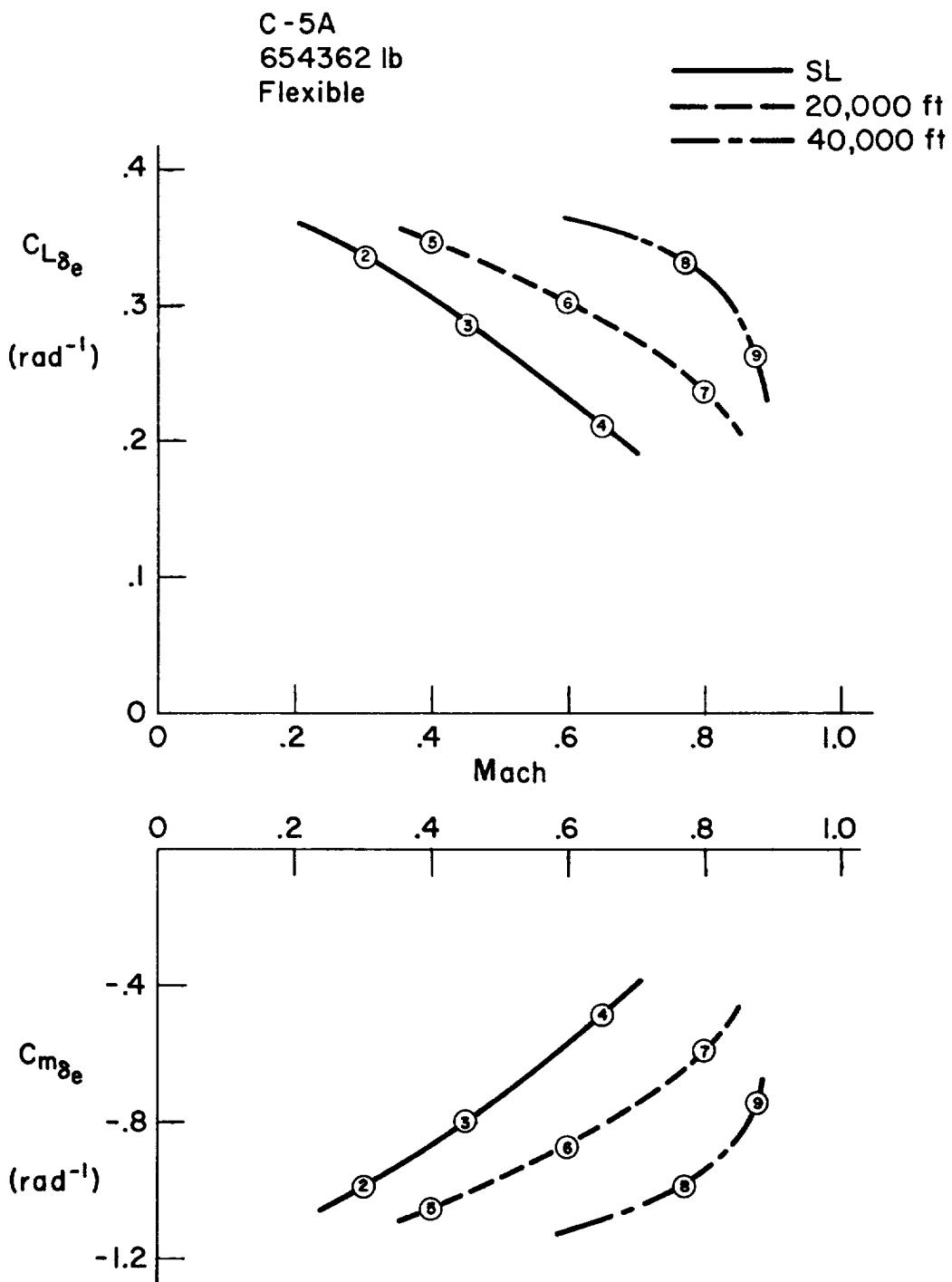


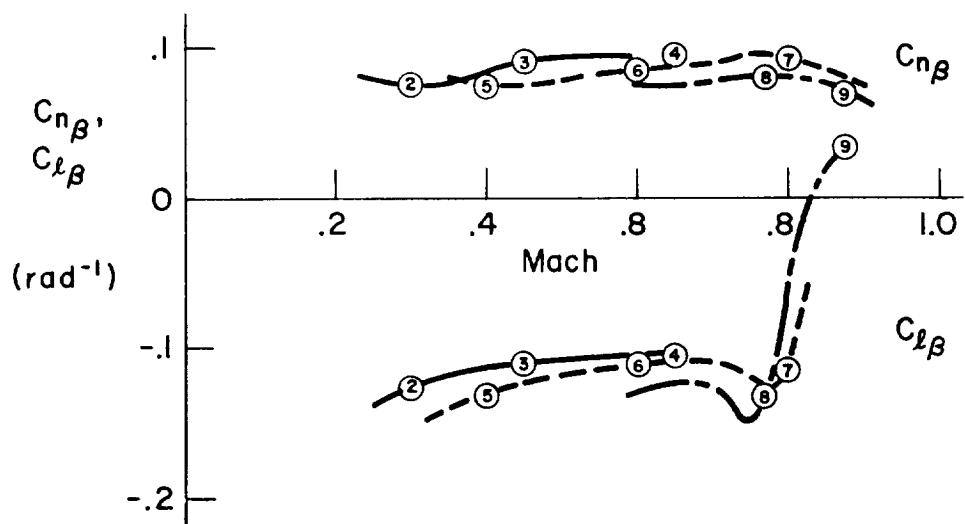
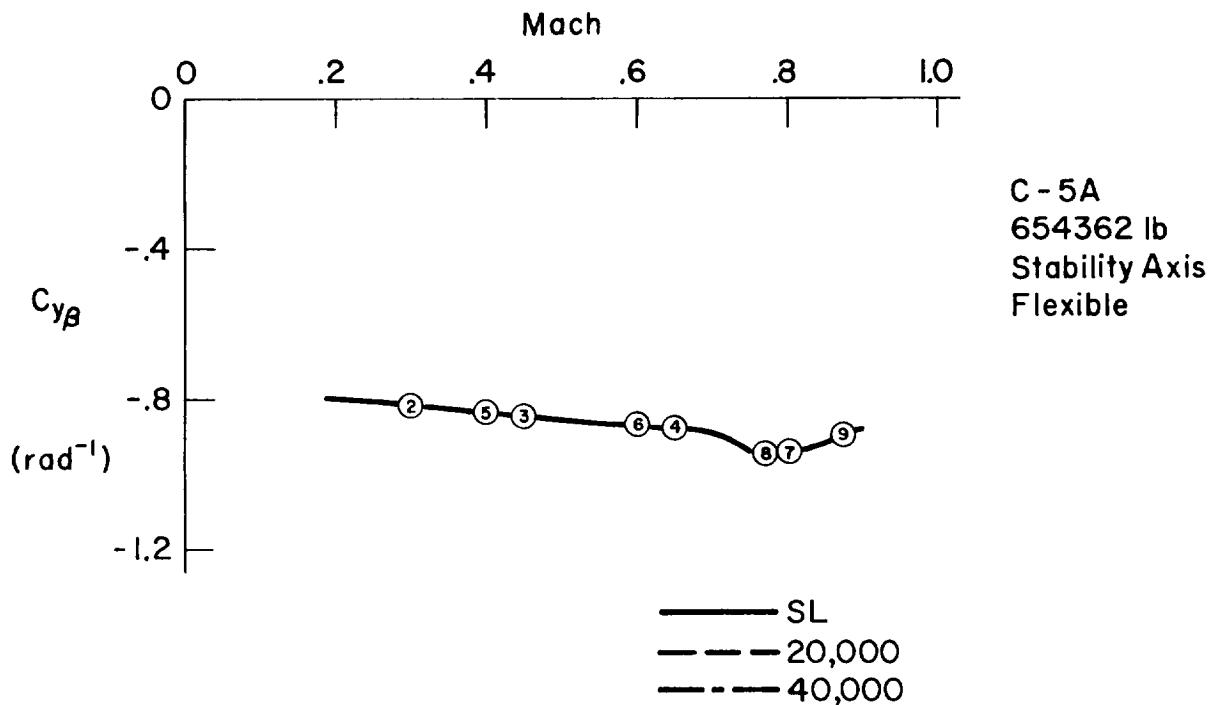
C-5A
654362 lb
Flexible

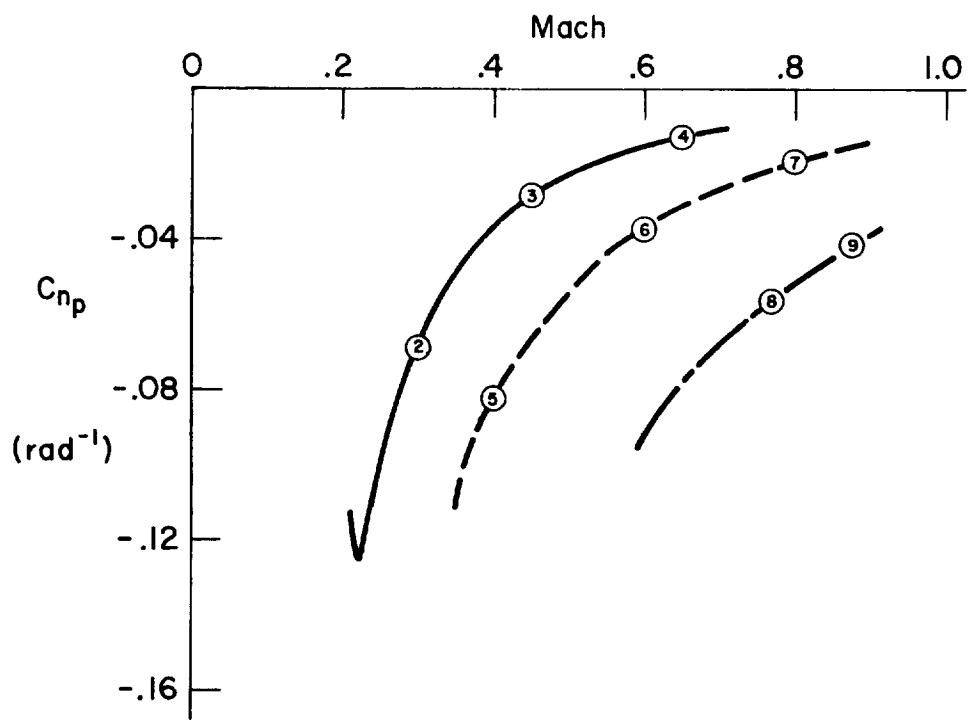
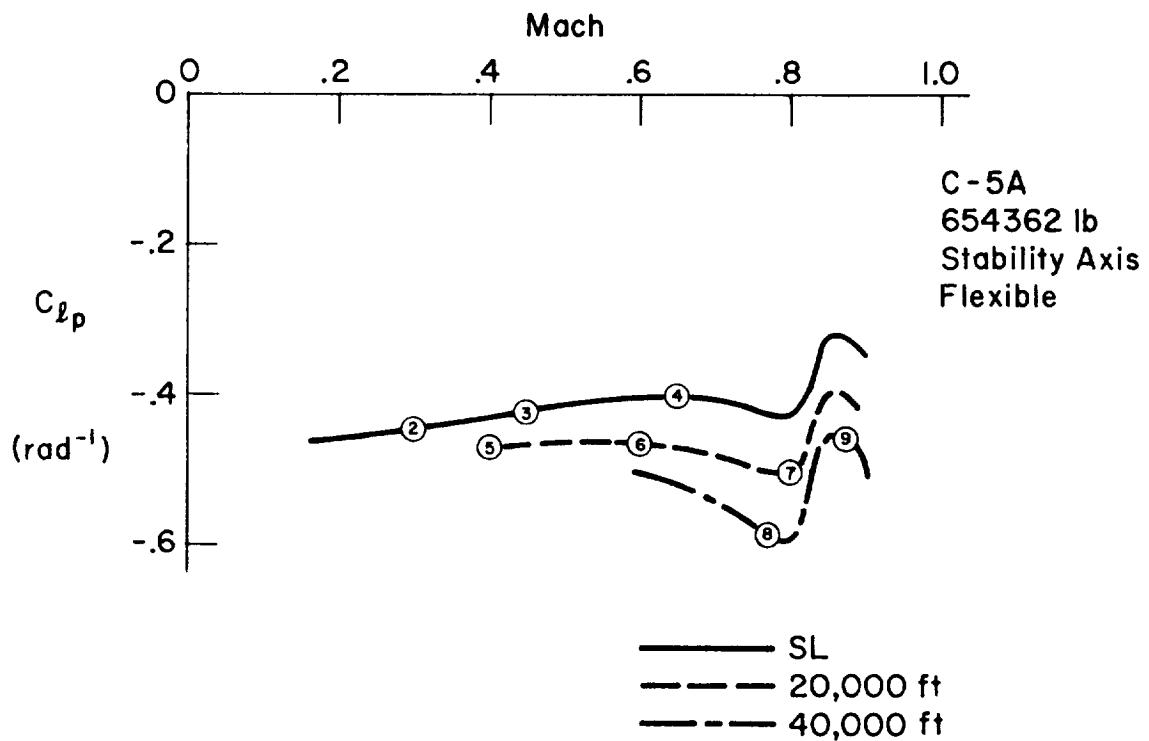


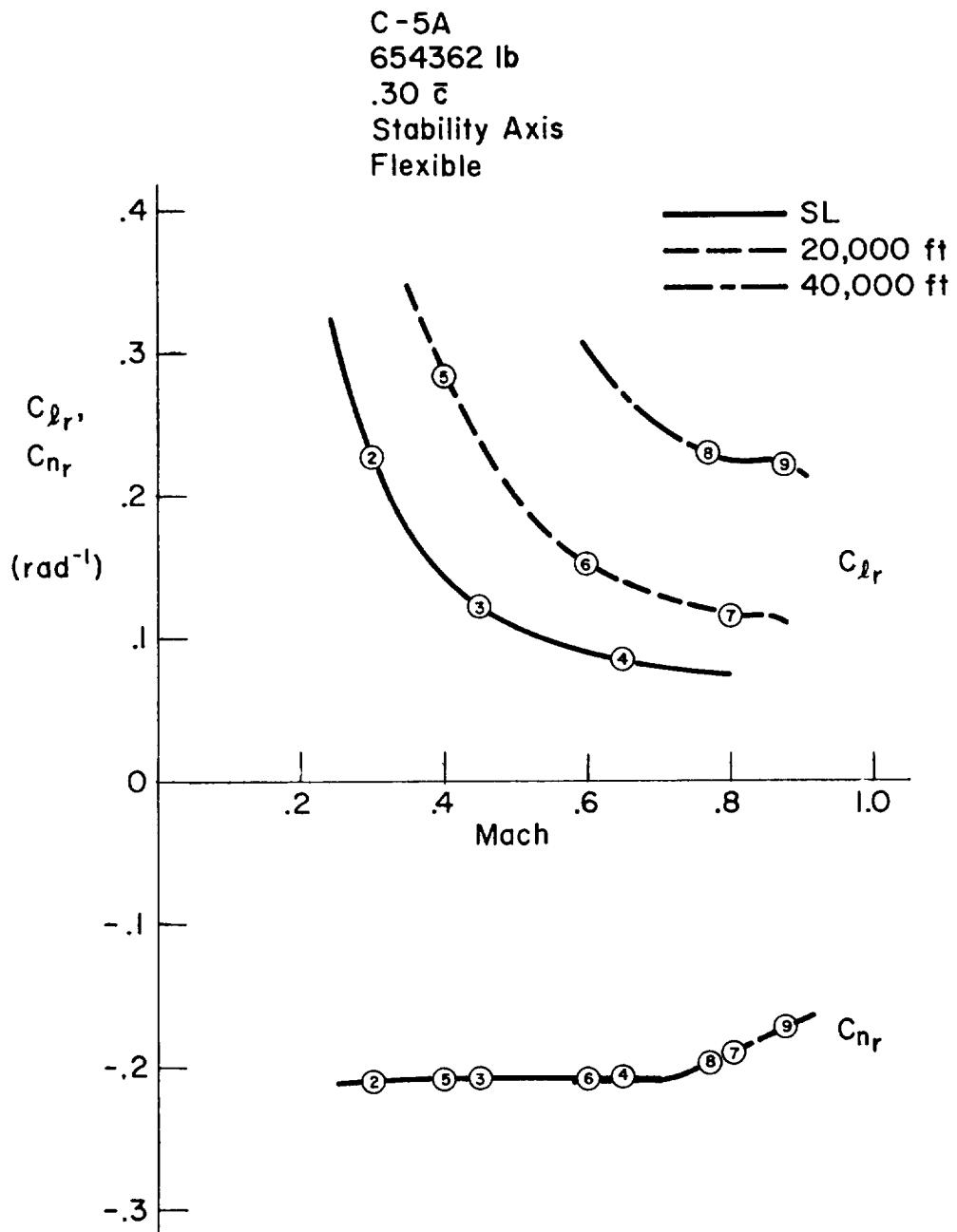


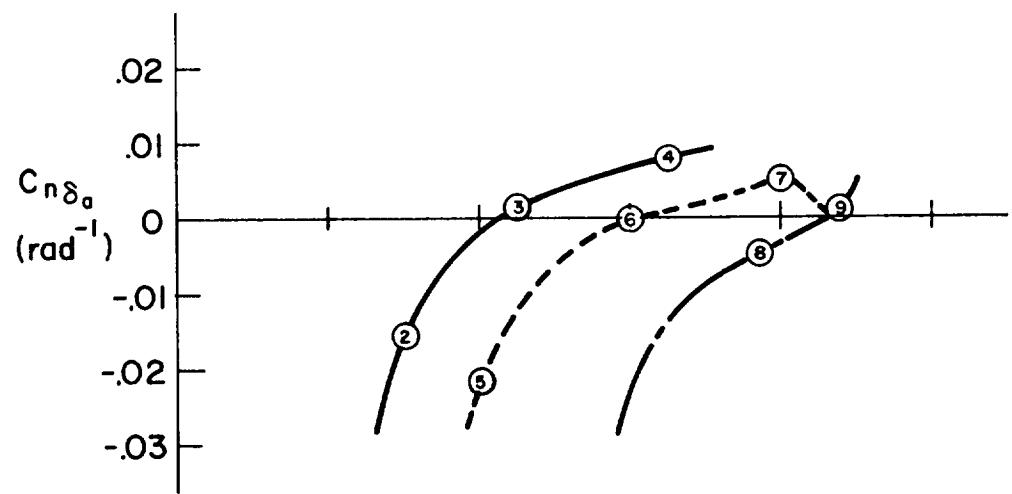
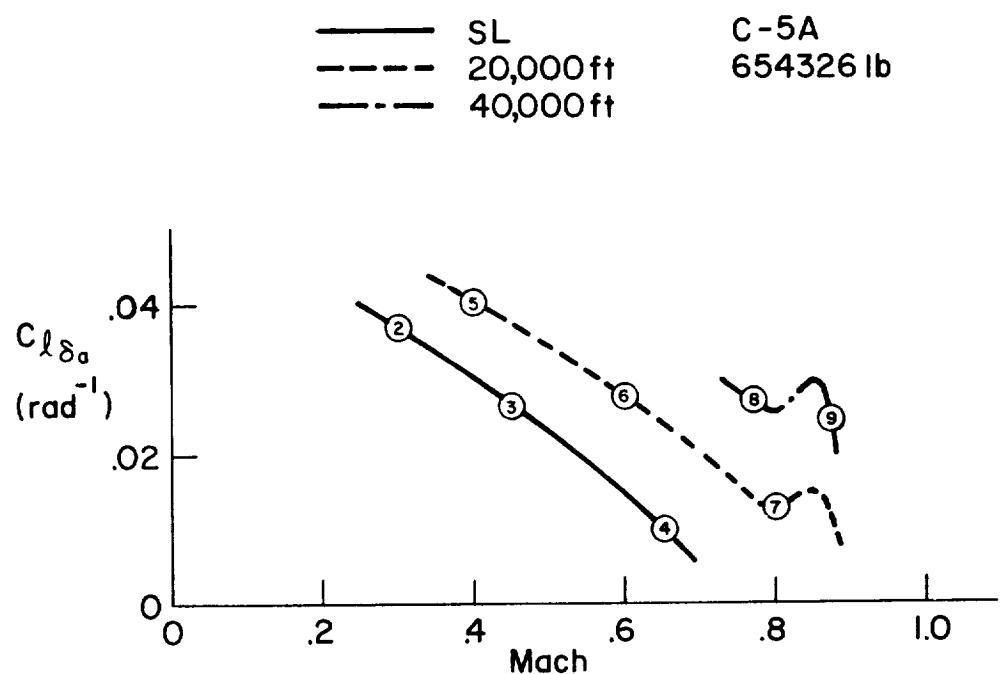


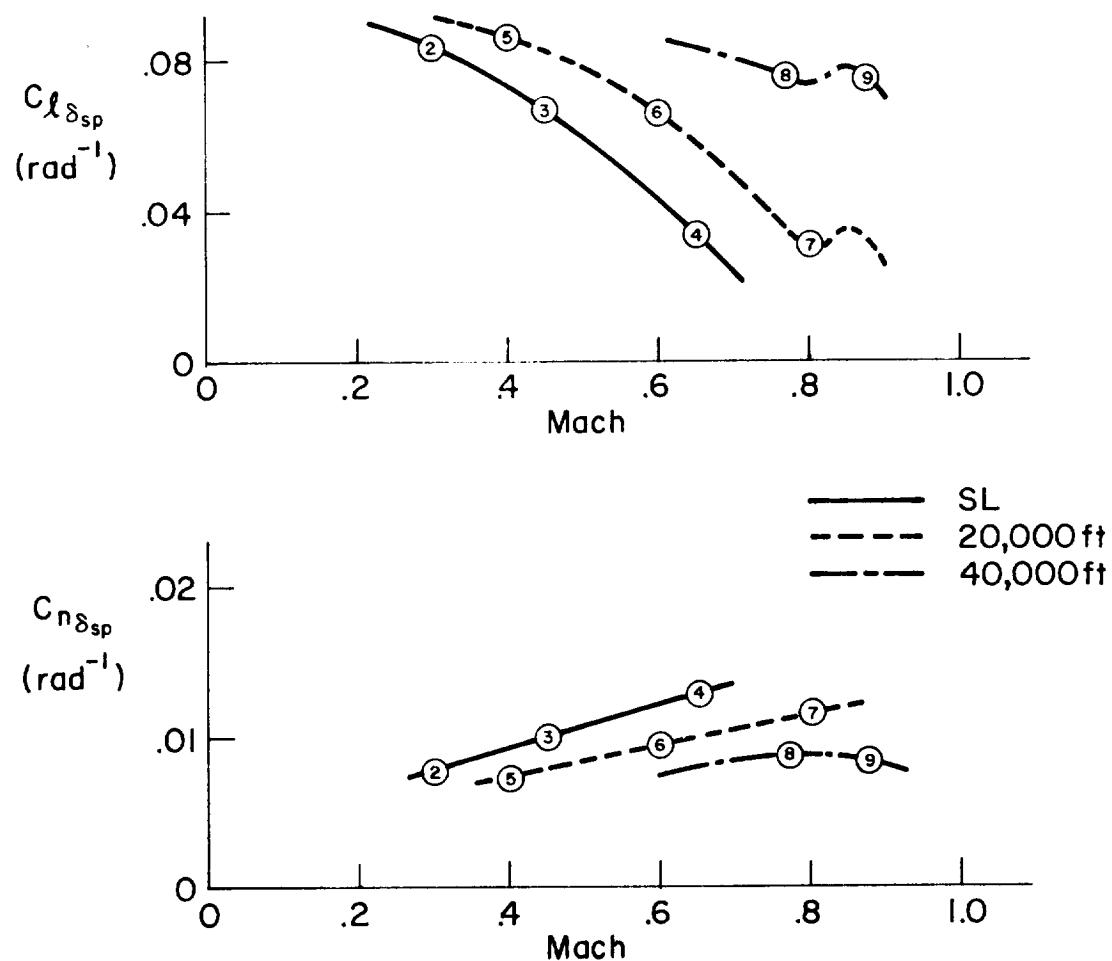
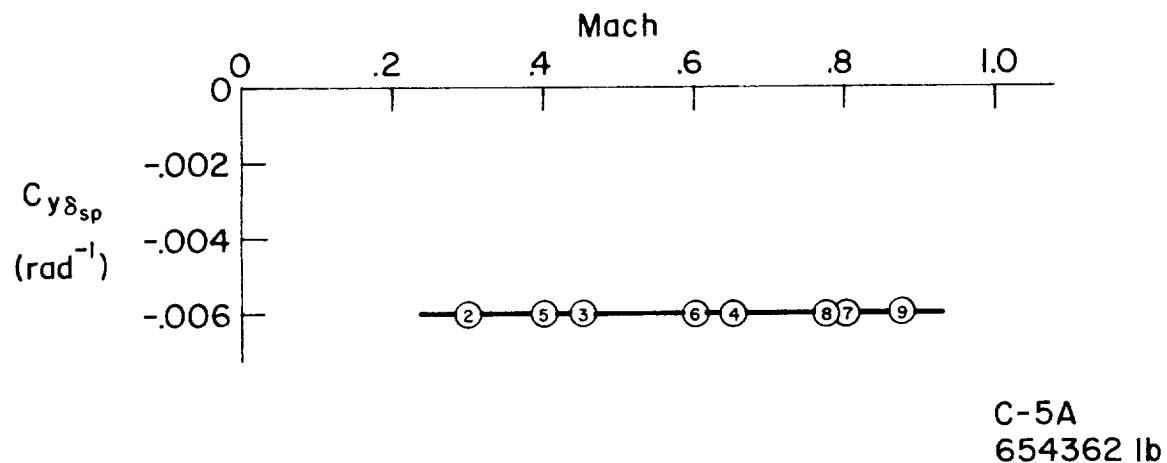


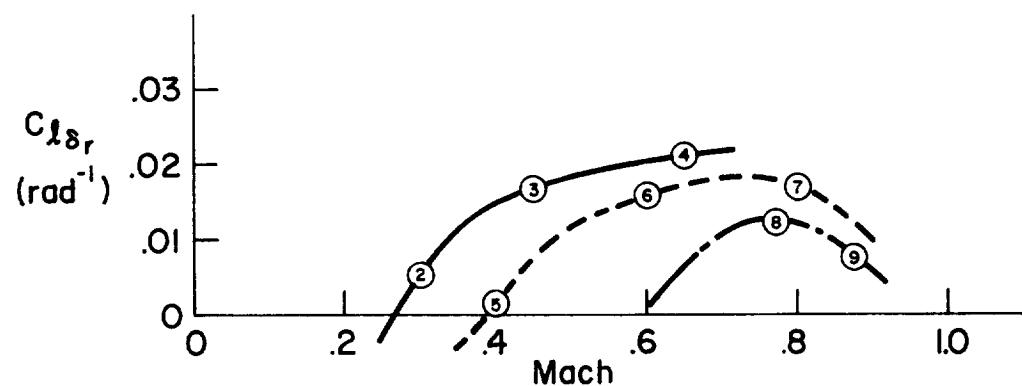
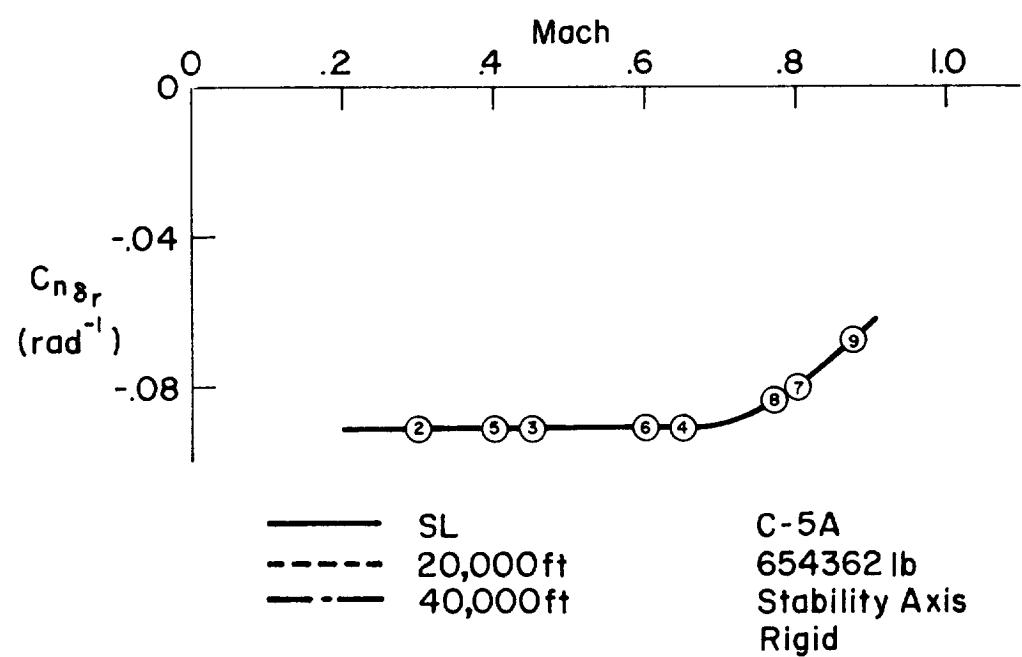
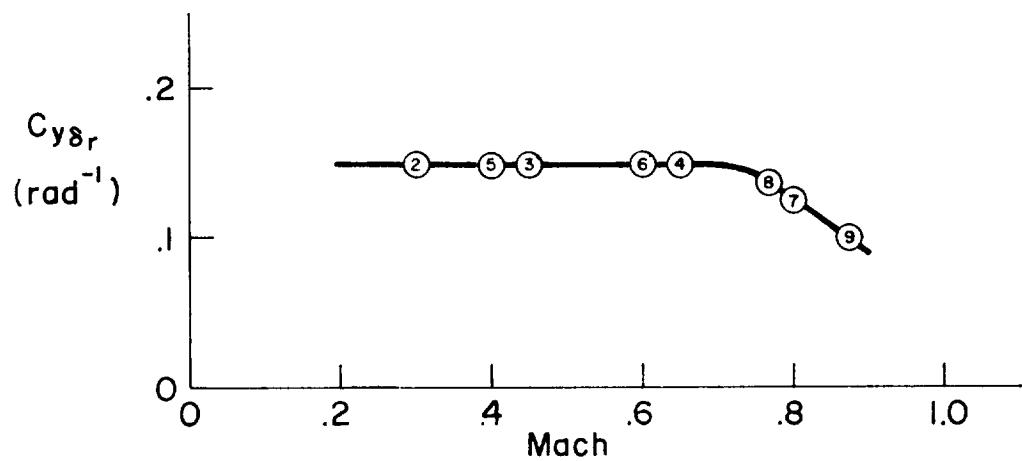












C-5A DIMENSIONAL, MASS AND FLIGHT CONDITION PARAMETERS

TABLE X-2

$S = 6200 \text{ sq ft}$, $b = 219.20 \text{ ft}$, $\bar{c} = 30.10 \text{ ft}$

F/C #	1	2	3	4	5	6	7	8	9
H(FT)	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K
M(-)	.221	.300	.450	.650	.400	.600	.800	.770	.875
VTO(FPS)	246.	335.	502.	726.	415.	622.	830.	745.	847.
VTO(KTAS)	146.	198.	298.	430.	246.	369.	492.	442.	502.
VTO(KCAS)	146.	198.	298.	430.	181.	275.	373.	233.	260.
W(L3S)	580756.	654399.	654399.	654399.	654399.	654399.	654399.	654399.	654399.
C.G.1(MGC)	.300	.300	.300	.300	.300	.300	.300	.300	.300
I X (SLUG-FT SQ)	.191E+8	.278E+8	.278E+8	.278E+8	.278E+8	.278E+8	.278E+8	.276E+8	.278E+8
I Y (SLUG-FT SQ)	.313E+8	.318E+8	.318E+8	.318E+8	.318E+8	.318E+8	.319E+8	.318E+8	.318E+8
I Z (SLUG-FT SQ)	.470E+8	.562E+8							
I XZ(SLUG-FT SQ)	.250E+7	.246E+7							
EPSILCN(DEG)	-5.08	-4.91	-4.91	-4.91	-4.91	-4.91	-4.91	-4.91	-4.91
Q(PSF)	72.2	133.	300.	626.	109.	245.	436.	164.	211.
QC(PSF)	73.0	136.	315.	695.	113.	268.	510.	189.	255.
ALPHA(DEG)	2.70	7.30	1.60	-50.0	5.00	2.20	1.00	3.50	4.90
GAMMA(DEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.
LXPF(T)	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7
LZP(FT)	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10	-8.10
ITH(DEG)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
XI(DEG)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
LTH(FT)	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50

TABLE X-3
C-5A LONGITUDINAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
XU *	-.0214	-.00343	-.00583	-.00970	-.00297	-.00313	-.0150	-.00379	-.0330
ZU *	-.231	-.121	-.104	-.0915	-.0913	-.0798	-.0112	-.0605	.168
PU *	-.778E-5	.000232	-.612E-4	-.000185	.000277	.930E-4	-.000433	-.000233	.00167
XW	.0957	.130	.0686	.0236	.106	.0440	.0224	.0304	.000142
ZW	-.634	-.572	-.834	-.123	-.405	-.618	-.925	-.427	-.387
MW	-.00145	-.00240	-.00309	-.00309	-.00163	-.00210	-.00333	-.00176	-.00196
ZWD	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZQ	0.	0.	0.	0.	0.	0.	0.	0.	0.
MWD	-.000884	-.000698	-.000630	-.000514	-.000392	-.000386	-.000347	-.000182	-.000158
MQ	-.610	-.773	-.108	-.139	-.525	-.766	-.102	-.506	-.551
XDE	.450	1.73	.728	-.350	1.79	.861	.0545	1.00	1.46
ZDE	-9.53	-13.5	-26.1	-40.1	-11.3	-22.4	-31.2	-16.4	-17.0
MDE	-.688	-.775	-1.41	-1.76	-.672	-1.25	-1.51	-.041	-.918
XDT	*554E-4	*491E-4							
ZDT	-.193E-5	-.172E-5							
MDT	*144E-6	*142E-6							
	+	+	+	+	+	+	+	+	+

C-3A ELEVATOR TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Open
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
Z(DET)1	*100	*C351	.0612	.232	.0283	.0271	(*-.0487)	.0506	*.453
*Z(DET)1	*119	*104	.0594	.0213	.0969	.0638	(*-.0648)	.0110	*.0716
Z(DET)2	*84.3	*706	.712	.752	.577	.608	*.570	*.435	*.373
*Z(DET)2	*86.5	*112	1.12	1.95	1.97	1.34	1.93	1.23	1.40
N(U /DE)									
A(U)	*450	1.73	.728	-.350	1.79	.861	.0545	1.00	1.46
1/T(U)1	15.6	19.1	26.1	1.92	24.4	34.2	2.29	4.24	*.287
1/T(U)2	(*482)	(*202)	(*196)	-.258	(*239)	(*442)	(*736)	(*593)	*.539
1/T(U)3	(*140)	(*639)	(*136)	37.9	(*439)	(*892)	(*18.3)	(*532)	*.56
N(W /DE)									
A(W)	*9.53	-13.5	-26.1	-.40.1	-11.3	-22.4	-31.2	-16.4	-17.0
1/T(W)1	18.4	19.8	28.2	33.3	24.8	35.5	41.1	43.1	-.0651
1/T(W)2	(*0730)	(*0308)	(*0428)	(*0751)	(*0304)	(*0323)	(*854)	(*0203)	*.0806
1/T(W)3	(*175)	(*107)	(*0795)	(*0609)	(*0852)	(*0642)	(*00922)	(*0400)	46.1
N(THE /DE)									
A(THE)	-.680	-.765	-.1.39	-1.74	-.667	-1.24	-1.50	-.938	-.015
1/T(THE)1	*0610	*0342	*0149	*0115	*0302	*00913	*0161	*00817	*.0216
1/T(THE)2	*582	*505	.777	1.17	.353	.578	.862	.394	*.350
N(HD /DE)									
A(HD)	9.54	13.6	26.1	40.1	11.5	22.4	31.2	16.5	17.1
1/T(HD)1	*0211	-.00248	*00448	*00852	-.00376	-.000206	*0159	-.300655	*.0422
1/T(HD)2	-2.88	-2.68	-3.94	-5.26	-2.66	-4.00	-5.24	-3.78	-3.73
1/T(HD)3	3.73	3.70	5.34	7.02	3.37	5.01	6.55	4.43	4.30
N(AZP /DE)									
A(AZP)	4.6.0	49.0	87.7	102.	43.2	79.2	91.2	*.0.2	*.7.7
1/T(AZP)1	-.0179	.0189	-.00337	*00558	.0169	*.00414	-.682E-4	*.00430	-.00226
1/T(AZP)2	*0197	-.0215	*.00784	*.00795	-.0211	-.00435	*.152	-.00501	*.0440
Z(AZP)1	*193	*124	*121	*124	*0990	*.0980	*.104	*.0783	*.0556
W(AZP)1	1.50	1.65	2.50	3.81	1.52	2.38	3.43	2.14	2.20

C-5A THRUST TRANSFER FUNCTION FACTORS
 SAS Off — Bowweight Loop Open
 (BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	S _L .221	S _L .300	S _L .450	S _L .650	S _L .400	S _L .600	S _L .800	S _L .770	S _L .875
DE NCMINATOR	Z(DET)1 W(DET)1 Z(DET)2 W(DET)2	.100 .119 .843 .865	.0351 .104 .706 .112	.0612 .0594 .706 .157	.232 .0213 .752 .1.99	.0283 .0969 .577 .947	.0271 .0638 .608 .1.93	(-.0487) (.0648) .579 .1.93	.0506 .0110 .4.55 1.23
NUMERATORS	N(U /DTH)								
	A(U) 1/T(U)1 Z(U)1 W(U)1	.554E-4 -.0712 .836 .896	*491E-4 -.0525 .666 1.13	*491E-4 -.0336 .703 1.58	*491E-4 -.0290 .758 2.00	*491E-4 -.0552 .508 .939	*491E-4 -.0351 .596 1.33	*491E-4 -.0241 .583 1.93	*491E-4 -.0308 .399 1.21
	N(W /DTH)								
	A(W) 1/T(W)1 1/T(W)2 1/T(W)3	-.193E-5 -11.0 (-.726) (.223)	-172E-5 -24.0 (-.0564) (-.108)	-172E-5 -37.5 (-.589) (.0862)	-172E-5 -55.6 (-.934) (.0667)	-172E-5 -31.4 (-.414) (.C776)	-172E-5 -46.5 (-.0189) (.0651)	-172E-5 -59.3 (-.138) (.66.9)	-172E-5 -59.3 (-.847) (.0552)
	N(THE /DTH)								
	A(THE) 1/T(THE)1 1/T(THE)2	.148E-6 (.930) (.398)	.147E-6 (.887) (.397)	.143E-6 .143 .728	.142E-6 .028 1.19	.145E-6 (.847) (.314)	.143E-6 .157 .529	.142E-6 -.116 .945	.142E-6 *.0164 .358
	N(HD /DTH)								
	A(HD) 1/T(HD)1 Z(HD)1 W(HD)1	.454E-5 .137 .715 2.71	.795E-5 .172 .451 2.24	.309E-5 .0967 .345 4.82	.129E-5 .022 .235 10.3	.938E-5 .159 .355 1.87	.360E-5 .109 .276 .4.19	.180E-5 -.114 .112 7.98	.471E-5 *.00332 .229 3.37
	N(AZP /DTH)								
	A(AZP) 1/T(AZP)1 1/T(AZP)2 Z(AZP)1 W(AZP)1	-.140E-4 -.00740 .147 .501 1.53	-.137E-4 -.0130 .217 .310 1.56	-.133E-4 -.00413 .103 .269 2.26	-.136E-4 -.0131 .026 .250 3.21	-.135E-4 -.00209 .206 .245 1.41	-.135E-4 -.674E-4 .117 .214 2.12	-.135E-4 -.00405 -.114 .179 2.93	-.134E-4 -.00308 .00828 .00630 1.87
	+ + + + + + + + +								

TABLE X-6

C-5A STICK FORCE TRANSFER FUNCTION FACTORS
SAS Off — Bowweight Loop Closed
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	\$L	\$L	\$L	\$L	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DEACTIVATOR									
Z(DET)1	*11.0	*03.76	*06.46	*24.7	*03.04	*02.85	(*04.54)	*04.62	*45.9
*(DET)1	*11.0	*10.1	*05.66	*01.97	*09.28	*06.03	(*06.13)	*01.04	*06.93
Z(DET)2	*78.3	*68.2	*67.7	*69.3	*55.3	*57.5	*54.3	*41.5	*36.1
*(DET)2	*93.6	1.16	1.65	2.17	.991	1.42	2.06	1.30	1.45
NUMERATORS									
N(W/FST)									
A(U)	-.00201	-.00430	-.00132	*000637	-.00542	-.00156	-.989E-4	-.00211	-.00263
1/T(U)1	15.6	19.1	26.1	1.92	24.4	34.2	2.29	4.24	*28.7
1/T(U)2	(*48.2)	(*20.2)	(*19.6)	-2.58	(*23.9)	(*44.2)	(*73.6)	(*59.3)	*53.9
1/T(U)3	(1.40)	(1.639)	(1.36)	37.9	(*43.9)	(*892)	(18.2)	(*53.2)	45.6
N(W/FST)									
A(W)	*04.27	*03.35	*04.72	*07.3C	*03.42	*04.05	*0567	*0345	*0307
1/T(W)1	18.4	19.8	28.2	33.3	24.8	35.5	41.1	43.1	-.0651
1/T(W)2	(*0.730)	(*0.308)	(*0.428)	(*0.751)	(*0.304)	(*0.323)	(*864)	(*49.3)	*0806
1/T(W)3	(*17.0)	(*10.7)	(*0.795)	(*0.665)	(*0.852)	(*0.642)	(*0.0922)	(*0.490)	46.1
N(THE/FST)									
A(THE)	*0.0305	*0.0190	*0.0252	*0.0317	*0.0202	*0.0225	*0.0272	*0.0197	*0.0165
1/T(THE)1	*0.610	*0.342	*0.149	*0.115	*0.0302	*0.0913	*0.161	*0.0817	*0.316
1/T(THE)2	*.582	*.505	*.777	*1.17	*.353	*.578	*.862	*.394	*.350
N(HD/FST)									
A(HD)	-.0428	-.0338	-.0472	-.073C	-.0347	-.0405	-.0567	-.0345	-.0308
1/T(HD)1	*0.0211	*0.0248	*0.0448	*0.0852	*0.0376	*0.00206	*0.159	*0.00655	*0.422
1/T(HD)2	-2.88	-2.68	-3.94	-5.26	-2.65	-4.00	-5.24	-3.78	-3.73
1/T(HD)3	3.73	3.70	5.34	7.02	3.37	5.01	6.55	4.43	4.30
N(AZP/FST)									
A(AZP)	-.206	-.122	-.159	-.186	-.131	-.143	-.166	-.126	-.104
1/T(AZP)1	-.0179	*.0189	-.00337	*CC0558	*0169	*00414	*.682E-4	*00430	*00226
1/T(AZP)2	*.0197	-.0215	*.00784	*.00756	-.0211	-.00436	*0150	*00501	*0440
Z(AZP)1	*19.8	*124	*121	*124	*0990	*0980	*104	*0783	*0556
W(AZP)1	1.50	1.65	2.50	3.81	1.52	2.38	3.47	2.14	2.20

TABLE X-7

C-5A THRUST TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Closed
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DE Nominator									
Z(DET)1	*110	*0376	*0646	*247	*0304	*0285	(*0454)	*0462	*459
W(DET)1	*110	*101	*0566	*0197	*0928	*0603	(*0613)	*0104	*0693
Z(DET)2	.783	.682	.677	.693	.553	.575	.543	.415	.361
W(DET)2	.936	.116	1.65	2.17	.991	1.42	2.05	1.30	1.45
Numerators									
N(U /DTH)	*554E-4	*491E-4							
A(U)	-.0636	-.0501	-.0307	-.0248	-.0518	-.0317	-.0213	-.0282	-.0238
1/T(U)1	*781	*644	*669	*699	*466	*563	*547	*380	*327
Z(U)1	*959	1.17	1.67	2.18	.983	1.41	2.06	1.28	1.36
N(W /DTH)									
A(W)	-.195E-5	-.173E-5	-.174E-5	-.175E-5	-.173E-5	-.173E-5	-.174E-5	-.173E-5	-.173E-5
1/T(W)1	-.211	-.236	-.367	-.0351	-.305	-.476	-.00478	-.583	-.0139
1/T(W)2	-.252	(-.168)	(-.744)	-.117	(-.292)	(-.115)	-.142	(-.944)	.628
1/T(W)3	-10.5	(-.111)	(-.0875)	-53.5	(-.0798)	(-.0659)	-65.4	(-.0559)	-73.0
N(THE/DTH)									
A(THE)	*146E-6	*146E-6	*142E-6	*141E-6	*144E-6	*142E-6	*141E-6	*142E-6	*142E-6
1/T(THE)1	(* .853)	(* .867)	.145	.0288	(* .826)	*163	-.117	*0168	.137
1/T(THE)2	(* .402)	(* .400)	.717	1.20	(* .316)	.519	.964	.353	.906
N(HD /DTH)									
A(HD)	*456E-5	*796E-5	*311E-5	*132E-5	*540E-5	*362E-5	*183E-5	*473E-5	*502E-5
1/T(HD)1	.135	.169	.0962	.0228	.155	.109	-.113	*00322	.284
Z(HD)1	.713	.449	.345	.235	.353	.275	.112	.228	-.116
W(HD)1	2.73	2.26	4.84	10.2	1.90	4.21	7.98	3.39	3.07
N(AZP/DTH)									
A(AZP)	-.139E-4	-.137E-4	-.134E-4	-.132E-4	-.135E-4	-.133E-4	-.132E-4	-.133E-4	-.133E-4
1/T(AZP)1	-.00740	-.0130	-.00191	.000443	-.0131	-.00209	-.674E-4	-.00405	-.00308
1/T(AZP)2	*146	*216	*103	*022C	*206	*117	-.116	*00828	*334
Z(AZP)1	*486	*207	*267	*249	*242	*212	*180	*163	*0118
W(AZP)1	1.54	1.57	2.28	3.25	1.42	2.14	2.94	1.93	1.88
+	+	+	+	+	+	+	+	+	+

TABLE X-8

C-5A LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS OFF

(BODY AXIS SYSTEM)

F/C *	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
R	.221	.300	.450	.650	.400	.600	.800	.770	.875
STICK FIXED									
D(G)/D(U) (DEG/KT)	-.00658	.00729	-.0135	-.0256	.0112	.000581	-.0478	.00193	-.127
NZA (G/RAD)	4.54	5.26	11.6	25.0	4.71	11.0	21.5	9.05	9.07
DE/G (DEG/G)	13.2	16.7	8.23	4.91	15.6	7.27	6.38	10.1	12.7
CAP (RAD/SEC/SEC/G)	.156	.224	.200	.149	.182	.158	.167	.166	.203
PHYSOID(2) (SEC)	--	--	--	--	--	--	{ 14.2 }	--	--
{ TUCK(2) }									
1/C(1/10)	4.28	2.72	2.77	3.11	1.93	2.09	1.94	1.32	1.10
STICK FREE									
FST/KT (LB/KT)	--	.292	-.687	-.232	-.0256	-.561	-.292	.265	-.0122
FST/G (LB/G)	60.2	127.	88.7	55.2	59.1	79.3	70.5	93.2	132.
*	+	+	+	+	+	+	+	+	+

TABLE X-9
C-5A LATERAL-DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
Y	.221	.300	.450	.650	.400	.600	.800	.770	.875
YY	-.0775	-.0995	-.152	-.231	-.0673	-.106	-.151	-.0636	-.0684
YB	-19.1	-33.3	-76.8	-16.8	-27.9	-65.8	-125.	-47.4	-58.0
LB	-.635	-.863	-1.60	-3.07	-7.47	-1.33	-2.38	-1.08	.333
NB	.110	.150	.560	1.32	.106	.432	.885	.237	.386
LP	-1.09	-.997	-1.36	-1.85	-.707	-.988	-1.42	-.706	-.632
NP	-.156	-.150	-.113	-.107	-.120	-.0921	-.0906	-.0776	-.0716
LR	.613	.399	.344	.360	.324	.282	.303	.233	.256
NR	-.231	-.187	-.310	-.455	-.113	-.203	-.251	-.0991	-.0930
Y*DA	-.000443	-.947E-4	-.000142	-.0C0C205	-.625E-4	-.937E-4	-.000125	-.522E-4	-.593E-4
L'DA	.461	.321	.516	.446	.284	.434	.370	.298	.357
N'DA	.0522	-.0126	.0500	.165	-.0212	.0343	.0850	.00618	.0414
Y*DR	.0212	.0181	.0271	.0352	.0119	.0179	.0200	.00910	.00760
L'DR	.105	.0852	.229	.5CC	.0625	.187	.292	.112	.107
N'DR	-.213	-.282	-.639	-1.34	-.231	-.522	-.830	-.324	-.338
	+	+	+	+	+	+	+	+	+

TABLE X-10
C-5A ATTERRON TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C *	1	2	3	4	5	6	7	8	9
H	SL	SL	SL	SL	20 K	20 K	20 K	40 K	40 K
M	.221	.300	.450	.650	.400	.600	.800	.770	.875
DENOMINATOR									
1/T(DET)1	.0283	.0162	.0161	.0139	.00800	.0103	.00788	.00520	-.0264
1/T(DET)2	1.13	1.04	1.44	1.96	.766	1.07	1.51	.793	.582
Z(DET)1	.226	.184	.209	.227	.103	.138	.144	.0564	.197
W(DET)1	.530	.608	.875	1.25	.549	.771	1.03	.618	.605
NUMERATORS									
N(B / DA)									
A(B)	-.000443	-.947E-4	-.000142	-.000142	-.625E-4	-.937E-4	-.000125	-.522E-4	-.593E-4
1/T(B)1	*203	*0473	*292	*0455	*0184	*145	-.0595	*0389	*0932
1/T(B)2	-2.75	1.78	-1.09	*1.48	*1.11	-1.95	*917	2.72	-1.64
1/T(B)3	72.7	-564.	253.	844.	-1046.	191.	676.	-232.	183.
N(P / DA)									
A(P)	.461	.321	.516	.446	.284	.434	.370	.298	.357
1/T(P)1	-.00541	-.0105	-.00167	-.000367	-.0106	-.00190	-.655E-4	-.00257	-.00318
Z(P)1	*422	*382	*284	*256	*349	*222	*194	*165	*163
W(P)1	.456	.368	.877	1.62	.238	.749	1.22	.515	.596
N(R / DA)									
A(R)	.0522	-.0126	.0500	.165	-.0212	.0343	.0850	.00618	.0414
1/T(R)1	*505	-.224	*796	*1.72	-.133	*574	1.20	*327	*333
Z(R)1	-.560	(*258)	-.295	*0953	(*164)	*413	*0352	(*612)	-.215
W(R)1	.645	(*4.88)	.771	.410	(*2.35)	.782	*448	(*2.69)	.584
N(Phi / DA)									
A(Phi)	*464	*320	*518	*444	*281	*435	*370	*298	*360
Z(Phi)1	*415	*340	*284	*254	*276	*221	*194	*159	*160
W(Phi)1	.452	.364	.875	1.62	.235	.748	1.22	.515	.595
N(AYP / DA)									
A(AYP)	7.89	1.54	8.20	17.3	*542	6.26	9.84	2.88	6.22
1/T(AYP)1	.273	*C515	-.334	-.0418	*0191	*178	-.0507	*0453	*110
Z(AYP)2	-.451	-3.35	*339	1.31	-7.49	-.396	*774	-.882	-.289
Z(AYP)1	*186	*284	*209	*114	*353	*208	*0941	*305	*220
W(AYP)1	.595	.753	.571	1.45	*693	*866	1.22	.728	.698

C-5A RUDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

TABLE X-11

F/C #	1	2	3	4	5	6	7	8	9
H	SL .221	SL .300	SL .450	SL .650	20 K .400	20 K .600	20 K .800	40 K .770	40 K .875
M									
DENCM INATOR									
1/T(DEF)1	.0283	CL62	.0161	.0139	.00800	.0103	.00788	.00520	-.0264
1/T(OET)2	1.13	1.04	1.44	1.96	.766	1.07	1.51	.793	.582
L(CET)1	.226	.184	.209	.227	.103	.138	.144	.0564	.197
W(CET)1	.530	.608	.875	1.25	.549	.771	1.03	.618	.605
NUMERATORS									
N(A/DR)									
A(B)	.0212	CL81	.0271	.0392	.0119	.0179	.00200	.00910	.00760
1/T(B)1	-.0559	-.C424	-.0120	-.00394	-.0423	-.0123	-.00571	-.C140	-.0162
1/T(B)2	1.25	1.03	1.42	1.93	.718	1.03	1.47	.733	.644
1/T(B)3	10.4	16.3	24.1	34.6	20.1	29.7	41.7	36.4	45.6
N(P/DR)									
A(P)	.105	C852	.229	.500	.0625	.187	.292	.112	.107
i/T(P)1	-.00568	-.C117	-.00173	.000377	-.0119	-.00194	-.665E-4	-.00260	-.00336
L(P)1	{ .719}	{ 1.19}	{ 1.70}	{ 2.42}	{ 1.17}	{ 1.55}	{ 2.16}	{ 1.44}	-.262
W(P)1	{ -1.78}	{ -2.39}	{ -2.38}	{ -2.94}	{ -2.32}	{ -2.16}	{ -2.78}	{ -2.03}	1.18
N(R/DR)									
A(R)	-.213	-.282	-.639	-1.34	-.231	-.522	-.830	-.324	-.338
1/T(R)1	1.26	1.02	1.43	1.95	.694	1.04	1.49	.733	-.141
1/T(R)2	{ -.0541}	{ .201}	{ .211}	{ .293}	{ .190}	{ .151}	{ .192}	{ .117}	.181
1/T(R)3	{ -.251}	{ .276}	{ .251}	{ .243}	{ .282}	{ .242}	{ .232}	{ .242}	.676
N(PHI/DR)									
A(PHI)	.0949	.C490	.212	.511	.0259	.167	.290	.0924	.0783
L(PHI)1	{ .704}	{ 1.21}	{ 1.70}	{ 2.42}	{ 1.29}	{ 1.58}	{ 2.16}	{ 1.49}	-.404
W(PHI)1	{ -2.01}	{ -4.16}	{ -2.57}	{ -2.88}	{ -5.22}	{ -2.39}	{ -2.79}	{ -2.39}	1.38
N(AYP/DR)									
A(AYP)	-11.2	-16.3	-36.7	-77.2	-13.4	-30.0	-48.9	-18.8	-20.3
1/T(AYP)1	-.0668	-.C481	-.0180	-.00808	-.0442	-.0163	-.00822	-.C162	-.0156
1/T(AYP)2	1.32	.599	1.39	1.89	.645	.981	1.42	.663	.721
Z(AYP)1	.0988	.170	.C992	.0816	.180	.0991	.0887	.111	.0362
W(AYP)1	.577	.770	1.09	1.58	.745	1.04	1.38	.924	.871
	+	+	+	+	+	+	+	+	+

TABLE X-12
C-5A LATERAL-DIRECTIONAL HANDLING QUALITIES PARAMETERS
SAS Off
(BODY AXIS SYSTEM)

		+	+	+	+	+	+	+	+	+	+	+
F/C #	1	2	3	4	5	6	7	8	9			
H	SL	SL	SL	SL	20 K	20 K	40 K	40 K	40 K			
K	.221	.300	.450	.650	.400	.600	.800	.770	.875			
DR PERIOD (SEC)	12.2	10.5	7.35	5.16	11.5	8.23	6.16	10.2	10.6			
L/C(1/2)	2.11	1.69	1.94	2.12	.939	1.26	1.31	.512	1.82			
SPIRAL (2) (SEC)	--	--	--	--	--	--	--	--	--			
P(1)	.387	.226	.371	.431	.242	.398	.386	.310	--			
P(2)	.161	-.000993	.308	.326	-.117	.324	.291	.163	--			
P(3)	.215	.132	.316	.355	.180	.359	.339	.310	--			
P(2)/P(1)	.416	-.0C440	.828	.755	-.484	.813	.753	.527	--			
P(OSC)/P(AV)	.413	1.01	.0939	.14C	3.50	.0778	.110	.310	--			
W(PHI)/W(D)	.854	.599	1.00	1.3C	.428	.971	1.18	.834	.983			
DEL-B-MAX	.522	.395	.0537	.119	.530	.0811	.0794	.186	.104			
PHI TO BETA, PHASE	-288.	60.8	-307.	46.7	56.6	-309.	50.1	-308.	183.			
PHI TO BETA	1.10	1.34	1.25	1.24	1.63	1.47	1.42	1.92	.882			
PHI TO VE	.255	.230	.142	.0977	.309	.186	.135	.296	.120			
	+	+	+	+	+	+	+	+	+			

C-5A DATA SOURCES

C-5 Flight Control Report (Aerospace Vehicle) Stability and Control,
Lockheed-Georgia Rept. No. LG1US42-1-1, 8 Feb. 1966

SECTION XI

XB-70A

XB-70A BACKGROUND

The XB-70A was originally designed as a weapons systems with long range supersonic cruise capabilities. The two aircraft built became research aircraft to explore SST-related problems.

The two XB-70A's were identical except that the first airplane (XB-70A-1) had zero geometric dihedral while the second had 5 deg geometric dihedral. The first airplane is considered here.

Pitch control employs interconnected elevon and canard surfaces except in takeoff and landing where the canard is locked and a fixed canard flap is used. Roll control is obtained through differential action of the elevons. Yaw control is provided by rotation of the vertical stabilizers about a 45 deg hinge line.

The airplane is equipped with stability augmentation in all axes.

Data shown here is a composite of many sources. The object was to use flight test data where possible.

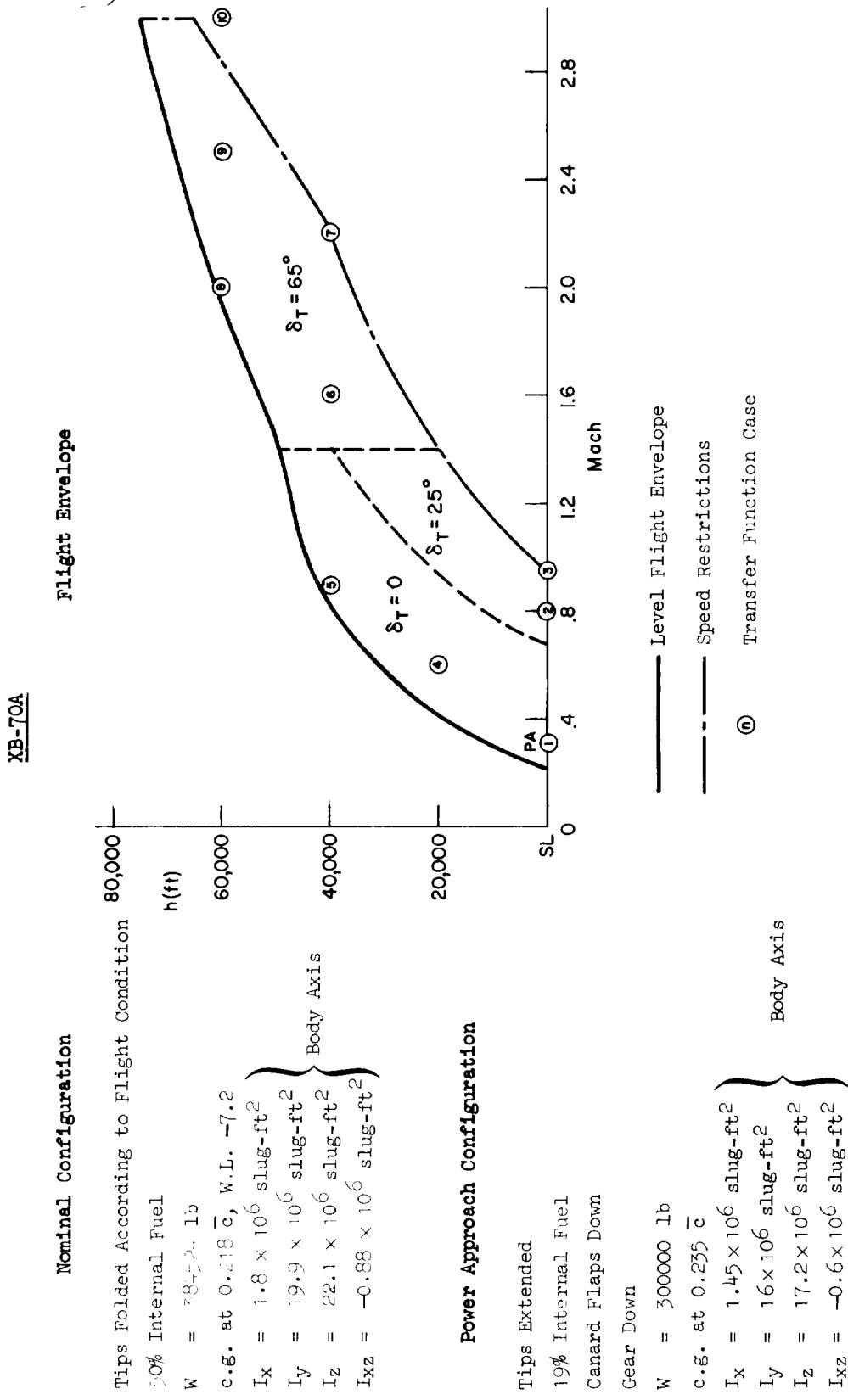


Figure XI-1. XB-70A Flight Conditions

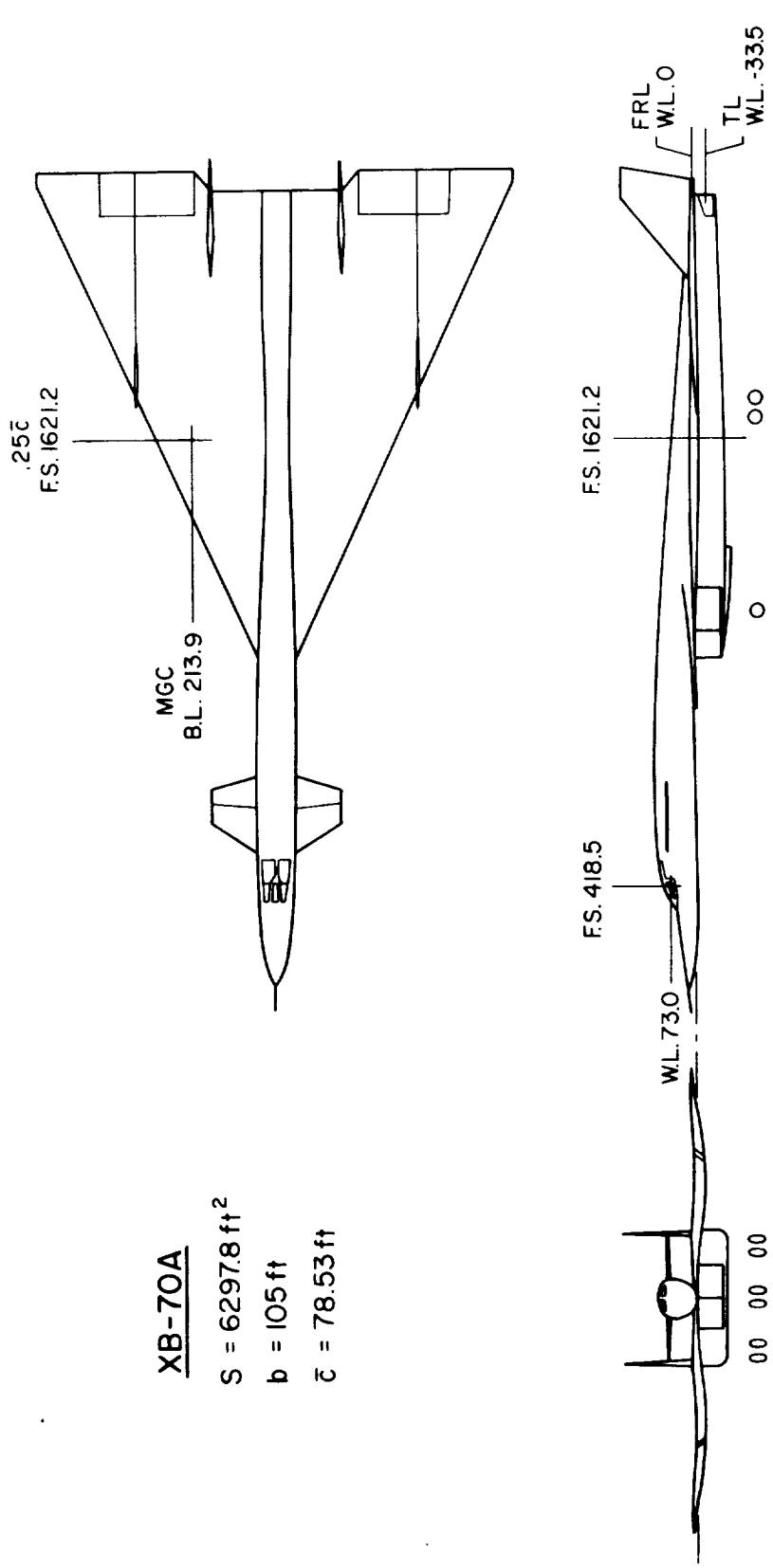
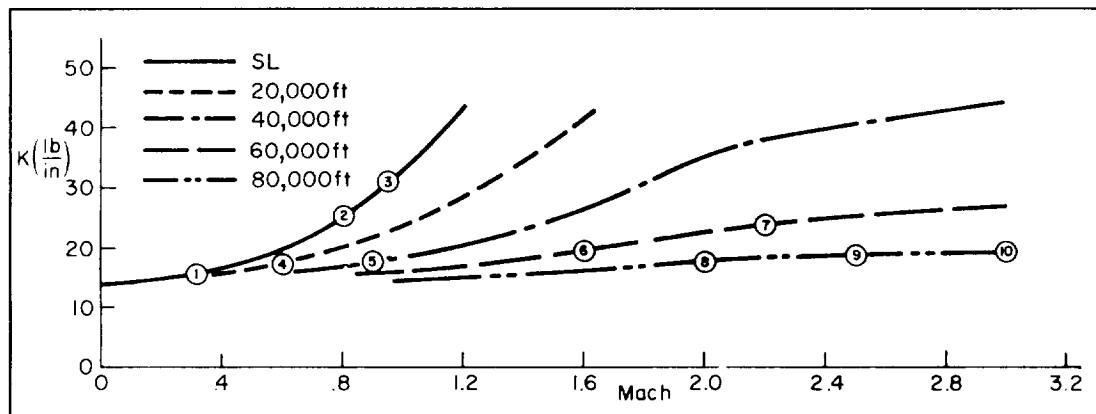
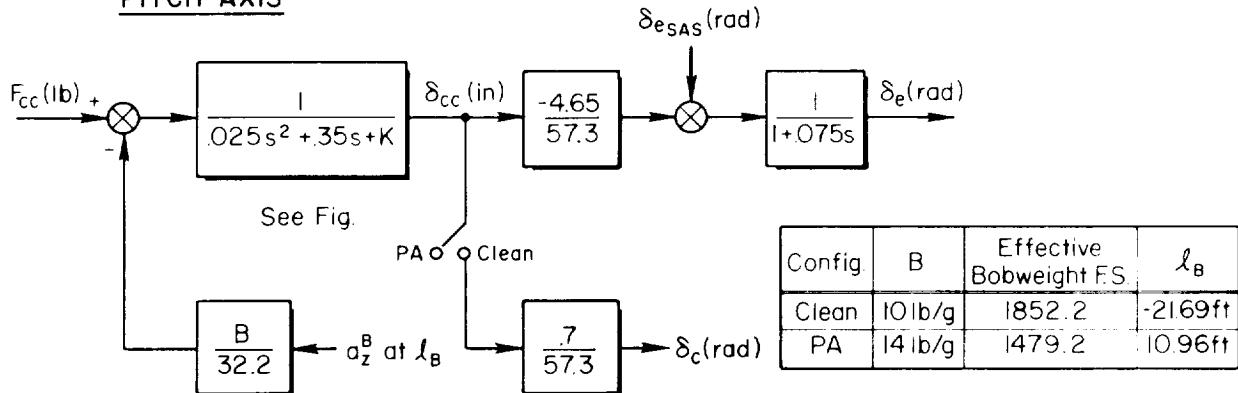


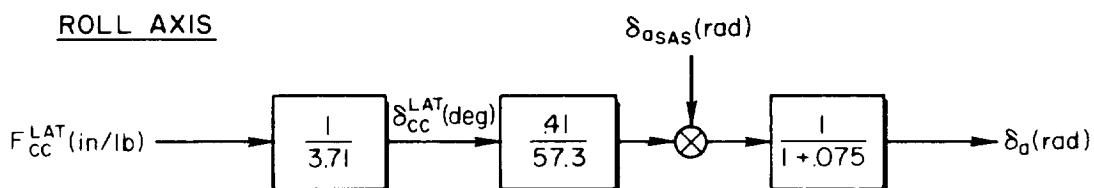
Figure XI-2. XB-70A General Arrangement

XB-70A

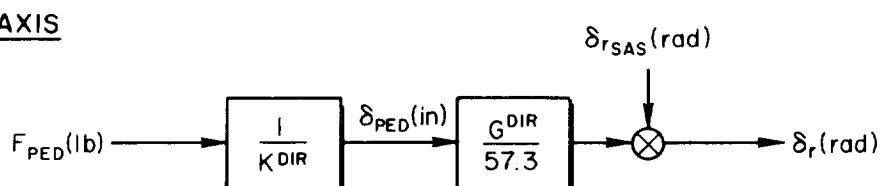
PITCH AXIS



ROLL AXIS



YAW AXIS

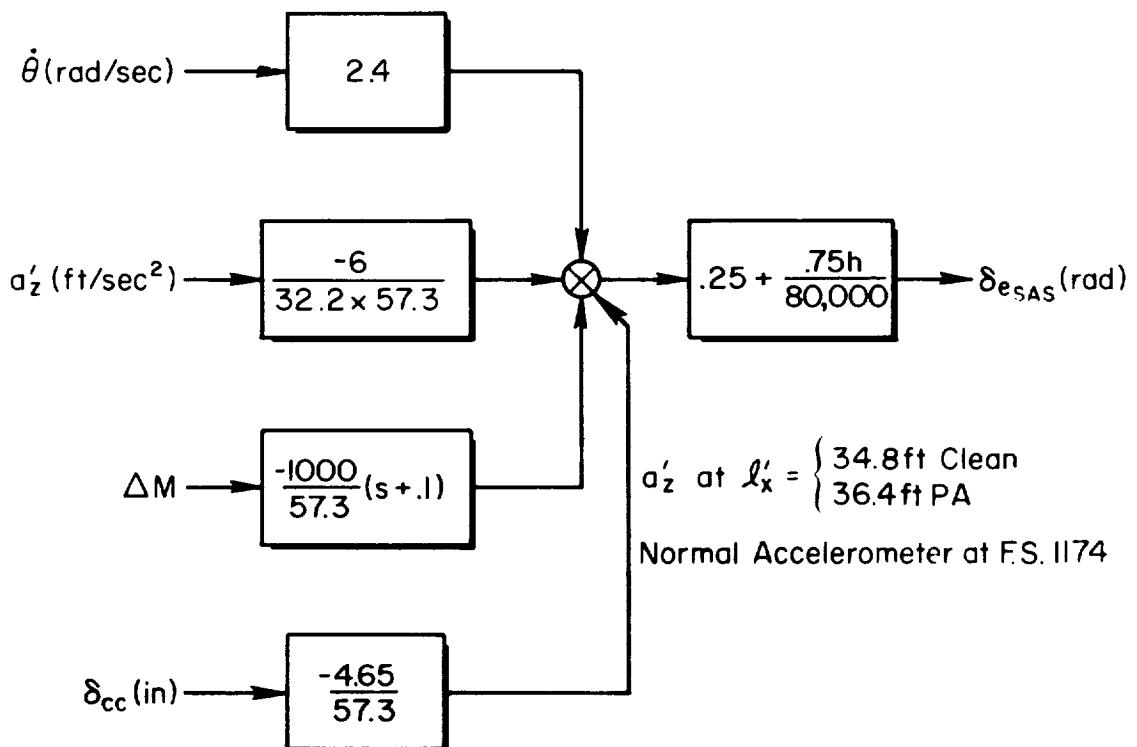


Config.	K ^{DIR}	G ^{DIR}
Gear UP	28 lb/in	.96 deg/in
Gear DN	31 lb/in	4.0 deg/in

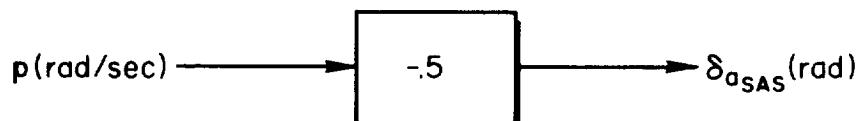
Figure XI-3. XB-70A Control System

XB-70A

PITCH SAS



ROLL SAS



YAW SAS

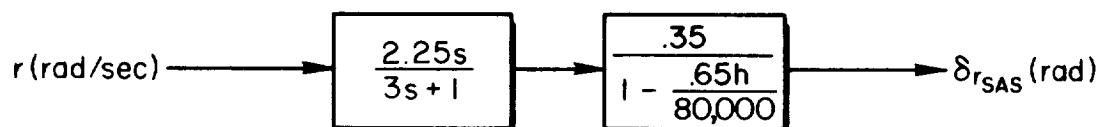


Figure XI-4. XB-70A SAS

TABLE XI-1

XB-70A

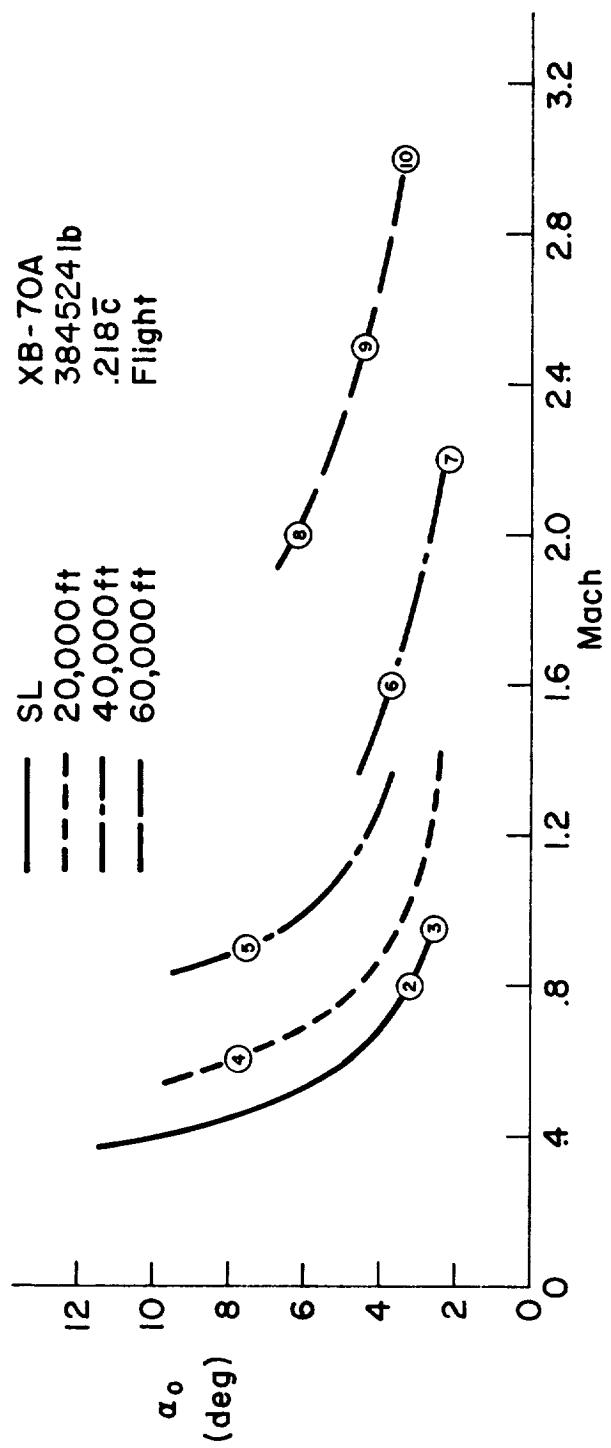
Power Approach Nondimensional Stability Derivatives

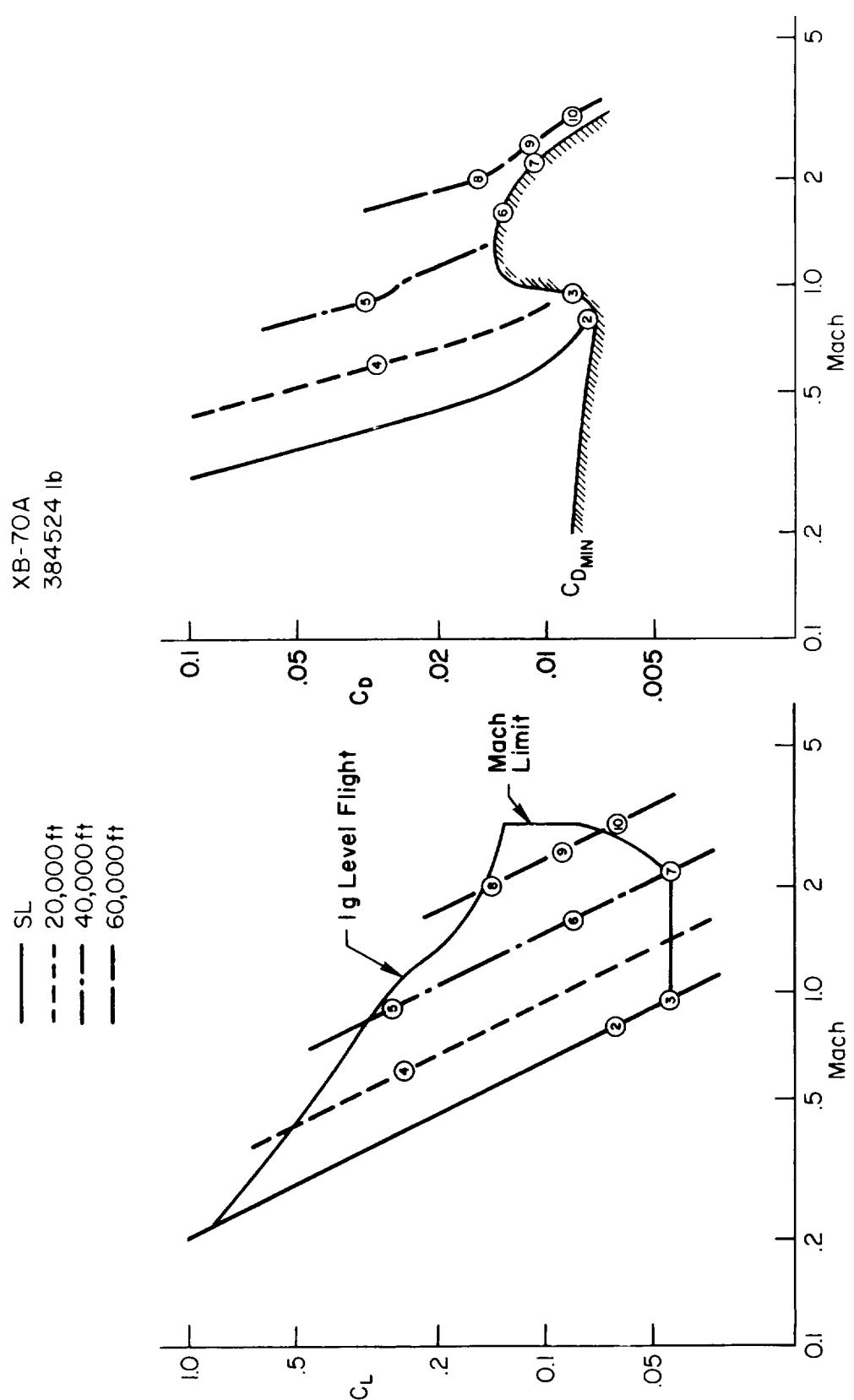
h = sea level

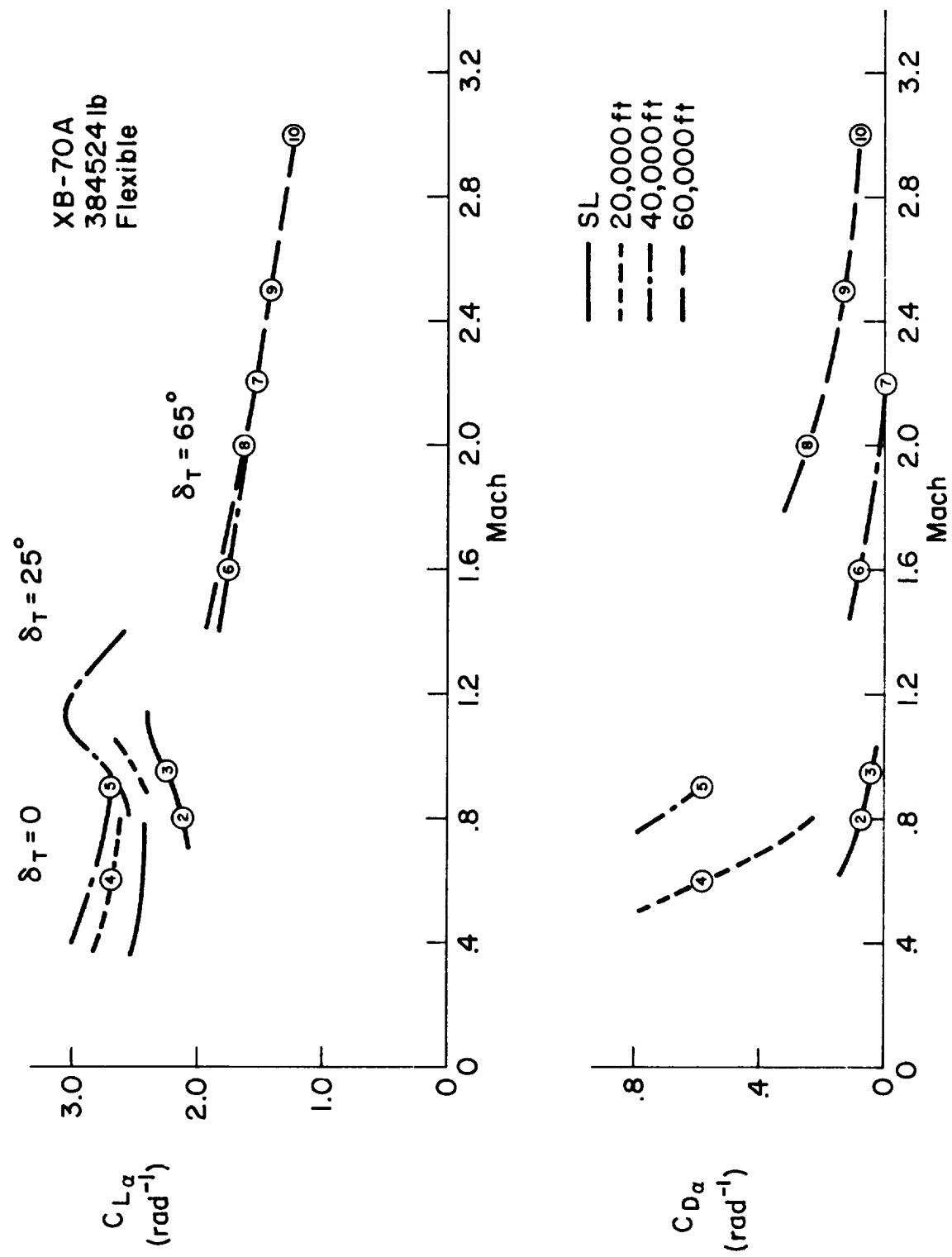
 $V_{TO} = 347 \text{ ft/sec} = 205 \text{ kt}$ $\alpha_0 = 7.5 \text{ deg}$

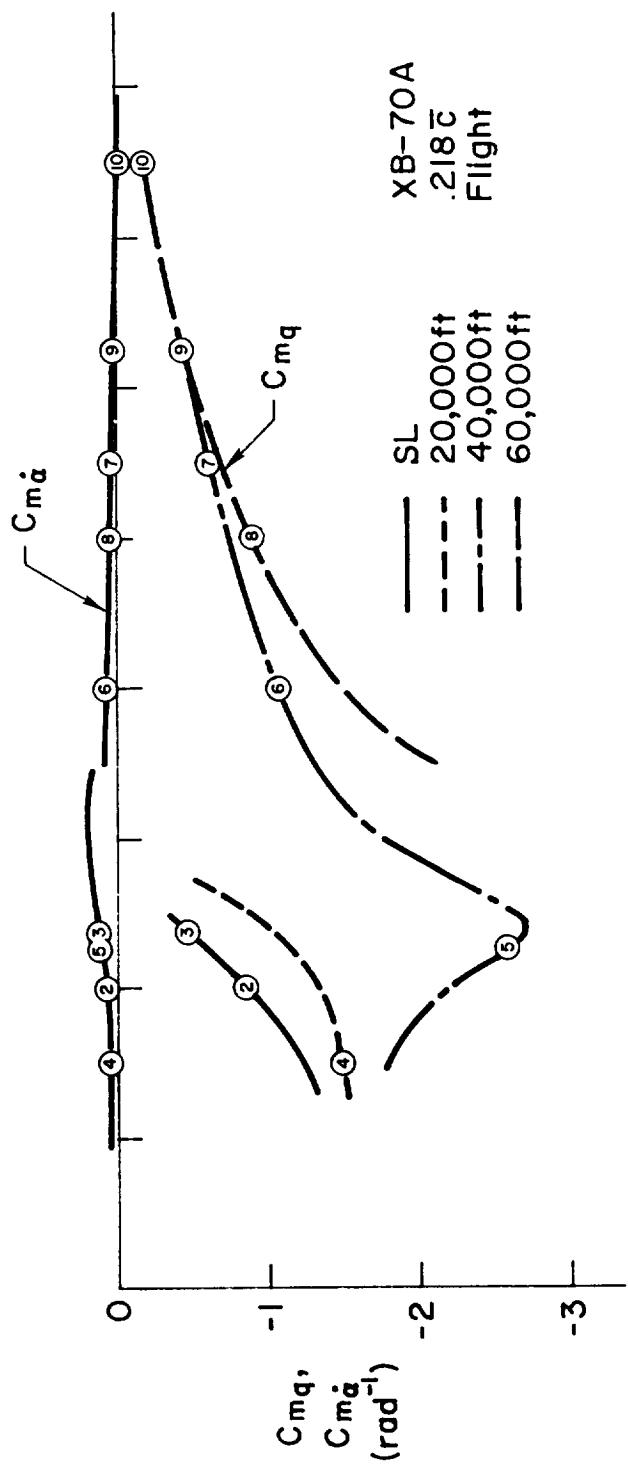
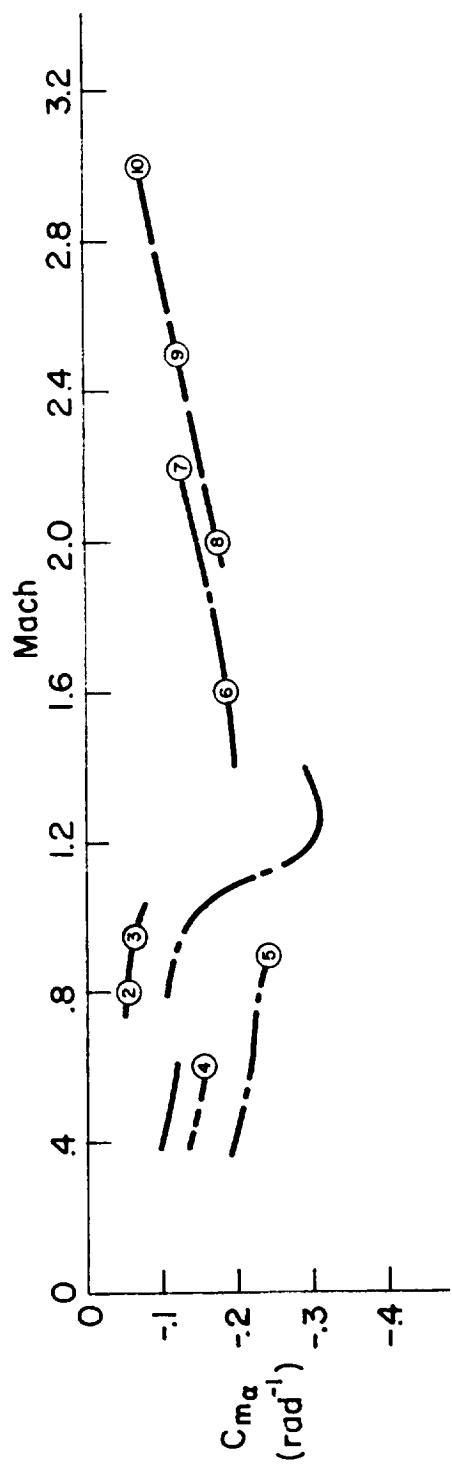
Longitudinal	Lateral-Directional (Body Axis)
---------------------	--

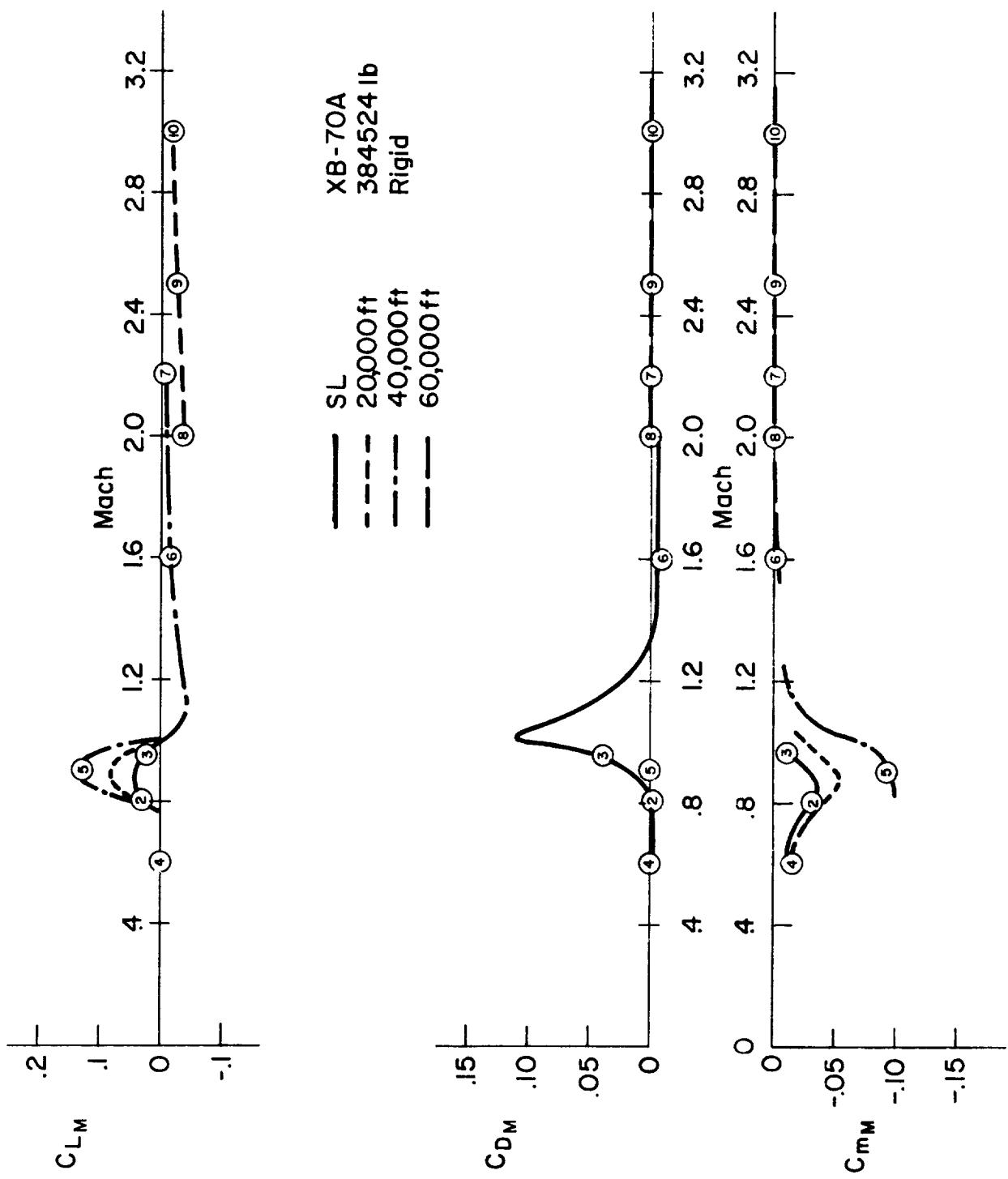
$C_L = .333$	$C_{y\beta} = -.183/\text{rad}$
$C_D = .055$	$C_{n\beta} = .132/\text{rad}$
$C_{L\alpha} = 2.6/\text{rad}$	$C_{\ell\beta} = -.072/\text{rad}$
$C_{D\alpha} = .56/\text{rad}$	$C_{\ell p} = -.18/\text{rad}$
$C_{m\alpha} = -.23/\text{rad}$	$C_{np} = -.26/\text{rad}$
$C_{m\dot{\alpha}} = +.05/\text{rad}$	$C_{\ell r} = -.03/\text{rad}$
$C_{mq} = -1.5/\text{rad}$	$C_{nr} = -.25/\text{rad}$
$C_{L\delta_e} = .46/\text{rad}$	$C_{y\delta_a} = -.063/\text{rad}$
$C_{m\delta_e} = -.19/\text{rad}$	$C_{\ell\delta_a} = .042/\text{rad}$
	$C_{n\delta_a} = -.0052/\text{rad}$
	$C_{y\delta_r} = .12/\text{rad}$
	$C_{\ell\delta_r} = -.0018/\text{rad}$
	$C_{n\delta_r} = -.103/\text{rad}$



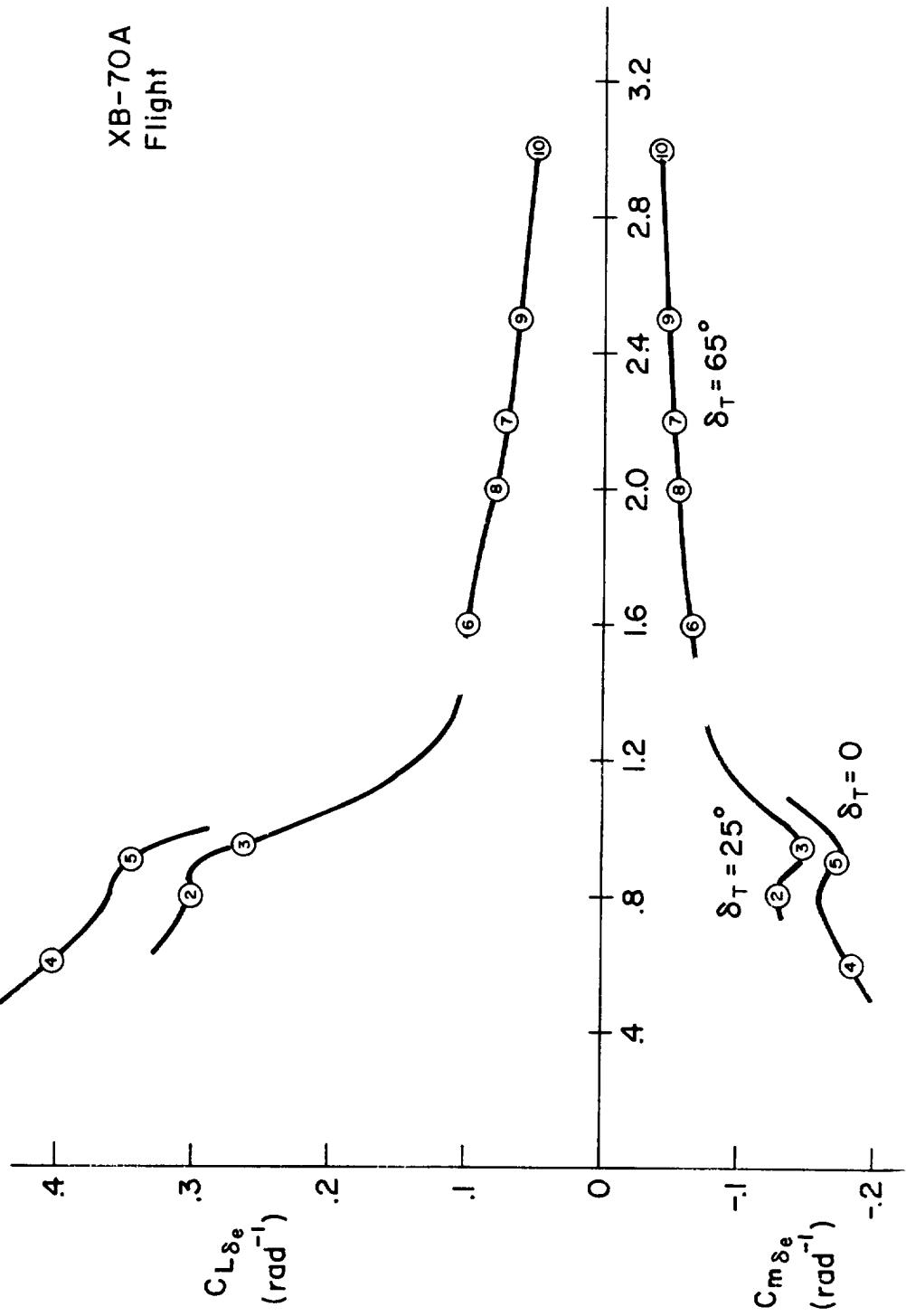


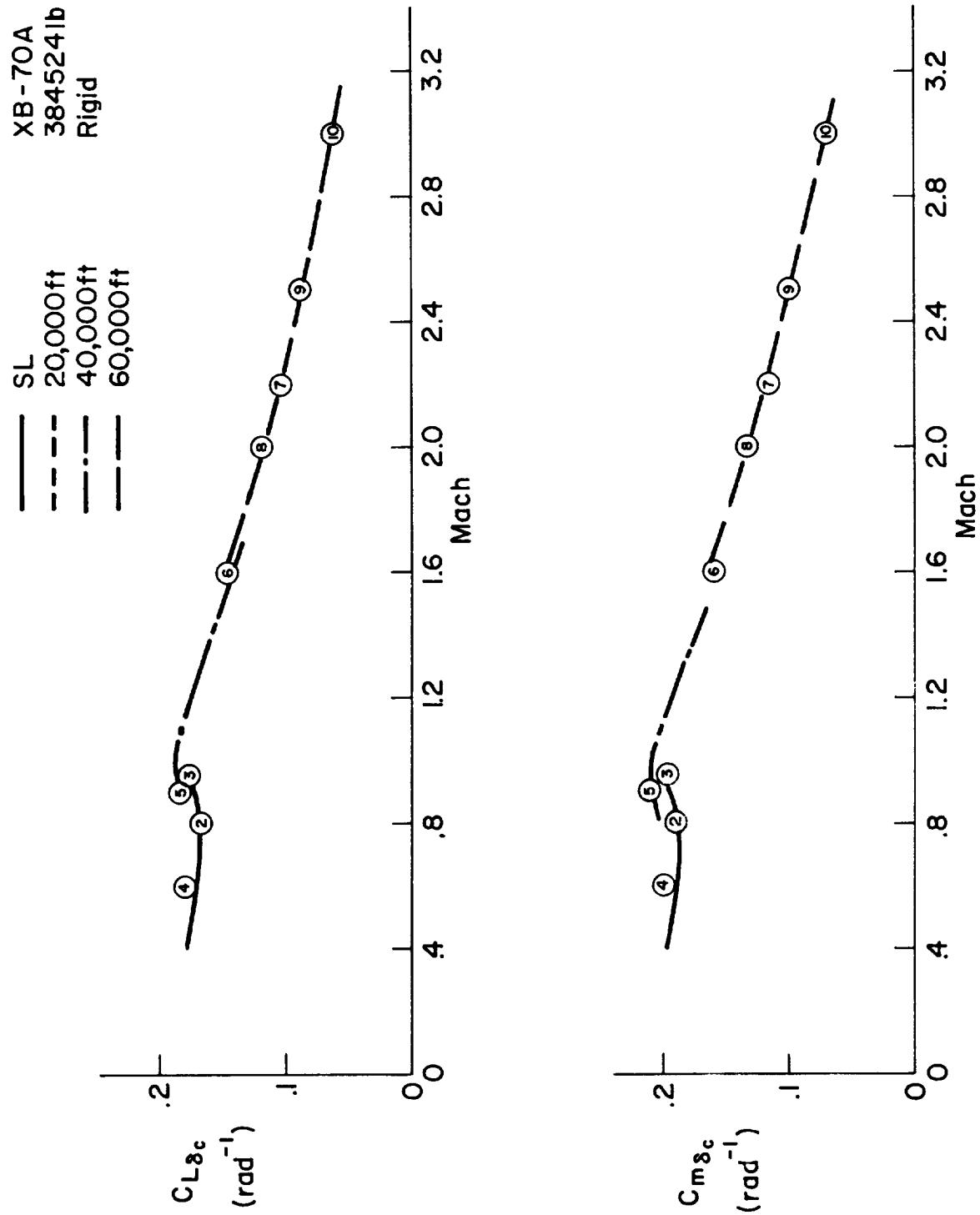


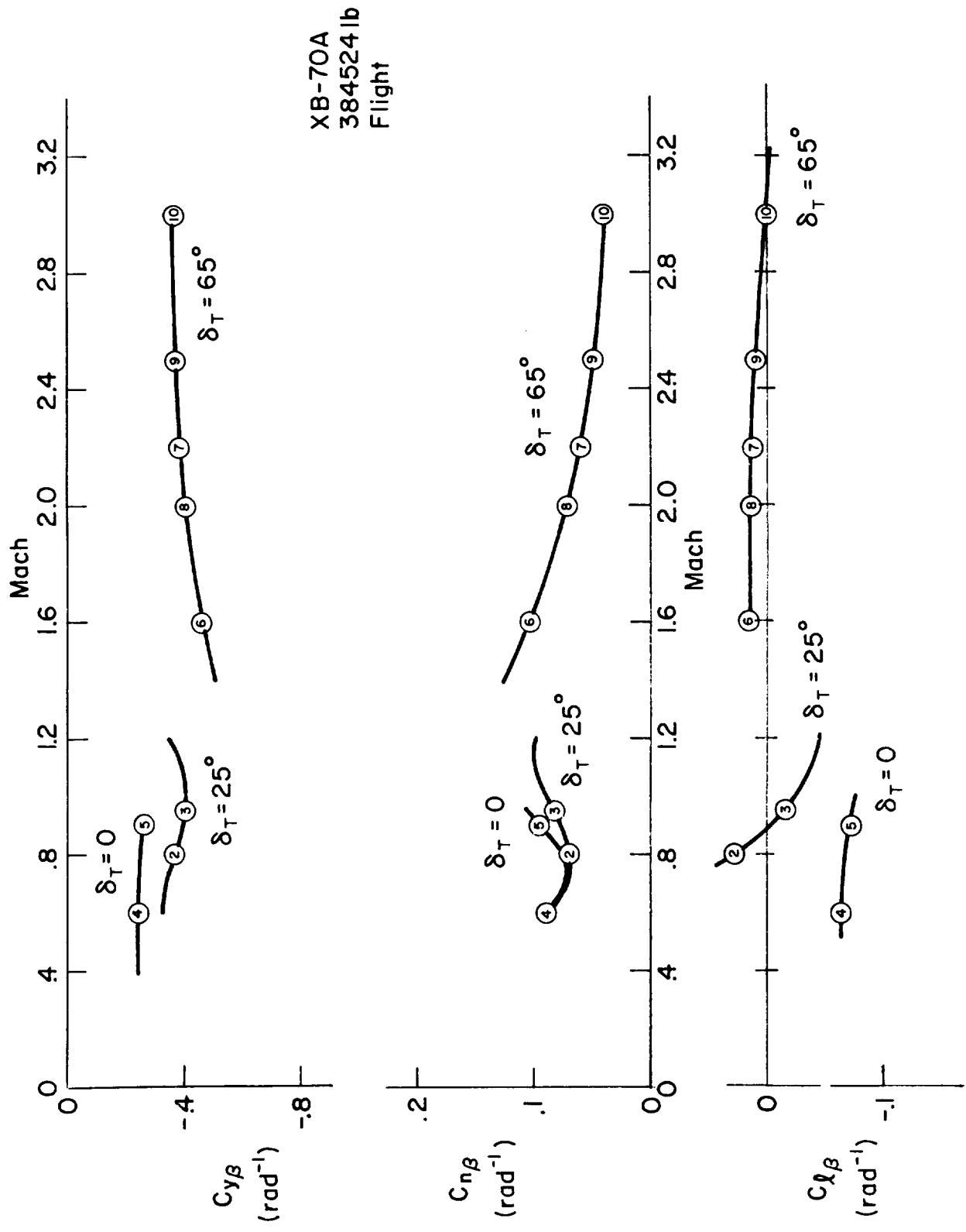


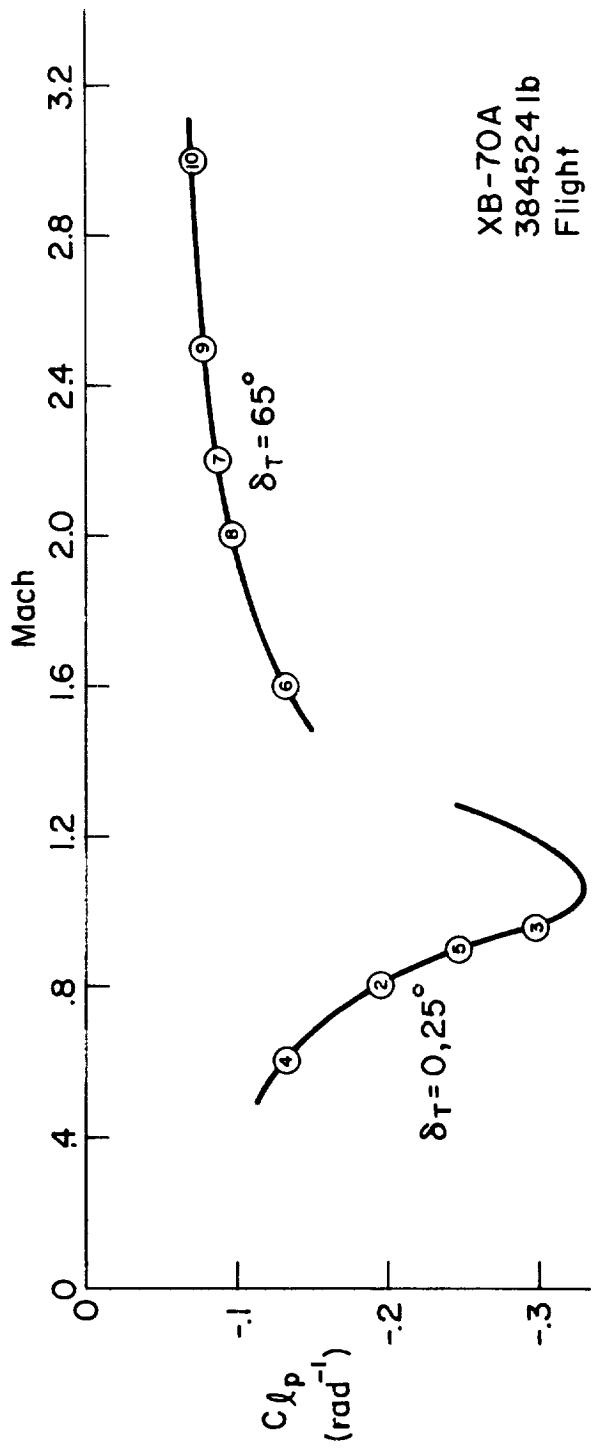


XB-70A
Flight

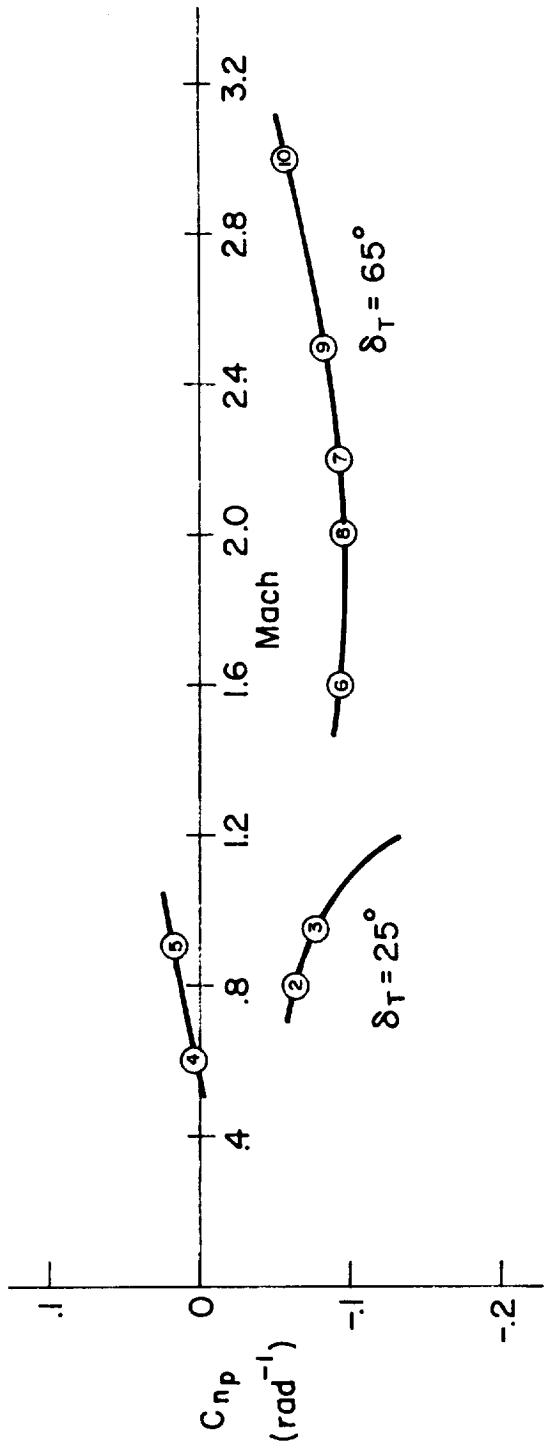


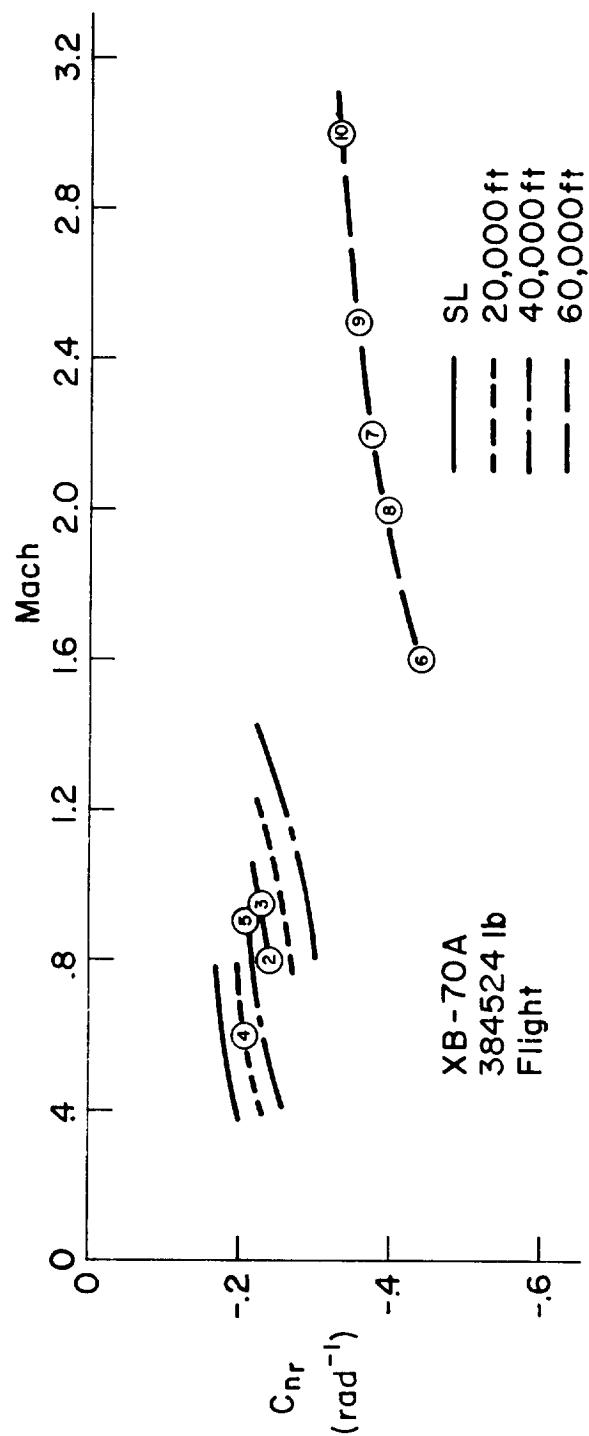
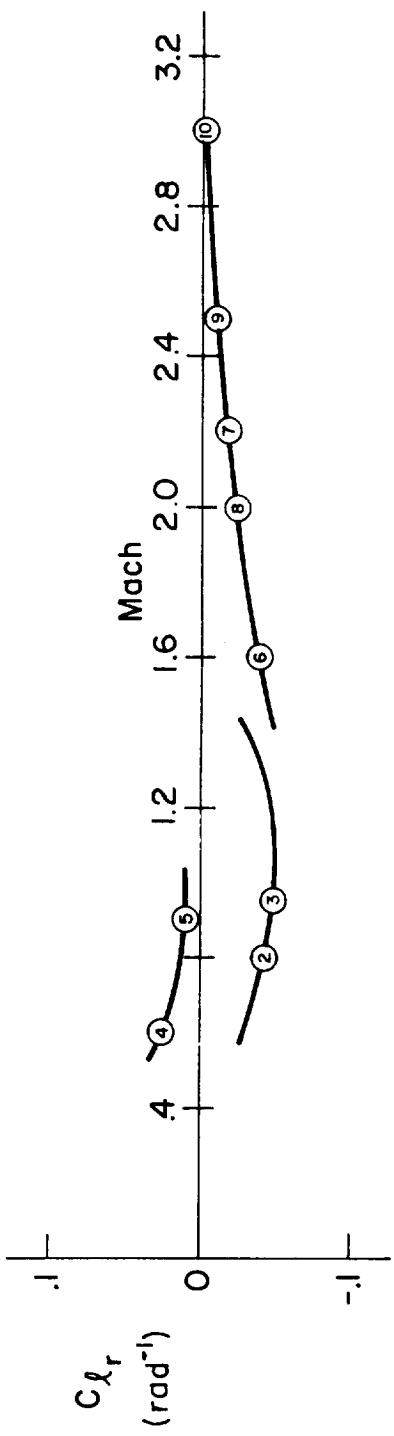


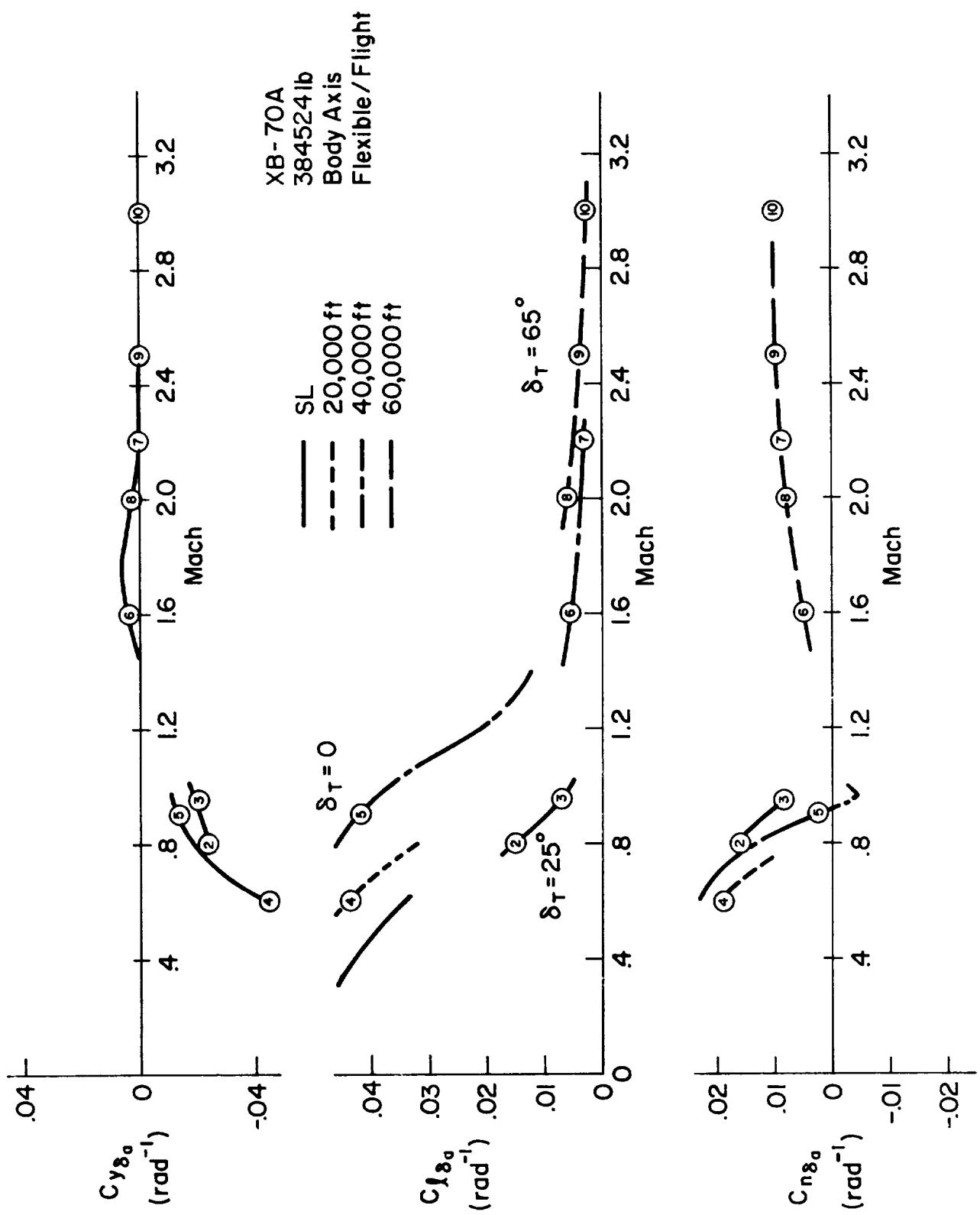




XB-70A
384524 lb
Flight







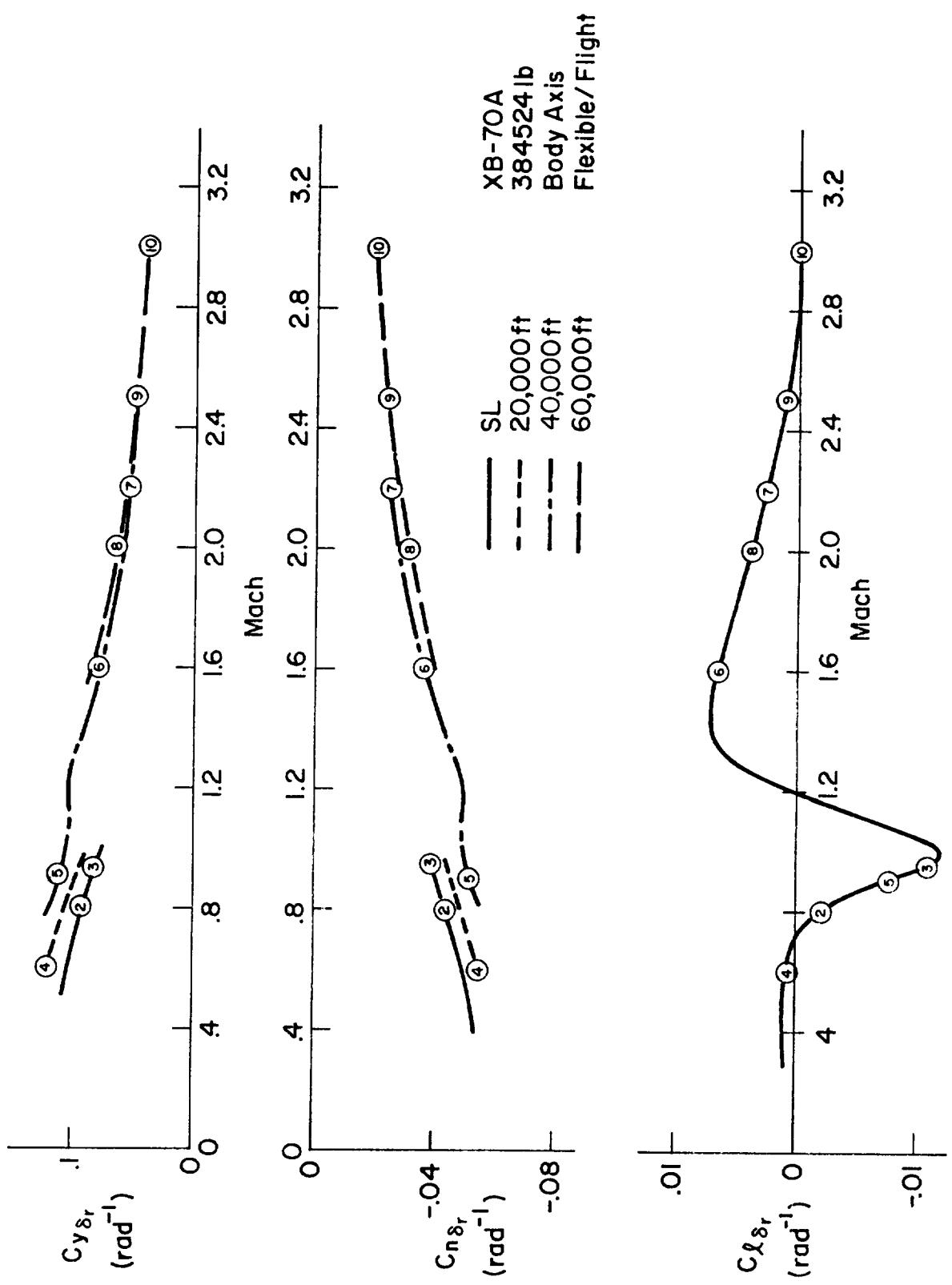


TABLE XI-2
XB-70A DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS
 $S = 6297.8 \text{ sq ft}$, $b = 105.0 \text{ ft}$, $\bar{c} = 78.53 \text{ ft}$

F/C #	1	2	3	4	5	6	7	8	9	10
H(FT)	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K
H(-)	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
VTO(FPS)	346.	893.	1060.	622.	871.	1548.	2129.	1936.	2420.	2904.
VTO(KTAS)	205.	529.	628.	369.	516.	918.	1261.	1147.	1433.	1720.
VTO(KCAS)	205.	529.	628.	275.	278.	528.	710.	432.	535.	630.
W(LBS)	300017.	384546.	384546.	384546.	384546.	384546.	384546.	384546.	384546.	384546.
C.G.(MCC)	.235	.218	.218	.218	.218	.218	.218	.218	.218	.218
I _X (SLUG-FT SQ)	.145E+7	.180E+7								
I _Y (SLUG-FT SQ)	.160E+8	.100E+8								
I _Z (SLUG-FT SQ)	.172E+8	.221E+8								
I _{XZ} (SLUG-FT SQ)	-600035.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.	-880050.
EPSILON(DEC)	2.18	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Q(PSF)	142.	948.	1336.	245.	224.	707.	1335.	424.	663.	954.
QC(PSF)	146.	1109.	1666.	268.	273.	1105.	2253.	703.	1139.	1675.
ALPHA(DEC)	7.50	3.20	2.60	7.70	7.50	3.70	2.30	6.20	4.40	3.40
GAMMA(DEC)	0.	c.	0.	0.	0.	0.	0.	0.	0.	0.
LXP(FT)	99.0	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7	97.7
LZP(FT)	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70	-6.70
ITH(DEC)	0.	c.	0.	0.	0.	0.	0.	0.	0.	0.
XI(UEG)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LTH(FT)	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
+	+	+	+	+	+	+	+	+	+	+

TABLE XI-3

XB-70A LONGITUDINAL DIMENSIONAL DERIVATIVES
 (BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	+	+	+
H	SL	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00		
XU *	- .0105	- .00514	- .0352	.00472	.00212	- .00221	- .00780	- .00166	- .00267	- .00285		
ZU *	- .0893	- .0188	- .00588	- .0271	- .0399	- .00543	- .00141	- .00494	- .00149	.00135		
MU *	.00343	- .00113	- .000452	.000199	- .000644	.796E-4	.000143	.000152	.436F-4	- .376E-4		
XW	.0327	.06229	.0698	.00819	.00700	.0282	.0349	.00776	.00969	.00983		
ZW	- .757	- 1.19	- 1.50	- 5.80	- 380	- 424	- 515	- 192	- 204	- 218		
MW	- .0290	- .00285	- .00376	- .00302	- .00316	- .00429	- .00403	- .00189	- .00163	- .00114		
ZWD	0..	0..	0..	0..	0..	0..	0..	0..	0..	0..	C..	
ZQ	0..	0..	0..	0..	0..	0..	0..	0..	0..	0..		
MWD	.715E-4	.000161	.000277	.610E-4	.567E-4	.285E-4	.114E-4	.655E-5	0..	0..		
MQ	- .749	- 1.75	- 1.10	- 1.13	- 1.30	- 9.30	- 731	- 383	- 213	- 128		
XDE	5.77	7.67	7.61	6.55	4.87	1.87	1.53	1.50	1.26	1.22		
ZDE	- 43.8	- 137.	- 168.	- 48.4	- 37.0	- 29.0	- 38.0	- 13.8	- 16.4	- 20.6		
MDE	- .836	- 7.46	- 11.9	- 2.61	- 2.24	- 3.11	- 4.62	- 1.61	- 2.06	- 2.45		
XDES	5.77	8.37	8.44	7.01	5.30	2.40	1.98	1.93	1.61	1.49		
ZDES	- 43.8	- 150.	- 186.	- 51.9	- 40.3	- 37.2	- 49.2	- 17.8	- 20.9	- 25.1		
MDES	- .836	- 6.10	- 9.92	- 2.24	- 1.90	- 2.27	- 3.50	- 1.20	- 1.57	- 1.98		
XDTH	.000107	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	.837E-4	
ZDTH	0..	0..	0..	0..	0..	0..	0..	0..	0..	0..	0..	
MOTH	.138E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	.220E-6	
	+	+	+	+	+	+	+	+	+	+	+	

XB-70A ELEVATOR TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Open
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	.807	.81.	.850	.600	.40 K	.20 K	.10 K	.00 K	.00 K	.00 K
M	.310									
DENOMINATOR										
1/T(DET)1	{ .0652}	- .0942	- .0479	{ .0136}	- .0278	{ .0494}	{ .0217}	{ .2723}	{ .1118}	- .00101
1/T(DLT)2	{ .102}	*.0960	*.0806	{ .0499}	- .0430	{ .0161}	{ .0167}	{ .2121}	{ .110000}	*.0007
Z(DET)1	{ .591	*.654	*.487	*.526	*.460	*.247	*.204	*.145	*.125	*.0005
W(DET)1	1.25	2.14	2.37	1.59	1.78	2.65	2.99	1.93	1.00	*.002
NUMERATORS										
V(T/GE)										
A(T)	5.77	7.67	7.61	6.55	4.87	1.87	1.52	1.50	1.26	1.32
1/T(TU)1	6.60	4.96	75.7	*.286	*.280	1.66	2.59	2.26	3.05	3.46
2(TU)1	*.022	*.474	*.314	{ *50.8}	{ *32.2}	*.437	*.234	*.522	*.620	*.205
W(TU)1	*.652	*.848	*.982	{ 34.6}	{ 53.4}	*.357	*.426	*.164	*.102	*.157
V(TX/DE)										
A(TW)	*.43.8	-137.	-168.	-68.4	-37.0	-29.0	-28.0	-13.8	-16.4	-20.6
1/T(TW)1	7.30	-*.0705	-*.0075	-*.0358	{ -.0660}	{ -.251}	{ -.53.7}	{ 26.0}	{ 22.6}	{ 20.5}
1/T(TW)2	{ .0531}	*.0113			{ .0394}	{ .0326}	{ .0548}	{ .622}	{ .0187}	{ .000672}
1/T(TW)3	{ .0041}	50.2	76.4				{ .0112}	{ .00584}	{ .0100}	{ .000672}
V(THE/DE)										
A(THE)	-83.7	-7.48	-11.9	-2.61	-2.25	-3.11	-4.62	-1.62	-2.86	-2.65
1/T(THE)1	*.0104	*.00613	*.0354	-*.000936	-*.000709	*.00258	*.00703	*.00174	*.00273	*.00070
1/T(THE)2	*.401	1.14	1.44	*.523	*.323	*.323	*.482	*.175	*.101	*.208
V(HD/DE)										
A(THD)	4.4.2	137.	168.	46.5	37.3	29.0	38.0	13.0	16.4	20.6
1/T(THD)1	*.0425	*.0341	*.0311	-*.00902	*.00904	*.00724	-*.00034	*.00167	*.000723	*.000723
1/T(THD)2	-1.59	-6.57	-10.0	-3.59	-3.50	-7.55	-1.05	-4.59	-7.51	-8.42
1/T(THD)3	2.37	8.28	10.0	*.71	*.76	*.43	11.5	*.45	7.73	*.55
N(AZP/DE)										
A(AZP)	30.2	503.	000.	207.	182.	275.	414.	144.	185.	210.
1/T(AZP)1	*.00537	-*.00201	-*.00128	-*.000623	-*.000427	-*.00147	-*.001512	*.00147	-*.00161	-*.00161
1/T(AZP)2	*.0242	*.00224	*.0354	-*.0124	-*.00857	*.02236	*.00736	-*.00214	*.00286	*.00286
Z(AZP)1	*.115	*.144	*.161	*.091	*.0401	*.0642	*.0662	*.0420	*.0416	*.0416
W(AZP)1	2.08	3.57	4.27	2.01	1.86	2.50	3.20	1.04	2.27	2.65

TABLE XI-5
XB-70A THRUST TRANSFER FUNCTION FACTORS

TABLE XI-6
XB-70A STICK FORCE TRANSFER FUNCTION FACTORS
SAS Off — Bowweight Loop Closed)

(BODY AXIS SYSTEM)											
F/C #	1	2	3	4	5	6	7	P	Q	R	T
H	\$L .800	\$L .950	2C K .600	40 K .600	40 K 2.20	KA K 2.00	KA K 2.00				
M	.310										
DENOMINATOR											
1/T(DEF1)	14.5	-0.079	-0.0201	11.2	-0.0243	11.8	11.9	12.4	12.3	12.3	12.3
1/T(DEF12)	(.472)	.0596	(-.0275)	-0.0283	(.0516)	(.0272)	(.0468)	(.0468)	(.0468)	(.0468)	(.0468)
1/T(DEF13)	(.919)	10.0	(.9409)	11.6	(.0130)	(.0134)	(.0135)	(.0135)	(.0135)	(.0135)	(.0135)
Z(DEF1)	*514	*225	*383	*373	*373	*373	*373	*373	*373	*373	*373
W(DEF1)	1.34	3.57	2.12	2.15	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Z(DEF12)	*255	*284	*310	*295	*282	*282	*282	*282	*282	*282	*282
W(DEF12)	25.3	32.2	35.6	26.2	26.6	31.1	26.6	26.6	26.6	26.6	26.6
NUMERATORS											
H(U /FST)											
A(H)	-250.	-337.	-329.	-283.	-211.	-81.1	-6.0.	-6.0.	-6.0.	-6.0.	-6.0.
1/T(U)1	6.60	49.6	75.7	386	280	165	759.	759.	759.	759.	759.
Z(U)1	*422	*404	*314	(*508)	(*322)	*427	*0234	*0234	*0234	*0234	*0234
W(U)1	*652	*842	*842	(*34.0)	(*33.4)	*3=2	*425	*425	*425	*425	*425
Y(H W /FST)											
A(H)	1897.	5937.	7250.	2095.	1402.	1254.	1543.	565.	779.	779.	779.
1/T(W)1	7.20	-0.0705	-0.0175	34.4	53.7	167.	758.	726.	726.	726.	726.
1/T(W)2	(.531)	*0113	*0359	(-.0251)	(-.0251)	(-.0251)	(-.0251)	(-.0251)	(-.0251)	(-.0251)	(-.0251)
1/T(W)3	(.0361)	5C.2	76.4	(*0394)	(*0326)	(*0112)	(*0584)	(*0584)	(*0584)	(*0584)	(*0584)
Y(THE/FST)											
A(THE)	36.3	324.	517.	113.	97.2	125.	200.	69.8	80.4	80.4	80.4
1/T(THE)1	*0102	*00A19	*0354	-0.000935	-0.000935	*0258	*0072	*0072	*0072	*0072	*0072
1/T(THE)2	*001	1.14	1.44	*52.3	*328	*324	*482	*482	*482	*482	*482
Y(HD /FST)											
A(HD)	-1612.	-5946.	-7257.	-2114.	-1616.	-1256.	-655.	-655.	-655.	-655.	-655.
1/T(HD)1	-0186	*00425	*0341	-*C11	-*C002	*000906	*00724	*00724	*00724	*00724	*00724
1/T(HD)2	-1.57	-6.57	-10.0	-3.56	-3.50	-3.50	-1.55	-1.55	-1.55	-1.55	-1.55
1/T(HD)3	2.37	8.28	10.9	4.71	4.76	8.43	11.5	11.5	11.5	11.5	11.5
Y(GA/FST)											
A(GA2)	-1427.	-25684.	-43278.	-8945.	-7837.	-11000.	-17013.	-6233.	-6233.	-6233.	-6233.
1/T(GA2)	(.537)	(.CC20)	(.CC18)	(.0CC67)	(.0CC67)	(.0CC67)	(.0CC67)	(.0CC67)	(.0CC67)	(.0CC67)	(.0CC67)
Z(GA2)	*242	*115	*144	*151	*151	*151	*151	*151	*151	*151	*151
W(GA2)	2.04	3.57	4.27	2.01	2.01	1.36	2.00	2.00	2.00	2.00	2.00

TABLE XI-7

XB-70A THRUST TRANSFER FUNCTION FACTORS
SAS Off — Bobweight Loop Closed
(BODY AXIS SYSTEM)

F/C	$\#$	1	2	3	4	5	6	7	8	9	10
H		SL	SL	SL	SL	$40K$	$40K$	$40K$	$60K$	$60K$	AC
		$.310$	$.800$	$.950$	$.950$	$.600$	$.900$	1.60	2.00	2.00	2.00
DE Nominator											
$1/T(DEF1)$		14.5	-0.0579	-0.0201	11.2	0.0243	11.8	11.0	12.4	12.2	-0.000009
$1/T(DEF2)$		0.0596	0.0536	(-0.0276)	-0.0383	(-0.0516)	(-0.272)	(-0.0666)	(-0.126)	(-0.126)	$.00000000$
$1/T(DEF3)$		10.0	10.5	(-0.0405)	11.6	(-0.0139)	(-0.0124)	(-0.0165)	(-0.0085)	(-0.0085)	12.2
$Z(TDEF1)$		$.514$	$.229$	$.0150$	$.393$	$.373$	$.157$	$.0762$	$.107$	$.0554$	-0.0241
$W(DEF1)$		1.34	3.97	5.05	2.12	2.15	3.25	3.05	2.20	2.20	2.00
$Z(DEF1)$		$.255$	$.284$	$.267$	$.210$	$.296$	$.282$	$.250$	$.274$	$.274$	$.274$
$W(DEF1)$		25.3	32.2	35.6	26.2	26.6	28.0	31.1	26.6	27.6	28.0
NUMERATORS											
$N(U/DTH)$											
$A(U)$		0.000107	$.837E-4$	$.837E-4$	$.837E-4$	$.837E-4$	$.837E-4$	$.837E-4$	$.837E-4$	$.837E-4$	$.837E-4$
$1/T(U)$	1	-0.0251	-0.0101	-0.00750	-0.0195	-0.0125	-0.00515	-0.00372	-0.00157	-0.00147	-0.00147
$1/T(U)$	12	14.5	10.1	10.5	11.2	11.7	11.9	11.0	12.5	12.4	-0.00124
$Z(U)$	1	$.508$	$.212$	$.00227$	$.338$	$.301$	$.115$	$.0462$	$.0223$	$.0522$	$.0759$
$W(U)$	1	1.33	3.96	5.04	2.07	2.13	3.23	3.04	2.15	2.04	2.36
$Z(U)$	12	$.255$	$.284$	$.267$	$.310$	$.296$	$.282$	$.250$	$.281$	$.274$	$.274$
$W(U)$	12	25.3	32.2	35.6	26.2	26.6	28.0	31.1	26.6	27.6	28.0
$N(W/DTH)$											
$A(W)$		$.372E-4$	$.000194$	$.000231$	$.000123$	$.000186$	$.000339$	$.000438$	$.001423$	$.000521$	$.000679$
$1/T(W)$	11	$1.9.0$	-0.00353	-0.00264	12.0	-0.00963	$.00517$	-0.00236	$.00202$	$.0142E-4$	$.000789$
$1/T(W)$	12	(-0.227)	$-.500$	$-.164$	(-0.118)	$-.318$	$.0165$	$.0589$	$.01P4$	-0.1117	-0.1117
$Z(W)$	13	(-0.101)	11.0	11.1	(-0.0362)	12.4	12.7	13.0	12.7	12.0	-0.0257
$W(W)$	1	$.221$	$.250$	$.224$	$.290$	$.279$	$.260$	$.235$	$.268$	$.250$	$.250$
$Z(W)$	12	$1c.5$	32.8	36.0	26.6	26.6	28.0	31.1	26.7	27.6	28.0

TABLE XI-7 (Concluded)

$N(THE/C1H)$							
A(THE)	-1.36E-6	.219E-6	.219E-6	.219E-6	.220E-6	.220E-6	.220E-6
1/T(THE)1	1.2.1	-1.25	-.134	.165	-.175	.0594	.053
1/T(THE)2	(.705)	1.34	1.75	.490	.276	.406	.520
1/T(THE)3	(.678)	11.3	11.2	12.3	12.6	12.8	13.1
Z(THE)1	*3C2	*248	*225	*287	*277	*260	*235
W(THE)1	25.4	32.0	35.2	26.1	26.6	27.9	31.0
$N(HCO/OTH)$							
A(HD)	*1.40E-4	*4.67E-5	*380E-5	*1.12E-4	*1.09E-4	*540E-5	*642E-5
1/T(HD)1	*31.0	-324	-.109	.677C	-.0817	.0383	.0543
1/T(HD)2	15.7	9.86	10.5	10.8	11.3	11.7	12.4
Z(HD)1	*44.3	*0.136	-.108	.222	.266	.0514	*0.510
W(HD)1	1.91	9.06	11.6	3.63	3.59	6.39	9.75
Z(HD)2	*23.2	*216	*30.2	*31.9	*30.2	*29.1	*27.4
W(HD)2	25.4	32.6	36.2	26.2	26.6	28.1	31.2
$N(AZP/DH)$							
A(AZP)	-1.35E-4	-.214E-4	-.214E-4	-.214E-4	-.214E-4	-.215E-4	-.215E-4
1/T(AZP)1	-0.124	-.001201	-.00138	-.00138	-.00135	-.0000298	-.00103
1/T(AZP)2	*49.1	-.403	-.131	.124	-.119	*0.654	*0.779
1/T(AZP)3	13.3	11.1	11.1	12.1	12.5	12.7	13.0
Z(AZP)1	*30.7	*164	*165	*152	*0.763	*0.709	*0.671
W(AZP)1	1.71	3.63	4.42	2.03	1.93	2.65	3.43
Z(AZP)2	*277	*255	*231	*291	*280	*262	*237
W(AZP)2	25.3	32.0	35.2	26.1	26.6	27.9	31.0
	*	*	*	*	*	*	*

TABLE XI-8

XB-70A ELEVATOR TRANSFER FUNCTION FACTORS
SAS On — Bowweight Loop Open
(BODY AXIS SYSTEM)

F/C #	+												+												
	H	M	SL .310	SL .809	SL .950	SL .600	20 K .600	40 K .900	40 K 1.60	60 K 2.20	60 K 2.00														
DENOMINATOR																									
1/T(DET)1	13.3		12.3		13.3		15.2		14.8		13.3		13.3		13.3		13.3		13.3		13.3		13.3		13.3
1/T(DET)2	(.211)		(.575)		(.656)		(.390)		3.1.0		(.296)		(.317)		1.5.2		1.5.2		1.5.2		1.5.2		1.5.2		1.5.2
1/T(DET)3	(.101)		(.0533)		(.0722)		(.0726)		13.3		(.0496)		(.0542)		13.3		13.3		13.3		13.3		13.3		13.3
Z(DET)1	.687		.811		.735		.625		*4.4		*8.18		*7.62		*3.2		*3.2		*3.2		*3.2		*3.2		*3.2
W(DET)1	1.4		3.09		3.78		2.10		*0.50		2.79		*0.23		*0.24		*0.24		*0.24		*0.24		*0.24		*0.24
W(DET)2	.275		*222		*201		*272		*267		*253		*279		*265		*265		*265		*265		*265		*265
Z(DET)2	25.5		31.2		34.5		25.5		25.9		27.3		27.3		30.3		30.3		30.3		30.3		30.3		30.3
NUMERATORS																									
N(U /DE)	5.26		3.29		1.99		3.84		2.51		4.80		1.36		62.8		*42.1		13.3		13.3		13.3		13.3
A(U)	6.60		12.3		12.2		15.3		13.3		13.3		13.3		13.3		13.3		13.3		13.3		13.3		13.3
1/T(U)1	1.3.3		6.3.7		124.		37.4		42.5		35.9.		13.3		13.3		13.3		13.3		13.3		13.3		13.3
1/T(U)2	.022		.401		.313		.697		*98.9		*43.1		*0.204		*62.1		*67.7		*50.7		*50.7		*50.7		*50.7
Z(U)1	.652		*87.5		1.02		*451		*3.07		*3.63		*44.2		*16.7		*18.6		*20.1		*20.1		*20.1		*20.1
Z(U)2	.277		*226		*205		*273		*269		*256		*23.0		*26.6		*25.7		*25.3		*25.3		*25.3		*25.3
W(U)2	25.3		31.9		35.1		26.1		26.5		27.7		30.3		26.5		27.4		27.4		27.4		27.4		27.4
N(W /DE)																									
A(W)1	-29.9		-58.8		-43.8		-43.8		-28.4		-19.1		-7.51		-7.51		-3.45		-5.77		-6.54		-6.54		-6.54
1/T(W)1	7.30		*0.245		-0.0150		12.3		12.3		0.0150		-0.0157		-0.0157		-0.0122		-0.0122		-0.0122		-0.0122		-0.0122
1/T(W)2	13.3		-0.0259		*0.0432		37.9		62.8		-0.0178		-0.0202		-0.0202		-0.0102		-0.0102		-0.0102		-0.0102		-0.0102
1/T(W)3	(.0531)		13.3		13.3		(-0.1111)		(-0.104)		13.3		13.3		13.3		13.3		13.3		13.3		13.3		13.3
1/T(W)4	(.0941)		64.5		125.		(.0248)		(.0268)		262.		542.		542.		542.		542.		542.		542.		542.
Z(W)1	.277		*226		*205		*273		*269		*256		*23.0		*26.6		*25.7		*25.3		*25.3		*25.3		*25.3
W(W)1	25.3		31.9		35.1		26.1		26.5		27.7		30.3		26.5		27.4		27.4		27.4		27.4		27.4

TABLE XI-8 (Concluded)

$\Delta(\text{THE}/\text{DE})$	-76.4	-42.8	-5.32	-1.75	-1.40	-1.80	-2.17	-1.25
$A(\text{THE})$.0104	.00523	.0354	.726E-4	.00599	.00253	.00729	.00252
$1/T(\text{THE})$	1.17	1.50	.535	.336	.298	.503	.180	.167
$1/T(\text{THE})^2$	1.3.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
$1/T(\text{THE})^3$	2.220	.200	.269	.265	.252	.227	.264	.255
$Z(\text{THE})$	25.3	31.8	35.0	26.0	26.4	27.7	30.8	26.5
$W(\text{THE})$								27.8
$\Delta(\text{HD}/\text{DE})$								
$A(\text{HD})$	40.3	58.9	43.8	28.7	19.2	7.53	3.47	5.60
$1/T(\text{HD})$	-.0196	.00473	.C343	-.00912	-.00630	.00182	.00727	.00127
$1/T(\text{HD})^2$	1.5.1	8.62	12.2	-4.32	4.39	8.46	13.3	5.34
$1/T(\text{HD})^3$	2.37	-8.67	13.3	4.54	-4.70	13.3	-11.7	6.81
$1/T(\text{HD})^4$	13.3	12.3	-15.3	13.3	13.3	14.5	13.3	13.3
$Z(\text{HD})$	1	.218	.196	.267	.262	-42.3	13.3	-15.5
$W(\text{HD})$	1	25.3	32.2	35.6	26.2	.240	.257	.244
$\Delta(\text{AZP}/\text{DE})$								
$A(\text{AZP})$	35.7	35.9	476.	142.	118.	168.	208.	50.3
$1/T(\text{AZP})$	0.0537	-.00139	-.00136	.548E-4	.00427	-.00114	-.00167	-.00163
$1/T(\text{AZP})^2$	1.0242	.00661	.0356	-.C0923	-.00680	.00295	.00279	.00267
$1/T(\text{AZP})^3$	1.3.3	13.3	13.2	13.3	13.3	13.3	13.3	13.3
$Z(\text{AZP})$	1.15	.194	.229	.151	.121	.153	.143	.147
$b(\text{AZP})$	2.03	3.55	4.23	2.02	1.87	2.58	3.35	2.27
$Z(\text{AZP})^2$	2.220	.200	.270	.265	.253	.228	.265	.255
$W(\text{AZP})$	25.3	31.7	35.0	25.5	26.4	30.7	26.5	27.8
	+	+	+	+	+	+	+	+

TABLE XI-9
XB-70A THRUST TRANSFER FUNCTION FACTORS

		SAS On — Bobweight Loop Open						SAS On — Bobweight Loop Closed					
F/C #		+	+	+	+	+	+	+	+	+	+	+	+
H		1	2	3	4	5	6	7	8	9	10	11	12
N		S _L .310	S _L .800	S _L .950	2C K .6CC	4C K .9CC	4C K 1.6C	4C K 2.2C	5C K 3.0C	5C K 2.5C	4C K 2.0C	4C K 2.0C	4C K 2.0C
DENOMINATOR													
1/T(DET)1	13.3	13.3	13.3	13.3	1.48	13.3	13.3	13.3	1.54	1.54	1.54	1.54	1.54
1/T(DET)2	(.211)	(.575)	(.656)	(.790)	3.10	(.276)	(.317)	(.317)	3.16	3.16	3.16	3.16	3.16
1/T(DET)3	(.101)	(.0533)	(.0722)	(.0726)	13.3	(.0496)	(.0542)	(.0542)	13.3	13.3	13.3	13.3	13.3
Z(DET)1	.687	.811	.735	.925	*404	*818	*796	*796	*742	*742	*742	*742	*742
W(DET)1	1.41	3.09	3.78	2.10	.0501	2.79	2.23	2.23	.0394	.0394	.0394	.0394	.0394
Z(DET)2	.275	.222	.201	.272	.267	.228	.228	.228	.265	.265	.265	.265	.265
W(DET)2	25.5	31.2	34.5	25.5	25.9	27.3	30.2	30.2	26.1	27.0	27.0	27.0	27.0
NUMERATORS													
N($\frac{W}{DTH}$)	A(U)1	.00105	.822E-4	.825E-4	.810E-4	.808E-4	.808E-4	.822E-4	.822E-4	.822E-4	.822E-4	.822E-4	.822E-4
	1/T(U)1	-.022	-.00523	-.00523	-.00523	-.00523	-.00523	-.00523	-.00523	-.00523	-.00523	-.00523	-.00523
	1/T(U)2	13.3	12.3	13.3	12.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
	Z(U)1	.664	.705	.629	.756	.752	.536	.525	.443	.443	.443	.443	.443
	W(U)1	1.33	3.07	3.77	1.92	1.94	2.71	3.24	1.96	2.12	2.12	2.12	2.12
	Z(U)2	.275	.222	.201	.273	.269	.255	.255	.267	.267	.267	.267	.267
	W(U)2	25.5	31.2	34.5	25.4	25.9	27.3	30.3	26.1	27.0	27.0	27.0	27.0
N($\frac{W}{DTH}$)	A($\frac{W}{DTH}$)1	*160E-4	*261E-4	*254E-4	*197E-4	*191E-4	*219E-4	*207E-4	*135E-4	*146E-4	*158E-4	*158E-4	*158E-4
	1/T($\frac{W}{DTH}$)1	*0153	-.0045	-.00283	-.00569	-.00112	-.00112	-.00112	-.00112	-.00112	-.00112	-.00112	-.00112
	1/T($\frac{W}{DTH}$)2	*0254	*0539	*0871	*0519	*0928	*0676	*0676	*0676	*0676	*0676	*0676	*0676
	1/T($\frac{W}{DTH}$)3	*0.52	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
	1/T($\frac{W}{DTH}$)4	13.3	45.0	66.2	33.6	49.9	112.	174.	160.	217.	217.	217.	217.
	Z($\frac{W}{DTH}$)1	.278	.221	.200	.272	.266	.257	.257	.264	.264	.264	.264	.264
	W($\frac{W}{DTH}$)1	25.1	31.9	35.2	26.1	26.5	27.9	30.5	26.1	27.0	27.0	27.0	27.0

TABLE XI-9 (Concluded)

$\eta(\text{THE}/\text{ETH})$.443E-6	.129E-5	.158E-5	.107E-5	.125E-5	.139E-5	.170E-5	.113E-5	.131E-5	.147E-5
$A(\text{THE})$.0463	.0846	.108	.0761	.0956	.0977	.101	.0610	.0610	.0610
$1/T(\text{THE})1$	13.3	14.4	14.4	10.5	30.5	465	162	187	187	187
$1/T(\text{THE})2$	(.987)	(.403)	13.2	13.3	13.3	13.3	13.3	13.2	13.2	13.2
$1/T(\text{THE})3$	{ .403)	13.3	13.2	13.3	13.3	13.3	13.3	13.2	13.2	13.2
$Z(\text{THE})1$.278	.220	.199	.269	.264	.251	.226	.263	.254	.251
$W(\text{THE})1$	25.2	31.9	35.2	26.0	26.5	27.9	31.0	26.6	27.5	27.9
$\eta(\text{HD}/\text{DTH})$										
$A(\text{HD})$	-2.12E-5	-2.15E-4	-2.16E-4	-.863E-5	-1.12E-4	-1.38E-4	-1.74E-4	-4.56E-5	-8.00E-5	-1.00E-4
$1/T(\text{HD})1$.0455	.0826	.0922	.0631	.0905	.0957	.0887	.0875	.0875	.0875
$1/T(\text{HD})2$	3.62	10.3	5.01	4.52	7.02	9.49	6.45	6.52	6.52	6.52
$1/T(\text{HD})3$	13.3	8.07	-10.9	-8.60	-7.53	-8.30	-10.3	13.3	11.4	11.4
$1/T(\text{HD})4$	-19.3	13.3	13.3	13.3	13.3	13.3	13.3	-15.4	13.3	13.3
$Z(\text{HD})1$.343	.218	.198	.257	.255	.248	.225	.247	.247	.247
$W(\text{HD})1$	23.4	32.1	35.4	26.9	27.2	28.2	31.2	27.4	28.0	28.2
$\eta(\text{AZP}/\text{DTP})$										
$A(\text{AZP})$	-2.78E-4	-2.95E-4	-2.95E-4	-.000129	-.000129	-.000101	-.000116	-.000145	-.000113	-.000128
$1/T(\text{AZP})1$	0.0123	-.001201	-.00138	-.00057	-.00057	-.000517	-.000517	-.000517	-.000517	-.000517
$1/T(\text{AZP})2$.221	.471	.0847	.103	.0704	.0948	.0976	.0966	.0966	.0966
$1/T(\text{AZP})3$	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
$Z(\text{AZP})1$.261	.155	.192	.132	.0695	.0724	.0751	.0657	.0657	.0657
$W(\text{AZP})1$	2.00	3.63	4.33	2.05	1.89	2.59	3.41	1.65	2.08	2.08
$Z(\text{AZP})2$.277	.220	.199	.265	.251	.226	.264	.264	.264	.264
$W(\text{AZP})2$	25.3	31.8	35.2	26.0	26.5	27.9	30.9	26.6	27.5	27.9
+	+	+	+	+	+	+	+	+	+	+

TABLE XI-10
XB-70A ELEVATOR TRANSFER FUNCTION FACTORS
SAS On — Bobweight Loop Closed
(BODY AXIS SYSTEM)

F/C #	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
H	S _L .310	S _L .800	S _L .950	S _L .600	S _L .900	S _L 1.60	S _L 2.20	S _L 2.50	S _L 2.80	S _L 3.00	S _L 3.20
DE NUMERATOR											
1/T(DET)1	1.4.4	10.9	11.6	11.5	1.84	12.2	12.4	1.85	2.05	1.05	1.05
1/T(DET)2	(.187)	(.484)	(.637)	(.348)	3.22	(.277)	(.302)	3.06	3.27	3.24	3.24
1/T(DET)3	(.0930)	(.0435)	(.0587)	(.0660)	1.18	(.0454)	(.0486)	12.4	12.4	12.3	12.3
Z(DET)1	.616	.622	.540	.663	.374	.760	.702	.26	.26	.28	.28
W(DET)1	1.47	4.18	4.95	2.59	0.470	3.20	3.75	.0377	.0377	.0397	.0397
Z(DET)2	*256	*258	*201	*229	*287	*279	*241	*277	*265	*265	*265
W(DET)2	25.6	31.2	34.4	25.4	25.8	27.2	30.2	26.1	27.2	27.2	27.2
NUMERATORS											
A(W/DET)	-4.26	-3.97	-3.13	-6.66	-6.72	-2.87	-1.94	-2.41	-2.41	-2.41	-2.41
A(U)	6.63	(.452)	(.314)	(.297)	(.275)	(.440)	52.6	41.1	38.0	35.3	35.3
1/T(U)	11	6.68	(.866)	(1.01)	.501	.329	(.353)	115.	112.	115.	115.
1/T(U)	12										
Z(TU)	11	*92.2	*81.0	*75.6	*80.9	*80.9	*02.6	*82.8	*60.1	*60.4	*60.4
W(U)	11	*65.2	52.9	64.7	36.1	29.7	62.6	.431	.163	.152	.152
W(W/DET)											
A(W)	32.3	71.1	69.1	49.3	51.1	44.5	48.3	31.5	32.7	32.8	32.8
1/T(W)	11	7.30	.0233	(-.005)	(-.0733)	(-.0108)	(-.0121)	.00267	-0.00670	-0.00670	-0.00670
1/T(W)	12	6.58	-.0240	(.0423)	(.0262)	(.0282)	(.0123)	.00046	*0.00327	*0.00327	*0.00327
1/T(W)	13	(.0531)	(.819)	(.753)	(.008)	(*00)	(*026)	41.1	38.0	38.0	38.0
1/T(W)	14	(.0941)	(.53.2)	(.64.9)	(36.3)	(39.7)	(62.6)	116.	112.	112.	112.
W THE (DET)											
AT (THE)	*620	2.90	3.70	2.13	2.41	2.77	3.44	2.12	2.52	2.52	2.52
1/T (THE)	1	*00623	*0354	-0.00259	*00242	*00254	*00757	*00221	*00206	*00206	*00206
1/T (THE)	2	*501	1.16	1.48	*525	*327	*380	*172	*172	*172	*172
1/T (THE)	3	6.67	77.1	75.4	46.8	38.4	42.0	40.5	35.3	35.3	35.3

TABLE XI-10 (Concluded)

$A(HD/DE)$	-32.6	-71.2	-69.1	-49.8	-51.5	-44.6	-48.3	-31.7	-33.9	-26.0
$A(HD)$	-0.0186	.00469	.0343	-.00975	-.00704	.00153	.00726	.000478	.00235	.00272
$1/T(HD)1$	-1.59	-7.64	12.3	-3.85	-2.82	7.98	-12.8	5.17	6.54	7.71
$1/T(HD)2$	-2.37	4.55	-12.4	4.48	4.35	-8.59	{ .974}	-6.62	-8.22	-9.18
$1/T(HD)3$	6.68	49.8	41.7	38.7	30.2	22.1	(15.3)	23.1	22.3	22.6
$A(AZP/CE)$	-29.0	-212.	-293.	-159.	-184.	-221.	-287.	-176.	-214.	-247.
$A(AZP)$.00537	-.00137	-.00130	-.000182	-.000163	-.00123	-.000578	-.00179	-.00027	-.000574
$1/T(AZP)1$.00659	.0356	-.00959	-.00725	-.00276	.00785	.00227	.00325	.00325	.00320
$1/T(AZP)2$	-.0242	86.1	51.8	40.7	45.9	44.3	27.5	26.6	26.6	35.0
$1/T(AZP)3$	66.7	115	185	222	134	123	107	102	102	101.4
$Z(AZP)1$	2.08	3.56	4.24	2.02	1.87	2.58	3.37	1.05	2.28	2.61
$W(AZP)1$	+	+	+	+	+	+	+	+	+	+

TABLE XI-11
XB-TOA THRUST TRANSFER FUNCTION FACTORS
SAS On — Bobweight Loop Closed
(BODY AXIS SYSTEM)

F/C *	1	2	3	4	5	6	7	8	9	10
H	S _L .800	S _L .950	S _L .600	2C K .600	40 K .900	40 K 1.60	40 K 2.20	60 K 2.00	60 K 2.50	60 K 3.00
DENOMINATOR										
1/T(DET)1	1.4.4	1C.9	11.6	1.84	12.2	12.4	1.85	2.05	1.05	
1/T(DET)2	(.187)	(.494)	(.637)	(.348)	(.227)	(.302)	(.306	3.27	2.04	
1/T(DET)3	(.930)	(.0435)	(.0587)	(.0660)	(.118)	(.0454)	(.2485)	12.4	12.3	
Z(DET)1	.616	.622	.540	.863	.374	.760	.709	*244	*370	
W(DET)1	1.4.7	4.18	4.99	2.50	.0470	3.20	3.75	*0.77	*0.79	
Z(DET)2	*256	*253	*229	*301	*287	*270	*241	*277	*265	
W(DET)2	25.6	31.2	34.4	25.4	25.8	27.2	30.2	26.1	27.0	
NUMERATORS										
Y(U /DT _H)										
A(U)	*000105	*822E-4	*817E-4	*808E-4	*824E-4	*828E-4	*822E-4	*827E-4	*927E-4	
1/T(U)1	-0.0206	-0.00593	-0.00394	-0.0128	-0.0089	-0.00375	-0.00225	-0.00433	-0.0036	*927E-4
1/T(U)2	14.4	11.1	11.8	11.6	12.1	12.4	12.5	12.7	12.7	
Z(U)1	516	439	439	674	701	476	440	*412	*412	
W(U)1	1.44	4.11	4.92	2.30	2.20	3.09	3.72	2.15	2.37	
Z(U)2	*255	*259	*230	*373	*290	*271	*243	*279	*270	
W(U)2	25.6	31.2	34.5	25.4	25.8	27.3	30.3	26.1	27.3	
N(W /DT _H)										
A(W)	*160E-4	*261E-4	*254E-4	*197E-4	*219E-4	*191E-4	*207E-4	*135E-4	*145E-4	
1/T(W)1	(-0.667)	-0.0427	-0.00277	-0.00353	-0.00573	-0.00217	-0.00112	-0.00231	-0.00146	
1/T(W)2	(.312)	(.567)	(.891)	(.773)	(.924	(.976	(.973	(.973	(.973	
1/T(W)3	(.987)	14.0	14.1	13.5	13.7	13.7	13.7	13.5	13.5	
1/T(W)4	(11.1)	44.5	65.8	33.7	45.8	112.	174.	160.	217.	
Z(W)1	*297	*219	*196	*271	*265	*247	*221	*261	*261	
W(W)1	25.6	31.7	34.9	26.5	26.5	27.8	30.6	26.5	27.5	

TABLE XI-11 (Concluded)

$\eta(\text{THE}/\text{DTH})$	$\cdot 442 \cdot E-6$	$\cdot 129 \cdot E-5$	$\cdot 158 \cdot E-5$	$\cdot 107 \cdot E-5$	$\cdot 125 \cdot E-5$	$\cdot 139 \cdot E-5$	$\cdot 170 \cdot E-5$	$\cdot 113 \cdot E-5$	$\cdot 131 \cdot E-5$	$\cdot 147 \cdot E-5$
$A(\text{THE})$	$\cdot 0467$	$\cdot 0845$	$\cdot 110$	$\cdot 0772$	$\cdot 0958$	$\cdot 102$	$\cdot 102$	$\cdot 0909$	$\cdot 0909$	$\cdot 0909$
$1/T(\text{THE})^1$	13.0	1.11	1.39	2.98	4.52	1.50	1.50	2.9	2.9	2.9
$1/T(\text{THE})^2$	$(\cdot 023)$	$(\cdot 49)$	$(\cdot 127)$	$(\cdot 13.8)$	(13.4)	(13.6)	(13.7)	(13.5)	(13.5)	(13.5)
$1/T(\text{THE})^3$	$(\cdot 404)$	$(\cdot 285)$	$(\cdot 214)$	$(\cdot 192)$	$(\cdot 268)$	$(\cdot 262)$	$(\cdot 246)$	$(\cdot 252)$	$(\cdot 248)$	$(\cdot 27.9)$
$Z(\text{THE})^1$	25.2	31.0	35.2	26.0	26.5	27.9	27.9	27.5	27.5	27.9
$w(\text{THE})^1$										
$\eta(\text{HD}/\text{DTH})$										
$A(\text{HD})^1$	$\cdot 212 \cdot E-5$	$\cdot 215 \cdot E-4$	$\cdot 216 \cdot E-4$	$\cdot 863 \cdot E-5$	$\cdot 112 \cdot E-4$	$\cdot 138 \cdot E-4$	$\cdot 174 \cdot E-4$	$\cdot 456 \cdot E-5$	$\cdot 800 \cdot E-5$	$\cdot 100 \cdot E-4$
$1/T(\text{HD})^1$	$\cdot 173$	$\cdot 0443$	$\cdot 0820$	$\cdot 0858$	$\cdot 0620$	$\cdot 0896$	$\cdot 0953$	$\cdot 0876$	$\cdot 0868$	$\cdot 0870$
$1/T(\text{HD})^2$	-2.2	-7.69	-11.0	4.86	4.47	7.27	10.4	5.42	6.58	7.40
$1/T(\text{HD})^3$	$(\cdot 927)$	$(\cdot 927)$	$(\cdot 996)$	$(\cdot 996)$	-8.35	-7.44	-8.38	10.8	13.6	-11.4
$1/T(\text{HD})^4$	(5.66)	(11.9)	(11.9)	(11.9)	14.6	13.9	12.9	11.7	15.4	-11.0
$Z(\text{HD})^1$	47.5	218	203	233	244	253	232	241	249	13.2
$w(\text{HD})^1$	27.6	32.1	35.4	26.8	27.1	28.2	31.2	27.4	28.0	28.2
$\eta(\text{AZP}/\text{DTH})$										
$A(\text{AZP})^1$	$\cdot 278 \cdot E-4$	$\cdot 055 \cdot E-4$	$\cdot 0001229$	$\cdot 843 \cdot E-4$	$\cdot 000101$	$\cdot 000116$	$\cdot 000145$	$\cdot 670 \cdot E-4$	$\cdot 000113$	$\cdot 0001129$
$1/T(\text{AZP})^1$	$\cdot 0123$	$\cdot 0201$	$\cdot 00138$	$\cdot 00697$	$\cdot 00485$	$\cdot 00134$	$\cdot 000527$	$\cdot 001180$	$\cdot 001180$	$\cdot 001180$
$1/T(\text{AZP})^2$										$\cdot 000157$
$1/T(\text{AZP})^3$										$\cdot 000060$
$Z(\text{AZP})^1$										
$w(\text{AZP})^1$										
$Z(\text{AZP})^2$										
$w(\text{AZP})^2$										

TABLE XI-12
XB-70A LONGITUDINAL HANDLING QUALITIES PARAMETERS

SAS off (BODY AXIS SYSTEM)									
F/C #	1	2	3	4	5	6	7	8	9
H	SL	SL	20 K	40 K	40 K	40 K	60 K	60 K	10
Y	.310	.800	.950	.900	1.50	2.20	2.00	2.00	3.00
Bobweight Loop Open									
D(G)/D(U)	(DEG/KT)	.0554	-.0129	-.0133	.0270	-.00273	-.00212	.00100	-.000481
NZA (G/RAD)	5.78	30.4	46.9	9.70	9.59	18.3	31.8	10.5	18.8
DE/J (DEG/G)	16.6	1.13	.570	5.52	9.34	7.02	3.48	12.5	7.68
CAP (RAD/SEC/SEC/G)	.243	.147	.119	.252	.366	.381	.281	.353	.178
PHUGD(2) (SEC)	--	(7.36)	(14.7)	--	(16.1)	--	--	--	(77.0)
1/C(1/10)	2.00	2.36	1.52	1.69	1.42	.696	.560	.400	.287
Bobweight Loop Closed									
FST/KT (LB/KT)	-.338	.0807	.0256	-.0513	.0589	-.0191	-.0172	-.0494	-.0112
FST/G (LB/G)	71.2	16.2	13.8	30.2	45.3	39.4	28.0	57.7	41.4
+	+	+	+	+	+	+	+	+	+

TABLE XI-13
XB-70A LATERAL DIRECTIONAL DIMENSIONAL DERIVATIVES
(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10	+
H	SL	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	60 K	.
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00	
YV	-.0508	-.213	-.266	-.0499	-.0352	-.113	-.129	-.0473	-.0548	-.0623	
YB	-17.6	-190.	-282.	-31.0	-30.6	-175.	-275.	-91.6	-133.	-181.	
LB*	-5.C4	9.67	-9.19	-6.11	-6.18	2.90	4.81	1.94	1.99	-56.9	
NB*	.898	1.60	3.73	.889	.881	2.04	2.21	.811	.912	1.16	
LP*	-1.71	-4.02	-7.36	-1.05	-1.26	-1.16	-1.03	-3.93	-4.13	-4.38	
NP*	-1.16	.0533	.145	.0417	.0572	-.0219	-.0507	-.0170	-.0193	-.0115	
LR*	-.213	-.636	-1.01	.259	.0927	-.202	-.0625	-.0399	.0212	.0849	
NR*	-.200	-.375	-.415	-.140	-.0883	-.307	-.367	-.134	-.151	-.174	
Y* DA	-.0175	-.0129	-.0133	-.00914	-.00176	.000481	0.	.231E-4	0.	0.	
L* DA	2.78	5.24	3.54	4.01	3.54	1.51	1.67	.966	.993	1.07	
N* DA	-.125	-.0386	-.201	-.0936	-.188	-.166	-.107	-.0638	-.0395	-.0427	
Y* DR	.0333	.0515	.0531	.0249	.0149	.0183	.0182	.00750	.00721	.00693	
L* DR	.118	-.0881	-.4.71	.260	-.455	2.10	1.75	.800	.481	.285	
N* DR	-.568	-1.24	-.1.41	-.421	-.330	-.845	-.1.07	-.425	-.485	-.582	
	+	+	+	+	+	+	+	+	+	+	+

TABLE XI-14
XB-70A ATTERRON TRANSISTER FUNCTION FACTORS
 SAS Off
 (BODY AXIS SYSTEM)

	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
F/C #	1	2	3	4	5	6	7	8
H	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00
DENOMINATOR								
1/T(DET)1	.0287	-.0158	.00706	.0270	.0133	-.00576	-.0131	-.0178
1/T(DET)2	1.77	4.15	7.27	*678	*745	1.19	*966	*396
Z(DET)1	.0615	.184	.197	.217	.266	.145	.200	.126
W(DET)1	1.27	1.28	1.94	1.23	1.16	1.38	1.43	1.779
NUMERATORS								
N(B/DA)								
A(B)	-.0175	-.0129	-.0132	-.00914	-.00176	.000481	.174	.231E-4
1/T(B)1	*0451	-21.9	*0451	-68.1	*0685	.0359	*0390	*0320
1/T(B)2	1.94	{ .559}	3.58	{ .786}	*241	1.06	1.37	*394
1/T(B)3	-27.9	{ .505}	-23.0	{ .213}	-368.	547.	7269.	*484
N(P/DA)								
A(P)	2.78	5.24	3.54	4.01	3.54	1.51	1.67	.993
1/T(P)1	-.0119	-.00193	-.00131	-.00691	-.00483	-.00132	-.00096	-.00102
Z(P)1	*184	*216	*211	*118	*0851	*144	*156	*103
W(P)1	*829	1.32	1.83	*866	*743	1.55	1.60	*970
N(R/DA)								
A(R)	-.125	-.0396	-.201	-.0936	-.188	-.166	-.107	-.0638
1/T(R)1	*407	-5.01	-.505	*430	*288	*283	*319	*148
1/T(R)2	-.607	{ .991}	*655	1.50	1.12	-.795	-.776	-.776
1/T(R)3	5.55	{ 1.28}	5.18	-2.54	-1.19	1.98	2.41	1.56
N(PHI/DA)								
A(PHI)	2.76	5.24	3.53	4.00	3.52	1.50	1.67	.959
1/T(PHI)1	*157	*215	*208	*115	*0804	*140	*155	*0923
W(PHI)1	*834	1.32	1.83	*874	*752	1.55	1.60	*979
N(AYP/DA)								
A(AYP)	*146	19.9	-10.0	12.0	3.84	-5.34	.791	.279
1/T(AYP)1	*0691	*157	*0251	-.150	*127	*0423	*0381	*0390
1/T(AYP)2	-497.	-1.93	19.0	*234	-.181	3.90	-19.1	-11.3
Z(AYP)1	-.198	*245	*133	*0817	-.196	*124	*0259	*430
W(AYP)1	*511	1.44	1.87	1.56	1.99	1.41	2.00	1.27

XB-70A RUDDER TRANSFER FUNCTION FACTORS

SAS Off

(BODY AXIS SYSTEM)

F/C *	1	2	+	3	4	+	5	+	6	7	+	8	+	9	+	10
H	SL	SL	+	SL	SL	+	20 K	+	40 K	+	40 K	+	60 K	+	60 K	+
M	.310	.800		.950	.600		.900		1.60		2.20		2.00		2.50	
DENOMINATOR																
1/T(DET)1	.0287	-.0158		.00706	.0270		.0133		-.00576		-.0131		-.0178		-.0152	
1/T(DET)2	1.77	4.15		7.27	.678		.745		.119		.966		.396		.395	
Z(DET)1	.0615	.184		.197	.217		.266		.145		.200		.126		.137	
W(DET)1	1.27	1.28		1.94	1.23		1.16		1.38		1.43		.779		.875	
NUMERATORS																
N(B/DR)																
A(B)	.0333	.0515		.0531	.0249		.0149		.0183		.0182		.00750		.00721	
1/T(B)1	.00130	.00337		-.00282	-.0153		-.0114		.0140		.00807		.00860		.00281	
1/T(B)2	1.73	4.07		10.5	.955		1.56		1.13		1.08		.395		.419	
1/T(B)3	17.5	24.4		19.8	18.4		17.8		53.9		62.9		68.0		72.3	
N(P/DR)																
A(P)	.118	-.0881		-4.71	.260		-.455		2.10		1.75		.800		.481	
1/T(P)1	-.0121	-.00197		-.00135	-.00694		-.00485		-.00132		-.000599		-.00180		-.00102	
1/T(P)2	4.77	6.67		{ .0939}	2.62		{ .0860}		{ 1.46}		{ .128}		{ .0821}		{ .0631}	
1/T(P)3	-4.91	-20.7		{ 2.57}	-3.43		{ 2.31}		{ 1.80}		{ 2.28}		{ 1.36}		{ 1.71}	
N(R/DR)																
A(R)	-.568	-1.24		-1.41	-.421		-.330		-.845		-1.07		-.425		-.485	
1/T(R)1	1.55	2.74		7.71	.570		.473		.243		.266		.142		.152	
Z(R)1	.178	{ .303}		.444	.317		.56		{ -.455}		{ -.367}		{ -.497}		{ -.367}	
W(R)1	.538	{ 4.14}		.292	.708		.757		{ 1.49}		{ 1.30}		{ .813}		{ .688}	
N(PHI/DR)																
A(PHI)	.0433	-.158		-4.78	.203		-.498		2.05		1.71		.754		.443	
1/T(PHI)1	6.53	6.28		{ .114}	2.83		{ .107}		{ 1.38}		{ 1.123}		{ .0735}		{ .0540}	
1/T(PHI)2	-9.93	-12.3		{ 2.56}	-4.16		{ 2.23}		{ 1.83}		{ 2.31}		{ 1.41}		{ 1.78}	
N(AYP/DR)																
A(AYP)	-43.9	-76.2		-113.	-23.9		-22.3		-40.2		-54.0		-21.7		-26.7	
1/T(AYP)1	-.0747	.0133		-.0119	-.0606		-.0352		.0259		.0148		.0170		.00651	
1/T(AYP)2	1.07	4.23		5.78	.383		.332		1.88		1.54		.755		.583	
Z(AYP)1	.715	-.125		.0668	.337		.406		-.194		-.103		-.169		-.0610	
W(AYP)1	.516	1.38		1.59	1.07		1.10		1.26		1.74		.891		1.19	

TABLE XI-16

XB-70A AILERON TRANSFER FUNCTION FACTORS

SAS On

(BODY AXIS SYSTEM)

F/C #	1	2	3	4	5	6	7	8	9	10
H	S _L	S _L	S _L	20 K	40 K	40 K	40 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DET NOMINATOR										
1/T(DET)1	*.0153	-.0115	*.00513	.00647	.00415	-.00392	-.00683	-.00774	-.00663	-.00649
1/T(DET)2	*.466	*.397	*.388	*.351	*.350	*.345	*.345	*.382	*.371	*.353
1/T(DET)3	3.00	6.73	8.86	2.75	2.65	2.00	1.90	*.953	*.943	*.955
Z(DET)1	*.377	*.781	*.633	*.304	*.335	*.215	*.278	*.147	*.193	*.217
W(DET)1	1.05	1.12	1.88	.957	.865	1.38	1.42	.777	.855	1.06
NUMERATORS										
V(P /DA)										
A(B)	-.0175	-.0129	-.0133	-.00914	-.00176	*.000481	*.173	*.231E-4	*.115	*.106
1/T(B)	1	*.0319	*.0723	*.0288	*.147	*.0511	*.0337	*.0290	*.0310	*.0351
1/T(B)	2	*.442	-21.7	*.498	*.68.0	*.266	*.333	*.257	*.271	*.268
1/T(B)	3	2.25	(* 533)	4.05	(* 961)	*.405	*.1.3	*.563	*.669	*.667
1/T(B)	4	-27.5	(* 1.09)	-21.3	(* .320)	-367.	545.	7261.		
V(P /UA)										
A(P)	2.78	5.24	3.54	4.01	3.54	1.51	1.67	*.966	*.993	*.107
1/T(P)	1	-.0118	-.00193	-.00131	-.00691	-.00483	-.00132	-.000596	-.00179	-.00102
1/T(P)	2	*.504	*.444	*.357	*.348	*.354	*.341	*.344	*.349	*.352
Z(P)	1	*.537	*.773	*.711	*.176	*.150	*.206	*.251	*.166	*.190
W(P)	1	*.674	1.14	1.77	*.846	*.721	1.53	1.57	*.947	*.971
V(R /DA)										
A(R)										
1/T(R)	1	-.125	-.0386	-.201	-.0936	-.183	-.156	-.107	-.0638	-.0395
1/T(R)	2	*.333	*.333	*.333	*.333	*.288	*.319	*.148	*.166	*.180
1/T(R)	3	*.407	-5.01	-.505	*.430	*.333	*.333	*.333	*.333	*.333
1/T(R)	4	-.607	(* 991)	*.655	*.150	*.112	-.795	-.776	-1.01	-1.07
1/T(R)	5	5.55	(* 1.28)	5.18	-2.54	-1.19	1.98	2.41	1.56	1.86

TABLE XI-16 Continued

$\text{V}(\text{PHI}/\text{DA})$								
A(PHI)	2.76	5.24	3.53	4.00	3.52	1.50	1.67	.959
1/T(PHI)1	.501	.445	.358	.348	.354	.341	.344	.349
Z(PHI)1	.507	.772	.708	.172	.145	.202	.249	.162
W(PHI)1	.680	1.14	1.77	.654	.730	1.54	1.58	.956
$\text{V}(\text{AYP}/\text{DA})$								
A(AYP)	*146	19.9	-10.0	12.0	3.84	-5.34	.791	.279
1/T(AYP)1	.05C4	.C734	.C206	-.160	.113	.0411	.0393	.0357
1/T(AYP)2	*454	.724	.426	.211	-.206	.338	.341	.313
1/T(AYP)3	-457	-2.08	16.8	.360	.344	3.73	-16.8	-9.47
Z(AYP)1	-.0762	.734	.445	.137	-.0790	.174	.187	.108
W(AYP)1	.534	1.37	1.94	1.53	1.94	1.45	2.18	1.48
	*	*	*	*	*	*	*	*

TABLE XI-17

XB-70A RUDDER TRANSFER FUNCTION FACTORS

SAS On
(BODY AXIS SYSTEM)

F/C #	+	+	+	+	+	+	+	+	+	+	+	+	+	+
H	1	2	3	4	5	6	7	8	9	10				
M	.310	SL .800	SL .950	20 K .600	40 K .900	40 K 1.60	40 K 2.20	60 K 2.00	60 K 2.50	60 K 3.00				
DEFINATOR														
1/T(DET)1	*0153	-0.0115	*00513	*00647	*00415	-0.00392	-0.00683	-0.00774	-0.00663	-0.00649				
1/T(DET)2	*466	*297	*388	*351	*350	*345	*382	*371	*353					
1/T(DET)3	3.00	6.73	8.86	2.75	2.65	2.00	1.90	.953	.943	.955				
Z(DET)1	*377	*781	*633	*304	*335	*215	*278	*147	*193	*217				
W(DET)1	1.05	1.12	1.88	.957	.865	1.38	1.42	.777	.855	1.06				
NUMERATORS														
N(B /DF)														
A(B)	*0333	*0515	*0531	*0249	*0149	*0183	*0182	*00750	*00721	*00693				
1/T(B)1	-0.00454	*0.0126	-0.00251	-0.00985	-0.00747	*0.0944	*0.0464	*0.0368	*0.00840	*0.00654				
1/T(B)2	*333	*333	*333	*333	*333	*333	*333	*333	*333	*333				
1/T(B)3	3.07	6.73	(* 967)	2.72	4.10	1.60	1.79	*750	*864	*947				
1/T(B)4	17.6	24.3	(* 16.3)	18.7	17.0	54.1	63.1	68.1	72.4	86.6				
N(P /DF)														
A(P)	*118	-*0.0197	-*0.0135	-0.00694	-0.00485	-0.00132	-0.000599	-0.00180	-0.00102	-0.00102				
1/T(P)1	-.0121	*333	*333	*333	*333	*333	*333	*333	*333	*333				
1/T(P)2	*3.3	(* 4.77)	(* 6.67)	*0.939	(* 2.62)	*0.860	*1.46	*1.28	*0.821	*0.631				
Z(P)1	(* 4.91)	(* -20.7)	2.57	(* -3.43)	2.31	1.80	2.28	1.36	1.71					
W(P)1														
N(R /DF)														
A(R)	-.568	-1.24	-1.41	-*421	-*330	-*845	-1.07	-4.25	-4.65	-5.82				
1/T(R)1	*333	-.198	*333	*333	*333	*219	*227	*129	*131	*482E-7				
1/T(R)2	2.95	*258	9.82	2.74	2.92	*333	*280	*333	*269	*0485				
1/T(R)3	(* 214)	(* 333	(* 494)	(* 389)	(* 514)	-*379	*333	-389	*323	*333				
1/T(R)4	(* 390)	6.73	(* .258)	(* .322)	(* .305)	1.99	2.00	1.14	1.09	.969				

TABLE XI-17 Continued

$\chi(\rho_{HI}/DF)$								
A(ρ_{HI})	.0433	-•158	-4•78					
1/T(ρ_{HI})1	.333	•333	.333	-•498	2.05	1.71	•754	•443
1/T(ρ_{HI})2	5.67	6.68	(•119)	(2.56)	(2.61)	(.333	(.333	.0485
1/T(ρ_{HI})3	-11.5	-11.5	(2.56)	-4.50	(2.23)	(•134)	(•119)	-.134
					(1.83)	(2.31)	(1.41)	.333
$\chi(AYP/DF)$								
A(AYP)	-4.3.9	-76.2	-113.	-23.9	-40.2	-54.0	-21.7	-26.7
1/T(AYP)1	-•0475	•0777	-•00867	-•0371	-•0213	•0200	•00934	•00314
1/T(AYP)2	•333	•333	•333	•333	•333	•333	•333	•333
1/T(AYP)3	2.86	6.73	7.80	2.76	2.46	2.43	2.34	•967
Z(AYP)1	•362	-•C860	•0496	•367	•435	-•168	-•0869	•00620
W(AYP)1	.423	1.37	1.65	.534	.553	1.25	1.76	1.22
+	+	+	+	+	+	+	+	+

TABLE XI-18
XB-70A LATERAL DIRECTIONAL HANDLING QUALITIES PARAMETERS

SAS Off	(BODY AXIS SYSTEM)
1.0	1.0

F/C #	1	2	3	4	5	6	7	8	9	10
H	SL	SL	SL	20 K	40 K	40 K	60 K	60 K	60 K	60 K
M	.310	.800	.950	.600	.900	1.60	2.20	2.00	2.50	3.00
DR PERIOD (SEC)	4.94	4.98	3.30	5.25	5.60	4.60	4.50	8.13	7.25	5.75
L/C(1/2)	.559	1.70	1.82	2.02	2.51	1.32	1.85	1.15	1.25	.989
SPIRAL (2) (SEC)	--	43.9	--	--	120.	52.8	38.9	45.6	1.075.	
P(1)	1.11	1.45	.461	2.20	1.67	1.70	2.28	4.06	3.32	2.34
P(2)	-.0279	1.38	.398	1.59	.869	1.55	2.22	3.89	--	2.33
P(3)	1.04	1.50	.435	2.82	2.04	1.70	2.40	4.72	--	2.35
P(2)/P(1)	-.0251	.954	.863	.724	.521	.909	.973	.958	--	.995
P(OSC)/P(AV)	1.05	.0329	.0593	.160	.315	.0473	.0135	.0605	--	.00265
W(PHI)/W(D)	.655	1.03	.943	.713	.646	1.13	1.12	1.26	1.15	.979
DEL-B-MAX	.607	.0689	.0658	.452	.447	.219	.175	.510	.303	.165
PHI TO BETA, PHASE	48.7	244.	55.2	22.8	386.	211.	197.	194.	190.	22.3
PHI TO BETA	1.86	1.90	.652	3.42	3.56	1.31	2.17	3.15	2.57	.405
PHI TO VE	.308	.122	.0352	.432	.471	.0973	.117	.302	.198	.0259

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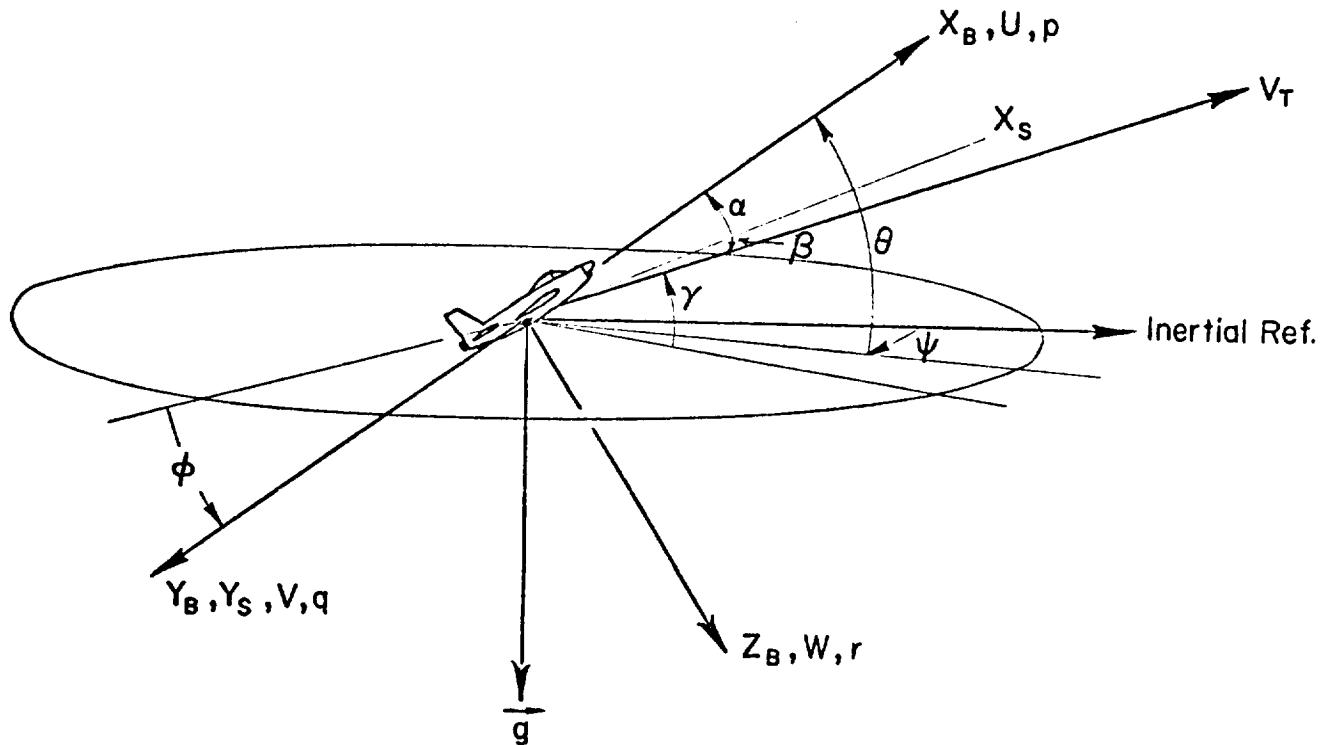
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APPENDIX A

AXIS SYSTEMS, SYMBOLS, COMPUTER MNEMONICS, AND DERIVATIVE DEFINITIONS

1. AXIS SYSTEMS



X_B, Y_B, Z_B - The Body-Axis System consists of right-handed, orthogonal axes whose origin is fixed at the nominal aircraft center of gravity. It's orientation remains fixed with respect to the aircraft, the X_B and Z_B axes being in the plane of symmetry. The exact alignment of X_B axis is arbitrary, herein it is taken along the body centerline reference.

X_S, Y_S, Z_S - The Stability-Axis System is that particular body-axis system for which the X_S -axis is coincident with the projection of the total steady-state velocity vector (V_T) on the aircraft's plane of symmetry. It's orientation remains fixed with respect to the aircraft.

2. SYMBOLS

a	Speed of sound in air	ft/sec
a_y	Lateral acceleration along the y-body axis at the center of gravity (positive out right wing)	ft/sec ²
a'_y	Lateral acceleration parallel to the y-body axis at a distance ℓ_x and ℓ_z from the c.g., $a'_y = a_y + \ell_x \dot{r} - \ell_z \dot{p}$	ft/sec ²
a'_z	Normal acceleration parallel to the z-body axis at a distance ℓ_x from the c.g., $a'_z = a_z - \ell_x \dot{q}$	ft/sec ²
a_B	Normal acceleration parallel to the z-body axis at a distance ℓ_B from the c.g.	
b	Reference wing span	ft
B	Bobweight gain	lb/g
B.L.	Buttock line	
\bar{c}	Reference chord	ft
C	Longitudinal feel system damping	lb/in./sec
c.g.	Center of gravity	
D	Aerodynamic force (drag) along the total velocity vector (positive aft)	lb
FRL	Fuselage reference line (parallel to x-body axis)	
F.S.	Fuselage station	
	Longitudinal control column force (+ aft)	lb
F_{ST}	Longitudinal stick force (+ aft)	lb
F_{ST}^{LAT}	Lateral stick force (+ right)	lb
F_{ped}	Rudder pedal force (+ right)	lb
g	Acceleration due to gravity	ft/sec ²
G	Pilot control to surface gearing	deg/in. or deg/deg

<i>h</i>	Altitude	ft
<i>I</i>	Longitudinal feel system inertia	lb/in./sec ²
<i>I_x, I_y, I_z</i>	Moments of inertia referred to body axis (unless otherwise specified)	slug-ft ²
<i>I_{xz}</i>	Product of inertia referred to body axis (unless otherwise specified)	slug-ft ²
<i>jω</i>	The imaginary portion of the complex variable $s = \sigma \pm j\omega$	rad/sec
<i>l_B</i>	Effective distance of bobweight from c.g. (positive forward)	ft
<i>l_x</i>	Distance along the x-body axis from the c.g. (positive forward)	ft
<i>l_{th}</i>	Perpendicular distance from c.g. to thrust line (positive for nose-up pitching moment due to thrust)	ft
<i>l_z</i>	Distance along the z-body axis from the c.g. (positive down)	ft
<i>K</i>	Longitudinal feel system spring constant	lb/in.
KTAS	Knots true airspeed	
KCAS	Knots calibrated airspeed	
<i>K'</i>	Feel system spring constant per unit dynamic pressure	(lb/in.)/psf
<i>L</i>	Rolling moment about the x-axis due to aerodynamic torques (positive right wing down)	ft-lb
<i>L</i>	Aerodynamic force (lift) perpendicular to the total velocity vector in the aircraft's plane of symmetry (positive up)	lb
<i>m</i>	Mass	slugs
<i>M</i>	Mach number	
<i>M</i>	Pitching moment about the y-axis due to aerodynamic torques (positive nose up)	ft-lb
MAC	Mean aerodynamic chord	ft
MGC	Mean geometric chord	ft

N	Aerodynamic normal force along the z-body axis, <u>but</u> positive up	lb
N	Yawing moment about z-axis due to aerodynamic torques (positive nose right)	ft-lb
p	Roll rate, angular velocity about x-axis (positive right wing down)	rad/sec
q	Pitch rate, angular velocity about y-axis (positive nose up)	rad/sec
\bar{q}	Dynamic pressure, $1/2 \rho V_{T_0}^2$	lb/ft ²
r	Yaw rate, angular velocity about z-axis (positive nose right)	rad/sec
r_{RG}	Yaw rate gyro signal	rad/sec
s	Laplace operator, $\sigma + j\omega$	rad/sec
S	Reference wing area	ft ²
TED	Trailing edge down	
TEU	Trailing edge up	
TL	Thrust line	
u	Linear perturbed velocity along the x-axis (positive forward)	ft/sec
U_0	Linear steady-state velocity along the x-axis (positive forward)	ft/sec
v	Linear perturbed velocity along the y-axis (positive out right wing)	ft/sec
V_s	Stall speed	
V_{T_0}	Total linear steady-state velocity (positive forward)	kt
w	Linear perturbed velocity along the x-axis (positive down)	
W.L.	Water line	in.
W	Weight	lb
W_0	Linear steady-state velocity along the z-axis (positive down)	ft/sec

X	Aerodynamic force along the x-axis (positive forward)	
Y	Aerodynamic force along y-axis (positive out right wing)	lb
Z	Aerodynamic force along z-axis (positive down)	lb
α	Perturbed angle of attack	rad
α_0	Steady-state (trim) angle of attack relative to the FRL	deg
β	Sideslip angle	rad
γ_0	Steady-state flight path angle	deg
δ_a	Aileron control surface deflection (includes spoiler effects, etc.) (positive for positive rolling moment)	rad
δ_e	Elevator surface deflection from trim (positive for nose-down pitching moment for aft surface)	rad
δ_{eo}	Trim elevator deflection	deg
δ_{cc}	Longitudinal control column deflection from trim (positive aft)	deg
δ_{ST}	Longitudinal stick deflection from trim (positive aft)	in.
δ_{ST}^{LAT}	Lateral stick deflection from trim (positive right)	in.
δ_{ped}	Rudder pedal deflection from trim (positive right pedal forward)	in.
δ_w	Lateral wheel deflection from trim (positive about x-axis)	deg
δ_s	Stabilizer surface deflection from trim (positive for TED)	rad
δ_{sp}	Spoiler surface deflection (positive up)	rad
δ_v	Vertical tail deflection from trim (positive for nose-left yawing moment)	rad
δ_r	Rudder deflection [positive for nose-left yawing moment (negative N)]	rad

Δ	Denominator of airframe transfer function	
ϵ	Angle between principle inertia axis and FRL (positive about y-axis)	deg
ζ_i	Damping ratio of linear second-order mode particularized by the subscript	
θ	Pitch angle, $\int q dt$ for straight and level flight, positive nose up	rad
i_{TH}	Inclination of thrust line with FRL [posi- tive gives negative (-) z force]	deg
ρ	Mass density of air	slugs/ft ³
σ	The real portion of the complex variable $s = \sigma + j\omega$	rad/sec
ϕ	Roll angle, $(\cos \theta_0 \int p dt - \sin \theta_0 \int r dt)$ in straight and level flight (positive right wing down)	rad
ω_i	Undamped natural frequency of a second-order mode, particularized by subscript	rad/sec

Special Subscript

a	Aileron
cc	Control column
d	Dutch roll
e	Elevator
G	Gyro
INS	Inertial navigation system
p	Phugoid
r	Rudder
R	Roll subsidence
s	Spiral
SAS	Stability augmentation system
sp	Short period
ST	Stick

Special Superscript

DIR	Directional control system (e.g., rudder pedal)
LAT	Lateral control system

Symbols Unique to Specific Aircraft

ARI	Aileron-rudder interconnect (F-4)	
BLC	Boundary layer control (F-10 ⁴ , F-4)	
K _{FLEX} ^{DIR}	Rudder flexure coefficient (F-4)	
P _{BF}	Bellows force parameter (F-4)	ft ²
q _B	Bellows pressure (F-4)	lb/ft ²
δ _d	Yaw damper surface deflection (F-10 ⁴) (positive for nose-left yawing moment)	rad
δ _{t_a}	Aileron tab deflection (CV-880M)	rad
δ _{t_{ac}}	Commanded aileron tab deflection (CV-880M)	rad
δ _{t_e}	Elevator tab deflection (CV-880M)	rad
(δ _{t_e} - δ _e) _c	Commanded elevator-elevator servo tab combination (input linkage) (CV-880M)	rad
δ _{t_r}	Rudder tab deflection (CV-880M)	rad
(δ _{t_r} - δ _r) _c	Commanded rudder-rudder servo tab combination (input linkage)(CV-880M)	rad

3. COMPUTER PRINTOUT MNEMONICS

a. DIMENSIONAL, MASS, AND FLIGHT CONDITION PARAMETERS

<u>COMPUTER PRINT OUT</u>	<u>STANDARD NOTATION, DEFINITION</u>
S	S , wing reference area
B	b , wing span
C	\bar{c} , mean geometric chord
F/C#	Flight Condition number
H(FT)	h , altitude, feet
SL	Sea Level
M(-)	M, Mach number
VTO(FPS)	V_{TO} , true airspeed, knots
VTO(KTAS)	V_{T_0} , true airspeed knots
VTO(KTCS)	V_{T_0} , calibrated airspeed, knots
W(LBS)	W , weight, pounds
C.G.(MGC)	c.g., center of gravity relative to mean geometric chord
IX	I_x
IY	I_y
IZ	I_z
IXZ	I_{xz}
	Body axis (FRL) moments of inertia, slugs-ft ²
EPSILON(DEG)	ϵ , inclination of principle axis with respect to FRL, degrees
Q(PSF)	q , dynamic pressure, psf
QC(PSF)	q_c , impact pressure, psf
ALPHA(DEG)	α_o , FRL angle of attack, degrees
GAMMA(DEG)	γ_o , flight path angle, degrees
LXP(FT)	ℓ_x , x distance to pilot, ft
LZP(FT)	ℓ_z , z distance to pilot, ft
ITH(DEG)	i_{th} , thrust incidence with respect to FRL, degrees
XI(DEG)	ξ_o , $i_{th} + \alpha_o$, degrees
LTH(FT)	ℓ_{th} , perpendicular distance to thrust line from c.g., ft

b. LONGITUDINAL PARAMETERS

<u>COMPUTER PRINT OUT</u>	<u>STANDARD NOTATION, DEFINITION</u>	
XU*	X_u^*	1/sec
ZU*	Z_u^*	1/sec
MU*	M_u^*	1/sec-ft
XW	X_w	1/sec
ZW	Z_w	1/sec
MW	M_w	1/sec-ft
ZWD	Z_w^*	1/sec ²
ZQ	Z_q	1/sec
MWD	M_w^*	1/sec-ft
MQ	M_q	1/sec
^t XDDD	X_δ	ft/sec ² -rad
ZDDD	Z_δ	ft/sec ² -rad
MDDD	M_δ	1/sec ²
DTH	δ_{th}	Thrust
FST	Fst	Stick force
U	u	fps
W	w	fps
THE	θ	rad
HD	\dot{h}	fps
AZP	a_z'	ft/sec ² at $X = l_x$

^tDDD signifies a control surface, e.g., for elevator DDD = DE; for aileron DDD = DA

c. LATERAL-DIRECTIONAL PARAMETERS

<u>COMPUTER PRINT OUT</u>	<u>STANDARD NOTATION, DEFINITION</u>	
YV	Y_v	1/sec
YB	Y_β	ft/sec ²
LB'	L'_β	1/sec ²
NB'	N'_β	1/sec ²
LP'	L'_p	1/sec
NP'	N'_p	1/sec
LR'	L'_r	1/sec
NR'	N'_r	1/sec
[†] Y*DDD	Y_δ^*	1/sec
L'DDD	L'_δ	1/sec ²
N'DDD	N'_δ	1/sec ²
B	β	rad
P	p	rad/sec
R	r	rad/sec
PHI	ϕ	rad
AYP	a'_y	ft/sec ² at ℓ_x, ℓ_z

[†]DDD signifies a control surface, e.g., for elevator DDD = DE; for aileron DDD = DA.

d. TRANSFER FUNCTION PARAMETERS

The following shorthand notation is used to print the factored polynomials for all transfer functions*:

$$(s + 1/T_x)_i = 1/T_{x_i}, \quad i = 1 \text{ to } k$$

$$(s^2 + 2\zeta\omega_n s + \omega_n^2)_j = \zeta_j; \omega_{n_j}, \quad j = 1 \text{ to } \ell$$

where $k + 2\ell = n$, the order of the polynomial

COMPUTER PRINT OUT

	<u>STANDARD NOTATION, DEFINITION</u>
DET	Roots of the denominator
N(X/Y)	Numerator N_y^x
A(X)	Gain of the transfer function x/y
$\dagger 1/T(X)I$	$1/T_{x_i}$, rad/sec
$\dagger Z(X)J$	ζ_j
$\dagger W(X)J$	ω_{n_j} , rad/sec

For example:

DENOMINATOR	
$1/T(\text{DET})_1$.0318
$1/T(\text{DET})_2$	2.20
$Z(\text{DET})_1$.0609
$W(\text{DET})_1$	1.13

NUMERATORS	
$N(B / DR)$	
$A(B)$.0295
$1/T(B)_1$	-.0494
$1/T(B)_2$	2.05
$1/T(B)_3$	42.3

Translates to: $\frac{\beta}{\delta_r} = \frac{.0295(s - .0494)(s + 2.05)(s + 42.3)}{(s + .0318)(s + 2.20)(s^2 + 2 \times .0609 \times 1.13s + 1.13^2s^2)}$

*The transfer function x/y is written as:

$$x/y = \frac{N_y^x}{\Delta} = \frac{A_x(s^m + s^{m-1} + \dots + s^0)}{(s^n + s^{n-1} + \dots + s^0)}$$

†Any roots enclosed in parentheses imply the opposite order of what is specified, e.g., $Z(\text{DET})_1 = (0.00132) \Rightarrow 1/T(\text{DET})_1 = 0.00132$

e. LONGITUDINAL HANDLING QUALITY PARAMETERS

<u>COMPUTER PRINT OUT</u>	<u>STANDARD NOTATION, DEFINITION</u>	<u>EQUATION</u>
D(G)/D(U) (DEG/KT)	$\partial\gamma/\partial u$, degrees/knot	$(1.689)(57.3) \frac{\left[N_0^0(s) + \frac{W_0}{V_{T_0}^2} N_0^U(s) - \frac{U_0}{V_{T_0}^2} N_0^W(s) \right]}{\frac{U_0}{V_{T_0}} N_0^U(s) + \frac{W_0}{V_{T_0}} N_0^W(s)}, \text{ for } s = 0$
NZA (G/RAD)	N_{za} , g/rad	$\frac{-U_0}{g} \frac{\hat{N}_0^{az}(s)}{\hat{N}_0^W(s)}, \text{ for } s = 0$
DE/G (DEG/G)	δ_e/g , degrees/g	$57.3 \left(\frac{1}{g} \frac{\hat{N}_0^{az}(s)}{\hat{\Delta}(s)} \right)^{-1}, \text{ for } s = 0$
CAP (RAD/SEC/SEC/G)	Control anticipation parameter, rad/sec ² /g	$- \left(\frac{s^2 \hat{N}_0^0(s)}{\hat{\Delta}(s)} \Big _{s=\infty} \right) \left/ \left(\frac{1}{g} \frac{\hat{N}_0^{az}}{\hat{\Delta}} \Big _{s=0} \right) \right.$
PHUGOID(z) (TUCK(2))	The phugoid time to double amplitude, seconds	$\frac{\ln 2}{ \zeta_{ph} \omega_{n_{ph}} }, \text{ for } \zeta_{ph} < 0$
1/C(1/10)	Short period inverse cycles to 1/10 amplitude	$\frac{2\pi}{\ln 10} \sqrt{\frac{\zeta_{sp}^2}{1 - \zeta_{sp}}} \text{ for } 0 \leq \zeta_{sp} < 1$
FST/KT (LB/KT)	Stick force per knot, pounds/knot	$1.689 \left[\frac{u}{F_{st}}(s) \right]^{-1} \text{ for } s = 0$
FST/G (LB/G)	Stick force per g, pounds per g	$\left[\frac{1}{g} \frac{\hat{N}_{Fst}^{az}}{\hat{\Delta}} \right]^{-1} \text{ for } s = 0$
--	The parameter has no meaning or is not defined at this flight condition	

*The hat (\hat{N}) notation implies constant speed ($u = \theta_0 = 0$).

f. LATERAL-DIRECTIONAL HANDLING QUALITY PARAMETERS

<u>COMPUTER PRINT OUT</u>	<u>STANDARD NOTATION, DEFINITION</u>	<u>EQUATION</u>
DR PERIOD (SEC)	Dutch roll period, seconds	$2\pi/\omega_{nd} \sqrt{1 - \zeta_d^2}$
$1/C(1/2)$	Dutch roll inverse cycles to $1/2$ amplitude	$\frac{2\pi}{\ln 2} \sqrt{\frac{\zeta_d^2}{1 - \zeta_d^2}}$, for $\zeta_d \geq 0$
SPIRAL (2) (SEC)	Spiral time to double amplitude, seconds	$T_s \ln 2$, for $1/T_s \leq 0$
P(I)	Roll rate at peak I for a unit step input of δ_a	$\frac{p_1 + p_3 - 2p_2}{p_1 + p_3 + 2p_2}$, for $\zeta_d \leq 0.2$
P(OSC)/P(AV)	A measure of the oscillatory to the average roll rate	$\frac{p_1 - p_2}{p_1 + p_2}$, for $\zeta_d > 0.2$
W(PHI)/W(D)	Ratio of the roll frequency to the dutch roll frequency	$\omega_{n\phi}/\omega_{nd}$
DEL-B-MAX	$\Delta\beta_m$: Maximum sideslip excursion at the c.g., occurring within two seconds or one half-period of the dutch roll, whichever is greater for a step aileron-control command	
PHI to BETA, PHASE	ψ/β at $s = (\zeta; \omega_n)_d$, degrees	
PHI TO BETA	$ \psi/\beta $ at $s = (\zeta; \omega_n)_d$, rad/rad	
PHI TO VE	* $ \psi/v_e $ at $s = (\zeta; \omega_n)_d$, deg/fps	

$$*v_e = (\beta)(v_{EAS}), v_{EAS} = \sqrt{\frac{2q}{\rho_0}}$$

4. NONDIMENSIONAL DERIVATIVE DEFINITIONS

a) Longitudinal Body Axis

$$C_N = \frac{N}{\bar{q} S}, \text{ positive up}$$

$$C_X = -\frac{X}{\bar{q} S}, \text{ positive aft}$$

$$C_{N\alpha} = \partial C_N / \partial \alpha$$

$$C_M = \frac{M}{\bar{q} S c}$$

$$C_{N\dot{\alpha}} = \frac{2V_{T_0}}{c} \partial C_N / \partial \dot{\alpha}$$

$$C_{M\alpha} = \partial C_M / \partial \alpha$$

$$C_{NM} = \partial C_N / \partial M$$

$$C_{M\dot{\alpha}} = \frac{2V_{T_0}}{c} \partial C_M / \partial \dot{\alpha}$$

$$C_{N\delta} = \partial C_N / \partial \delta$$

$$C_{MM} = \partial C_M / M$$

$$C_{X\alpha} = \partial C_X / \partial \alpha$$

$$C_{Mq} = \frac{2V_{T_0}}{c} \partial C_M / \partial q$$

$$C_{XM} = \partial C_X / \partial M$$

$$C_{X\delta} = \partial C_X / \partial \delta$$

b) Longitudinal Stability Axis

$$C_L = \frac{L}{\bar{q} S}, \text{ positive up}$$

$$C_D = \frac{D}{\bar{q} S}, \text{ positive aft}$$

$$C_{L\alpha} = \partial C_L / \partial \alpha$$

$$C_{L\dot{\alpha}} = \frac{2V_{T_0}}{c} \partial C_L / \partial \dot{\alpha} \quad \text{Pitching moment}$$

$$C_{LM} = \partial C_L / \partial M$$

derivatives are

$$C_{L\delta} = \partial C_L / \partial \delta$$

identical to

$$C_{D\alpha} = \partial C_D / \partial \alpha$$

those for body axis

$$C_{DM} = \partial C_D / \partial M$$

$$C_{D\delta} = \partial C_D / \partial \delta$$

c) Lateral Body and Stability Axis

Though physically and numerically different,* see Appendix B, the same symbols are used for body axis and stability axis lateral rolling and yawing moment derivatives. The sideforce derivatives (C_y , etc.) are physically and numerically the same in both axis systems. When the rolling or yawing moment derivatives are given in this report the axis system is specified. When using the following all quantities should be for the same axis system.

$$C_y = \frac{Y}{qS}$$

$$C_l = \frac{L}{qSb}$$

$$C_n = \frac{N}{qSb}$$

$$C_{y\beta} = \partial C_y / \partial \beta$$

$$C_{l\beta} = \partial C_l / \partial \beta$$

$$C_{n\beta} = \partial C_n / \partial \beta$$

$$C_{y\delta} = \partial C_y / \partial \delta$$

$$C_{l_p} = \frac{2V T_o}{b} \partial C_l / \partial p$$

$$C_{n_p} = \frac{2V T_o}{b} \partial C_N / \partial p$$

$$C_{l_r} = \frac{2V T_o}{b} \partial C_l / \partial r$$

$$C_{n_r} = \frac{2V T_o}{b} \partial C_N / \partial r$$

$$C_{l\delta} = \partial C_l / \partial \delta$$

$$C_{n\delta} = \partial C_n / \partial \delta$$

*The exception is the zero trim angle of attack condition.

5. DIMENSIONAL STABILITY DERIVATIVE DEFINITIONS

The same symbols are used for body- and stability-axis dimensional derivatives. Care should be exercised so that a consistent set of quantities are used.

a) Longitudinal Body Axis

$$X_u^* = X_u + T_u \cos \xi_o \quad 1/\text{sec}$$

$$X_u = \frac{\rho S U_o}{m} \left(-\frac{M}{2} C_{X_M} - C_X + \frac{W_o}{2U_o} C_{X_\alpha} \right) \quad 1/\text{sec}$$

$$X_w = \frac{\rho S U_o}{2m} \left[-C_{X_\alpha} - 2 \frac{W_o}{U_o} \left(C_X + \frac{M}{2} C_{X_M} \right) \right] \quad 1/\text{sec}$$

$$X_{\delta_e} = -\frac{\rho S V_{T_o}^2}{2m} C_{X_{\delta_e}} \quad \frac{\text{ft}}{\text{sec}^2 \text{rad}}$$

$$Z_u^* = Z_u - T_u \sin \xi_o \quad 1/\text{sec}$$

$$Z_u = \frac{\rho S U_o}{m} \left(-\frac{M}{2} C_{N_M} - C_N + \frac{W_o}{2U_o} C_{N_\alpha} \right) \quad 1/\text{sec}$$

$$Z_w = \frac{\rho S U_o}{2m} \left[-C_{N_\alpha} - 2 \frac{W_o}{U_o} \left(C_N + \frac{M}{2} C_{N_M} \right) \right] \quad 1/\text{sec}$$

$$Z_{\dot{w}} = -\frac{\rho S c}{4m} \frac{U_o}{V_{T_o}} C_{N_{\dot{\alpha}}} \quad \frac{\text{ft}}{\text{sec}^2}$$

$$Z_{\delta_e} = -\frac{\rho S V_{T_o}^2}{2m} C_{N_{\delta_e}} \quad \frac{\text{ft}}{\text{sec}^2 \text{rad}}$$

$$M_u^* = M_u + \frac{\ell_{th}}{I_y} T_u \quad \frac{1}{\text{sec-ft}}$$

$$\begin{aligned}
M_u &= \frac{\rho S c U_o}{I_y} \left[\frac{M}{2} C_{mM} + C_m - \frac{W_o}{2U_o} C_{m\alpha} \right] & \frac{1}{\text{sec-ft}} \\
M_w &= \frac{\rho S c U_o}{2I_y} \left[C_{m\alpha} + \frac{2W_o}{U_o} (C_m + \frac{M}{2} C_{mM}) \right] & \frac{1}{\text{sec-ft}} \\
M_{\dot{w}} &= \frac{\rho S c^2}{4I_y} \frac{U_o}{V_{T_o}} C_{m\alpha} & \frac{1}{\text{sec-ft}} \\
M_\alpha &= U_o M_w & 1/\text{sec}^2 \\
M_{\dot{\alpha}} &= U_o M_{\dot{w}} & 1/\text{sec} \\
M_q &= \frac{\rho S c^2 V_{T_o}}{4I_y} C_{mq} & 1/\text{sec} \\
M_{\delta_e} &= \frac{\rho S c V_{T_o}^2}{2I_y} C_{m\delta_e} & 1/\text{sec}^2 \\
T_u &= \frac{1}{am} \partial T / \partial M & 1/\text{sec}
\end{aligned}$$

b) Lateral Body Axis

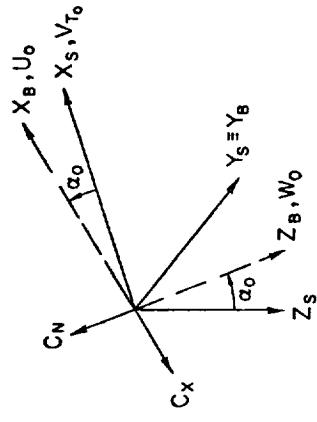
$$\begin{aligned}
Y_v &= (\rho S V_{T_o} / 2m) C_{y\beta} & 1/\text{sec} \\
Y_\beta &= V_{T_o} Y_v & \text{ft/sec}^2 \\
Y_{\delta_a} &= (\rho S V_{T_o}^2 / 2m) C_{y\delta_a} & \text{ft/sec}^2 \\
Y_{\delta_r} &= (\rho S V_{T_o}^2 / 2m) C_{y\delta_r} & \text{ft/sec}^2 \\
Y_{\delta_r^*} &= (\rho S V_{T_o} / 2m) C_{y\delta_r} & 1/\text{sec} \\
L_\beta &= (\rho S V_{T_o}^2 b / 2I_x) C_{l\beta} & 1/\text{sec}^2 \\
L_p &= (\rho S V_{T_o} b^2 / 4I_x) C_{l_p} & 1/\text{sec} \\
L_r &= (\rho S V_{T_o} b^2 / 4I_x) C_{l_r} & 1/\text{sec}
\end{aligned}$$

L_{δ_a}	$= (\rho S V_{T_0}^2 b / 2 I_x) C_{L_{\delta_a}}$	$1/\text{sec}^2$
L_{δ_r}	$= (\rho S V_{T_0}^2 b / 2 I_x) C_{L_{\delta_r}}$	$1/\text{sec}^2$
$y_{\delta_a^*}$	$= (\rho S V_{T_0}^2 / 2m) C_{y_{\delta_a}}$	$1/\text{sec}$
N_β	$= (\rho S V_{T_0}^2 b / 2 I_z) C_{N_\beta}$	$1/\text{sec}^2$
N_p	$= (\rho S V_{T_0}^2 b^2 / 4 I_z) C_{N_p}$	$1/\text{sec}$
N_r	$= (\rho S V_{T_0}^2 b^2 / 4 I_z) C_{N_r}$	$1/\text{sec}$
N_{δ_a}	$= (\rho S V_{T_0}^2 b / 2 I_z) C_{N_{\delta_a}}$	$1/\text{sec}^2$
N_{δ_r}	$= (\rho S V_{T_0}^2 b / 2 I_z) C_{N_{\delta_r}}$	$1/\text{sec}^2$
L'_β	$= (L_\beta + I_{xz} N_\beta / I_x) G$	$1/\text{sec}^2$
L'_p	$= (L_p + I_{xz} N_p / I_x) G$	$1/\text{sec}$
L'_r	$= (L_r + I_{xz} N_r / I_x) G$	$1/\text{sec}$
$L_{\delta_r'}$	$= (L_{\delta_r} + I_{xz} N_{\delta_r} / I_x) G$	$1/\text{sec}^2$
$L_{\delta_a'}$	$= (L_{\delta_a} + I_{xz} N_{\delta_a} / I_x) G$	$1/\text{sec}^2$
N'_β	$= (N_\beta + I_{xz} L_\beta / I_z) G$	$1/\text{sec}^2$
N'_p	$= (N_p + I_{xz} L_p / I_z) G$	$1/\text{sec}$
N'_r	$= (N_r + I_{xz} L_r / I_z) G$	$1/\text{sec}$
$N_{\delta_r'}$	$= (N_{\delta_r} + I_{xz} L_{\delta_r} / I_z) G$	$1/\text{sec}^2$
$N_{\delta_a'}$	$= (N_{\delta_a} + I_{xz} L_{\delta_a} / I_z) G$	$1/\text{sec}^2$
G	$= \frac{1}{1 - \frac{I_{xz}^2}{I_x I_z}}$	

APPENDIX B

TRANSFORMATION OF STABILITY AXIS DERIVATIVES TO BODY AXIS

a. NON-DIMENSIONAL STABILITY AXIS TO BODY AXIS



LONGITUDINAL

Body Axis

$$\begin{aligned}
 C_N &= C_L \cos \alpha_0 + C_D \sin \alpha_0 \\
 C_X &= C_D \cos \alpha_0 - C_L \sin \alpha_0 \\
 C_{X_\alpha} &= C_{L\alpha} \cos \alpha_0 - C_L \sin \alpha_0 + C_D \sin \alpha_0 + C_D \cos \alpha_0 \\
 C_{N_\alpha} &= C_{L\alpha} \cos \alpha_0 \\
 C_{N_q} &= C_{Lq} \cos \alpha_0 \\
 C_{N_M} &= C_{LM} \cos \alpha_0 + C_{DM} \sin \alpha_0 \\
 C_{X_6} &= C_{L6} \cos \alpha_0 + C_{D6} \sin \alpha_0 \\
 C_{X_\alpha} &= C_{D\alpha} \cos \alpha_0 - C_D \sin \alpha_0 - C_{L\alpha} \sin \alpha_0 - C_L \cos \alpha_0 \\
 C_{X_d} &= -C_{Ld} \sin \alpha_0 \\
 C_{X_q} &= -C_{Lq} \sin \alpha_0 \\
 C_{X_M} &= C_{DM} \cos \alpha_0 - C_{LM} \sin \alpha_0 \\
 C_{X_6} &= C_{D6} \cos \alpha_0 - C_{L6} \sin \alpha_0
 \end{aligned}$$

$C_m, C_{m\alpha}, C_{mq}, C_{mM}, C_{m6}$ - UNCHANGED

LATERAL

Body Axis

$$\begin{aligned}
 (C_{L\beta})_B &= C_{L\beta} \cos \alpha_0 - C_{n\beta} \sin \alpha_0 \\
 (C_{Lp})_B &= C_{Lp} \cos^2 \alpha_0 - (C_{Lr} + C_{np}) \sin \alpha_0 \cos \alpha_0 + C_{nr} \sin^2 \alpha_0 \\
 (C_{Lr})_B &= C_{Lr} \cos^2 \alpha_0 - (C_{nr} - C_{lp}) \sin \alpha_0 \cos \alpha_0 - C_{np} \sin^2 \alpha_0 \\
 (C_{Ls})_B &= C_{Ls} \cos \alpha_0 - C_{ns} \sin \alpha_0 \\
 (C_{np})_B &= C_{np} \cos \alpha_0 + C_{l\beta} \sin \alpha_0 \\
 (C_{np})_B &= C_{np} \cos^2 \alpha_0 - (C_{nr} - C_{lp}) \sin \alpha_0 \cos \alpha_0 - C_{lr} \sin^2 \alpha_0 \\
 (C_{nr})_B &= C_{nr} \cos^2 \alpha_0 + (C_{lr} + C_{np}) \sin \alpha_0 \cos \alpha_0 + C_{lp} \sin^2 \alpha_0 \\
 (C_{ns})_B &= C_{ns} \cos \alpha_0 + C_{ls} \sin \alpha_0 \\
 C_{y\beta}, C_{y\beta_r}, C_{y\beta_a} &- UNCHANGED
 \end{aligned}$$

b. TRANSFORMATION OF DIMENSIONAL DERIVATIVES
FROM STABILITY AXIS TO BODY AXIS

Longitudinal

$$(X_u)_b = X_u \cos^2 \alpha_o - (X_w + Z_u) \sin \alpha_o \cos \alpha_o + Z_w \sin^2 \alpha$$

$$(X_{\dot{u}})_b = Z_w \sin^2 \alpha_o$$

$$(X_w)_b = X_w \cos^2 \alpha_o + (X_u - Z_w) \sin \alpha_o \cos \alpha_o - Z_u \sin^2 \alpha_o$$

$$(X_{\dot{w}})_b = X_w \cos^2 \alpha_o - Z_w \sin \alpha_o \cos \alpha_o$$

$$(X_{q;\delta})_b = X_{q;\delta} \cos \alpha_o - Z_{q;\delta} \sin \alpha_o$$

$$(Z_u)_b = Z_u \cos^2 \alpha_o - (Z_w - X_u) \sin \alpha_o \cos \alpha_o - X_w \sin^2 \alpha_o$$

$$(Z_{\dot{u}})_b = -Z_w \sin \alpha_o \cos \alpha_o$$

$$(Z_w)_b = Z_w \cos^2 \alpha_o + (Z_u + X_w) \sin \alpha_o \cos \alpha_o + X_u \sin^2 \alpha_o$$

$$(Z_{\dot{w}})_b = Z_w \cos^2 \alpha_o + X_w \sin \alpha_o \cos \alpha_o$$

$$(Z_{q;\delta})_b = Z_{q;\delta} \cos \alpha_o + X_{q;\delta} \sin \alpha_o$$

$$(M_u)_b = M_w \cos \alpha_o - M_u \sin \alpha_o$$

$$(M_{\dot{u}})_b = -M_w \sin \alpha_o$$

$$(M_w)_b = M_w \cos \alpha_o + M_u \sin \alpha_o$$

$$(M_{\dot{w}})_b = M_w \cos \alpha_o$$

$$(M_{q;\delta})_b = M_{q;\delta}$$

$$(I_y)_b = I_y$$

Lateral-Directional

$$(Y_v; \delta)_b = Y_v; \delta$$

$$(Y_{\dot{v}})_b = Y_{\dot{v}}$$

$$(Y_p)_b = Y_p \cos \alpha_o - Y_r \sin \alpha_o$$

$$(Y_r)_b = Y_r \cos \alpha_o + Y_p \sin \alpha_o$$

$$(L'_v; \delta)_b = L'_v; \delta \cos \alpha_o - N'_v; \delta \sin \alpha_o$$

$$(L'_{\dot{v}})_b = L'_{\dot{v}} \cos \alpha_o - N'_{\dot{v}} \sin \alpha_o$$

$$(L'_p)_b = L'_p \cos^2 \alpha_o - (L'_r + N'_p) \sin \alpha_o \cos \alpha_o + N'_r \sin^2 \alpha_o$$

$$(L'_r)_b = L'_r \cos^2 \alpha_o - (N'_r - L'_p) \sin \alpha_o \cos \alpha_o - N'_p \sin^2 \alpha_o$$

$$(N'_v; \delta)_b = N'_v; \delta \cos \alpha_o + L'_v; \delta \sin \alpha_o$$

$$(N'_{\dot{v}})_b = N'_{\dot{v}} \cos \alpha_o + L'_{\dot{v}} \sin \alpha_o$$

$$(N'_p)_b = N'_p \cos^2 \alpha_o - (N'_r - L'_p) \sin \alpha_o \cos \alpha_o - L'_r \sin^2 \alpha_o$$

$$(N'_r)_b = N'_r \cos^2 \alpha_o + (L'_r + N'_p) \sin \alpha_o \cos \alpha_o + L'_p \sin^2 \alpha_o$$

$$(I_x)_b = I_x \cos^2 \alpha_o + 2I_{xz} \sin \alpha_o \cos \alpha_o + I_z \sin^2 \alpha_o$$

$$(I_z)_b = I_z \cos^2 \alpha_o - 2I_{xz} \sin \alpha_o \cos \alpha_o + I_x \sin^2 \alpha_o$$

$$(I_{xz})_b = (I_z - I_x) \sin \alpha_o \cos \alpha_o + I_{xz}(\cos^2 \alpha_o - \sin^2 \alpha_o)$$

APPENDIX C
**EQUATIONS OF MOTION, TRANSFER FUNCTIONS,
AND COUPLING NUMERATORS**

1. Longitudinal

a. Equations

$$\begin{bmatrix} (1 - X_{\dot{u}})s - X_u^* & -X_{\dot{w}}s - X_w & (-X_q + W_o)s + g \cos \theta_o \\ -Z_{\dot{u}}s - Z_w^* & (1 - Z_w^*)s - Z_w & (-Z_q - U_o)s + g \sin \theta_o \\ -M_{\dot{u}}s - M_u^* & -(M_{\dot{w}}s + M_w) & s^2 - M_q s \end{bmatrix} \begin{bmatrix} u \\ w \\ \theta \end{bmatrix} = \begin{bmatrix} X_{\delta_e} \\ Z_{\delta_e} \\ M_{\delta_e} \end{bmatrix}$$

$$q' = .s\theta$$

$$\dot{h} = -w \cos \theta_o + u \sin \theta_o + (U_o \cos \theta_o + W_o \sin \theta_o)\theta$$

$$a_z = sw - U_o q + (g \sin \theta_o)\theta$$

$$a_z' = a_z - l_x s^2 \theta$$

$$\dot{h}' = \dot{h} + l_x \cos \theta_o \dot{\theta}$$

b. Transfer Functions

$$\frac{\theta}{\delta_e} = \frac{N \delta_e^\theta}{\Delta}$$

1) Denominator, $\Delta = As^4 + Bs^3 + Cs^2 + Ds + E$

$$A = (1 - Z_w^*)$$

$$B = -(M_q + X_u^*)(1 - Z_w^*) - Z_w - M_{\dot{u}}$$

$$C = M_q Z_w - M_{\dot{u}} + X_u^*[(M_q)(1 - Z_w^*) + Z_w + M_{\dot{u}}]$$

$$-X_w Z_u^* + W_o [M_w Z_u^* + M_u^*(1 - Z_w^*)] + g M_w \sin \theta_o$$

NOTE: Terms including $X_{\dot{u}}$, $Z_{\dot{u}}$, $M_{\dot{u}}$, $X_{\dot{w}}$ are neglected in polynomial expressions.

$$D = -X_u^*(M_q Z_w - M_\alpha) - M_u^* X_\alpha + M_q X_w Z_u^* + g [M_w Z_u^* + M_u^* (1 - Z_w)] \cos \theta_o + W_o (M_w Z_u^* - M_u^* Z_w) + g (M_w - M_w X_u^*) \sin \theta_o$$

$$E = g (M_w Z_u^* - M_u^* Z_w) \cos \theta_o + g (M_u^* X_w - M_w X_u^*) \sin \theta_o$$

2) Numerators

$N_\delta^\theta = A_\theta s^2 + B_\theta s + C_\theta$
$A_\theta = Z_\delta M_w + M_\delta (1 - Z_w)$
$B_\theta = X_\delta [M_w Z_u^* + M_u^* (1 - Z_w)] + Z_\delta (M_w - M_w X_u^*) - M_\delta [Z_w + X_u^* (1 - Z_w)]$
$C_\theta = X_\delta (M_w Z_u^* - M_u^* Z_w) + Z_\delta (M_u^* X_w - M_w X_u^*) + M_\delta (Z_w X_u^* - X_w Z_u^*)$

$N_\delta^u = A_u s^3 + B_u s^2 + C_u s + D_u$
$A_u = X_\delta (1 - Z_w)$
$B_u = -X_\delta [M_q (1 - Z_w) + Z_w + M_\alpha] + Z_\delta X_w - W_o [Z_\delta M_w + M_\delta (1 - Z_w)]$
$C_u = X_\delta (M_q Z_w - M_\alpha) - Z_\delta (g M_w \cos \theta_o + M_q X_w) + M_\delta [X_\alpha - (g \cos \theta_o) (1 - Z_w)] + W_o (Z_w M_\delta - M_w Z_\delta) + g X_\delta M_w \sin \theta_o$
$D_u = g (Z_w M_\delta - M_w Z_\delta) \cos \theta_o + g (X_\delta M_w - M_\delta X_w) \sin \theta_o$

$N_\delta^w = A_w s^3 + B_w s^2 + C_w s + D_w$
$A_w = Z_\delta$
$B_w = -Z_\delta (M_q + X_u^*) + U_o M_\delta + X_\delta Z_u^*$
$C_w = X_u^* (Z_\delta M_q - U_o M_\delta) + W_o (Z_\delta M_u^* - M_\delta Z_u^*) - g M_\delta \sin \theta_o + X_\delta (M_u^* U_o - Z_u^* M_q)$
$D_w = g (Z_\delta M_u^* - M_\delta Z_u^*) \cos \theta_o + g M_\delta X_u^* \sin \theta_o - X_\delta M_u^* g \sin \theta_o$

$N_{\delta}^{\dot{h}} = A_h^{\dot{h}} s^3 + B_h^{\dot{h}} s^2 + C_h^{\dot{h}} s + D_h^{\dot{h}}$
$A_h^{\dot{h}} = - \cos \theta_o A_w + \sin \theta_o A_u$
$B_h^{\dot{h}} = - \cos \theta_o B_w + \sin \theta_o B_u + (U_o \cos \theta_o + W_o \sin \theta_o) A_\theta$
$C_h^{\dot{h}} = - \cos \theta_o C_w + \sin \theta_o C_u + (U_o \cos \theta_o + W_o \sin \theta_o) B_\theta$
$D_h^{\dot{h}} = - \cos \theta_o D_w + \sin \theta_o D_u + (U_o \cos \theta_o + W_o \sin \theta_o) C_\theta$

$N_{\delta}^{a_z'} = A_{a_z'} s^4 + B_{a_z'} s^3 + C_{a_z'} s^2 + D_{a_z'} s + E_{a_z'}$
$A_{a_z'} = A_w - l_x A_\theta$
$B_{a_z'} = B_w - l_x B_\theta - U_o A_\theta$
$C_{a_z'} = C_w - l_x C_\theta - U_o B_\theta + g \sin \theta_o A_\theta$
$D_{a_z'} = D_w - U_o C_\theta + g \sin \theta_o B_\theta$
$E_{a_z'} = + g \sin \theta_o C_\theta$

To obtain a_z , let $l_x = 0$.

2. Lateral

a. Equations

$$\begin{bmatrix} s - Y_v & -\frac{W_o s + g \cos \theta_o}{V_{T_o}} & \frac{U_o s - g \sin \theta_o}{V_{T_o} s} \\ -L_p' & s(s - L_p') & -L_r' \\ -N_p' & -N_p' s & s - N_r' \end{bmatrix} \begin{bmatrix} \beta \\ \frac{p}{s} \\ r \end{bmatrix} = \begin{bmatrix} Y_{\delta_a}^* & Y_{\delta_r}^* \\ L_{\delta_a}' & L_{\delta_r}' \\ N_{\delta_a}' & N_{\delta_r}' \end{bmatrix} \begin{bmatrix} \delta_a \\ \delta_r \end{bmatrix}$$

$$v = V_{T_o} \beta \quad a_y = sv + U_o r - W_o p - g(\cos \theta_o) \varphi$$

$$\varphi = \frac{p}{s} + \frac{r}{s} \tan \theta_o \quad a_y' = a_y + l_x l_{lat} sr - l_z sp$$

$$\psi = \frac{1}{\cos \theta_o} \frac{r}{s}$$

b. Transfer Functions

$$\frac{\varphi}{\delta_a} = \frac{N_a^\varphi}{\Delta_{lat}} ; \quad \frac{r}{\delta_r} = \frac{N_r^r}{\Delta_{lat}} ; \quad \text{etc.}$$

1) Denominator, $\Delta_{lat} = as^4 + bs^3 + cs^2 + ds + e$

$$a = 1$$

$$b = -(Y_v + L_p^i + N_r^i)$$

$$c = \frac{U_o}{V_{T_o}} N_\beta^i + L_p^i(Y_v + N_r^i) - N_p^i L_r^i + Y_v N_r^i - \frac{W_o L_\beta^i}{V_{T_o}}$$

$$d = \frac{U_o}{V_{T_o}} (N_p^i L_\beta^i - L_p^i N_\beta^i) + Y_v (N_p^i L_r^i - L_p^i N_r^i) - \frac{g}{V_{T_o}} (L_\beta^i \cos \theta_o + N_\beta^i \sin \theta_o) \\ + \frac{W_o}{V_{T_o}} (L_\beta^i N_r^i - N_\beta^i L_r^i)$$

$$e = \frac{g}{V_{T_o}} [(L_\beta^i N_r^i - N_\beta^i L_r^i) \cos \theta_o - (N_p^i L_\beta^i - L_p^i N_\beta^i) \sin \theta_o]$$

2) δ (δ_a or δ_r) Numerators

$N_\delta^\beta = A_\beta s^3 + B_\beta s^2 + C_\beta s + D_\beta$
$A_\beta = Y_\delta^*$
$B_\beta = -Y_\delta^* [L_p^i + N_r^i] - N_\delta^i \frac{U_o}{V_{T_o}} + \frac{W_o}{V_{T_o}} L_\delta^i$
$C_\beta = Y_\delta^* (L_p^i N_r^i - N_p^i L_r^i) + L_\delta^i \frac{g}{V_{T_o}} \cos \theta_o + (N_\delta^i L_p^i - L_\delta^i N_p^i) \frac{U_o}{V_{T_o}}$
$+ \frac{W_o}{V_{T_o}} (N_\delta^i L_r^i - L_\delta^i N_r^i) + N_\delta^i \frac{g}{V_{T_o}} \sin \theta_o$
$D_\beta = \frac{g}{V_{T_o}} (N_\delta^i L_r^i - L_\delta^i N_r^i) \cos \theta_o + \frac{g}{V_{T_o}} (N_p^i L_\delta^i - N_\delta^i L_p^i) \sin \theta_o$

$$N_{\delta}^p = A_p s^3 + B_p s^2 + C_p s + D_p$$

$$A_p = L_{\delta}'$$

$$B_p = Y_{\delta}^* L_{\beta}' - L_{\delta}' (N_r' + Y_v) + N_{\delta}' L_r'$$

$$C_p = Y_{\delta}^* (L_r' N_{\beta}' - L_{\beta}' N_r') + L_{\delta}' Y_v N_r' - N_{\delta}' Y_v L_r' + (L_{\delta}' N_{\beta}' - N_{\delta}' L_{\beta}') \frac{U_o}{V T_o}$$

$$D_p = - \frac{g}{V T_o} (L_{\delta}' N_{\beta}' - N_{\delta}' L_{\beta}') \sin \theta_o$$

$$N_{\delta}^r = A_r s^3 + B_r s^2 + C_r s + D_r$$

$$A_r = N_{\delta}'$$

$$B_r = Y_{\delta}^* N_{\beta}' + L_{\delta}' N_p' - N_{\delta}' (Y_v + L_p')$$

$$C_r = Y_{\delta}^* (L_{\beta}' N_p' - N_{\beta}' L_p') - L_{\delta}' Y_v N_p' + N_{\delta}' Y_v L_p' + \frac{W_o}{V T_o} (L_{\delta}' N_{\beta}' - N_{\delta}' L_{\beta}')$$

$$D_r = \frac{g}{V T_o} (L_{\delta}' N_{\beta}' - N_{\delta}' L_{\beta}') \cos \theta_o$$

$$N_{\delta}^{\Phi} = A_{\Phi} s^2 + B_{\Phi} s + C$$

$$A_{\Phi} = A_p + A_r \tan \theta_o$$

$$B_{\Phi} = B_p + B_r \tan \theta_o$$

$$C_{\Phi} = C_p + C_r \tan \theta_o$$

$$N_{\delta}^{a_y} = A_{a_y}^1 s^4 + B_{a_y}^1 s^3 + C_{a_y}^1 s^2 + D_{a_y}^1 s + E_{a_y}^1$$

$$A_{a_y}^1 = V_{T_o} A_{\beta} + l_{x_{lat}} A_r - l_z A_p$$

$$B_{a_y}^1 = V_{T_o} B_{\beta} + U_o A_r - W_o A_p + l_{x_{lat}} B_r - l_z B_p$$

$$C_{a_y}^1 = V_{T_o} C_{\beta} + U_o B_r - W_o B_p - g \cos \theta_o A_{\phi} + l_{x_{lat}} C_r - l_z C_p$$

$$D_{a_y}^1 = V_{T_o} D_{\beta} + U_o C_r - W_o C_p - g \cos \theta_o B_{\phi} + l_{x_{lat}} D_r - l_z D_p$$

$$E_{a_y}^1 = U_o D_r - W_o D_p - g \cos \theta_o C_{\phi}$$

To obtain a_y , let $l_{x_{lat}} = l_z = 0$.

