NASA Contract Report 177959

Design Verification and Fabrication of Active Control Systems for the DAST ARW-2 High Aspect Ratio Wing, Part 2 - Appendices

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C. R. McGehee

The BOEING Co.
Wichita, KS 67277

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National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665

TABLE OF CONTENTS

PART 2
APPENDICES

LIST OF FIGURES

FIGURE

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

FIGURE

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

FIGURE

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

FIGURE

LIST OF FIGURES (CONTINUED)

FIGURE

LIST OF FIGURES (CONTINUED)

FIGURE

LIST ON FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

FIGURE

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONCLUDED)

INTRODUCTION

This volume contains the appendices for Boeing document D500-10897-1, "Design Verification and Fabrication of Active Control Systems for the DAST ARW-2 High Aspect Ratio Wing", the final report summarizing the work accomplished under Contract NAS1-16010.

Appendix A contains data defining the aerodynamics and inertias used in the airplane and control systems linear analyses and nonlinear simulation. A study is presented in Appendix B that compares servoactuator bench test results to analysis and investigates various factors that affect actuator performance and stability. Appendix C contains data which summarizes the airplane stability and performance with the final flutter suppression system. The data contained in Appendix D shows stability and performance sensitivity to variation in the dynamics and location of the control system components. Appendix E contains data that shows the relative gain and phase stability margins of each individual ACS and AFCS feedback loop and the compatibility of the combined loops.

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APPENDIX A

DAST ARW-2 AERODYNAMIC, INERTIA AND THRUST DATA

This appendix contains the aerodynamic and inertia data used in airplane and control systems linear analyses and non-linear simulation. It also contains speed brake and thrust data used in the determination of speed brake requirements.

List of data included:

- Longitudinal derivatives

  25 percent MAC C.G.
  8 flight conditions

- Lateral-directional derivatives

  25 percent MAC C.G.
  8 flight conditions

- Non-linear C_L and C_M versus alpha

  8 flight conditions

- Moments of inertia

  3 weight-C.G. combinations, body axis

- Plots of C_D versus alpha with speed brakes

- Plots of thrust versus altitude for constant Mach numbers and percent RPM

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PARAMETER	UNITS	MANEUVER		LAUNCH	GUST		HIGH ALTITUDE	CRUISE	MAXIMUM q
		DESIGN COND. MACH: 0.35 ALT: SEA LEVEL q: 181 PSF G.W.: 2500 LBS	FLIGHT COND. MACH: 0.42 ALT: 10000 FT. q: 182 PSF G.W.: 2500 LBS	MACH: 0.40 ALT: 15000 FT. q: 133.7 PSF G.W.: 2500 LBS	DESIGN COND. MACH: 0.60 ALT: 7000 FT. q: 411 PSF G.W.: 2350 LBS	FLIGHT COND. MACH: 0.70 ALT: 15000 FT. q: 410 PSF G.W.: 2350 LBS.	MACH: 0.70 ALT: 50000 FT. q: 83.5 PSF G.W.: 2350 LBS	MACH: 0.80 ALT: 46800 FT q: 126.4 PSF G.W.: 2350 LBS	MACH: 0.86 ALT: 15000 FT. q: 618.1 PSF G.W.: 2350 LBS.
C_L	---	0.394	0.39	0.534	0.163	0.163	0.804	0.531	0.109
C_{L_α}	1/DEGREE	0.096	0.097	0.094	0.100	0.107	0.102	0.14	0.114
$C_{L_{\hat{\dot\alpha}}}$	1/RADIAN	0.96	1.13	1.22	1.45	1.45	2.2	2.76	4.8
$C_{L_{\hat q}}$	1/RADIAN	5.78	5.82	5.9	5.3	5.3	6.6	6.4	4.8
C_{L_U}	1/FT/SEC	-0.00021	-0.00021	-0.00021	-0.00028	-0.00028	0.00016	0.0	-0.00054
$C_{L_{\delta_{STAB}}}$	1/DEGREE	0.014	0.014	0.014	0.014	0.0142	0.014	0.148	0.015
$C_{L_{\delta_{IA}}}$	1/DEGREE	0.0129	0.0129	0.0131	0.01195	0.0118	0.0132	0.01445	0.0094
$C_{L_{\delta_{OA}}}$	1/DEGREE	0.0031	0.0021	0.00256	0.0003	0.0001	0.0028	0.00201	-0.00113
C_{M_α}	1/DEGREE	-0.0048	-0.0038	-0.0044	-0.0022	-0.0035	0.004	-0.019	0.012
$C_{M_{\hat{\dot\alpha}}}$	1/RADIAN	-3.68	-4.55	-4.69	-5.55	-5.55	-8.45	-10.62	-12.04
$C_{M_{\hat q}}$	1/FT/SEC	-27.4	-27.55	-27.6	-28.8	-30.2	-31.5	-32.1	-32.5
C_{M_U}	1/FT/SEC	0.00013	0.00013	0.000312	0.0	0.0	0.0	0.0	0.0
$C_{M_{\delta_{STAB}}}$	1/DEGREE	-0.04	-0.041	-0.0405	-0.0427	-0.045	-0.045	-0.05	-0.0505
$C_{M_{\delta_{IA}}}$	1/DEGREE	0.00443	0.00443	0.00439	0.0048	0.0047	0.00395	0.00369	0.00388
$C_{M_{\delta_{OA}}}$	1/DEGREE	-0.0032	-0.0032	-0.00346	-0.00183	-0.00165	-0.00372	-0.0033	-0.00037
$\delta_{STAB_{TRIM}}$	DEGREE	0.63	0.59	0.2	1.63	1.63	0.35	0.2	2.18
C_D	---	0.03	0.032	0.0375	0.026	0.026	0.056	0.037	0.034
C_{D_a}	1/DEGREE	0.004	0.0042	0.0048	0.0	0.001	0.016	0.0095	0.0027
C_{D_U}	1/FT/SEC	0.0	0.0	0.0	0.0	0.0	0.00004	0.0001	0.0
$C_{D_{\delta_{STAB}}}$	1/DEGREE	0.0002	-0.0003	0.0005	0.0	-0.0005	0.0004	0.0004	-0.0007

FIGURE 1 LONGITUDINAL STABILITY DERIVATIVES AND TRIM COEFFICIENTS

DERIVATIVE	UNITS	MANEUVER		LAUNCH	GUST		HIGH ALTITUDE	CRUISE	MAXIMUM q
		DESIGN CONDITION MACH=0.35 SEA LEVEL q=181 PSF	FLIGHT CONDITION MACH=0.42 10,000 FT q=182 PSF	MACH-0.40 15,000 FT q=133.7 PSF	DESIGN CONDITION MACH=0.60 7,000 FT q=411 PSF	FLIGHT CONDITION MACH=0.70 15,000 FT q=410 PSF	MACH=0.70 50,000 FT q=83.5 PSF	MACH=0.80 46,800 FT q=126.4 PSF	MACH=0.86 15,000 FT q=618.1 PSF
C_{Y_β}	1 DEGREE	-.0203	-.0203	-.0201	-.0200	-.0200	-.0204	-.0215	-.0215
$C_{Y_{\hat{p}}}$	1/RADIAN	-.139	-.139	-.138	-.144	-.144	-.140	-.142	-.150
$C_{Y_{\hat{r}}}$	1/RADIAN	.535	.535	.538	.563	.563	.585	.609	.623
$C_{Y_{\delta r}}$	1/DEGREE	.00305	.00305	.00295	.00260	.00260	.00260	.00235	.00270
C_{ℓ_β}	1/DEGREE	-.0023	-.0023	-.0026	-.00243	-.00243	-.0041	-.0027	-.0020
$C_{\ell_{\hat{p}}}$	1/RADIAN	-.507	-.507	-.543	-.416	-.416	-.638	-.638	-.381
$C_{\ell_{\hat{r}}}$	1/RADIAN	.087	.087	.097	.063	.063	.124	.113	.044
$C_{\ell_{\delta r}}$	1/DEGREE	.00036	.00036	.00032	.00013	.00013	.0001	.00006	.00009
C_{n_β}	1/DEGREE	.00035	.00035	.0003	.0007	.0007	.00025	.0005	.0014
$C_{n_{\hat{p}}}$	1/RADIAN	.0028	.0028	-.002	.0161	.0161	-.0133	-.0121	.0274
$C_{n_{\hat{r}}}$	1/RADIAN	-.243	-.243	-.237	-.215	-.215	-.208	-.204	-.204
$C_{n_{\delta r}}$	1/DEGREE	-.000925	-.000925	-.00096	-.00101	-.00101	-.0018	-.00175	-.0016
$C_{Y_{\delta_{DS}}}$	1/DEGREE	.00012	.00012	.00018	.00059	.00059	.00094	.00133	.00125
$C_{\ell_{\delta_{DS}}}$	1/DEGREE	-.000292	-.000292	-.00029	-.000287	-.000287	-.000290	-.000300	-.000292
$C_{n_{\delta_{DS}}}$	1/DEGREE	-.000133	-.000133	-.000147	-.000192	-.000192	-.000203	-.000204	-.000224

FIGURE 2 LATERAL-DIRECTIONAL STABILITY DERIVATIVES

APPENDIX A

- MACH: 0.40
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

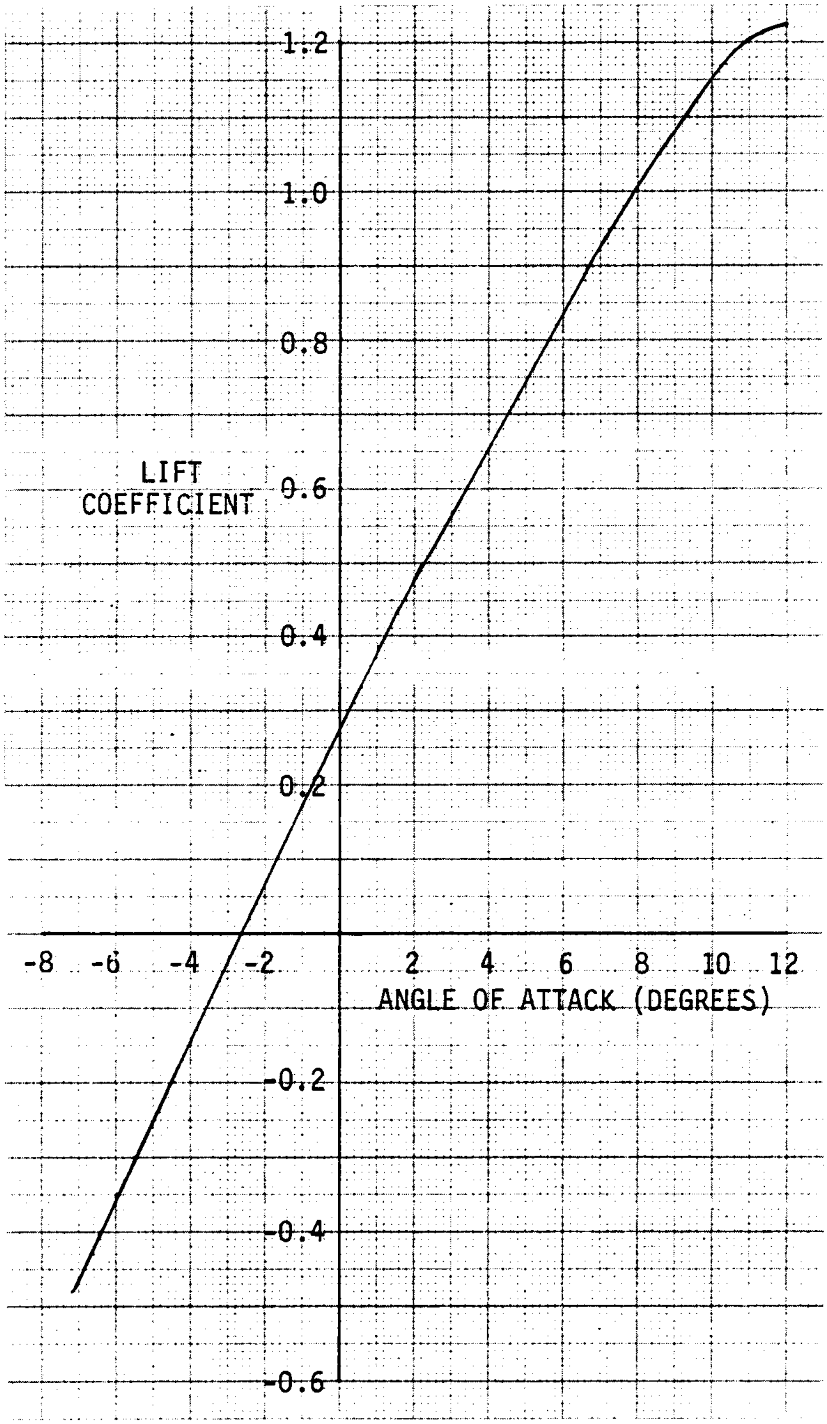

FIGURE 3

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, LAUNCH CONDITION

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- MACH: 0.40
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

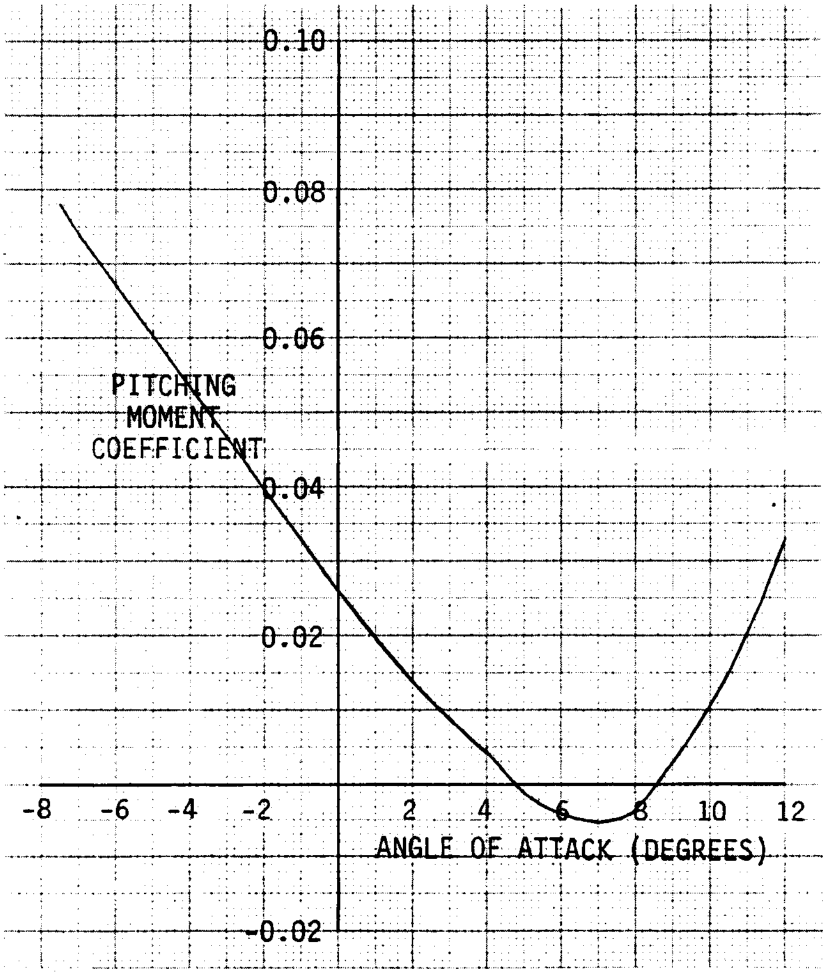

FIGURE 4

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, LAUNCH CONDITION

APPENDIX A

- MACH: 0.42
- ALTITUDE: 10,000 FEET
- STABILIZER: 0.0

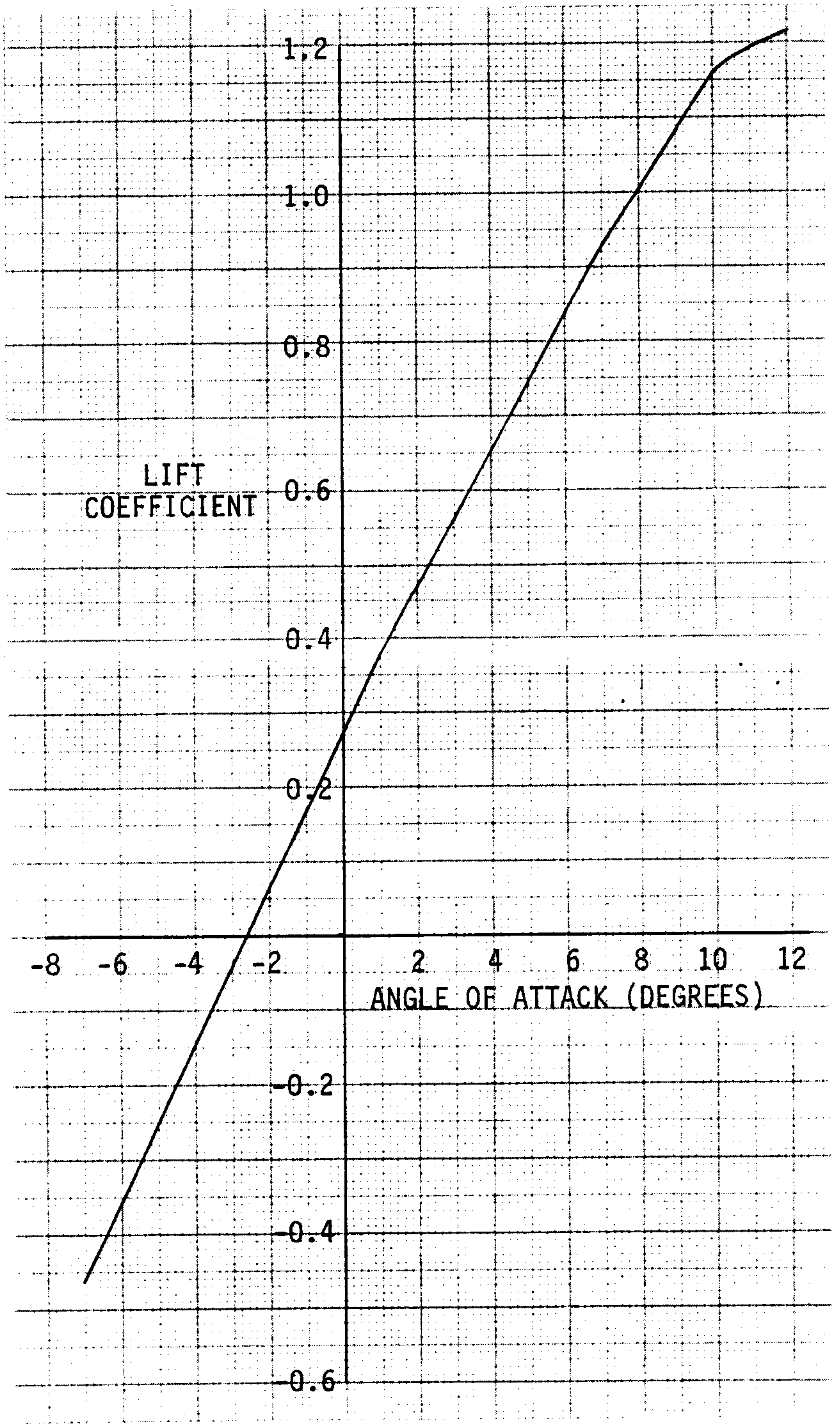

FIGURE 5

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA TEST CONDITION

- MACH: 0.42
- ALTITUDE: 10,000 FEET
- STABILIZER: 0.0

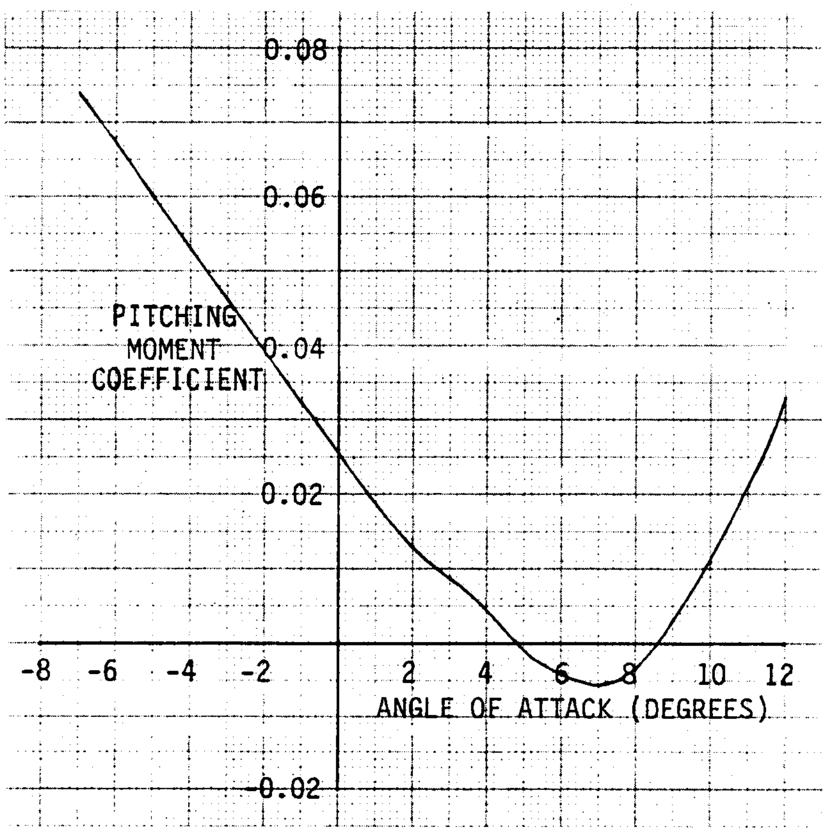

FIGURE 6

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA TEST CONDITION

APPENDIX A

- MACH: 0.35
- ALTITUDE: SEA LEVEL
- STABILIZER: 0.0

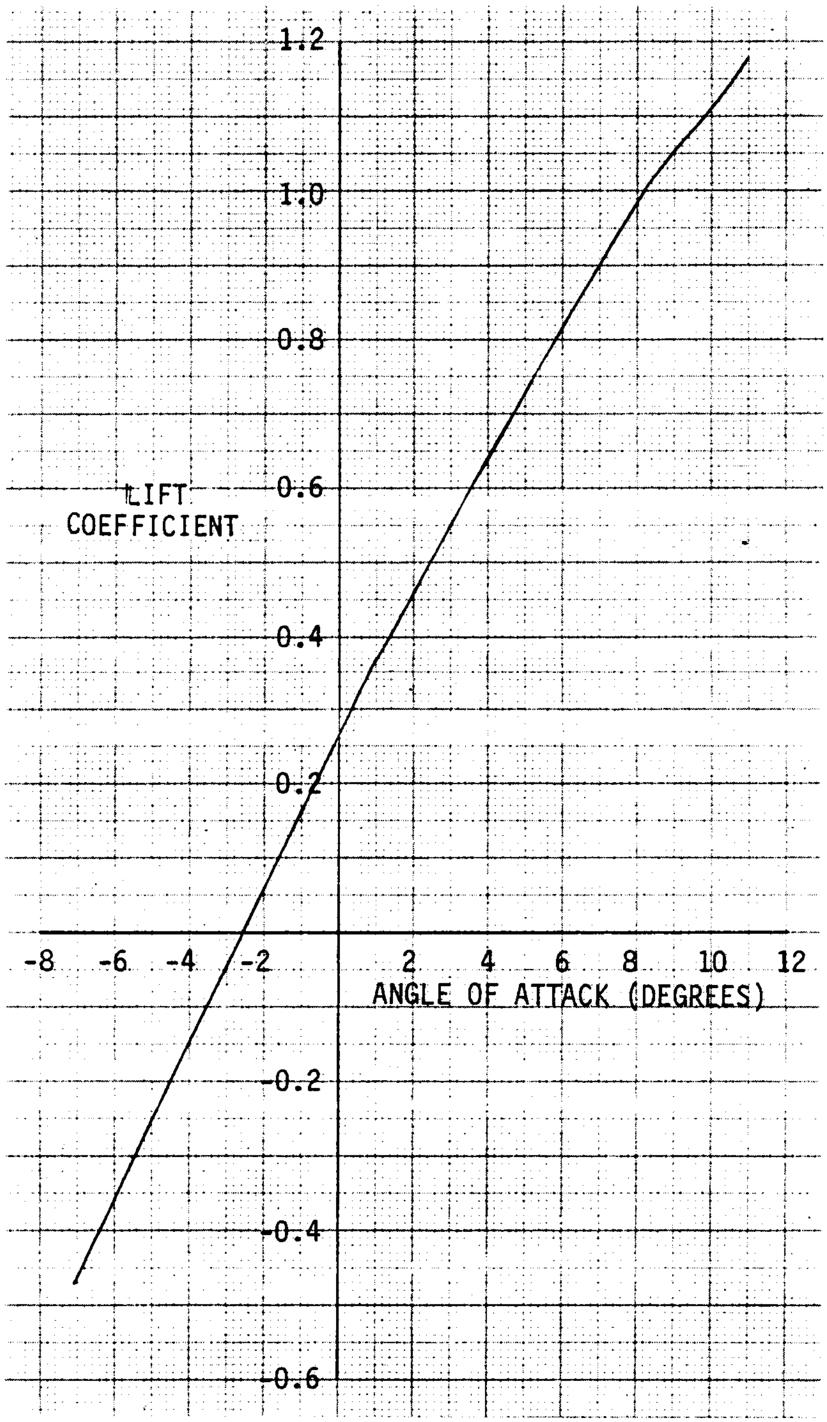

FIGURE 7

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA DESIGN CONDITION

- MACH: 0.35
- ALTITUDE: SEA LEVEL
- STABILIZER: 0.0

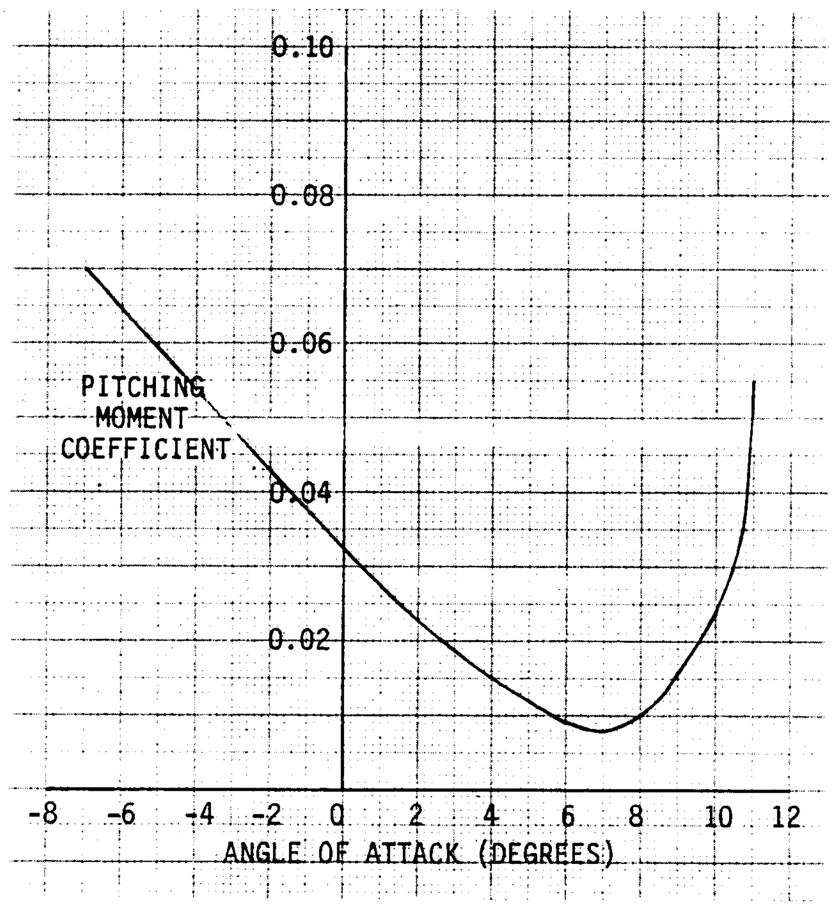

FIGURE 8

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, MLA DESIGN CONDITION

- MACH: 0.70
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

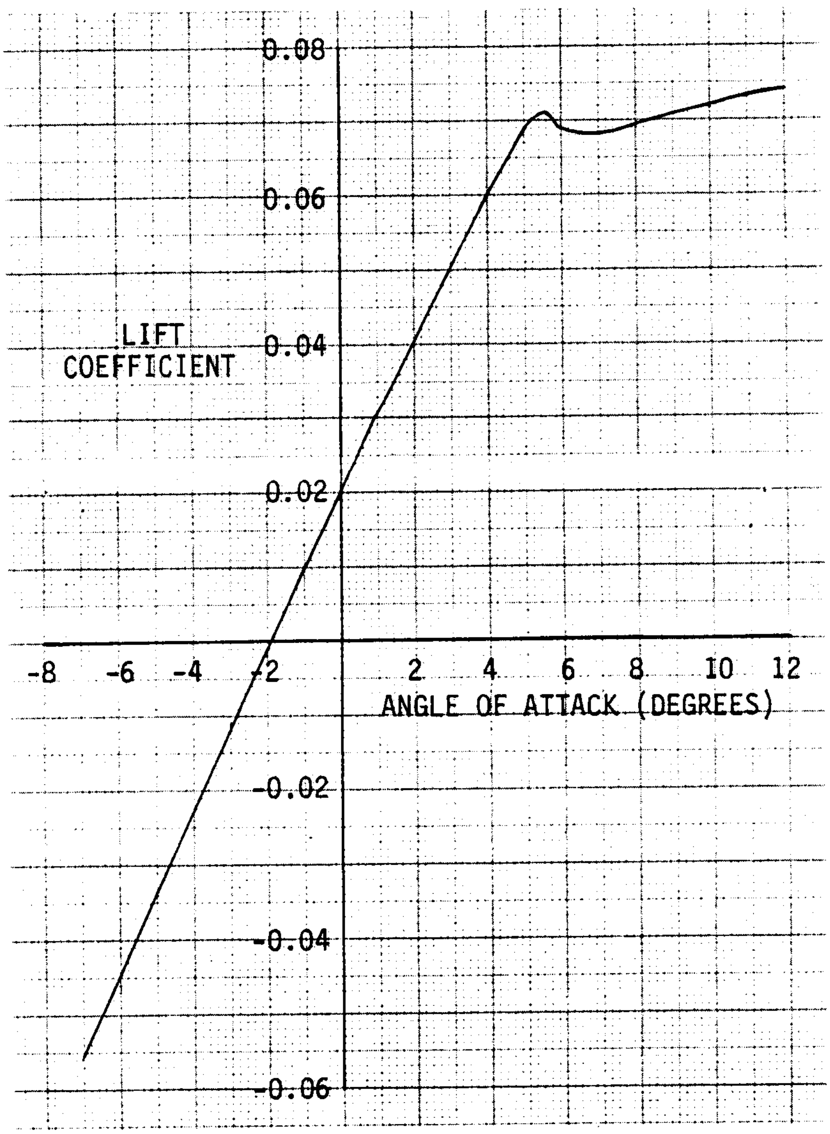

FIGURE 9

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA TEST CONDITION

- MACH: 0.70
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

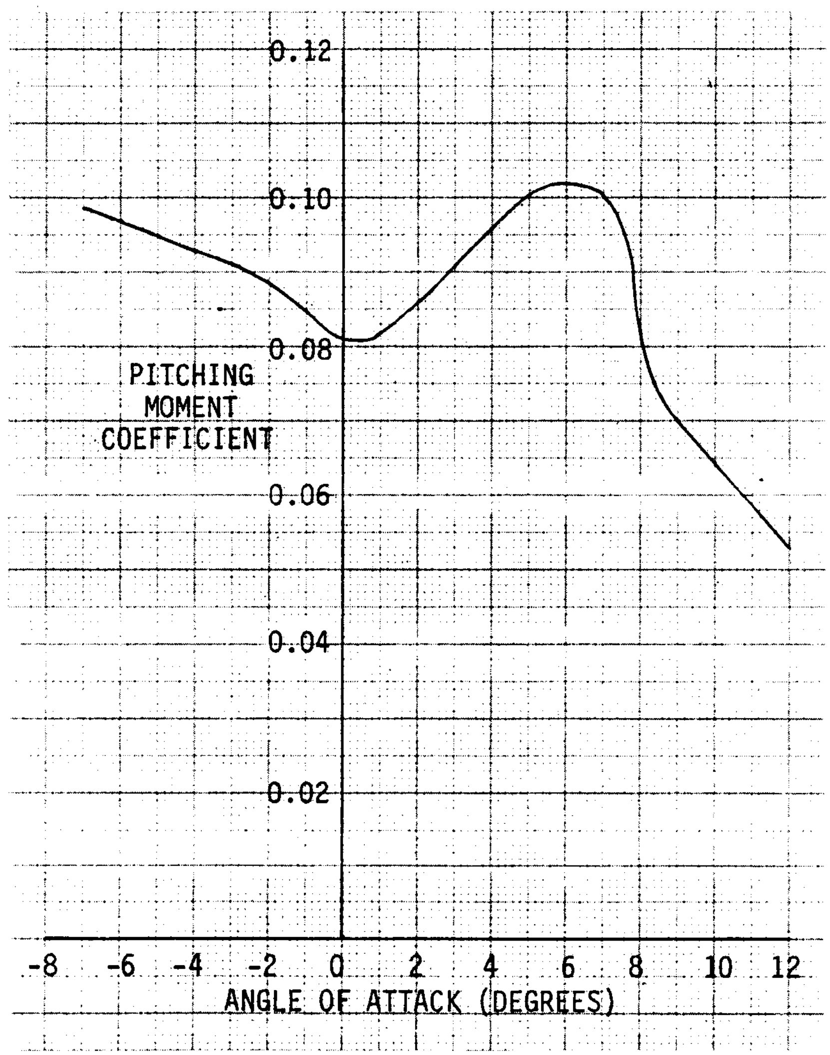

FIGURE 10

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA TEST CONDITION

- MACH: 0.60
- ALTITUDE: 7,000 FEET
- STABILIZER: 0.0

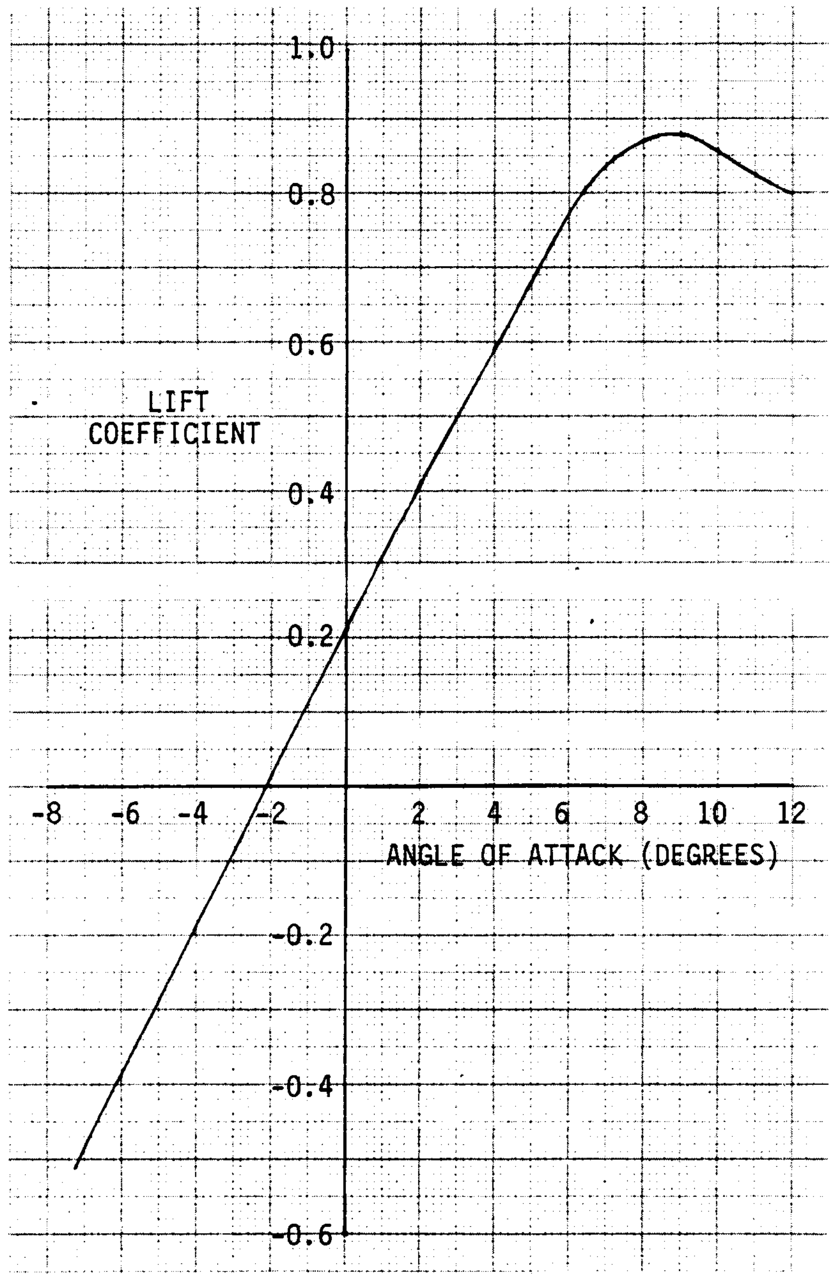

FIGURE 11

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA DESIGN CONDITION

- MACH: 0.60
- ALTITUDE: 7,000 FEET
- STABILIZER: 0.0

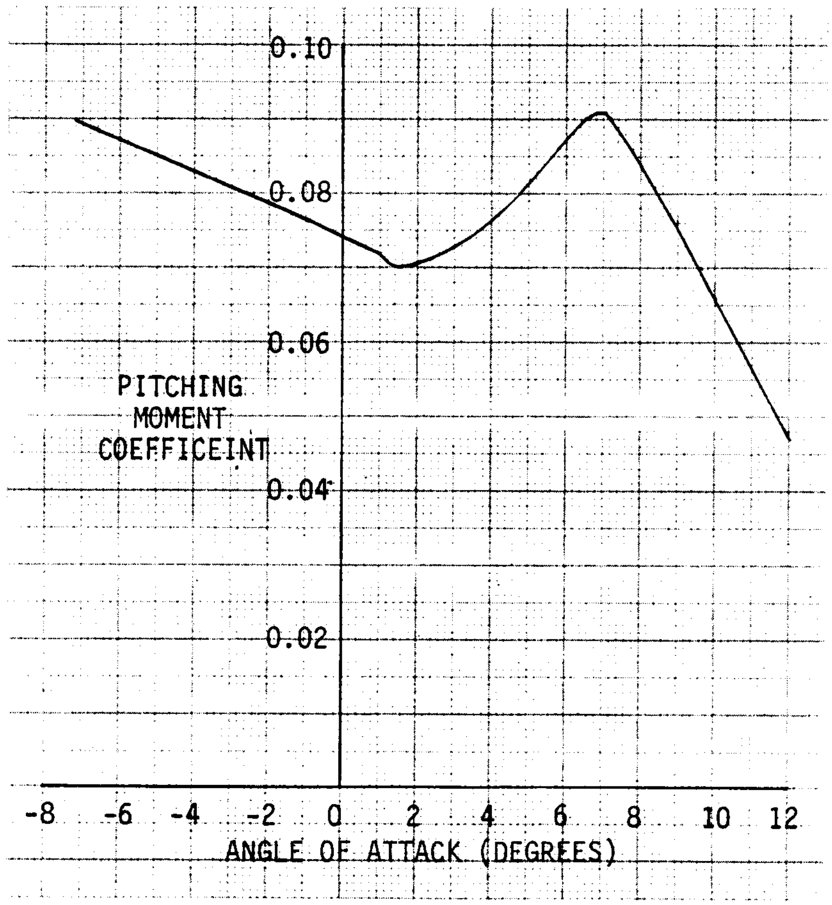

FIGURE 12

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, GLA DESIGN CONDITION

- MACH: 0.70
- ALTITUDE: 50,000 FEET
- STABILIZER: 0.0

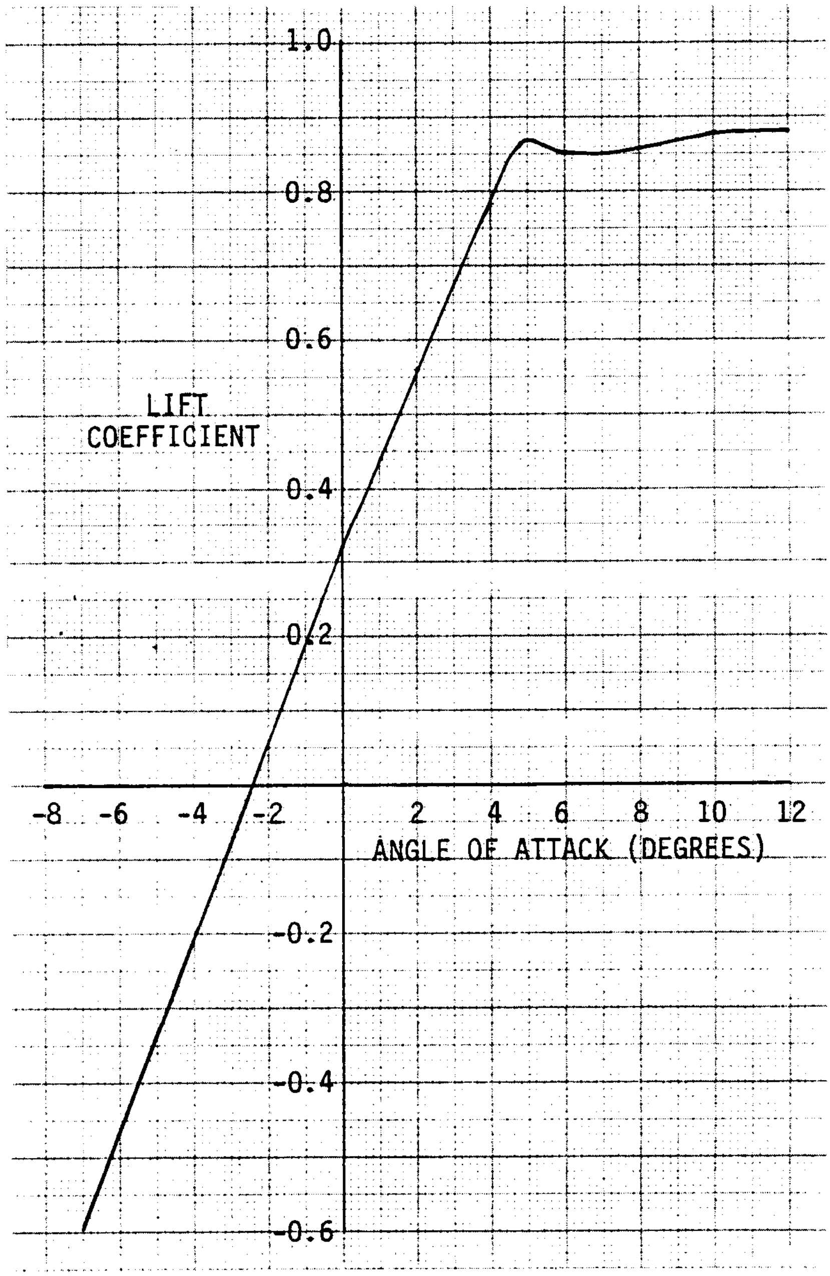

FIGURE 13

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, HIGH ALTITUDE CONDITION

APPENDIX A

- MACH: 0.70
- ALTITUDE: 50,000 FEET
- STABILIZER: 0.0

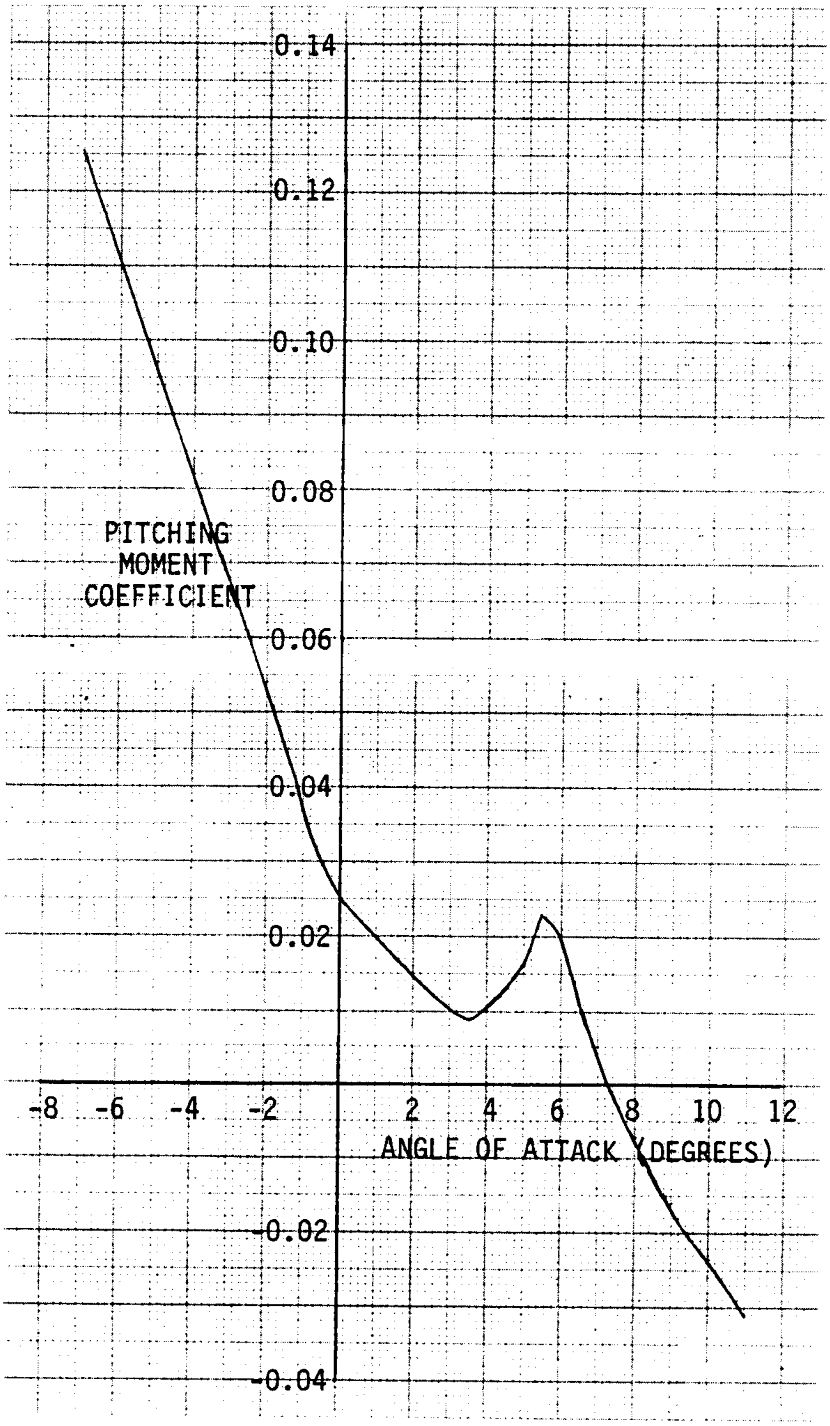

FIGURE 14

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, HIGH ALTITUDE CONDITION

- MACH: 0.80
- ALTITUDE: 46,800 FEET
- STABILIZER: 0.0

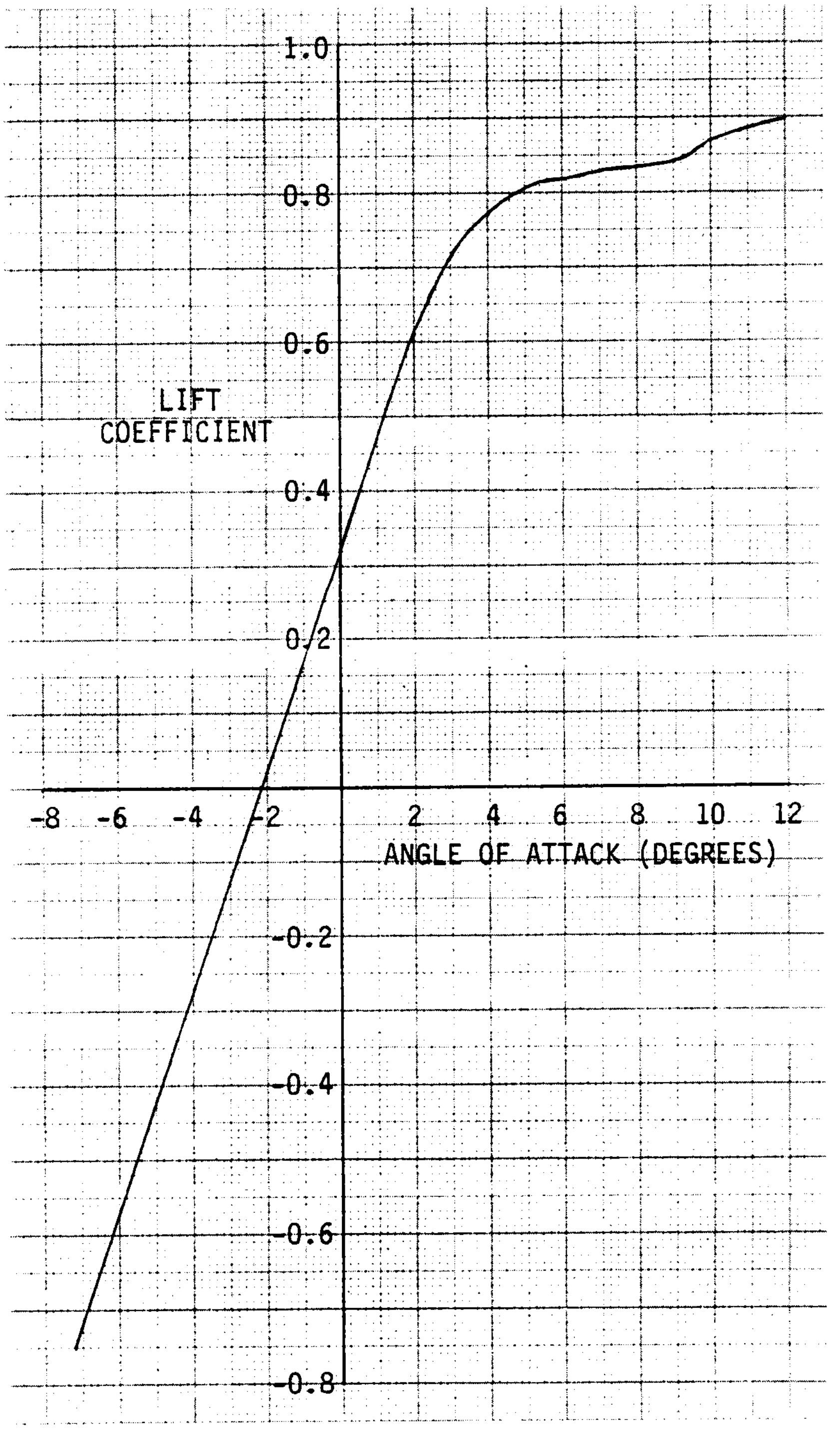

FIGURE 15

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, CRUISE CONDITION

APPENDIX A

- MACH: 0.80
- ALTITUDE: 46,800 FEET
- STABILIZER: 0.0

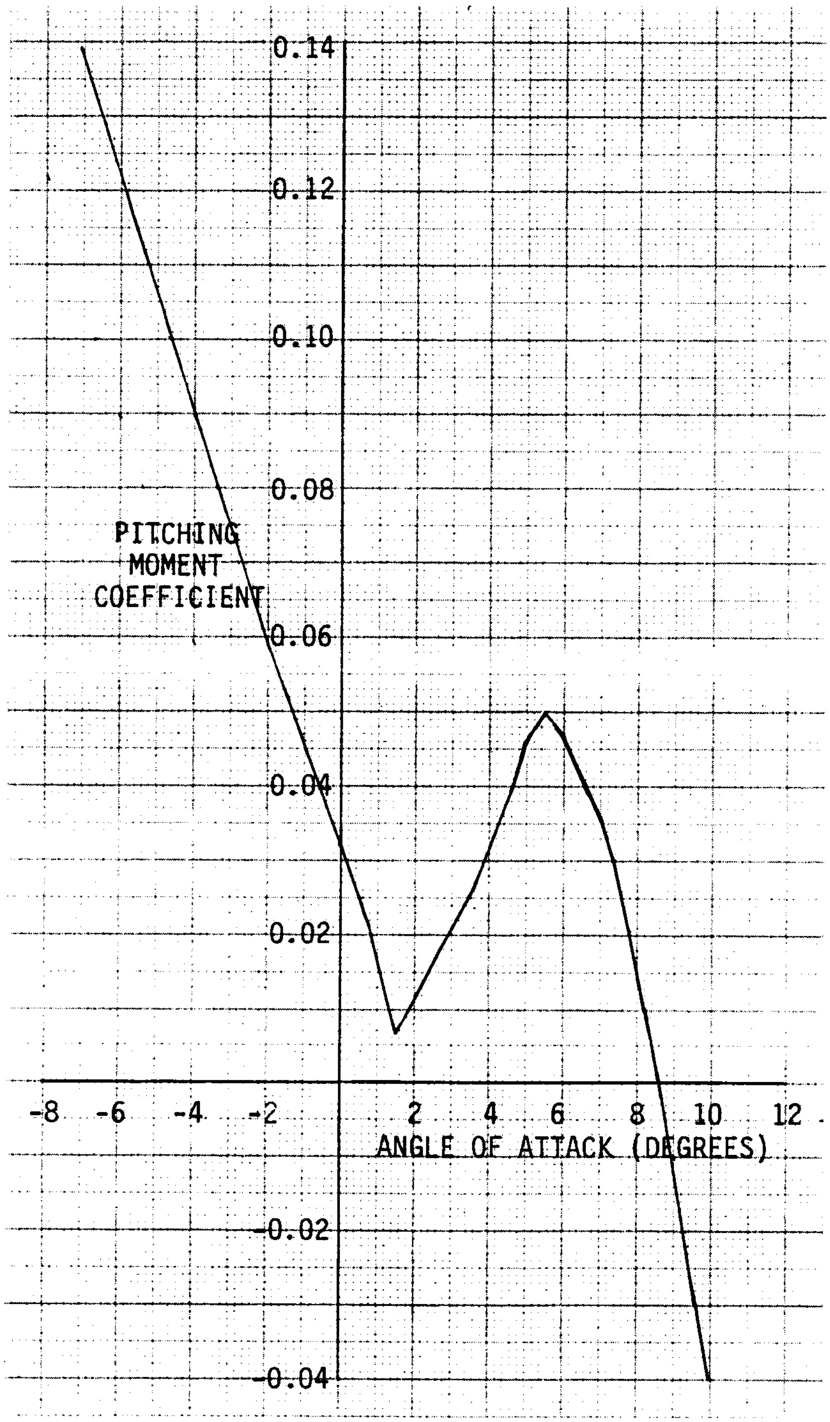

FIGURE 16

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK, CRUISE CONDITION

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

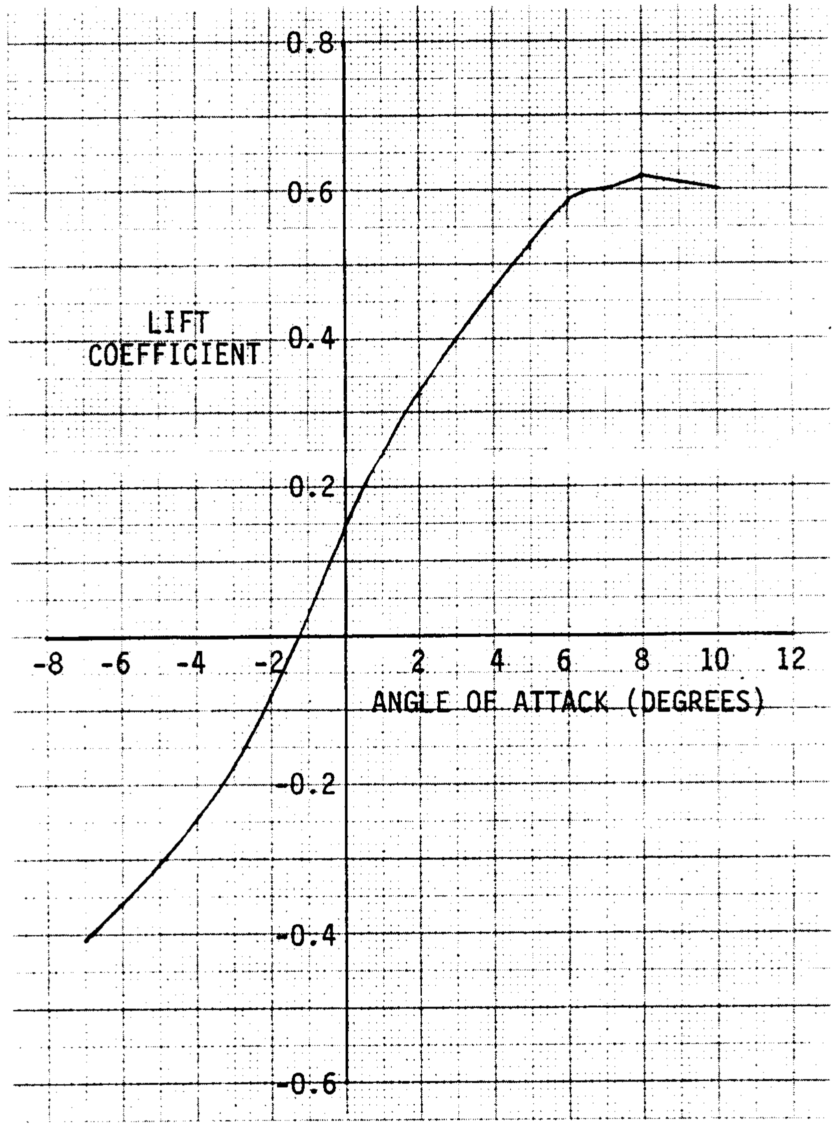

FIGURE 17

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK, MAXIMUM DYNAMIC PRESSURE CONDITION

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- STABILIZER: 0.0

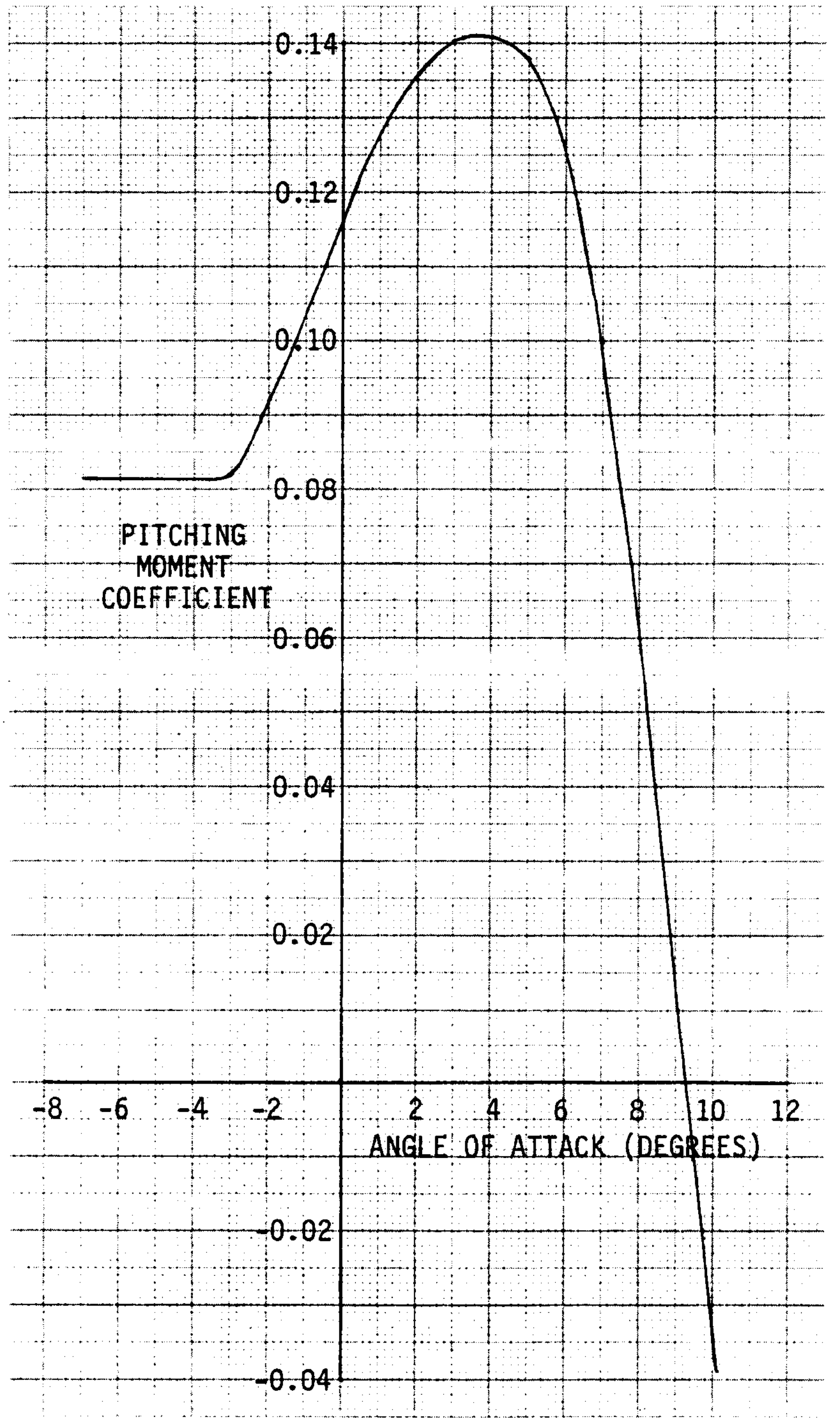

FIGURE 18

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK,
MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX A

GROSS WEIGHT (LBS)	C.G. (% MAC)	*MOMENT OF INERTIA (SLUG-FT^2)			
		I_{XX}	I_{YY}	I_{ZZ}	I_{XZ}
2500	19.93	163.5	2802.0	2286.3	20.25
2350	27.40	163.3	2173.8	2236.4	22.54
2200	32.75	163.1	2146.4	2210.5	24.16

*BODY AXIS

FIGURE 19

MOMENTS OF INERTIA

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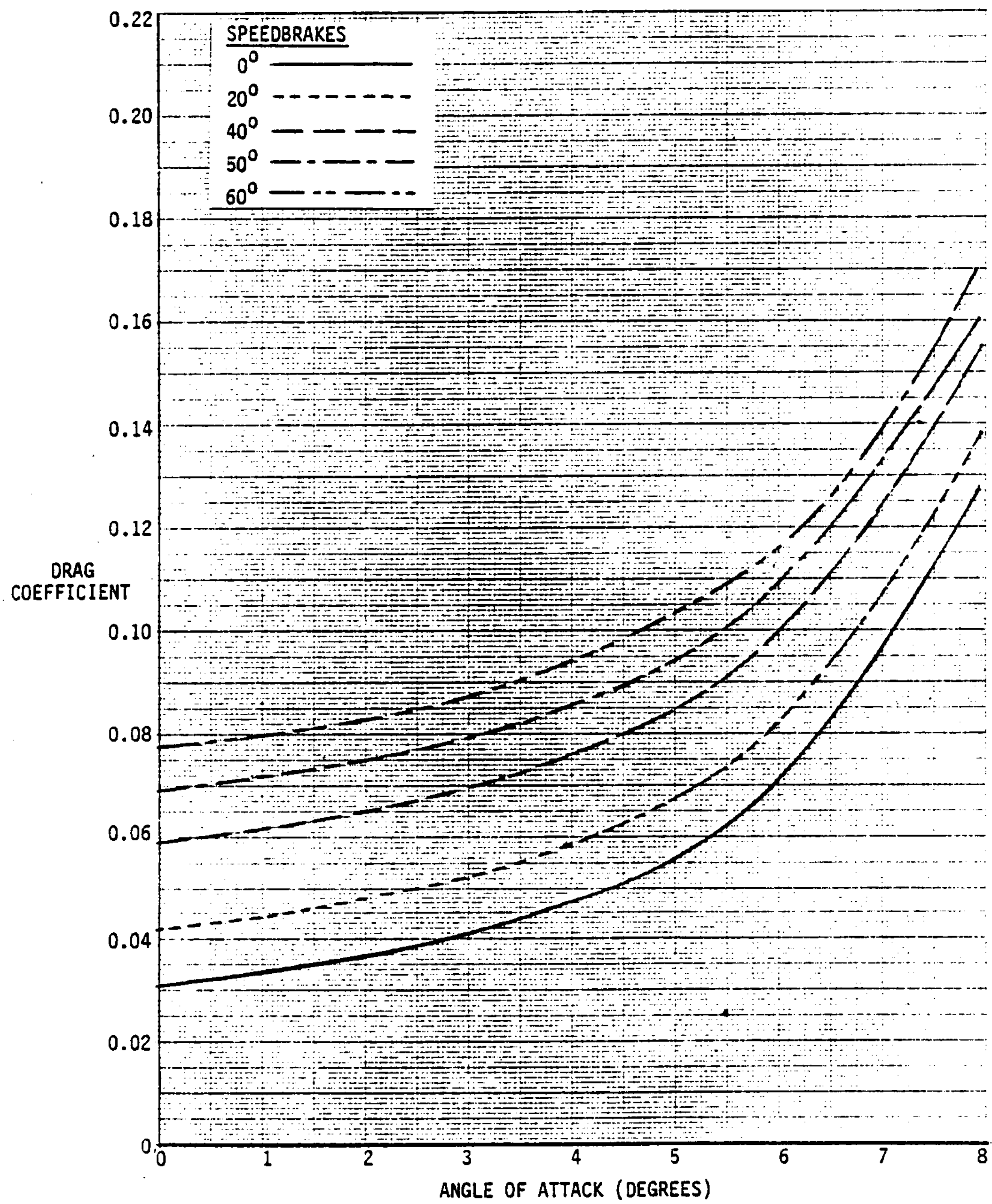

FIGURE 20

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.60, WITH SPEEDBRAKES

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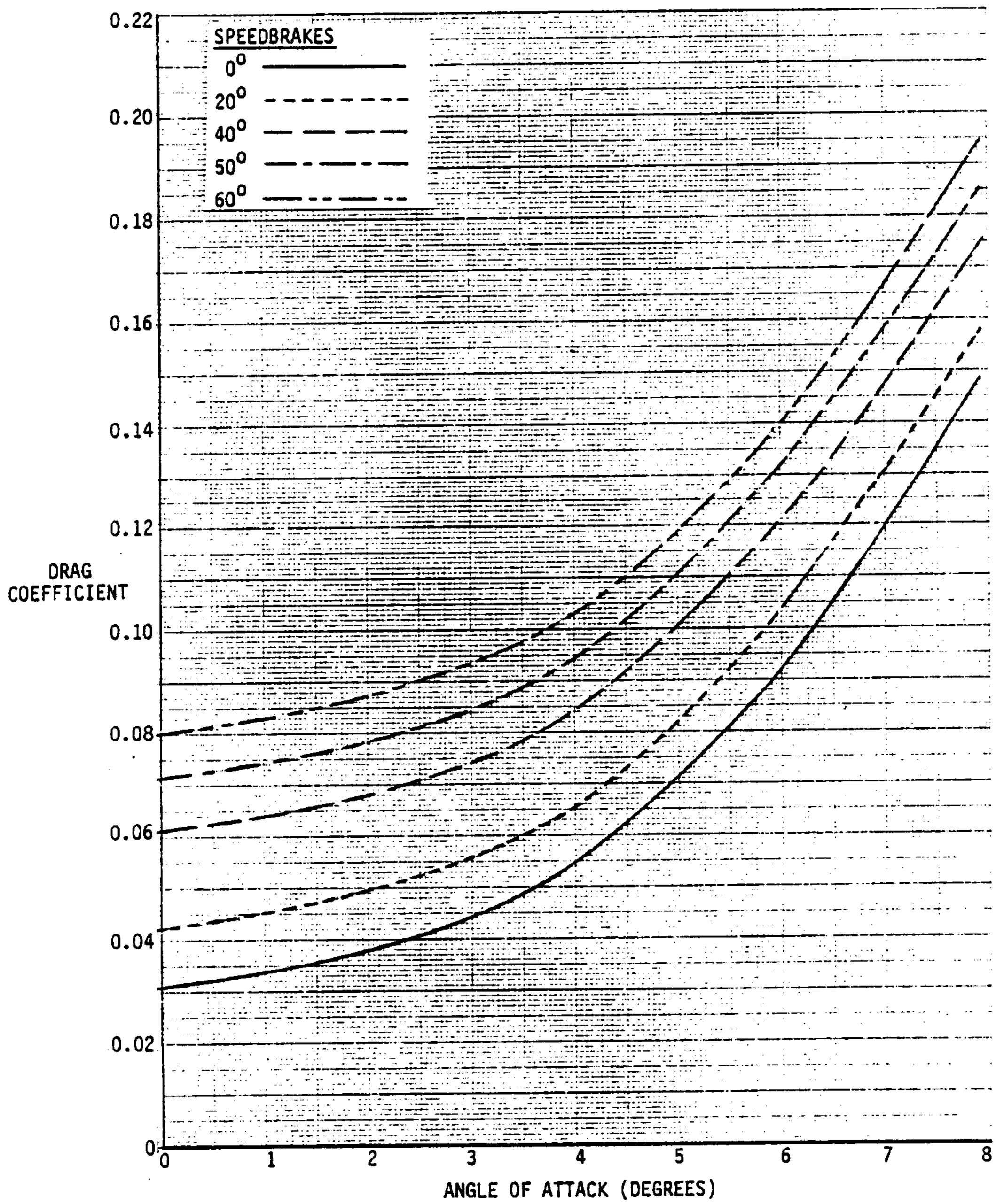

FIGURE 21

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.70, WITH SPEEDBRAKES

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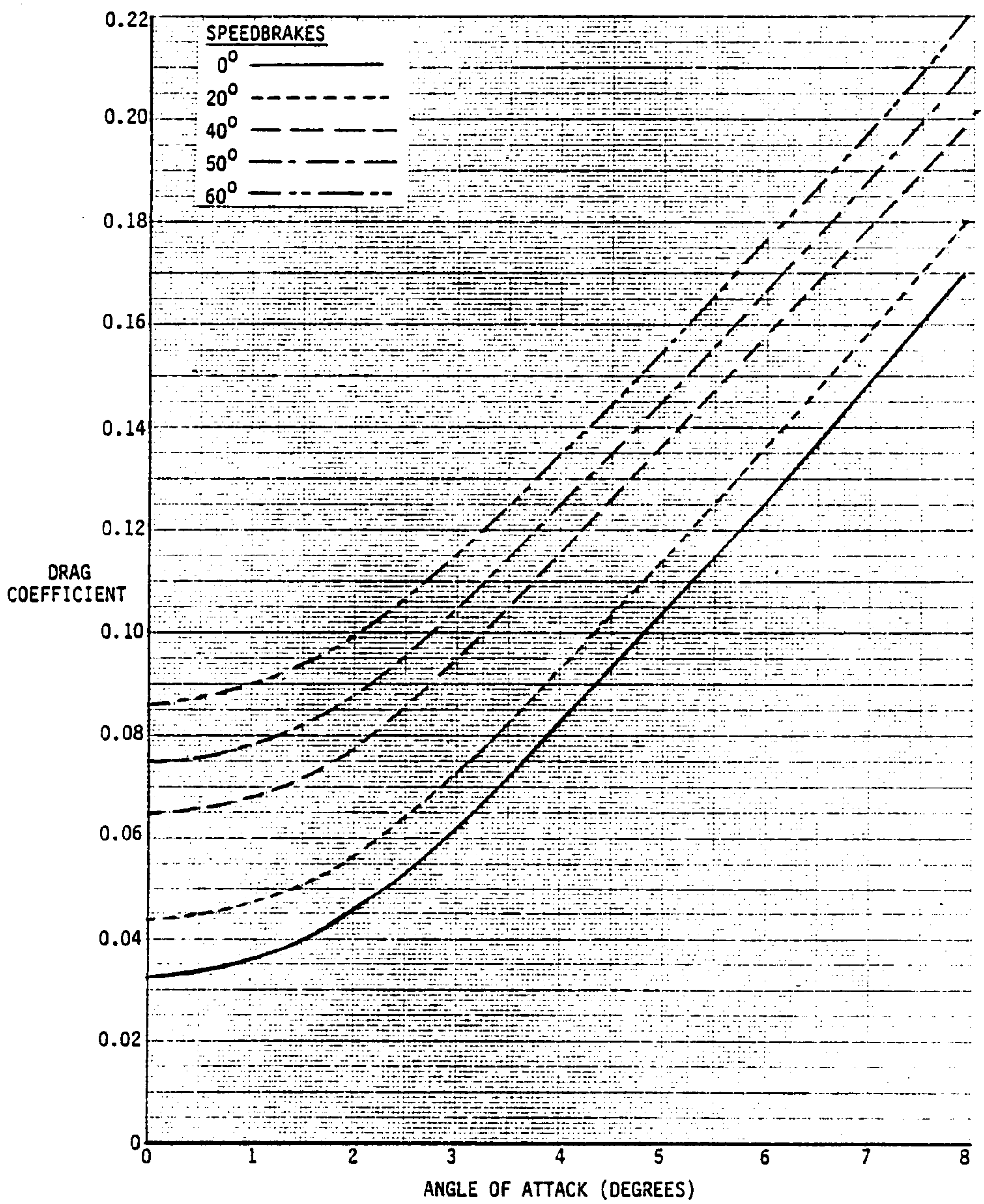

FIGURE 22

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES

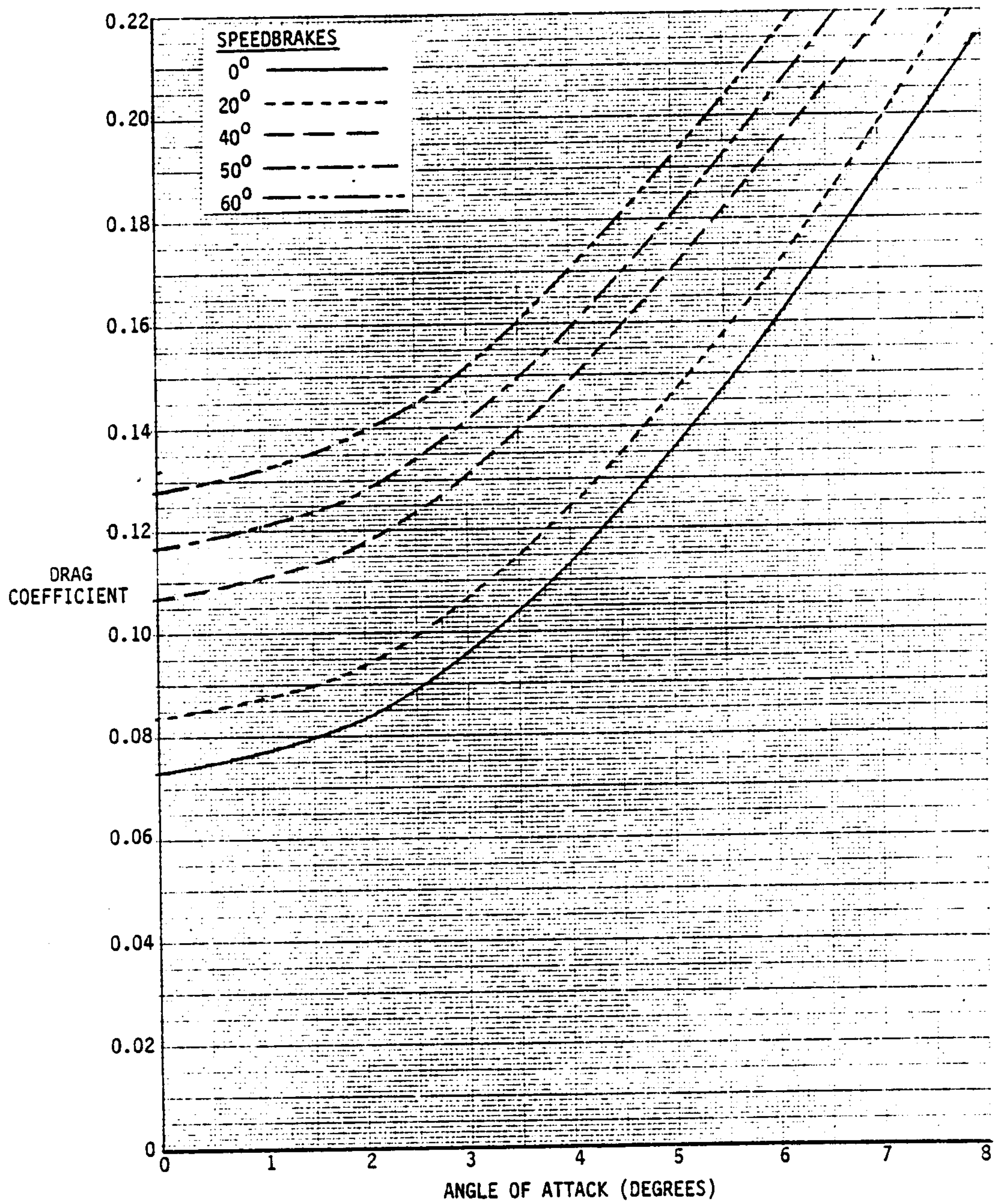

FIGURE 23

DRAG COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.90, WITH SPEEDBRAKES

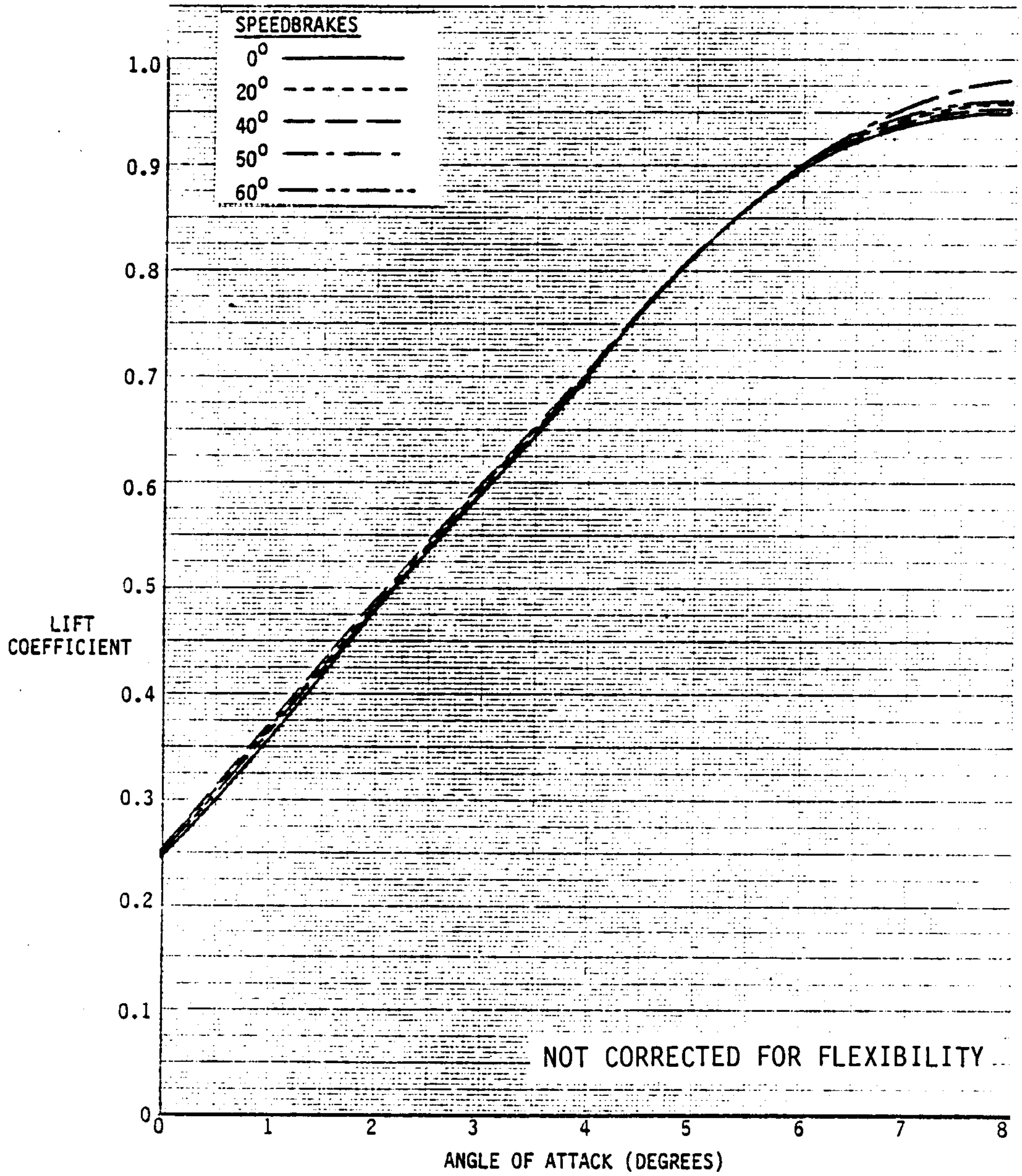

FIGURE 24

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.60, WITH SPEEDBRAKES

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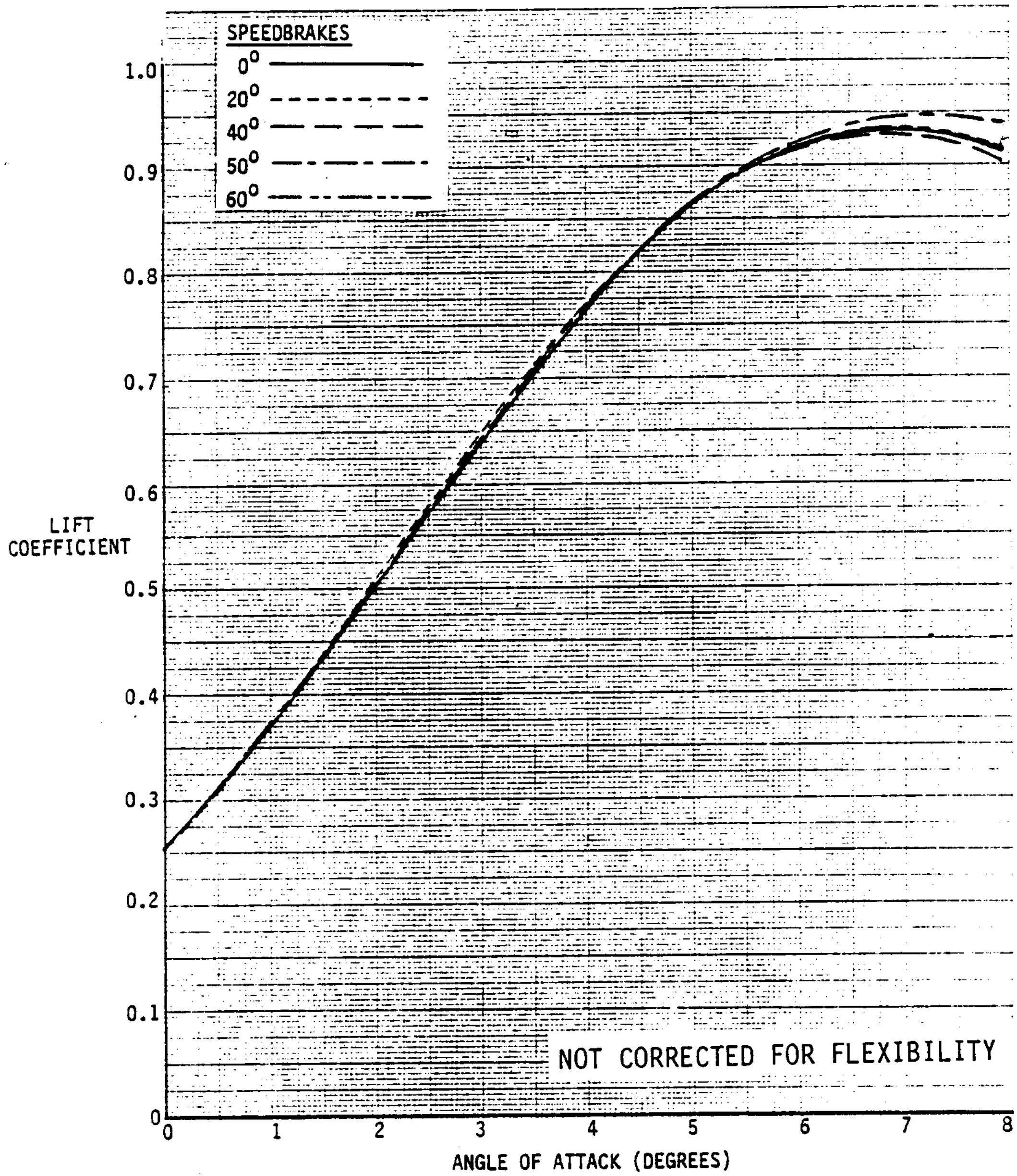

FIGURE 25

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.70, WITH SPEEDBRAKES

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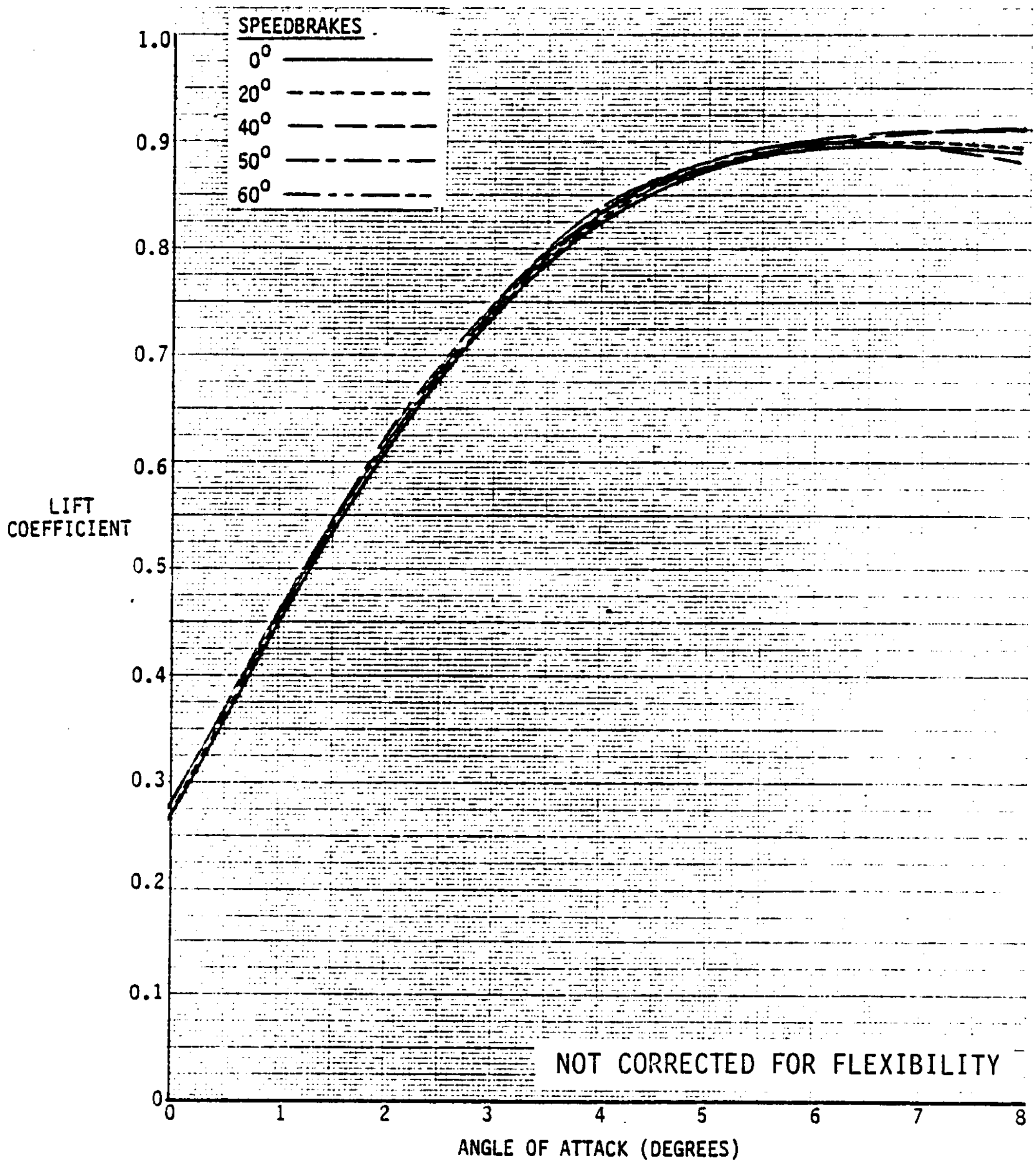

FIGURE 26

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES

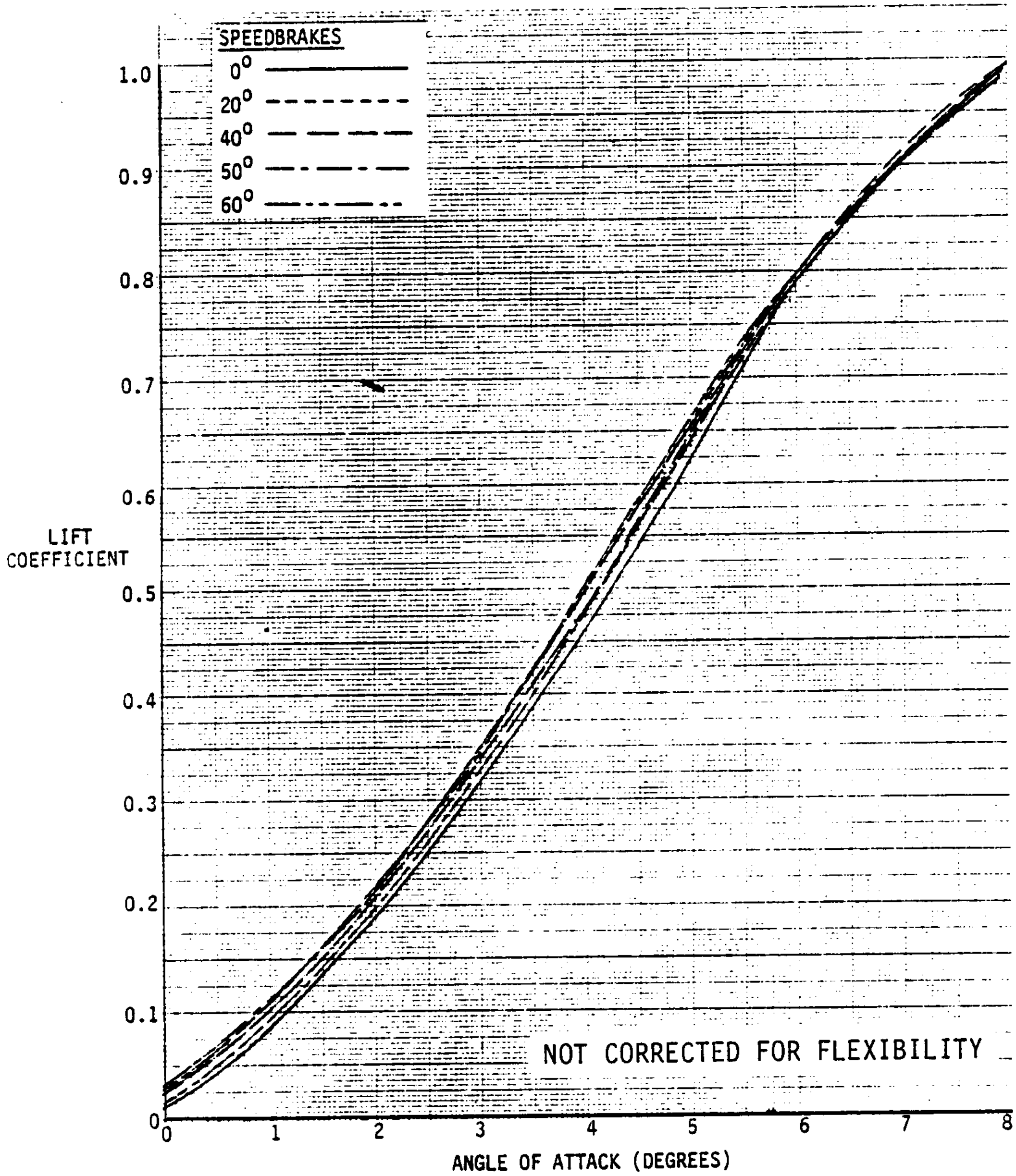

FIGURE 27

LIFT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.90, WITH SPEEDBRAKES

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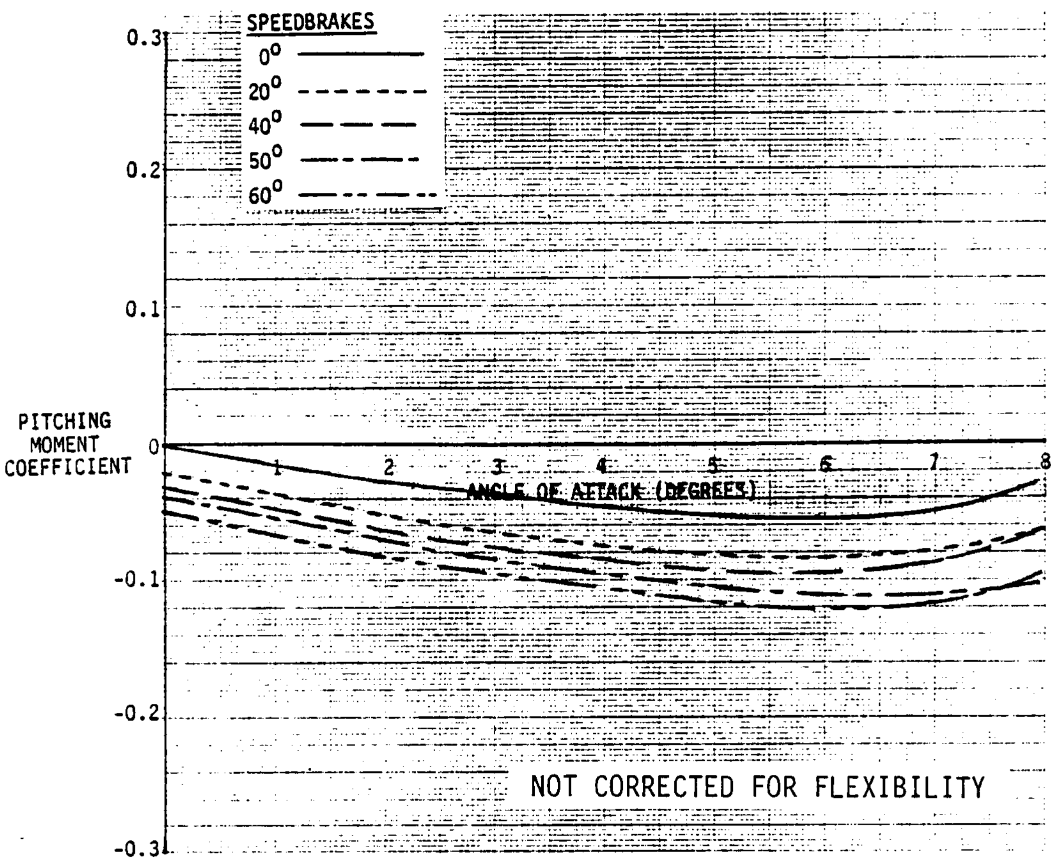

FIGURE 28

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.60, WITH SPEEDBRAKES

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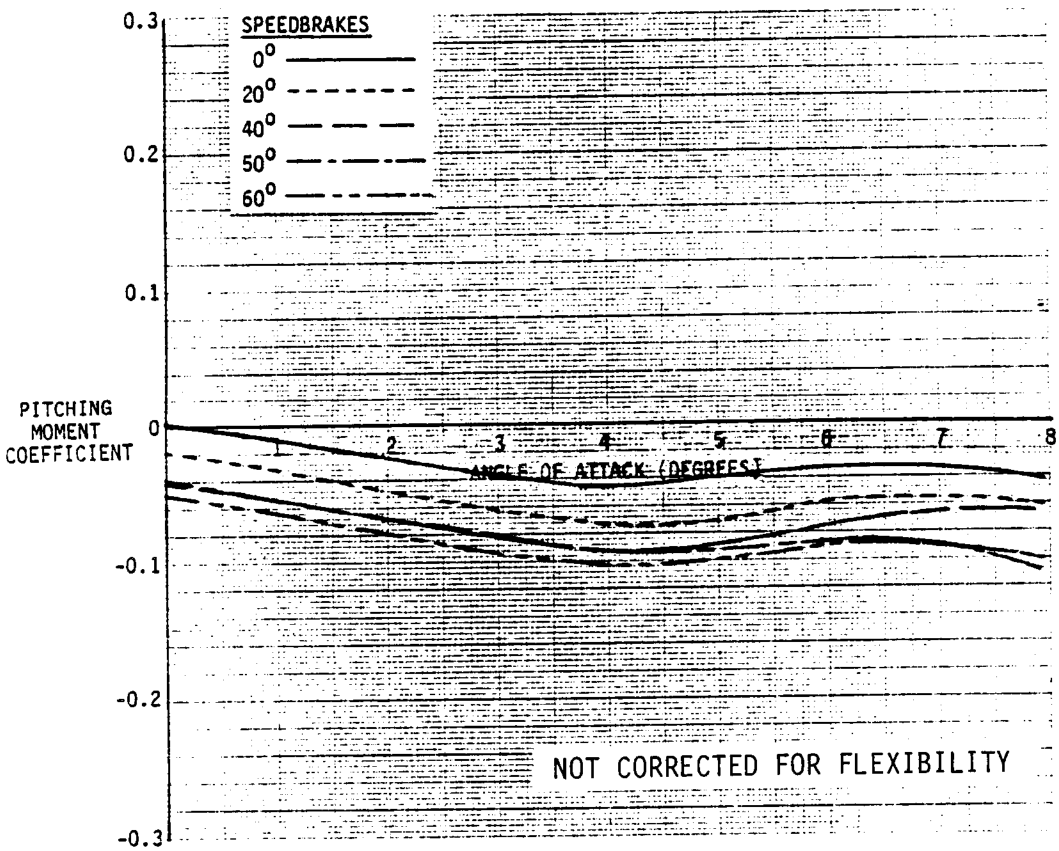

FIGURE 29

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.70, WITH SPEEDBRAKES

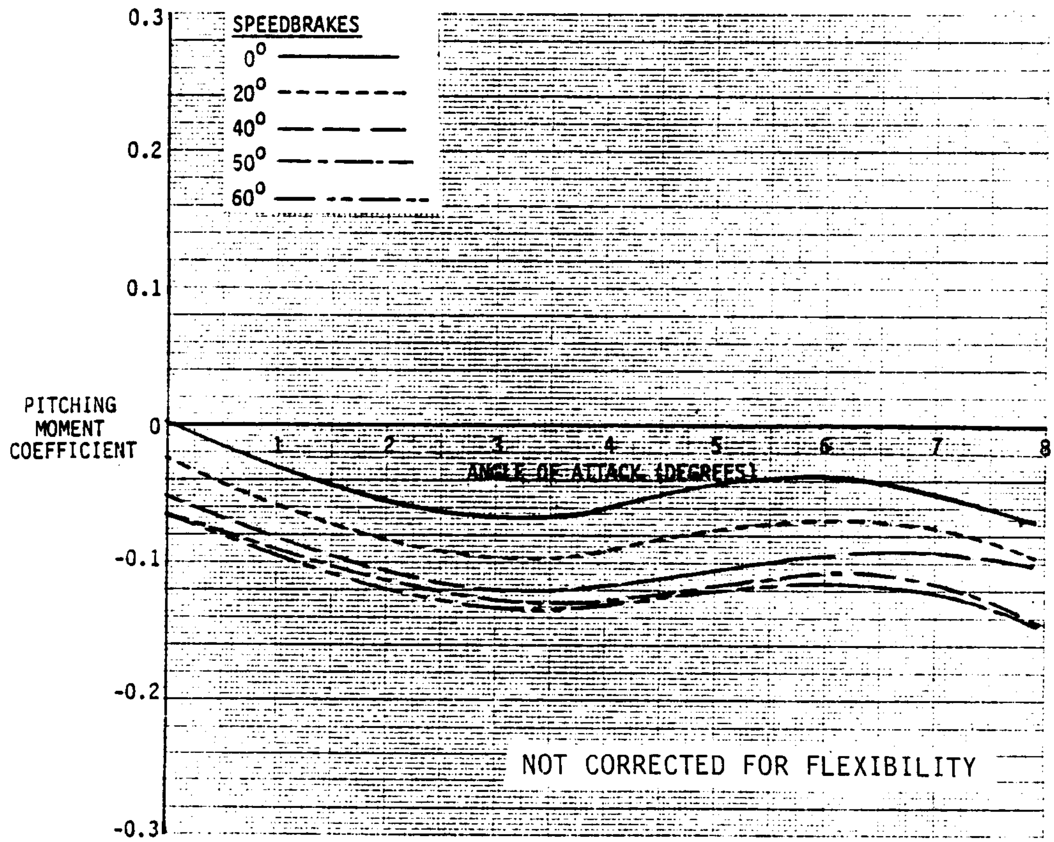

FIGURE 30

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.80, WITH SPEEDBRAKES

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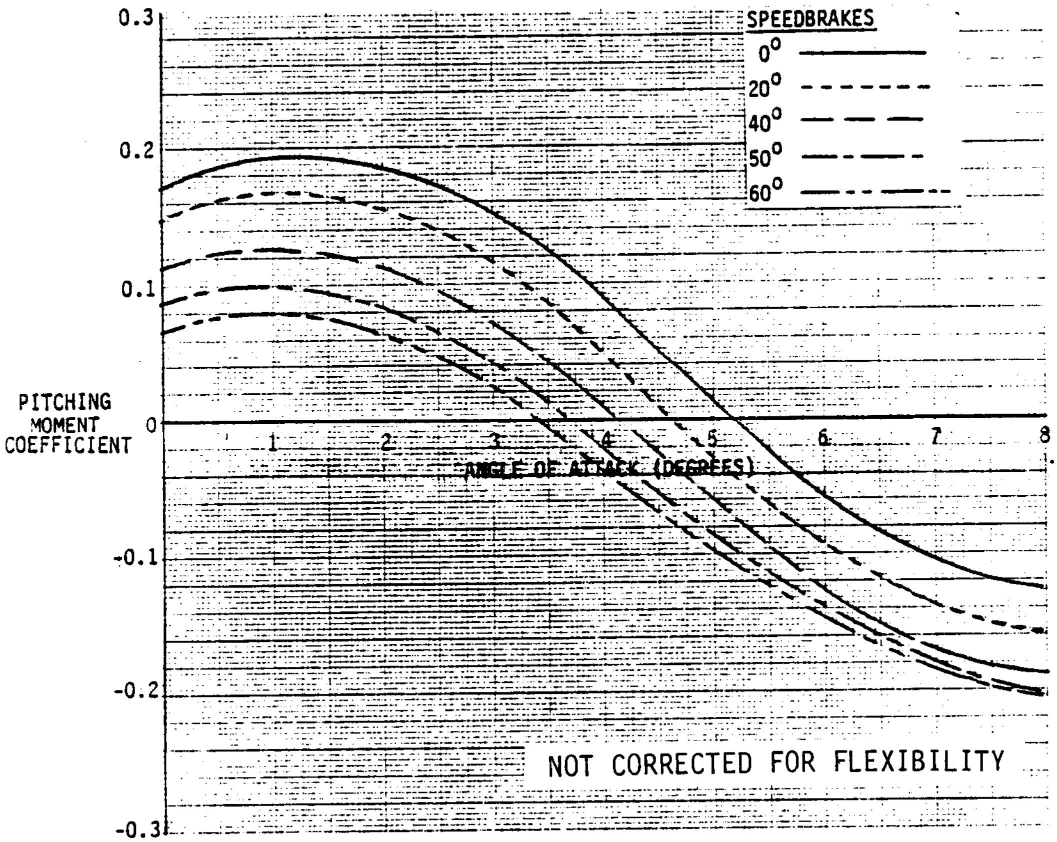

FIGURE 31

PITCHING MOMENT COEFFICIENT VERSUS ANGLE OF ATTACK AT MACH: 0.90, WITH SPEEDBRAKES

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OF POOR QUALITY

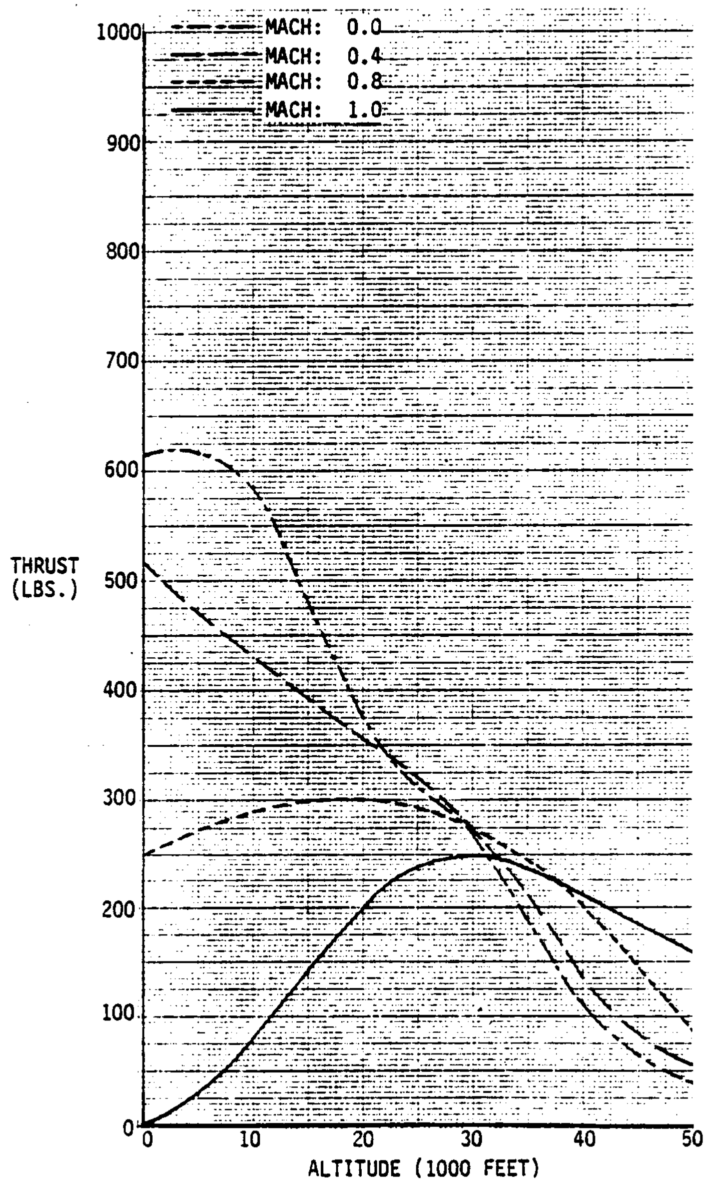

FIGURE 32

THRUST DATA FOR 80 PERCENT ENGINE RPM

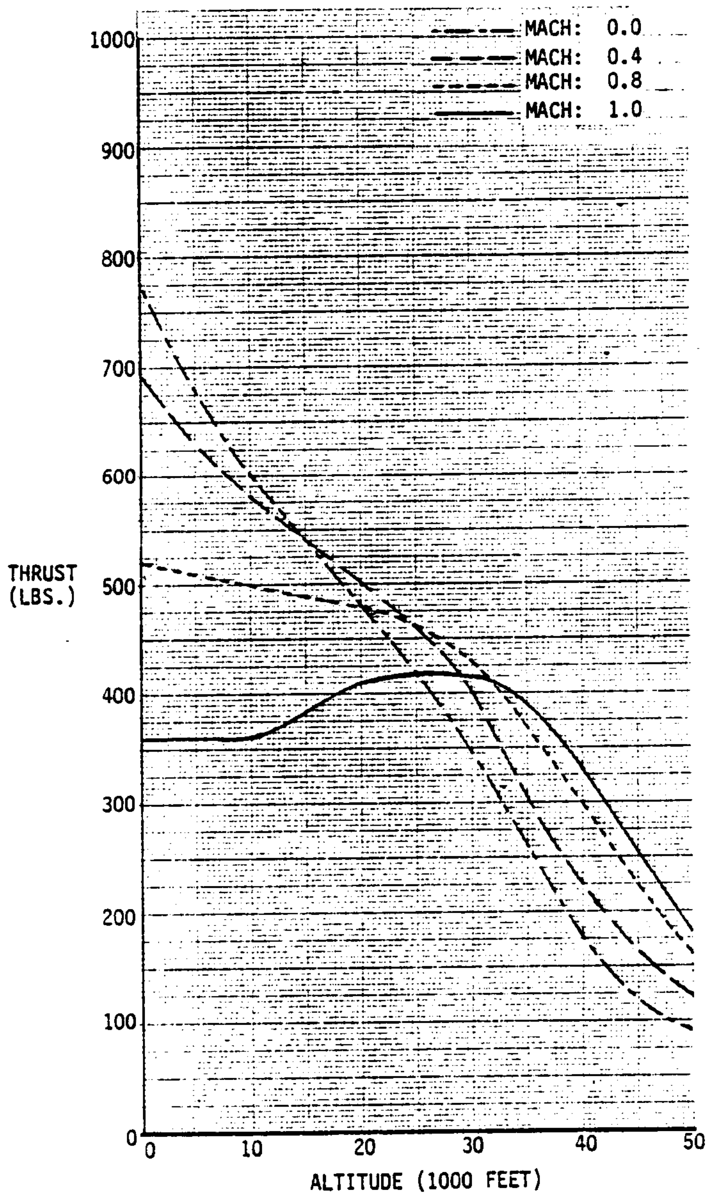

FIGURE 33

THRUST DATA FOR 85 PERCENT ENGINE RPM

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OF POOR QUALITY**

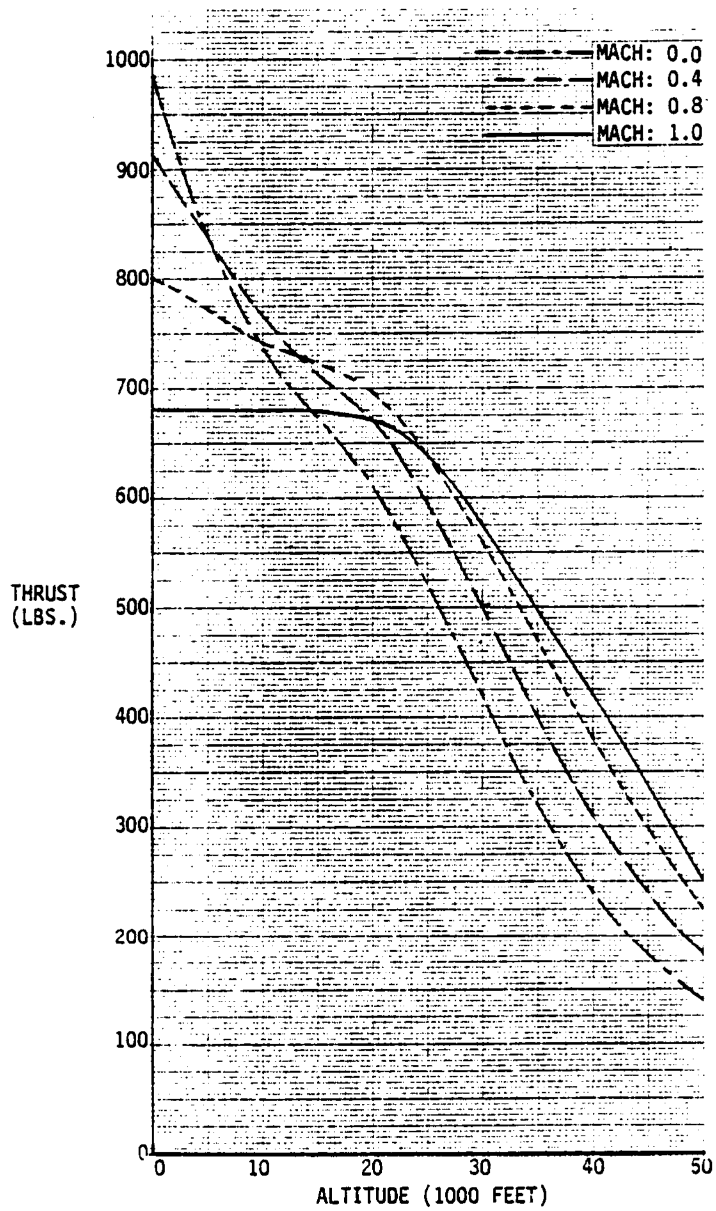

FIGURE 34

THRUST DATA FOR 90 PERCENT ENGINE RPM

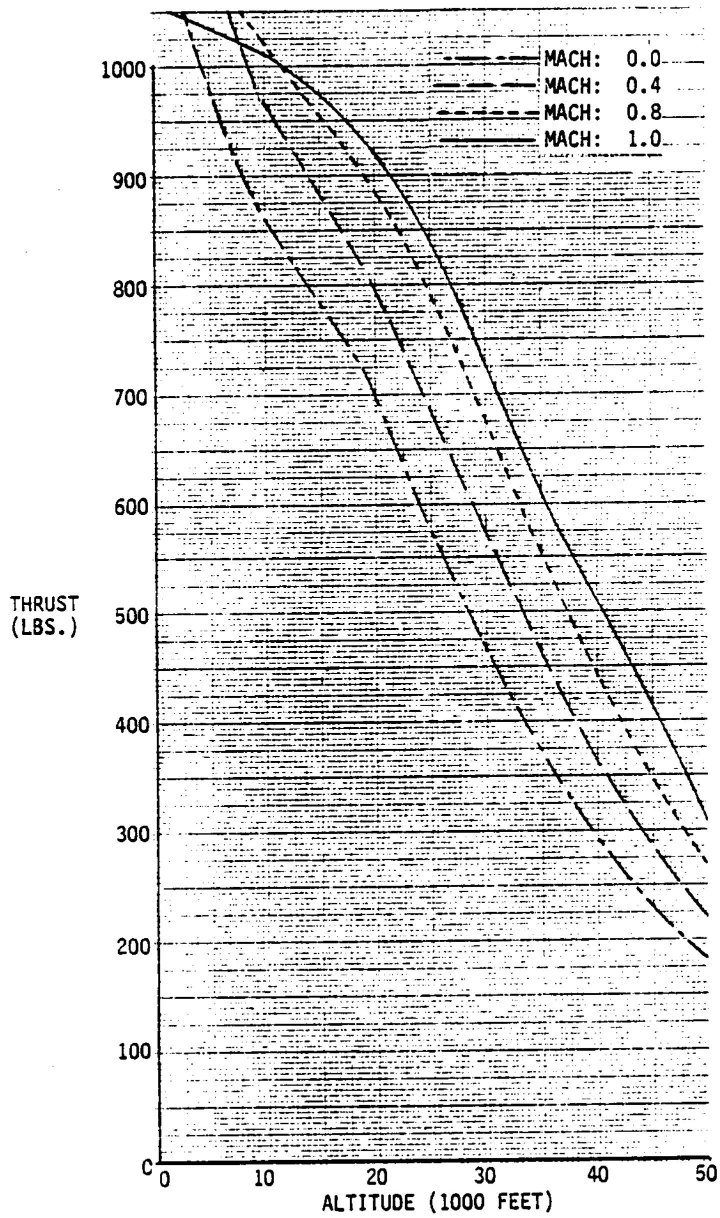

FIGURE 35

THRUST DATA FOR 95 PERCENT ENGINE RPM

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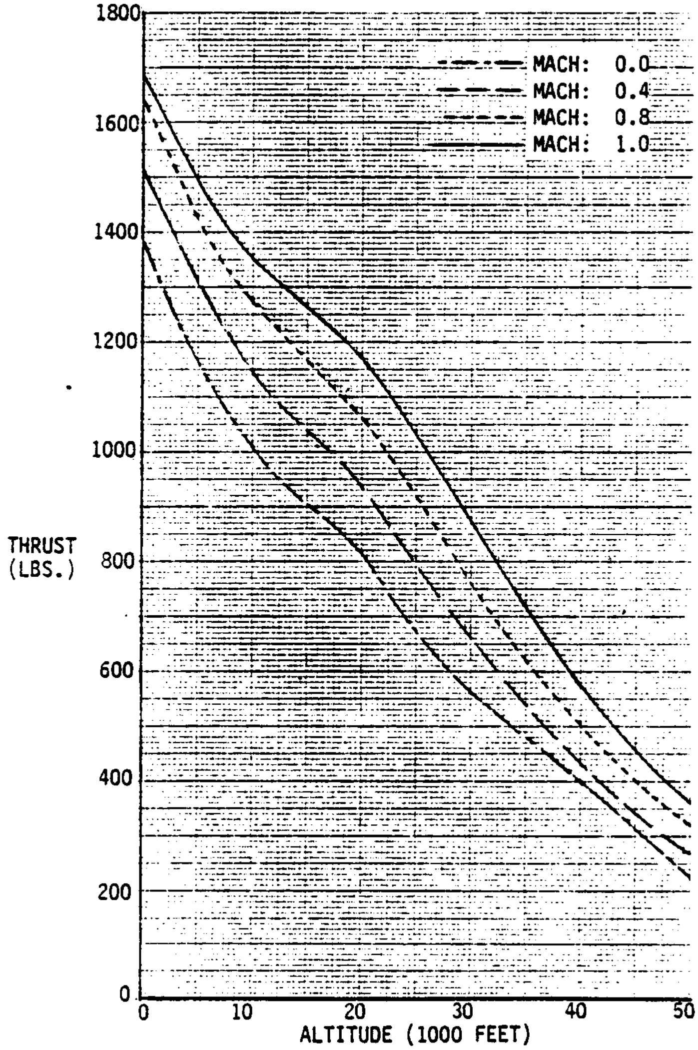

FIGURE 36

THRUST DATA FOR 100 PERCENT ENGINE RPM

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APPENDIX B

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

This appendix contains a study (see Figure 37) initiated when data obtained during bench testing of the servoactuator of DAST ARW-1 did not compare favorably with the model used for analysis.

The testing was conducted to determine if the DAST ARW-2 outboard aileron servovalves should be moved outboard closer to the actuators. Line lengths, load variations and position feedback gain variations were investigated.

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COORDINATION SHEET

TO Gary Hodges

NO. 3-75610-79-015
DATE 31 October 1979
MODEL DAST ARW-2

GROUP INDEX Flight Controls Analysis

SUBJECT DAST ARW-2 Outboard Aileron Servovalve Relocation Study

1.0 INTRODUCTION AND SUMMARY

The DAST ARW-1 outboard aileron servoactuators installed in the test vehicle have about 84 inches of 3/16-inch outside diameter steel tubing between the servovalves mounted in the center wing section and the actuators mounted out in the wing at the inboard edges of the ailerons. Ground testing on the test vehicle shows higher frequency servoactuator modes, at about 112, 155 and 380 hertz, which cause servoactuator instability at the desired feedback gains. In addition, a lower frequency dominant mode with peak at 50-60 hertz has been shown by analysis to couple adversely with wing structural elastic modes with the flutter suppression systems engaged. The higher frequency modes required addition of notch filters to reduce actuator gain at the mode frequencies. The lower frequency dominant mode will also require additional compensation to provide satisfactory performance from the flutter suppression system on the test vehicle.

As part of the subject study, testing was accomplished on a breadboard of the DAST ARW-1 outboard aileron servoactuator to establish the effects of line length between the servovalve and actuator and load inertia variations on the servoactuator dynamic performance. The testing was conducted to determine if the DAST ARW-2 outboard aileron servovalves should be moved outboard closer to the actuators and, if so, how much to alleviate the difficulties encountered with the DAST ARW-1 servoactuator.

The test results show that the servoactuator bandpass does not improve significantly as the length of the lines between the servoactuator and servovalve is shortened. In general, damping of the dominant, low frequency hydraulic fluid-actuator coupled mode increases as line length is shortened and as control surface inertia is decreased. But, the frequency of this mode, with position and pressure feedback gains constant, does not vary significantly with line length or load inertia variations.

The dominant mode, which appears to be a coupled hydraulic fluid-actuator mode, does not vary significantly in frequency or damping with changes in position feedback loop gain. The general trend is to decrease frequency and damping as position feedback gain increases. Pressure feedback increases the damping on this mode, but decreases damping on higher frequency fluid modes.

The two higher frequency fluid modes increase in frequency as the servovalve is moved closer to the actuator. With full length (84-inch) lines, the modes are at 160 and 380 hertz, but with lines reduced by half, the lower frequency mode is at 230 hertz and the other above 500 hertz.

FIGURE 37

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

C/S 3-75610-79-015
Page 2

The test results show that improved performance can be attained with shorter lines and reduced control surface inertia. The DAST ARW-2 outboard aileron servovalve should be moved farther outboard in the wing and the control surface inertia should be reduced. While this should improve the servoactuator performance, additional electronic compensation may be required to provide satisfactory performance from the flutter suppression system.

2.0 TEST RESULTS

The tests were conducted on a breadboard of the DAST ARW-1 outboard aileron servoactuator set up in the Hydraulics Laboratory. Position and load pressure feedback loops were closed on an EAI TR-48 analog computer. A 741 operational amplifier with current feedback was used to drive the electrohydraulic servovalve. Hydraulic power was provided by a portable hydraulic power unit capable of about 5 gallons per minute. The test set up with long lines between the servovalve and actuator was identical to the servoactuator functional test set up in August 1978.

The simulated load inertia used in the functional test was cut in half with a long bolt added so testing could be accomplished with full or half inertia, or with no inertia by removing the inertia from the actuator shaft. The lines between the servovalve and actuator used for the functional test were used for the full length lines tests. Another pair of lines were made up for the shorter lines tests.

Three groups of tests were accomplished. The first series were frequency response tests with variations in line length and simulated control surface inertia. The second series of tests were all with full line length to determine more exactly the nature of the dynamic response. In the third set, dynamic responses were obtained with full and 10-inch lines with position feedback gain variations.

Each time a change in the lines was made, the lines were bled and the actuator oscillated 4 or 5 degrees amplitude at 10 hz for about 5 minutes to preclude air being trapped in the lines and actuator.

2.1 Line Length and Load Inertia Variations

The servoactuator was first set up with the full length lines (84 inches) and frequency responses obtained for actuator shaft displacement due to displacement command for full (0.004 in-lb-sec^2), half and no load inertia. Then, the line length was shortened to three-quarter (63 inches), half (42 inches), one-quarter (21 inches) and the shortest practical lines (10 inches), consecutively, and the same frequency responses obtained. The resulting plots are shown on Figures 1 through 15. These frequency responses were all run with the nominal position and pressure feedback loop gains, 329.6 rad/sec and 0.5678 rad/sec, respectively. Different notch filters were required as the lines were shortened, because the higher frequency fluid modes increased in frequency.

The notch filters implemented in the servoactuator feedforward path for each of the line lengths are tabulated below.

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

C/S 3-75610-79-015
Page 3

LINE LENGTH	NOTCH FILTER(S)
Full	380 Hz
Three-Quarter	160, 380
Half	160, 240
One-Quarter	160, 240
10-inch	160, 430

The frequency responses all show a first order roll-off followed by a dominant mode peak in the 50-60 hertz range. Table I shows a summary of the frequency responses. In general, for a given line length, reducing the load inertia increased damping of the dominant mode (reduced peak magnitude), but changing line length did not affect this mode significantly in either damping or frequency. The dominant mode appears to be the coupled hydraulic fluid-actuator mode. With full load inertia, the actuator-surface mode is at 110-115 hertz.

With full length lines, higher frequency fluid modes are evident at 160 and 380 hertz (a notch filter was required at 380 hertz to reach the nominal feedback gains). With the lines reduced to 63 inches, these modes are at about 185 and 460 hertz. At half line length, the lower frequency mode has moved up to 230 hertz and the other is above 500 hertz. Thus, the two higher frequency fluid modes increase in frequency as the lines are shortened. The 230 hertz mode evident in the frequency responses with 10-inch lines is the servovalve. The servovalve mode is not apparent in the other frequency responses.

The dominant mode appears to change in damping and frequency with time. Figure 16 shows the frequency response of actuator position obtained in the functional tests in September 1978, with full length lines, full inertia and the same position and pressure feedback gains and notch filter as the response shown on Figure 1. The functional test frequency response shows the dominant mode peak at 72 hertz with amplitude about 2.27 degrees for the one degree amplitude command. Figure 1 shows the peak at 60 hertz with amplitude of about 2.03 degrees. The frequency response obtained during the functional test was run for 0.1 to 100 hertz frequency range, so the higher frequency modes cannot be compared. The 380 hertz mode was present and a notch filter at 380 hertz was required to attain the desired feedback gains. The difference in this mode would tend to suggest air was entrapped in the lines during the current test, but efforts were made to eliminate trapped air before any data was taken.

2.2 Dominant Mode Tests

After completion of the line length variation tests, the servoactuator breadboard was reassembled with the full length lines. Figures 17, 18 and 19 show frequency responses obtained at this time for full, half and no load inertia, respectively. A comparison of these plots with responses obtained initially,

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

C/S 3-75610-79-015
Page 4

Figures 1, 2 and 3, show the dominant mode to be lighter damped and at lower frequency. This response is more like that obtained on the servo-actuators installed in the DAST ARW-1 vehicle. Throughout the remainder of the testing on the breadboard setup, the response changed some from day to day, but essentially was the same.

A frequency response with the load inertia removed and low position feedback gain (90.91 rad/sec) only was run to compare with a response obtained during the DAST ARW-1 functional tests. The two responses are plotted on Figure 20. The dominant mode frequency is at 100 hertz for both responses. The lower frequency differences in the responses are probably due to actuator friction, with the friction less now than a year ago. However, the measured phase angles agree very well throughout the frequency range tested.

The hydraulic fluid mode at 160 hertz also changed some in nature. A notch filter had to be added when the breadboard was revised to return to full length lines. This notch was not required during the functional tests or when the breadboard was first assembled for the current tests.

A frequency response of the valve drive amplifier output voltage, shown on Figure 21, was run for a one degree actuator command, to determine if amplifier saturation was occurring. Near the dominant mode peak frequency, around 60 hertz, the voltage peaks at about 2.70 volts, with the maximum peak at 500 hertz of about 15.2 volts. Thus, the dominant mode is not being caused by nonlinear effects due to valve drive amplifier saturation.

Figure 22 shows the servoactuator frequency response obtained with the hydraulic supply pressure increased to 2000 psi. The dominant mode peak occurs at 62 hertz, slightly higher than obtained with 1500 psi supply pressure shown on Figure 17. Supply pressure does not affect the servoactuator dynamic response significantly.

2.3 Position Feedback Gain Variations

The final set of data run on the DAST ARW-1 outboard aileron servoactuator breadboard consisted of frequency responses for actuator displacement and load pressure for four low position loop gains and no pressure feedback or notch filters. Figures 23 through 26 show the actuator responses for the full length lines, and Figures 27 through 30 show the corresponding load pressure frequency responses. The actuator responses for 10-inch lines are shown on Figures 31 through 34 and Figures 35 through 38 show load pressure responses. The responses were obtained to determine if the dominant mode was affected by position feedback for the full length and 10-inch lines.

The four gains run were 19.18, 38.36, 76.72 and 115.08 rad/sec. The first two were obtained using a 2 degree command because the response was so small at the higher frequency fluid mode frequencies.

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

C/S 3-75610-79-015
Page 5

The dominant mode frequency, with full length lines, show only a weak dependence on position feedback gain. The peak frequency varies from about 85 hertz at 19.18 rad/sec down to about 80 hertz at 115.08 rad/sec. The higher frequency fluid modes are more apparent in the load pressure frequency responses.

The responses with 10-inch lines show little effect on the dominant mode frequency by the position loop gain. The peak occurs at about 85 hertz, except for the highest gain, 115.08 rad/sec, when it drops to about 82 hertz. With 10-inch lines, positon feedback gain could be raised to higher loop gain without driving the dominant mode unstable than with full length lines.

In general, results of these tests show little dependence of the dominant mode on position feedback gain, in either frequency or damping. Mode damping is hard to assess because as position loop gain is increased the first order actuator mode moves farther out on the real axis, resulting in increased response at the dominant mode frequency.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The test results discussed in Section 2, above, show that the dominant mode in the DAST ARW-1 outboard aileron response limits the dynamic performance capability of the servoactuator. Because the DAST ARW-2 outboard aileron servoactuator is similar in structure and actuator size, it will also have a dominant fluid-actuator mode of similar frequency and damping which will limit its capability.

This mode is not a strong function of line length (between the servovalve and actuator) or position feedback gain. The nature of the response does vary some with time, probably due to actuator and servovalve wear-in. The higher frequency modes increase in frequency as the line length is shortened, with the higher frequency mode above 500 hertz for 42-inch and shorter lines.

The dominant mode damping increased with a decrease in the simulated control surface inertia, but the inertia had no effect on the higher frequency fluid modes.

While the test results are not totally conclusive, the general trend shows that better dynamic performance can be attained with shorter lines between the servovalve and actuator and with lower control surface inertia. Therefore, it is recommended that the DAST ARW-2 outboard aileron servovalve be moved outboard in the wing from that shown on the design drawings to no more than 40-45 inches from the actuator between the wing spars. Also, the inertia of the outboard aileron should be reduced to the lowest value consistent with maintaining structural strength.

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

C/S 3-75610-79-015
Page 6

A more accurate mathematical representation of the outboard aileron servo-actuator should be developed to permit analytical exploration for additional electrical compensation to improve the actuator response. The data generated in this series of tests should aid in the mathematical formulation.

Other tests could be run on the breadboard test setup, such as other compensation and line diameter variations. Changing line diameter would require a change in the feedback potentiometer mounting to provide clearance for larger tube fittings at the actuator ports.

Frank Sevart

F. Sevart

CC: J. Arnold

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

TABLE I

SUMMARY OF FREQUENCY RESPONSE WITH LINE LENGTH AND LOAD INERTIA VARIATIONS BASED ON FIGURES 1 THROUGH 15

LINE LENGTH	INERTIA	DOMINANT MODE		90^o PHASE FREQUENCY (HZ)	HIGHER FREQUENCY MODES (FREQUENCY - HZ)				
		PEAK FREQUENCY (HZ)	PEAK AMPLITUDE (DEG)		SURFACE-ACTUATOR	#1 FLUID	#2 FLUID	#3 FLUID	SERVO-VALVE
FULL (84 INCHES)	FULL (0.004 IN-LB-SEC^2)	60	2.03	51	---	160	380	---	---
FULL	HALF (0.002 IN-LB-SEC^2)	62	1.54	50	---	130	380	---	---
FULL	NONE	50	1.14	52	---	140	380	---	---
3/4 (63 INCHES)	FULL	46	1.69	43	---	185	460	145	---
3/4	HALF	44	1.58	43	---	185	460	145	---
3/4	NONE	42	1.46	44	---	185	460	145	---
1/2 (42 INCHES)	FULL	52	1.73	46	105	230	---	---	---
1/2	HALF	50	1.45	47	115	230	---	---	---
1/2	NONE	48	1.35	49	---	230	---	---	---
1/4 (21 INCHES)	FULL	50	1.61	50	115	330	---	---	---
1/4	HALF	54	1.41	53	---	340	---	---	---
1/4	NONE	52	1.31	55	---	340	---	---	---
10 INCHES	FULL	60	1.62	56	115	430	---	---	230
10 INCHES	HALF	56	1.33	55	---	430	---	---	230
10 INCHES	NONE	54	1.20	59	---	410	---	---	230

NOTE: Position and pressure feedback gains held constant. Input amplitude 1.00 deg. Position loop gain 329.6 rad/sec, pressure loop gain 0.5678 rad/sec.

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

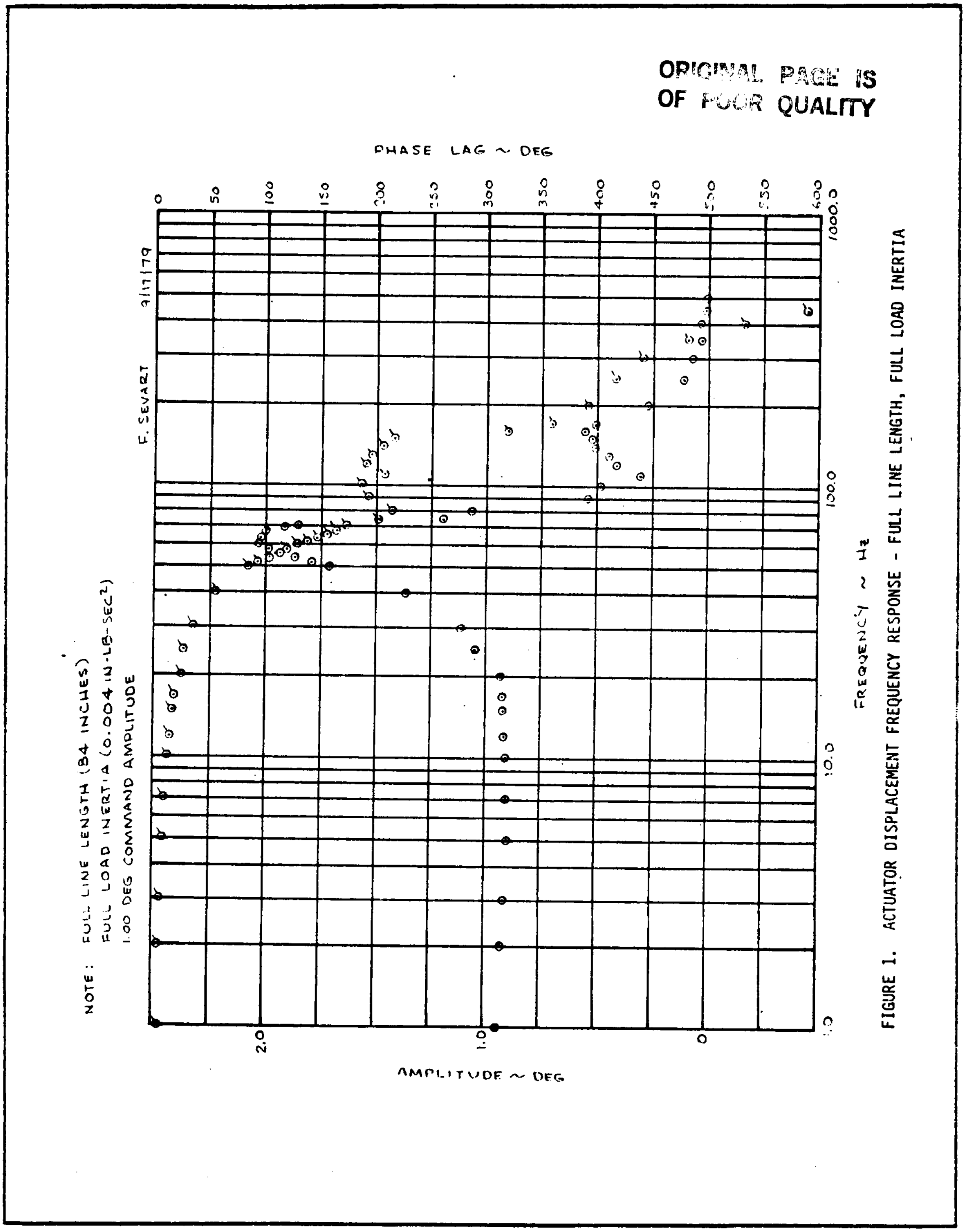

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

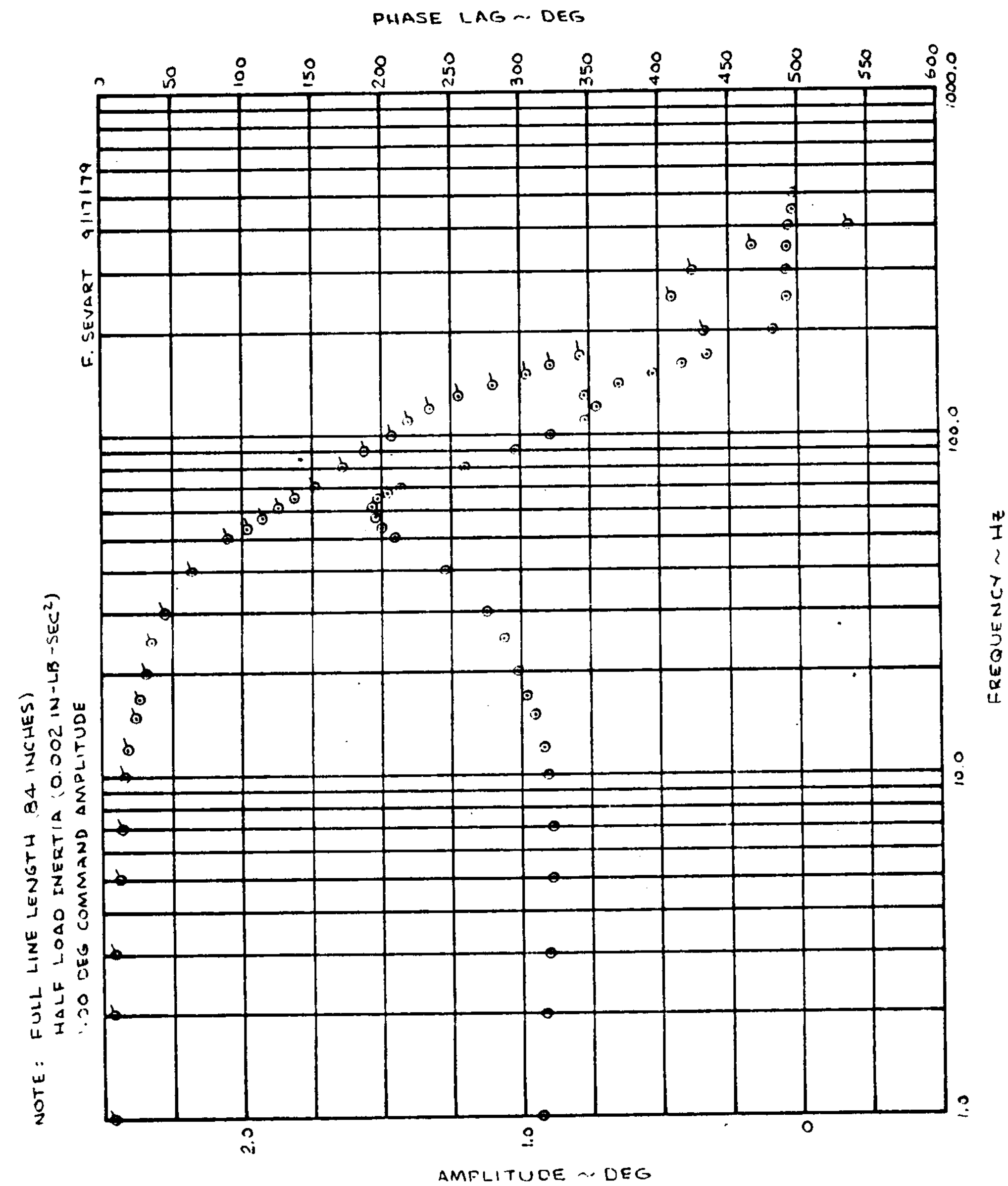

FIGURE 2. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, HALF LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

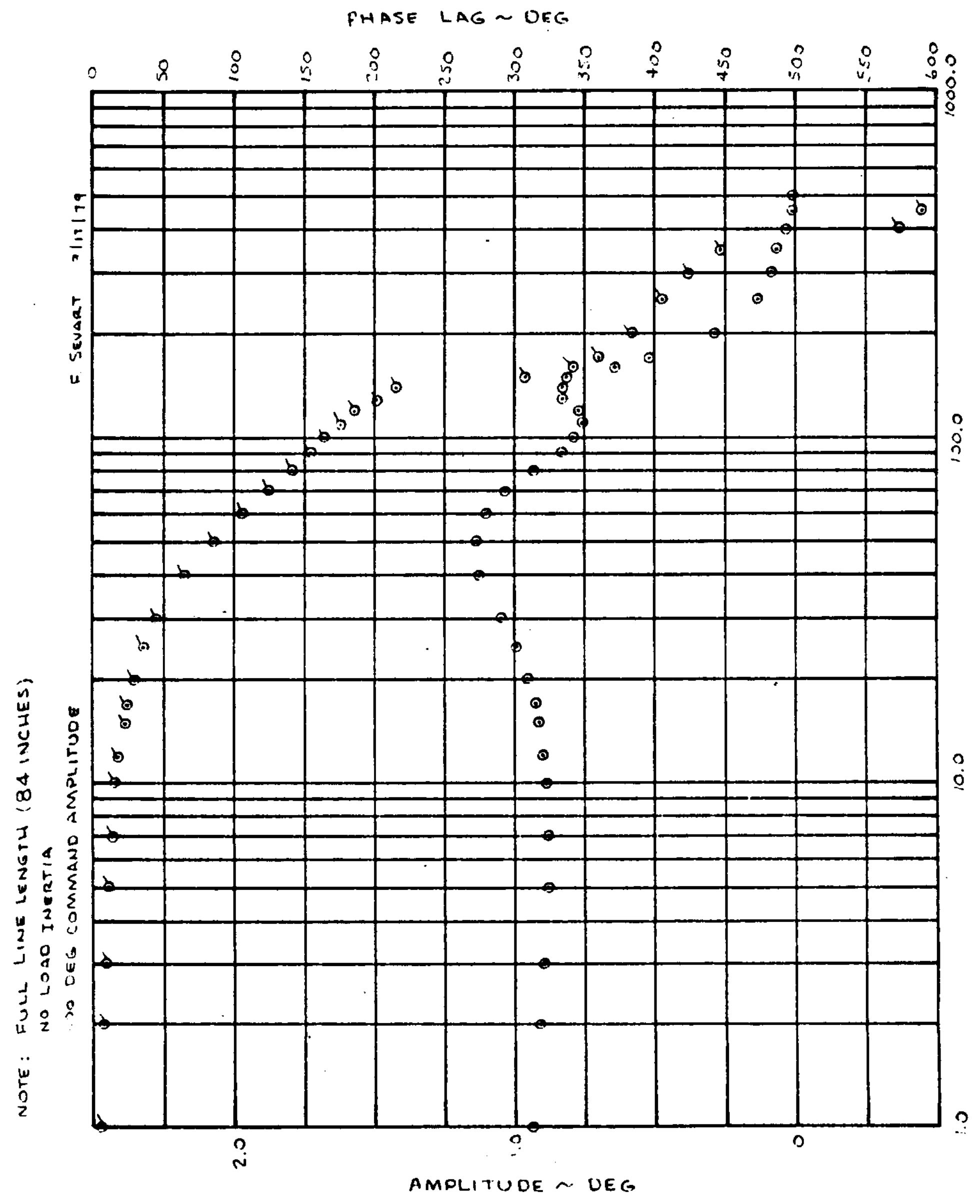

FIGURE 3. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, NO LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

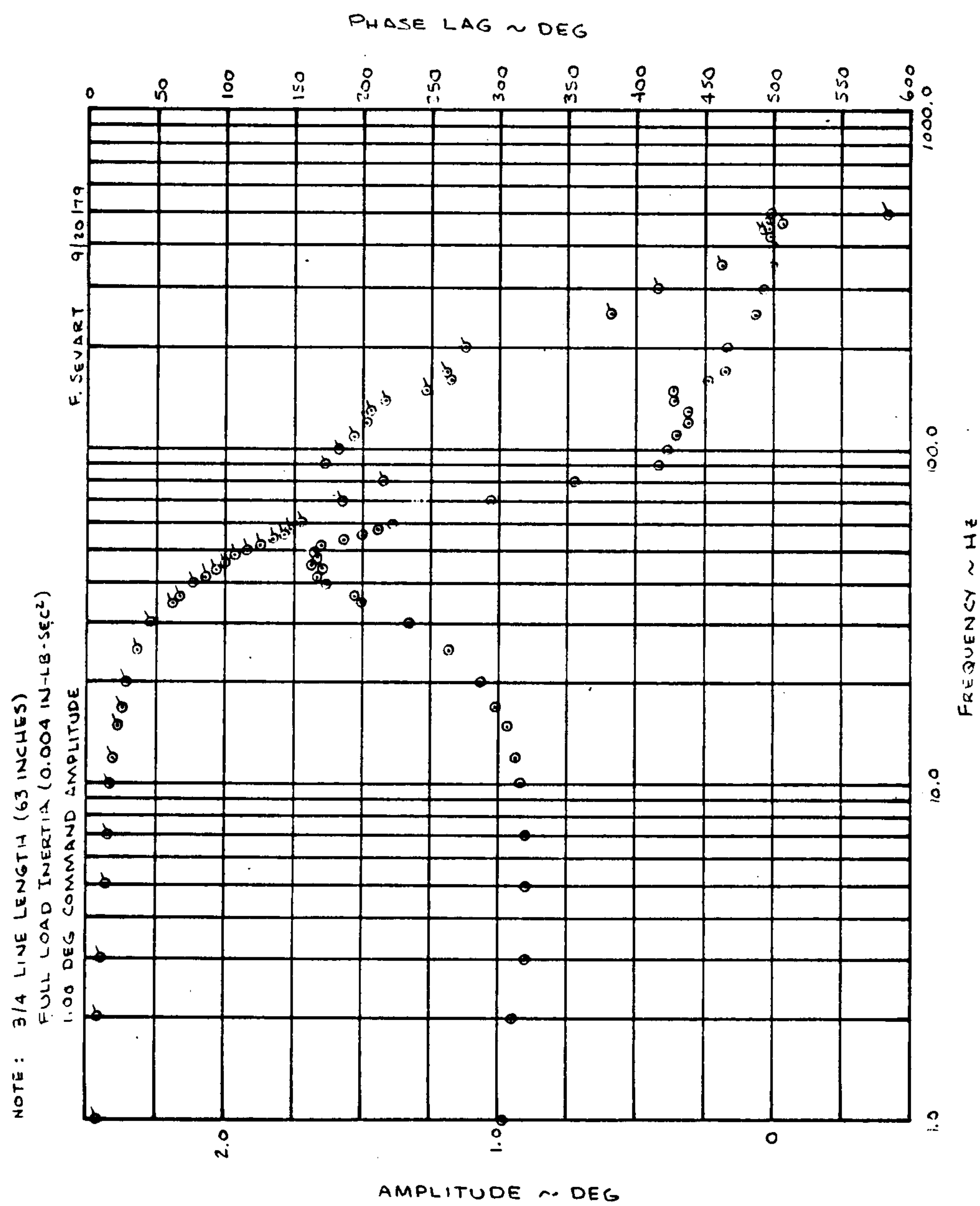

FIGURE 4. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - THREE-QUARTER LINE LENGTH, FULL LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

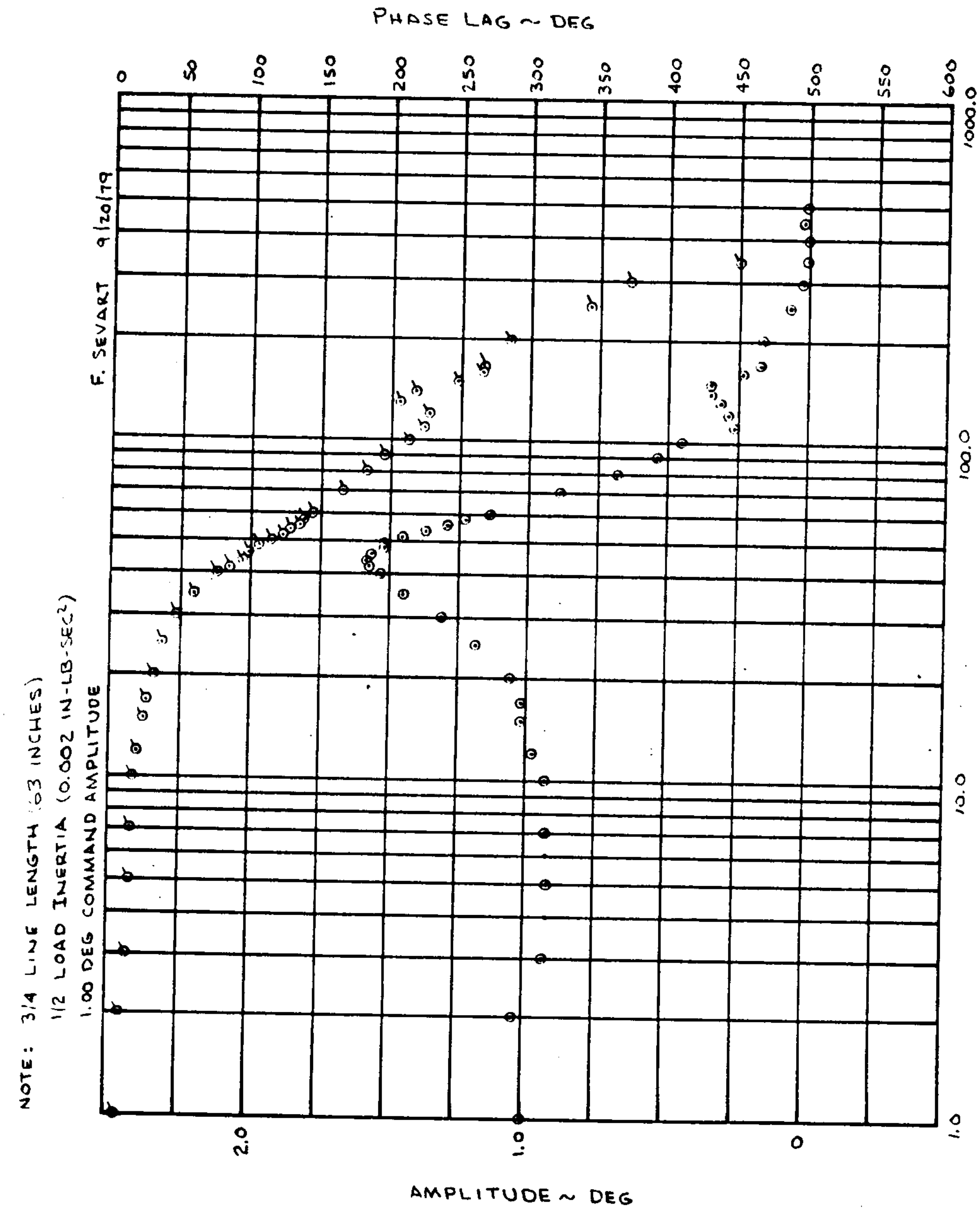

FIGURE 5. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - THREE-QUARTER LINE LENGTH, HALF LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

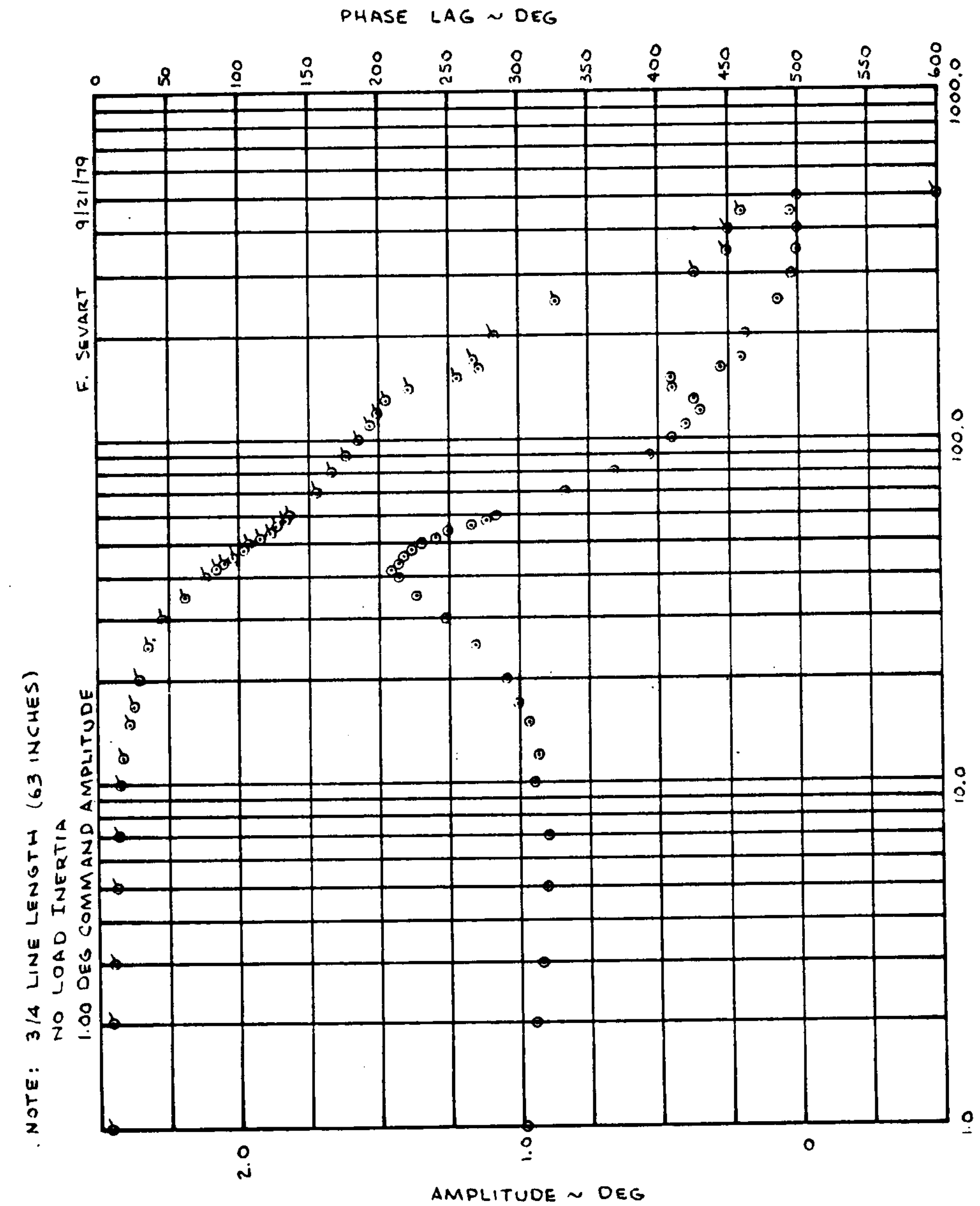

FIGURE 6. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - THREE-QUARTER LINE LENGTH, NO LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

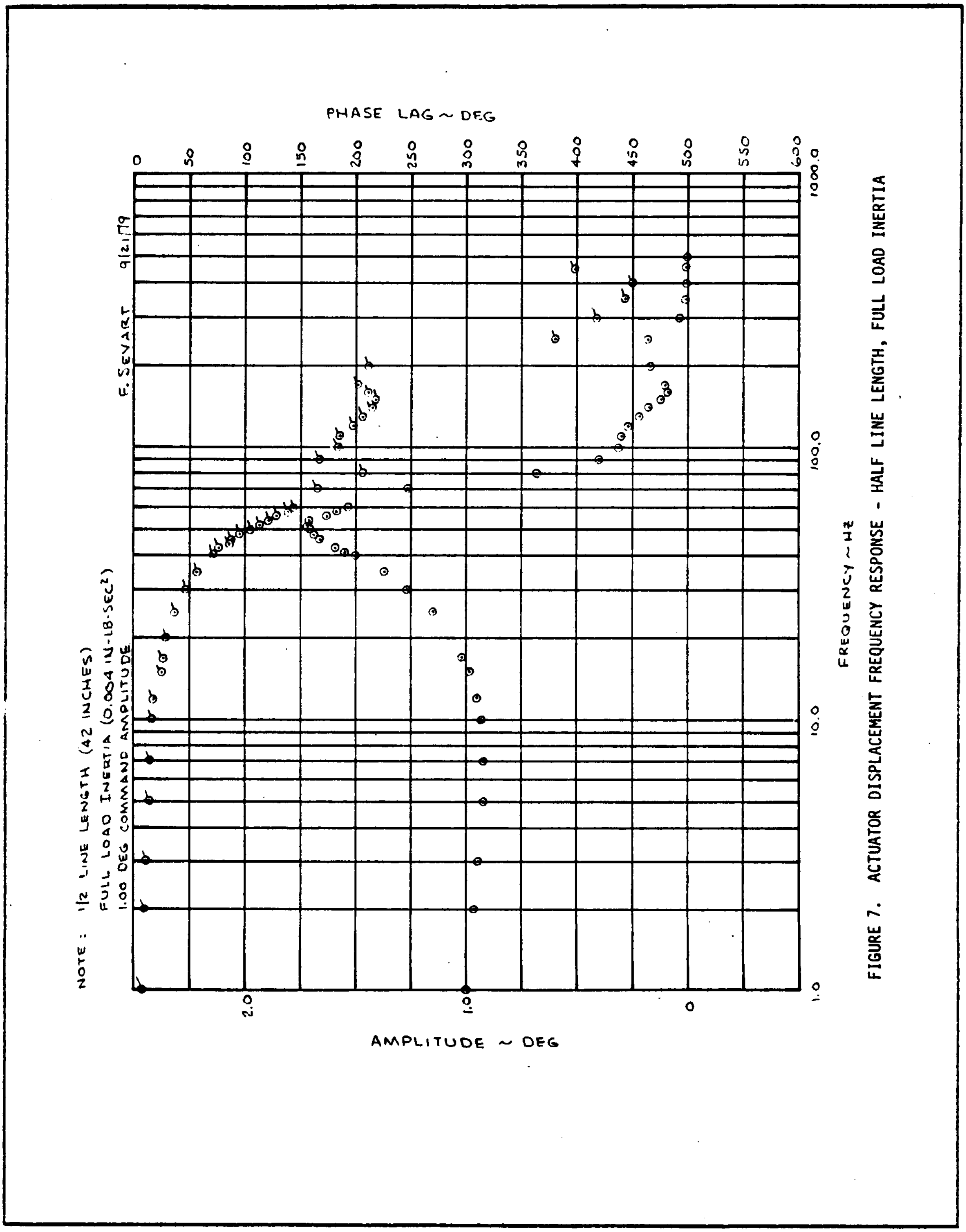

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

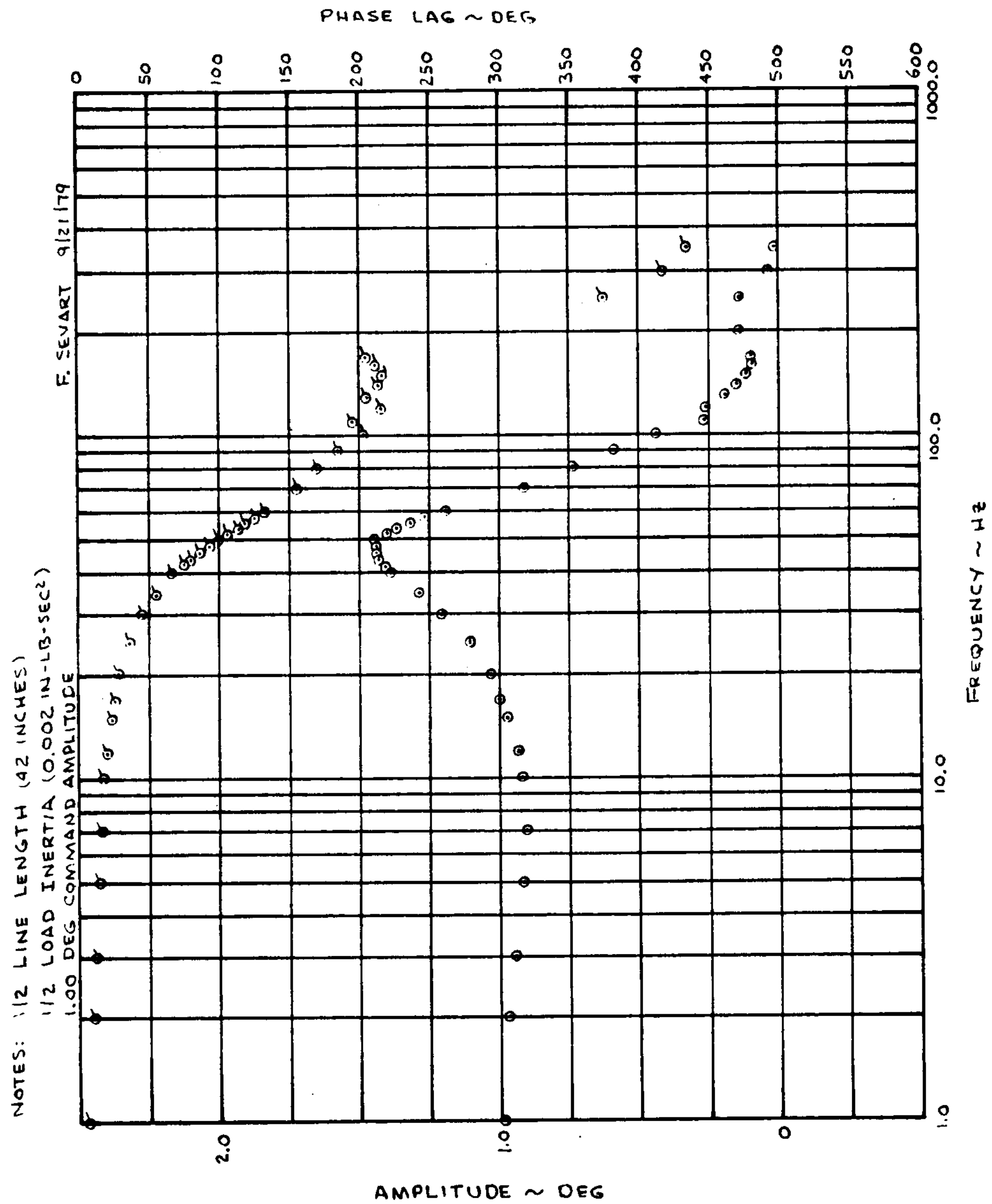

FIGURE 8. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - HALF LINE LENGTH, HALF LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

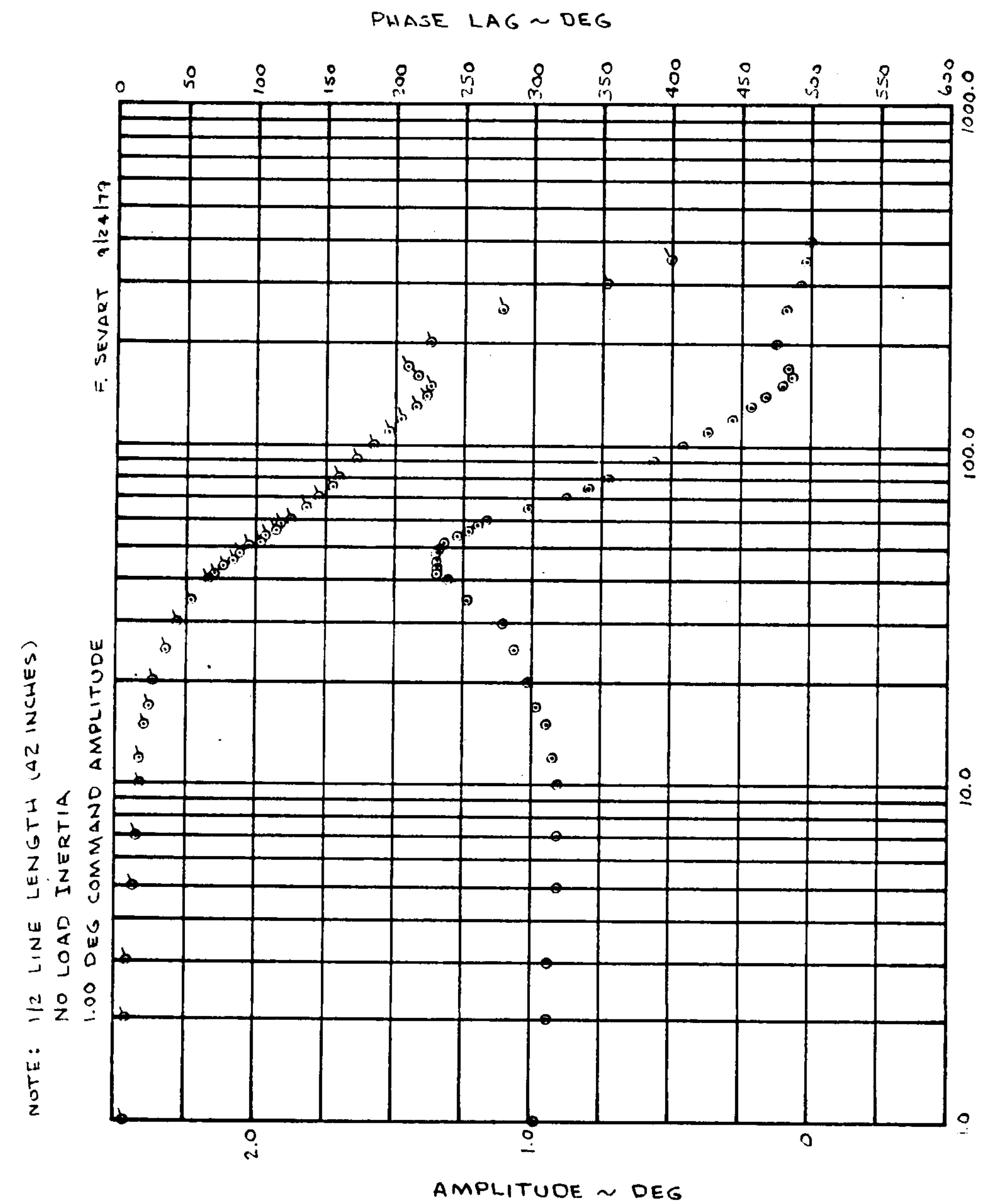

FIGURE 9. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - HALF LINE LENGTH, NO LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

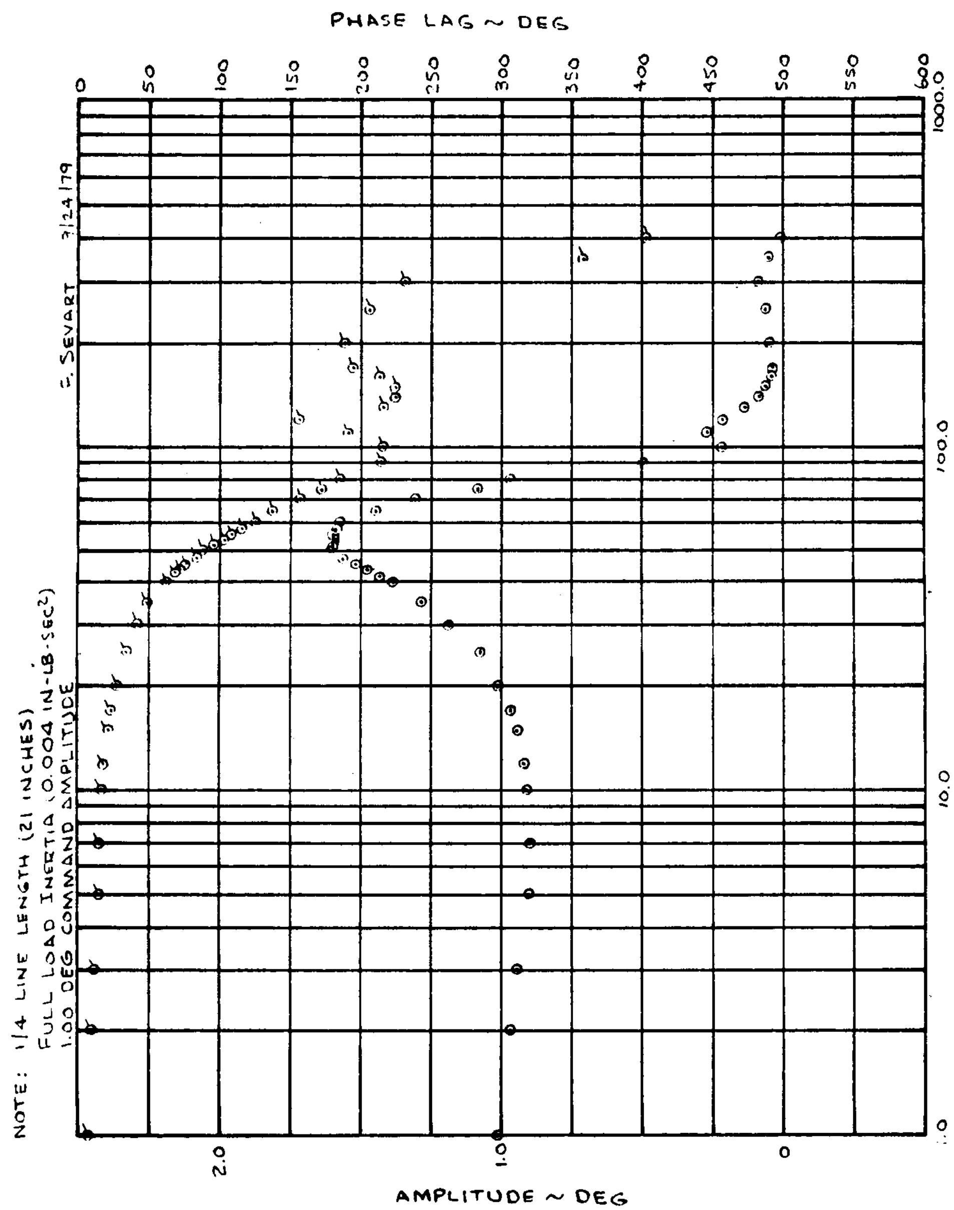

FIGURE 10. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - ONE-QUARTER LINE LENGTH, FULL LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

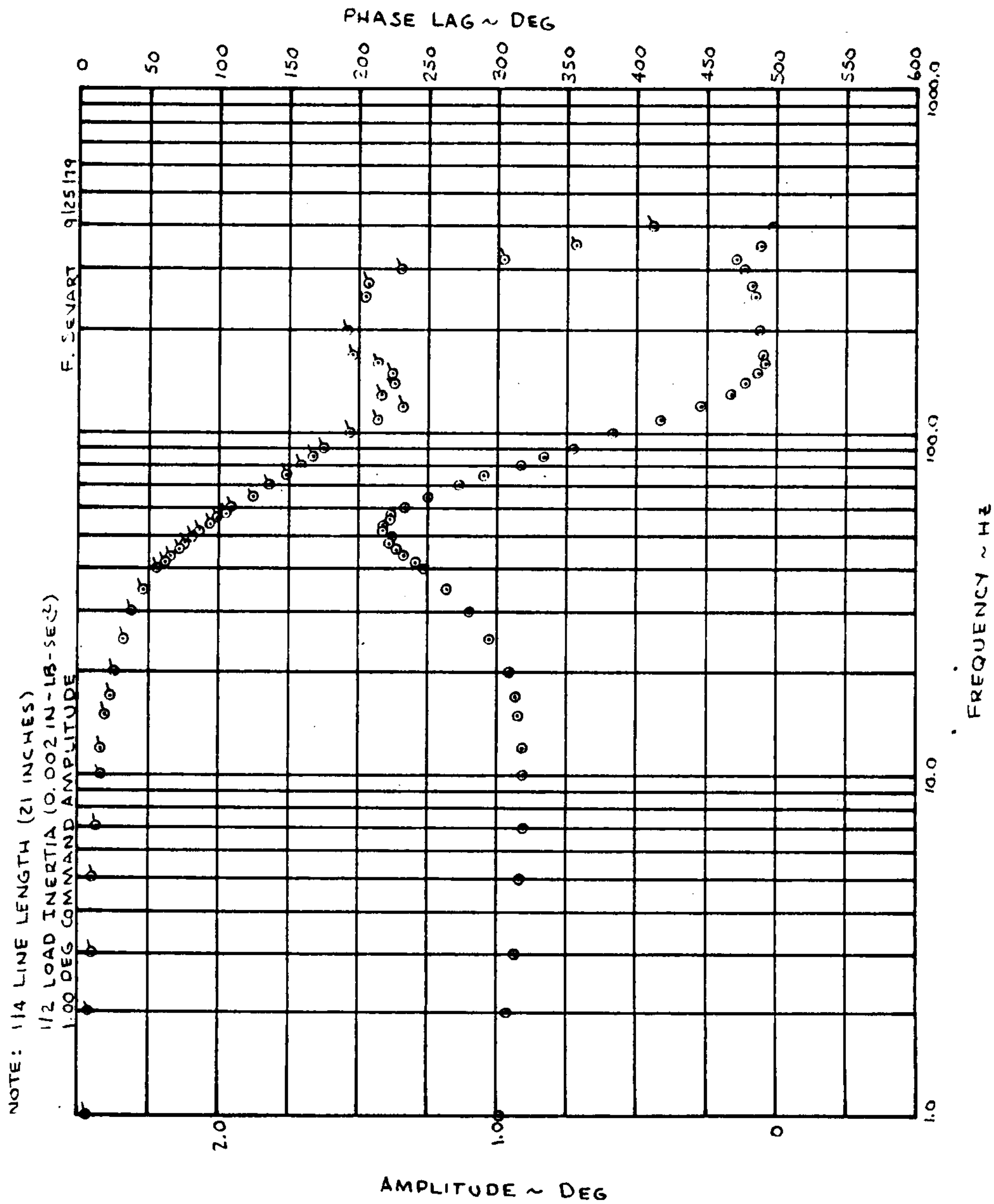

FIGURE 11. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - ONE-QUARTER LINE LENGTH, HALF LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

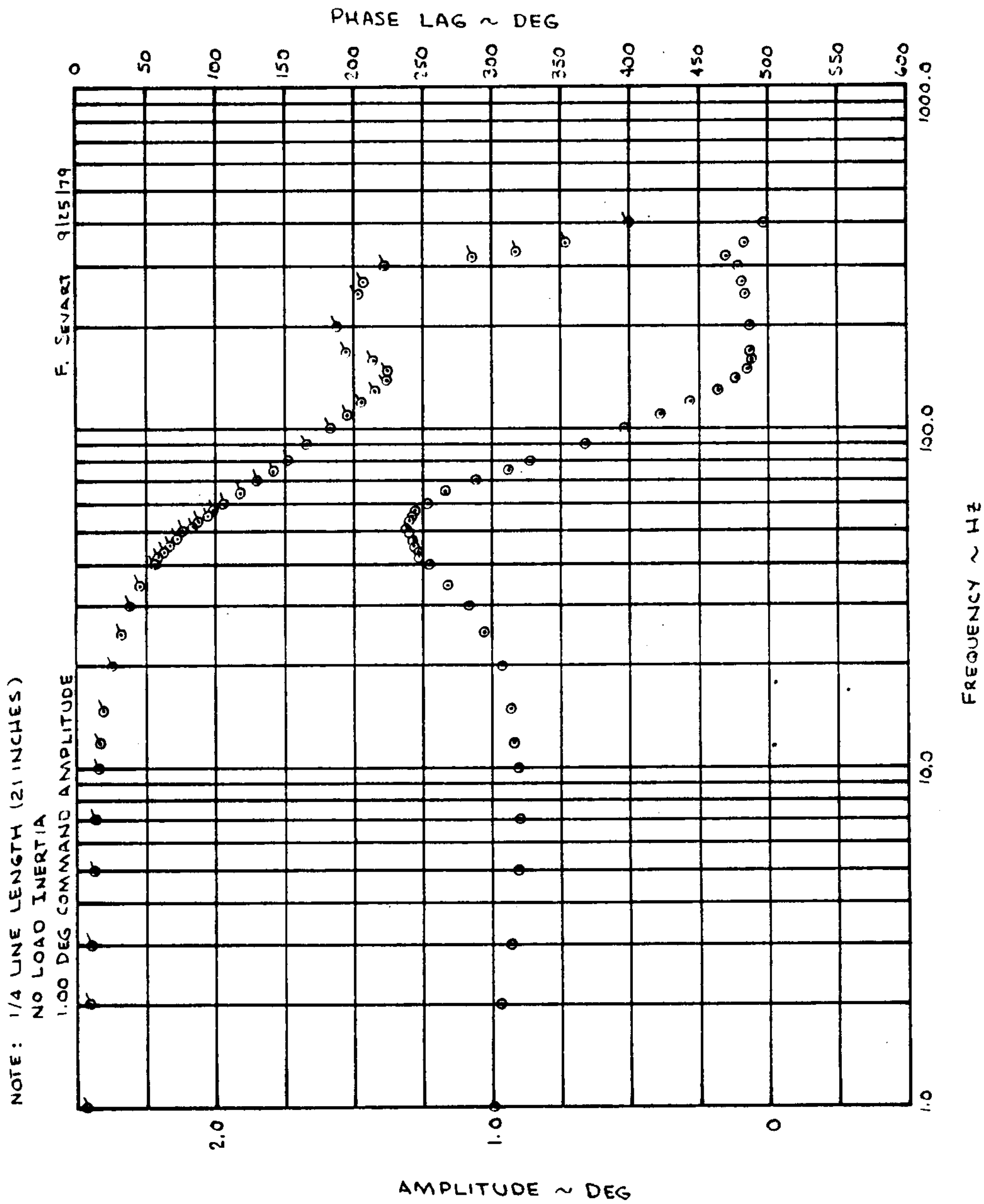

FIGURE 12. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - ONE-QUARTER LINE LENGTH, NO LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

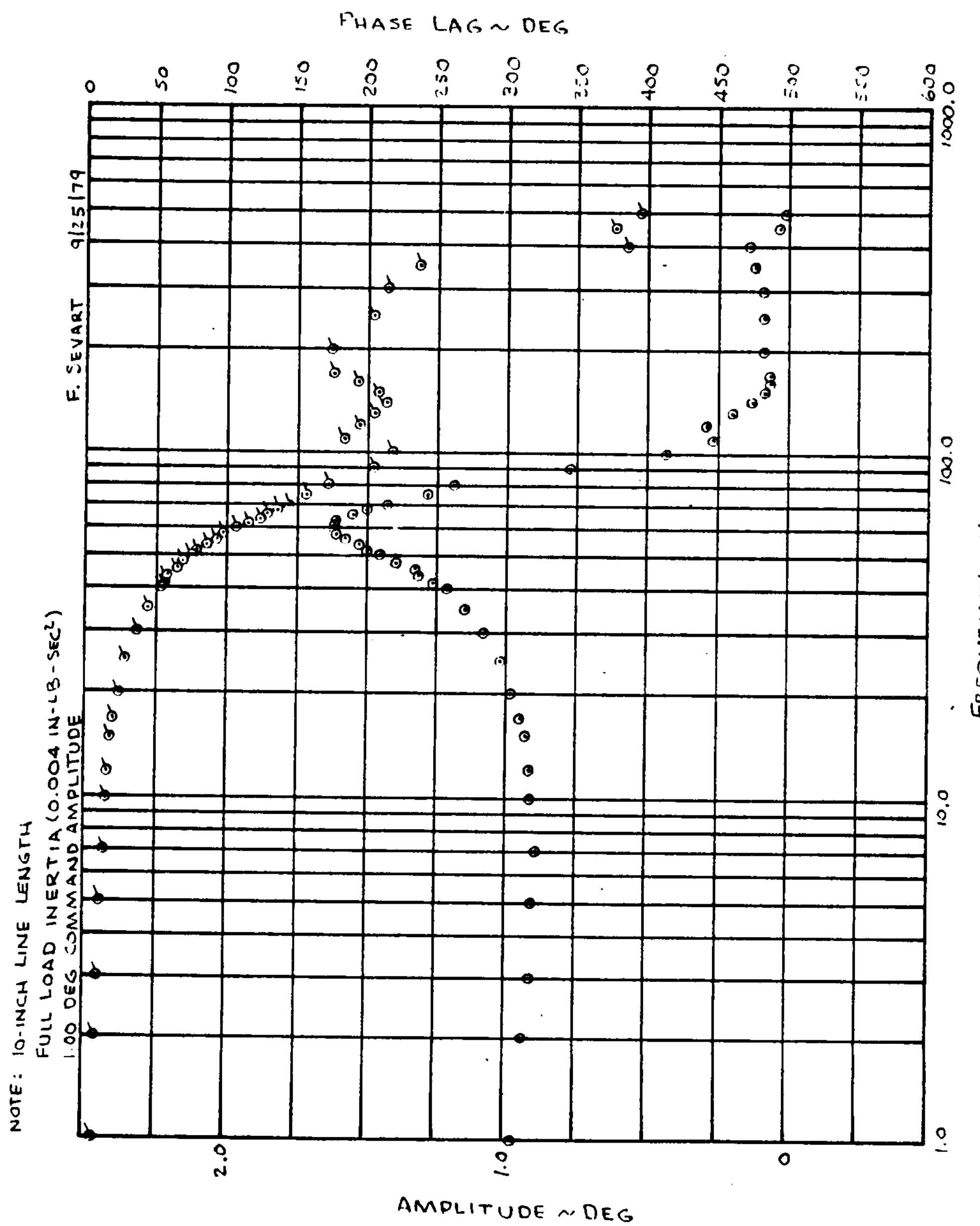

FIGURE 13. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

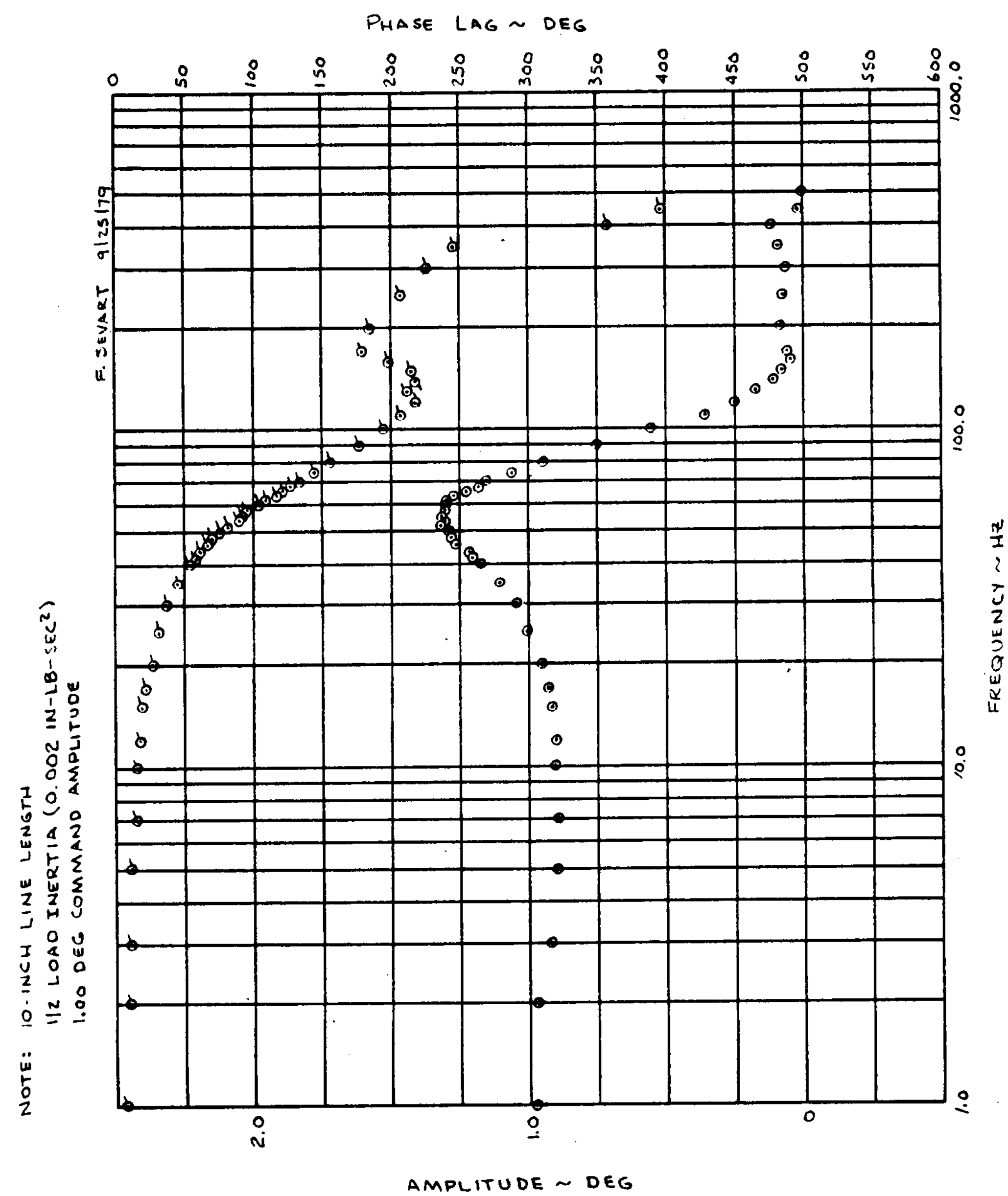

FIGURE 14. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, HALF LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

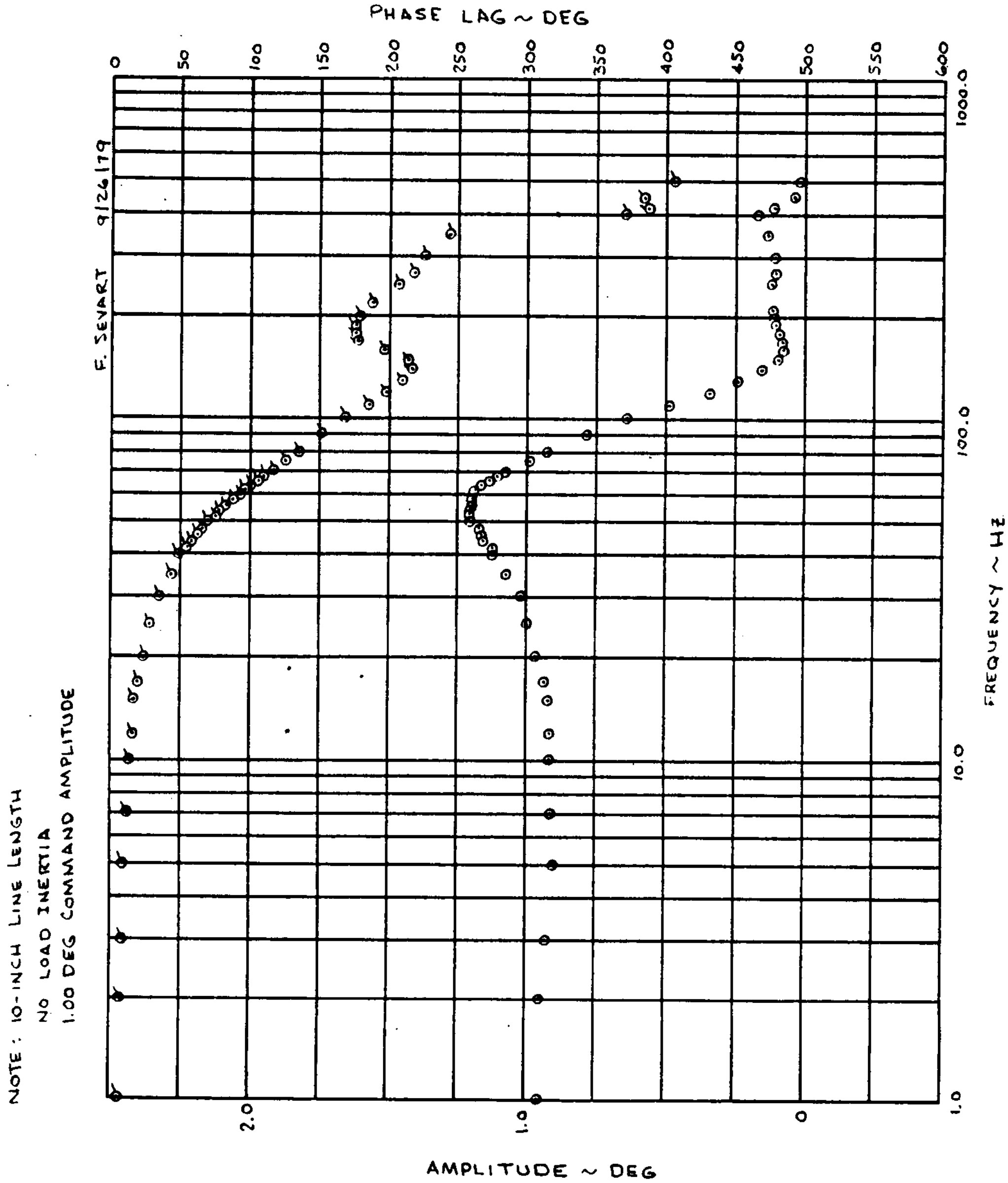

FIGURE 15. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, NO LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

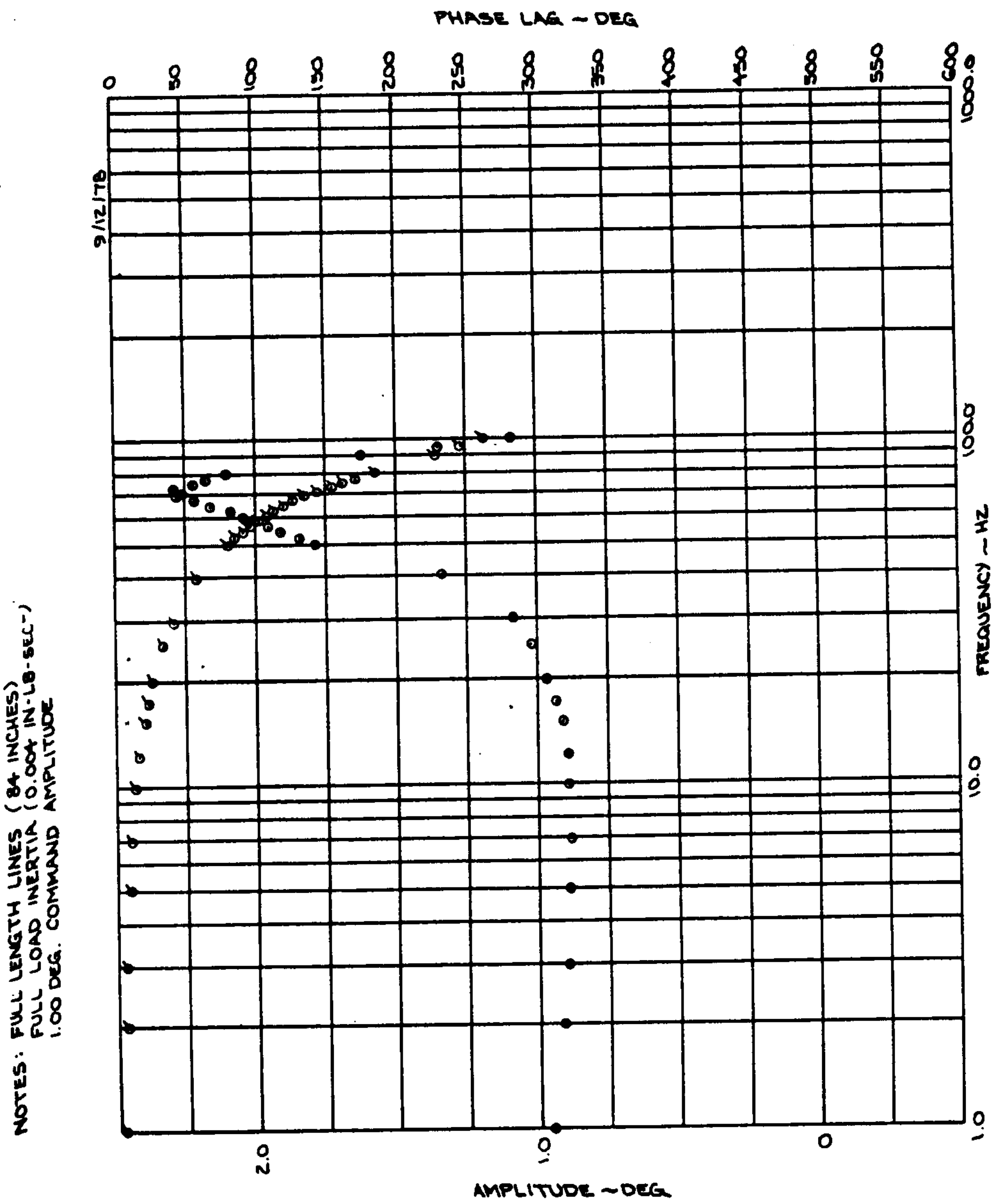

FIGURE 16. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, SEPT. 1978

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

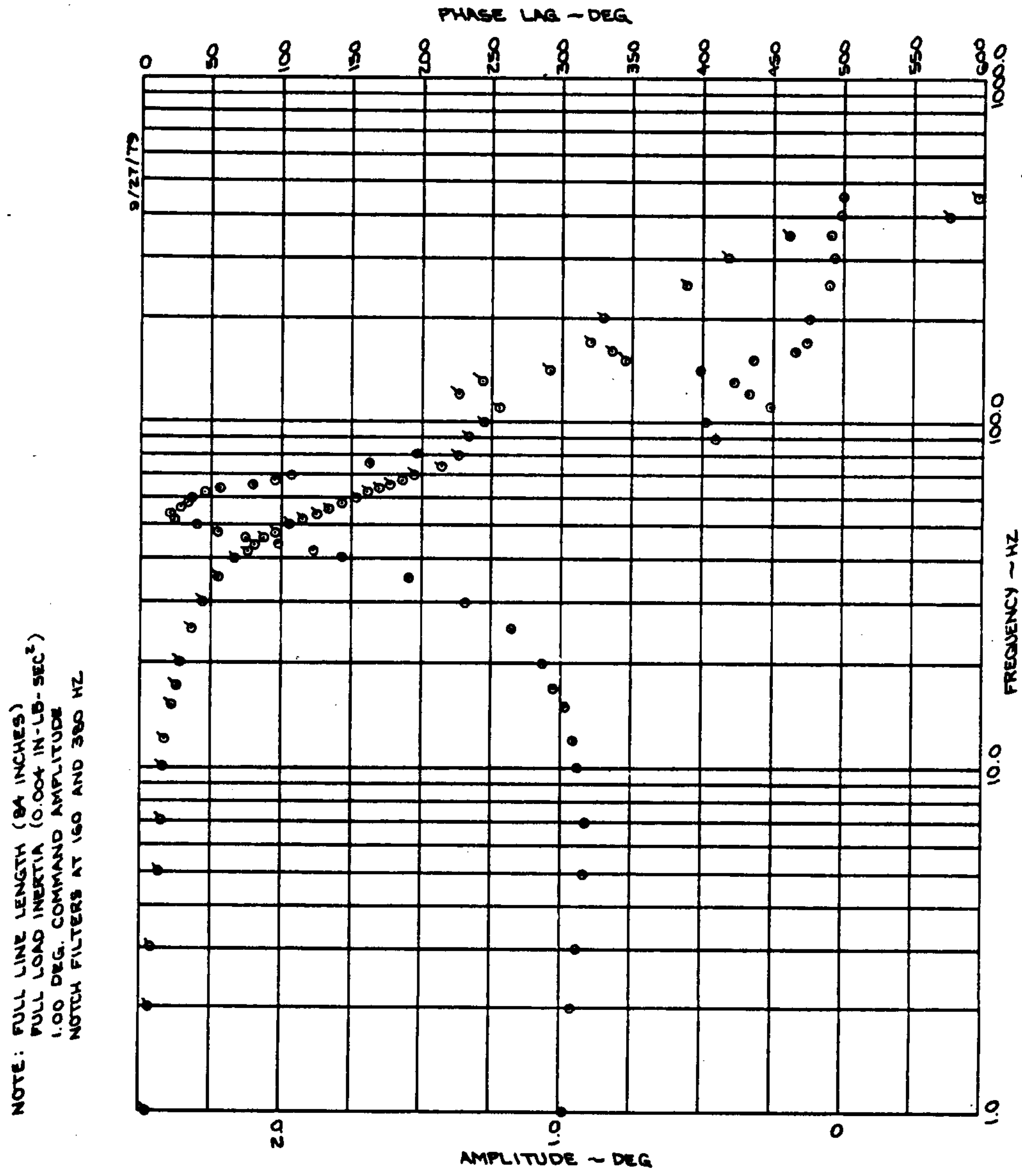

FIGURE 17. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

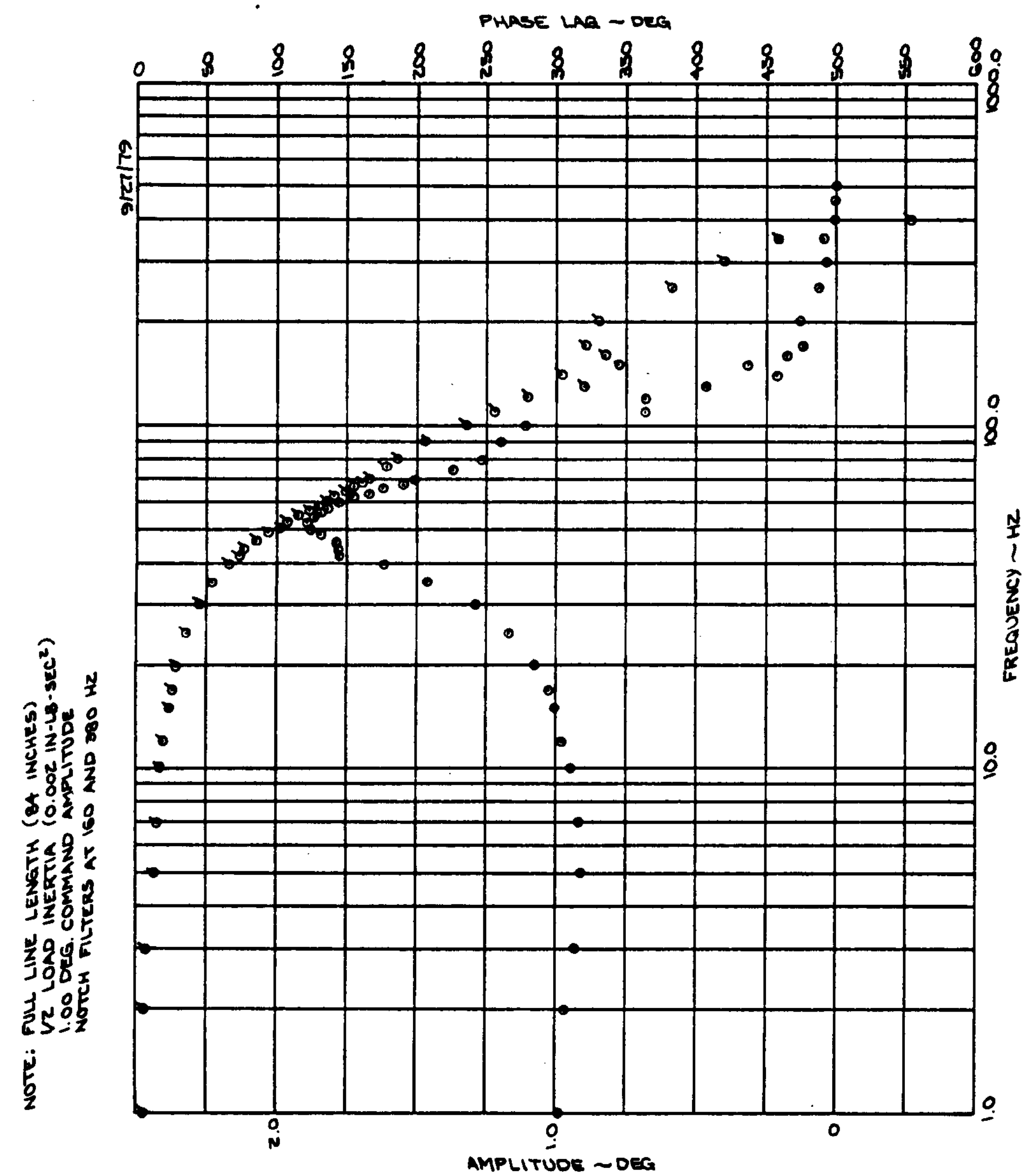

FIGURE 18. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, HALF LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

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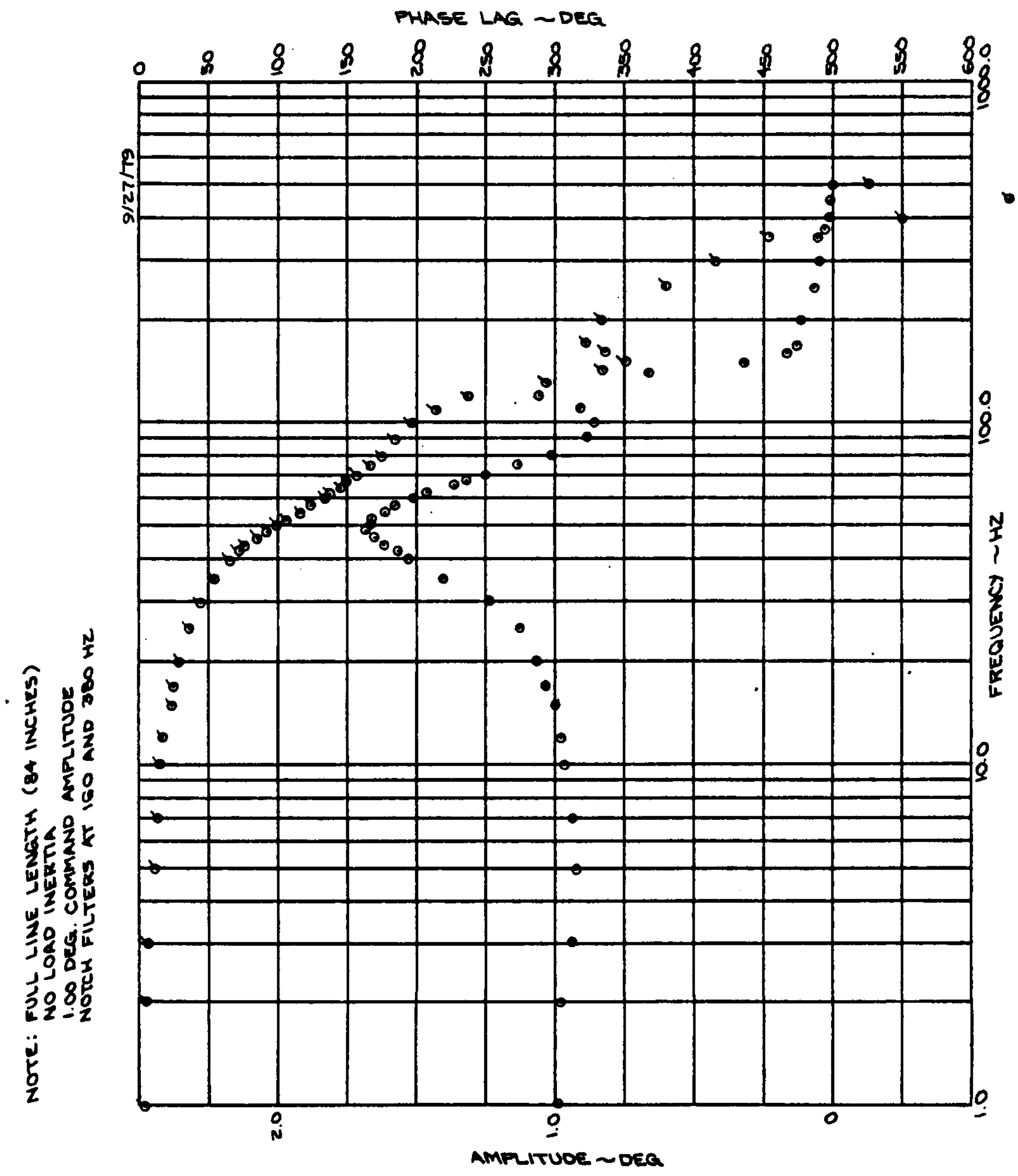


FIGURE 19. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, NO LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

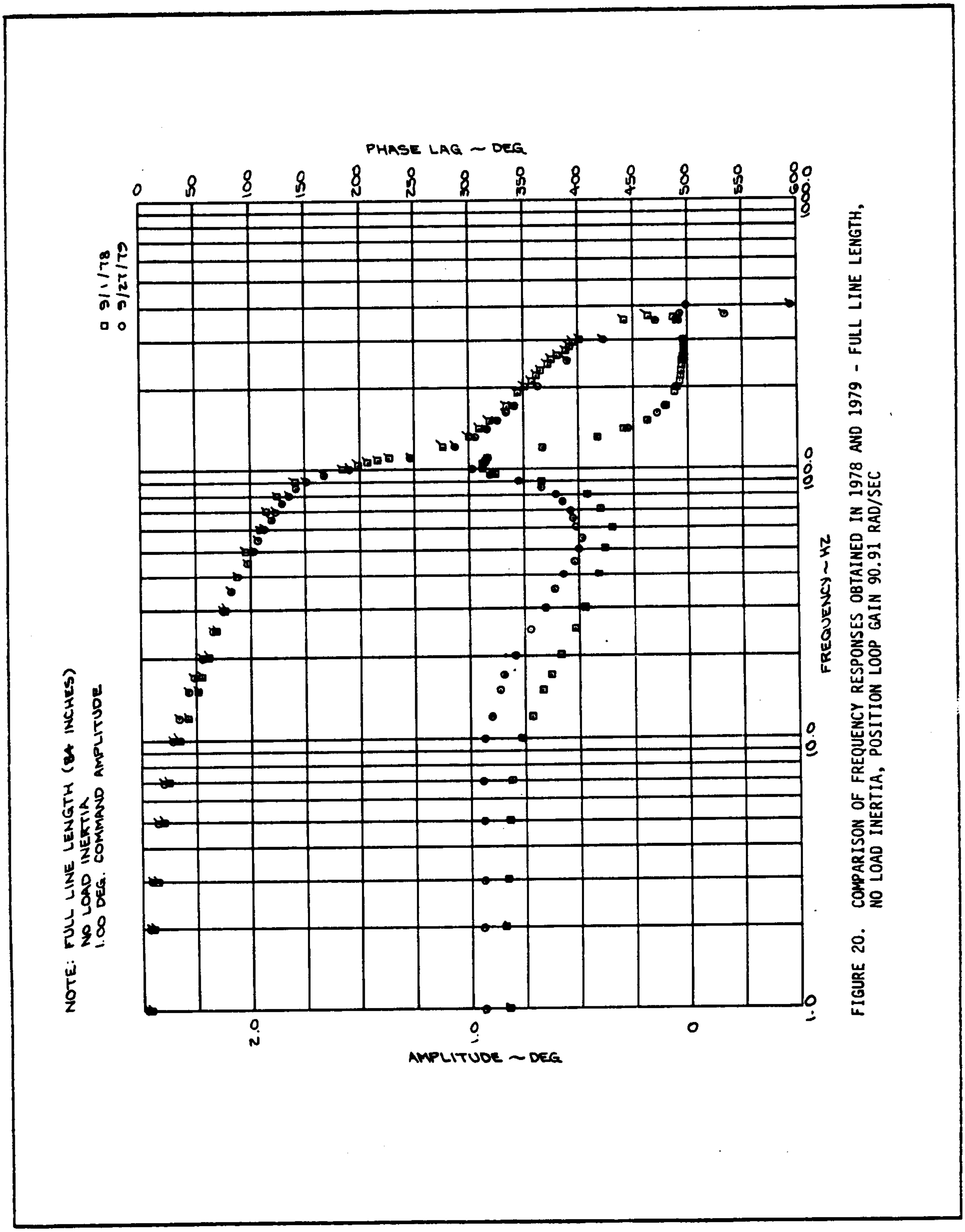


FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

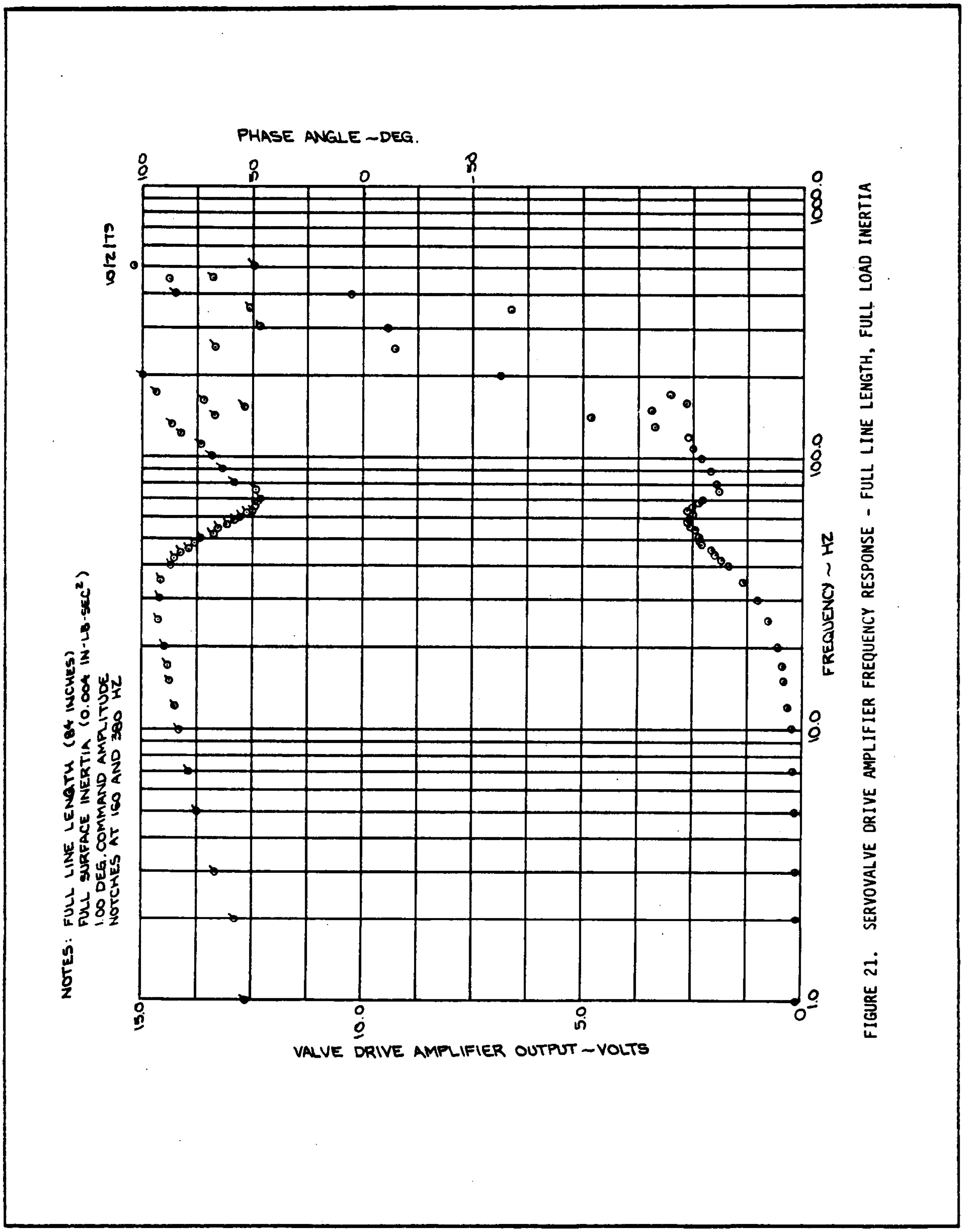


FIGURE 21. SERVOVALVE DRIVE AMPLIFIER FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

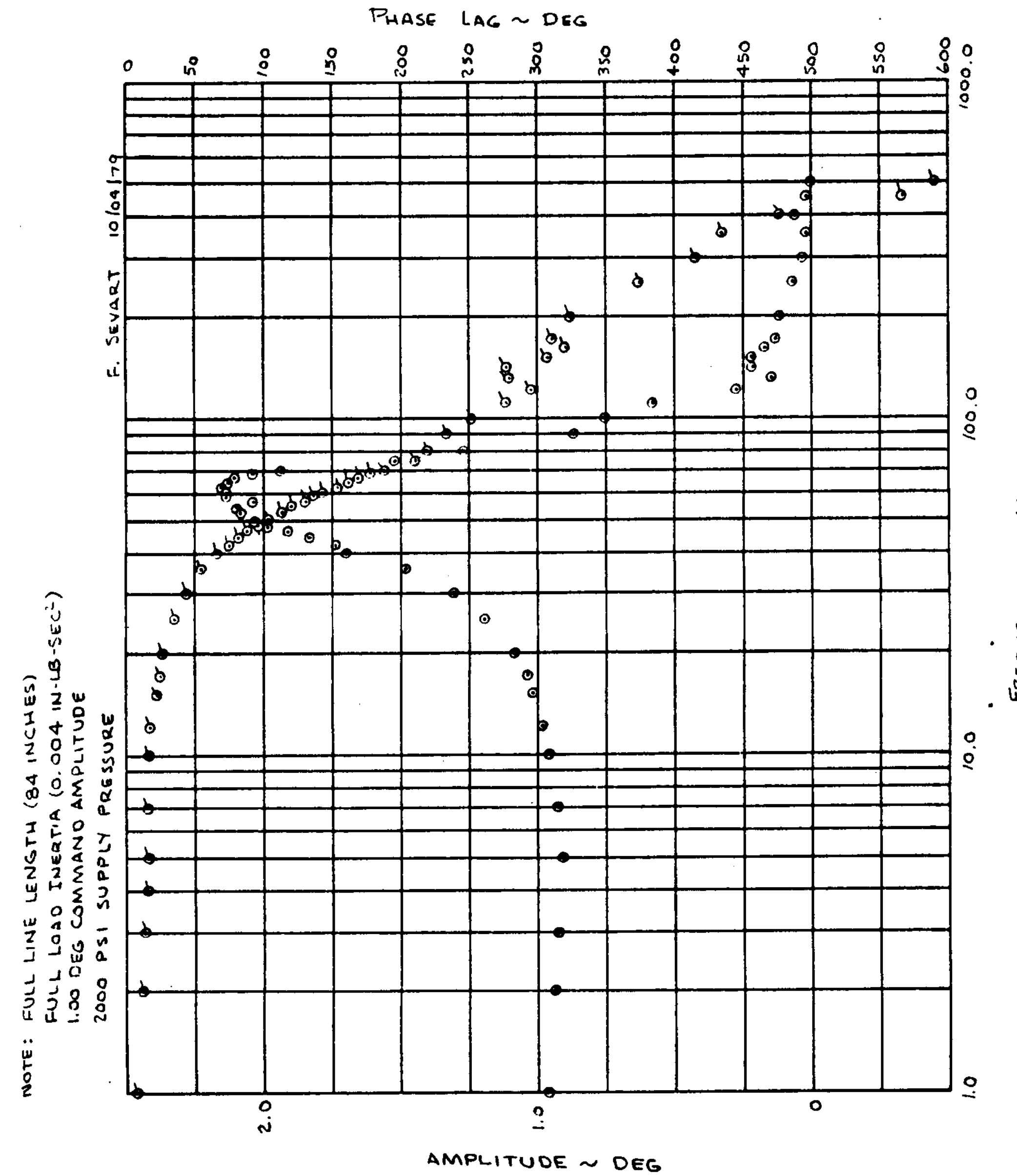


FIGURE 22. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, 2000 PSI SUPPLY PRESSURE

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

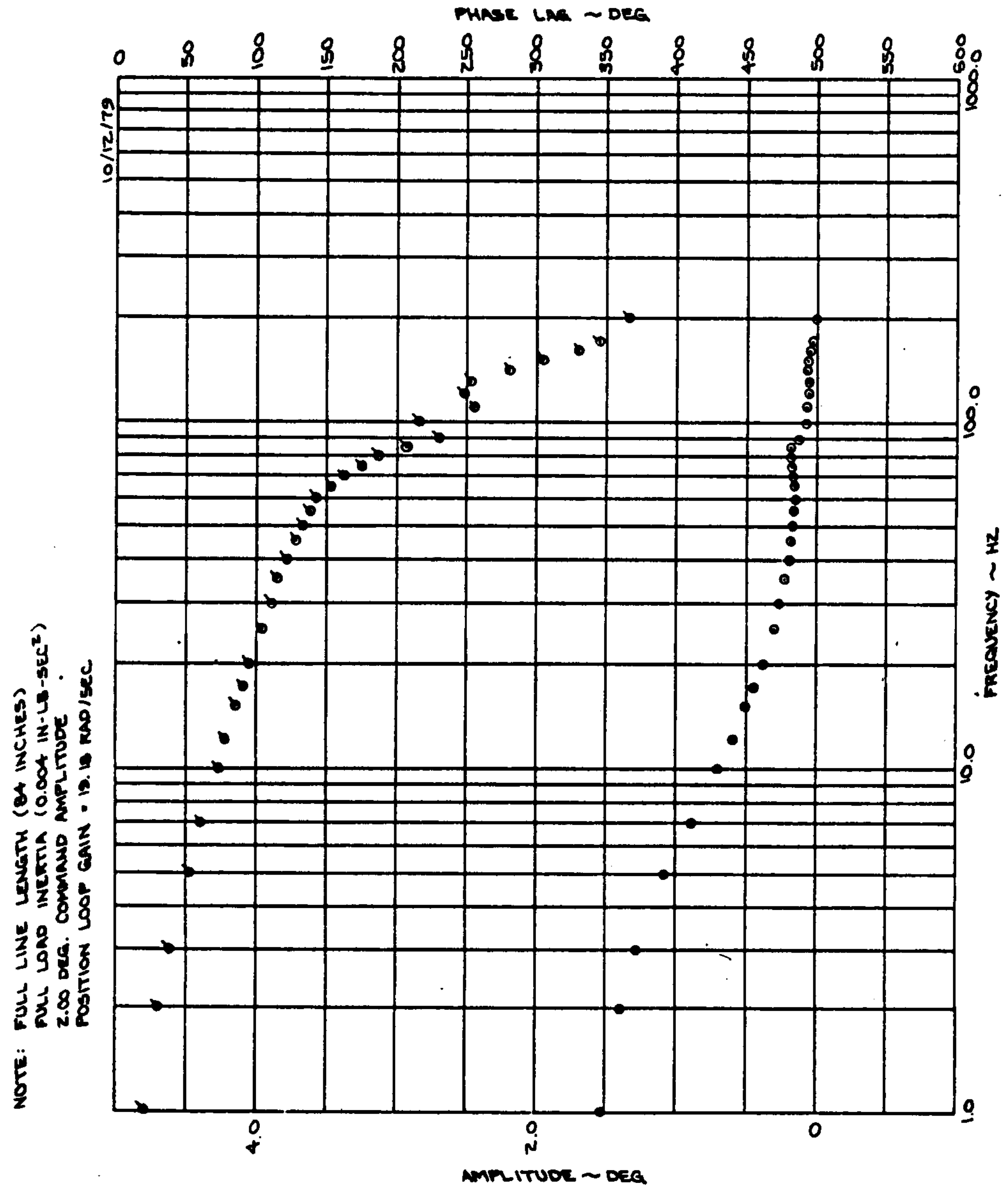


FIGURE 23. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 19.18 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

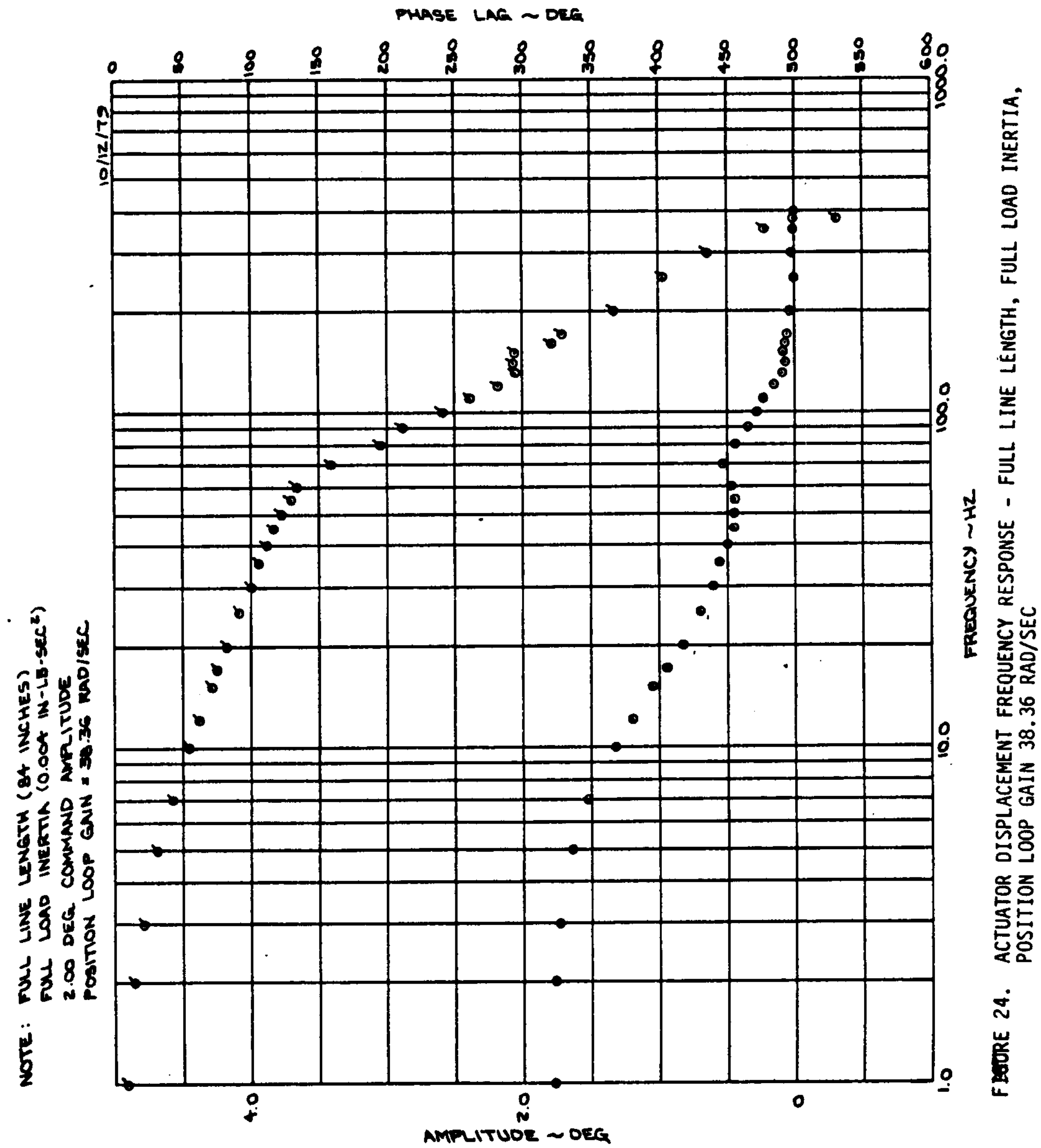


FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

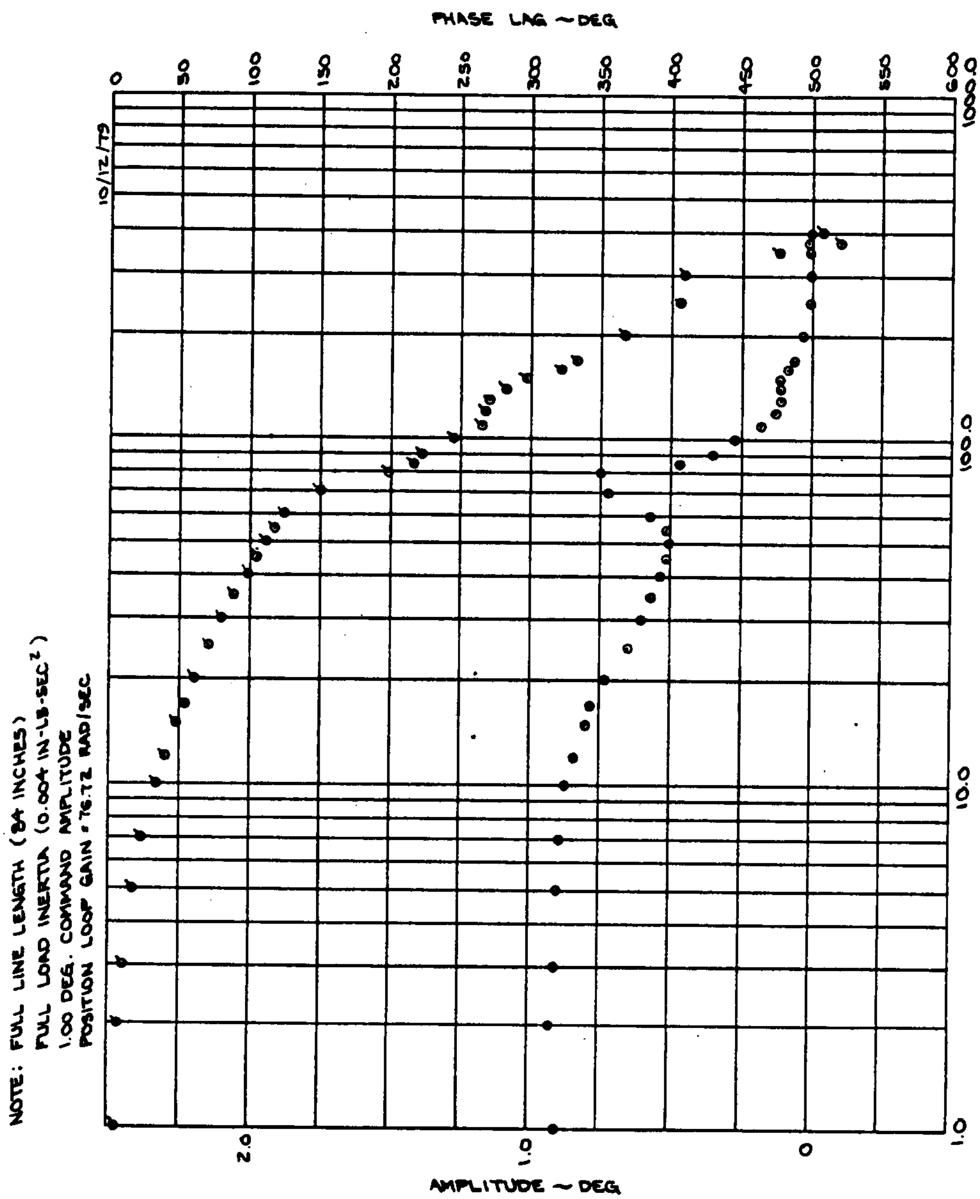


FIGURE 25. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 76.72 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

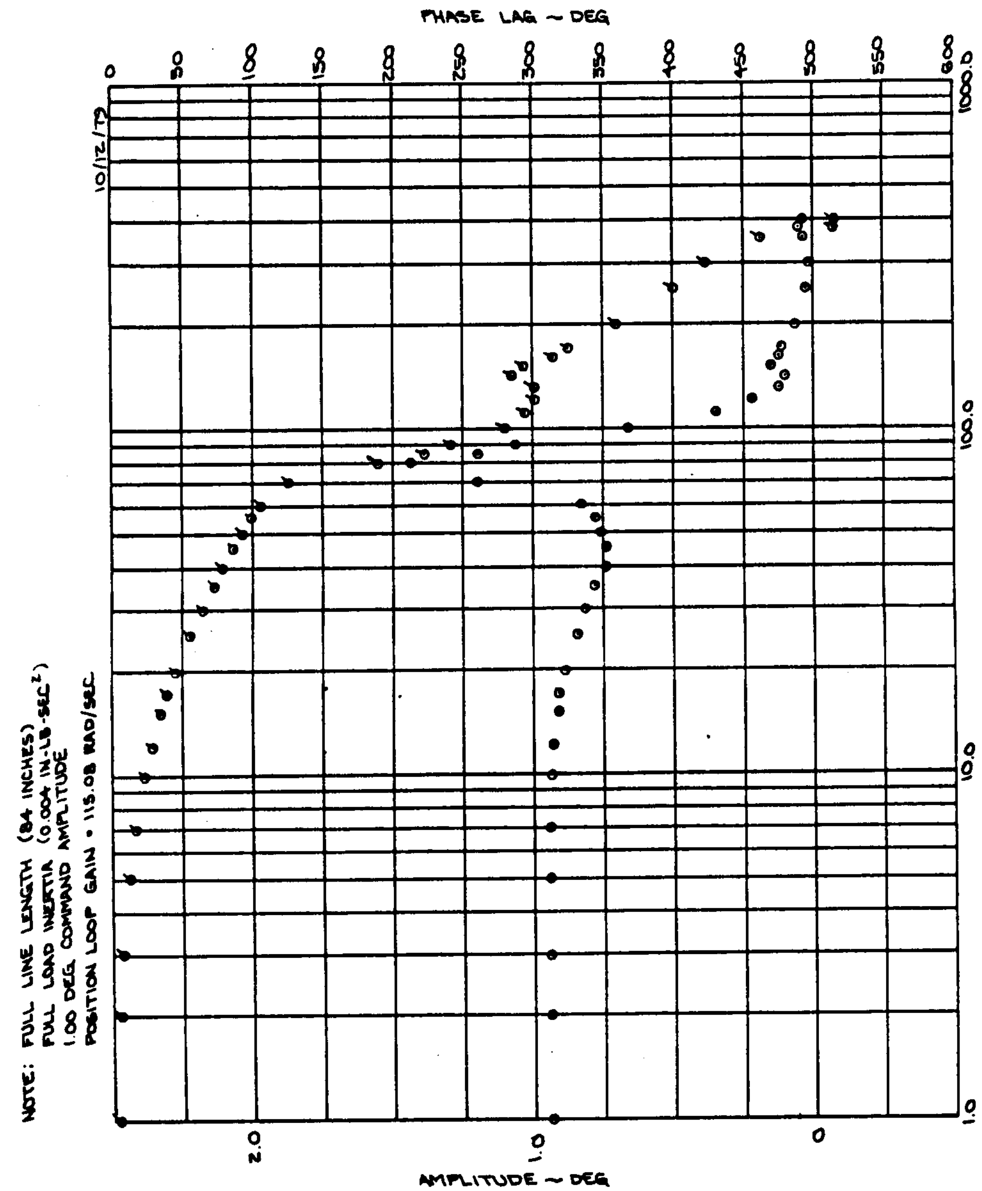


FIGURE 26. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 115.08 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

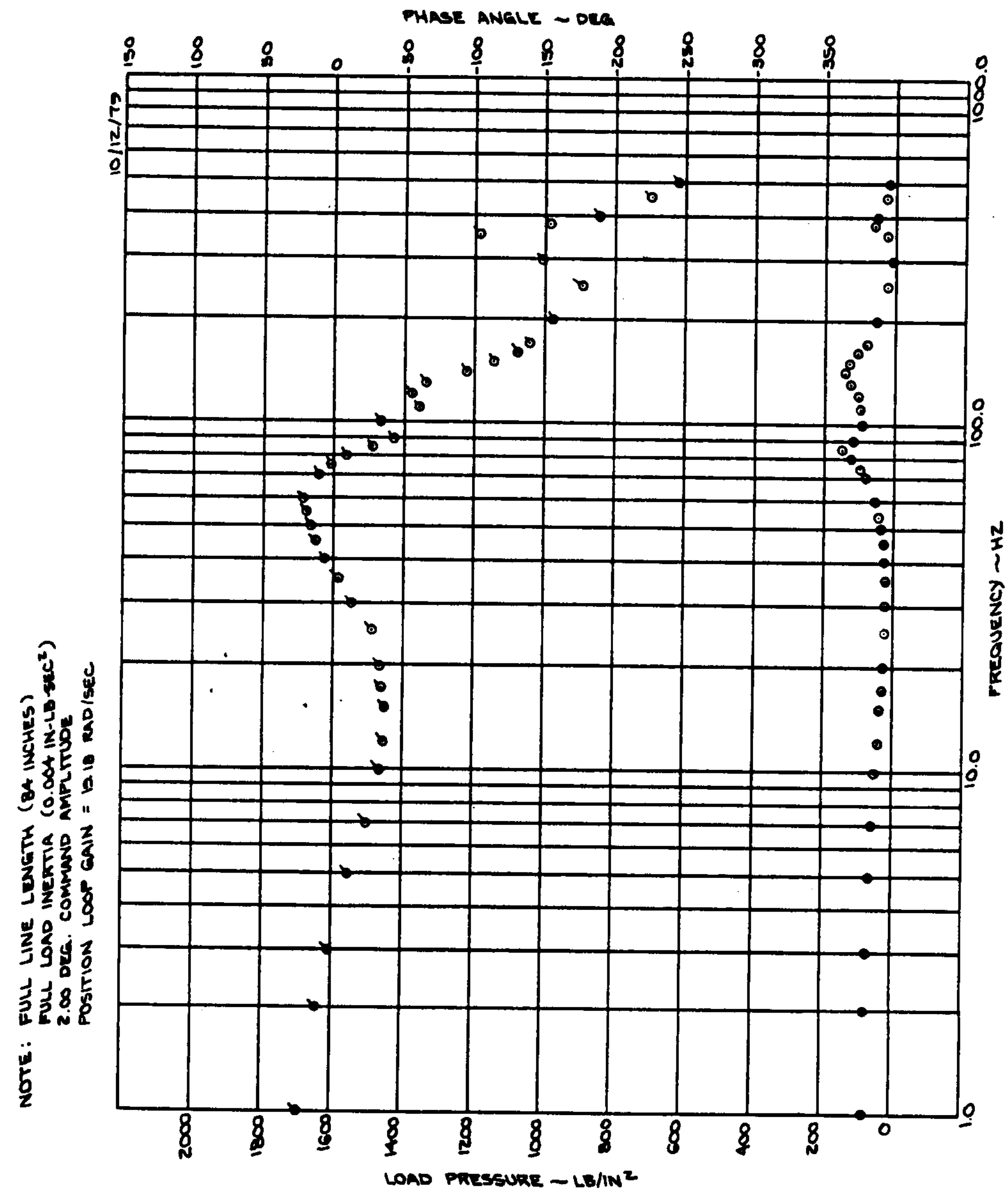


FIGURE 27. LOAD PRESSURE FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 19.18 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

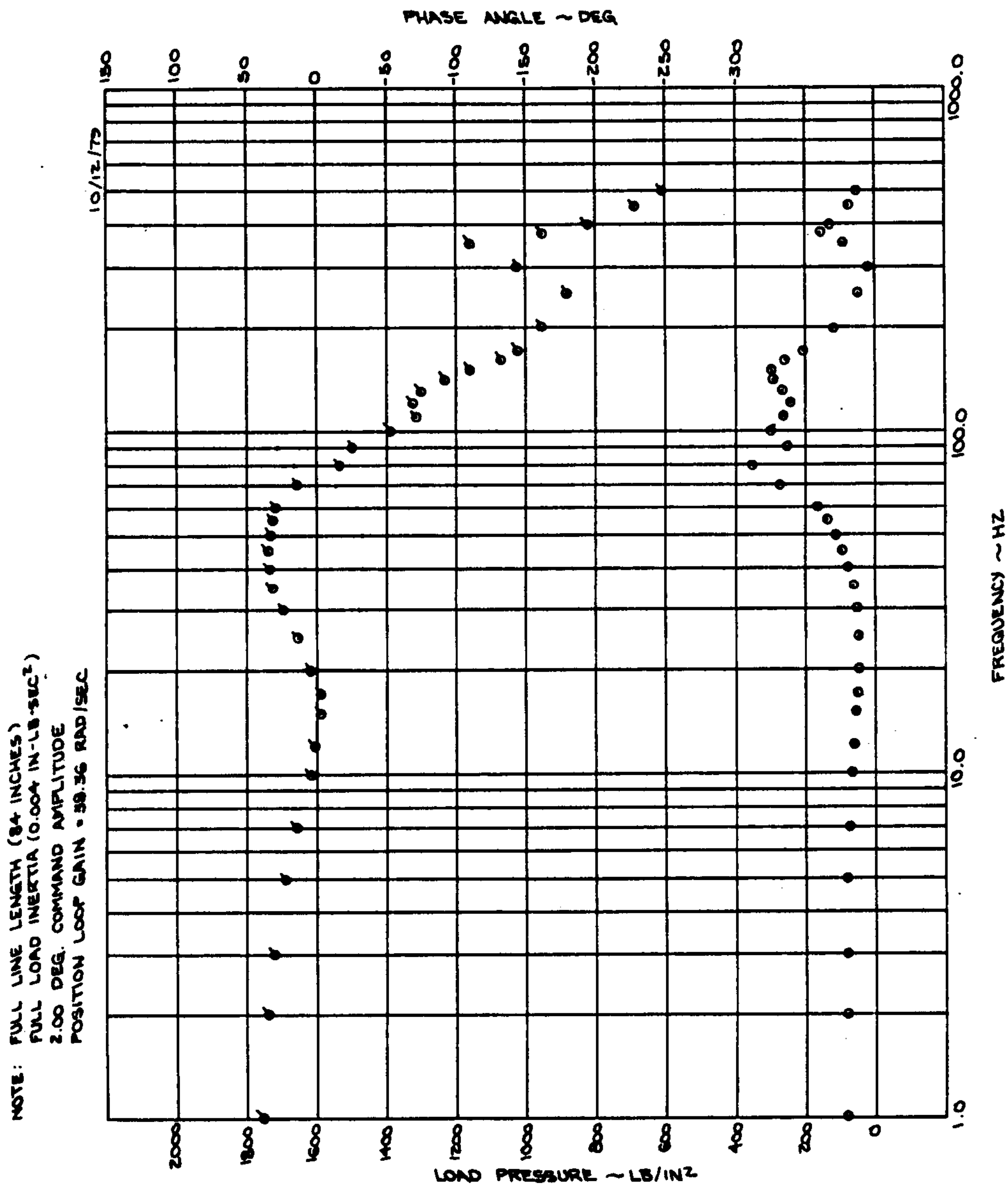


FIGURE 28. LOAD PRESSURE FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 38.36 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

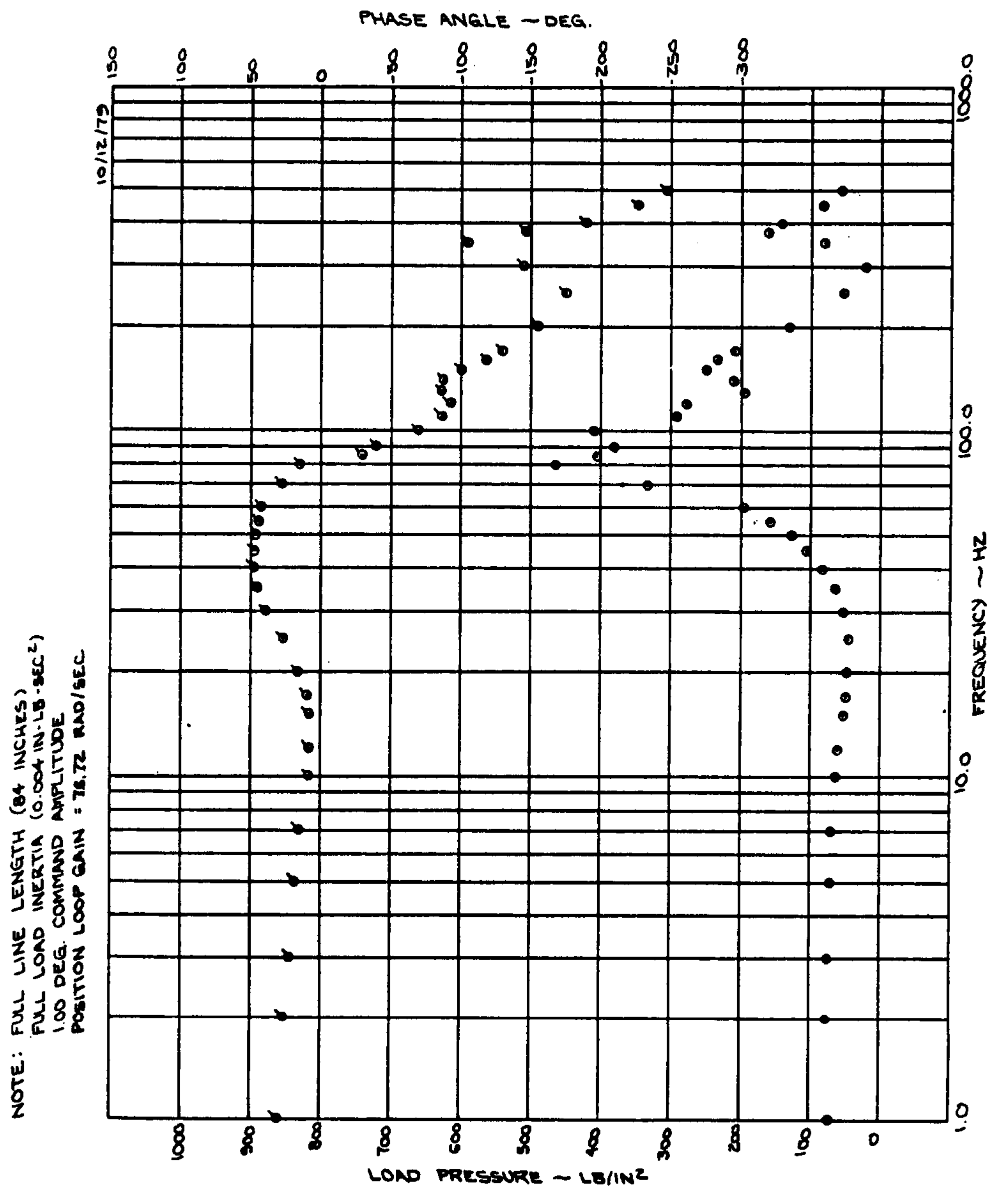


FIGURE 29. LOAD PRESSURE FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 76.72 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

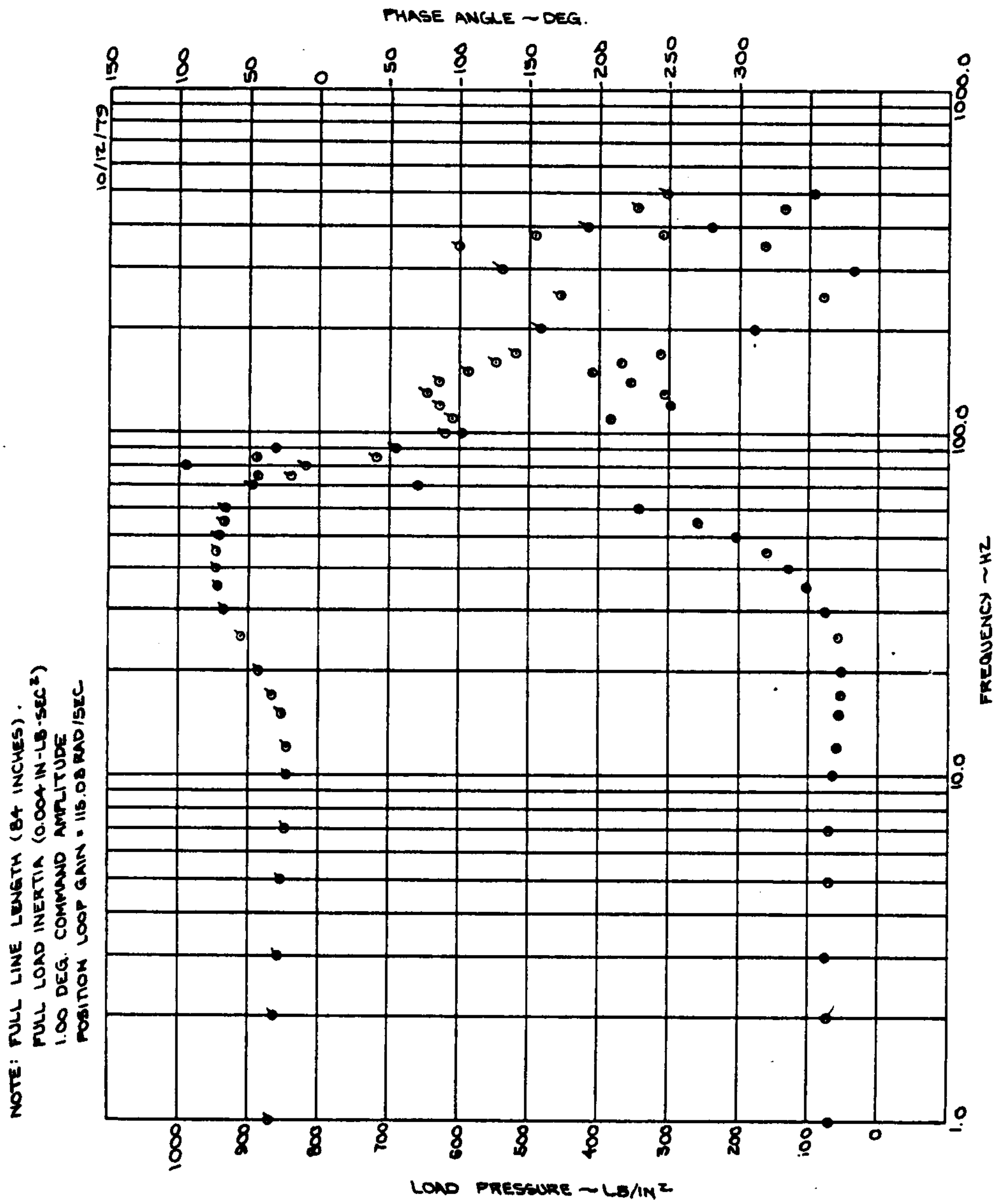


FIGURE 30. LOAD PRESSURE FREQUENCY RESPONSE - FULL LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 115.08 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

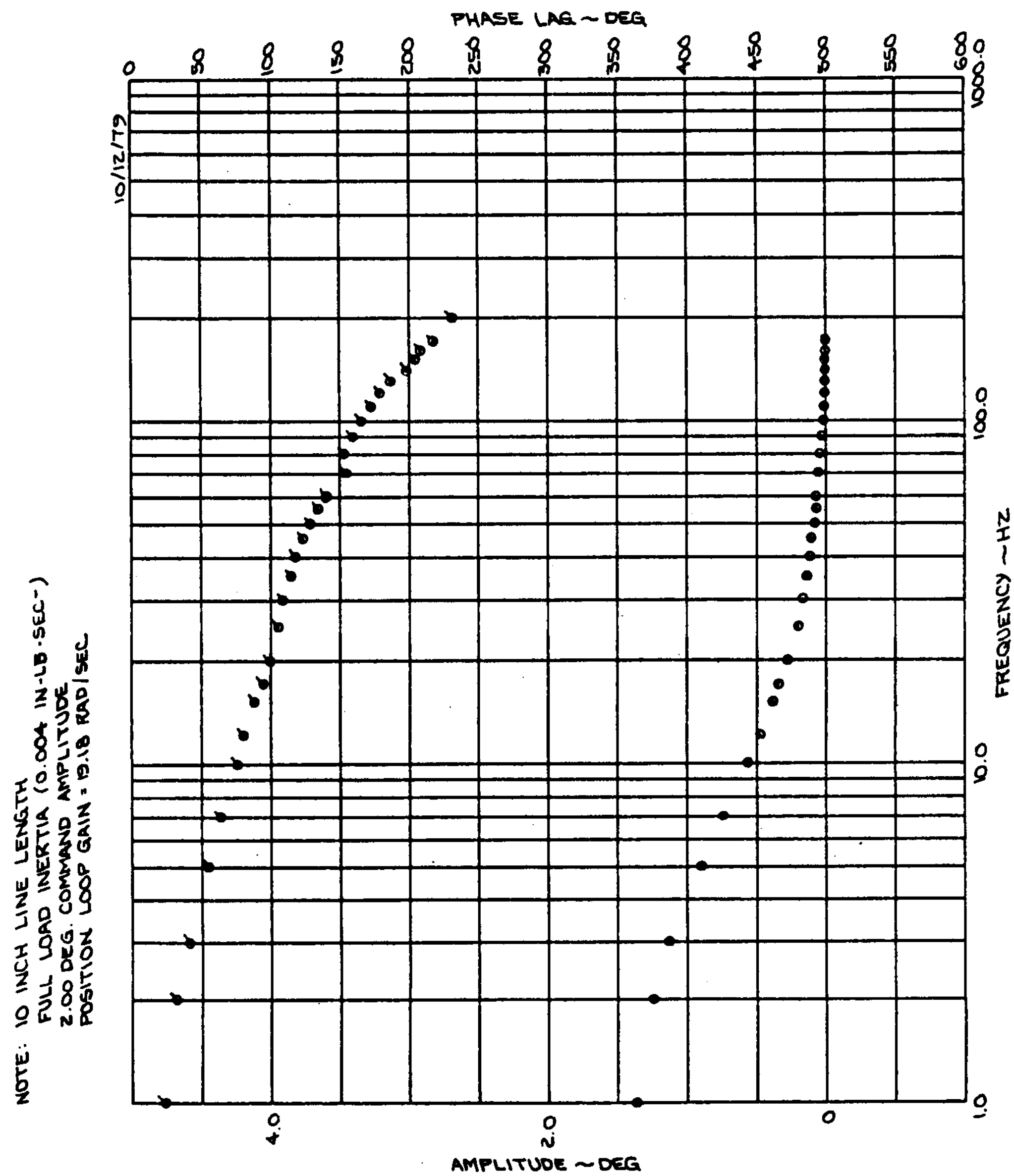


FIGURE 31. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 19.18 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

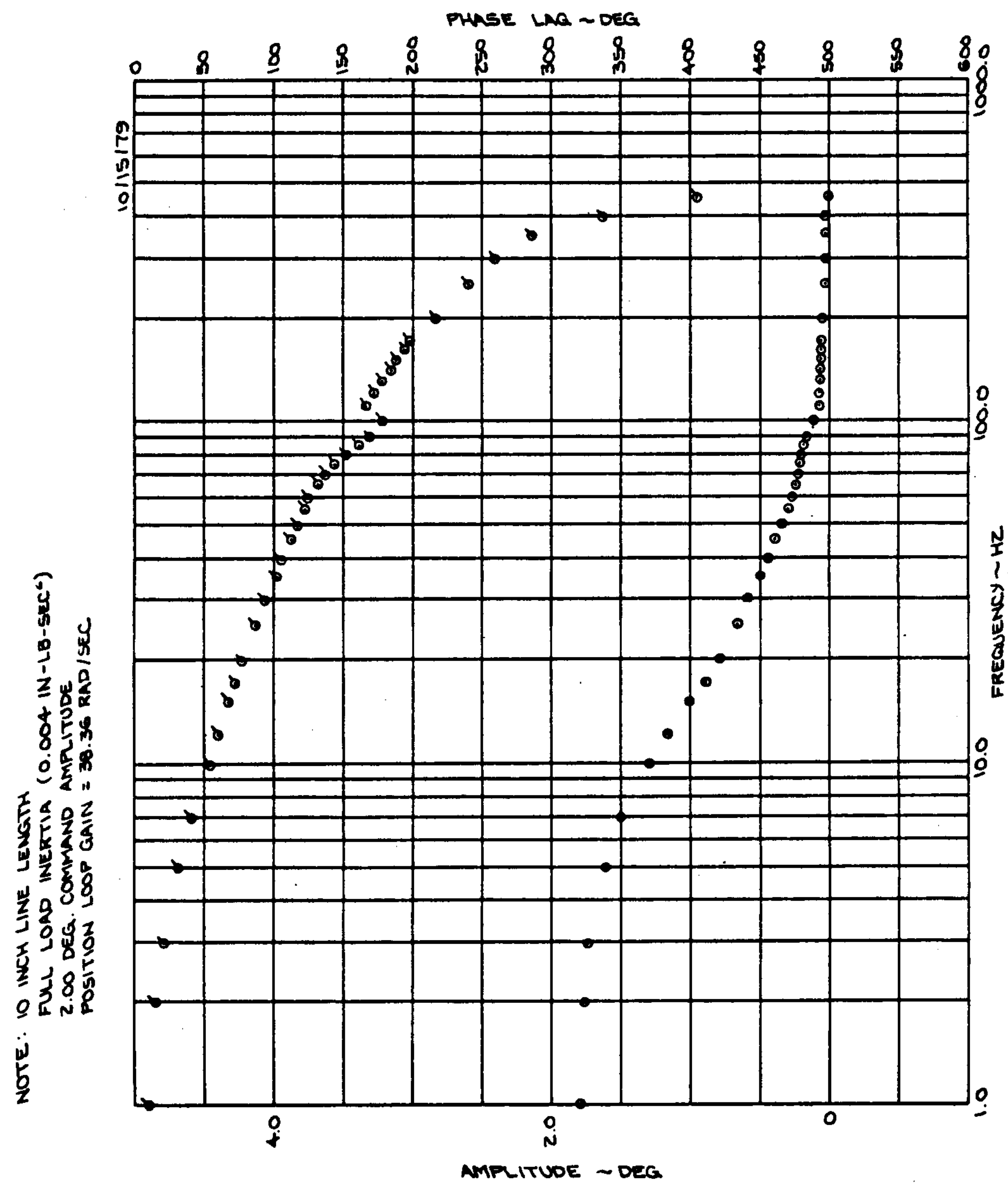


FIGURE 32. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 38.36 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

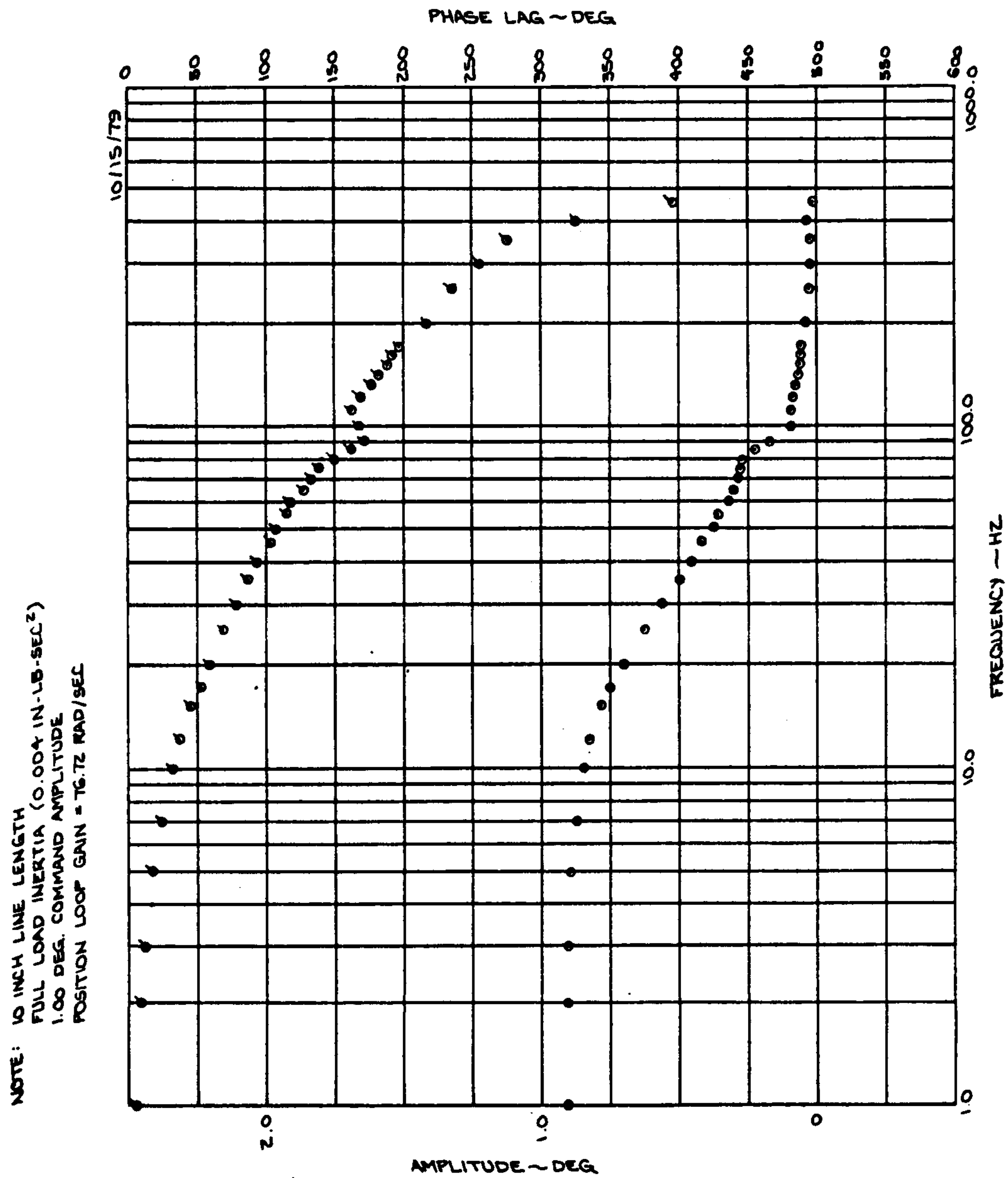


FIGURE 33. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 76.72 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

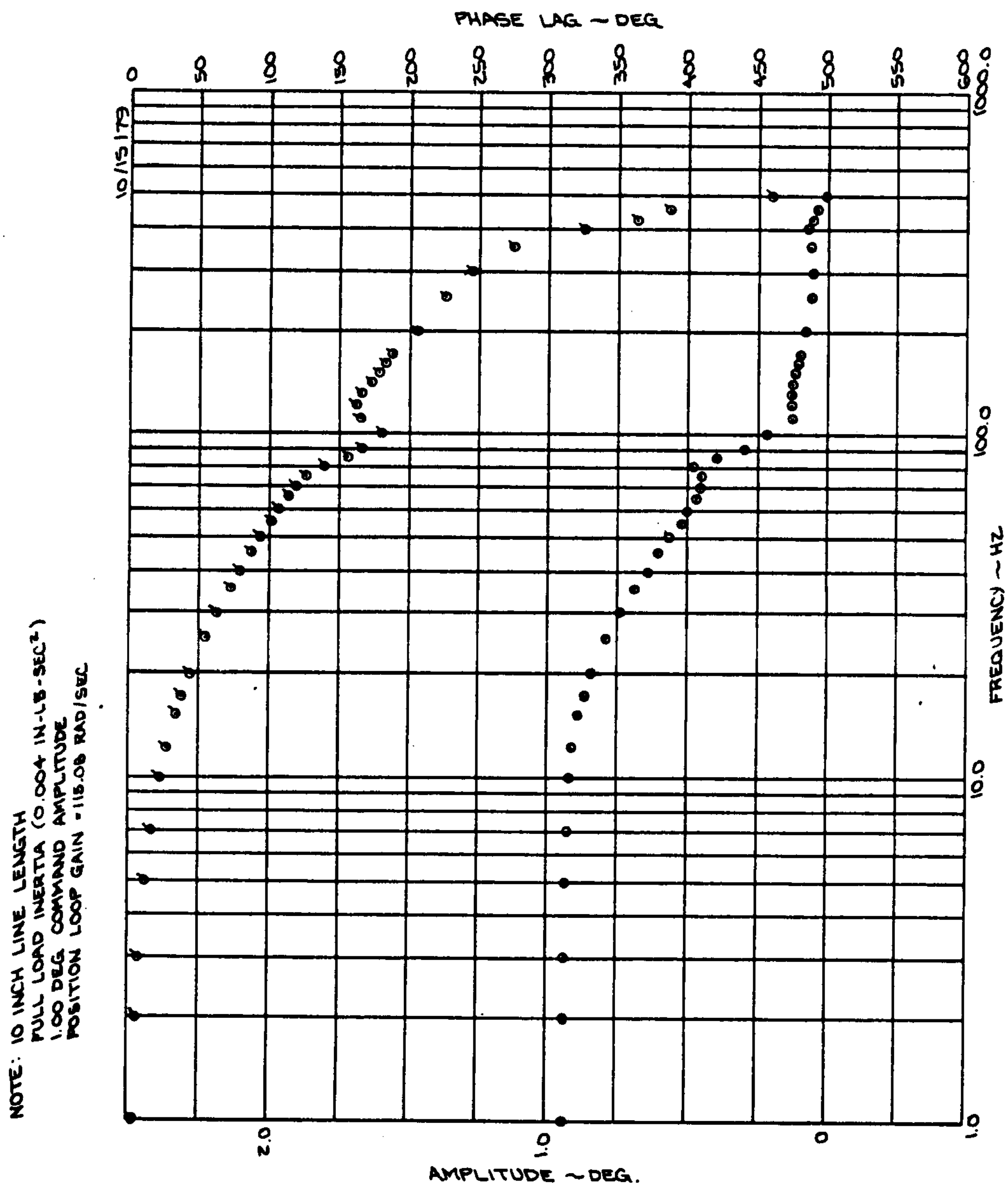


FIGURE 34. ACTUATOR DISPLACEMENT FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 115.08 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

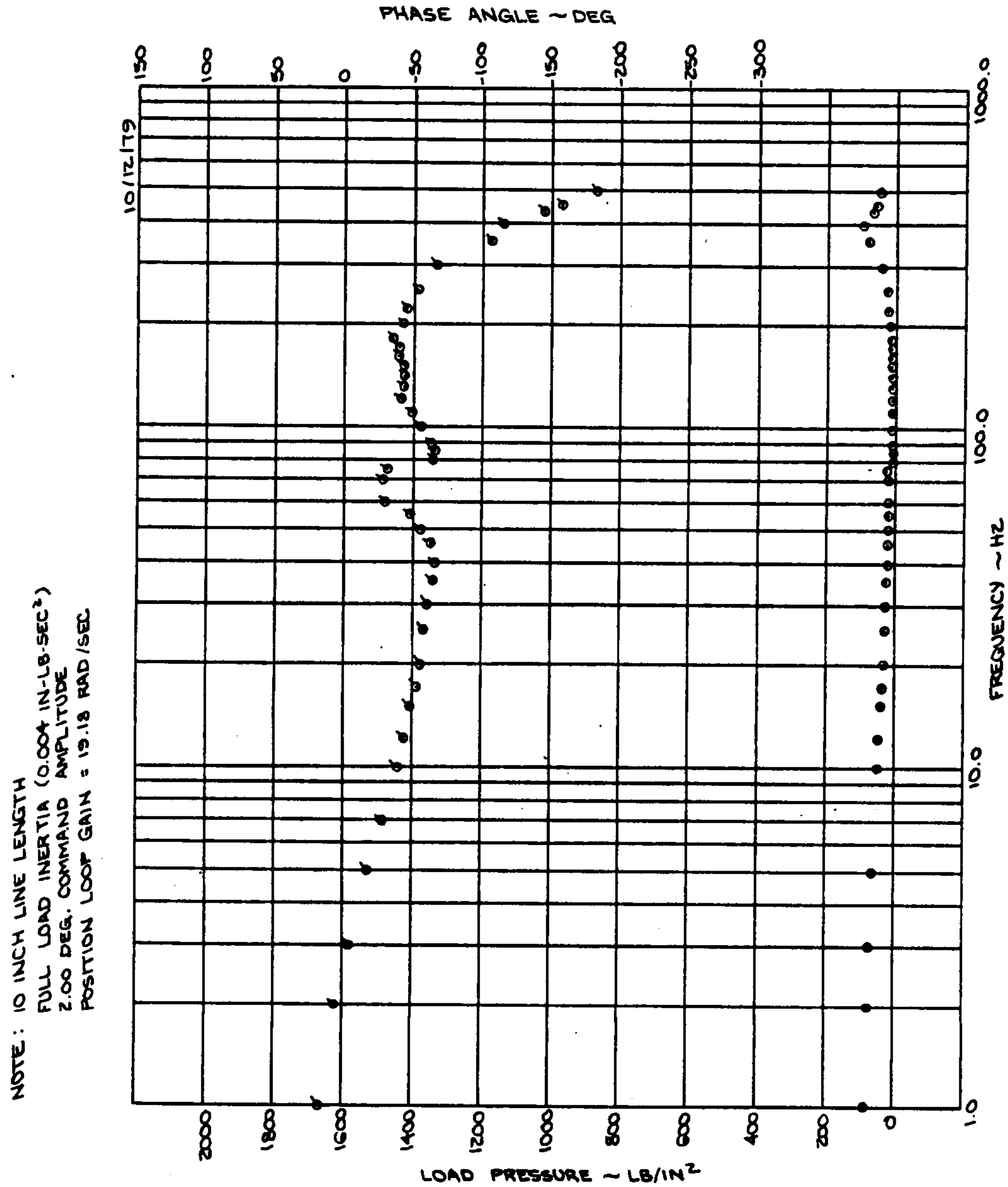


FIGURE 35. LOAD PRESSURE FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 19.18 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

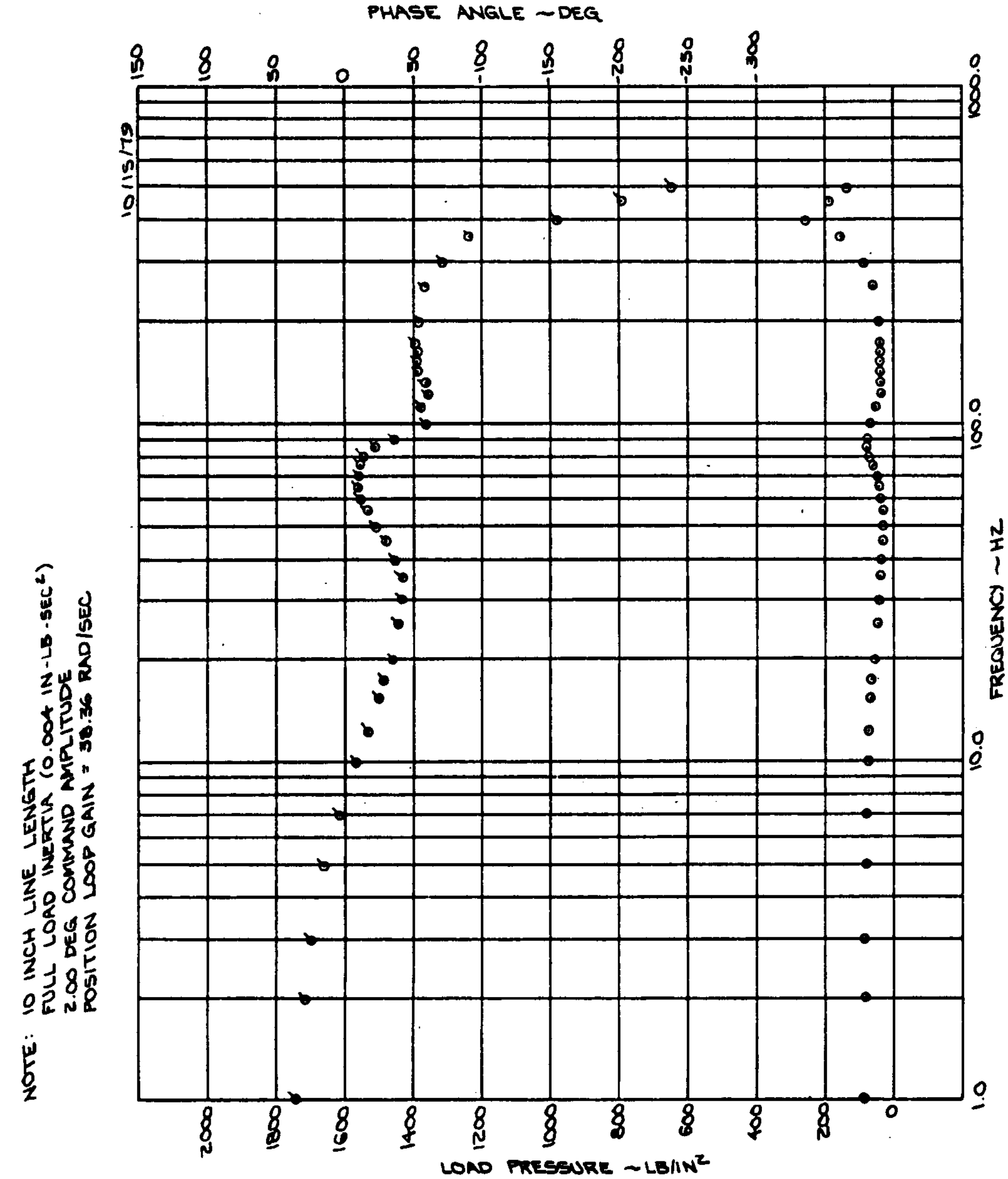


FIGURE 36. LOAD PRESSURE FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 38.36 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

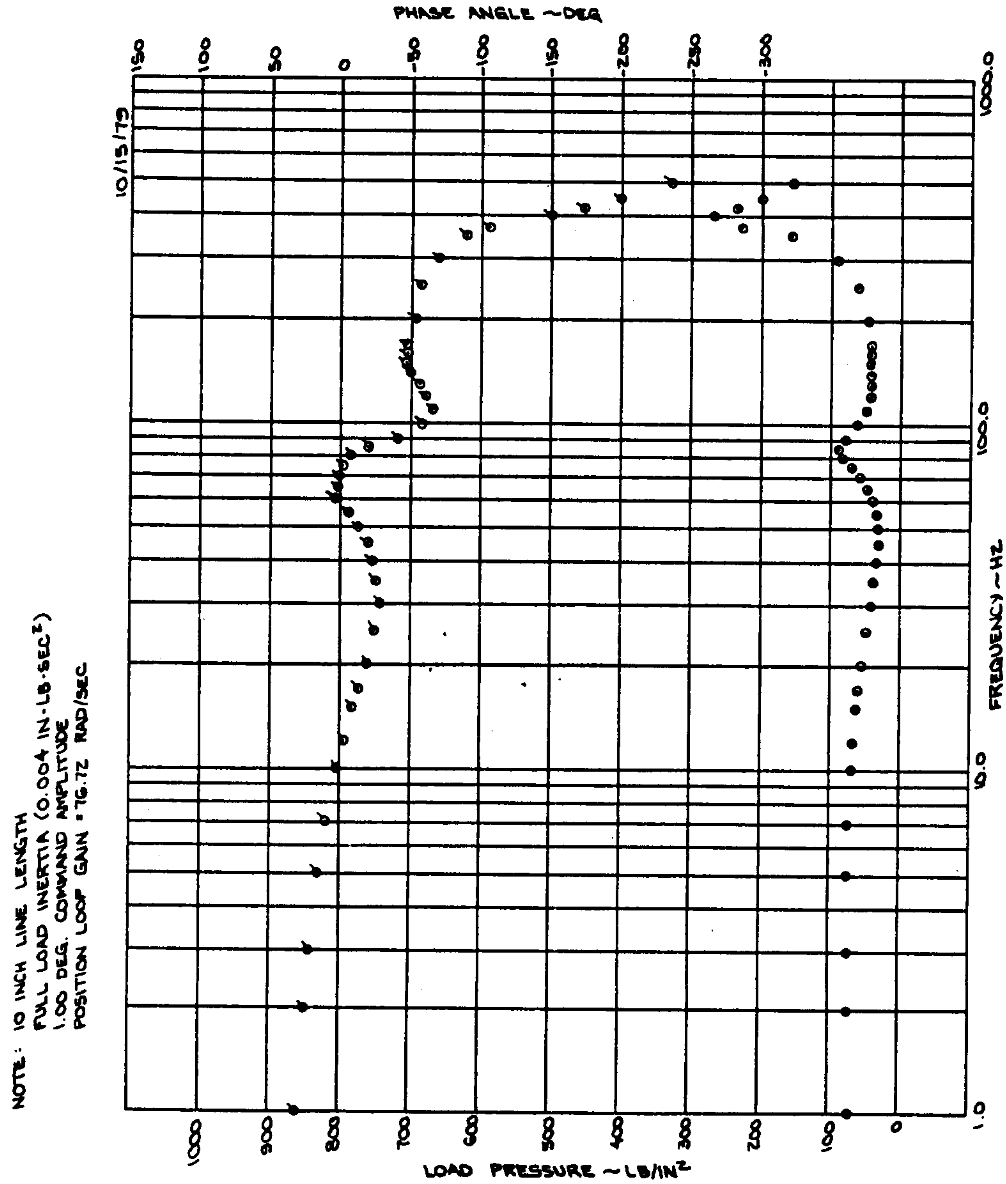


FIGURE 37. LOAD PRESSURE FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 76.72 RAD/SEC

FIGURE 37 (CONTINUED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

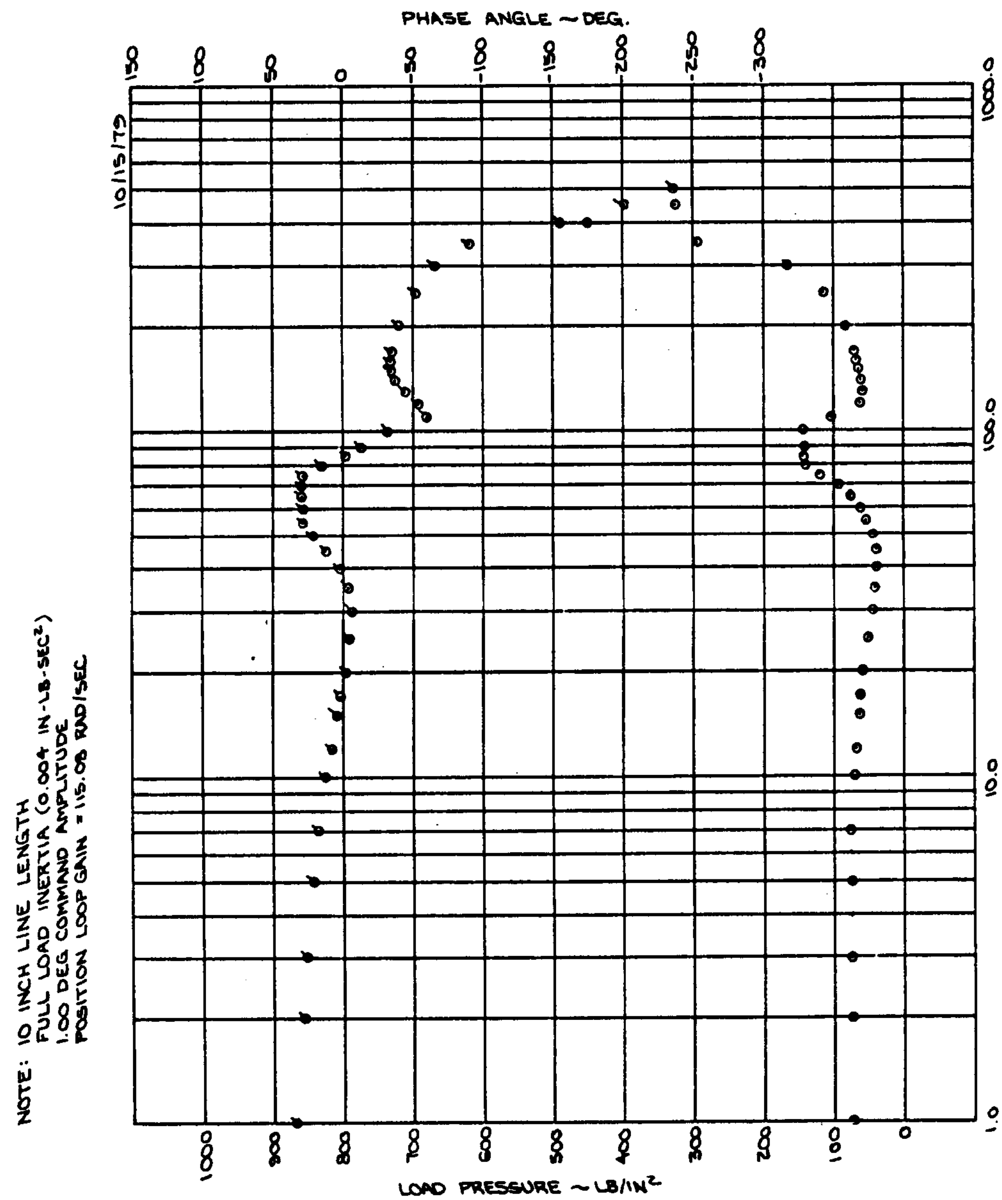


FIGURE 38. LOAD PRESSURE FREQUENCY RESPONSE - 10-INCH LINE LENGTH, FULL LOAD INERTIA, POSITION LOOP GAIN 115.08 RAD/SEC

FIGURE 37 (CONCLUDED)

DAST ARW-2 OUTBOARD AILERON SERVOVALVE RELOCATION STUDY

APPENDIX C

DAST ARW-2 FINAL FLUTTER SUPPRESSION SYSTEM PERFORMANCE DATA

This appendix contains data which summarizes the airplane stability and performance with the final flutter suppression system.

Figures 38 through 47 show the symmetric and antisymmetric mode damping ratios and frequencies for the critical flight conditions determined from analysis. This data verifies that the FSS meets the requirements to provide flutter mode stability and not reduce mode damping ratio below 0.01 or degrade damping of modes with damping ratios below 0.01.

Figures 48 through 59 show the improvement in flutter mode damping with the FSS operating. Damping ratio data is presented as a function of altitude and Mach number.

Figures 60 through 71 present root loci showing structural mode stability for flight conditions within the specified flight envelope. Figures 66, 67, 69 and 71 show the requirement for FSS antisymmetric filter gain scheduling and with gain scheduling, the FSS meets the specifications contained in the final report.

- MACH: 0.80
- ALTITUDE: 2,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	0.0122	14.2596	0.0121	14.2962
q_2 (FLUTTER MODE)	0.3347	17.1592	0.0161	23.5143
q_3	0.9976	21.9268	0.9871	16.7341
q_4	0.0050	21.7325	0.0141	21.8471
q_5	0.6064	25.5127	0.4438	20.0430
q_6	0.0088	33.1990	0.0089	33.1639
q_7	0.0883	33.9358	0.0804	34.5764
q_8	0.0143	63.2038	0.0110	63.2372
q_9	0.0332	67.6099	0.0220	67.4680
q_{10}	0.0524	70.5048	0.0525	73.6068
SERVOVALVE ACTUATOR	0.3997	49.9750	0.3997	49.9750
	0.2398	75.9960	0.1659	75.0067
ACTUATOR NOTCH	0.2995	75.9960	0.2338	99.1921
FILTER	1.0000	101.859	1.0000	83.4313
FILTER	1.0000	32.149	1.0000	30.9143
FILTER	1.0000	23.873	0.9421	19.6067
FILTER	1.0000	0.3138	-1.0000	0.0047
NOTCH 1	0.9089	15.768	0.8870	13.6199
NOTCH 2	0.3610	13.528	0.1995	8.8439

FIGURE 38

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.80, ALTITUDE: 2,000 FEET, UNSCALED EOM

- MACH: 0.83
- ALTITUDE: 3,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	0.0124	14.2621	0.0119	14.2970
q_2 (FLUTTER MODE)	-0.3887	22.6863	-0.0005	24.6051
q_3	0.0052	21.7357	0.0141	21.8201
q_4	0.7247	26.1847	0.5650	18.2150
q_5	0.0089	33.2006	0.0088	33.1688
q_6	0.0879	34.0812	0.0714	34.5287
q_7	0.0719	49.9889	0.0719	49.9936
q_8	0.0135	63.1943	0.0131	63.2054
q_9	0.0311	67.4124	0.0319	74.8774
q_{10}	0.0275	70.6794	0.0302	70.4984
SERVOVALVE ACTUATOR	0.3997	49.9750	0.3997	49.9750
	0.2398	75.9960	0.1379	76.1242
ACTUATOR NOTCH	0.2995	75.9960	0.4318	77.5717
FILTER	1.0000	101.8590	1.0000	83.4314
FILTER	1.0000	32.1490	1.0000	30.9143
FILTER	1.0000	23.873	1.0000	26.0924
FILTER	1.0000	0.3183	1.0000	0.0040
NOTCH 1	0.9089	15.7600	0.8660	13.5350
NOTCH 2	0.3610	13.5280	0.2824	8.5497

FIGURE 39

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.83, ALTITUDE: 3,000 FEET
UNSCALED EOM

- MACH: 0.86
- ALTITUDE: 4,500 FEET
- UNSCLACED EOM

MODE	OPEN LOOP DAMPING (ζ)	OPEN LOOP FREQUENCY (HZ)	CLOSED LOOP DAMPING (ζ)	CLOSED LOOP FREQUENCY (HZ)
q_1	0.0122	14.2672	0.0112	14.2990
q_2 (FLUTTER MODE)	-0.3804	21.5541	-0.0052	22.8822
q_3	0.0052	21.7436	0.0395	21.1449
q_4	0.9926	17.0430	0.9421	19.6067
q_5	0.6659	27.0143	0.5395	20.2787
q_6	0.0099	33.1943	0.0099	33.1576
q_7	0.0146	63.2357	0.0159	63.1720
q_8	0.0922	34.2070	0.0834	34.5844
q_9	0.0777	70.5908	0.0909	69.4682
q_{10}	0.0309	67.8201	0.0249	67.9937
SERVOVALVE ACTUATOR	0.3995	49.975	0.3995	49.9750
	0.2398	75.996	0.1390	77.2898
ACTUATOR NOTCH	0.2995	75.996	0.1078	64.5220
FILTER	1.0000	101.859	1.0000	83.4313
FILTER	1.0000	32.149	1.0000	30.9143
FILTER	1.0000	23.873	1.0000	27.1561
FILTER	1.0000	0.3183	1.0000	0.0039
NOTCH 1	0.9089	15.760	0.8660	13.6000
NOTCH 2	0.3610	13.528	0.1410	9.9618

FIGURE 40

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.83, ALTITUDE: 4,500 FEET
UNSCALED EOM

- MACH: 0.83
- ALTITUDE: 12,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	0.0109	14.2383	0.0127	14.2723
q_2 (FLUTTER MODE)	-0.1750	21.9798	0.0758	24.0437
q_3	0.0043	21.6806	0.0113	21.7943
q_4	0.5444	21.3533	0.3379	18.2829
q_5	0.0078	33.2336	0.0075	33.1881
q_6	0.0574	33.7194	0.0467	33.8662
q_7	0.0556	49.1129	0.0556	49.1155
q_8	0.0117	63.1413	0.0114	63.0909
q_9	0.0233	67.3304	0.0162	67.4250
q_{10}	0.0236	76.9607	0.0236	76.9206
SERVOVALVE ACTUATOR	0.3997	49.9746	0.3997	49.9746
	0.2398	75.9964	0.1521	75.9370
ACTUATOR NOTCH	0.2995	75.9964	0.0458	79.2888
FILTER	1.0000	101.859	1.0000	159.4733
FILTER	1.0000	32.1490	1.0000	28.6479
FILTER	1.0000	23.873	0.9421	19.5972
FILTER	1.0000	0.3183	1.0000	0.3306
NOTCH 1	0.9089	15.760	0.8660	13.5282
NOTCH 2	0.3610	13.528	0.2717	8.3831

FIGURE 41

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.83, ALTITUDE: 12,000 FEET
UNSCALED EOM

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	0.0105	14.235	0.0126	14.2748
q_2 (FLUTTER MODE)	-0.1190	20.137	0.1791	18.4863
q_3	0.0024	21.715	0.0094	21.8349
q_4	0.4521	23.349	0.1899	22.8006
q_5	0.0084	33.241	0.0083	33.1778
q_6	0.0619	33.711	0.0480	33.8741
q_7	0.05265	49.051	0.0526	49.0513
q_8	0.0118	63.182	0.0110	63.2372
q_9	0.0238	67.556	0.0222	67.4680
q_{10}	0.0524	73.600	0.0525	73.6068
SERVOVALVE ACTUATOR	0.3997	49.975	0.3997	49.9746
	0.2398	75.996	0.1659	75.0067
ACTUATOR NOTCH	0.2995	75.996	0.2338	99.1921
FILTER	1.0000	101.859	1.0000	83.4313
FILTER	1.0000	32.149	1.0000	30.9143
FILTER	1.0000	23.873	1.0000	22.4560
FILTER	1.0000	0.3183	1.0000	0.2479
NOTCH 1	0.9089	15.760	0.8660	13.5282
NOTCH 2	0.3610	13.528	0.2824	8.5497

FIGURE 42

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.86, ALTITUDE: 15,000 FEET
UNSCALED EOM

- MACH: 0.91
- ALTITUDE: 8,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	.0118	14.2669	.0105	14.2930
q_2 (FLUTTER MODE)	-.3719	20.9283	.1396	23.0510
q_3	.0053	21.7497	.0118	21.8901
q_4	.7715	23.0478	.5082	16.1943
q_5	.9997	30.4013	1.0000	30.1561
q_6	.0105	33.2166	.0104	33.1752
q_7	.0141	63.2675	.0151	63.1401
q_8	.0857	34.2771	.0772	34.4586
q_9	.0839	72.6943	.0775	73.8694
q_{10}	.0288	67.8790	.0264	67.5318
SERVOVALVE ACTUATOR	.3997	49.975	.3997	.3997
	.2398	75.996	.1468	77.0497
ACTUATOR NOTCH	.2995	75.996	.4253	74.9904
FILTER	1.0000	101.859	1.0000	101.85
FILTER	1.0000	32.149	1.000	30.9143
FILTER	1.0000	23.873	.9421	19.6067
FILTER	1.0000	.3183	1.0000	.0058
NOTCH 1	.9089	15.760	.8660	13.5350
NOTCH 2	0.3610	13.528	.0507	8.2607

FIGURE 43

SYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY, MACH: 0.91, ALTITUDE: 8,000 FEET
UNSCALED EOM

- MACH: 0.86
- ALTITUDE: 4,250 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	.0054	20.2309	.0134	20.2529
q_2 (FLUTTER MODE)	-.3753	22.3565	-.0091	24.6258
q_3	.0055	22.2038	.0077	22.1592
q_4	.6524	29.6768	.3488	24.6083
q_5	.0874	37.6338	.0860	37.5510
q_6	.0538	72.1019	.0214	70.1247
q_7	.0658	45.0295	.0658	45.0248
q_8	.0092	47.3439	.0092	47.3400
q_9	.0278	67.1995	.0214	66.8768
q_{10}	.0283	70.9873	.0166	74.0548
SERVOVALVE ACTUATOR	.3997	49.9746	.3997	49.9746
	.2398	75.9964	.1453	76.5859
ACTUATOR NOTCH	.2995	75.9964	.3397	106.6853
FILTER	1.000	101.8590	1.0000	64.6007
FILTER	1.000	49.6815	.9998	40.8756
FILTER	1.000	.3185	.1165	.3589
FILTER	1.000	278.5212	.5507	285.9078
FILTER	1.000	23.8854	.9421	19.6070
NOTCH 1	.9089	15.7675	.8963	14.4299
NOTCH 2	.3610	17.5159	.8314	16.5876

FIGURE 44

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.91, ALTITUDE: 4,250 FEET, UNSCALED EOM

- MACH: 0.83
- ALTITUDE: 12,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	0.0064	20.1646	0.0178	20.2533
q_2 (FLUTTER MODE)	-0.1899	23.1418	0.0777	26.8312
q_3	0.0054	22.1658	0.0090	22.1938
q_4	0.5910	21.9851	0.2517	21.9972
q_5	0.0566	36.8325	0.0541	37.0458
q_6	0.0503	44.0965	0.0503	44.1000
q_7	0.0074	47.3661	0.0074	47.3575
q_8	0.0226	66.8679	0.0224	66.8731
q_9	0.0213	70.1247	0.0213	70.1275
q_{10}	0.0166	74.0549	0.0220	72.4330
SERVOVALVE ACTUATOR	0.3997	49.9746	0.3997	49.9746
	0.2398	75.9964	0.1453	76.5859
ACTUATOR NOTCH	0.2995	75.9964	0.3397	106.6853
FILTER	1.0000	101.8590	1.0000	64.6007
FILTER	1.0000	49.6563	0.9998	40.8756
FILTER	1.0000	0.3183	0.0960	0.2884
FILTER	1.0000	278.5212	0.5507	285.9078
FILTER	1.0000	23.8732	1.0000	23.8732
NOTCH 1	0.9089	15.7601	0.9196	14.0567
NOTCH 2	0.3610	17.5070	0.3085	7.7074

FIGURE 45

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.83, ALTITUDE: 12,000 FEET, UNSCALED EOM

- MACH: 0.86
- ALTITUDE: 15,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	0.0032	20.1276	0.0323	19.7278
q_2 (FLUTTER MODE)	-0.1372	21.4575	0.0713	21.9226
q_3	0.0040	22.1686	0.0107	22.2626
q_4	0.4735	25.1816	0.2325	26.6431
q_5	0.0602	36.8933	0.0556	36.8799
q_6	0.0487	44.0945	0.0487	44.0945
q_7	0.0077	47.3698	0.0078	47.3650
q_8	0.0214	66.9585	0.0212	66.9456
q_9	0.0209	70.4047	0.0208	70.4031
q_{10}	0.0367	74.5435	0.0361	74.6541
SERVOVALVE ACTUATOR	0.3997	49.9746	0.3997	49.9746
	0.2398	75.9964	0.1254	78.3808
ACTUATOR NOTCH	0.2995	75.9964	0.1139	61.1523
FILTER	1.0000	101.8590	1.0000	76.3762
FILTER	1.0000	49.6563	1.0000	55.4267
FILTER	1.0000	0.3183	0.1093	0.2939
FILTER	1.0000	278.5212	0.1709	282.6790
FILTER	1.0000	23.8732	0.9547	19.6087
NOTCH 1	0.9089	15.7601	0.9574	15.5153
NOTCH 2	0.3610	17.5070	0.3177	7.7501

FIGURE 46

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.86, ALTITUDE: 15,000 FEET, UNSCALED EOM

- MACH: 0.91
- ALTITUDE: 8,000 FEET
- UNSCALED EOM

MODE	OPEN LOOP		CLOSED LOOP	
	DAMPING (ζ)	FREQUENCY (HZ)	DAMPING (ζ)	FREQUENCY (HZ)
q_1	.0050	20.2343	0.0137	20.2866
q_2 (FLUTTER MODE)	-.3671	21.7161	0.1111	22.4110
q_3	.0056	22.2082	0.0087	22.1624
q_4	.9876	27.8758	0.8512	25.0100
q_5	.7216	32.9130	.2549	25.8599
q_6	.0810	37.8481	.0821	37.8583
q_7	.0093	47.3721	.0094	47.3698
q_8	.0271	67.2262	.0214	66.8768
q_9	.0562	73.7946	.0213	70.1275
q_{10}	.0258	70.7357	.0166	74.0548
SERVOVALVE ACTUATOR	.3997	49.9746	.3997	49.9746
	.2398	75.9964	.1453	76.5859
ACTUATOR NOTCH	.2995	75.9964	.3397	106.6853
FILTER	1.000	23.8732	.9798	24.3810
FILTER	1.000	278.5212	1.000	285.9078
FILTER	1.000	49.6815	.9998	40.8756
FILTER	1.0000	.3185	.0980	.3615
FILTER	1.0000	101.9108	1.000	106.6853
NOTCH 1	.9089	15.7681	.9418	19.3288
NOTCH 2	.3610	17.5159	.8504	17.7972

FIGURE 47

ANTISYMMETRIC ELASTIC MODE DAMPING AND FREQUENCY WITH PARAMETER SCHEDULING, MACH: 0.91, ALTITUDE: 8,000 FEET, UNSCALED EOM

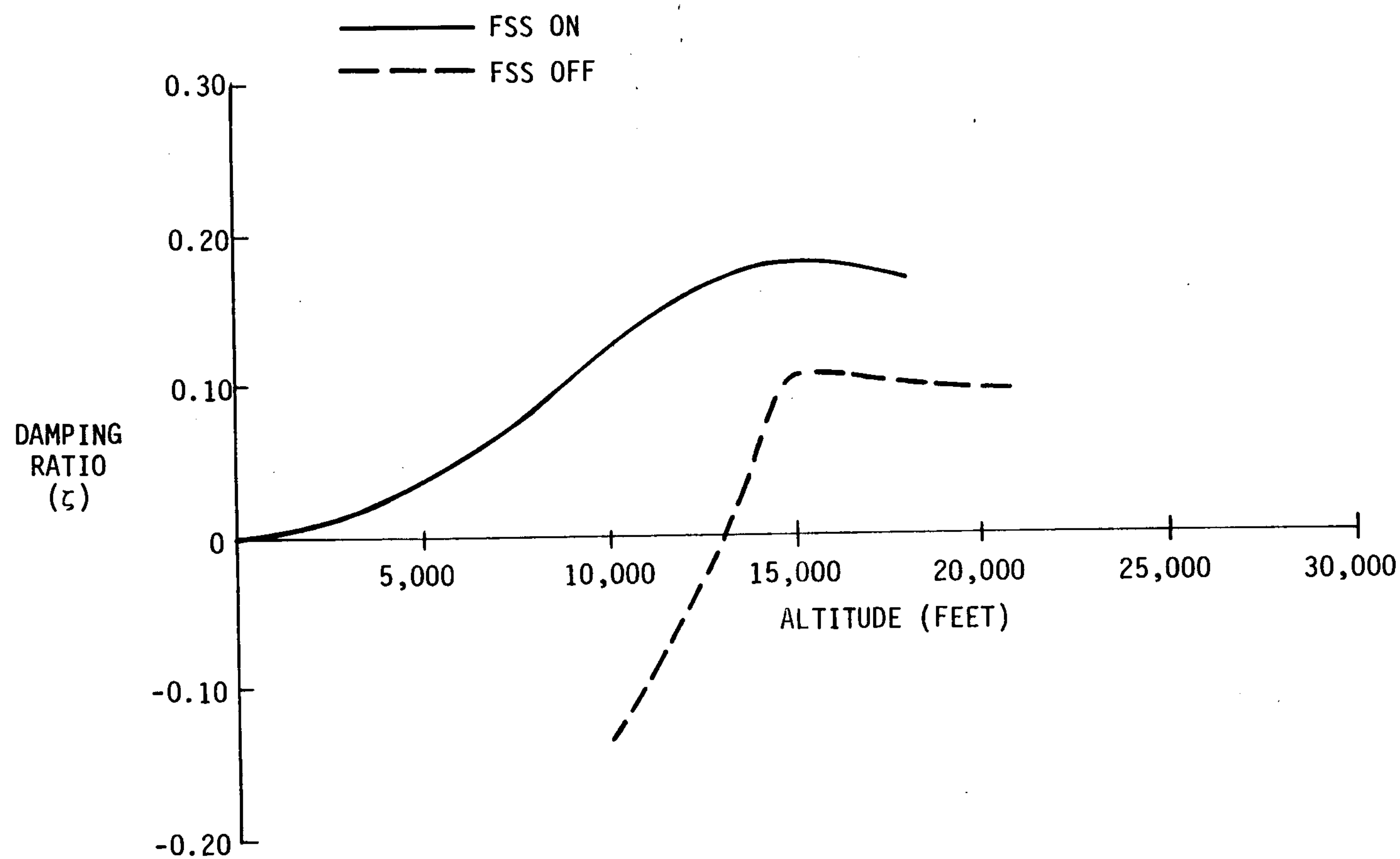


FIGURE 48

SYMMETRIC FLUTTER MODE DAMPING, MACH: 0.80

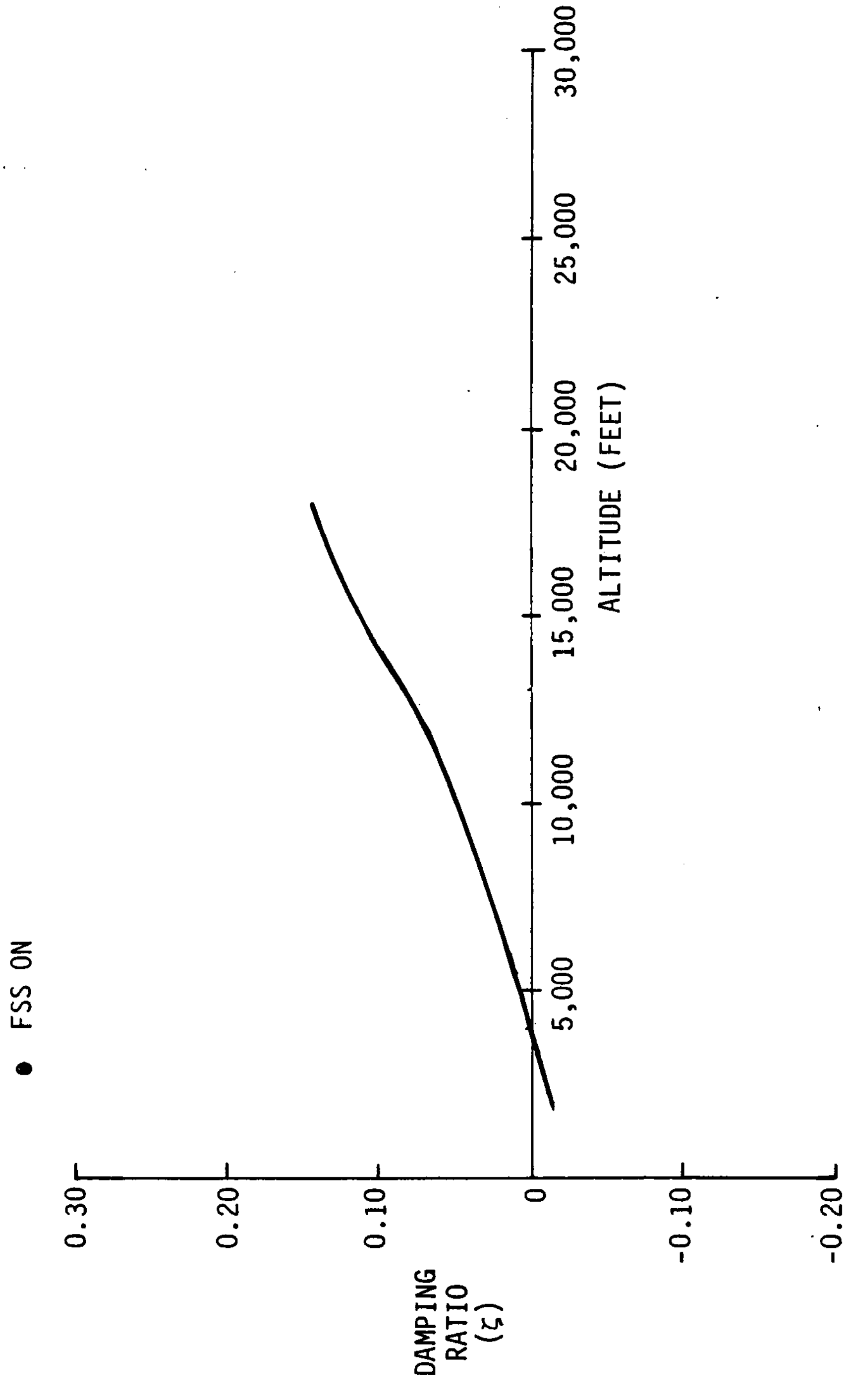


FIGURE 49

SYMMETRIC FLUTTER MODE DAMPING, MACH: 0.83

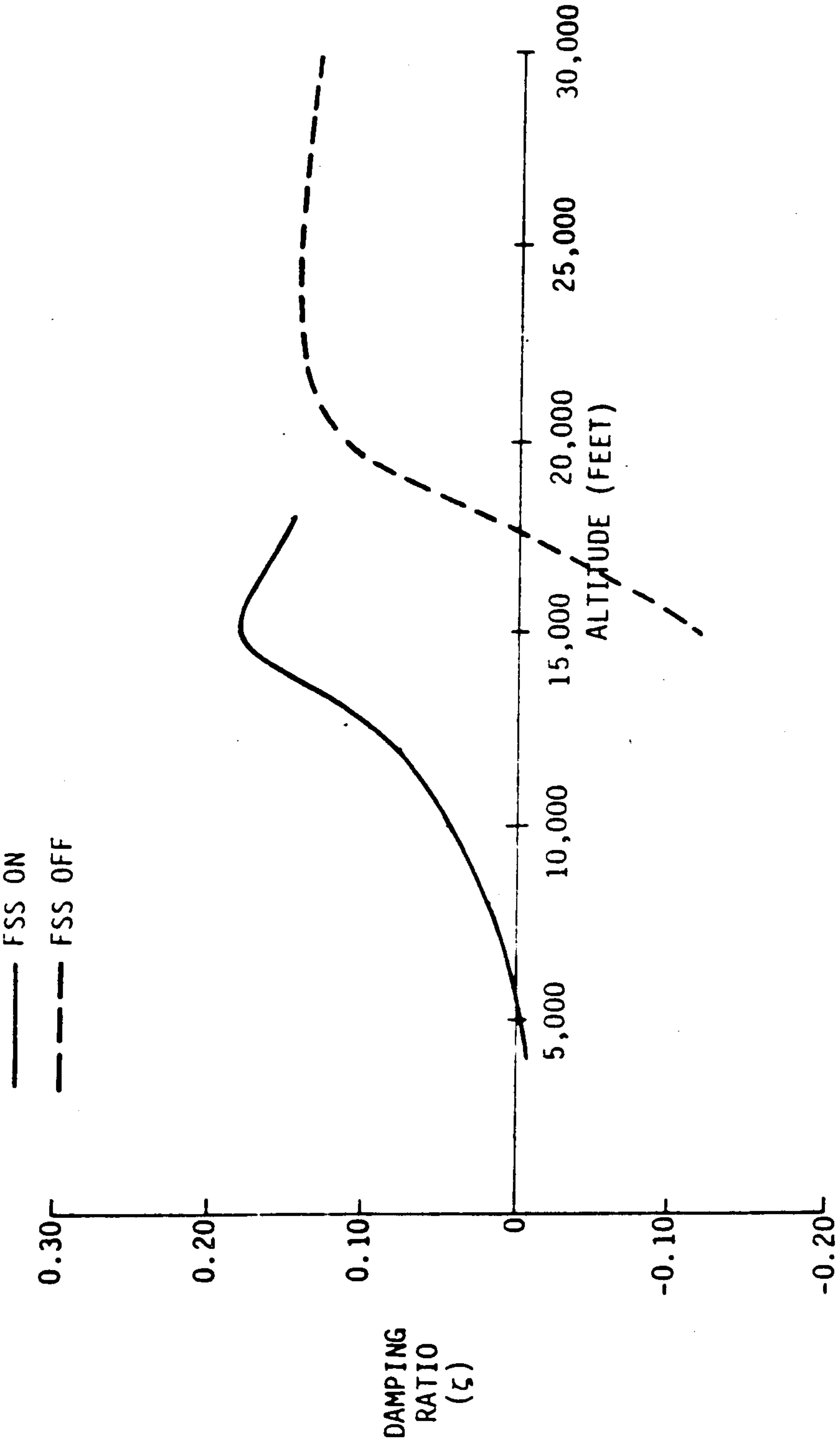


FIGURE 50

SYMMETRIC FLUTTER MODE DAMPING, MACH: 0.86

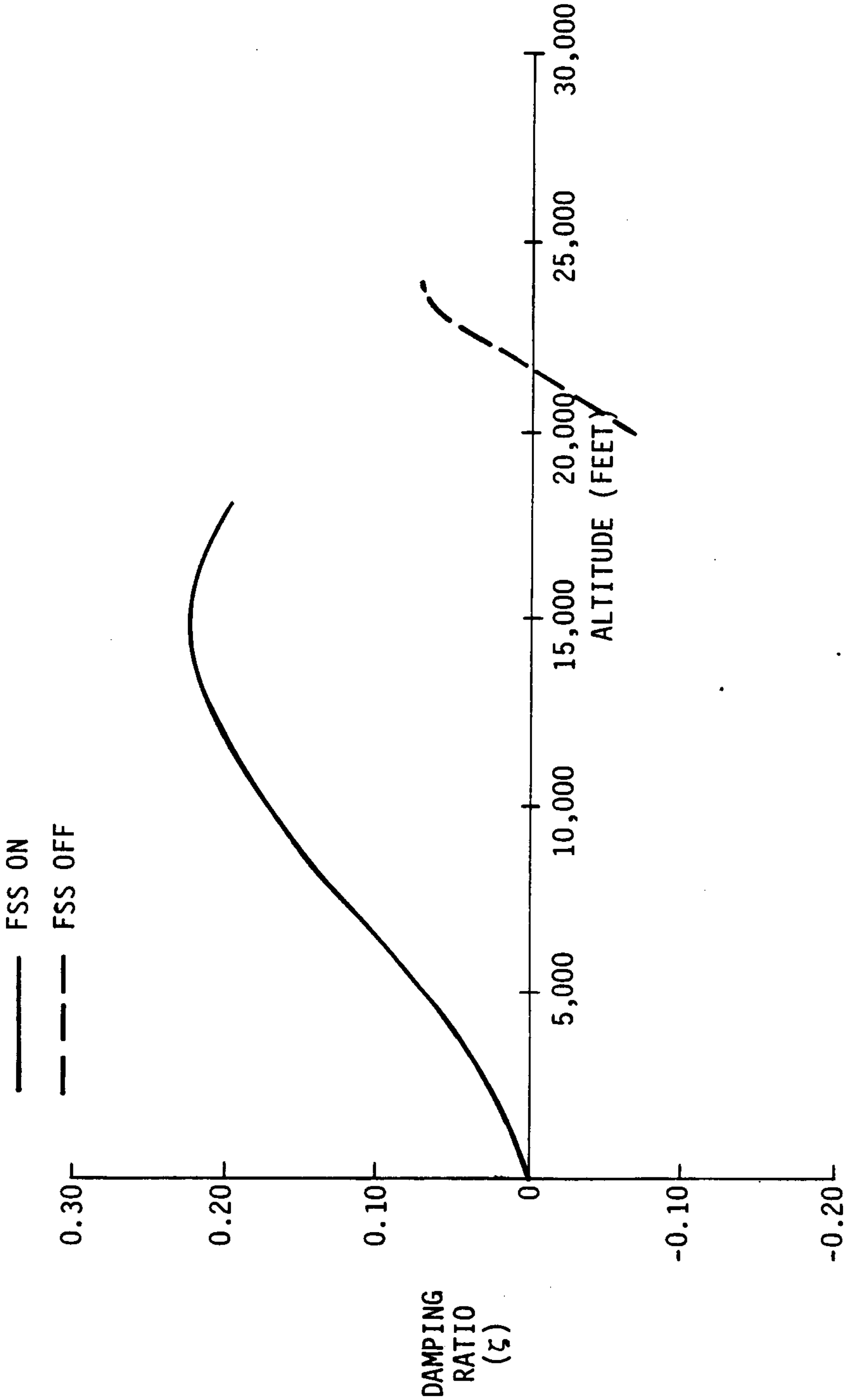


FIGURE 51

SYMMETRIC FLUTTER MODE DAMPING, MACH: 0.91

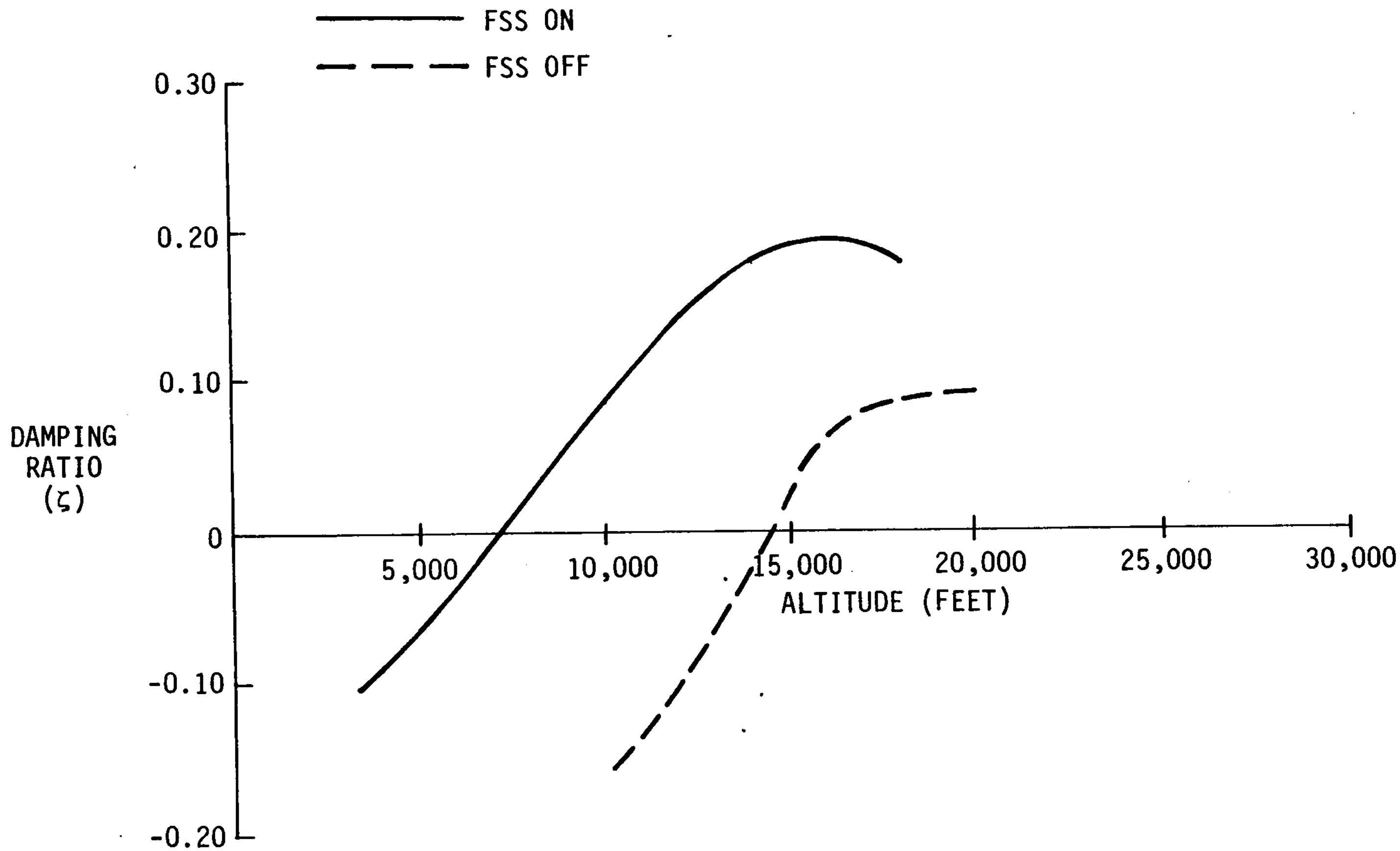


FIGURE 52

ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.80

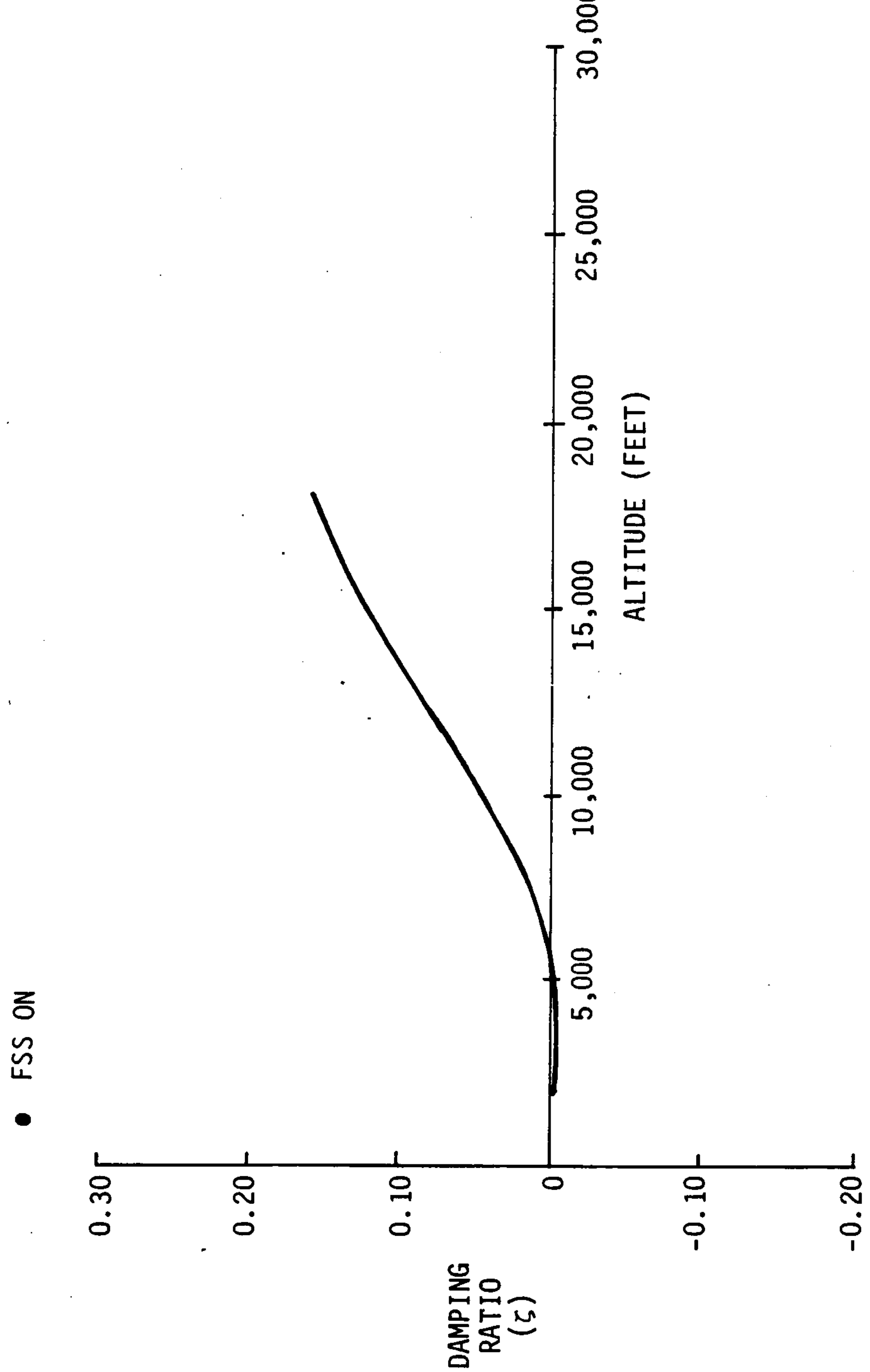


FIGURE 53

ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.83

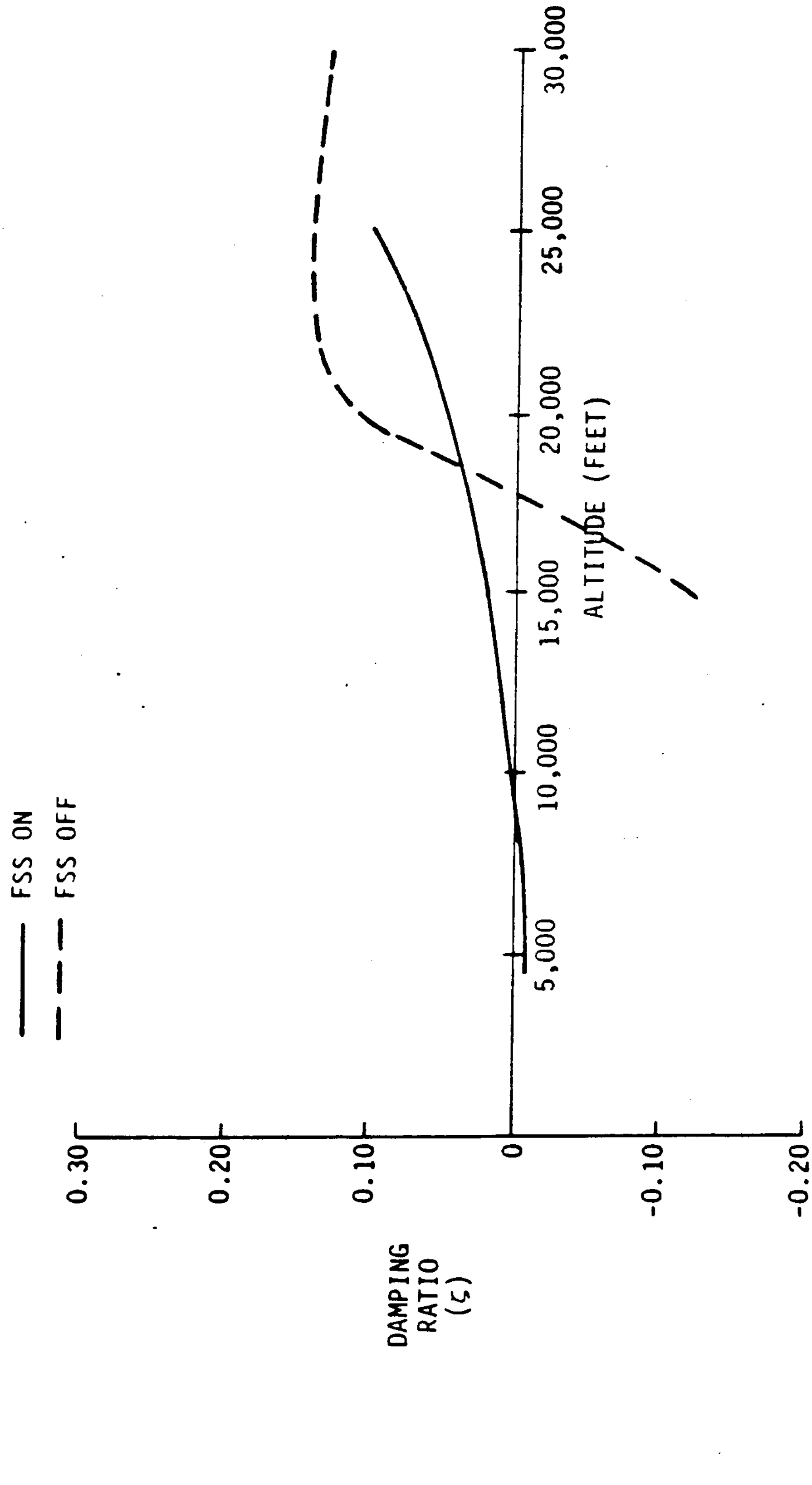


FIGURE 54

ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.86

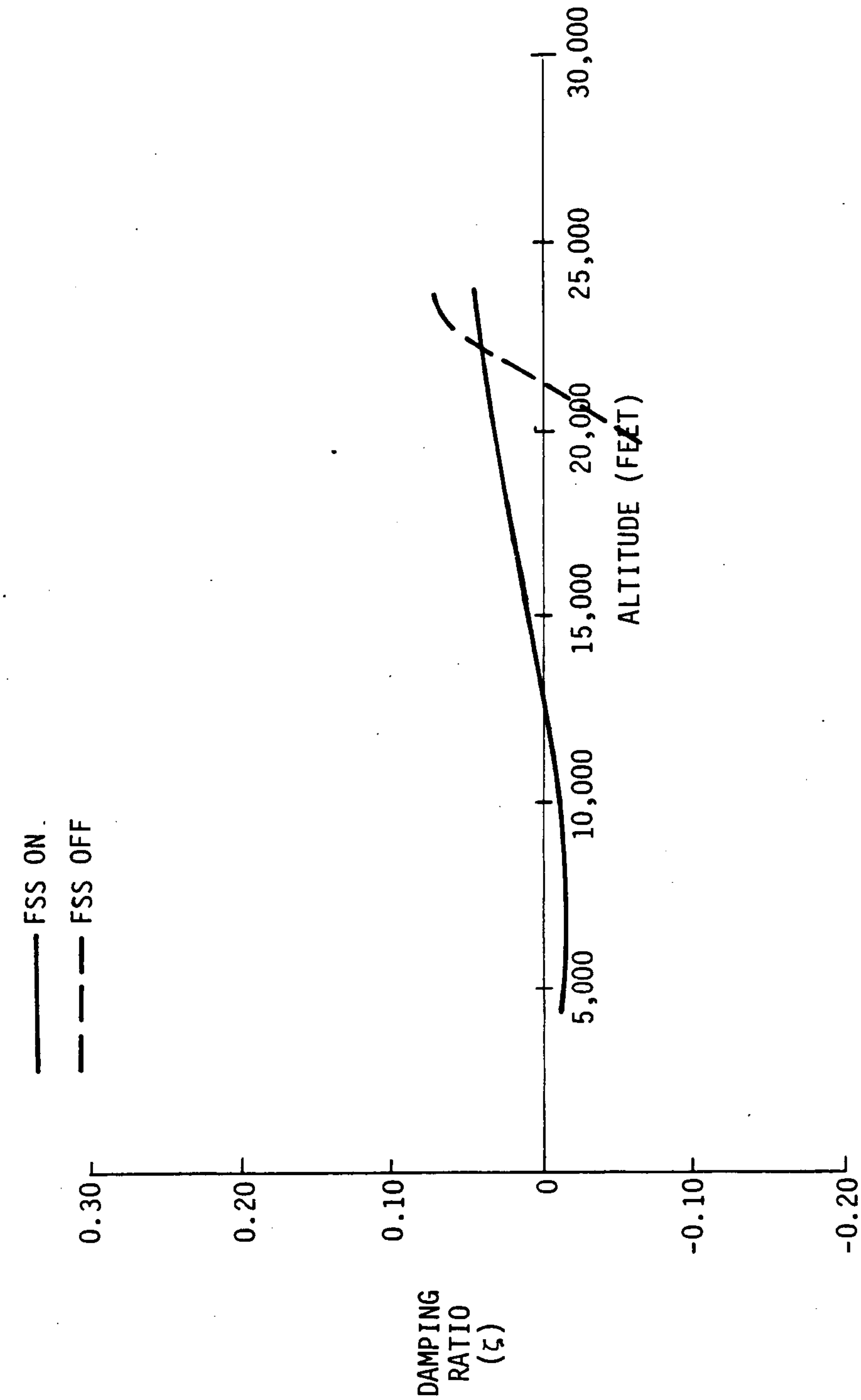


FIGURE 55

ANTISYMMETRIC FLUTTER MODE DAMPING, MACH: 0.91

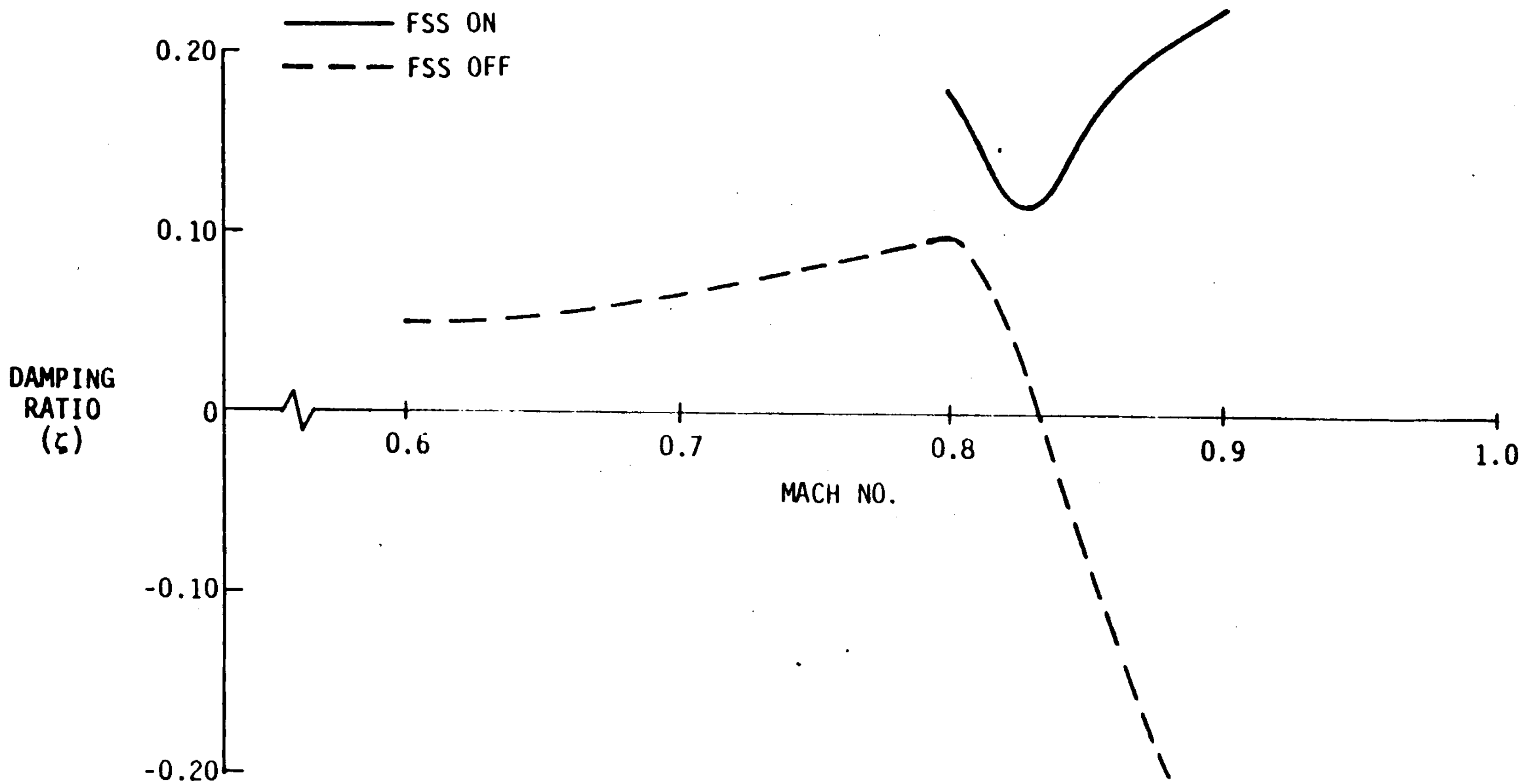


FIGURE 56

SYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 15,000 FEET

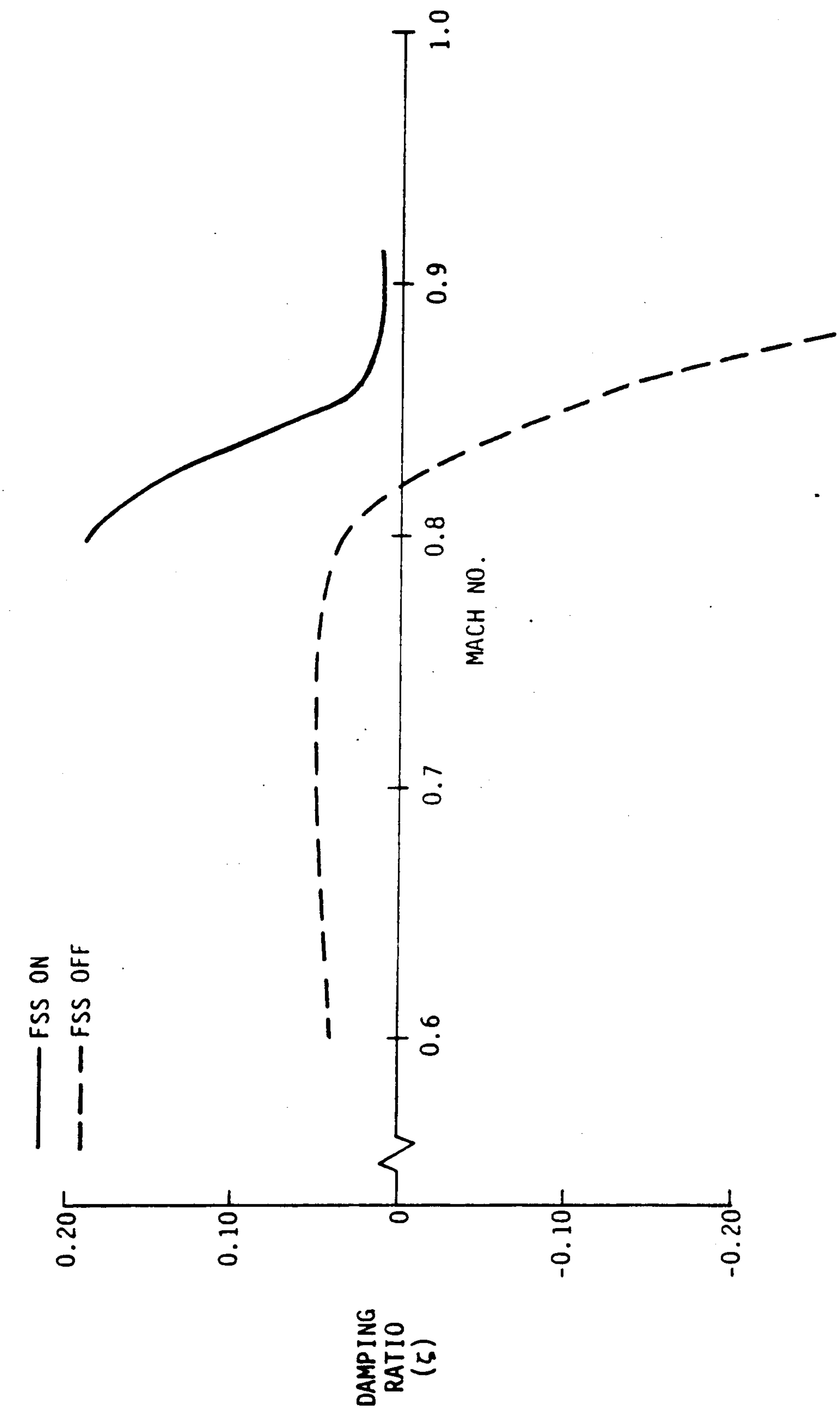


FIGURE 57

ANTISYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 15,000 FEET

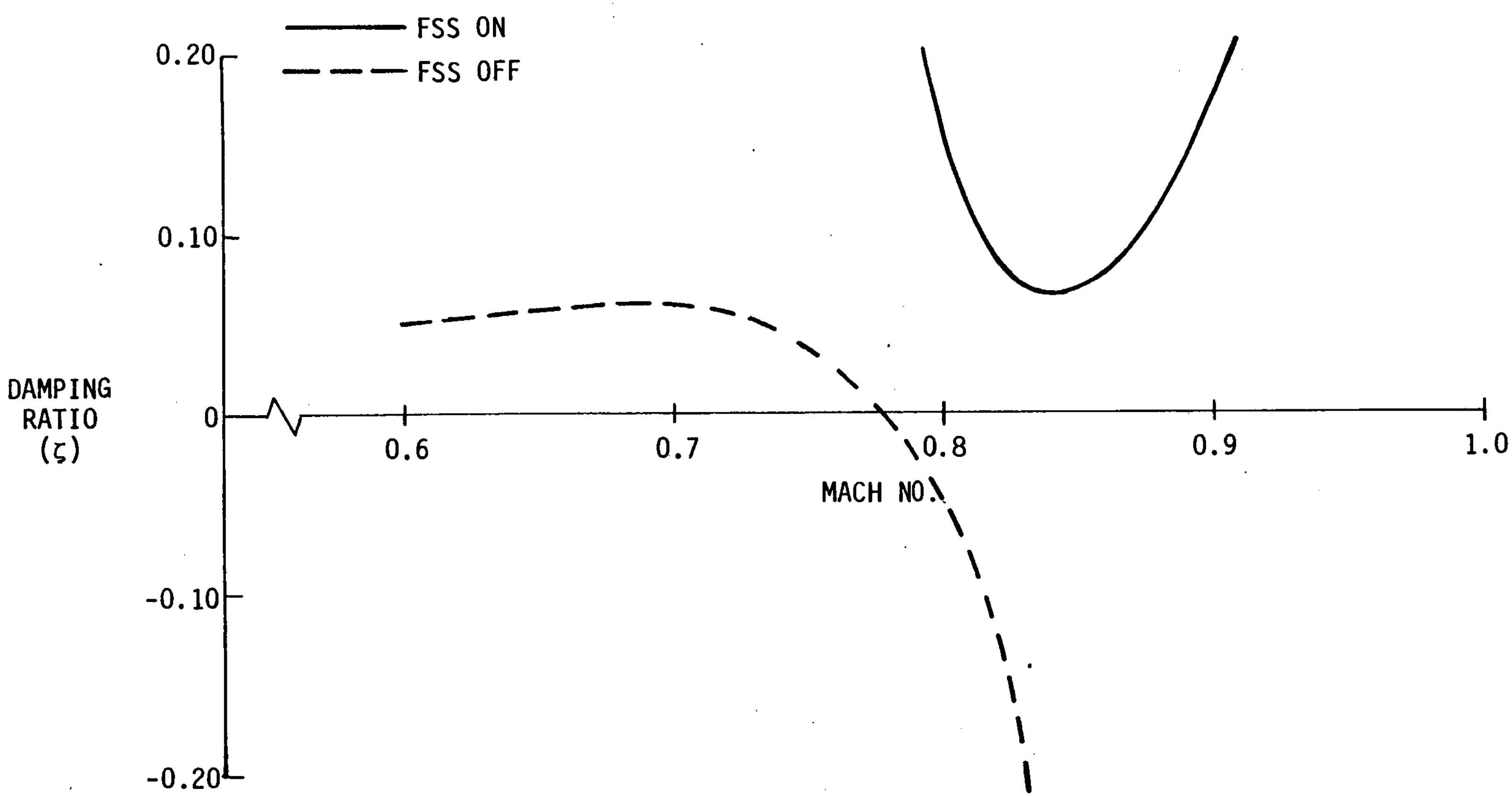


FIGURE 58

SYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 12,000 FEET

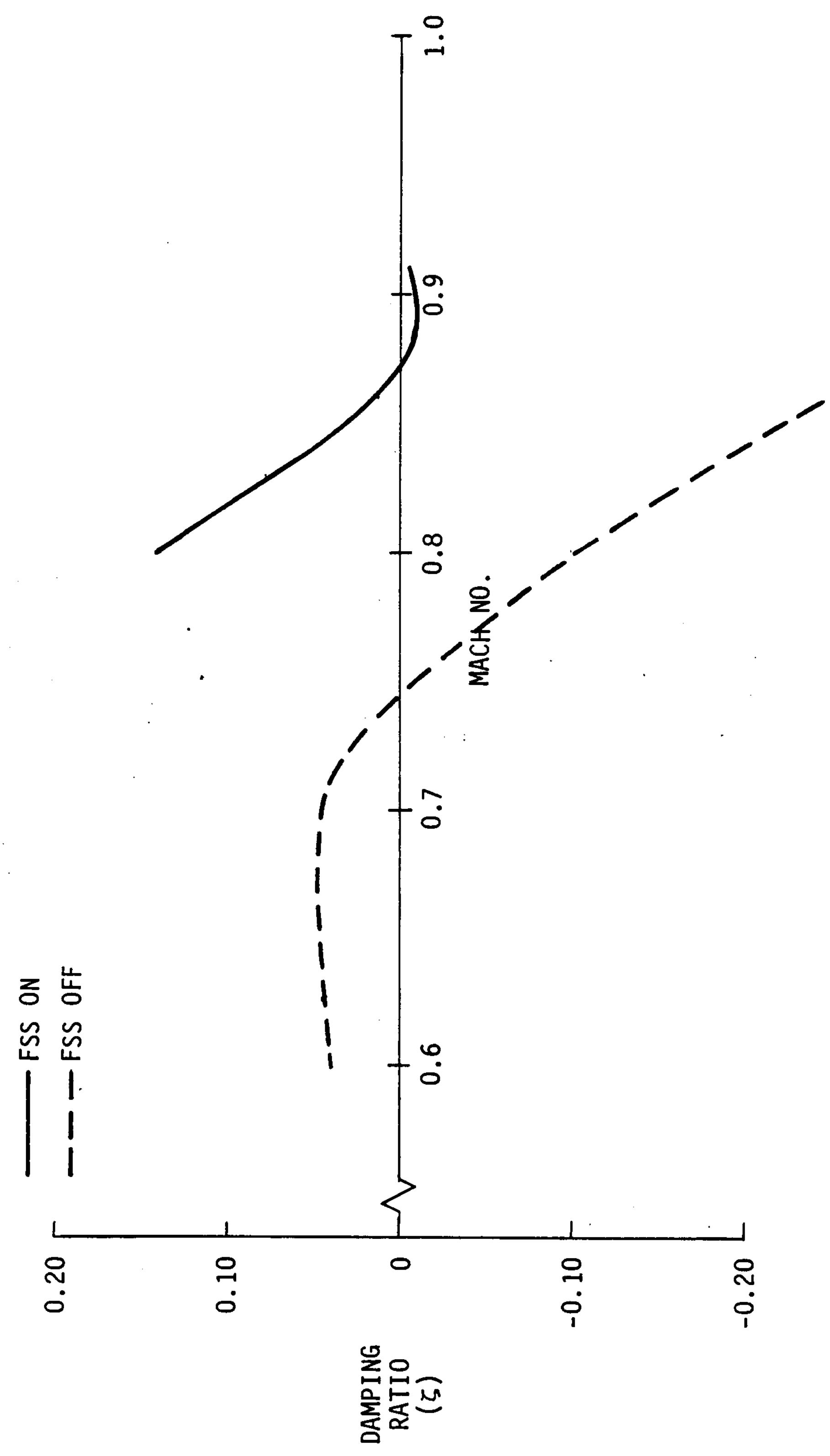


FIGURE 59

ANTISYMMETRIC FLUTTER MODE DAMPING, ALTITUDE: 12,000 FEET

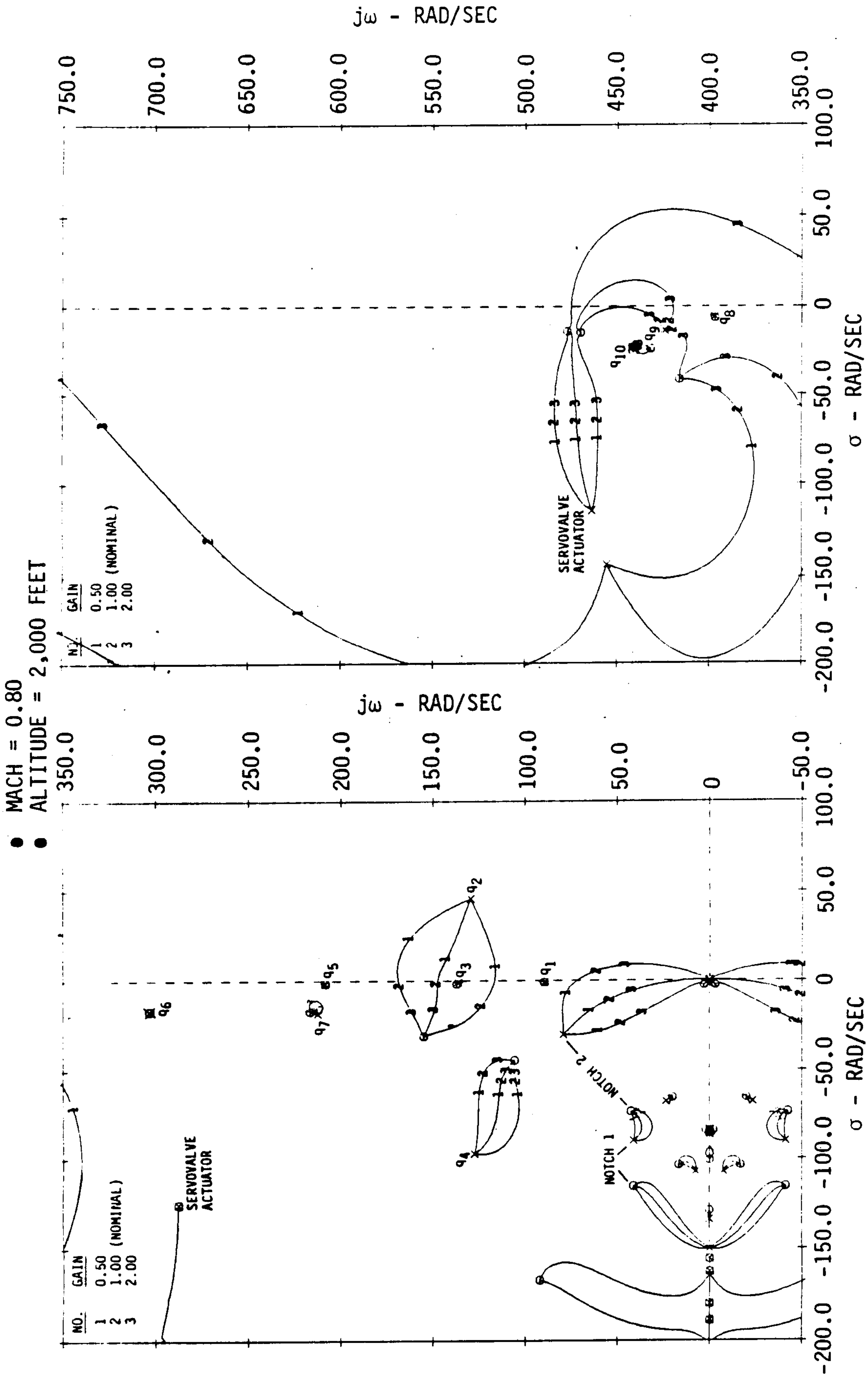


FIGURE 60

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.80, ALTITUDE: 2,000 FEET

- MACH = 0.83
- ALTITUDE = 3,000 FEET

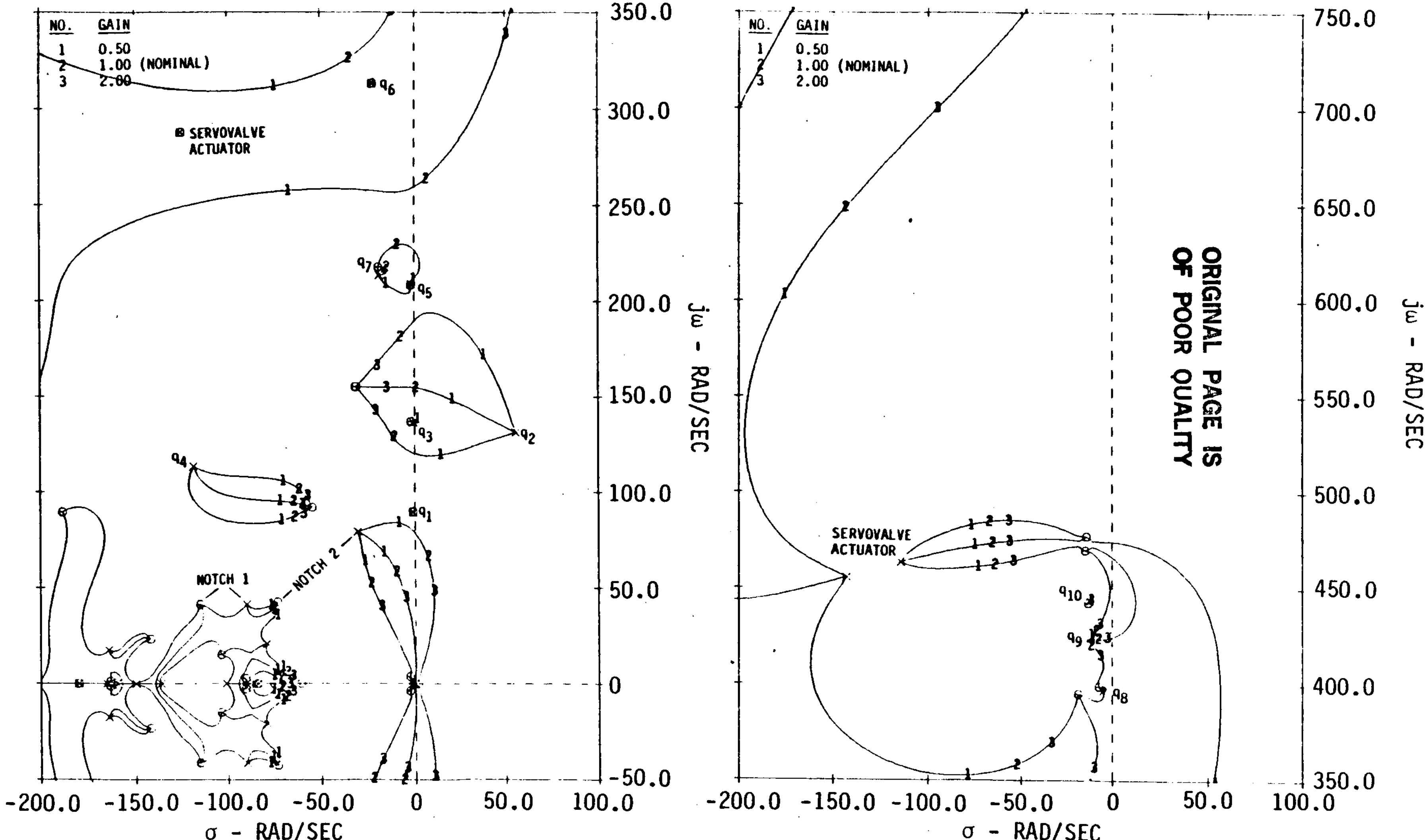


FIGURE 61

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM, MACH: 0.83, ALTITUDE: 3,000 FEET

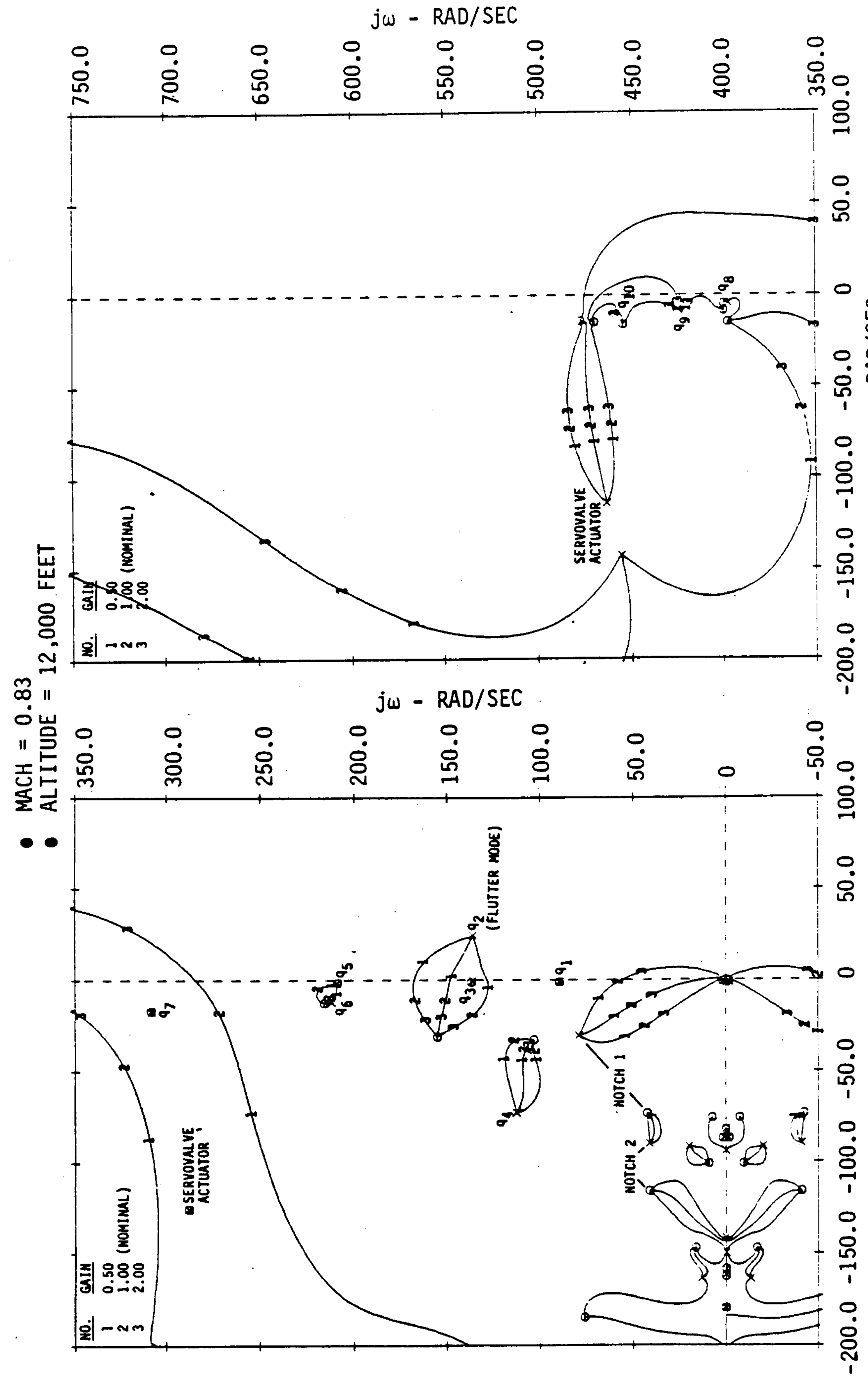


FIGURE 62

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.83, ALTITUDE: 12,000 FEET

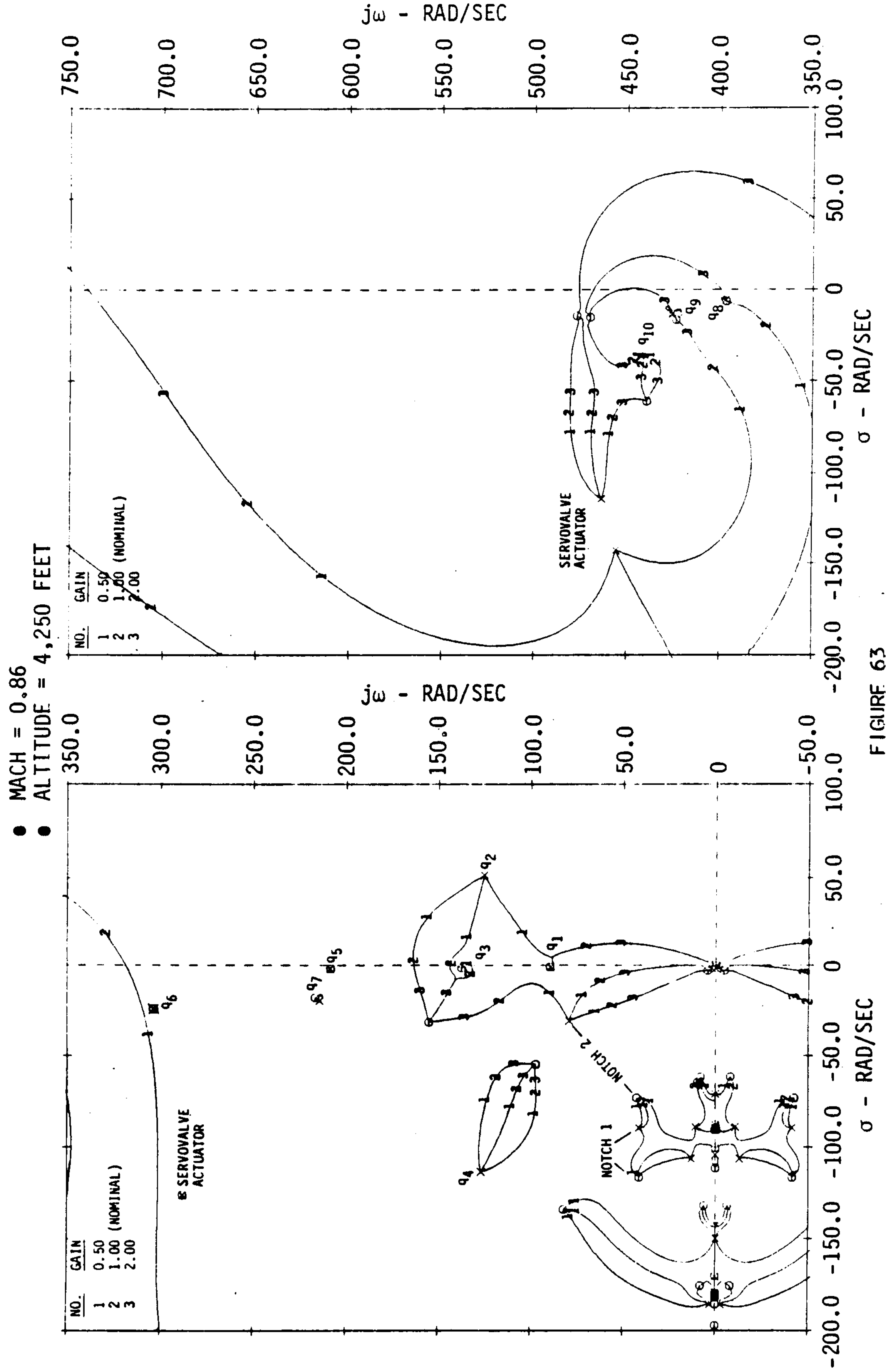


FIGURE 63

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 4,250 FEET

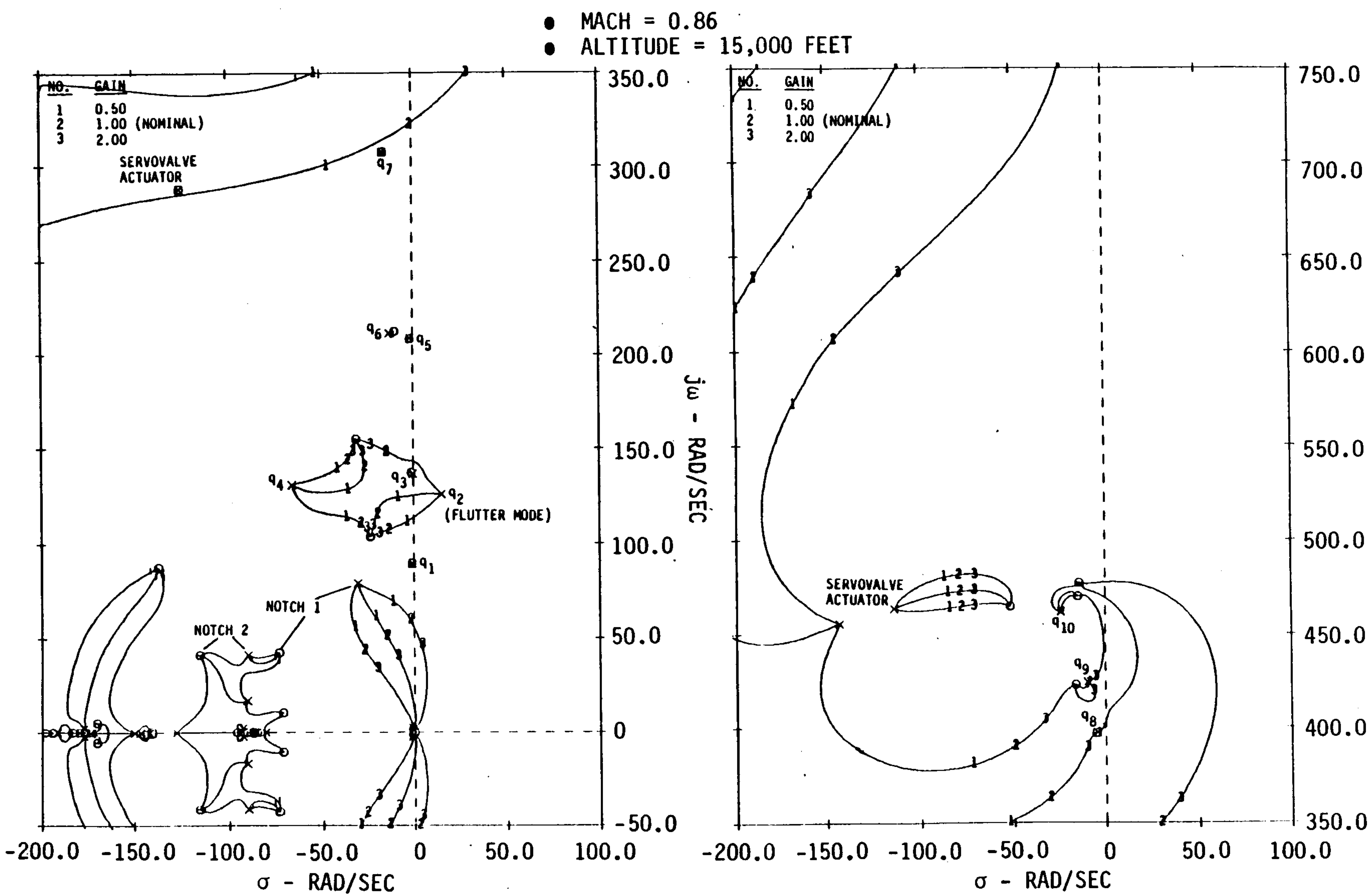


FIGURE 64

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 15,000 FEET

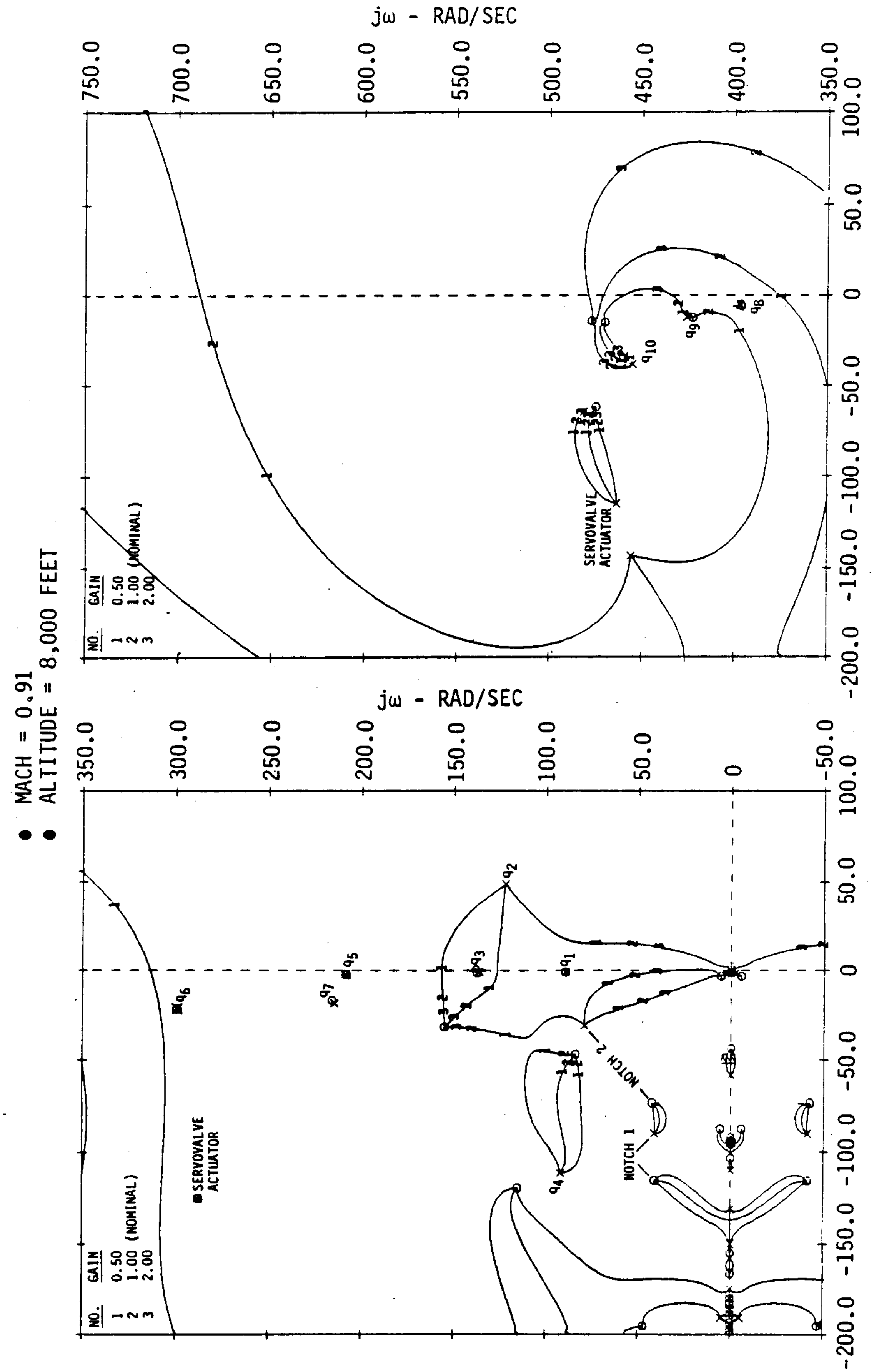


FIGURE 65

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.91, ALTITUDE: 8,000 FEET

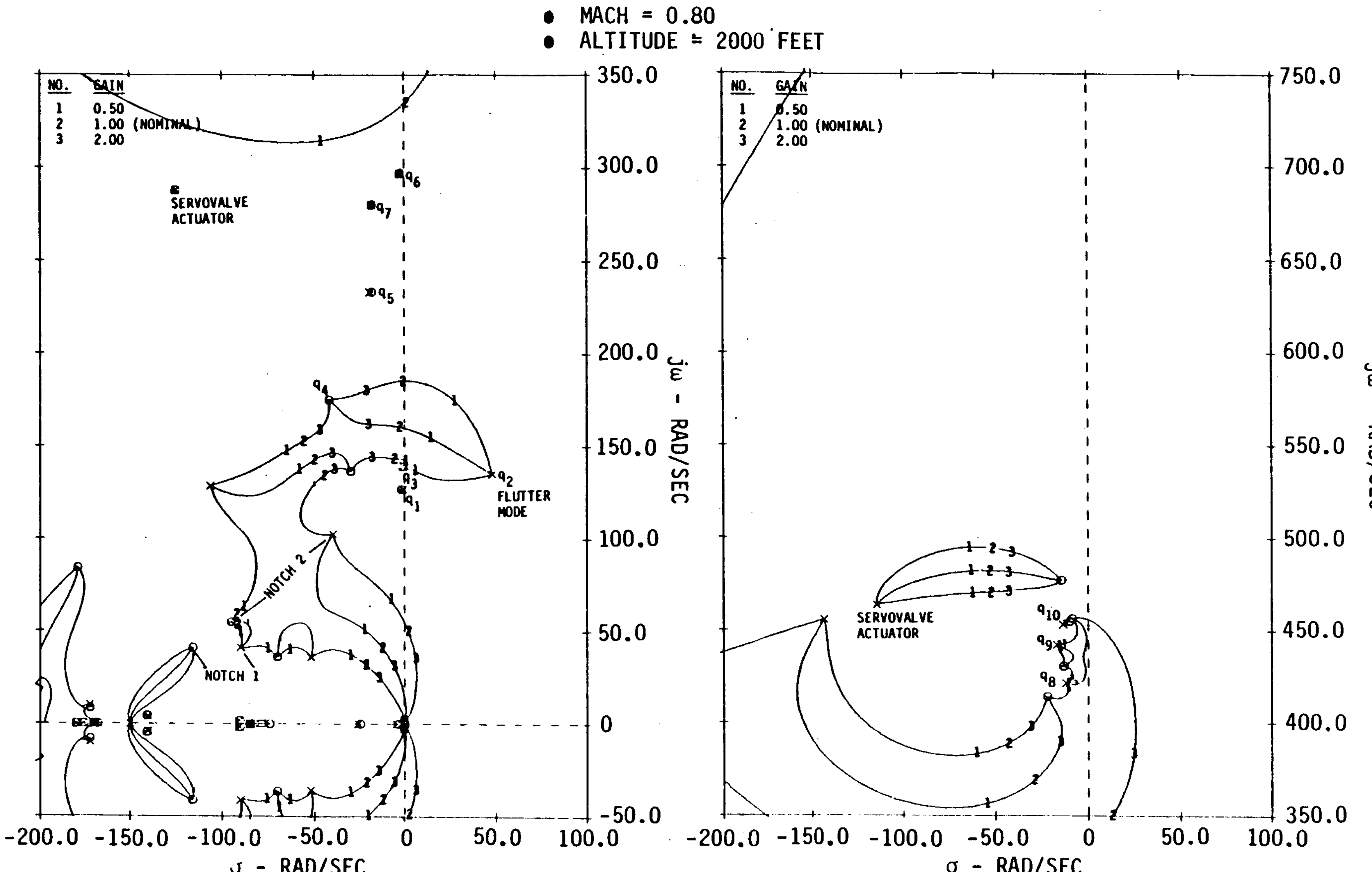


FIGURE 66

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING,
MACH: 0.80, ALTITUDE: 2,000 FEET

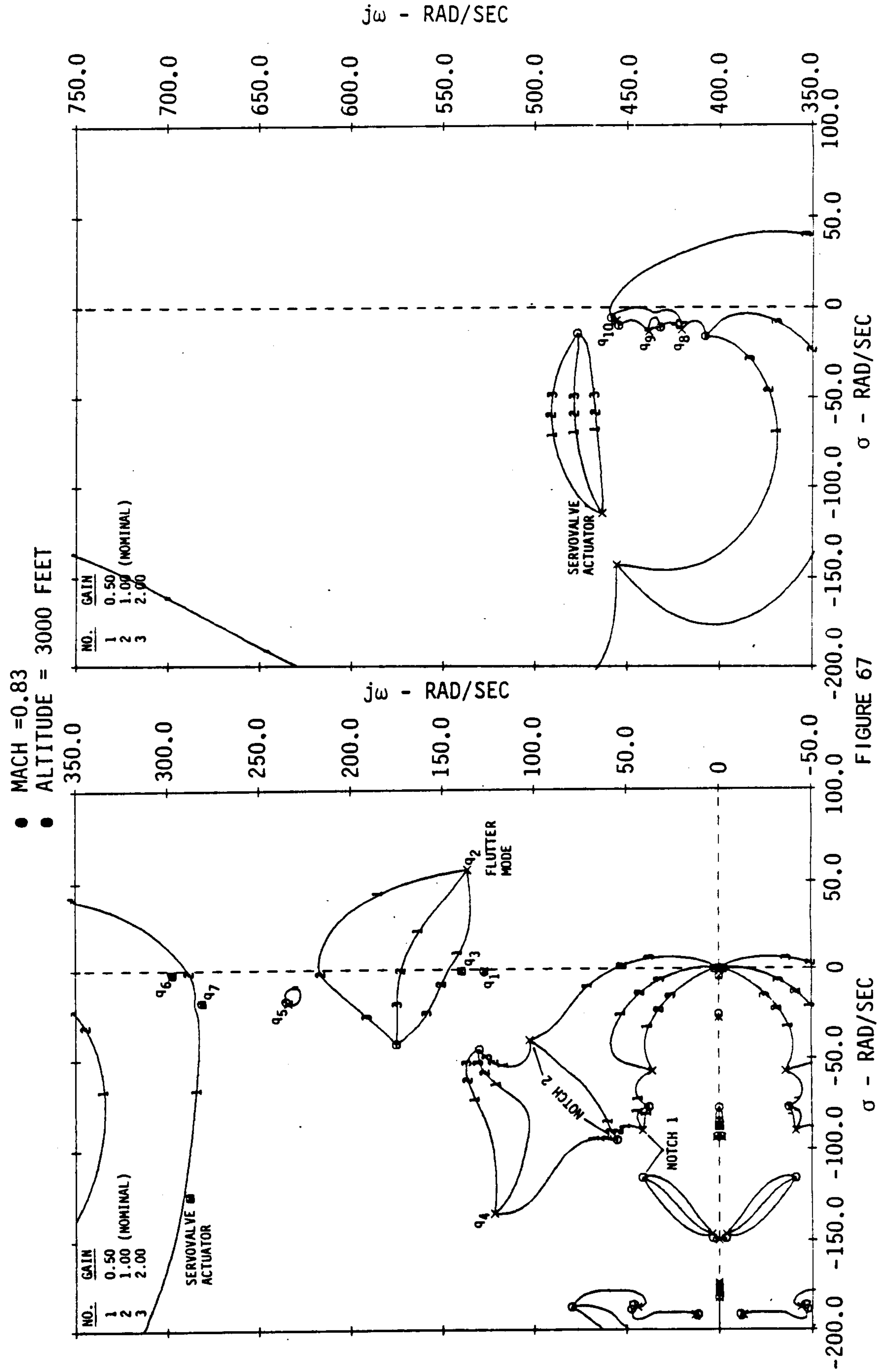


FIGURE 67

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING,
MACH: 0.83, ALTITUDE: 3,000 FEET

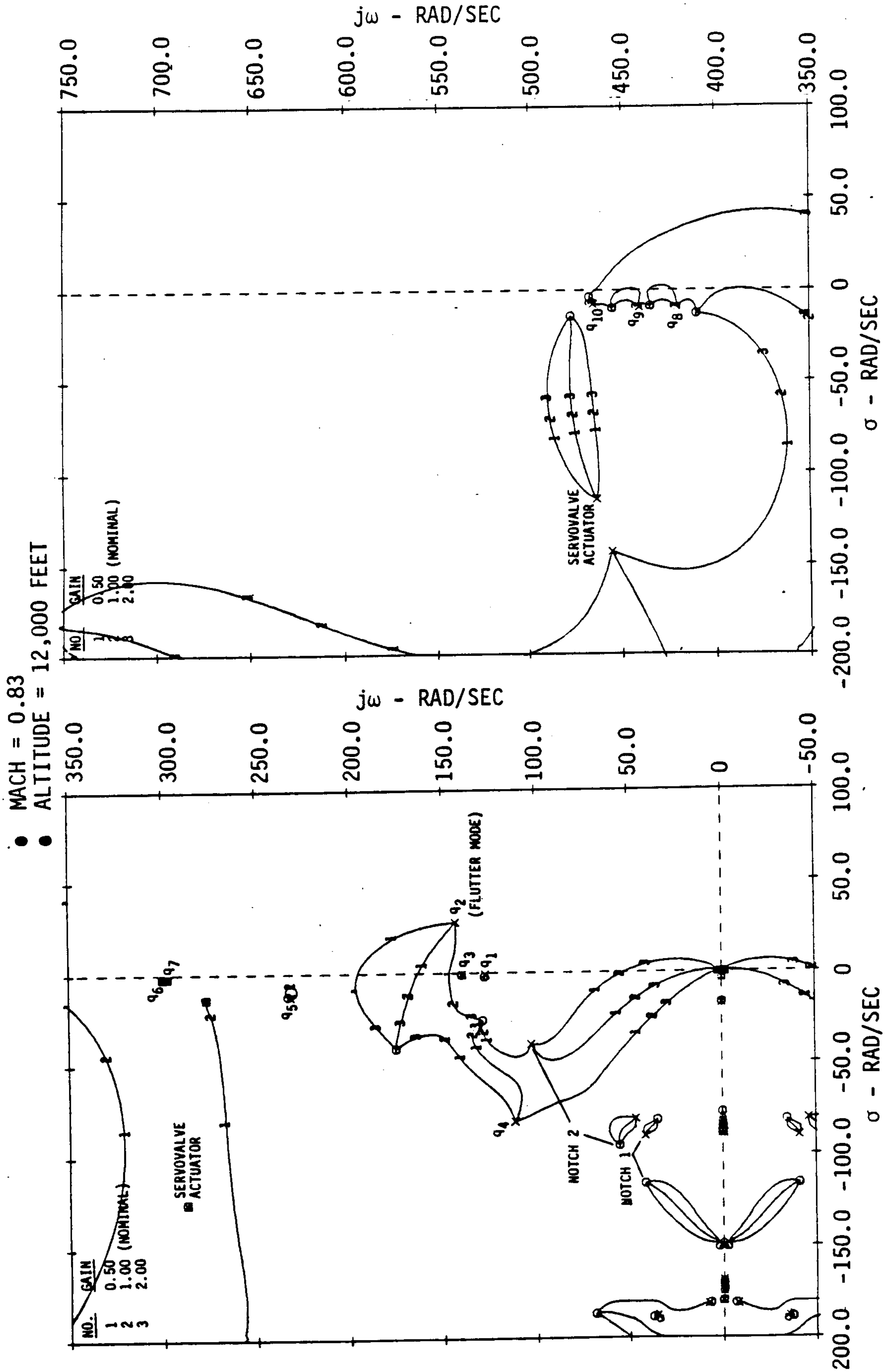


FIGURE 68

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, NOMINAL SYSTEM, MACH: 0.83, ALTITUDE: 12,000 FEET

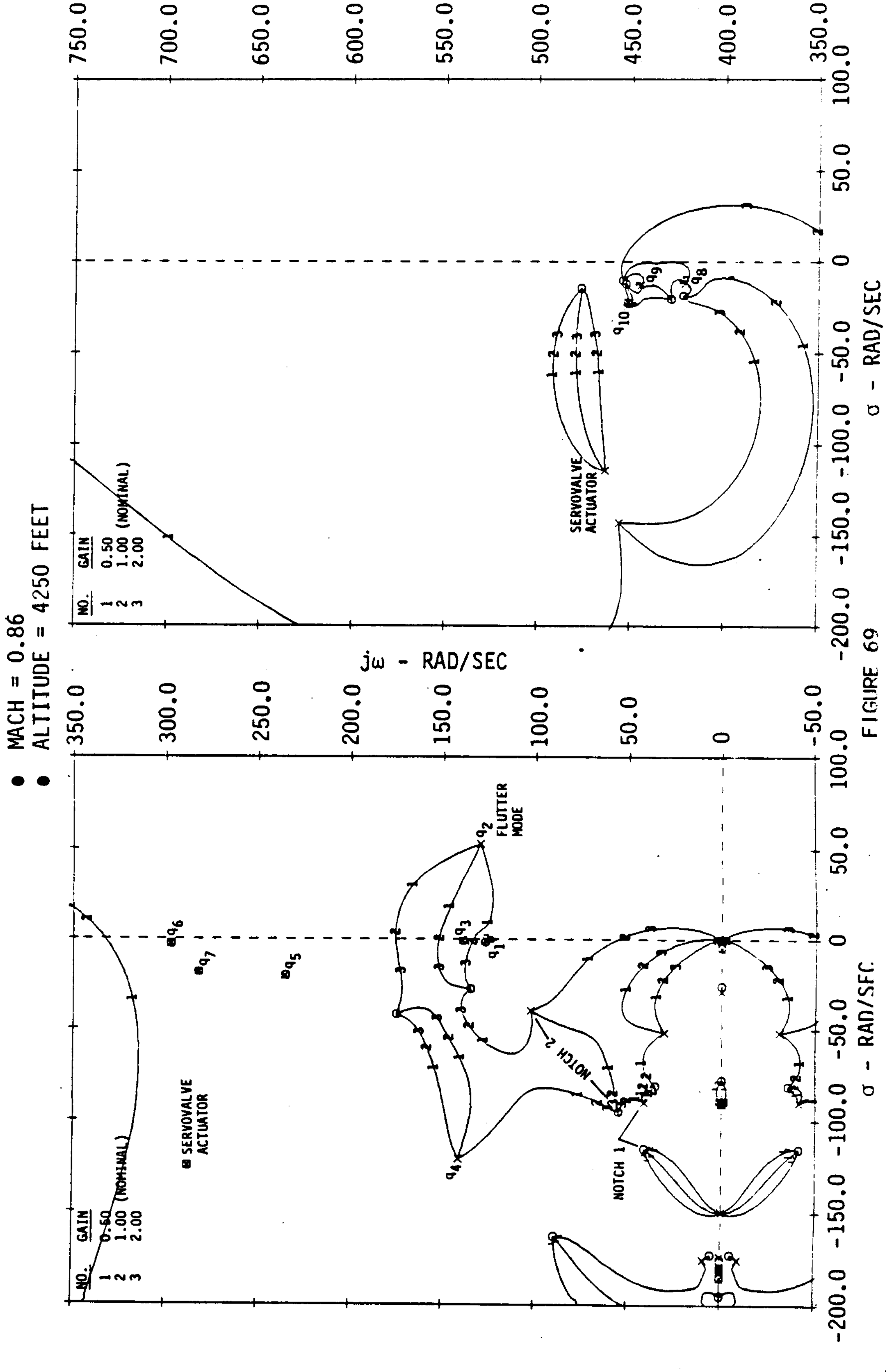


FIGURE 69

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING,
MACH: 0.86, ALTITUDE: 4,250 FEET

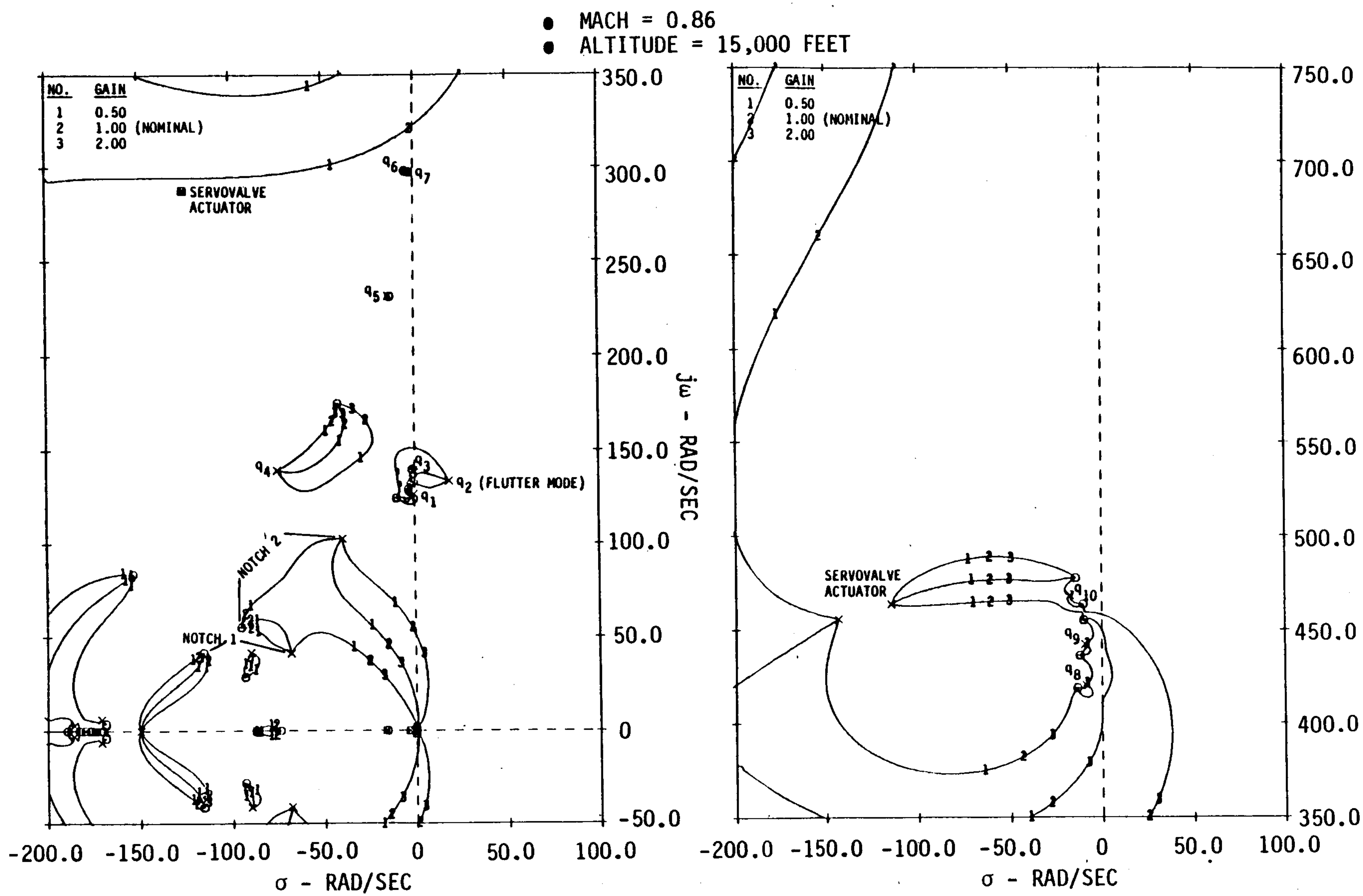


FIGURE 70

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, NOMINAL SYSTEM,
MACH: 0.86, ALTITUDE: 15,000 FEET

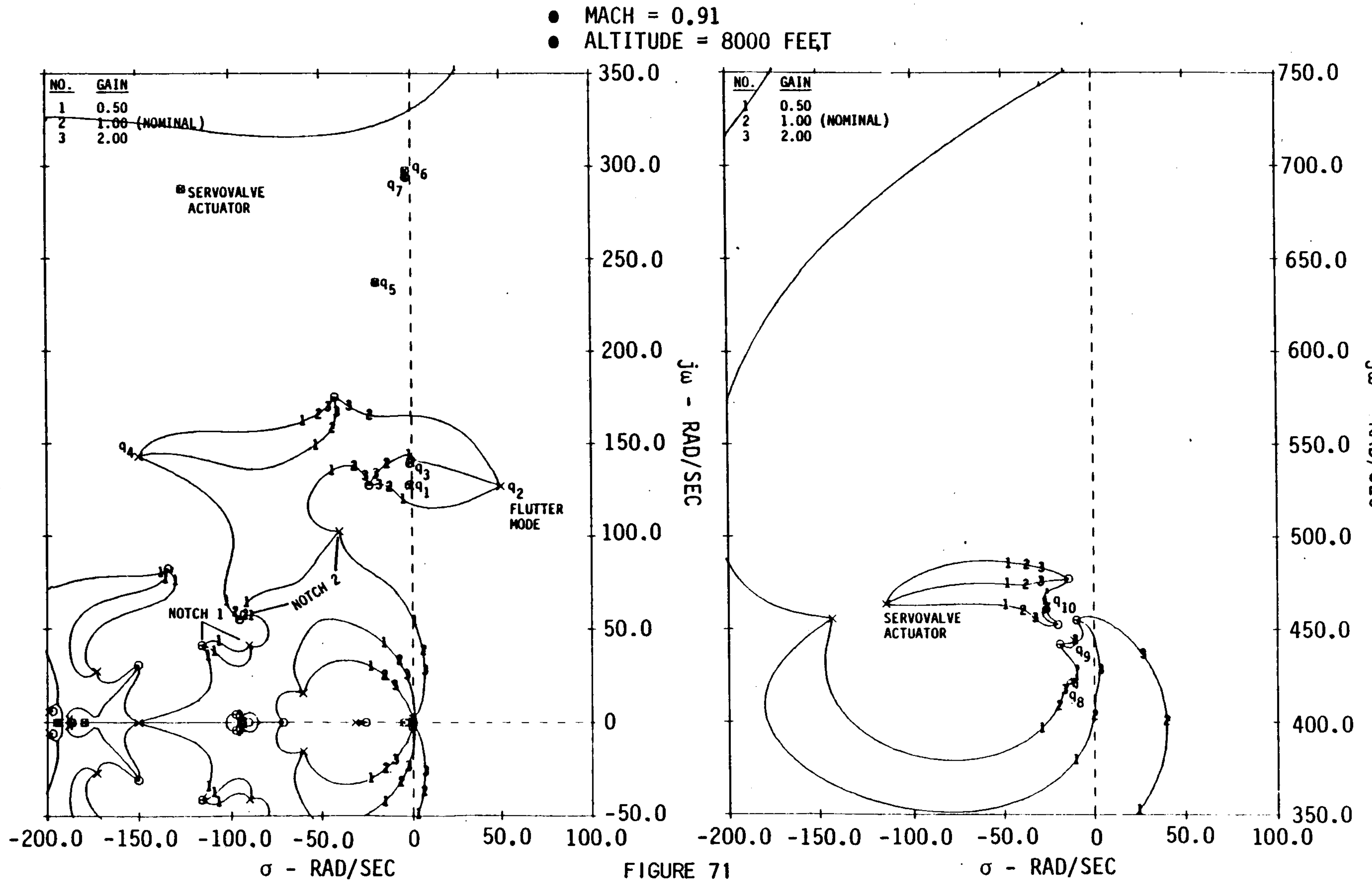


FIGURE 71

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH PARAMETER SCHEDULING,
MACH: 0.91, ALTITUDE: 8,000 FEET

APPENDIX D

DAST ARW-2 SENSITIVITY ANALYSIS DATA

This appendix contains data which summarizes the sensitivity of structural mode stability to variations in dynamics and locations of control system components. For the most part the sensitivity analysis was not repeated for the final FSS filters, however sensitivity to changes shown in this data and the root loci analysis performed using the latest filters indicate that results of this study are valid.

Figures 72 and 73 compare structural mode damping ratios for various accelerometer wing locations. The optimal sensor locations were selected by zero root locus as presented in the final report for sensors moved along front and rear spars. The sensor locations were varied inboard and outboard of the optimal up to two inches. The symmetric gain margin was not reduced below plus or minus 6 dB but the phase margin was reduced to 20 degrees when the sensors were separated by six inches. The antisymmetric gain and phase margins were reduced significantly when the sensors were separated by four inches.

The recommended installation of the symmetric accelerometers was plus or minus one inch of the wing station 82 on front spar and 84 on rear spar. The recommended installation of the antisymmetric accelerometers was plus or minus 0.5 inch of wing station 92 on both front and rear spars. The vertical accelerometer recommended location was at body station 265 plus or minus 2.5 inches.

Notch filters are used both in the FSS filter and servoactuator compensation. Sensitivity to notch filter parameter changes was analyzed. Figure 74 shows the transfer functions of the notch filters used in the symmetric and antisymmetric compensation. The final filters did not include the 170 and 230 radian notch filters, however the sensitivity analysis is presented here for future reference.

The summary of the notch filter sensitivity analysis is shown on Figures 74 through 82. The capacitors and resistors of the notch filters have very close tolerances and small sensitivity to temperature changes, therefore the parameter changes from nominal is expected to be small over the flight envelope. The damping ratio and frequency of the notch filters were varied plus and minus five percent and the damping ratio of the actual modes changed less than eight percent.

Several servovalves were evaluated in an effort to extend the servoactuator bandwidth. A Moog Series 31 servovalve was initially selected for the actuator model and later bench tested. The Series 31 servovalve has a wide bandwidth and improved FSS performance but was expensive and required complicated closed loop circuitry. A Hydraulic Research Model AR-25 servovalve was selected because it was a direct replacement for the Series 30 used for the ARW-1 servoactuator but had a wider bandwidth. The structural mode stability results of the three servovalves are shown on Figures 83 through 88. Figure 85 shows that a plus 6 dB gain margin cannot be achieved with the Series 30 servovalves. Although the AR-25 servovalve did not increase the servoactuator bandwidth, the increased servovalve bandwidth provided increased performance and 6 dB of gain margin was achieved.

Figures 88 and 89 when compared with Figures 83 and 86 respectively verify that the compensating actuator filter which cancels the surface-actuator mode is required. Figures 90 through 92 summarize the sensitivity analysis performed by varying the frequency of the surface-actuator mode with respect to the compensating filter frequency.

The results of this sensitivity study indicated that when the compensating filter was removed the symmetric airplane modes were destabilized and were difficult to stabilize and the antisymmetric filter mode lead phase margin was decreased to 40 degrees. The FSS was relatively insensitive to a plus or minus 20 percent frequency change in the surface-actuator mode.

Servoactuator pressure feedback gain was reduced to determine the effect on airplane stability. Figures 93 through 96 summarize this analysis. A reduction of 30 percent in pressure feedback gain did not reduce symmetric stability below specifications and the antisymmetric lag phase margin was reduced only to 40 degrees.

A hinge moment sensitivity analysis was performed to determine stability effects. Figure 97 shows the servoactuator gain and phase response to a hinge moment change at the filter frequency. The maximum aiding (surface trailing edge up) to the maximum resisting (trailing edge down) hinge moment causes approximately 45 degrees of phase lag and 4 dB loss in gain. Figures 98 through 104 summarize the hinge moment sensitivity analysis. Changes in hinge moment may require servoactuator gain scheduling. This should be evaluated further by ground and flight testing.

Other sensitivity studies showed that the airplane is relatively insensitive to small changes in stability derivatives and the active control systems tend to increase frequency and damping of the fuselage mode as shown on Figure 105.

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN — SENSOR LOCATION								
			FS 80 AND RS 82			FS 80 AND RS 84			FS 80 AND RS 86		
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES
q_1	14.2	0.0105	0.0125	0.0125	0.0125	0.0106	0.0118	0.0118	-0.0401	0.0108	0.0108
q_2	20.1	-0.1190	0.1062	0.1380	0.1106	0.0118	0.1652	0.1251	0.0108	0.2025	0.1442
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0092	0.0092	0.0092	0.0088	0.0088	0.0088
q_4	23.3	0.4521	0.7918	0.1783	0.2061	0.8138	0.1750	0.2266	0.8304	0.1755	0.2501
q_5	33.2	0.0084	0.0083	0.0083	0.0131	0.0082	0.0082	0.0082	0.0079	0.0079	0.0079
q_6	33.7	0.0619	0.0488	0.0488	0.0315	0.0529	0.0529	0.0315	0.0602	0.0602	0.0602
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0113	0.0120	0.0120	0.0112	0.0120	0.0119	0.0114	0.0114
q_9	67.6	0.0238	0.0202	0.0170	0.0230	0.0193	0.0217	0.0217	0.0195	0.0172	0.0172
q_{10}	73.6	0.0524	0.0401	0.0501	0.0552	0.0406	0.0505	0.0583	0.0419	0.0512	0.0512

BELOW DESIGN SPECS.

FIGURE 72

SYMMETRIC SENSOR LOCATION SENSITIVITY

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN								
			SENSOR LOCATION								
			FS 82 AND RS 82			FS 82 AND RS 84			FS 82 AND RS 86		
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES
q_1	14.2	0.0105	0.0129	0.0129	0.0129	0.0126	0.0126	0.0126	-0.0002	0.0117	0.0117
q_2	20.1	-0.1190	0.0743	0.1085	0.0844	0.1082	0.1368	0.1134	0.0117	0.1734	0.1351
q_3	21.7	0.0024	0.0098	0.0098	0.0098	0.0094	0.0094	0.0094	0.0090	0.0090	0.0090
q_4	23.3	0.4521	0.7640	0.1828	0.1855	0.7893	0.1791	0.2015	0.8106	0.1754	0.2273
q_5	33.2	0.0084	0.0084	0.0084	0.0104	0.0083	0.0083	0.0131	0.0080	0.0084	0.0084
q_6	33.7	0.0619	0.0428	0.0485	0.0436	0.0480	0.0505	0.0299	0.0571	0.0571	0.0571
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0119	0.0114	0.0119	0.0120	0.0113	0.0120	0.0119	0.0114	0.0120
q_9	67.6	0.0238	0.0226	0.0216	0.0234	0.0201	0.0168	0.0228	0.0222	0.0213	0.0235
q_{10}	73.6	0.0524	0.0428	0.0502	0.0574	0.0419	0.0500	0.0773	0.0437	0.0511	0.0566

BELOW DESIGN SPECS.

FIGURE 72 (CONTINUED)

SYMMETRIC SENSOR LOCATION SENSITIVITY

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN — SENSOR LOCATION								
			FS 84 AND RS 82			FS 84 AND RS 84			FS 84 AND RS 86		
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES
q_1	14.2	0.0105	0.0127	0.0127	0.0127	0.0129	0.0129	0.0129	0.0124	0.0124	0.0124
q_2	20.1	-0.1190	0.0496	0.0699	0.0684	0.0771	0.1071	0.0913	0.1272	0.1478	0.1235
q_3	21.7	0.0024	0.0104	0.0104	0.0104	0.0098	0.0098	0.0098	0.0092	0.0092	0.0092
q_4	23.3	0.4521	0.7357	0.1985	0.1591	0.7618	0.1844	0.1799	0.7896	0.1763	0.2065
q_5	33.2	0.0084	0.0087	0.0085	0.0093	0.0085	0.0084	0.0105	0.0081	0.0081	0.0081
q_6	33.7	0.0619	0.0417	0.0472	0.0526	0.0421	0.0574	0.0405	0.0534	0.0534	0.0351
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0119	0.0115	0.0119	0.0120	0.0114	0.0119	0.0119	0.0115	0.0119
q_9	67.6	0.0238	0.0231	0.0222	0.0236	0.0225	0.0213	0.0233	0.0228	0.0221	0.0237
q_{10}	73.6	0.0524	0.0485	0.0500	0.0565	0.0441	0.0502	0.0562	0.0455	0.0509	0.0554

FIGURE 72 (CONCLUDED)

SYMMETRIC SENSOR LOCATION SENSITIVITY

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN								
			SENSOR LOCATION								
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	FS 90 AND RS 90			FS 90 AND RS 92			FS 90 AND RS 94		
			+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES
q_1	20.1	0.0032	0.0261	0.0343	0.0177	0.0186	0.0530	0.0582	0.0154	0.0685	0.0843
q_2	21.5	-0.1372	0.0452	0.0172	0.0105	0.0640	0.0186	0.0093	0.0788	0:0154	0.0088
q_3	22.2	0.0040	0.0105	0.0105	0.0105	0.0093	0.0093	0.0093	0.0088	0.0088	0.0088
q_4	25.2	0.4735	0.8157	0.1545	0.0068	0.8373	0.1510	-0.0081	0.8535	0.1523	-0.0924
q_5	36.9	0.0602	0.0557	0.0557	0.0804	0.0615	0.0615	0.0615	0.0657	0.0657	0.0695
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0082	0.0082	0.0082	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214	0.0213	0.0202	0.0211	0.0213	0.0205	0.0222	0.0215	0.0209	0.0220
q_9	70.4	0.0209	0.0206	0.0195	0.0203	0.0204	0.0195	0.0205	0.0203	0.0195	0.0217
q_{10}	74.5	0.0367	0.0379	0.0365	0.0361	0.0388	0.0367	0.0358	0.0430	0.0371	0.0353

BELOW DESIGN SPECS.

FIGURE 73

ANTISYMMETRIC SENSOR LOCATION SENSITIVITY

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN								
			SENSOR LOCATION								
			FS 92 AND RS 90			FS 92 AND RS 92			FS 92 AND RS 94		
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES
q_1	20.1	0.0032				0.0802	0.0802	0.0802	0.0194	0.0531	0.0558
q_2	21.5	-0.1372				0.0274	0.0274	0.0107	0.0638	0.0194	0.0094
q_3	22.2	0.0040				0.0107	0.0107	0.0274	0.0094	0.0094	0.0094
q_4	25.2	0.4735				0.8127	0.1697	0.0373	0.8375	0.1525	-0.0147
q_5	36.9	0.0602				0.0556	0.0556	0.0775	0.0613	0.0613	0.0613
q_6	44.1	0.0487				0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077				0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214				0.0273	0.0217	0.0223	0.0212	0.0203	0.0225
q_9	70.4	0.0209				0.0223	0.0193	0.0218	0.0199	0.0189	0.0201
q_{10}	74.5	0.0367				0.0389	0.0361	0.0353	0.0447	0.0374	0.0327

BELOW DESIGN SPECS.

FIGURE 73 (CONTINUED)

ANTISYMMETRIC SENSOR LOCATION SENSITIVITY

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN, SENSOR LOCATION								
			FS 94 AND RS 90			FS 94 AND RS 92			FS 94 AND RS 94		
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES	+45 DEGREES	NOMINAL	-45 DEGREES
q_1	20.1	0.0032	0.0219	0.0219	0.0219	0.0292	0.0101	0.0365	0.0289	0.0335	0.0178
q_2	21.5	-0.1372	0.0001	-0.0102	-0.0054	0.0085	0.0101	0.0291	0.0462	0.0198	0.0108
q_3	22.2	0.0040	0.0015	0.0225	0.0225	0.0141	0.0141	0.0166	0.0108	0.0108	0.0108
q_4	25.2	0.4735	0.7721	0.1769	0.0561	0.7962	0.1642	0.0200	0.8181	0.1567	0.0148
q_5	36.9	0.0602	0.0369	0.0625	0.0919	0.0478	0.0571	0.0930	0.0556	0.0556	0.0900
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214	0.0209	0.0194	0.0196	0.0210	0.0196	0.0201	0.0210	0.0199	0.0208
q_9	70.4	0.0209	0.0190	0.0154	0.0159	0.0188	0.0152	0.0189	0.0184	0.0181	0.1930
q_{10}	74.5	0.0367	0.0435	0.0378	0.0328	0.0453	0.0382	0.0321	0.0465	0.0382	0.0316

BELOW DESIGN SPECS.

FIGURE 73 (CONCLUDED)

ANTISYMMETRIC SENSOR LOCATION SENSITIVITY

SYMMETRIC

	85 RAD. NOTCH	170 RAD. NOTCH
NOMINAL	$\frac{S^2 + 147.2S + 7225.0}{S^2 + 61.4S + 7225.0}$	$\frac{S^2 + 68.0S + 28900}{S^2 + 136.0S + 28900}$
ω_N 5% INCREASE	$\frac{S^2 + 154.6S + 7965.5}{S^2 + 64.4S + 7965.5}$	$\frac{S^2 + 71.5S + 31862}{S^2 + 142.8S + 31862}$
ω_N 5% DECREASE	$\frac{S^2 + 139.9S + 6520.6}{S^2 + 58.3S + 6520.6}$	$\frac{S^2 + 64.6S + 26082}{S^2 + 129.3S + 26082}$
$\|M\|$ 5% INCREASE	$\frac{S^2 + 149.3S + 7225.0}{S^2 + 59.3S + 7225.0}$	$\frac{S^2 + 65.8S + 28900}{S^2 + 138.19S + 28900}$
$\|M\|$ 5 % DECREASE	$\frac{S^2 + 145.0S + 7225.0}{S^2 + 63.6S + 7225.0}$	$\frac{S^2 + 70.3S + 28900}{S^2 + 133.7S + 28900}$

ANTISYMMETRIC

	110 RAD. NOTCH	230 RAD. NOTCH
NOMINAL	$\frac{S^2 + 190.5S + 12100}{S^2 + 79.4S + 12100}$	$\frac{S^2 + 92.0S + 52900}{S^2 + 184.0S + 52900}$
ω_N 5% INCREASE	$\frac{S^2 + 200.1S + 13340}{S^2 + 83.4S + 13340}$	$\frac{S^2 + 96.6S + 58322}{S^2 + 193.2S + 58322}$
ω_N 5% DECREASE	$\frac{S^2 + 181.0S + 10920}{S^2 + 75.5S + 10920}$	$\frac{S^2 + 87.4S + 47742}{S^2 + 174.8S + 47742}$
$\|M\|$ 5% INCREASE	$\frac{S^2 + 190.3S + 12100}{S^2 + 76.7S + 12100}$	$\frac{S^2 + 89.0S + 52900}{S^2 + 186.0S + 52900}$
$\|M\|$ 5% DECREASE	$\frac{S^2 + 187.6S + 12100}{S^2 + 82.3S + 12100}$	$\frac{S^2 + 95.1S + 52900}{S^2 + 180.8S + 52900}$

FIGURE 74

NOTCH FILTER TRANSFER FUNCTION FOR SENSITIVITY STUDIES

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	14.2	0.0105	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
q_2	20.1	-0.1190	0.1269	0.0939	0.1408	0.1308	0.1171	0.1104
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
q_4	23.3	0.4521	0.7868	0.7914	0.1774	0.1810	0.2010	0.2008
q_5	33.2	0.0084	0.0083	0.0083	0.0083	0.0083	0.0083	0.0130
q_6	33.7	0.0619	0.0480	0.0480	0.0480	0.0480	0.0480	0.0323
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0120	0.0113	0.0113	0.0120	0.0120
q_9	67.6	0.0238	0.0200	0.0202	0.0205	0.0168	0.0229	0.0228
q_{10}	73.6	0.524	0.0419	0.0419	0.0501	0.0499	0.0574	0.0572

FIGURE 75

SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 85 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	14.2	0.0105	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
q_2	20.1	-0.1190	0.1130	0.1028	0.1366	0.1364	0.0989	0.1225
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
q_4	23.3	0.4521	0.7888	0.7894	0.1723	0.1860	0.1973	0.2076
q_5	33.2	0.0084	0.0083	0.0083	0.0083	0.0083	0.0121	0.0480
q_6	33.7	0.0619	0.0480	0.0480	0.0480	0.0480	0.0366	0.0083
q_7	49.1	0.0	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0120	0.0113	0.0113	0.0113	0.0120
q_9	67.6	0.0238	0.0202	0.0200	0.0168	0.0168	0.0168	0.0229
q_{10}	73.6	0.524	0.419	0.0419	0.0499	0.0501	0.0499	0.0551

FIGURE 76

SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 170 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	14.2	0.0105	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
q_2	20.1	-0.1190	0.1162	0.0986	0.1413	0.1310	0.1134	0.1138
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
q_4	23.3	0.4521	0.7881	0.7904	0.1770	0.1812	0.2053	0.1975
q_5	33.2	0.0084	0.0083	0.0083	0.0083	0.0083	0.0480	0.0480
q_6	33.7	0.0619	0.0480	0.0480	0.0503	0.0480	0.0280	0.0316
q_7	49.1	0.05	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0120	0.0113	0.0113	0.0133	0.0120
q_9	67.6	0.0238	0.0200	0.0202	0.0168	0.0168	0.0229	0.0228
q_{10}	73.6	0.524	0.0420	0.0419	0.0501	0.0499	0.0574	0.0572

FIGURE 77

SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 85 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	14.2	0.0105	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
q_2	20.1	-0.1190	0.1064	0.1109	0.1377	0.1359	0.1006	0.1006
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
q_4	23.3	0.4521	0.7905	0.7875	0.1719	0.1866	0.2043	0.1987
q_5	33.2	0.0084	0.0083	0.0083	0.0083	0.0083	0.0480	0.0131
q_6	33.7	0.0619	0.0480	0.0480	0.0480	0.0499	0.0333	0.0259
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0120	0.0113	0.0113	0.0120	0.0120
q_9	67.6	0.0238	0.0202	0.0200	0.0168	0.0168	0.0228	0.0229
q_{10}	73.6	0.524	0.0419	0.0420	0.0499	0.0501	0.0572	0.0574

FIGURE 78

SYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 170 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	20.1	0.0032	0.0274	0.0226	0.0358	0.0308	0.0174	0.0274
q_2	21.5	-0.1372	0.0490	0.0426	0.0174	0.0184	0.0107	0.0107
q_3	22.2	0.0040	0.0107	0.0107	0.0107	0.0107	0.0425	0.0107
q_4	25.2	0.4735	0.8116	0.8206	0.1541	0.1572	0.0090	0.0113
q_5	39.9	0.0602	0.0556	0.0556	0.0556	0.0556	0.0859	0.0810
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214	0.0211	0.0212	0.0201	0.0201	0.0210	0.0210
q_9	70.4	0.0209	0.0201	0.0202	0.0189	0.0189	0.0199	0.0199
q_{10}	74.5	0.0367	0.0431	0.0431	0.0373	0.0375	0.0350	0.0351

BELOW DESIGN SPECS.

FIGURE 79

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 110 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	20.1	0.0032	0.0274	0.0274	0.0342	0.0324	0.0176	0.0177
q_2	21.5	-0.1372	0.0460	0.0446	0.0181	0.0181	0.0107	0.0107
q_3	22.2	0.0040	0.0107	0.0107	0.0107	0.0107	0.0440	0.0107
q_4	25.2	0.4735	0.8148	0.8169	0.1438	0.1664	-0.0181	0.0607
q_5	39.9	0.0602	0.0556	0.0556	0.0556	0.0556	0.0658	0.0726
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214	0.0212	0.0211	0.0201	0.0200	0.0210	0.0210
q_9	70.4	0.0209	0.0202	0.0201	0.0190	0.0189	0.0199	0.0199
q_{10}	74.5	0.0367	0.0430	0.0431	0.0375	0.0373	0.0350	0.0350

BELOW DESIGN SPECS.

FIGURE 80

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH FREQUENCY, 230 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	20.1	0.0032	0.0274	0.0274	0.0348	0.0318	0.0181	0.0172
q_2	21.5	-0.1372	0.0465	0.0441	0.0201	0.0164	0.0107	0.0107
q_3	22.2	0.0040	0.0107	0.0107	0.0107	0.0107	0.0107	0.0411
q_4	25.2	0.4735	0.8152	0.8167	0.1532	0.1578	0.0046	0.0148
q_5	39.9	0.0602	0.0556	0.0556	0.0556	0.0556	0.0836	0.0829
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214	0.0211	0.0212	0.0201	0.0201	0.0210	0.0210
q_9	70.4	0.0209	0.0201	0.0202	0.0189	0.0189	0.0199	0.0199
q_{10}	74.5	0.0367	0.0431	0.0431	0.0373	0.0375	0.0350	0.0350

FIGURE 81

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 110 RAD. NOTCH

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	+45 DEGREES		NOMINAL		-45 DEGREES	
			5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE	5% INCREASE	5% DECREASE
q_1	20.1	0.0032	0.0274	0.0274	0.0329	0.0340	0.0177	0.0176
q_2	21.5	-0.1372	0.0449	0.0459	0.0186	0.0177	0.0107	0.0107
q_3	22.2	0.0040	0.0107	0.0107	0.0107	0.0107	0.0107	0.0438
q_4	25.2	0.4735	0.8169	0.8143	0.1483	0.1633	0.0056	0.0141
q_5	39.9	0.0602	0.0556	0.0556	0.0556	0.0556	0.0786	0.0918
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.0214	0.0212	0.0211	0.0201	0.0201	0.0210	0.0210
q_9	70.4	0.0209	0.0202	0.0201	0.0189	0.0189	0.0199	0.0199
q_{10}	74.5	0.0367	0.0431	0.0431	0.0375	0.0373	0.0350	0.0350

FIGURE 82

ANTISYMMETRIC NOTCH FILTER SENSITIVITY TO NOTCH MAGNITUDE, 230 RAD. NOTCH

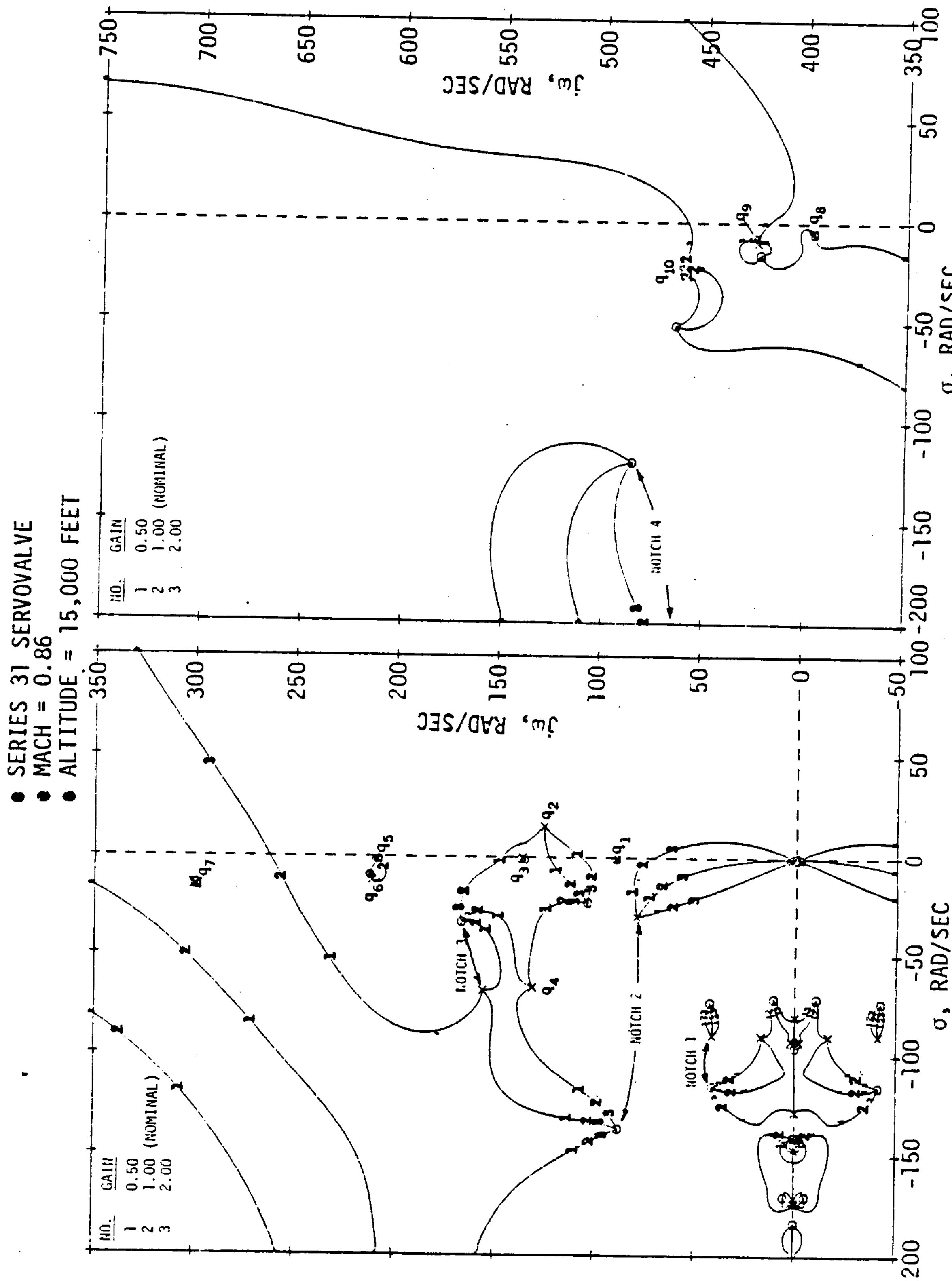


FIGURE 83

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, NOMINAL SYSTEM

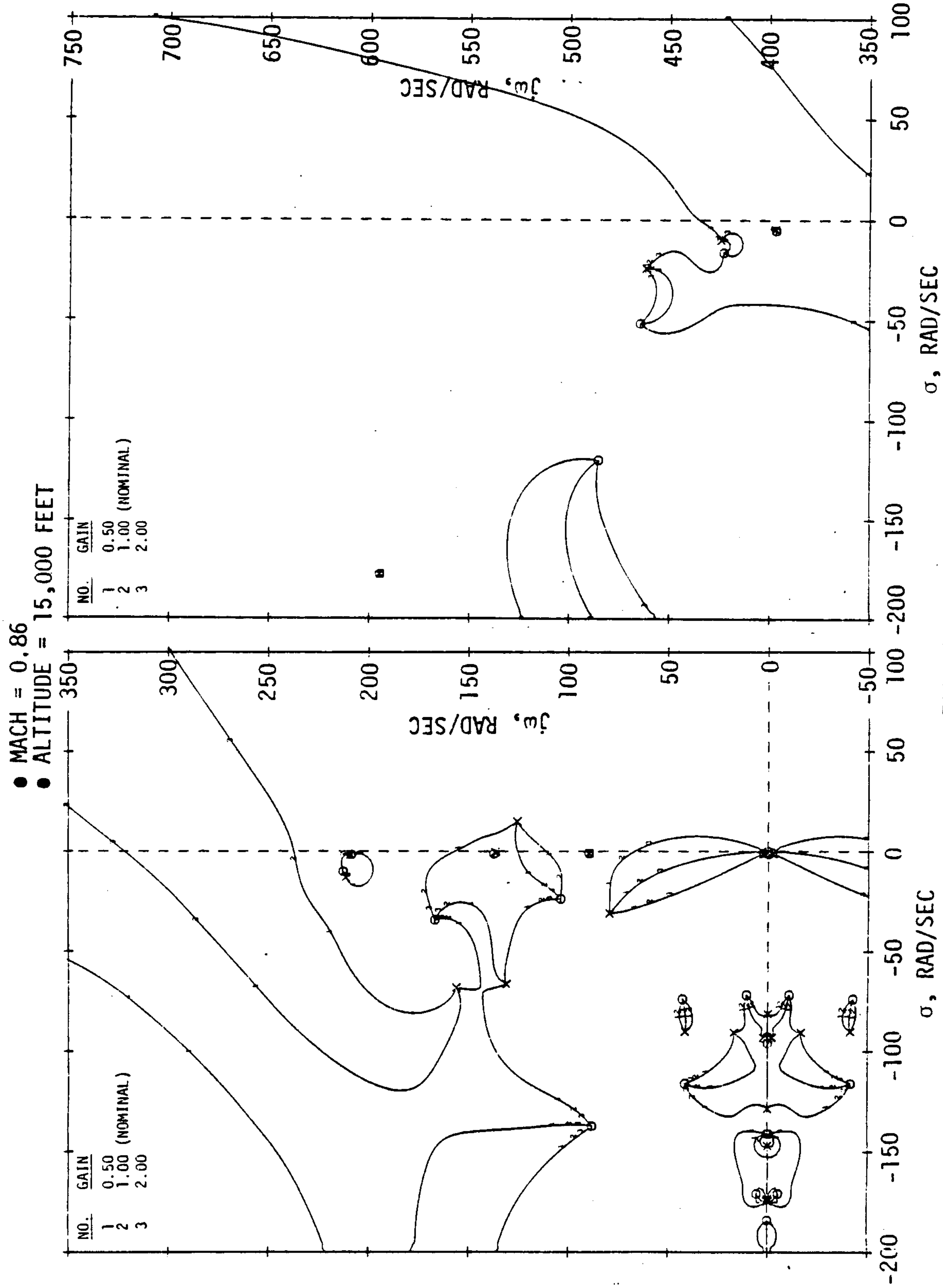


FIGURE 84

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS WITH AR-25 SERVOVALVE

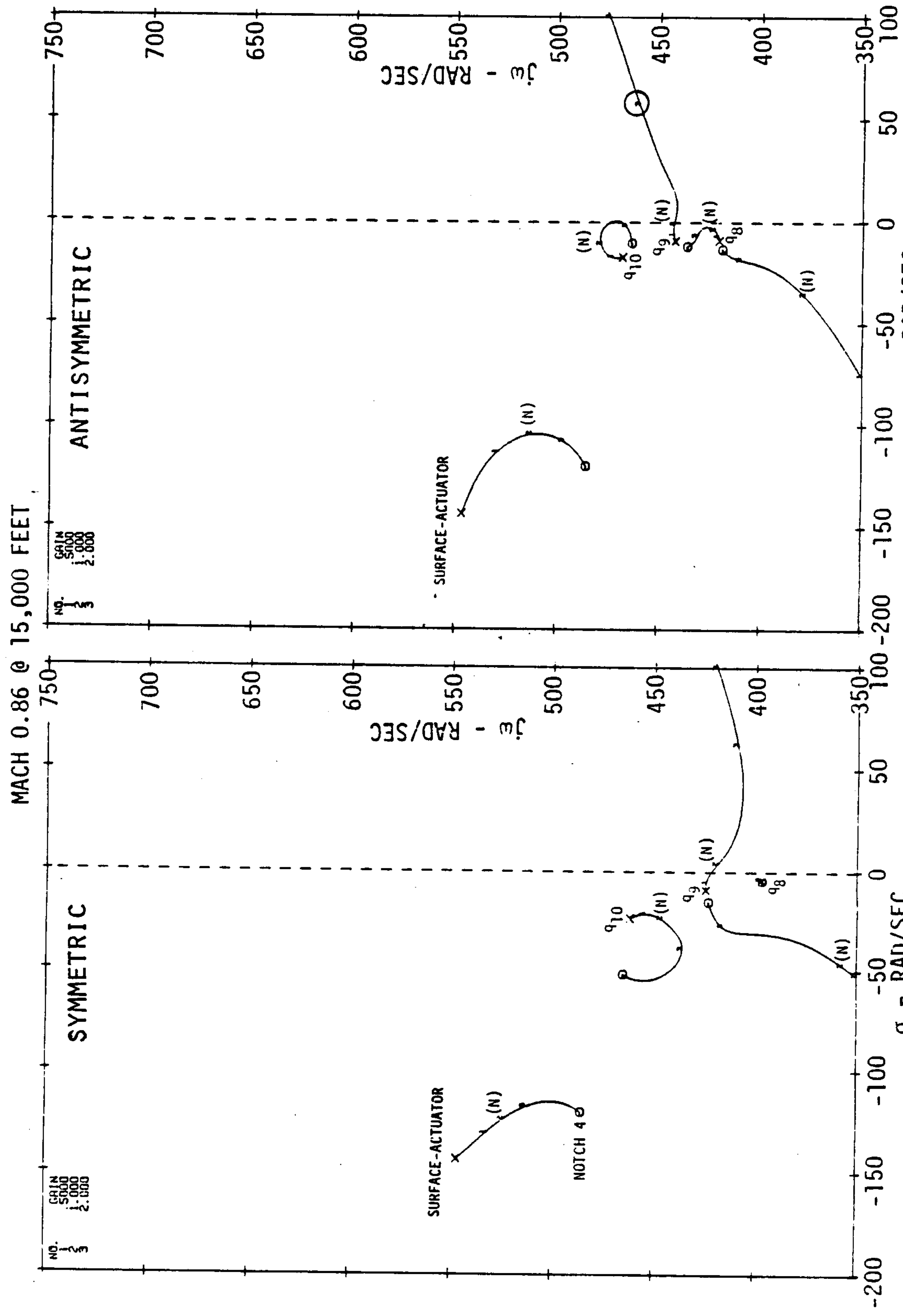


FIGURE 85

ROOT LOCUS OF SYMMETRIC AND ANTISYMMETRIC FSS WITH SERIES 30 SERVOVALVE

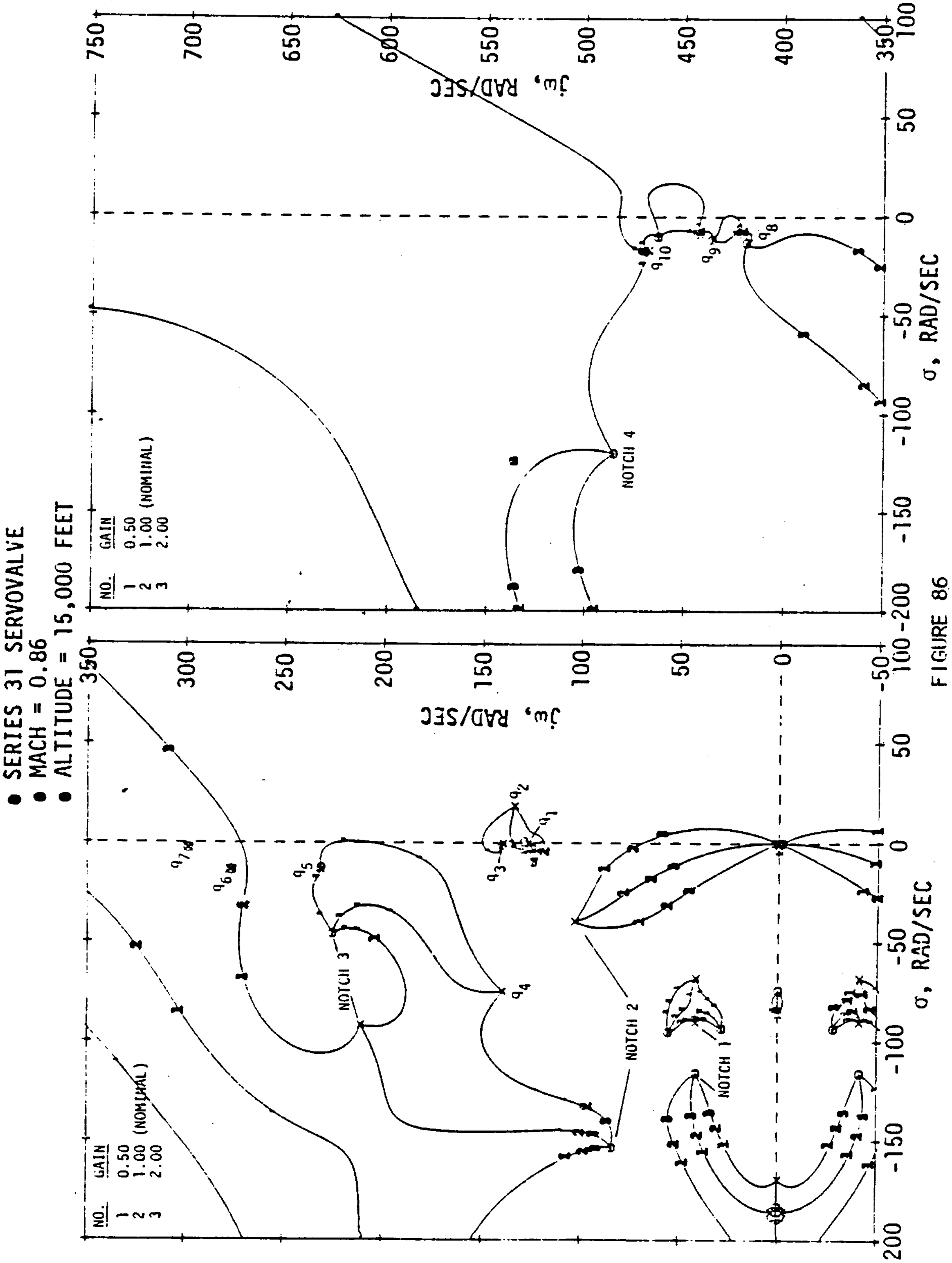


FIGURE 86

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, NOMINAL SYSTEM

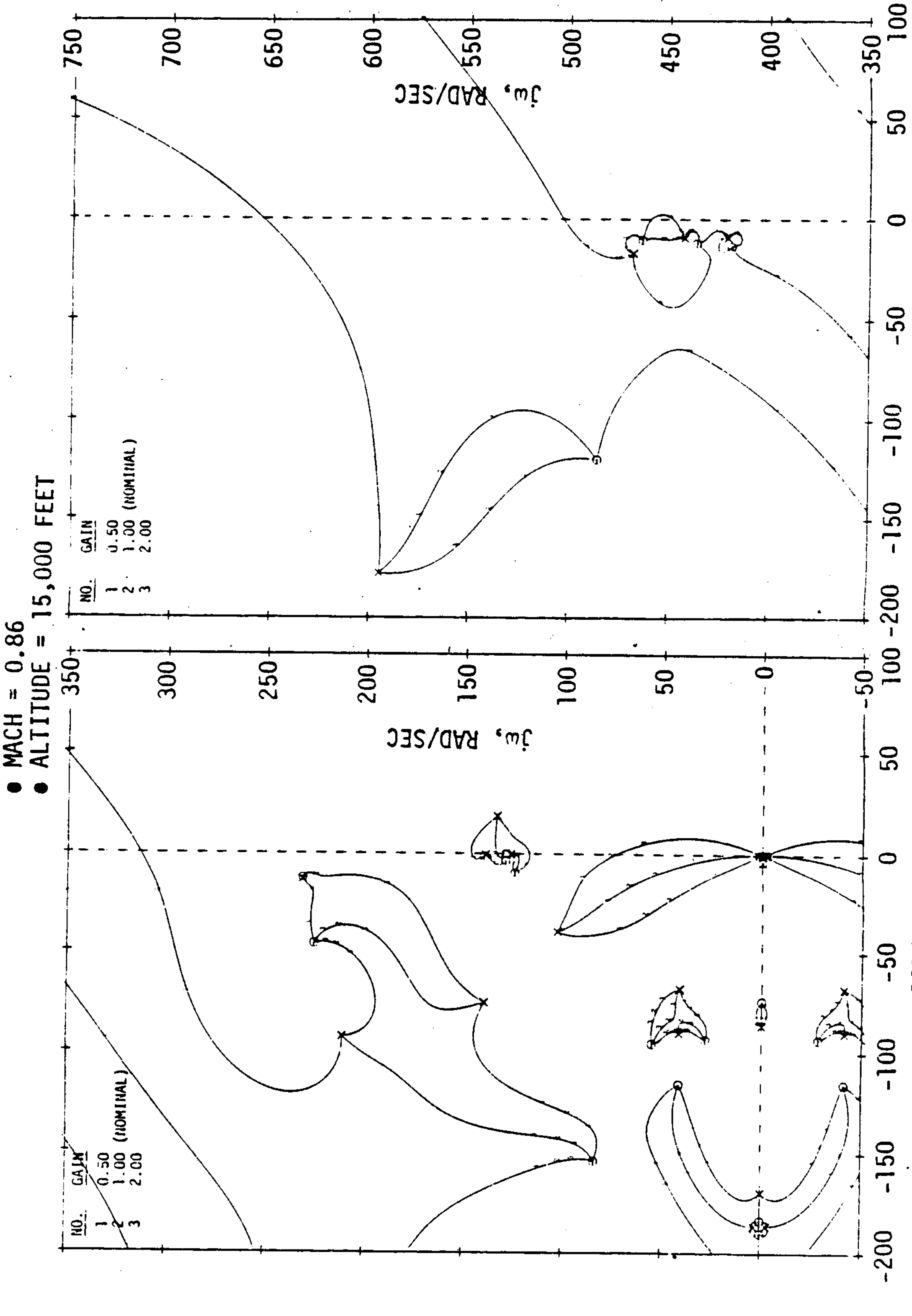


FIGURE 87

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH AR-25 SERVOVALVE

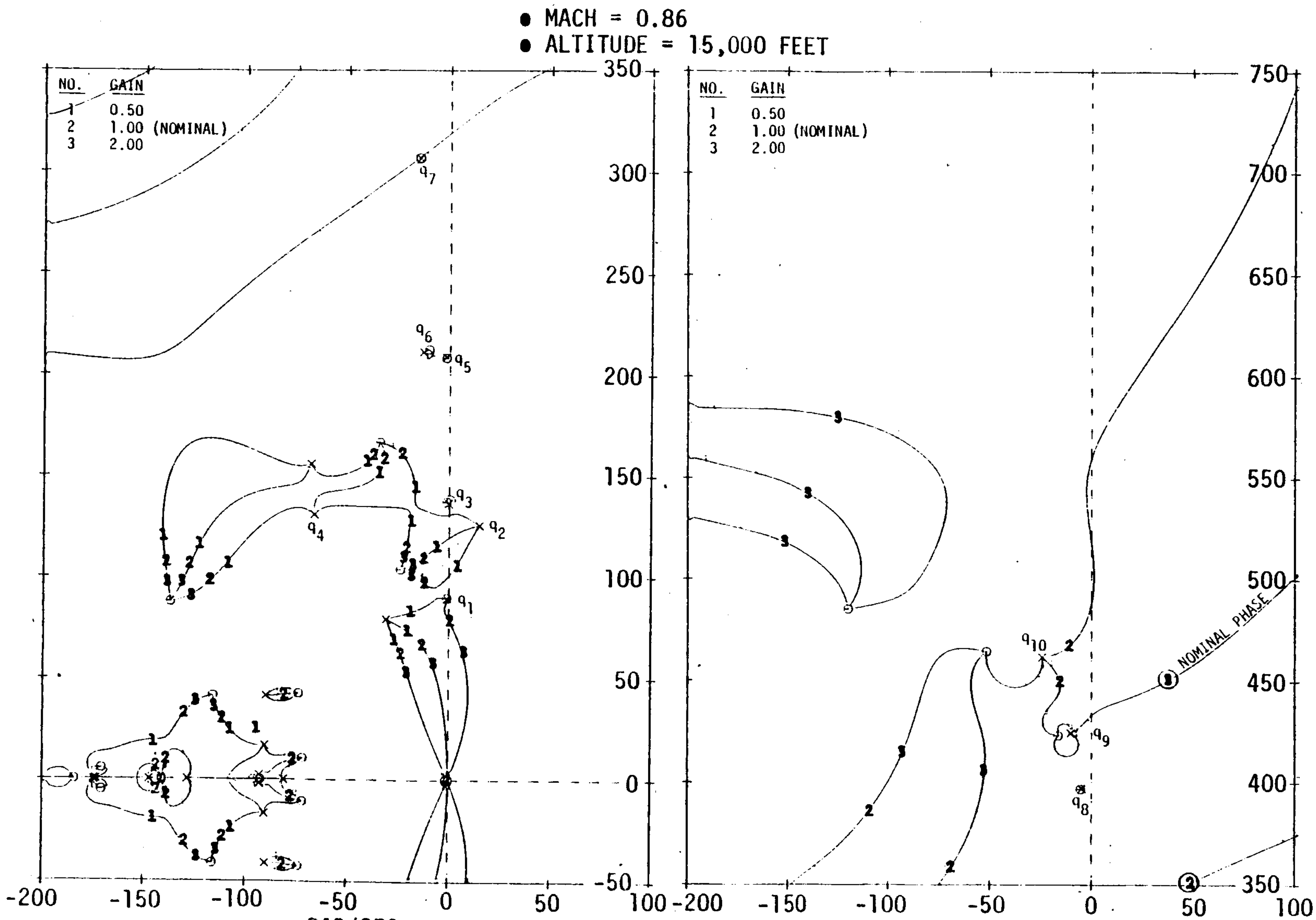


FIGURE 88

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF UNCOMPENSATING ACTUATOR

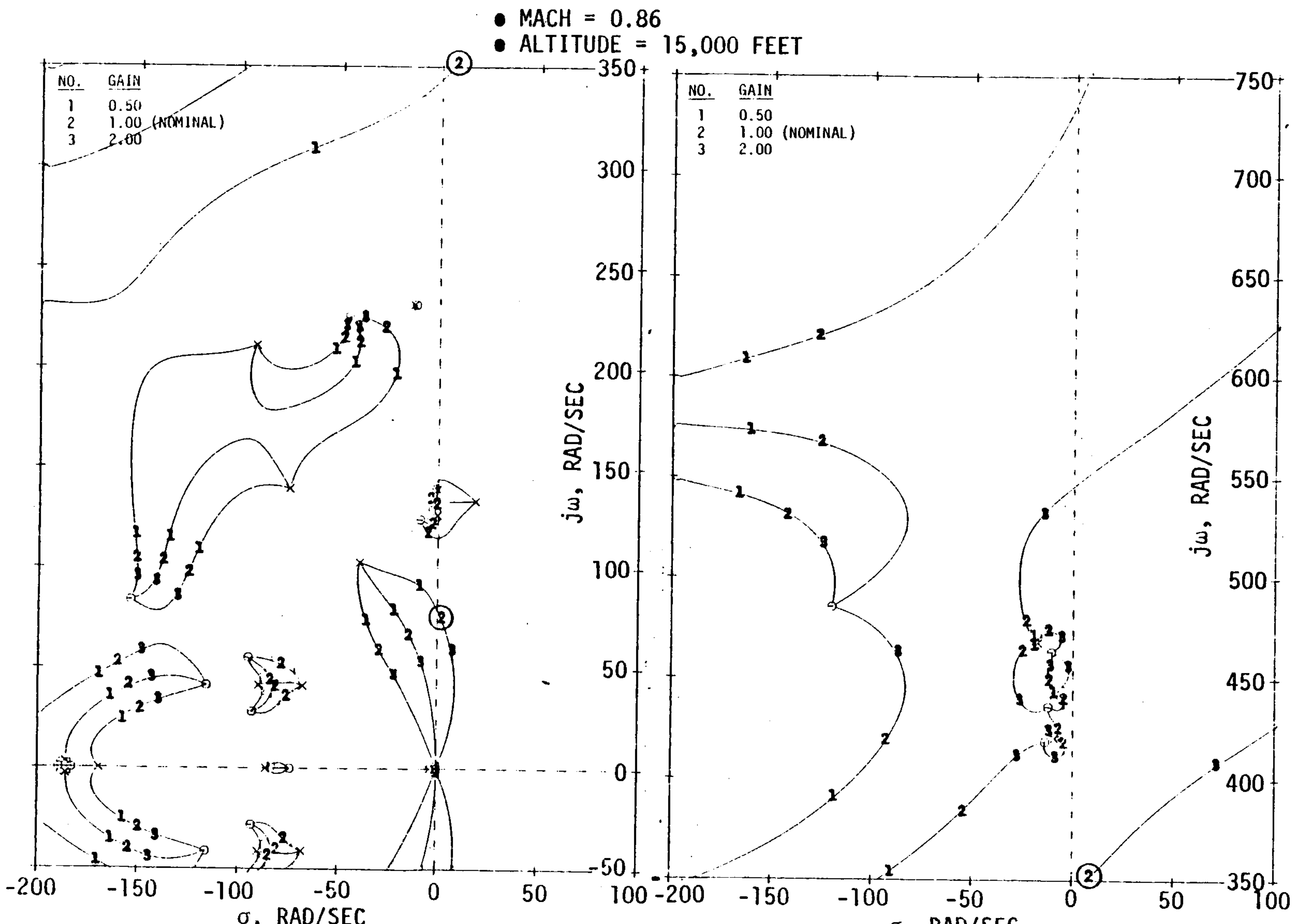


FIGURE 89

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, EFFECTS OF UNCOMPENSATING ACTUATOR

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
			+45 DEGREES		NOMINAL		-45 DEGREES	
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	20% INCREASE	20% DECREASE	20% INCREASE	20% DECREASE	20% INCREASE	20% DECREASE
q_1	14.2	0.0105	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
q_2	20.1	-0.1190	0.1074	0.1098	0.1344	0.1396	0.1138	0.1152
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
q_4	23.3	0.4521	0.7878	0.7908	0.1813	0.1759	0.1995	0.2043
q_5	33.2	0.0084	0.0083	0.0083	0.0083	0.0083	0.0083	0.0125
q_6	33.7	0.0619	0.0480	0.0480	0.0480	0.0490	0.0342	0.0222
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0119	0.0118	0.0119	0.0119	0.0121
q_9	67.6	0.0238	0.0228	0.0162	0.0175	0.0185	0.0224	0.0239
q_{10}	73.6	0.524	0.0426	0.0457	0.0478	0.0555	0.0552	0.0602

FIGURE 90

SYMMETRIC FSS SENSITIVITY TO SURFACE-ACTUATOR MODE CHANGE

ORIGINAL PAGE IS OF POOR QUALITY

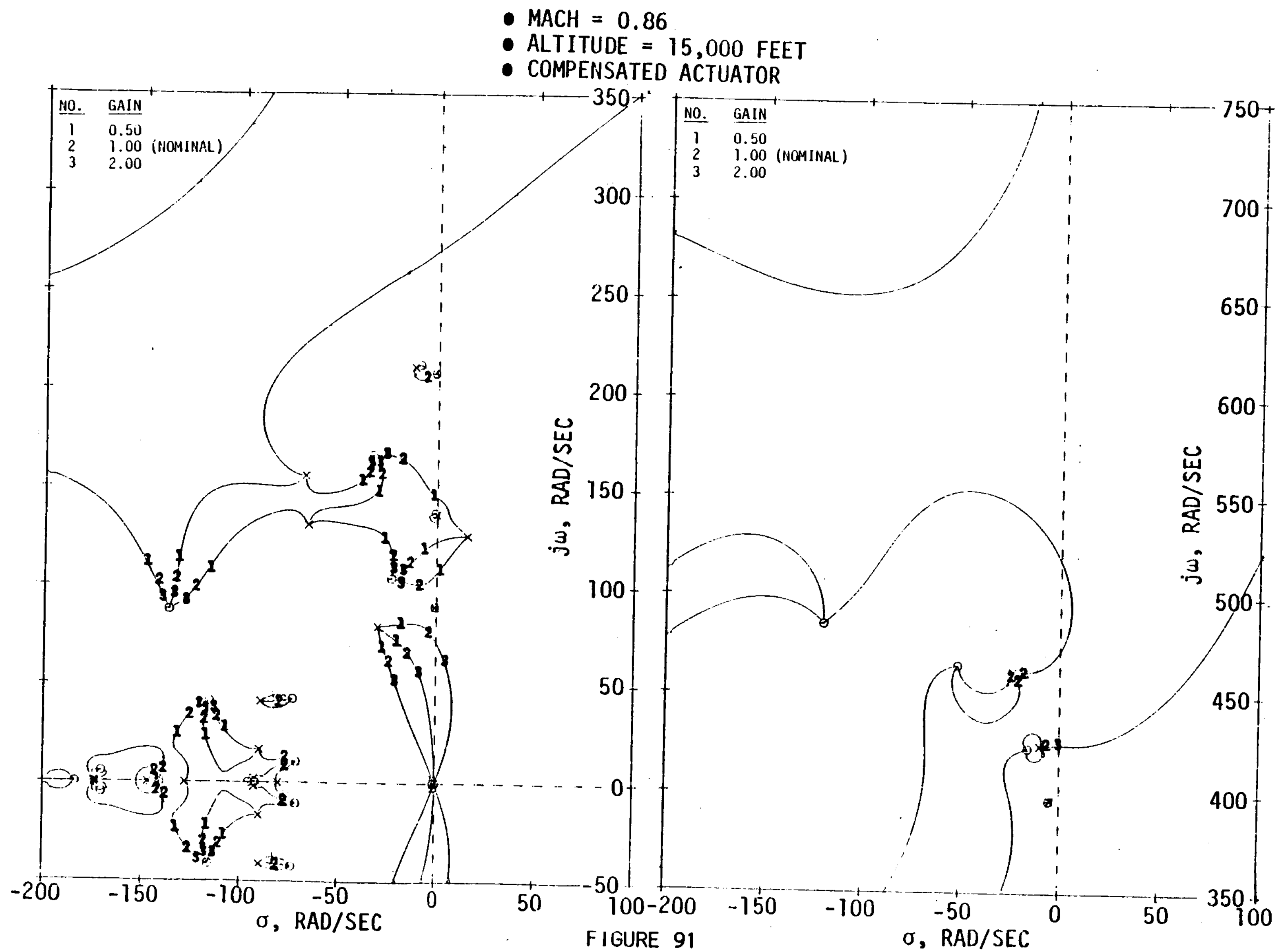


FIGURE 91

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF A 20% SURFACE-ACTUATOR MODE FREQUENCY INCREASE

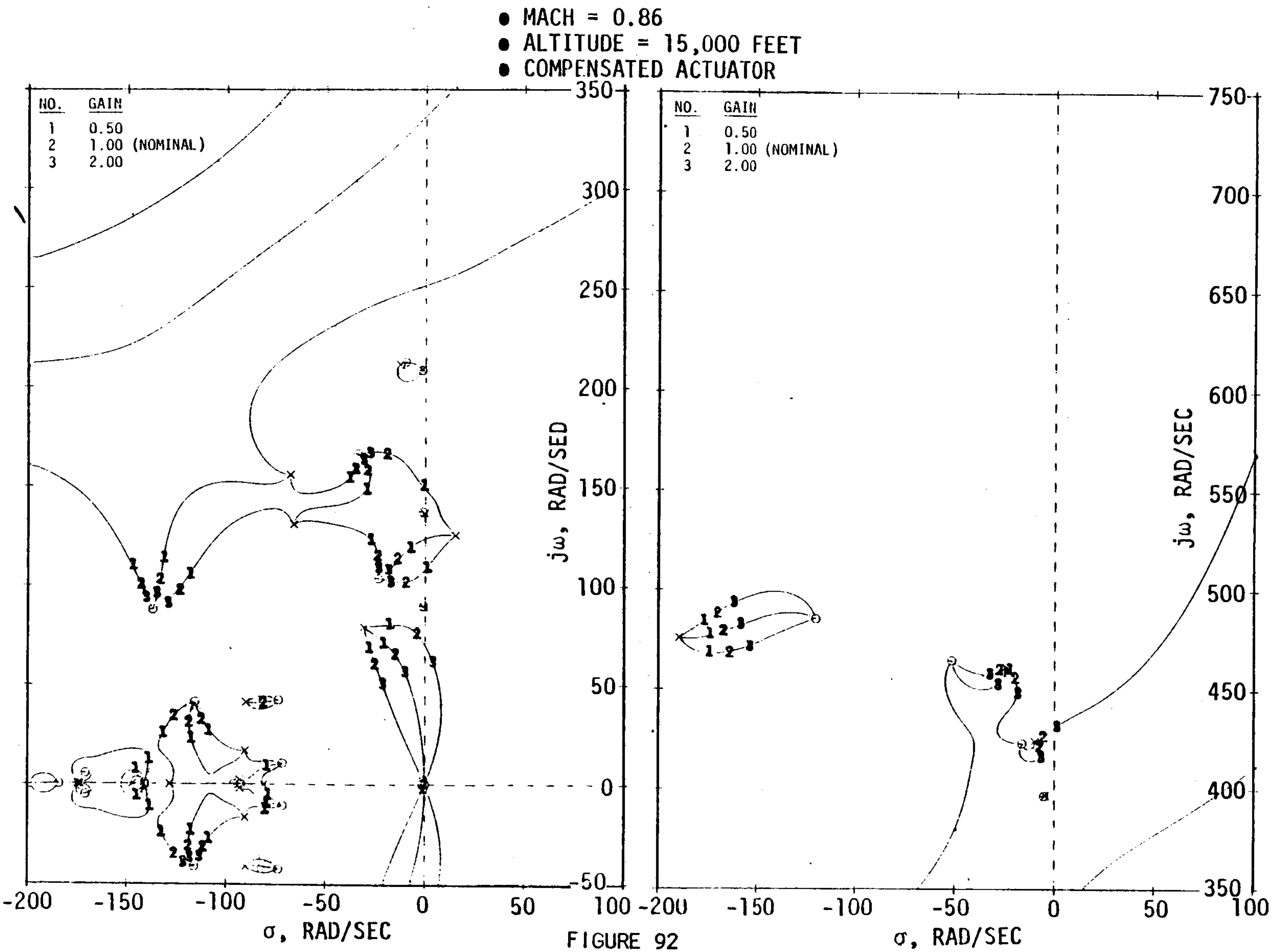


FIGURE 92

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF A 20% SURFACE-ACTUATOR MODE FREQUENCY DECREASE

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
			+45 DEGREES		NOMINAL PHASE		-45 DEGREES	
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	NOMINAL PRESSURE	30% DECREASE	NOMINAL PRESSURE	30% DECREASE	NOMINAL PRESSURE	30% DECREASE
q_1	14.2	0.0105	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
q_2	20.1	-0.1190	0.1082	0.1297	0.1398	0.1498	0.1134	0.1272
q_3	21.7	0.0024	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
q_4	23.3	0.4521	0.7893	0.7982	0.1791	0.1763	0.2015	0.2055
q_5	33.2	0.0084	0.0083	0.0083	0.0083	0.0083	0.0131	0.0200
q_6	33.7	0.0619	0.0480	0.0480	0.0505	0.0484	0.0299	0.0083
q_7	49.1	0.0527	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565
q_8	63.2	0.0118	0.0120	0.0120	0.0113	0.0104	0.0120	0.0120
q_9	67.6	0.0238	0.0201	0.0196	0.0168	0.0160	0.0228	0.0228
q_{10}	73.6	0.0524	0.0419	0.0410	0.0500	0.0503	0.0573	0.0579

FIGURE 93

SYMMETRIC FSS SENSITIVITY TO PRESSURE FEEDBACK GAIN REDUCTION

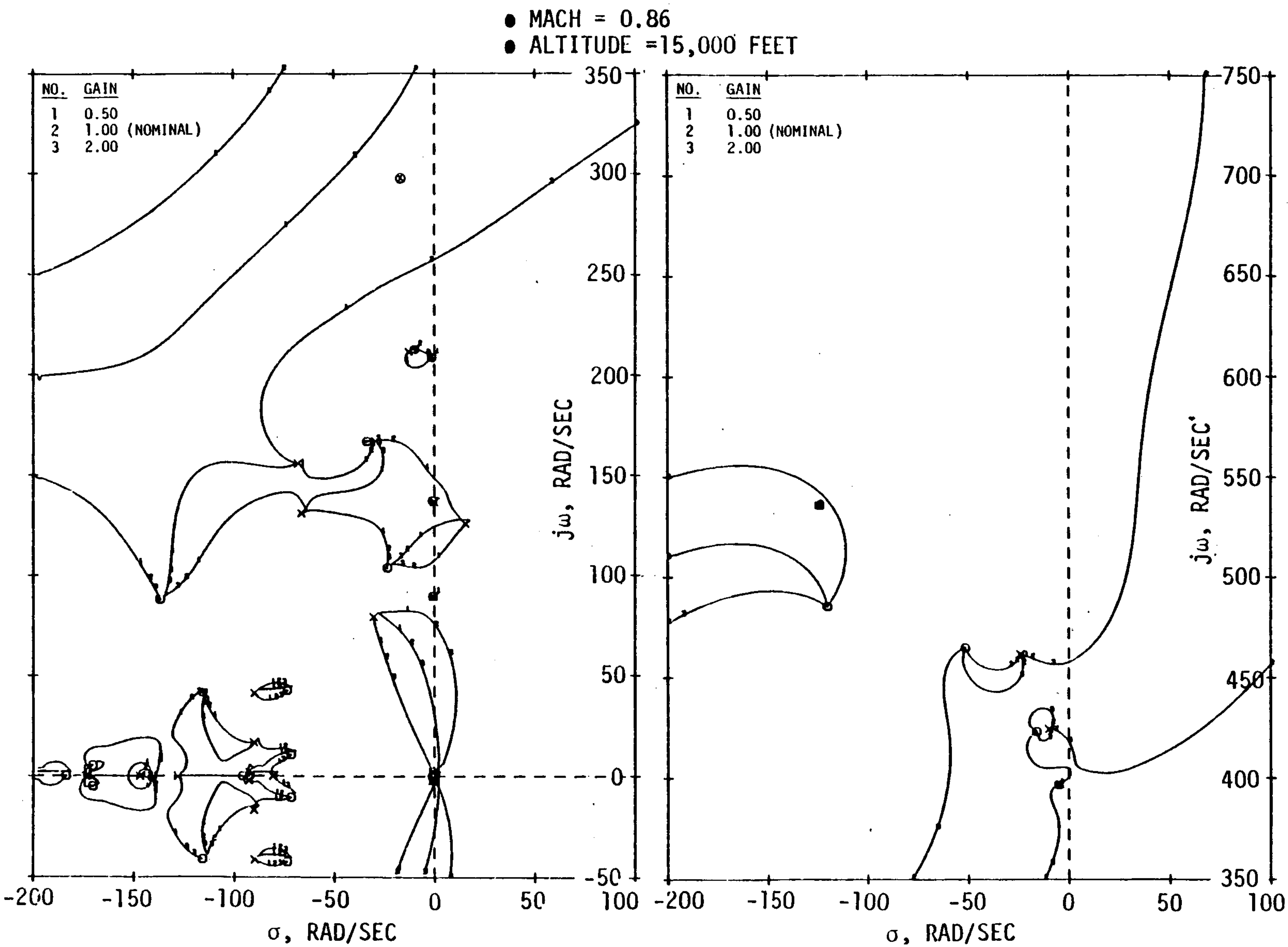


FIGURE 94

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, EFFECTS OF A 30% PRESSURE FEEDBACK GAIN REDUCTION

- MACH = 0.86
- ALTITUDE = 15,000 FEET
- WITHOUT FSS WASHOUT

MODE	OPEN LOOP		CLOSED LOOP DAMPING RATIO (ζ) - NOMINAL GAIN					
			+45 DEGREES		NOMINAL PHASE		-45 DEGREES	
	FREQUENCY (HZ)	DAMPING RATIO (ζ)	NOMINAL PRESSURE	30% DECREASE	NOMINAL PRESSURE	30% DECREASE	NOMINAL PRESSURE	30% DECREASE
q_1	20.1	0.0032	0.0274	0.0274	0.0333	0.0322	0.0176	0.0178
q_2	21.5	-0.1372	0.0454	0.0442	0.0182	0.0188	0.0107	0.0107
q_3	22.2	0.0040	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
q_4	25.2	0.4735	0.8159	0.8185	0.1554	0.1504	0.0095	-0.0031
q_5	39.9	0.0602	0.0556	0.0556	0.0556	0.0556	0.0834	0.0780
q_6	44.1	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487	0.0487
q_7	47.4	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
q_8	67.0	0.214	0.0212	0.0212	0.0194	0.0203	0.0210	0.0211
q_9	70.4	0.0209	0.0201	0.0202	0.0189	0.0192	0.0199	0.0200
q_{10}	74.5	0.0367	0.0431	0.0423	0.0374	0.0374	0.0350	0.0353

LESS THAN DESIGN SPECS.

FIGURE 95

ANTISYMMETRIC FSS SENSITIVITY TO PRESSURE FEEDBACK GAIN REDUCTION

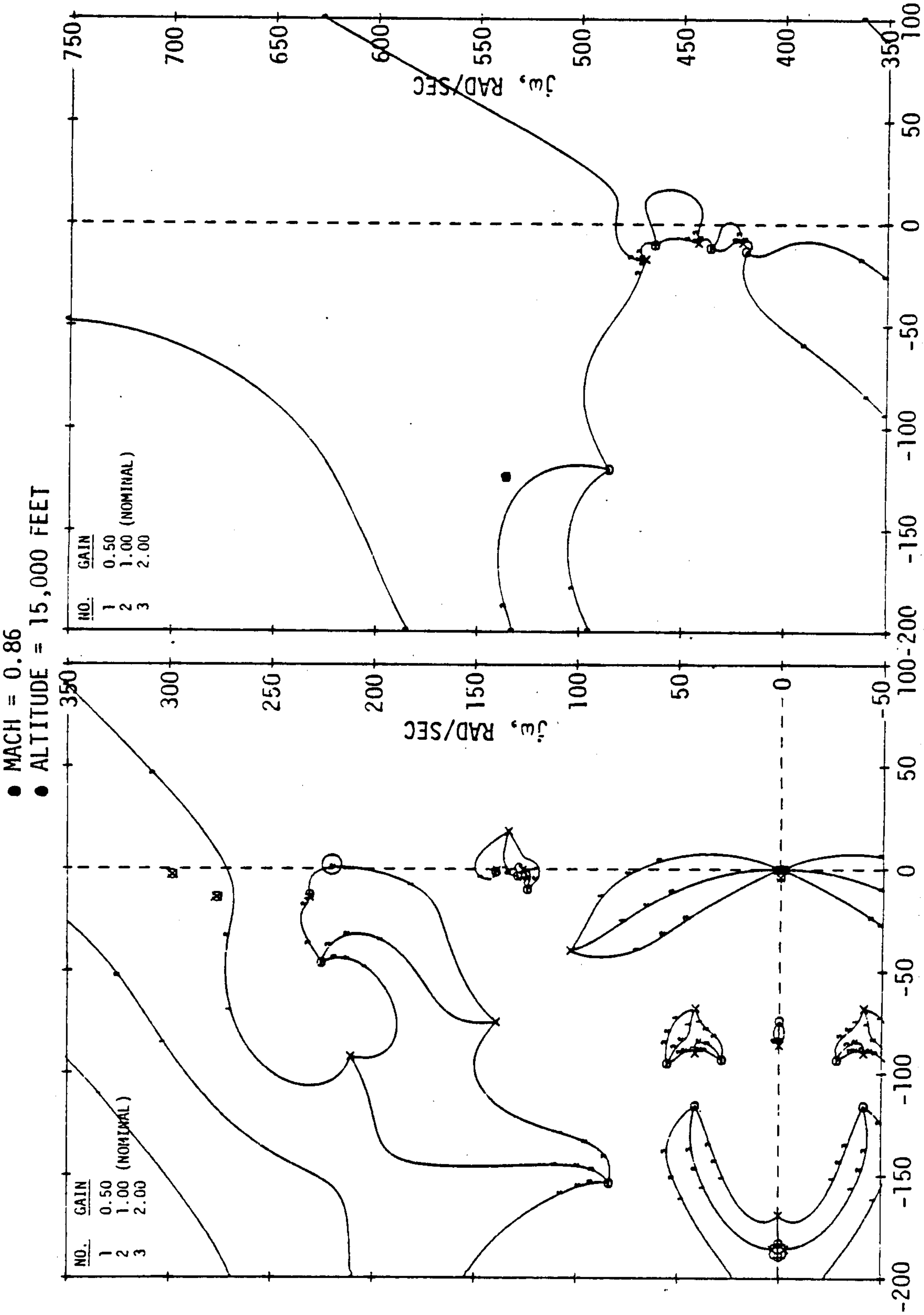


FIGURE 96

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS WITH A 30 PERCENT PRESSURE FEEDBACK GAIN REDUCTION

HINGE MOMENT	PHASE	GAIN
NO LOAD	-38.8 DEG.	+0.19 dB
MAXIMUM AIDING - 230 IN-LBS.	-23.9 DEG.	+0.62 dB
STATIC - 150 IN-LBS	-61.8 DEG.	-2.00 dB
MAXIMUM RESISTING - 230 IN-LBS	-68.6 DEG.	-3.04 dB

FIGURE 97

HINGE MOMENT SENSITIVITY
OUTBOARD SERVOACTUATOR GAIN AND PHASE RESPONSE @ 23.8 HZ

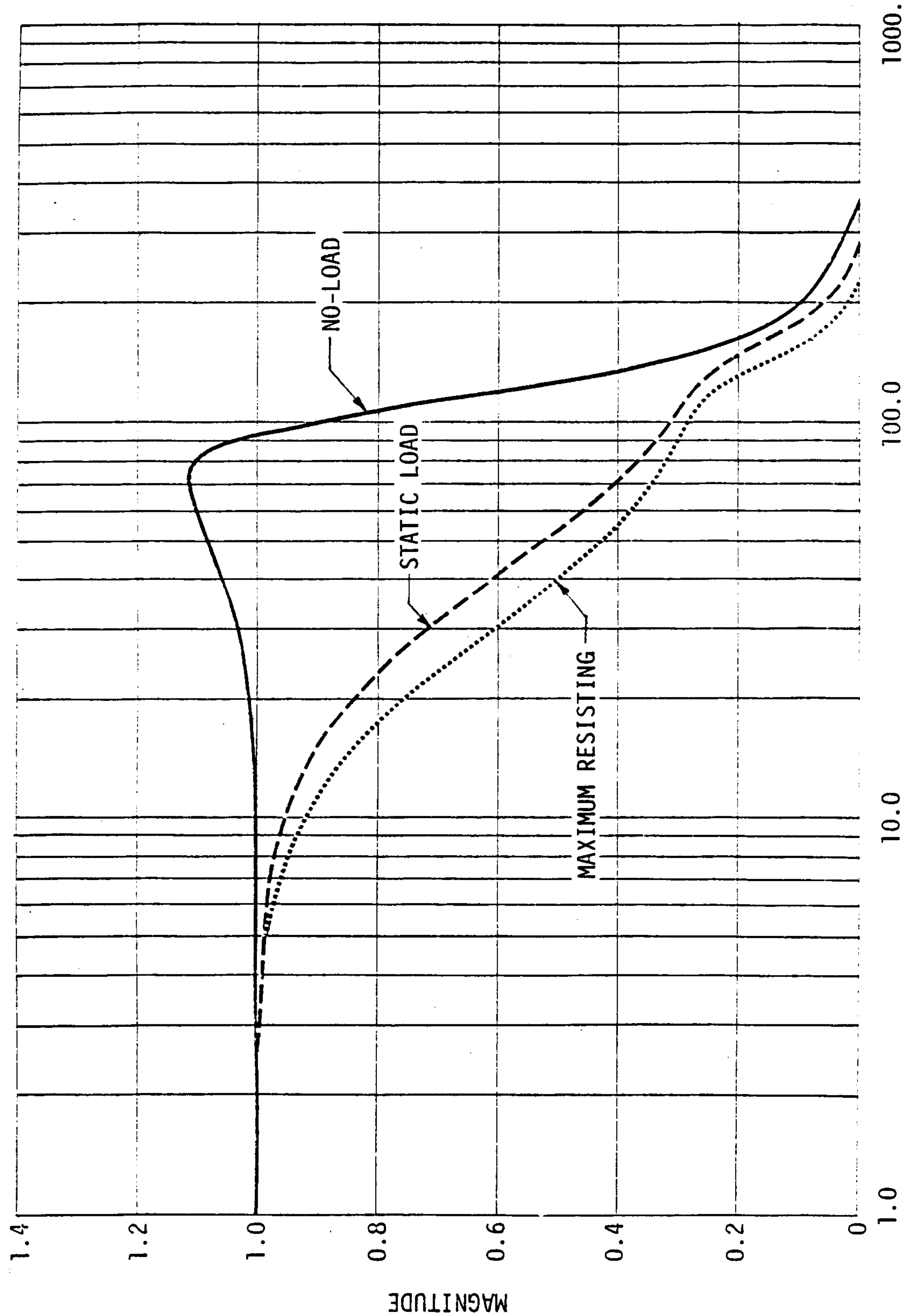


FIGURE 98

EFFECT OF HINGE MOMENT ON OUTBOARD SERVOACTUATOR AMPLITUDE FREQUENCY RESPONSE

ORIGINAL PAGE IS OF POOR QUALITY

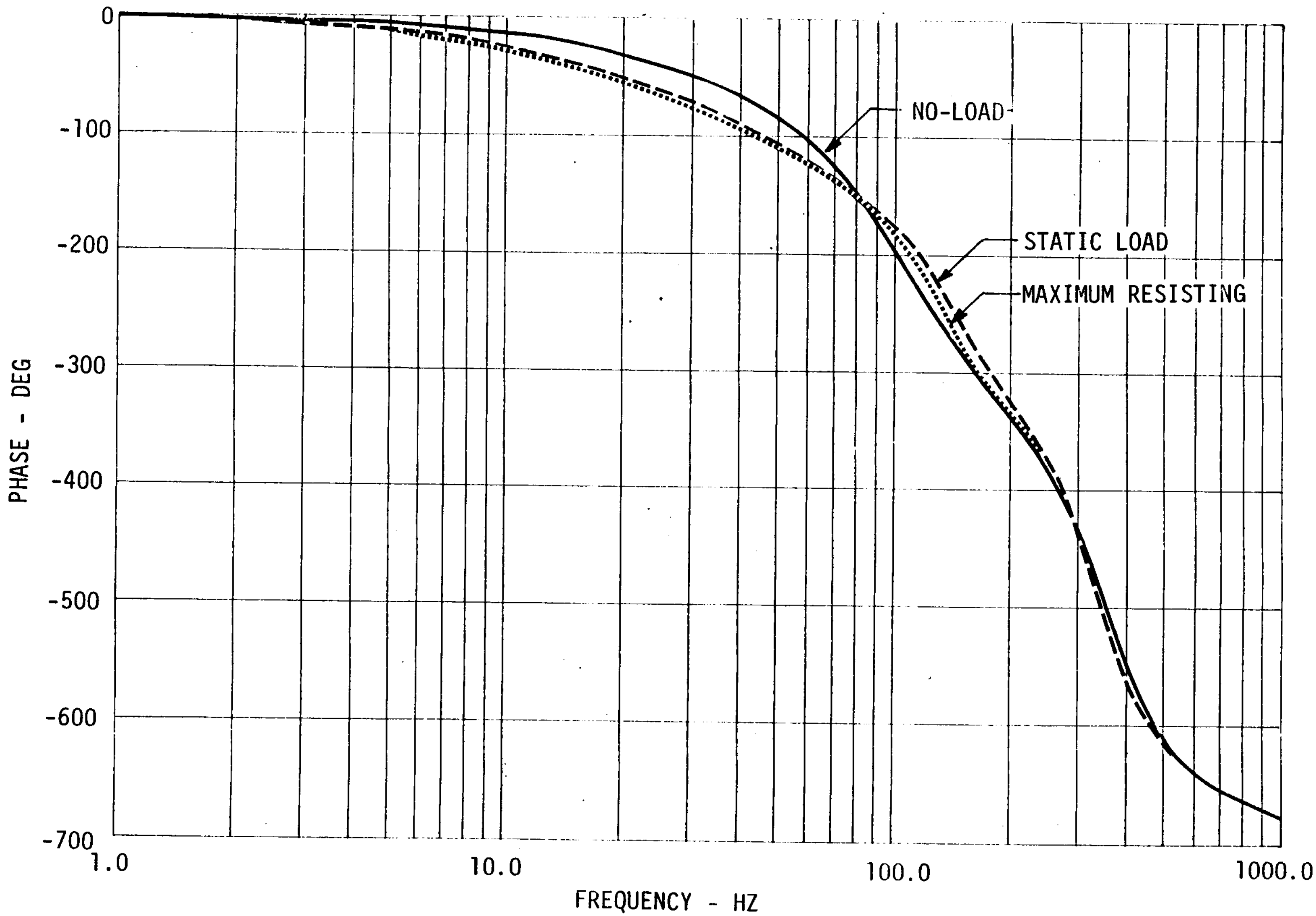


FIGURE 99

EFFECT OF HINGE MOMENT ON OUTBOARD SERVOACTUATOR PHASE FREQUENCY RESPONSE

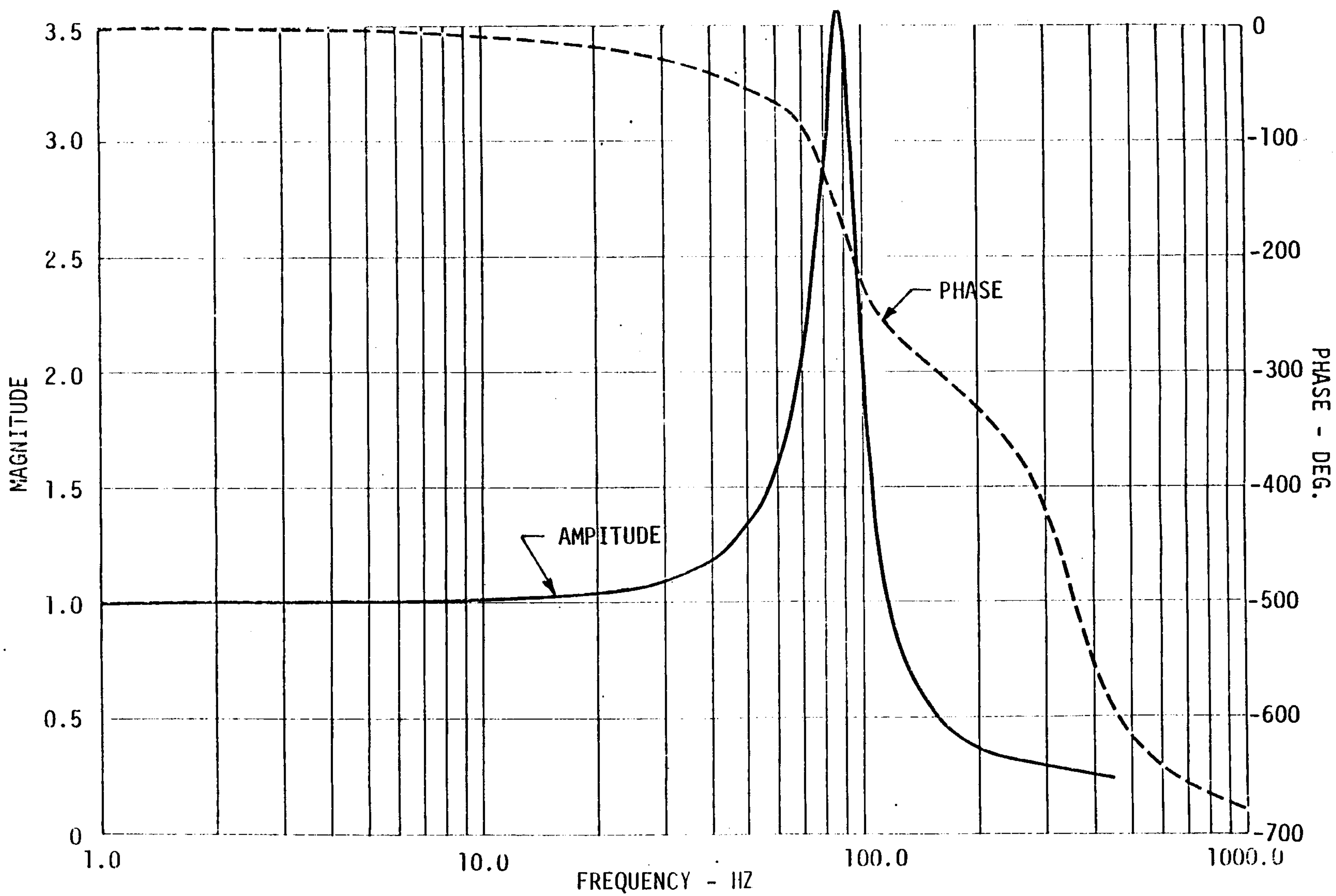


FIGURE 100

EFFECT OF MAXIMUM AIDING HINGE MOMENT ON OUTBOARD SERVOACTUATOR

ORIGINAL PAGE IS OF POOR QUALITY

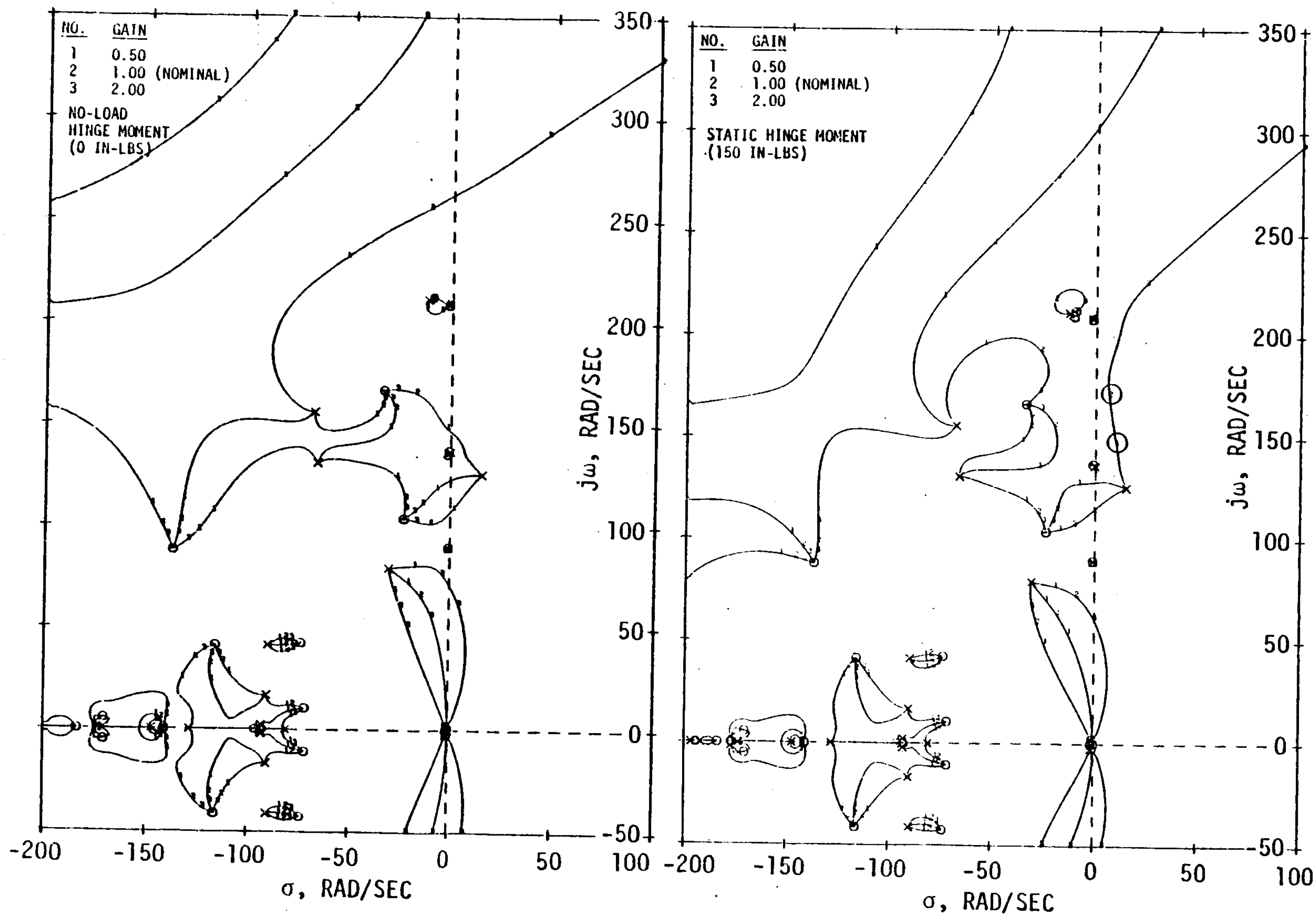


FIGURE 101

EFFECT OF HINGE MOMENT ON SYMMETRIC FSS

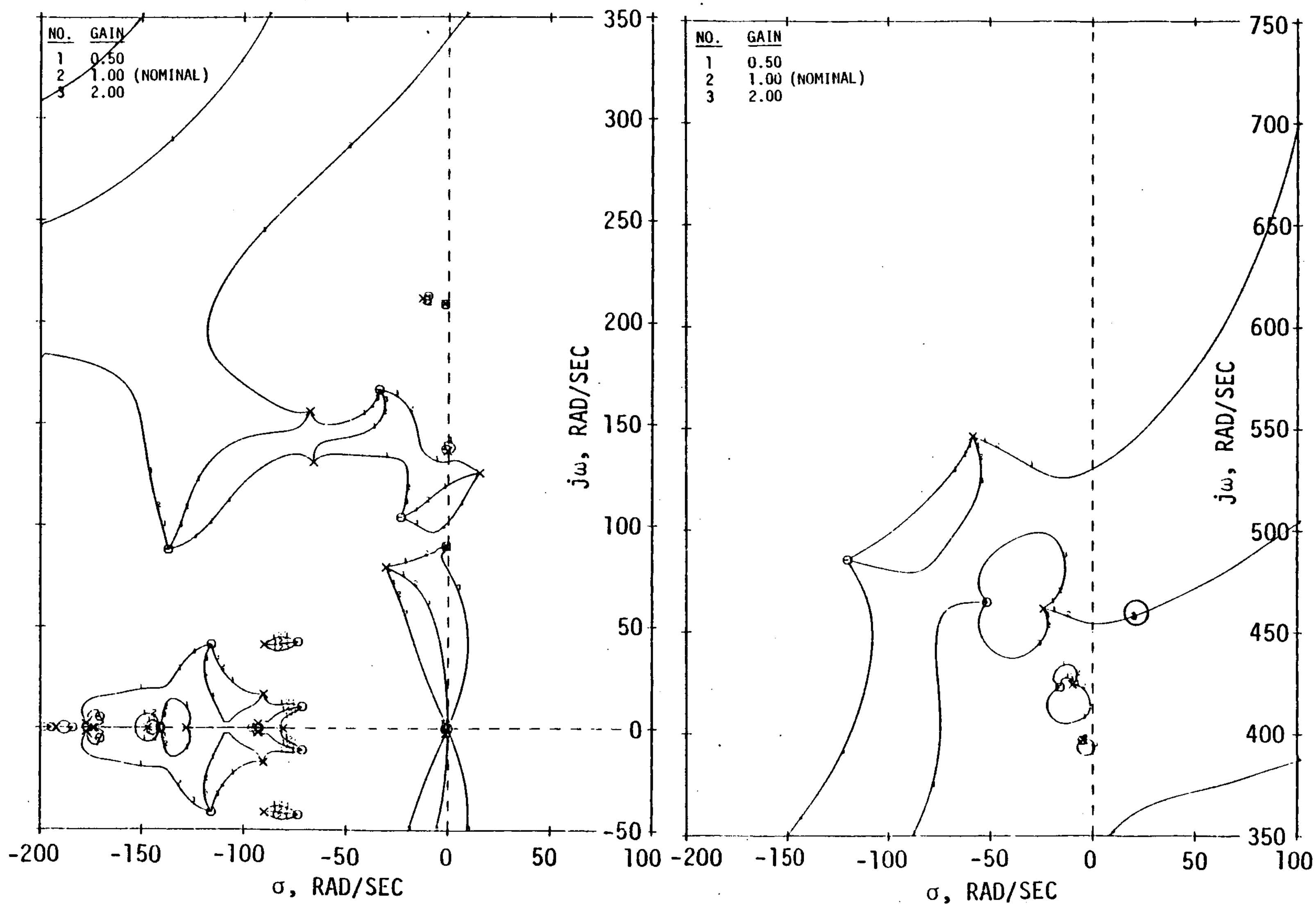


FIGURE 102

PHASE-GAIN ROOT LOCUS OF SYMMETRIC FSS, MAXIMUM HINGE MOMENT AIDING
(230 IN-LBS)

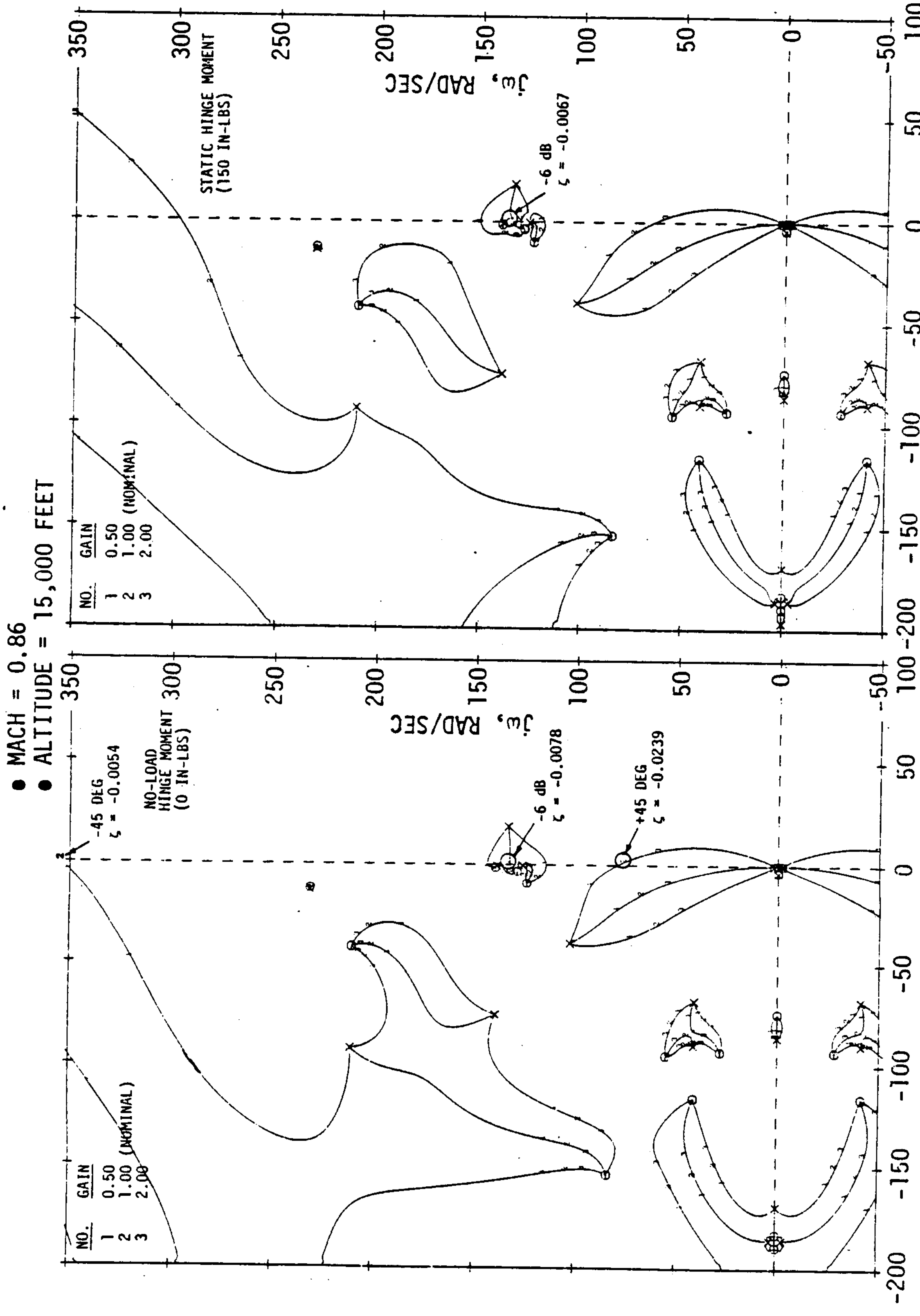


FIGURE 103

EFFECT OF HINGE MOMENT ON ANTISYMMETRIC FSS, UNCOMPENSATED ACTUATOR

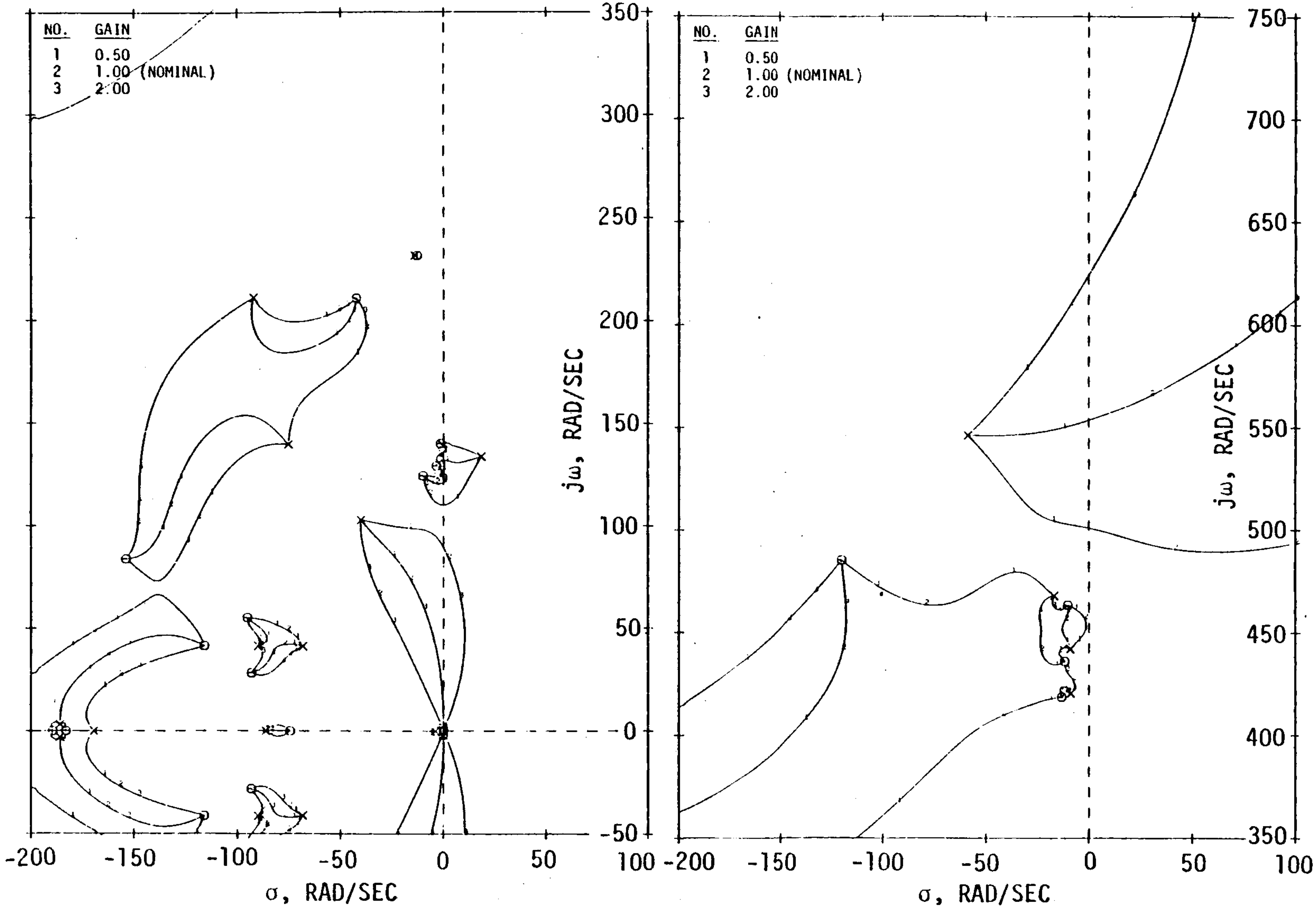


FIGURE 104

PHASE-GAIN ROOT LOCUS OF ANTISYMMETRIC FSS, MAXIMUM HINGE MOMENT AIDING
(230 IN-LBS)

MACH NO.	ALTITUDE (FEET)	OPEN LOOP			CLOSED LOOP (PCS, RSS, AND GLA)		
		REAL	IMAGINARY	ζ	REAL	IMAGINARY	ζ
0.35	SEA LEVEL	-0.660	±j88.500	0.007	-2.033	±j88.322	0.023
0.40	15,000	-0.590	±j88.480	0.007	-1.383	±j87.799	0.016
0.41	10,000	-0.645	±j89.379	0.007	-2.016	±j89.231	0.023
0.60	7,000	-0.915	±j89.463	0.010	-2.849	±j90.922	0.031
0.70	15,000	-0.921	±j89.455	0.010	-4.160	±j89.584	0.046
0.70	50,000	-0.518	±j89.329	0.006	-1.010	±j89.534	0.011
0.80	46,800	-0.577	±j89.400	0.006	-1.496	±j89.900	0.017
0.86	15,000	-0.936	±j89.436	0.010	-1.941	±j90.080	0.022

FIGURE 105

EFFECT OF ACS ON FUSELAGE MODE SYMMETRIC AIRPLANE

APPENDIX E

ACS/AFCS SYSTEMS ROOT LOCI

Gain and phase stability margins of each individual ACS and AFCS feedback loop, except the flutter system, are shown on the figures of this section. The stability margins of each loop were determined with each combination of systems that may be closed during some phase of flight testing. The margins were determined at various flight conditions spanning the total flight range. The root loci plots are identified in Figure 106 and shown on Figures 107 through 204. The stability margins were evaluated using QSE equations of motion. Each system loop was evaluated by ±4.5 dB gain and ±30 degrees phase margin criteria. Refer to Figure 106 as a guide to read gain and phase information.

FLIGHT CONDITION	AIRPLANE CONFIGURATION	RSS	RSS WITH PCS CLOSED	RSS WITH PCS AND GLA CLOSED	RSS WITH BCS CLOSED	PCS WITH RSS CLOSED	PCS WITH RSS AND GLA CLOSED	GLA AILERON WITH RSS,PCS AND GLA STAB. CLOSED	GLA STAB. WITH RSS,PCS AND GLA AILERON CLOSED	BCS WITH RSS CLOSED
MLA TEST MACH - 0.42 ALT - 10,000 FT	G.W. - 2500 LBS C.G. - 20% MAC	107	108	109	110	111	112	---	---	113
	G.W. - 2200 LBS C.G. - 33% MAC	114	115	116	117	118	119	120	121	122
GLA TEST MACH - 0.70 ALT - 15,000 FT	G.W - 2500 LBS C.G. - 20% MAC	123	124	125	126	127	128	129	130	131
	G.W. - 2200 LBS C.G. - 33% MAC	132	133	134	135	136	137	138	139	140
LAUNCH MACH - 0.40 ALT - 15,000 FT	G.W. - 2500 LBS C.G. - 20% MAC	141	142	143	144	145	146	---	---	147
	G.W. - 2200 LBS C.G. - 33% MAC	148	149	150	151	152	153	154	155	156
HIGH ALTITUDE MACH - 0.70 ALT - 50,000 FT	G.W. - 2500 LBS C.G. - 20% MAC	157	158	159	160	161	162	---	---	163
	G.W. - 2200 LBS C.G. - 33% MAC	164	165	166	167	168	169	170	171	172
CRUISE MACH - 0.80 ALT - 46,800 FT	G.W. - 2500 LBS C.G. - 20% MAC 1.0g FLIGHT	173	174	175	176	177	178	---	---	179
	G.W. - 2200 LBS C.G. - 33% MAC 1.2g FLIGHT	180	181	182	183	184	185	186	187	188
MAXIMUM Q (V_d) MACH - 0.86 ALT - 15,000 FT	G.W. - 2500 LBS C.G. - 20% MAC	189	190	191	192	193	194	---	---	195
	G.W. - 2200 LBS C.G. - 33% MAC	196	197	198	199	200	201	202	203	204

FIGURE 106

ROOT LOCI FIGURE IDENTIFICATION

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

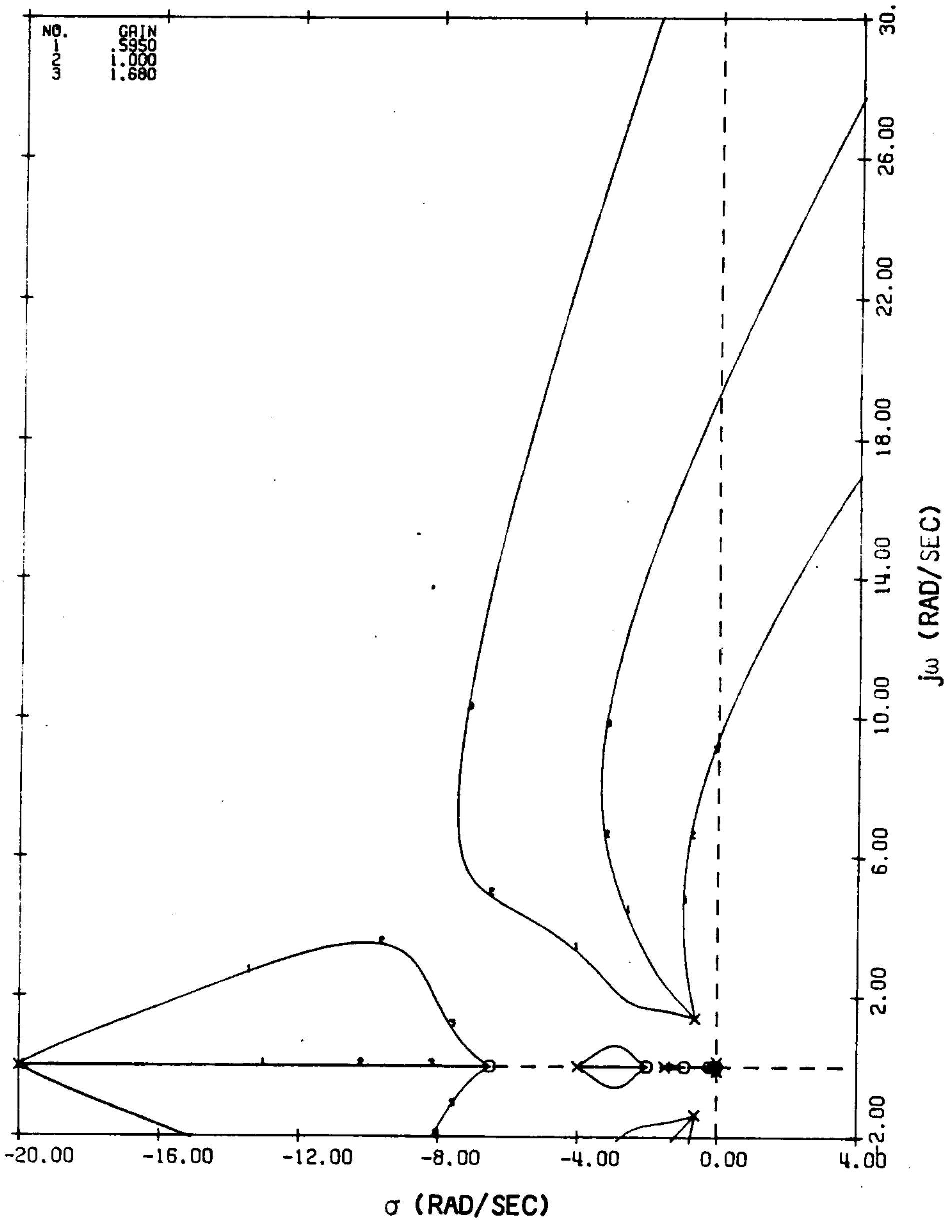


FIGURE 107

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

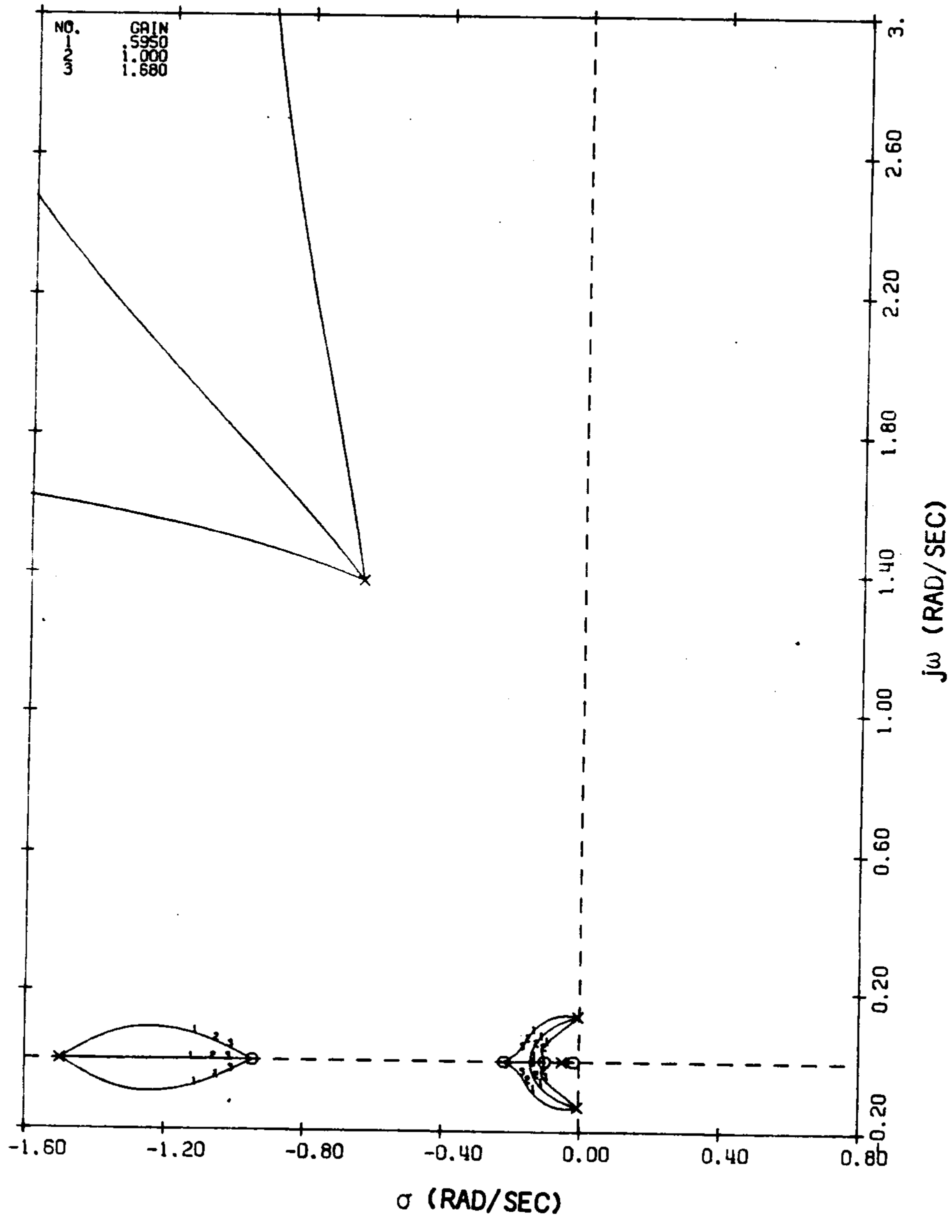


FIGURE 107 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

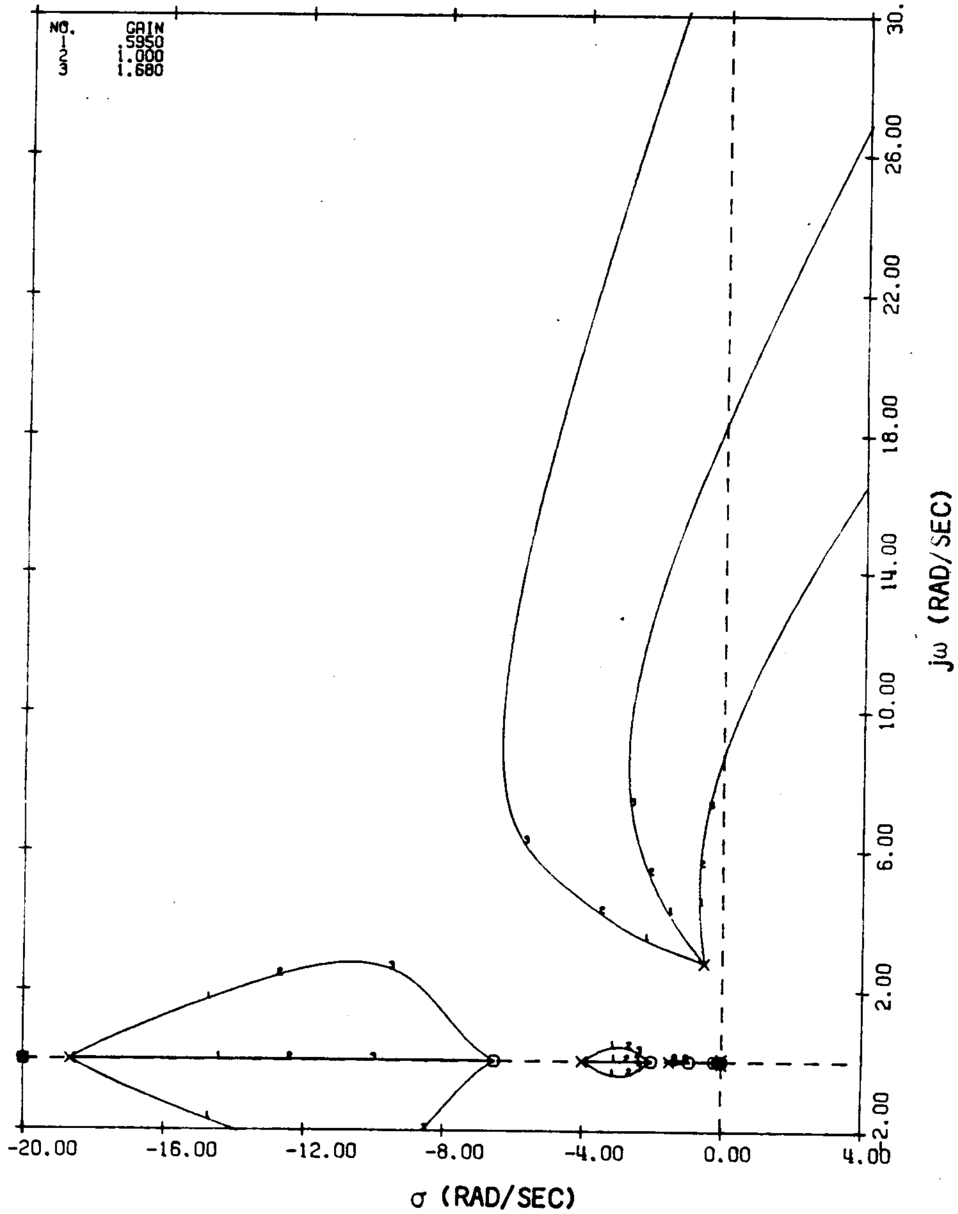


FIGURE 108

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

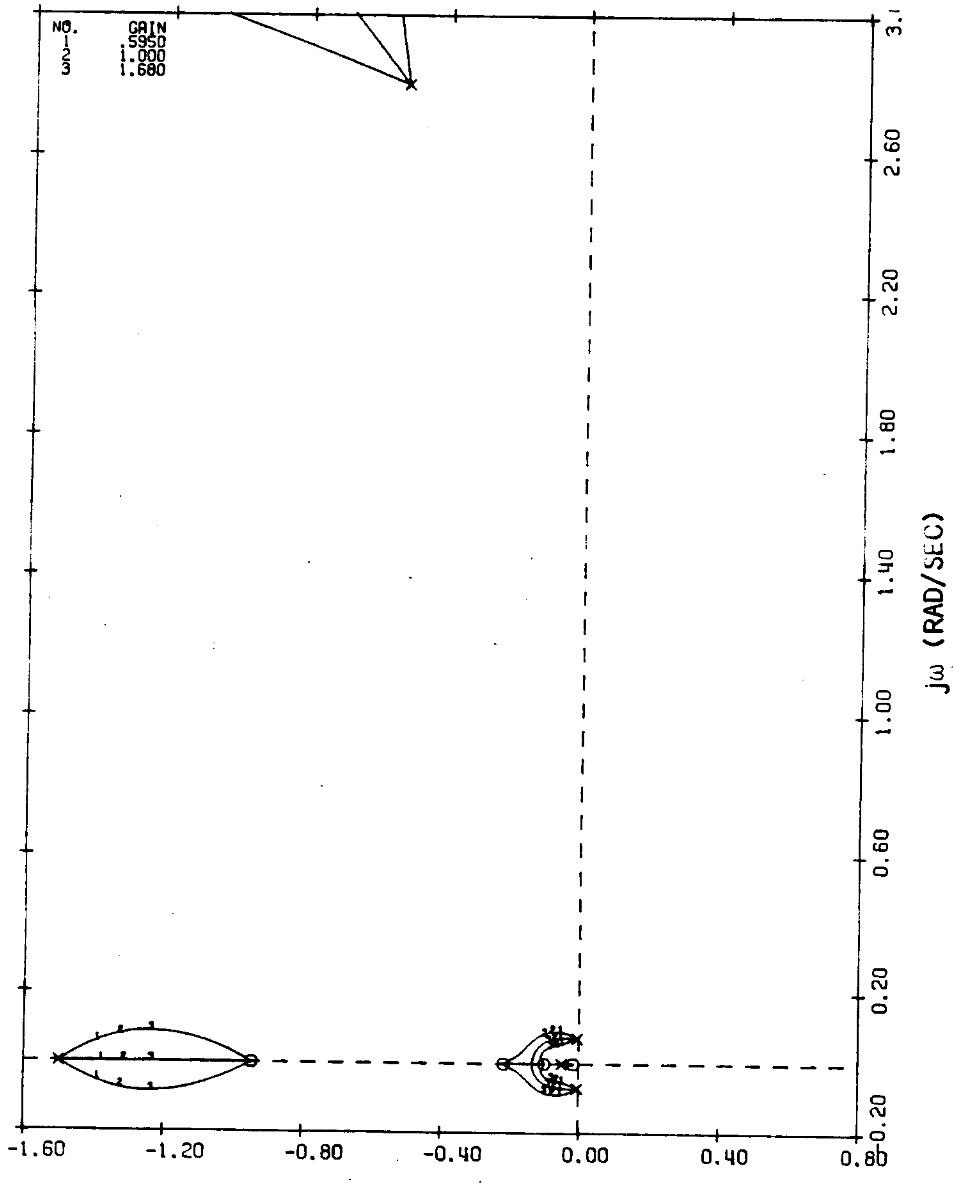


FIGURE 108 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

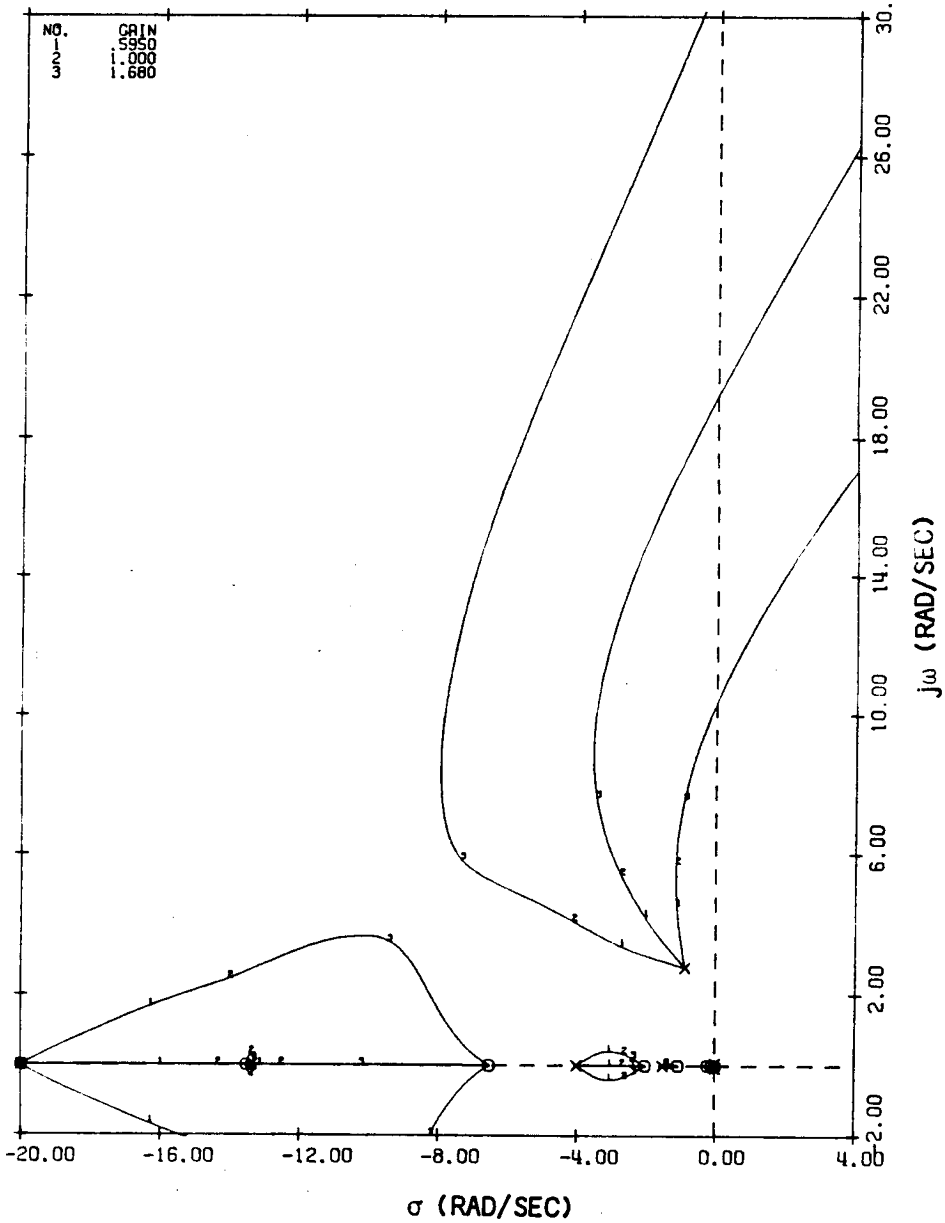


FIGURE 109

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

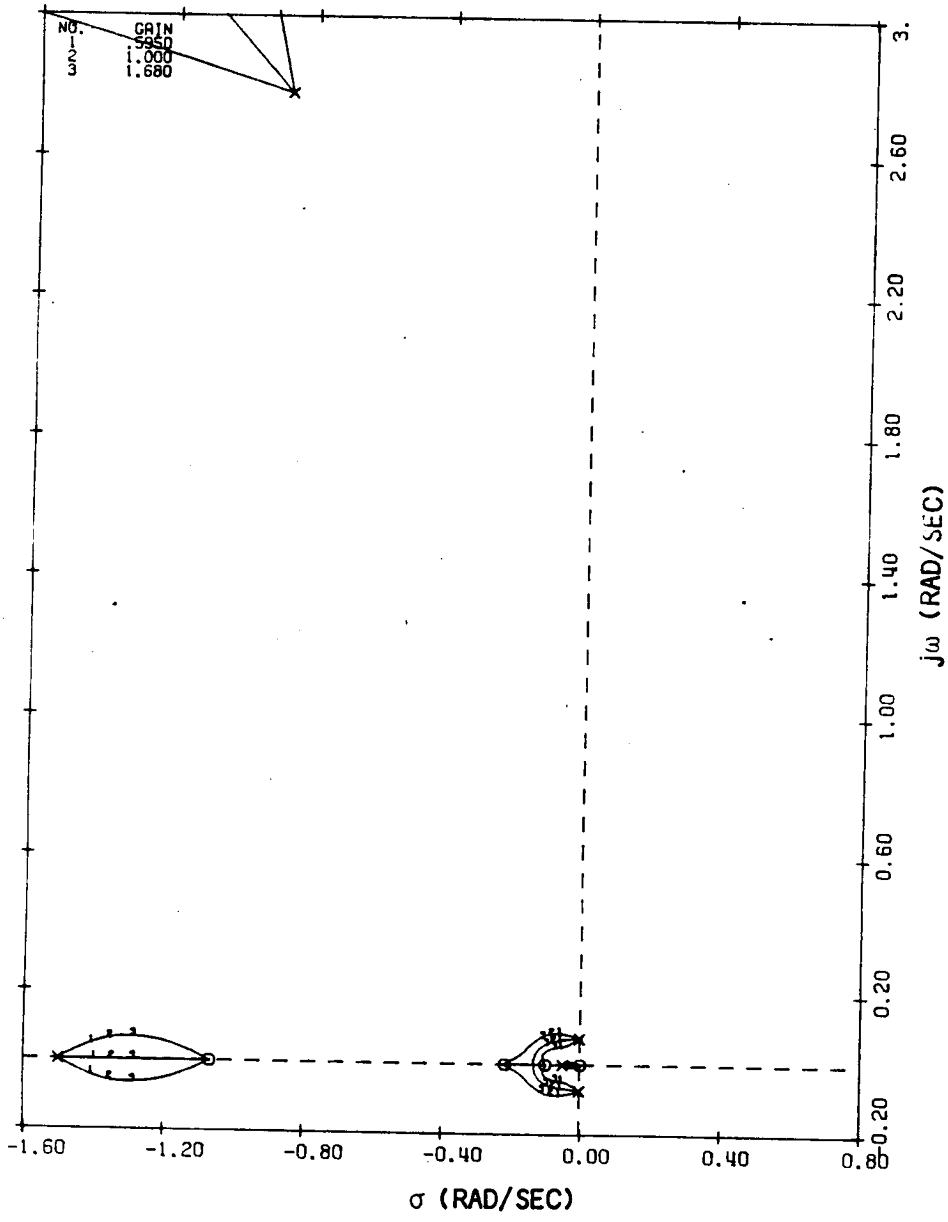


FIGURE 109 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

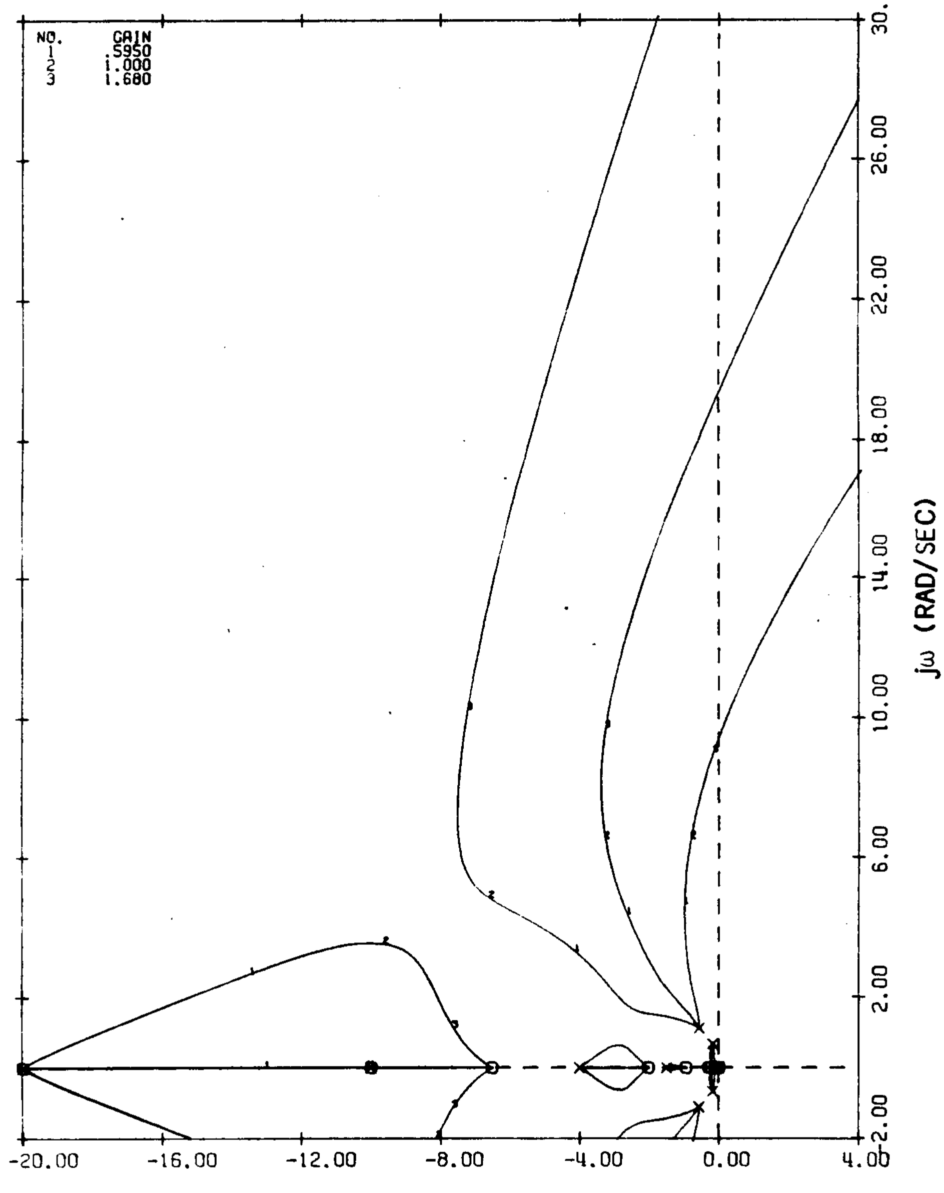


FIGURE 110

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

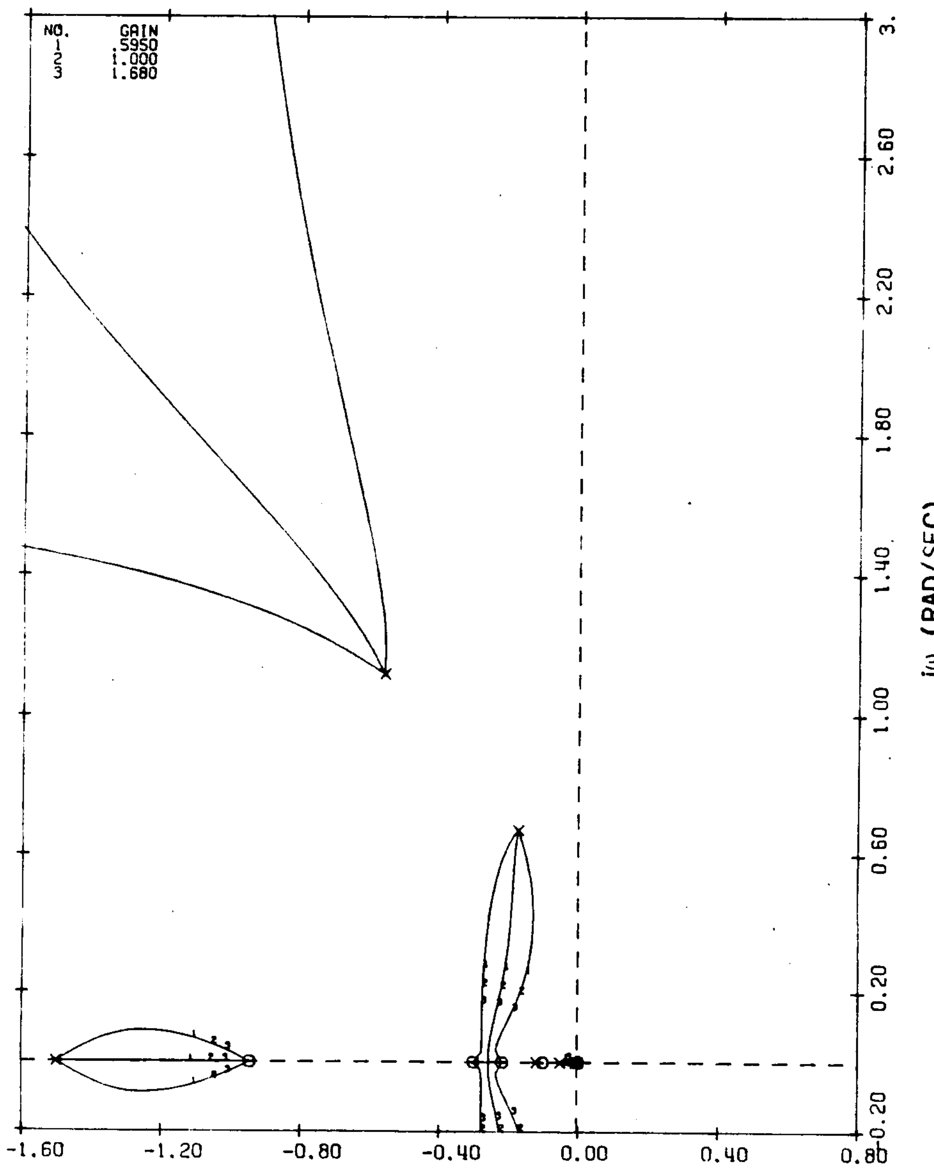


FIGURE 110 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

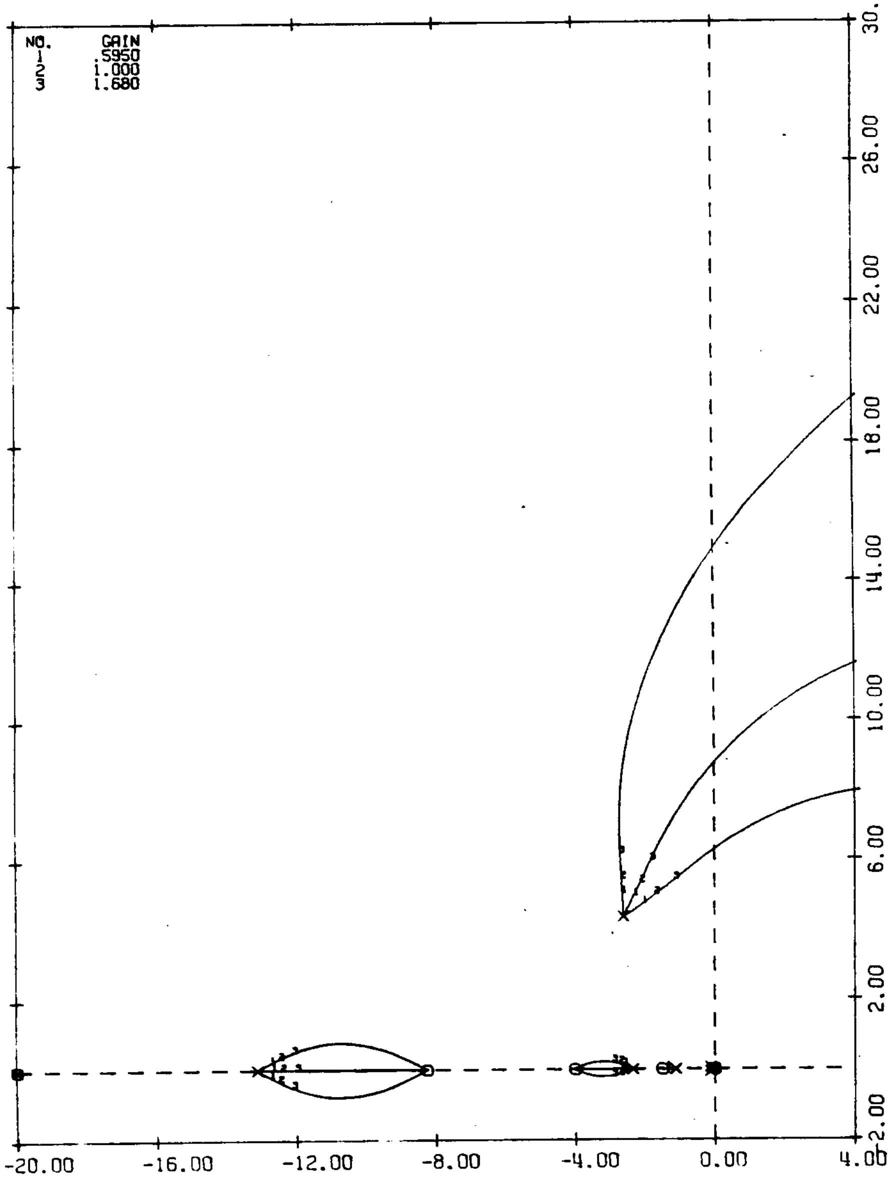


FIGURE 111

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

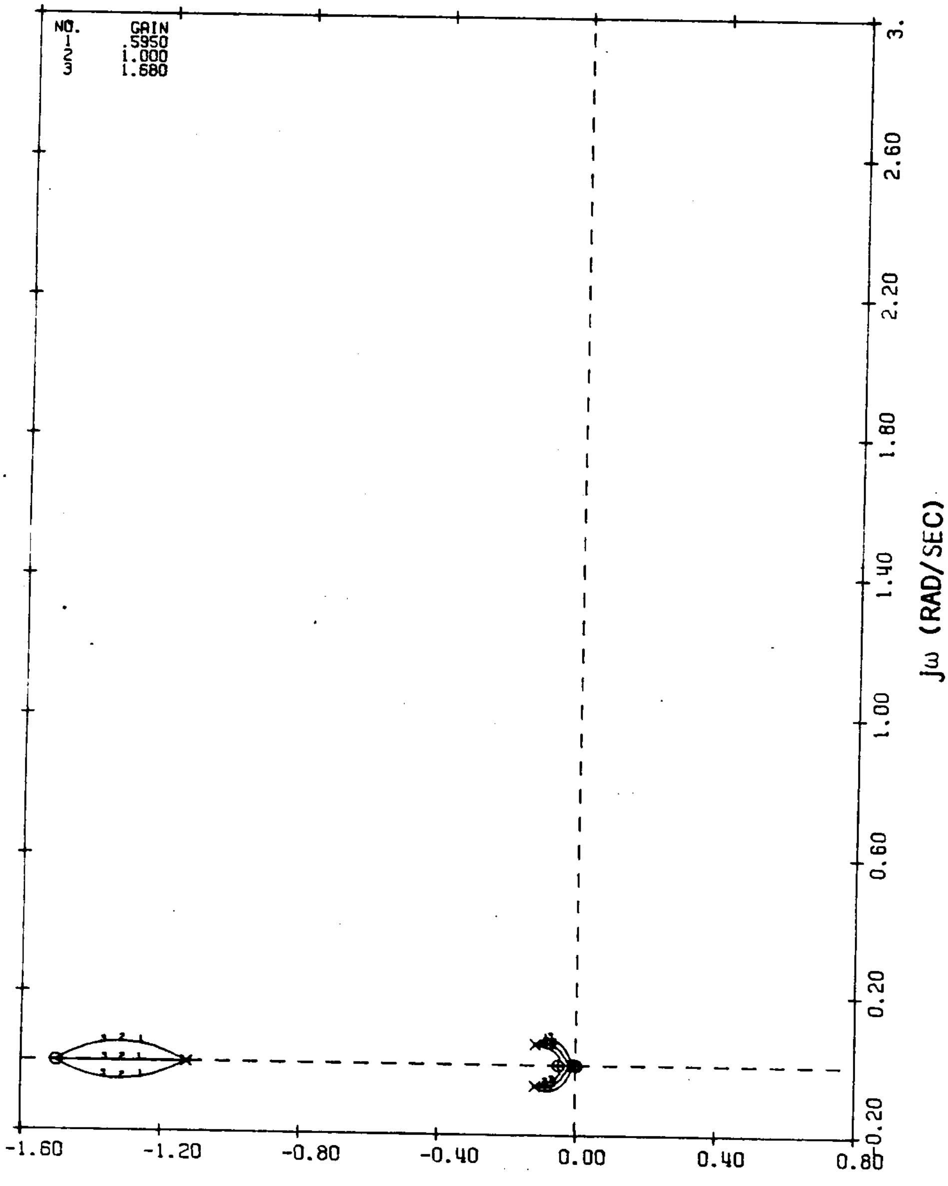


FIGURE 111 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

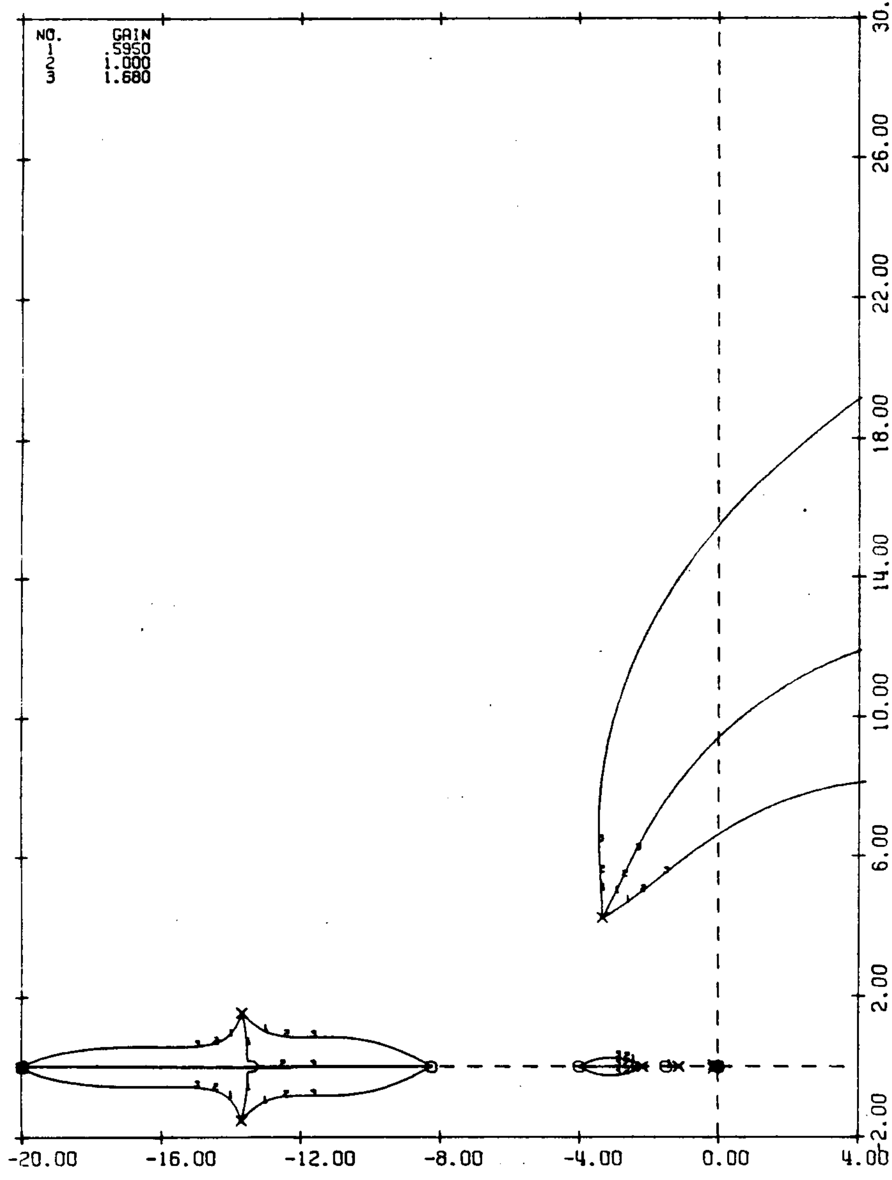


FIGURE 112

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

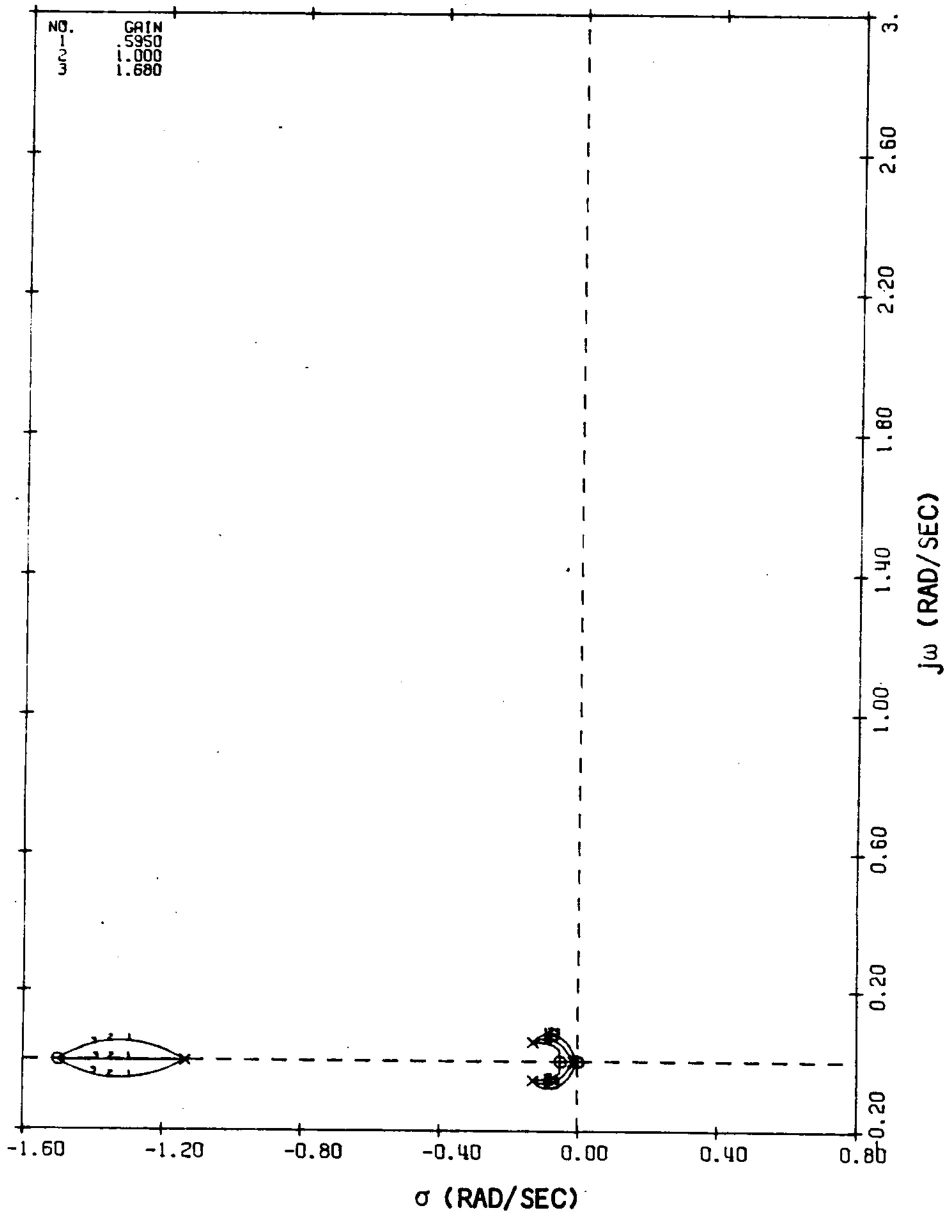


FIGURE 112 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

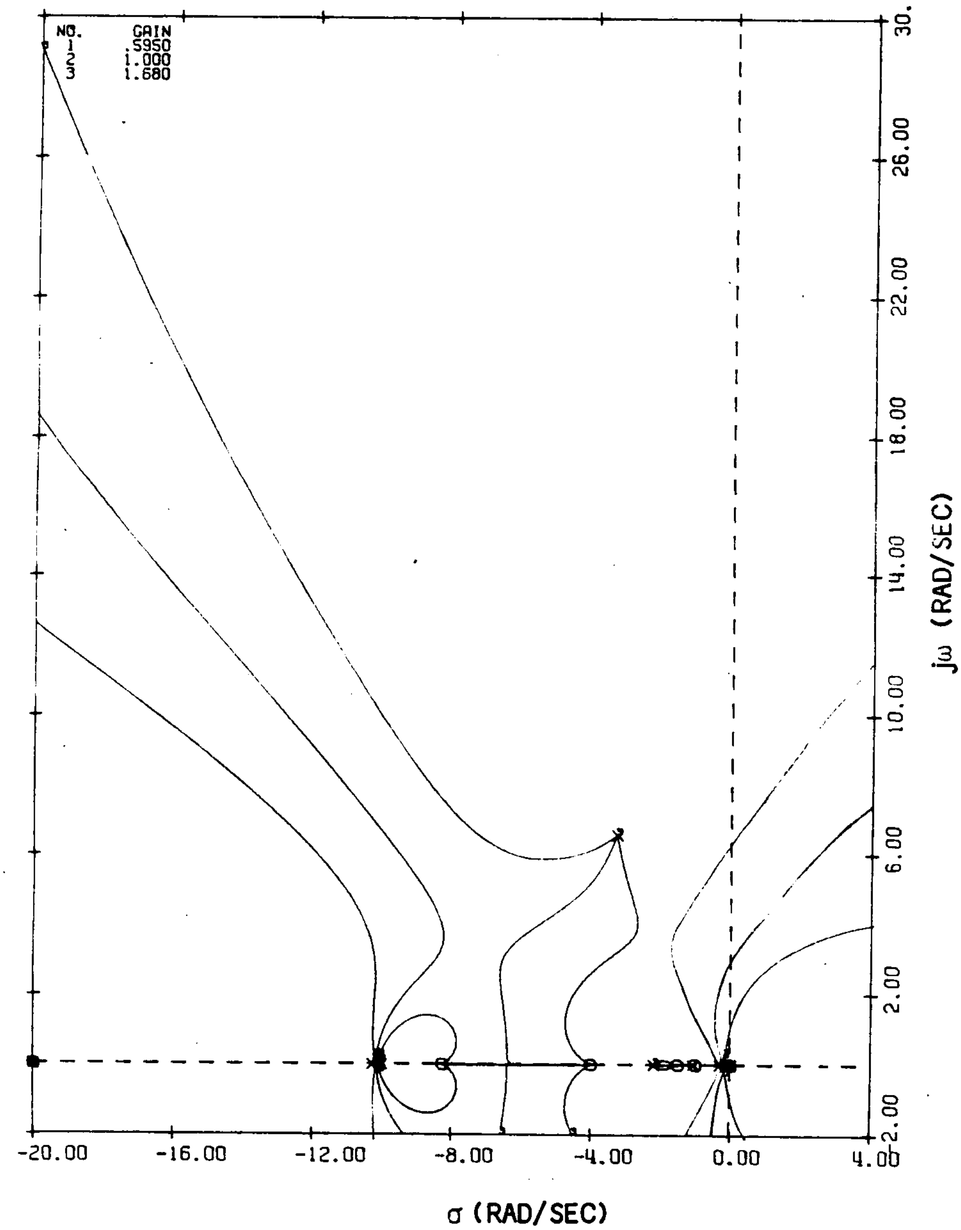


FIGURE 113

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

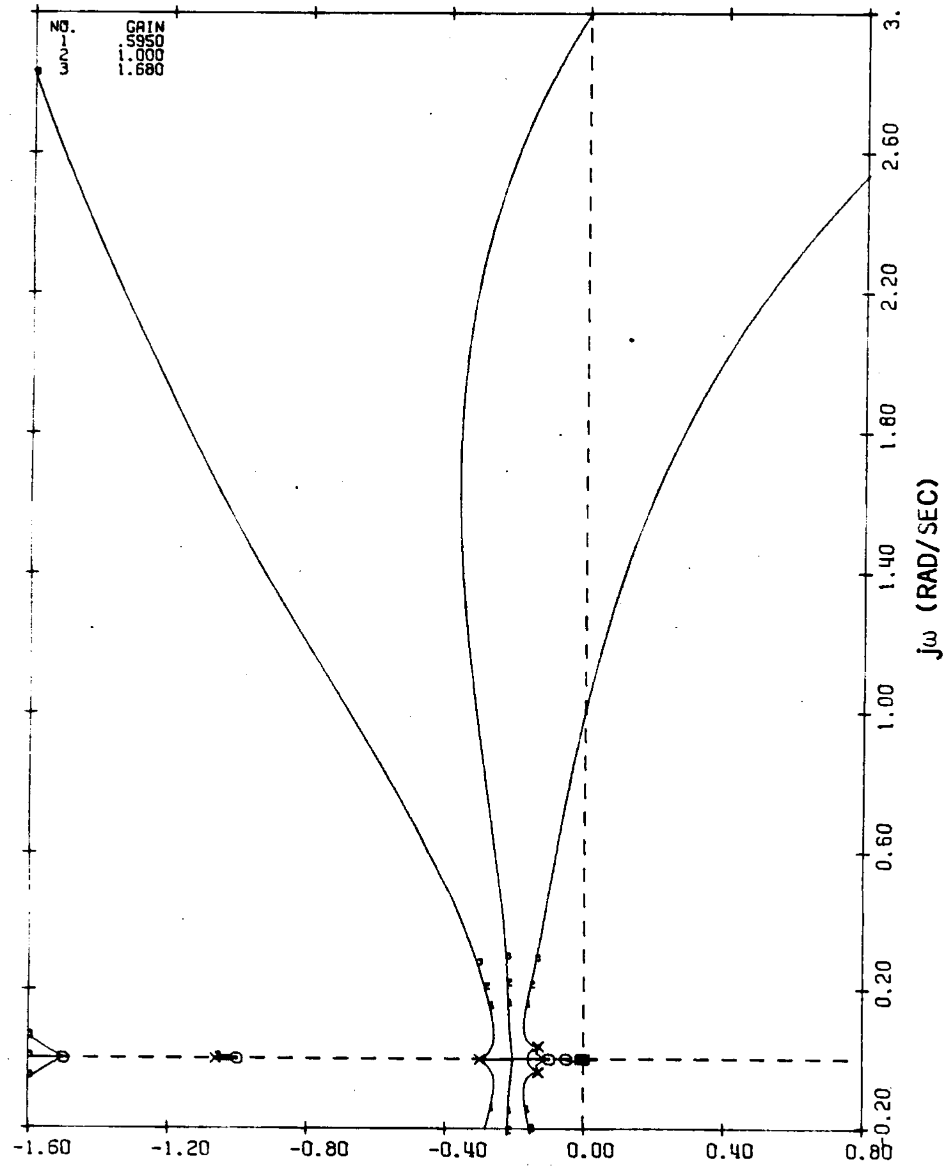


FIGURE 113 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

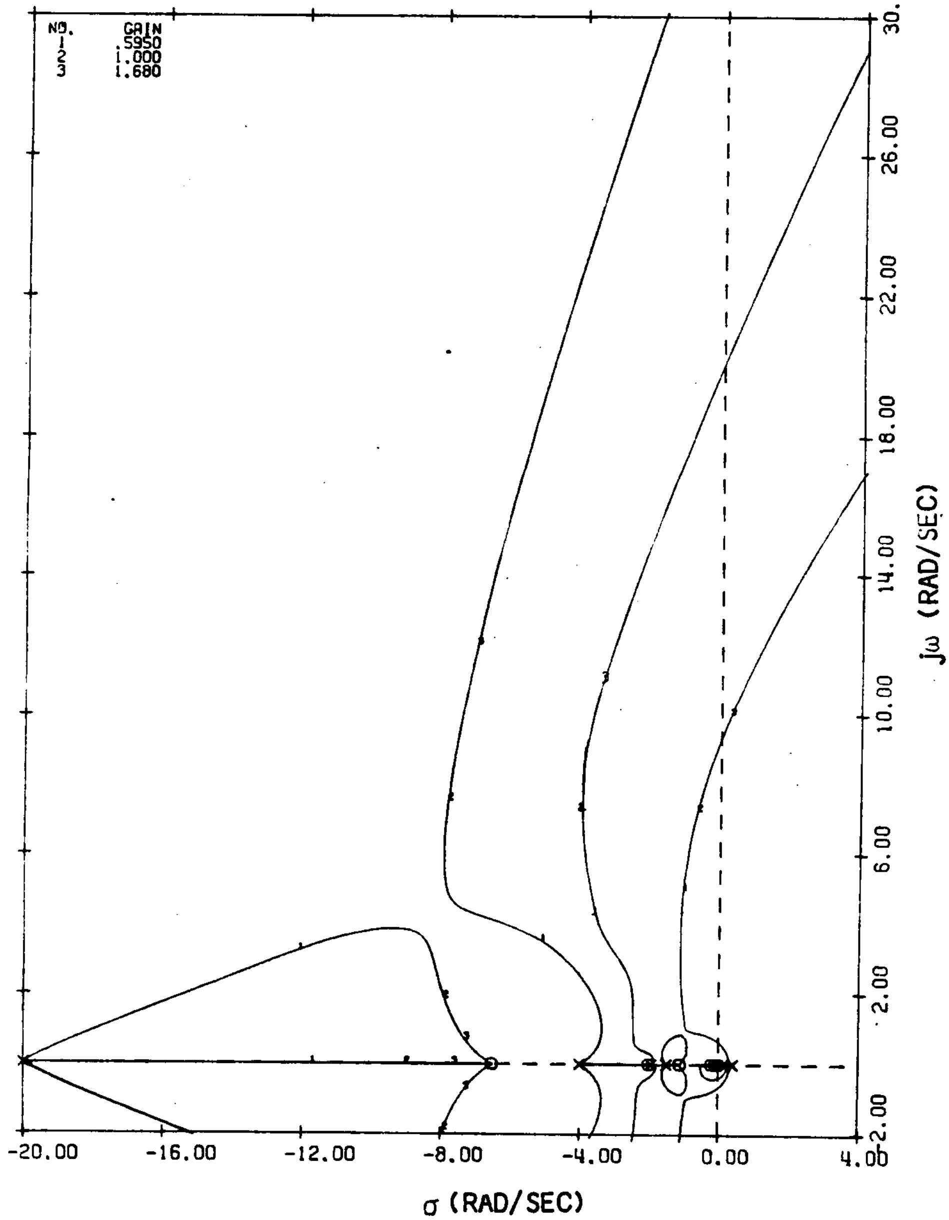


FIGURE 114

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- RSS
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

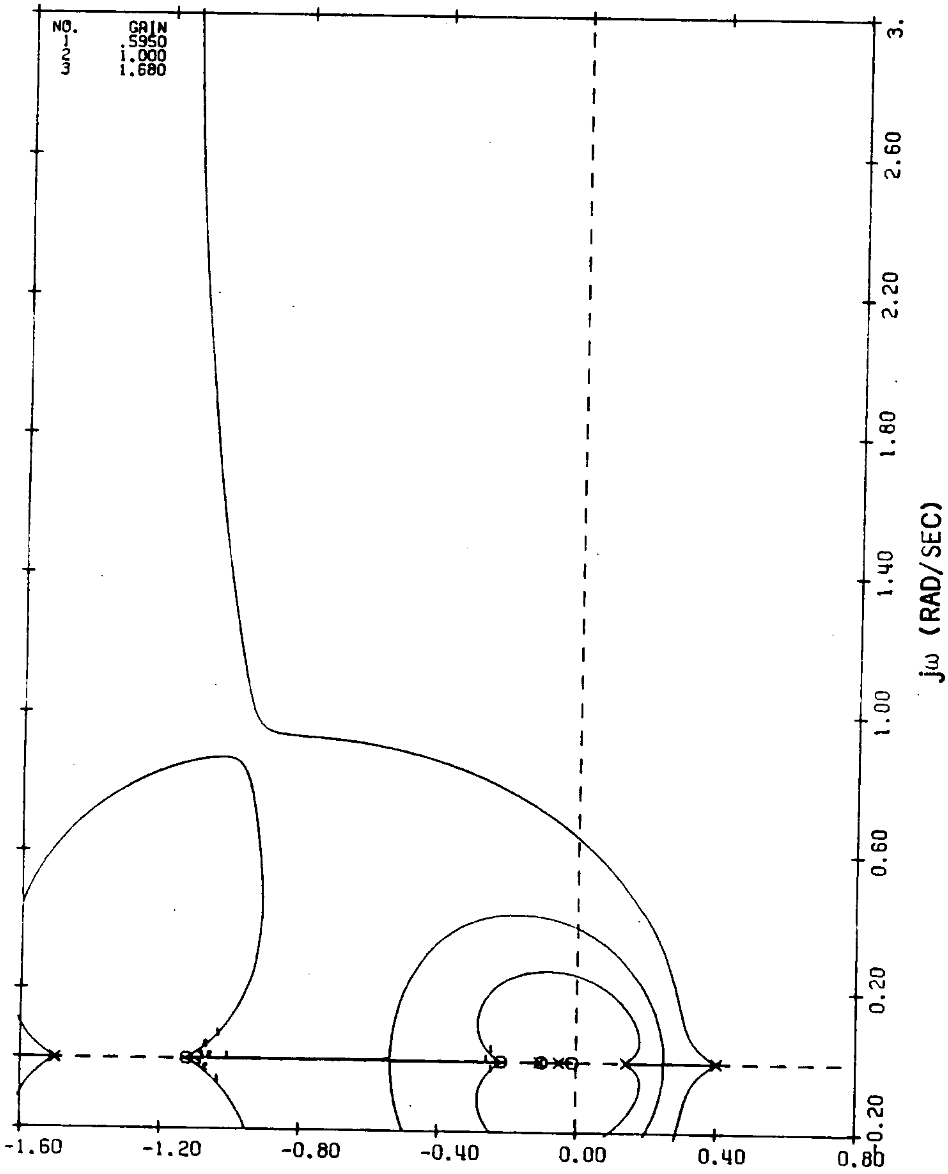


FIGURE 114 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

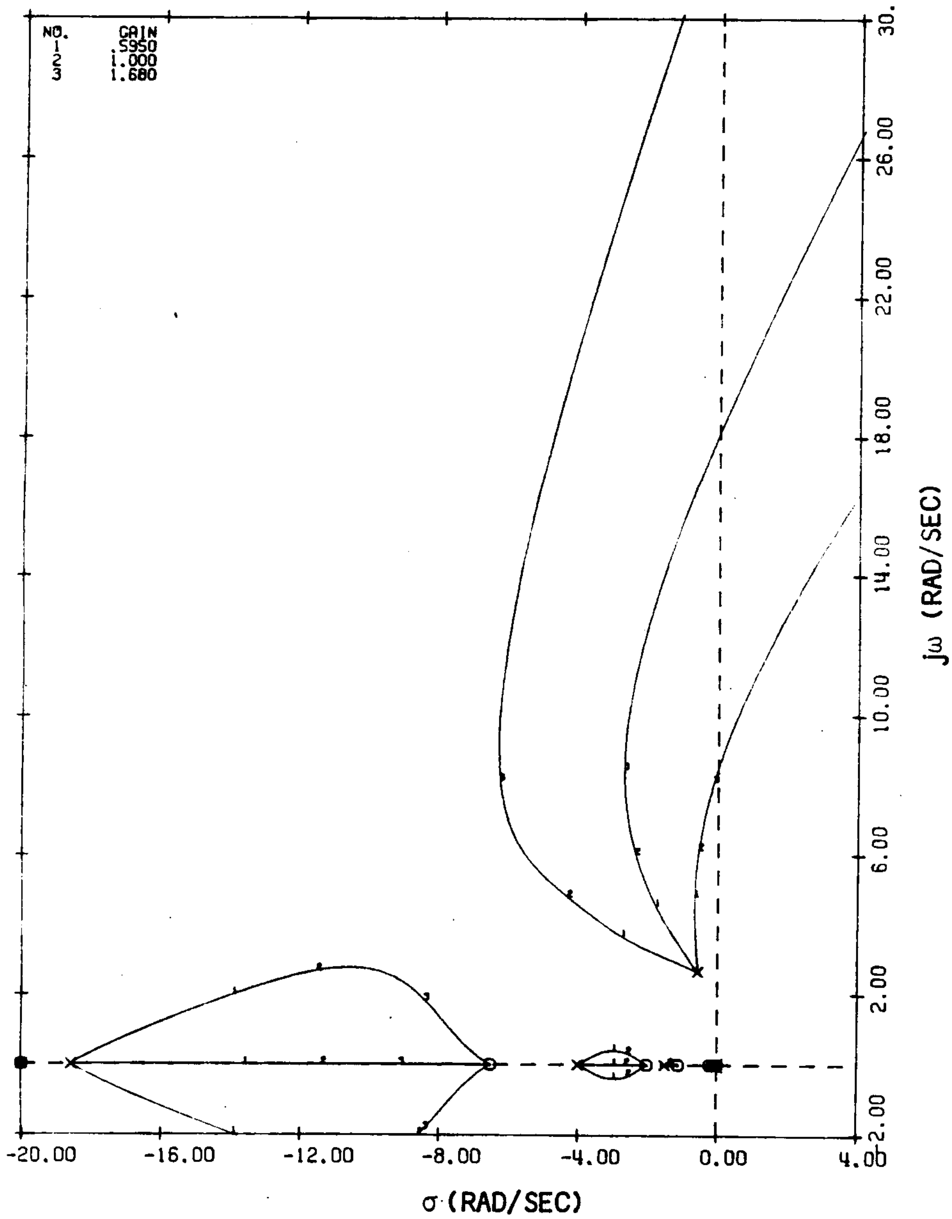


FIGURE 115

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

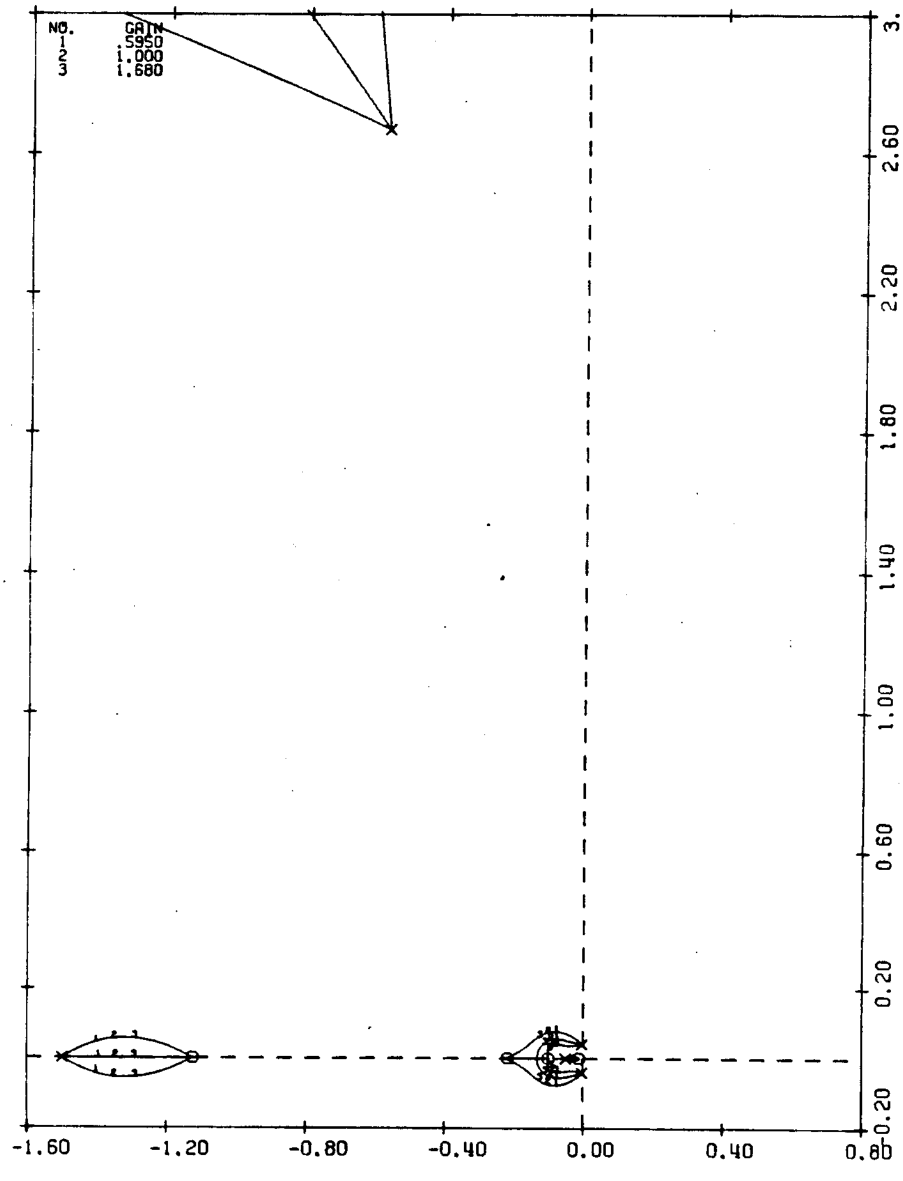


FIGURE 115 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

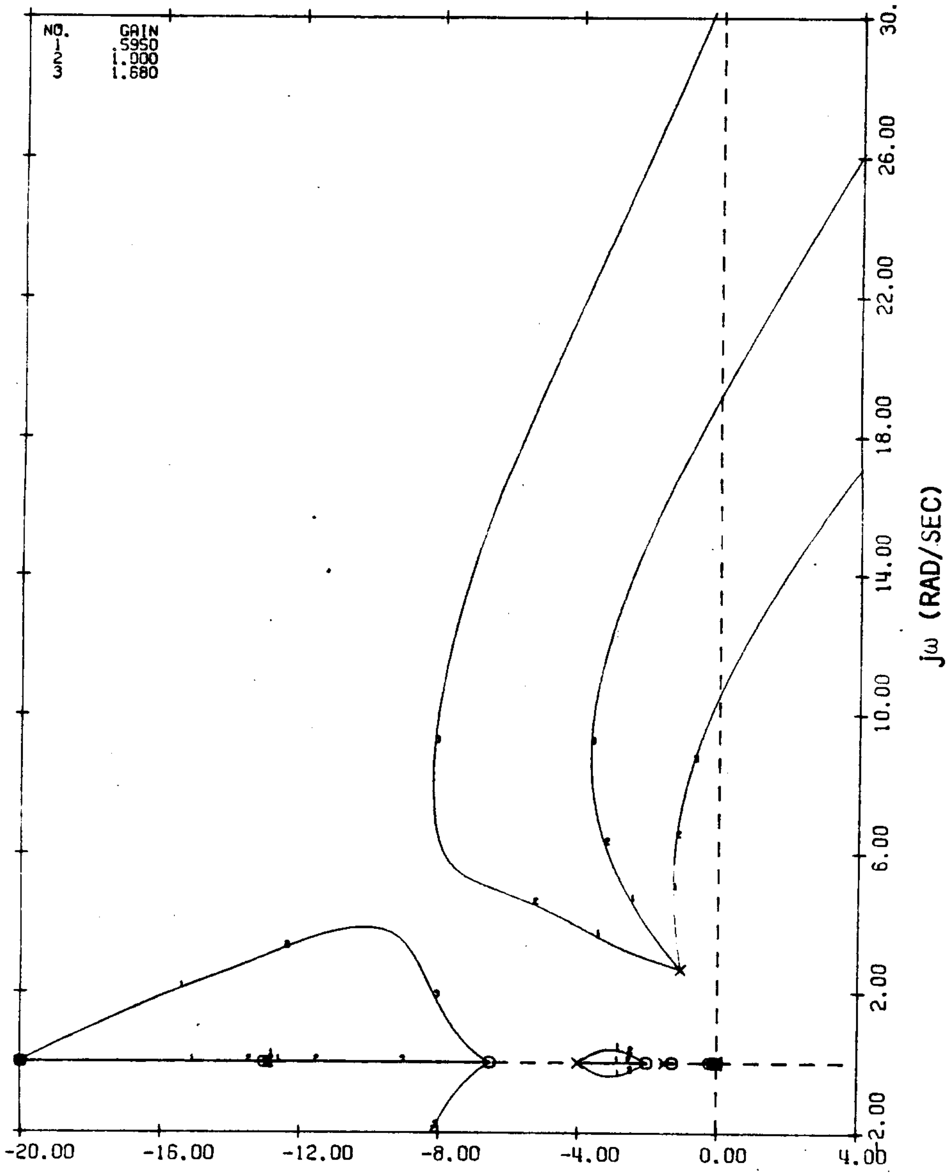


FIGURE 116

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION

C-2

- MLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

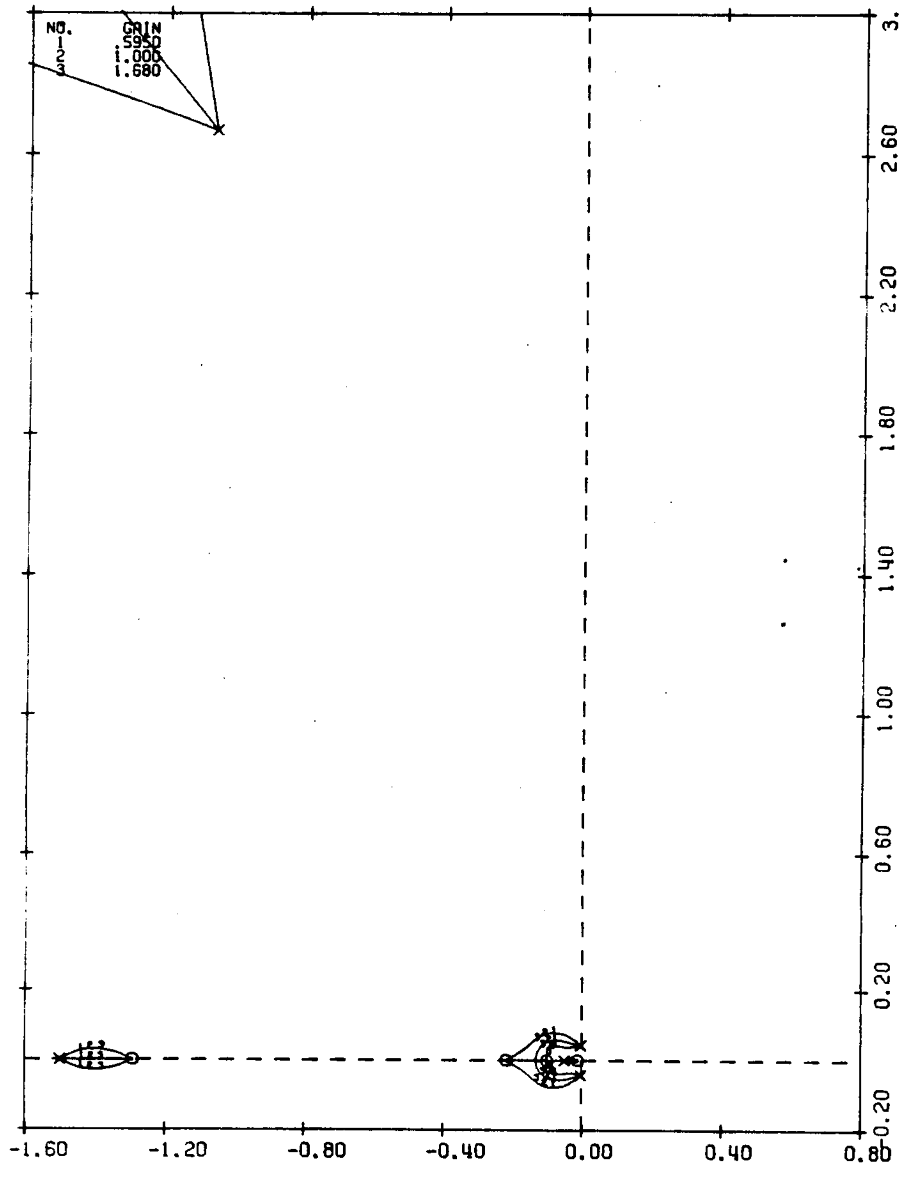


FIGURE 116 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

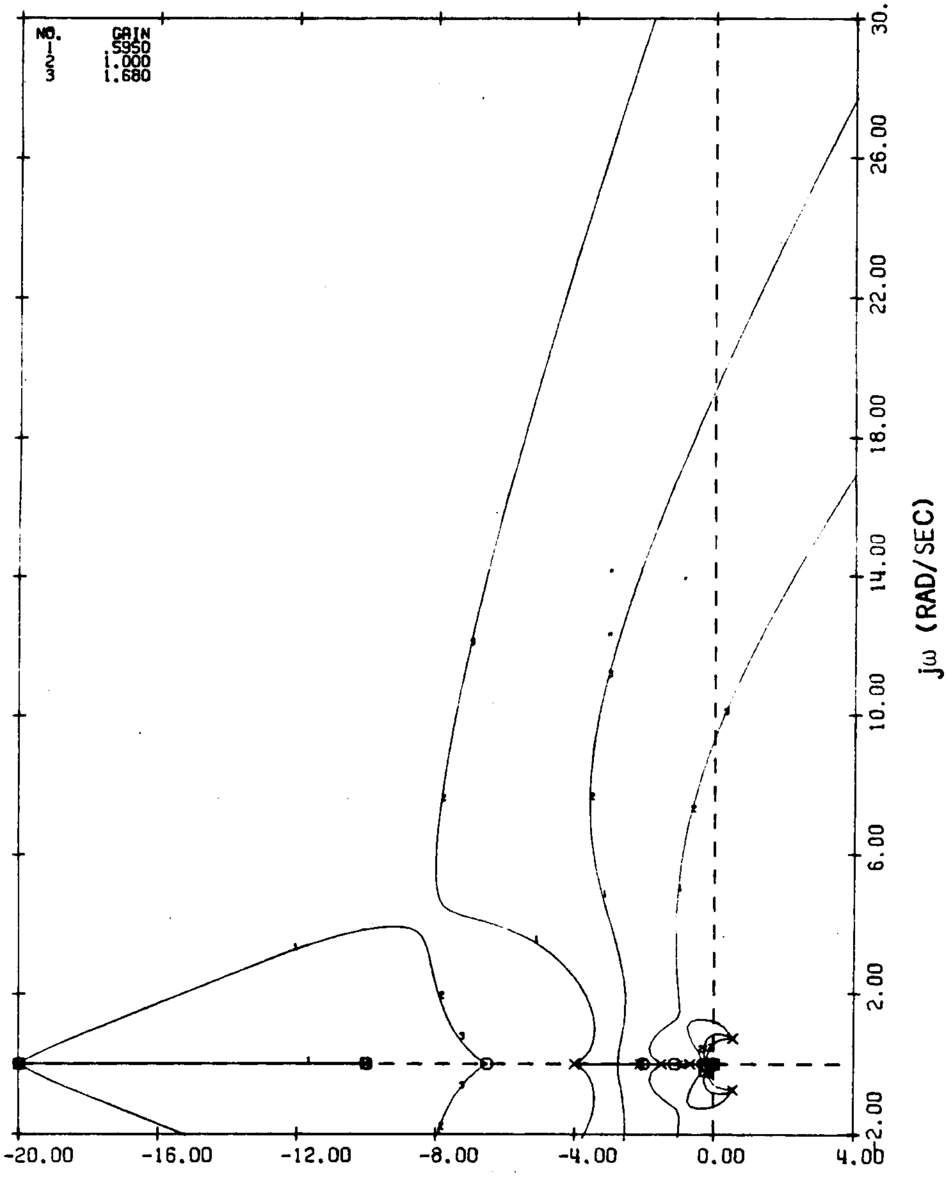


FIGURE 117

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

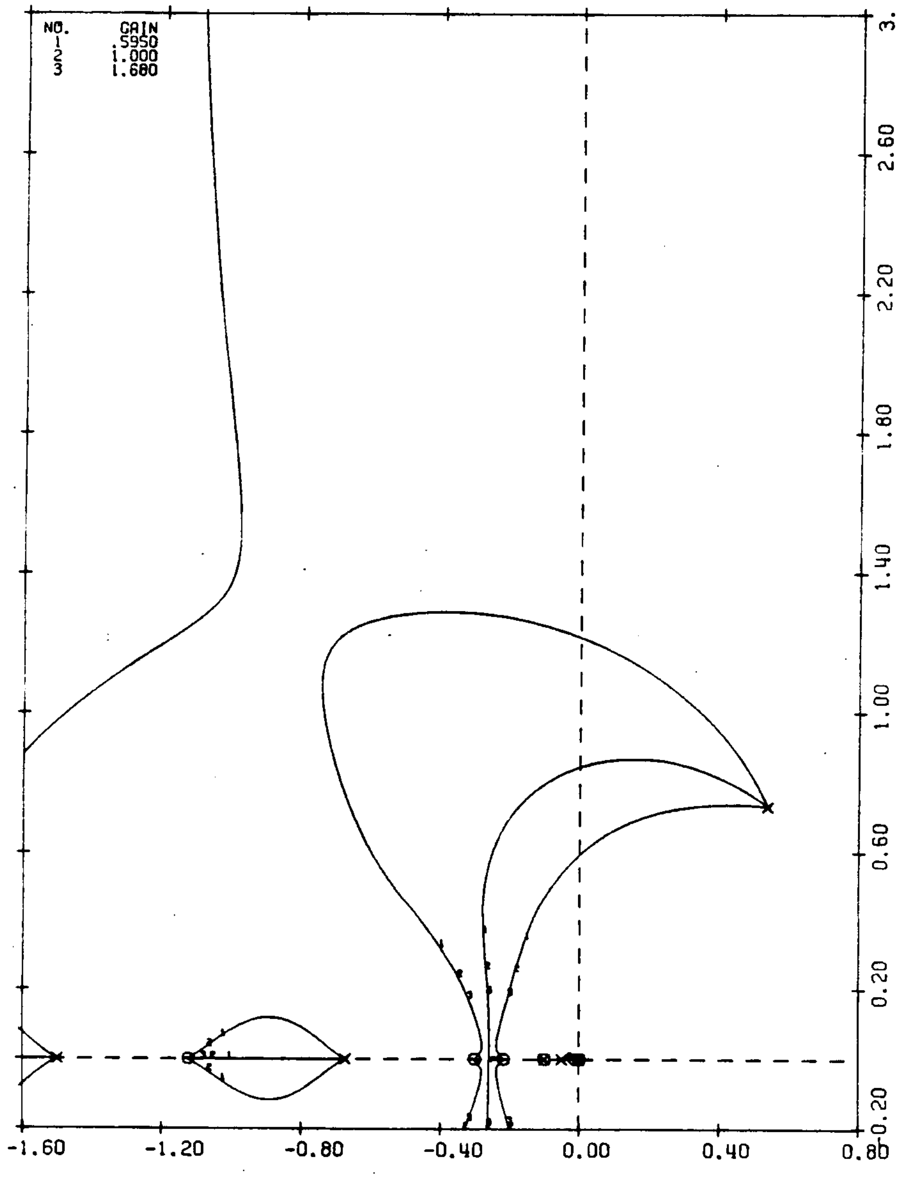


FIGURE 117 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

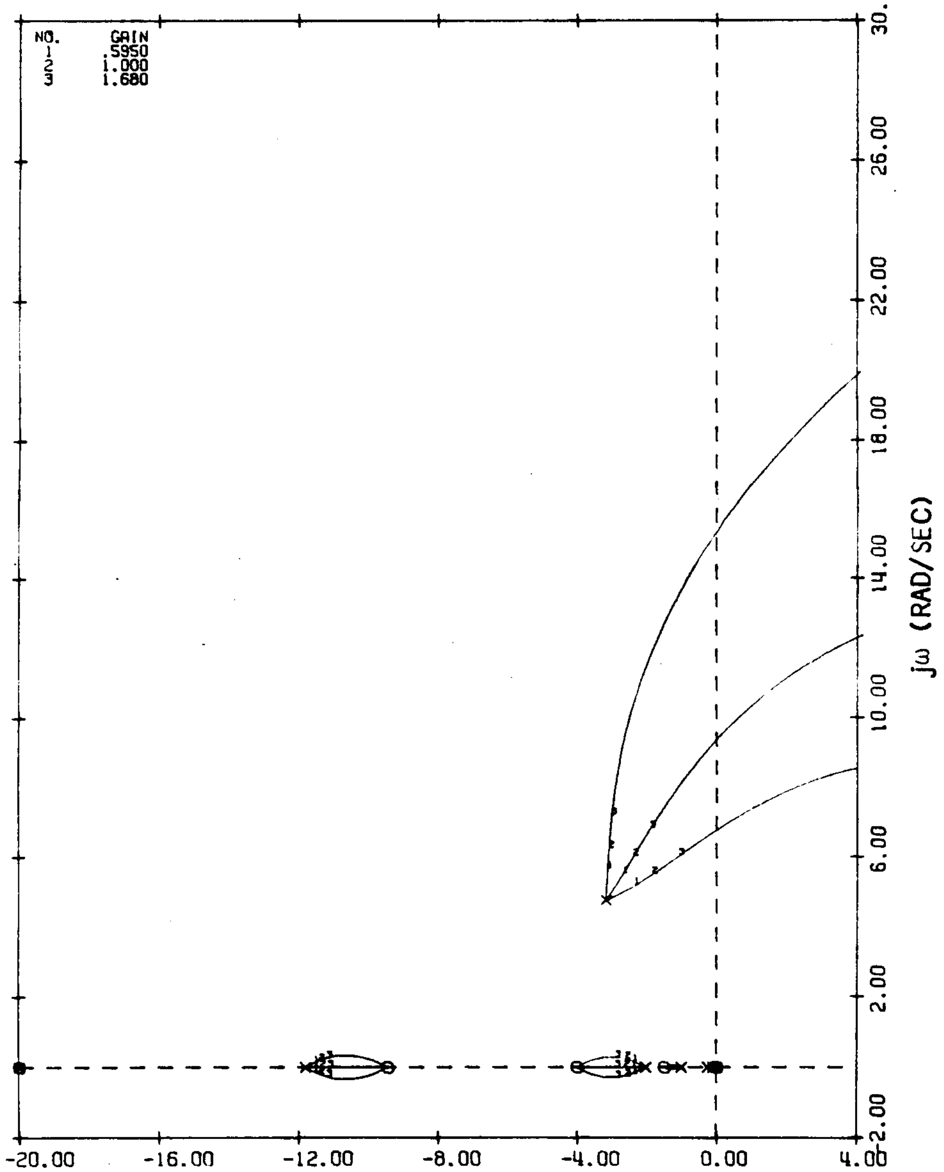


FIGURE 118

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

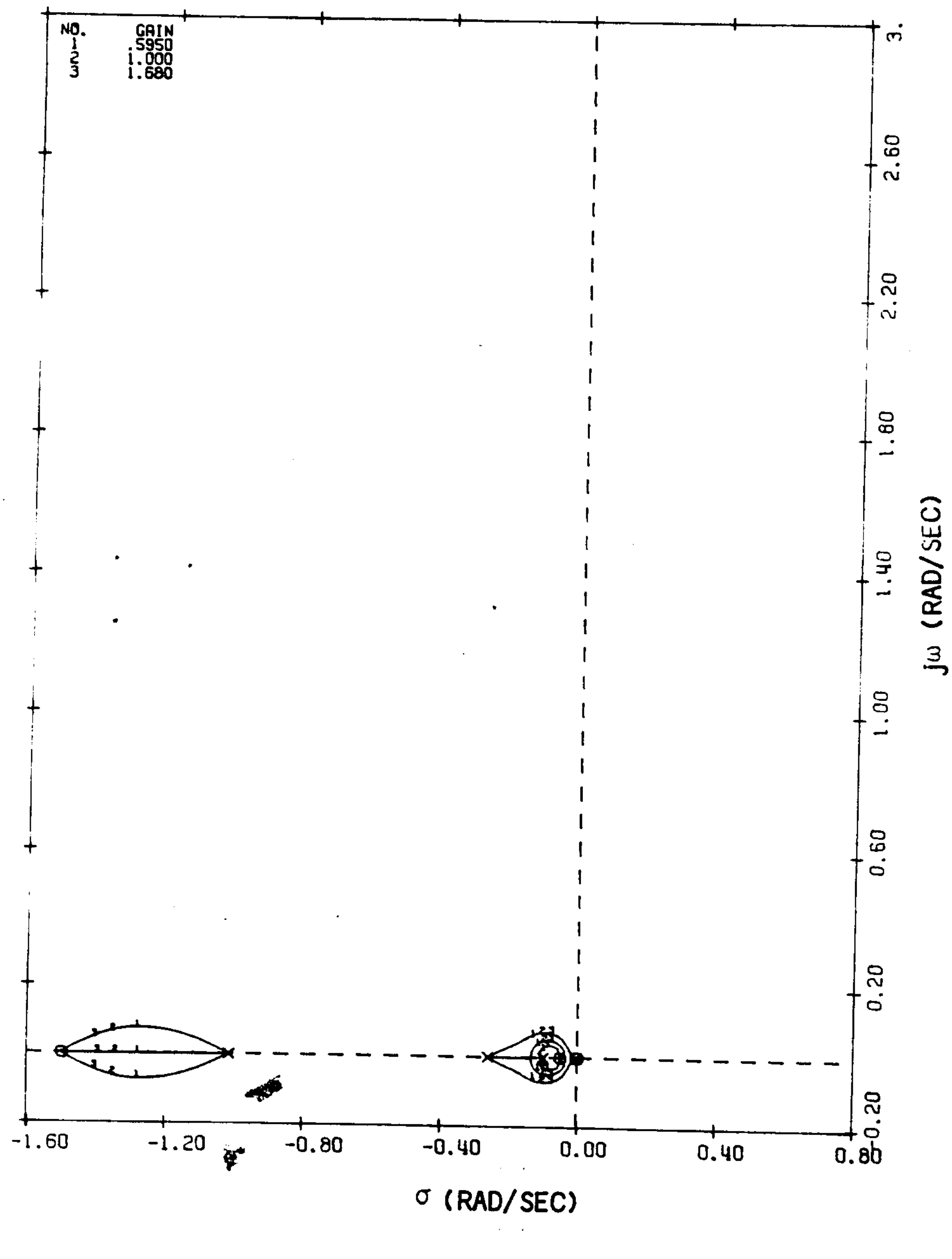


FIGURE 118 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

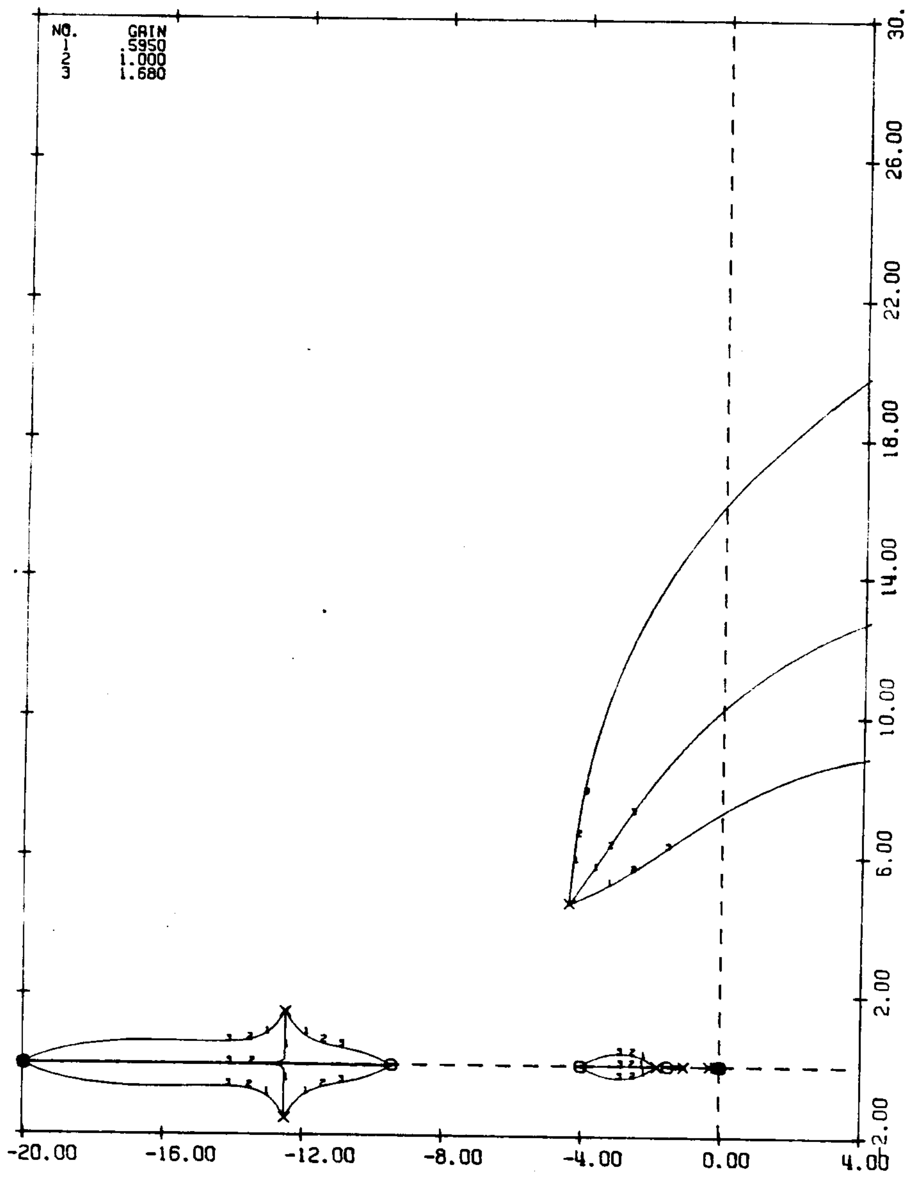


FIGURE 119

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

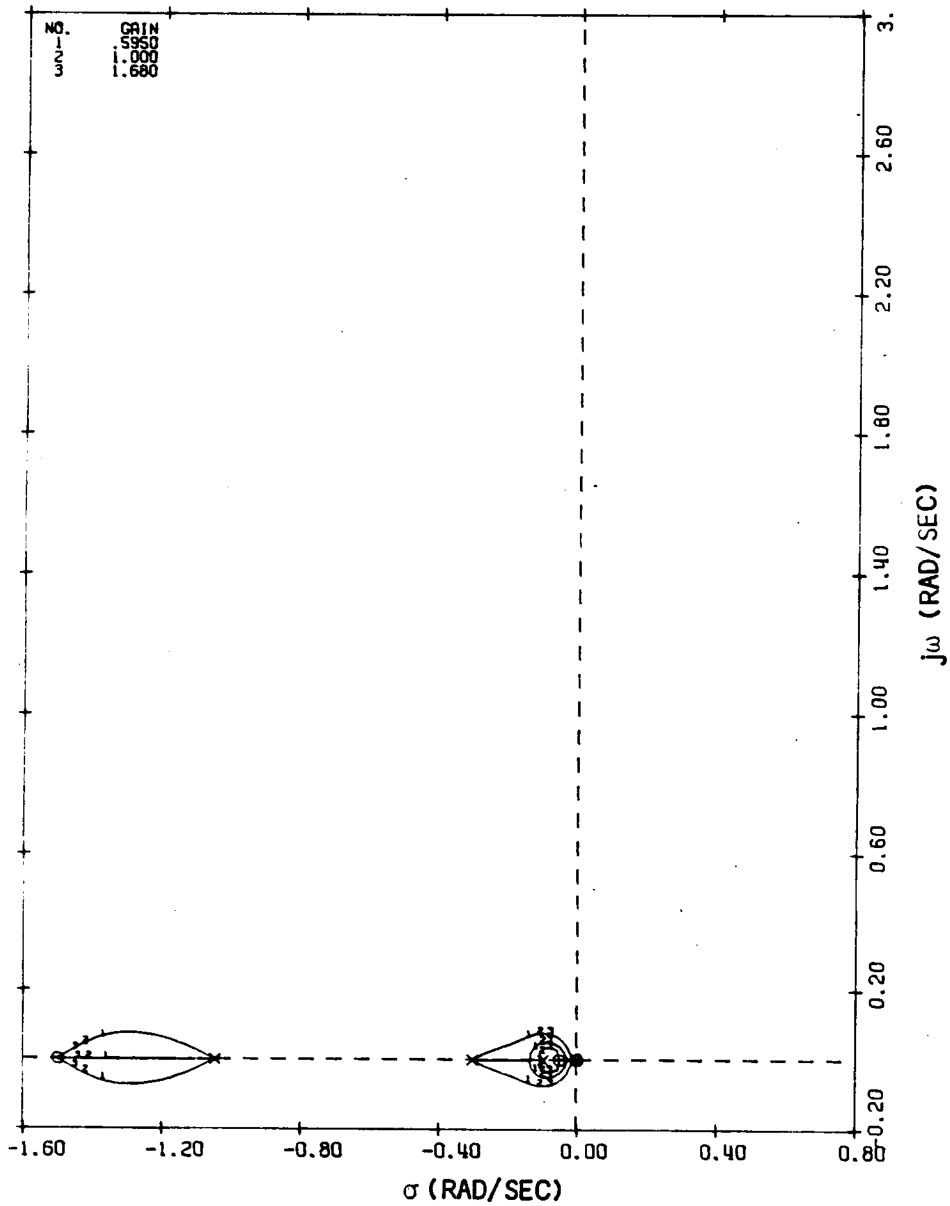


FIGURE 119 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

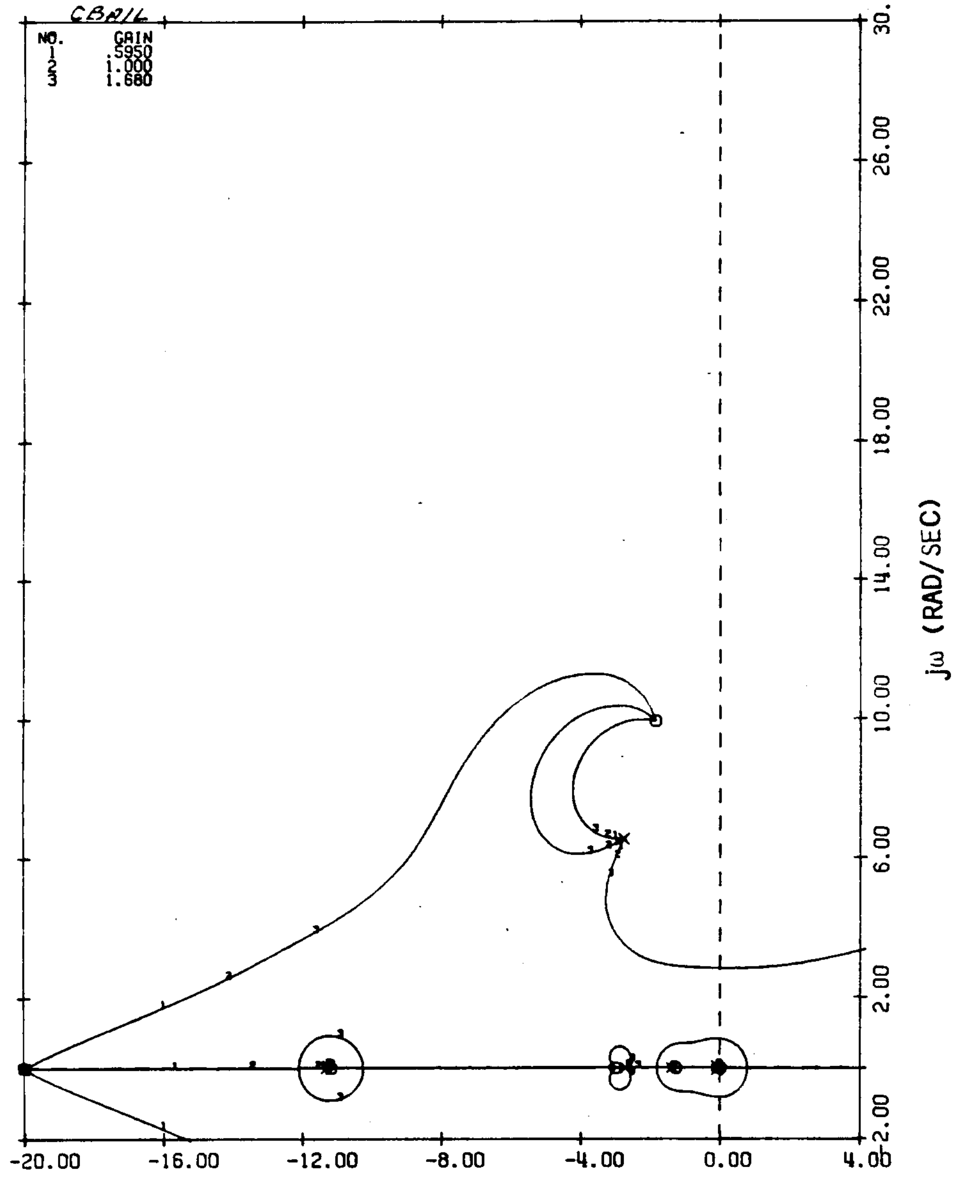


FIGURE 120

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

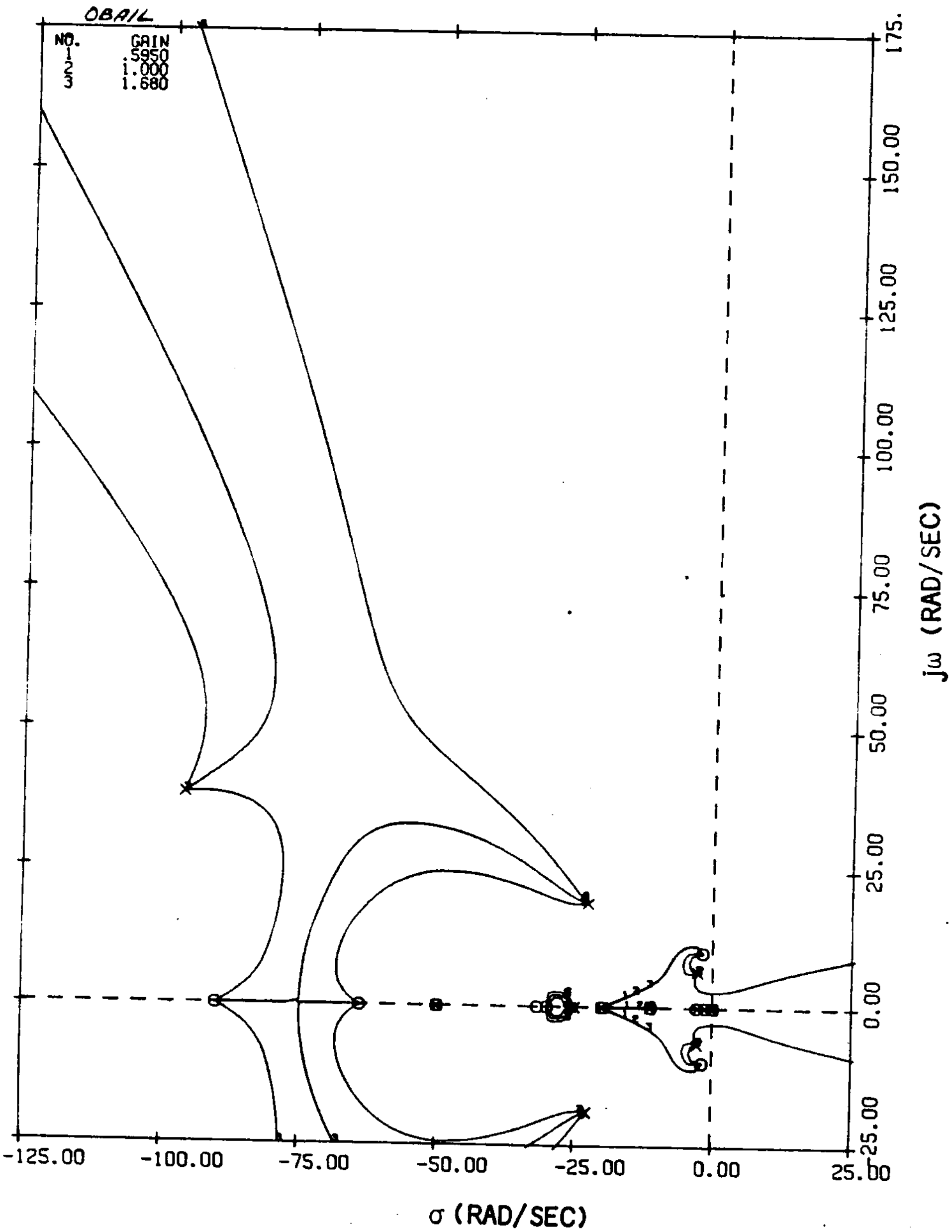


FIGURE 120 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

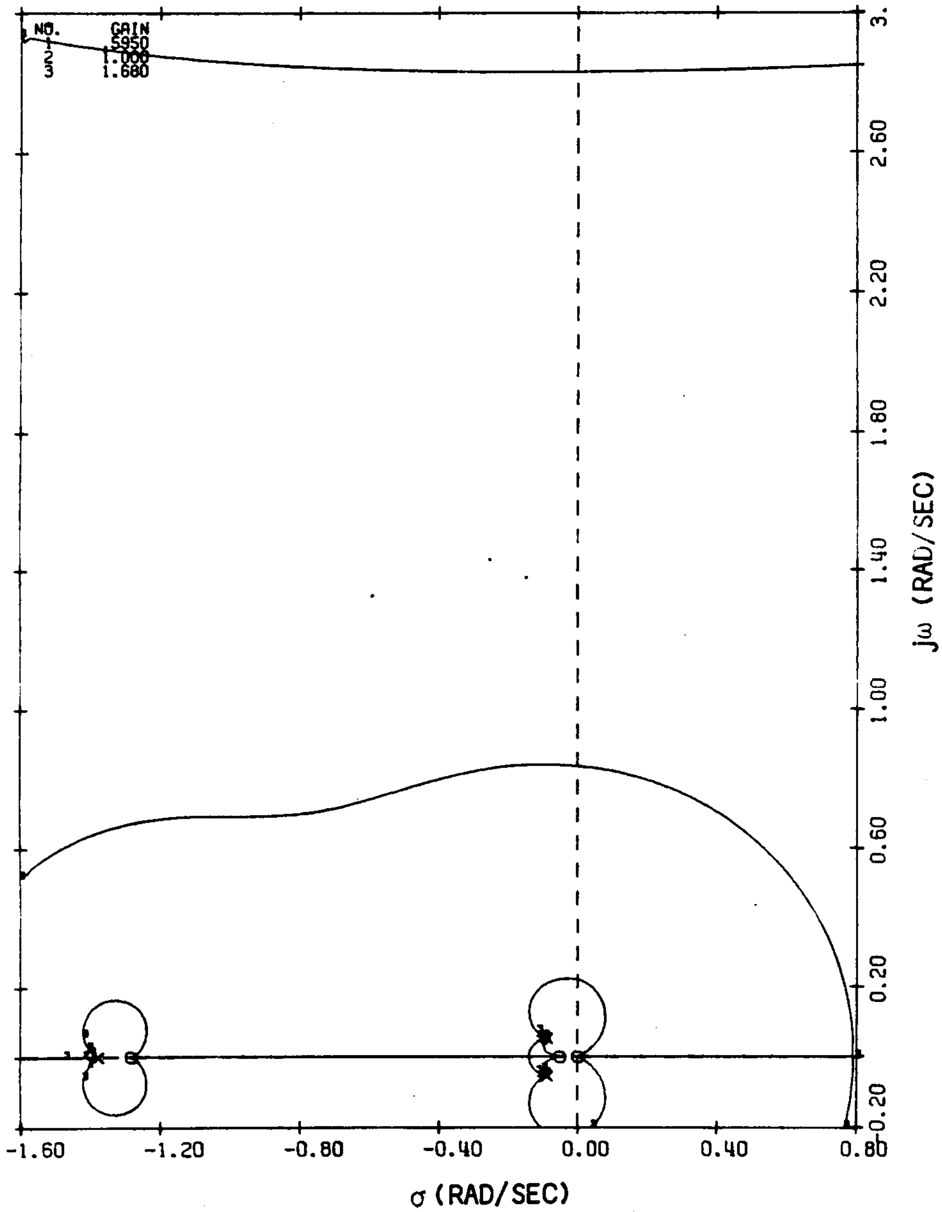


FIGURE 120 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

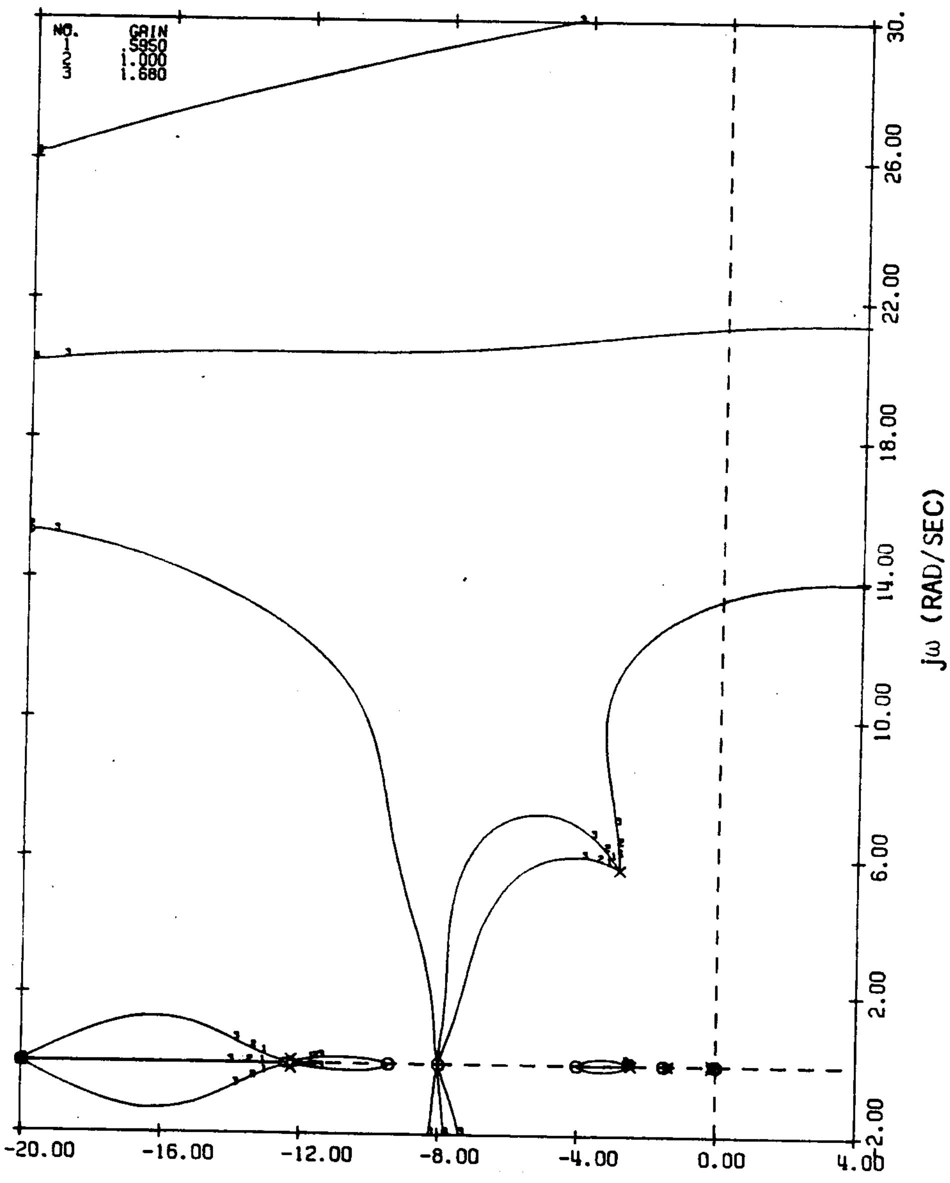


FIGURE 121

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

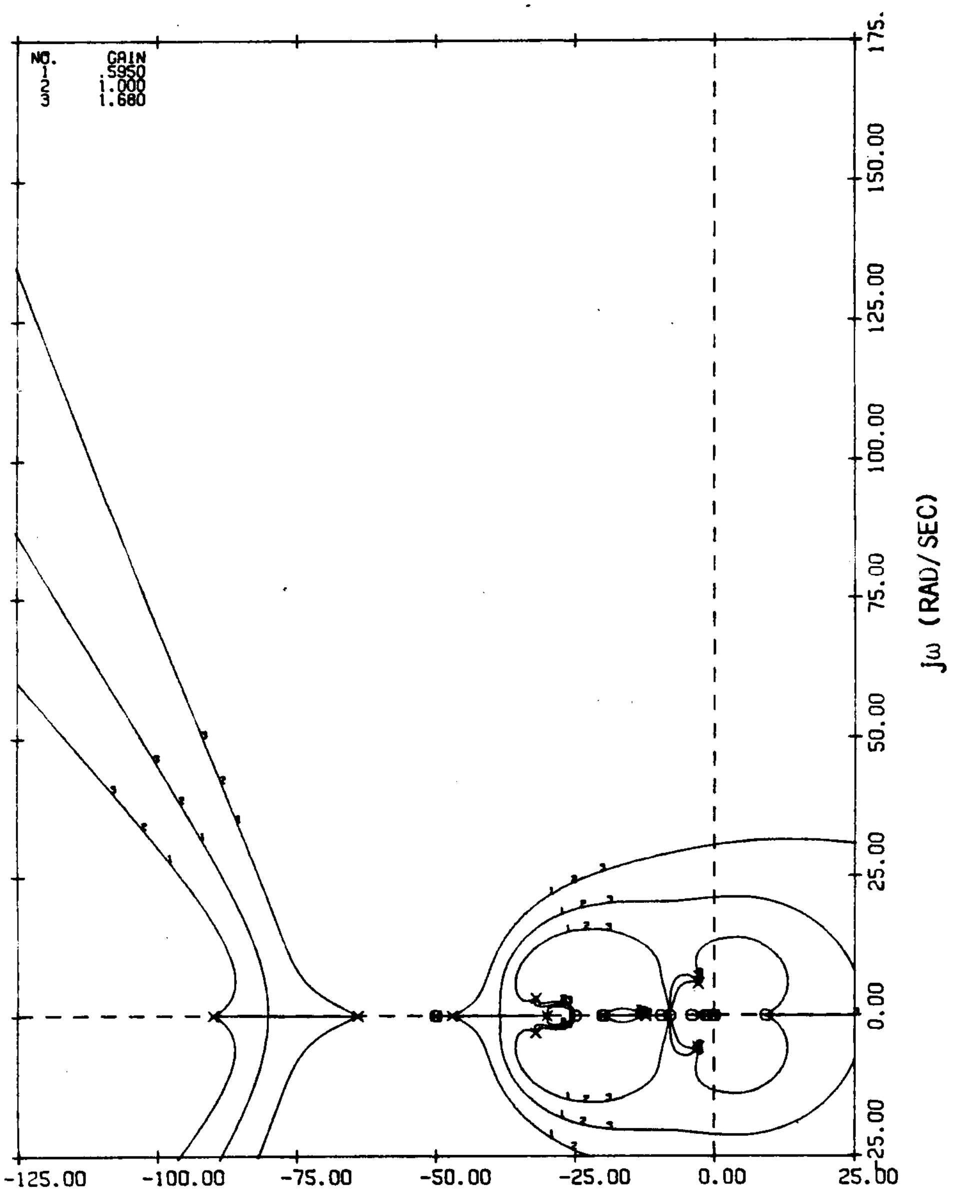


FIGURE 121 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

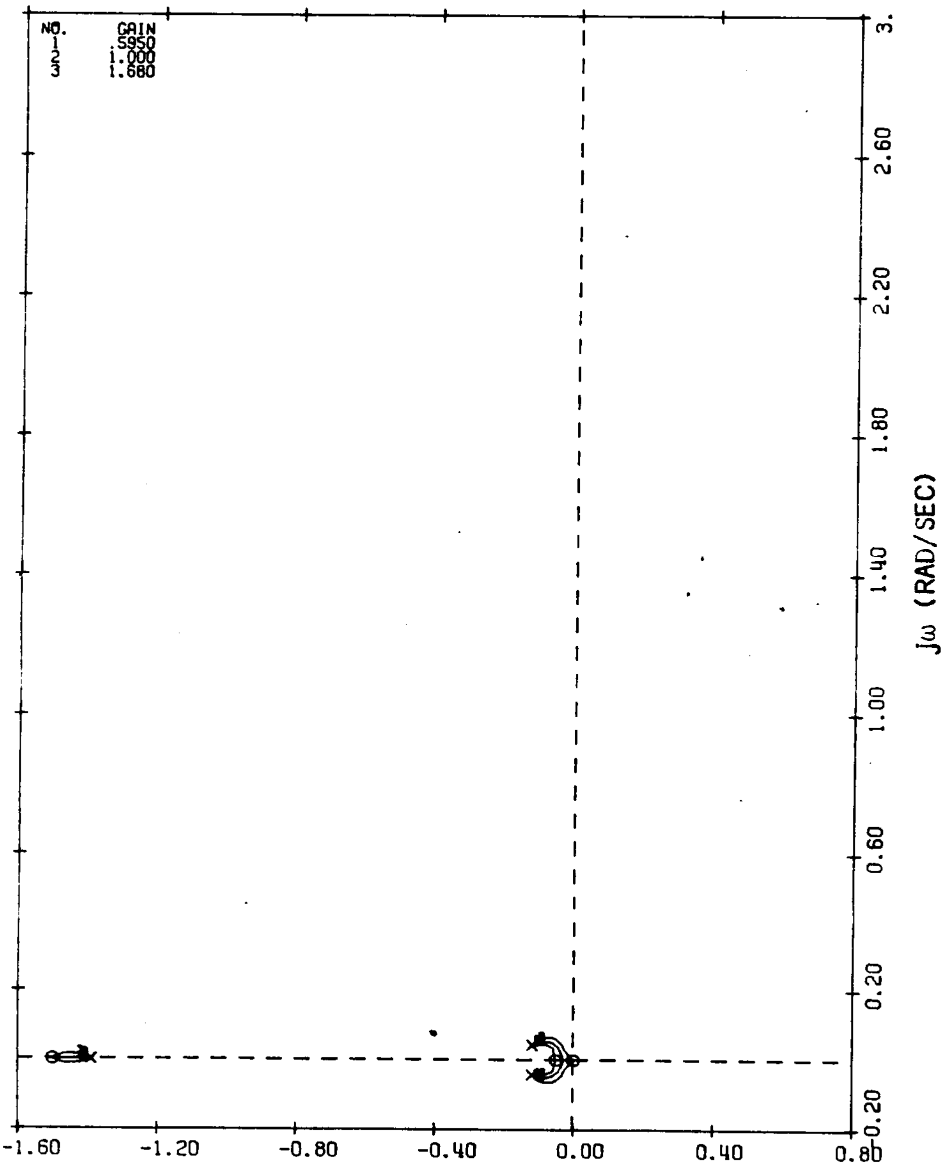


FIGURE 121 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MLA TEST CONDITION

APPENDIX E

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

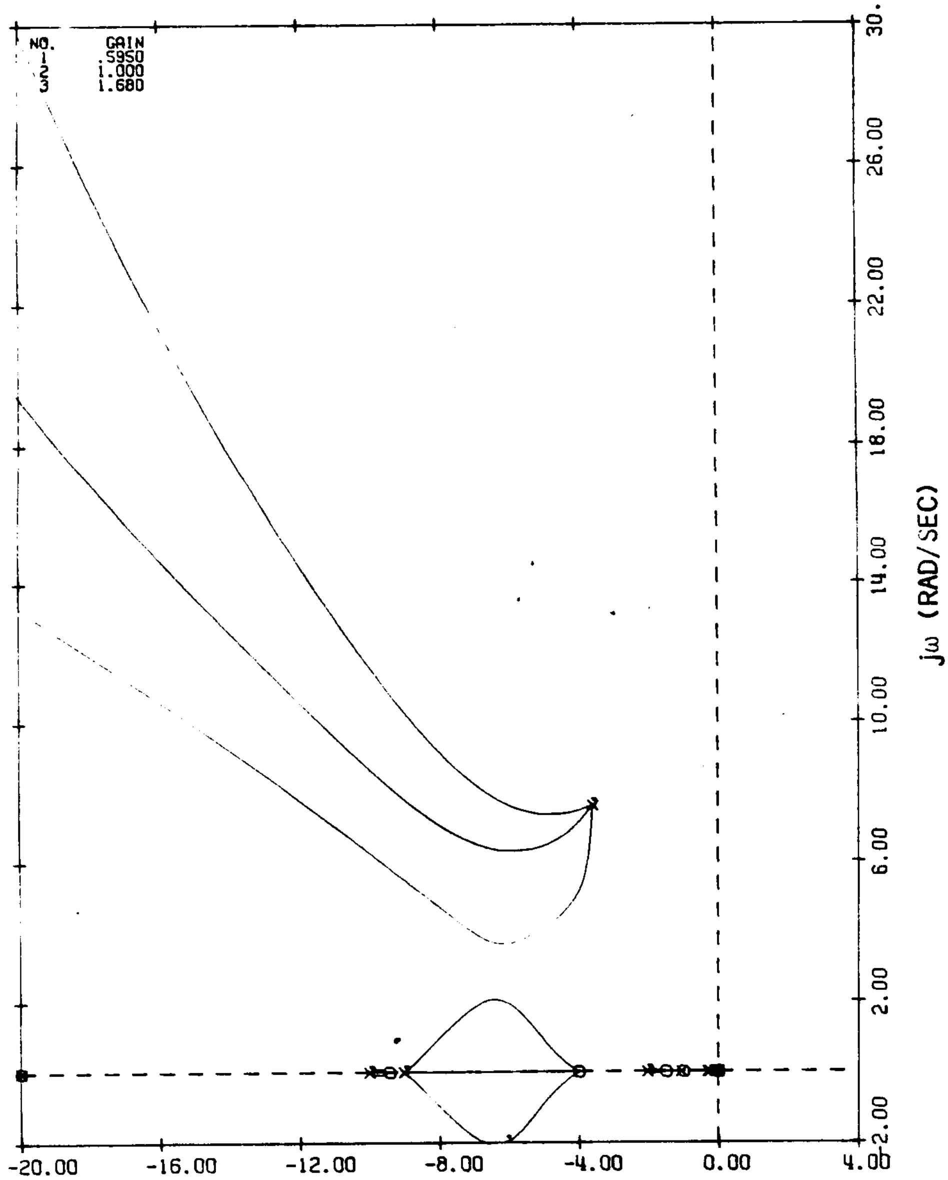


FIGURE 122

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION

- MLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.42
- ALTITUDE: 10,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

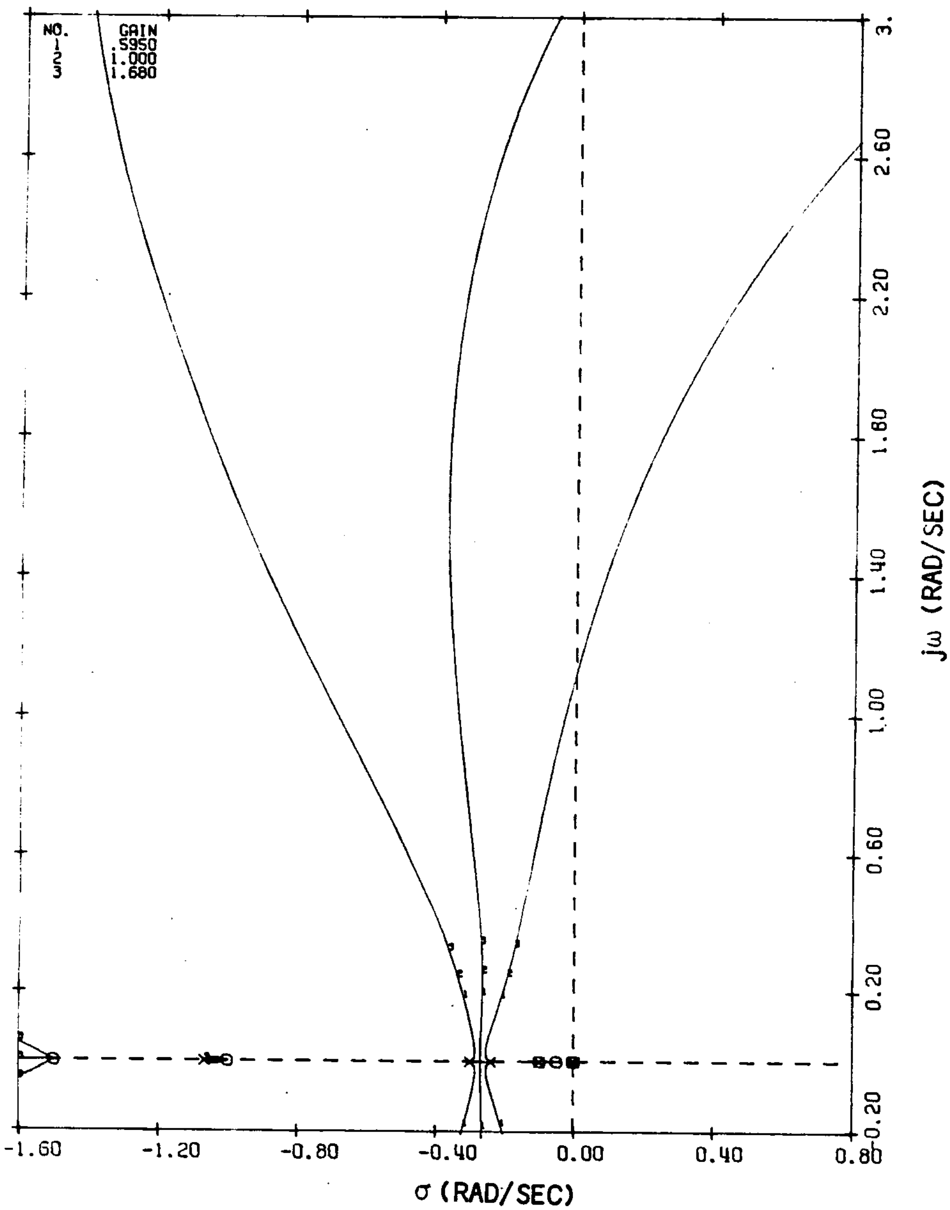


FIGURE 122 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MLA TEST CONDITION

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

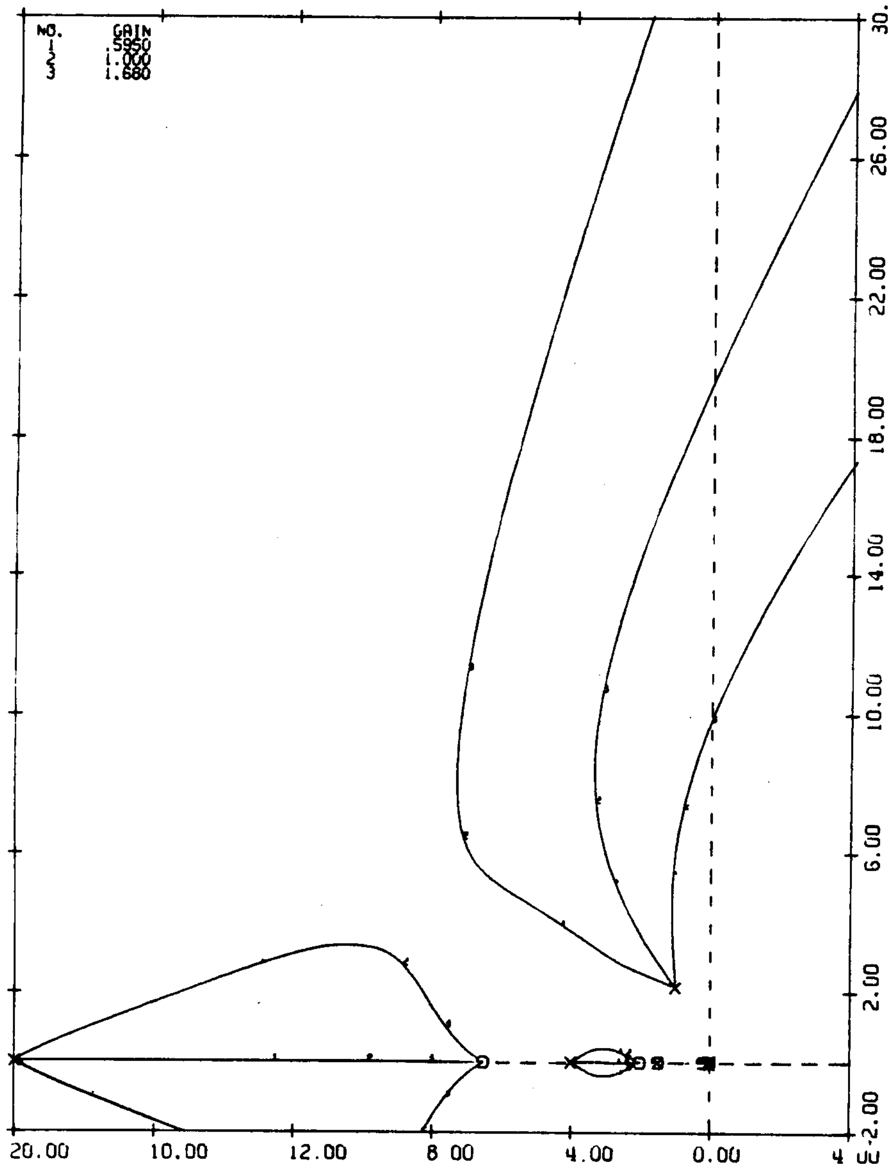


FIGURE 123

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

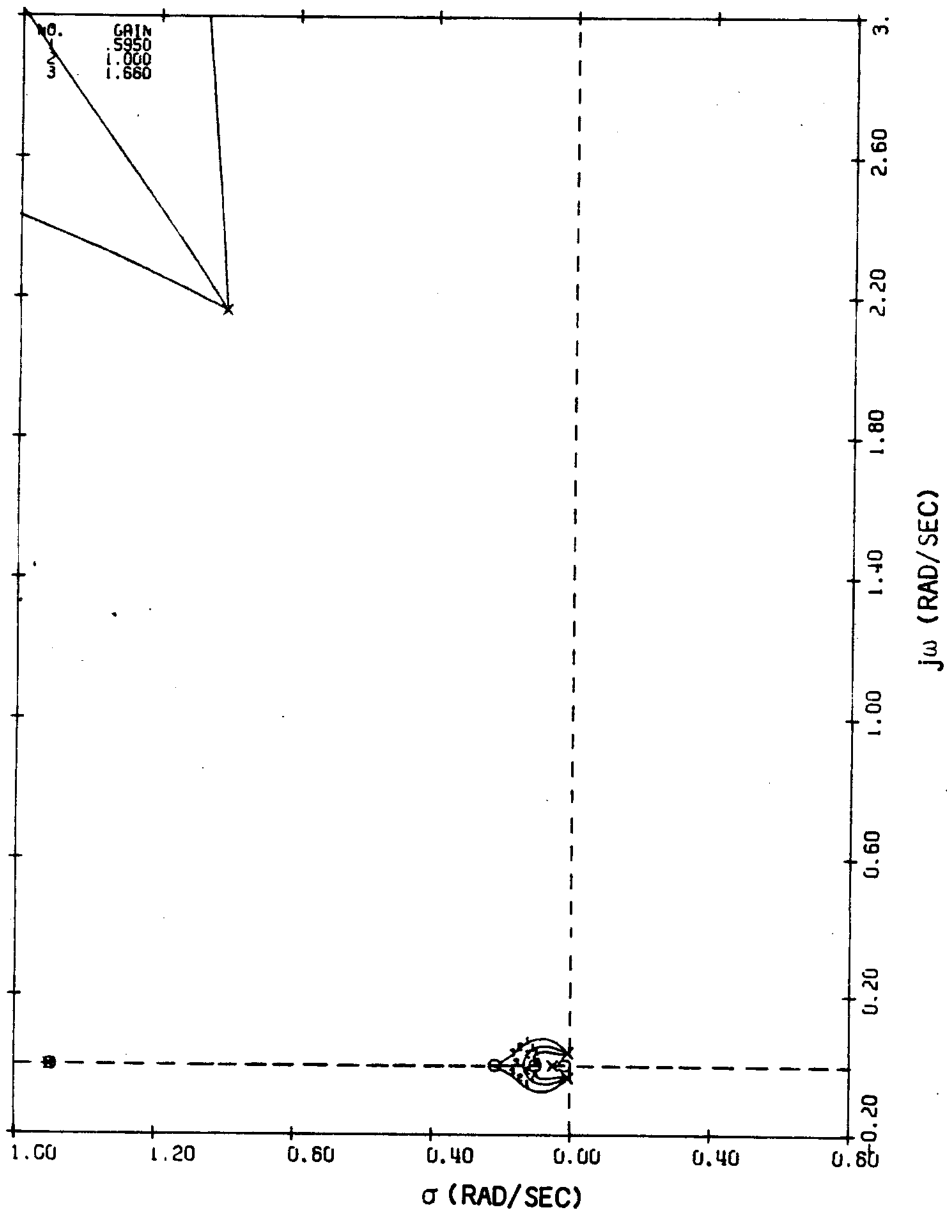


FIGURE 123 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

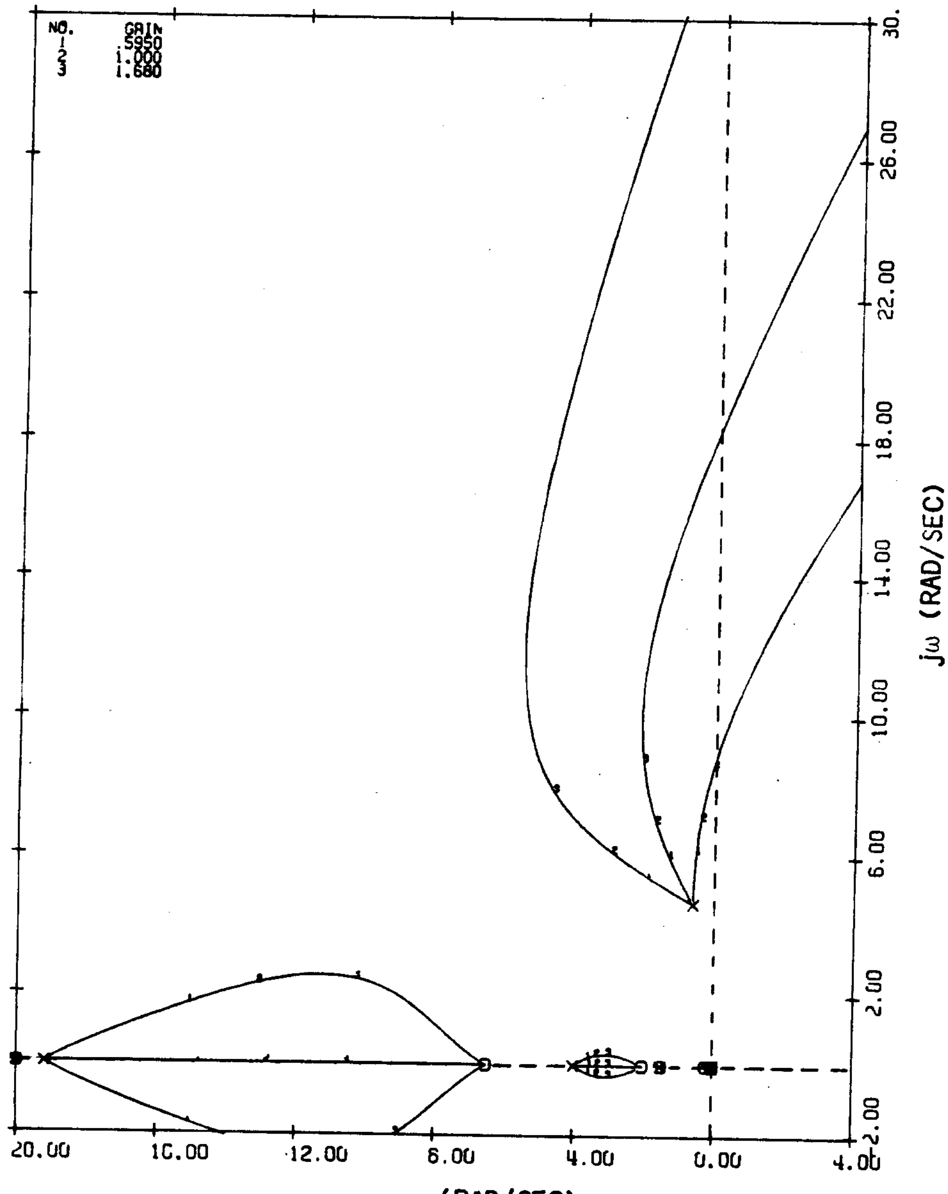


FIGURE 124

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

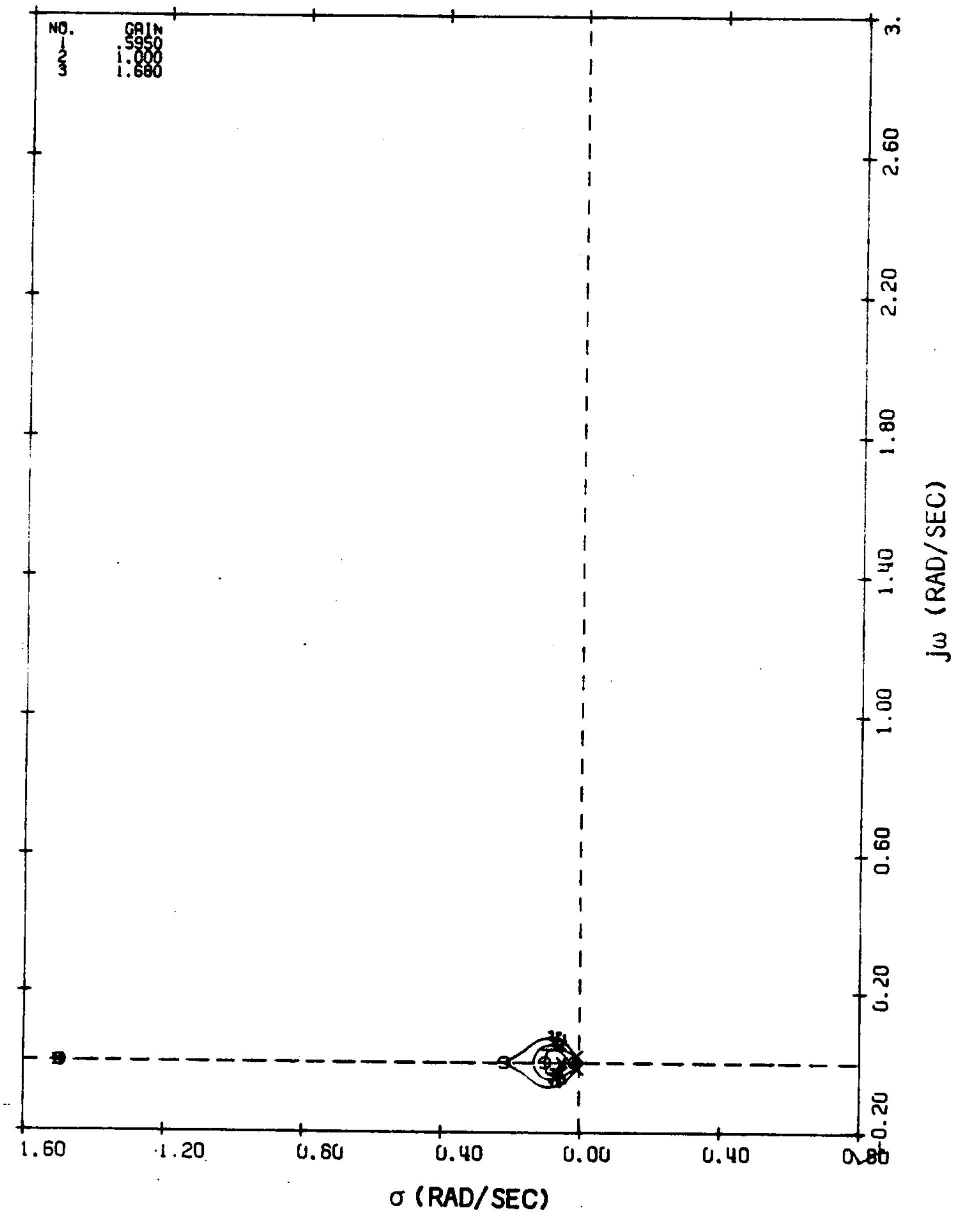


FIGURE 124 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

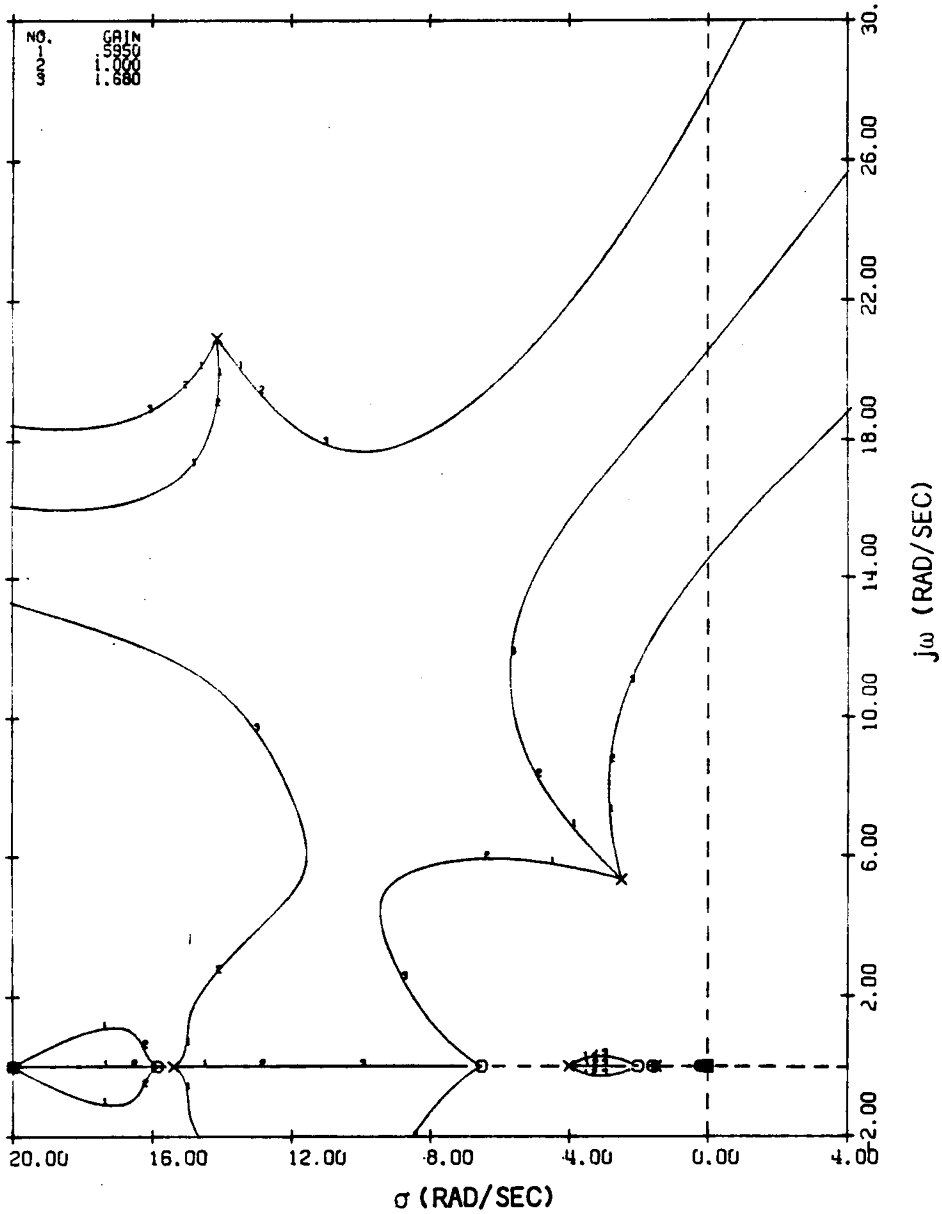


FIGURE 125

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

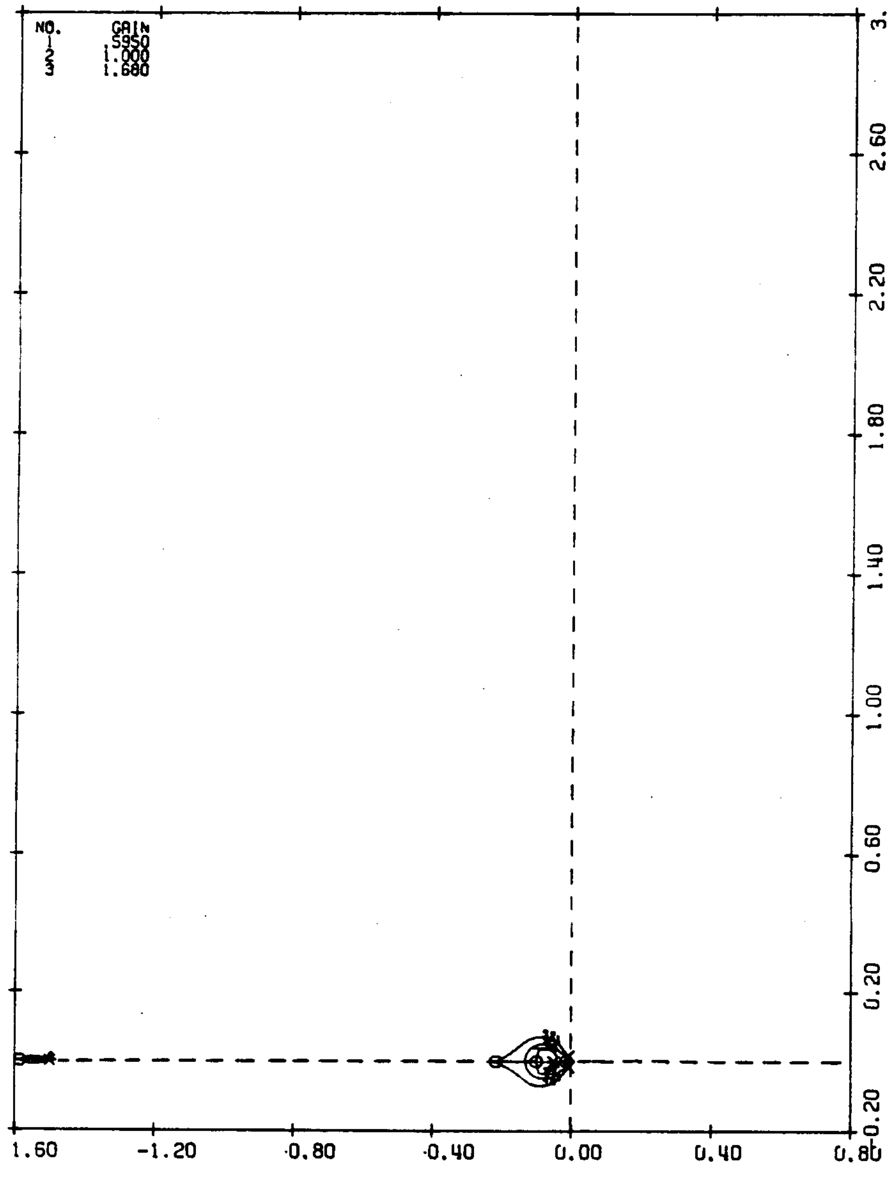


FIGURE 125 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

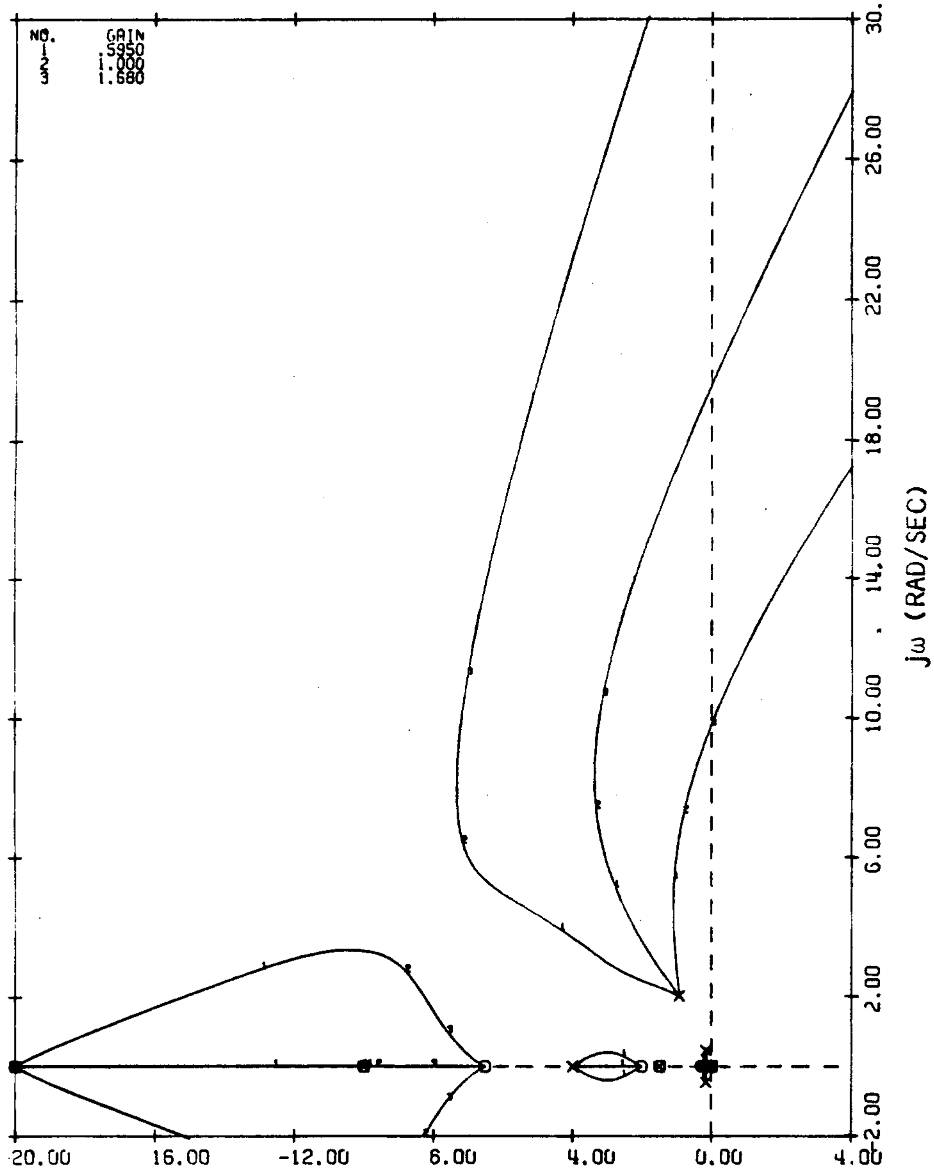


FIGURE 126

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

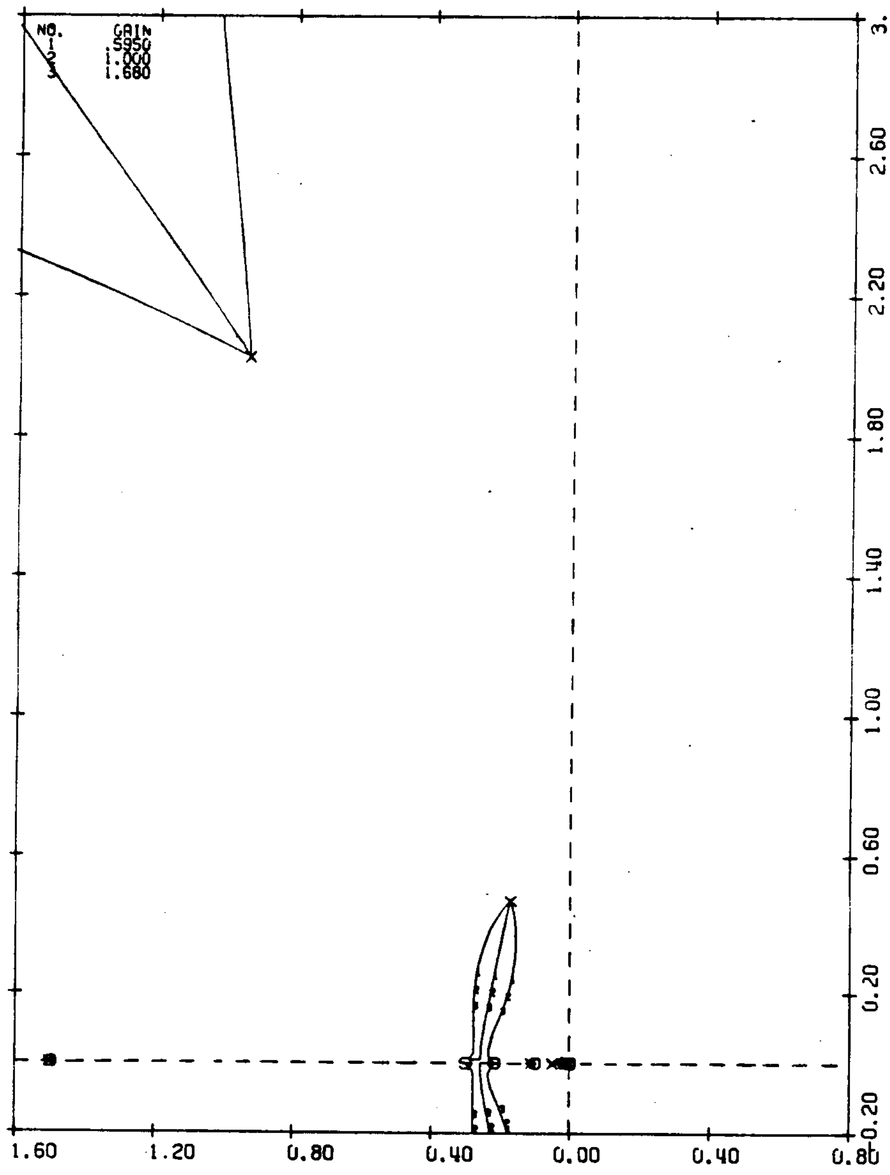


FIGURE 126 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

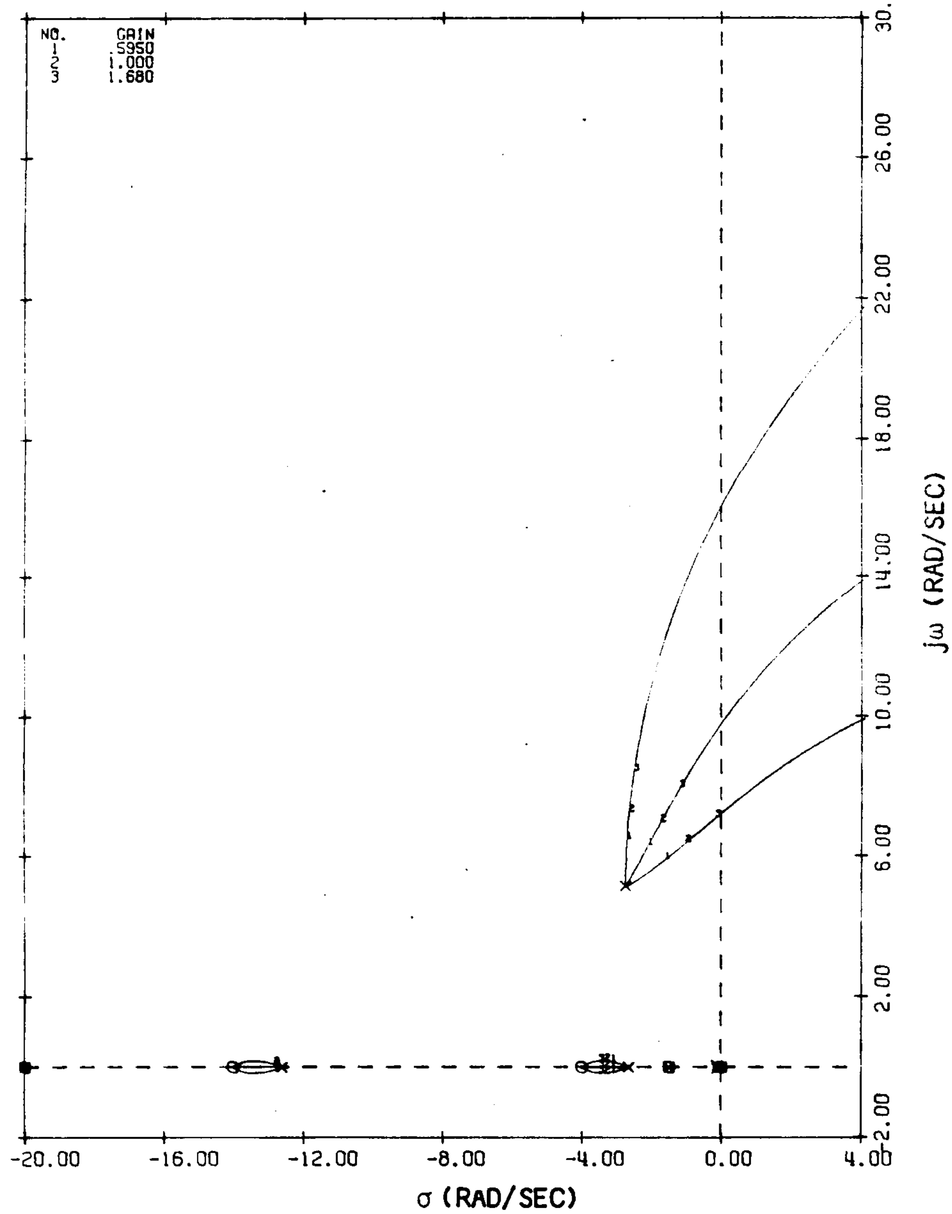


FIGURE 127

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

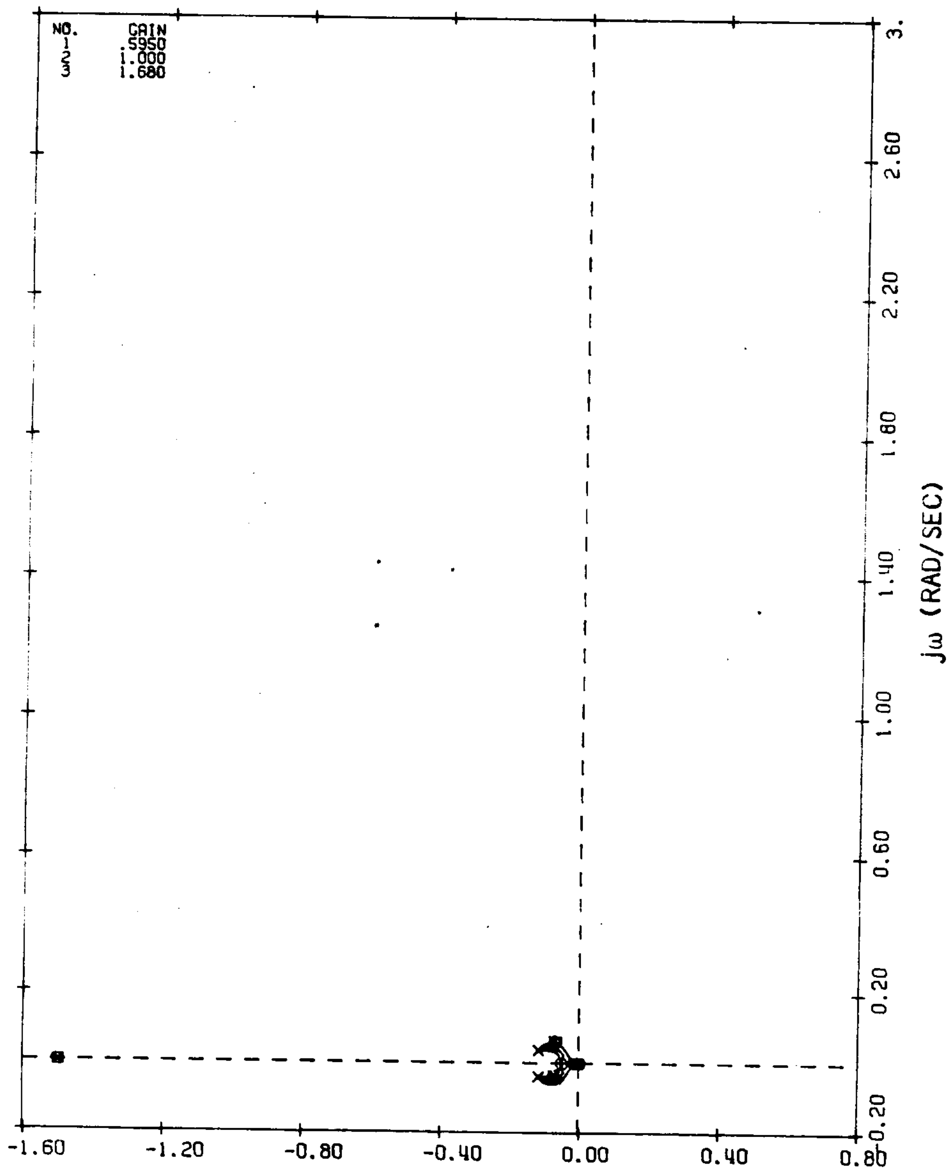


FIGURE 127 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

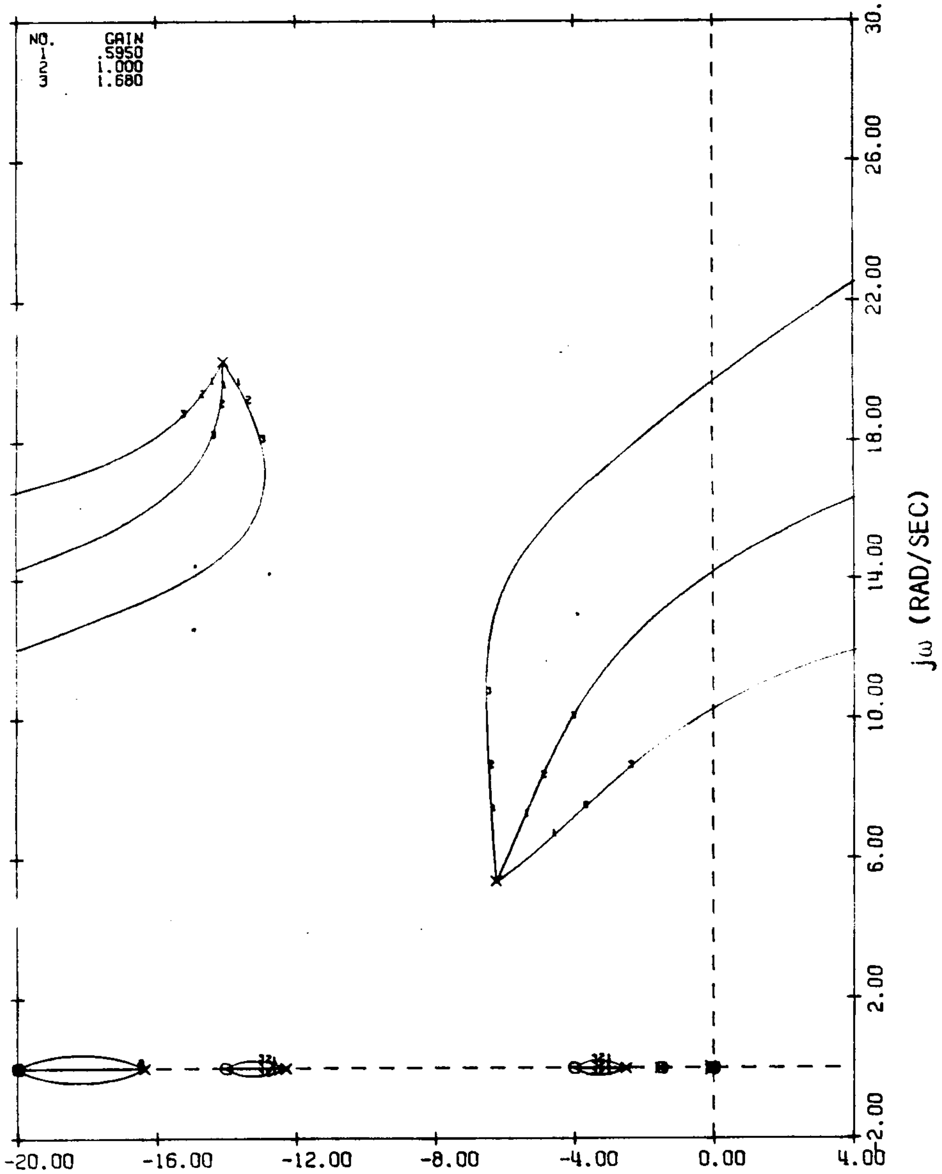


FIGURE 128

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

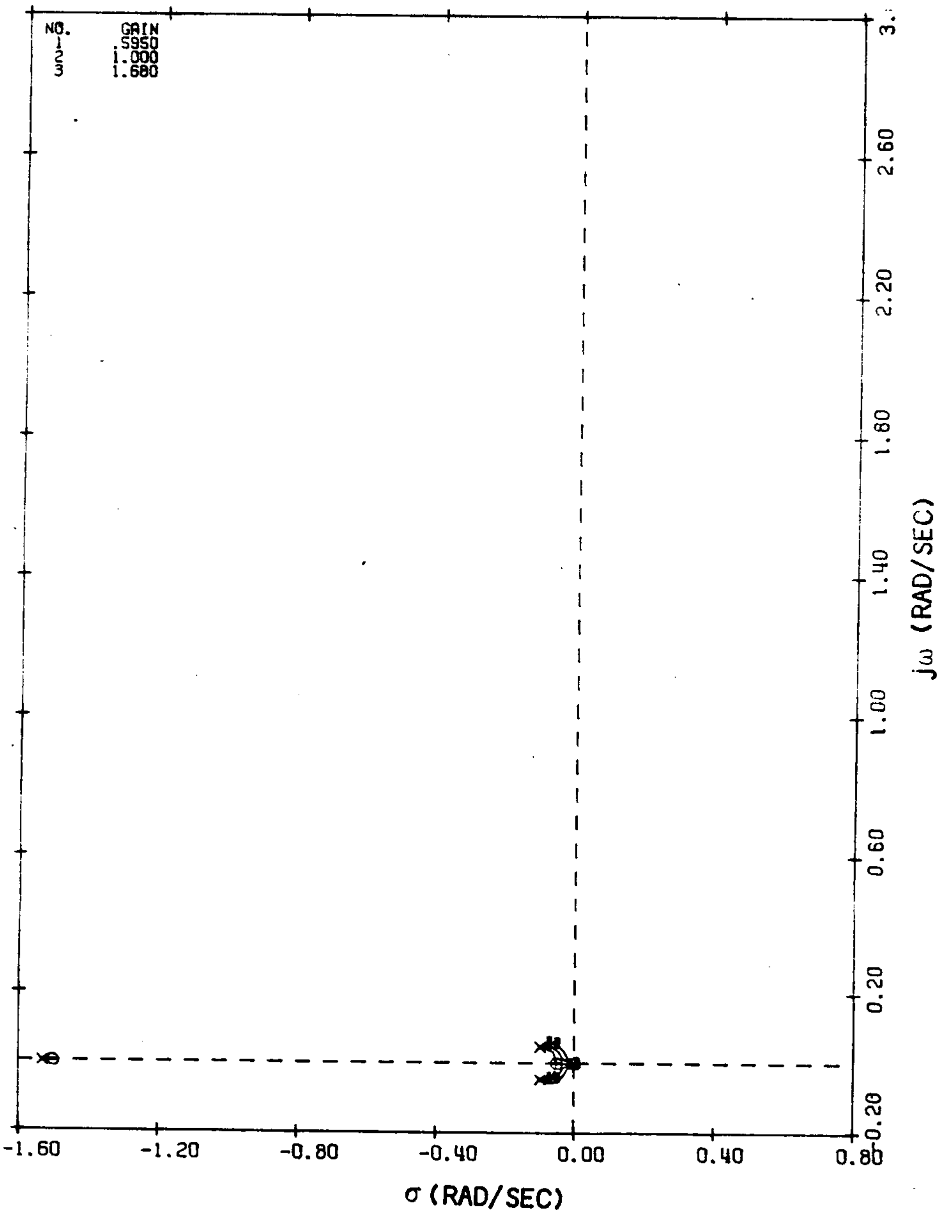


FIGURE 128 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

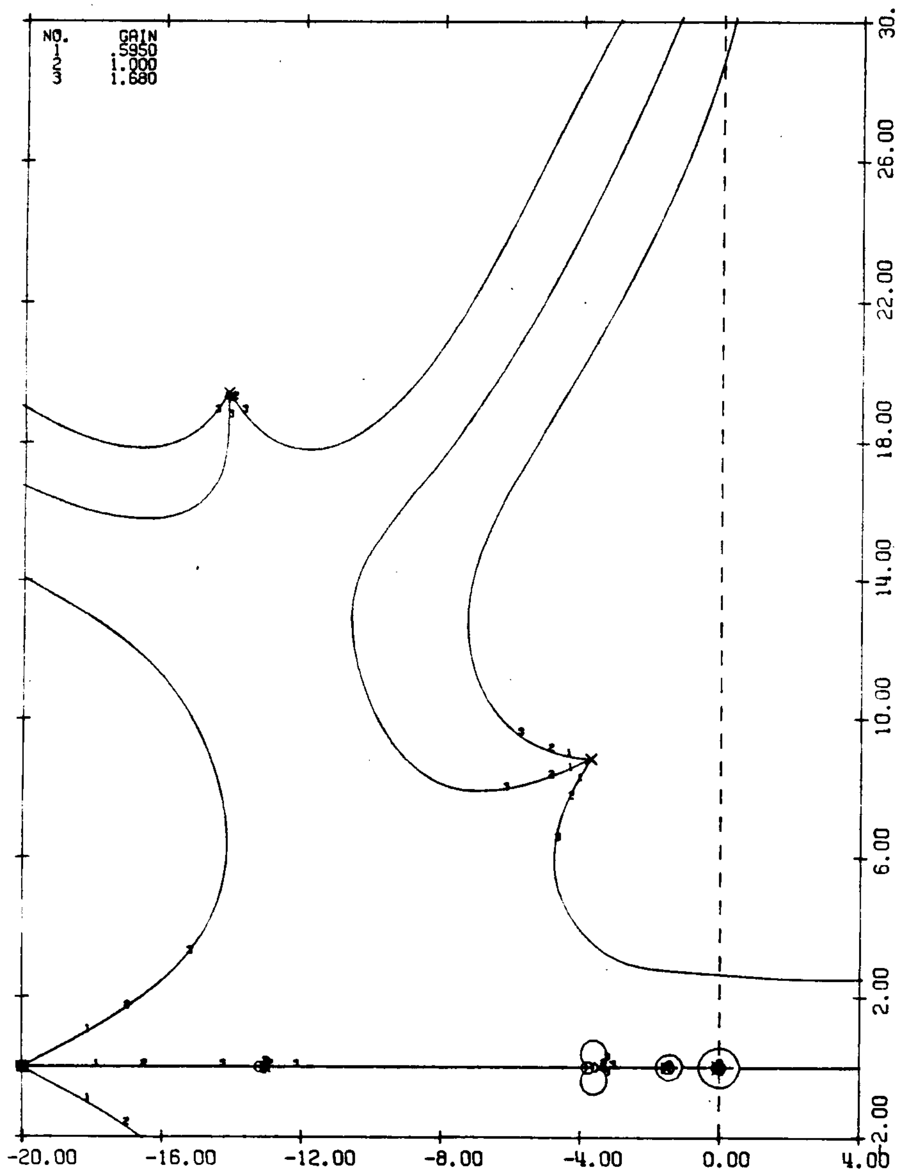


FIGURE 129

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

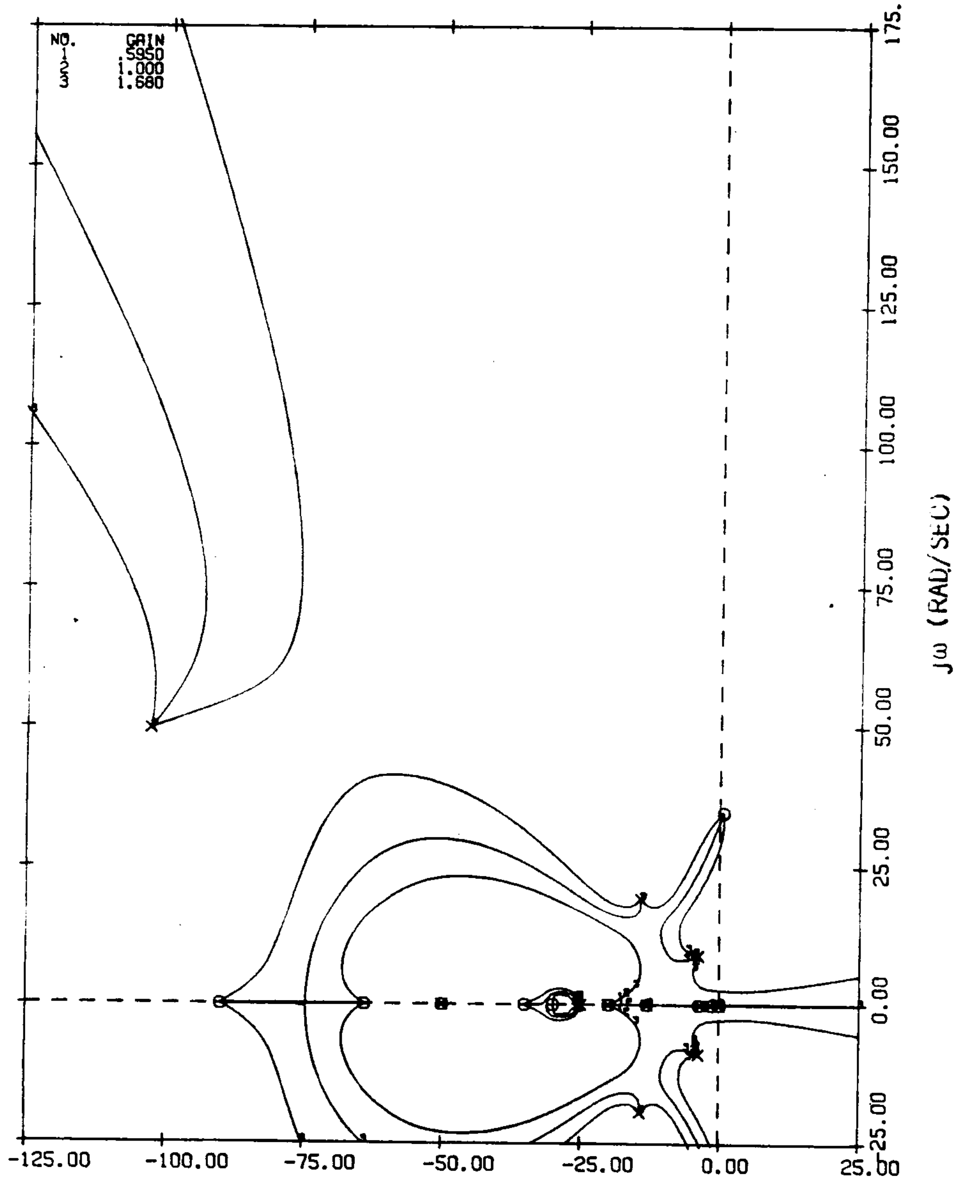


FIGURE 129 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

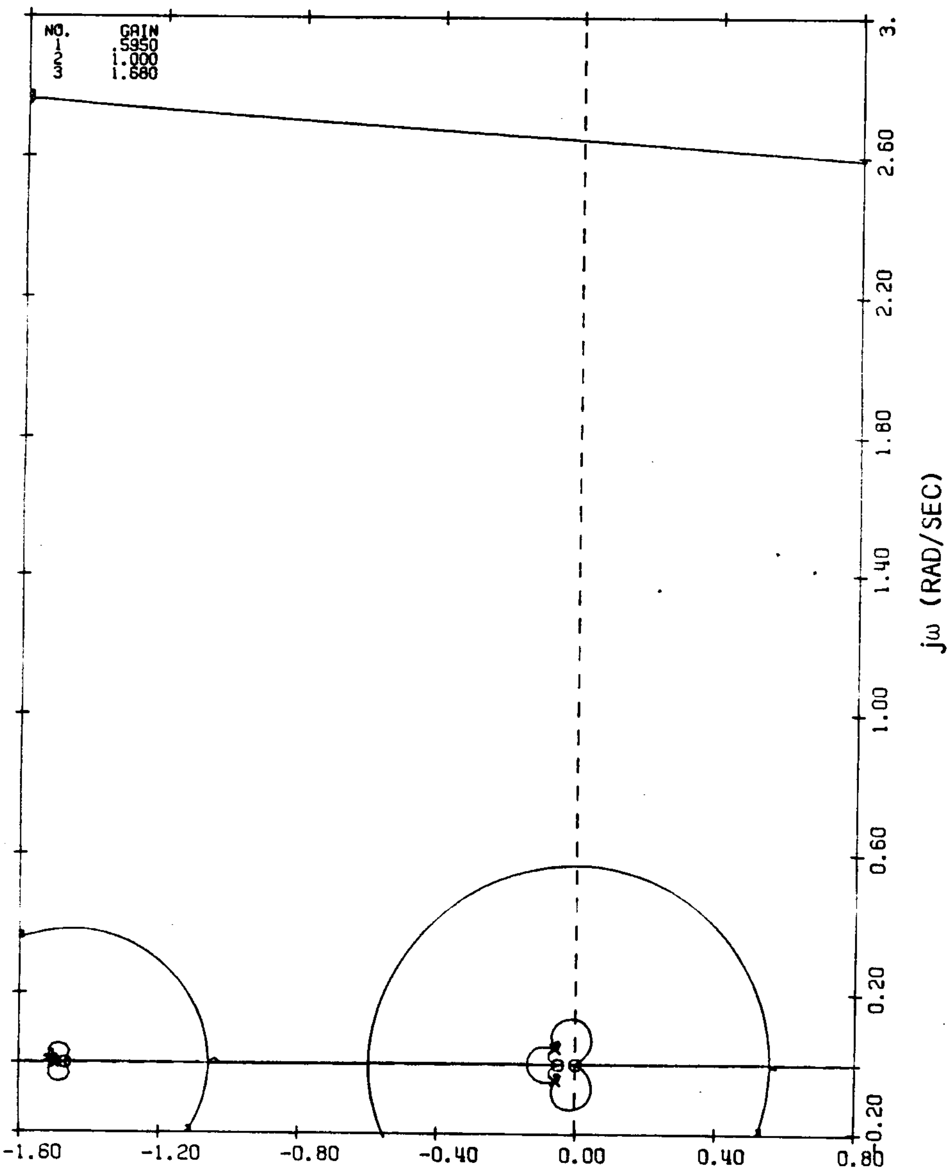


FIGURE 129 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

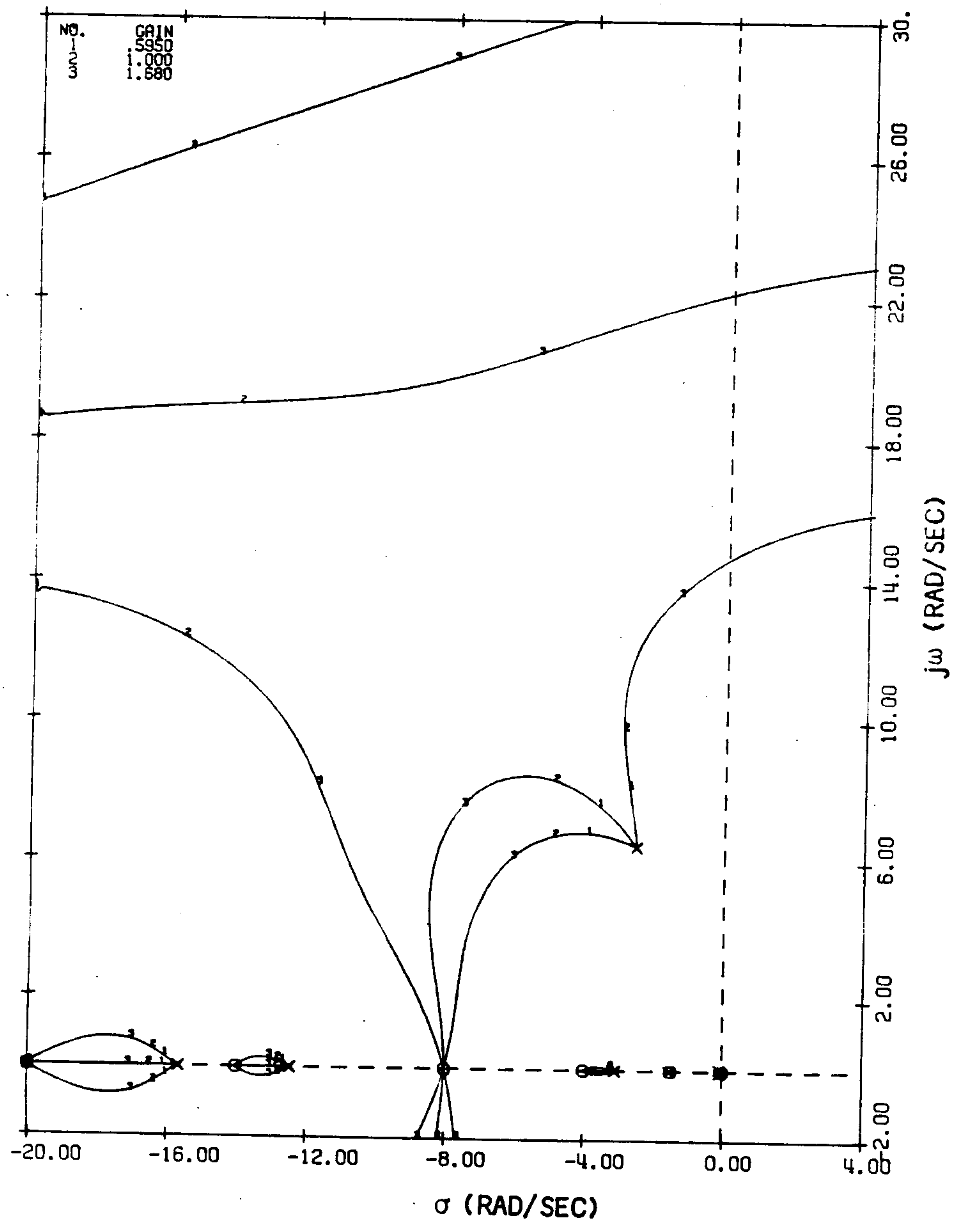


FIGURE 130

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

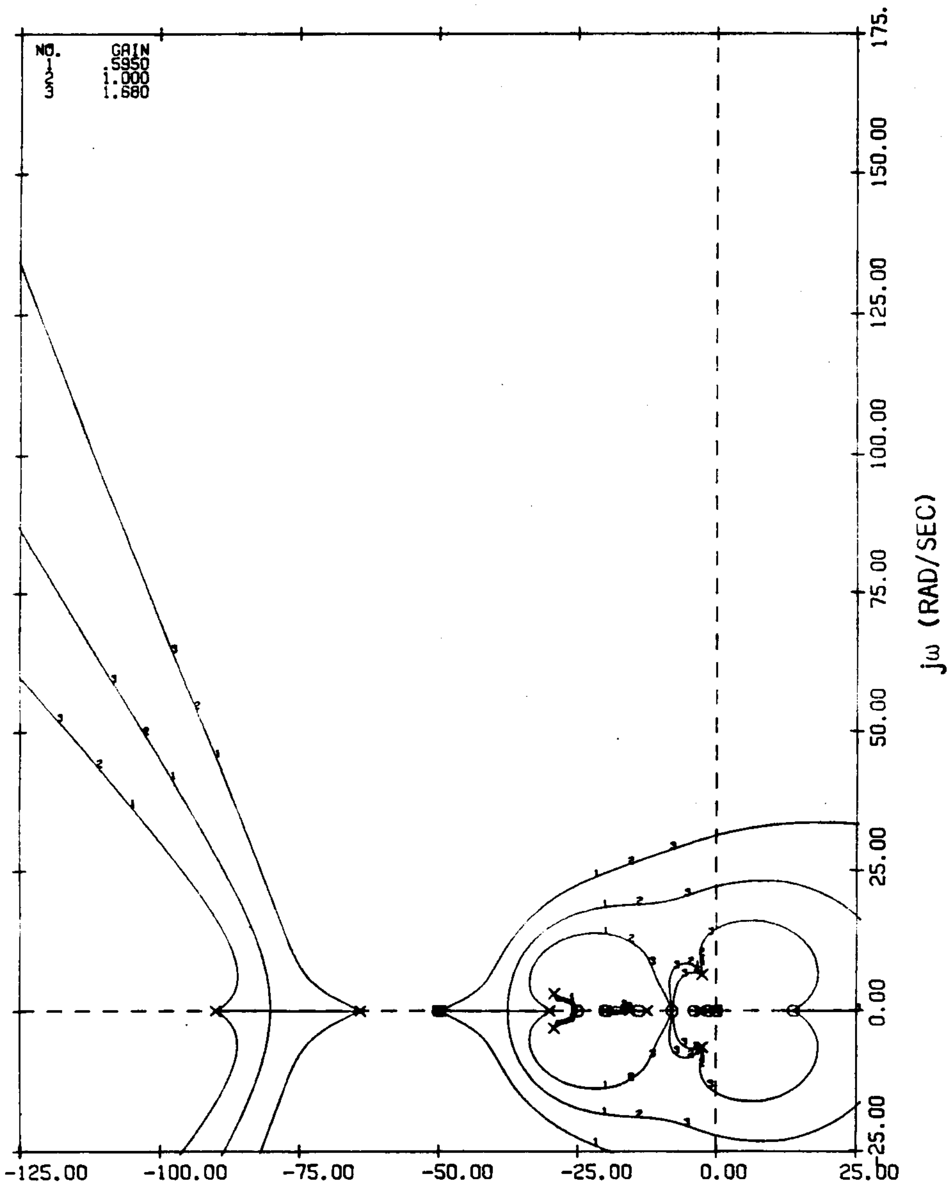


FIGURE 130 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

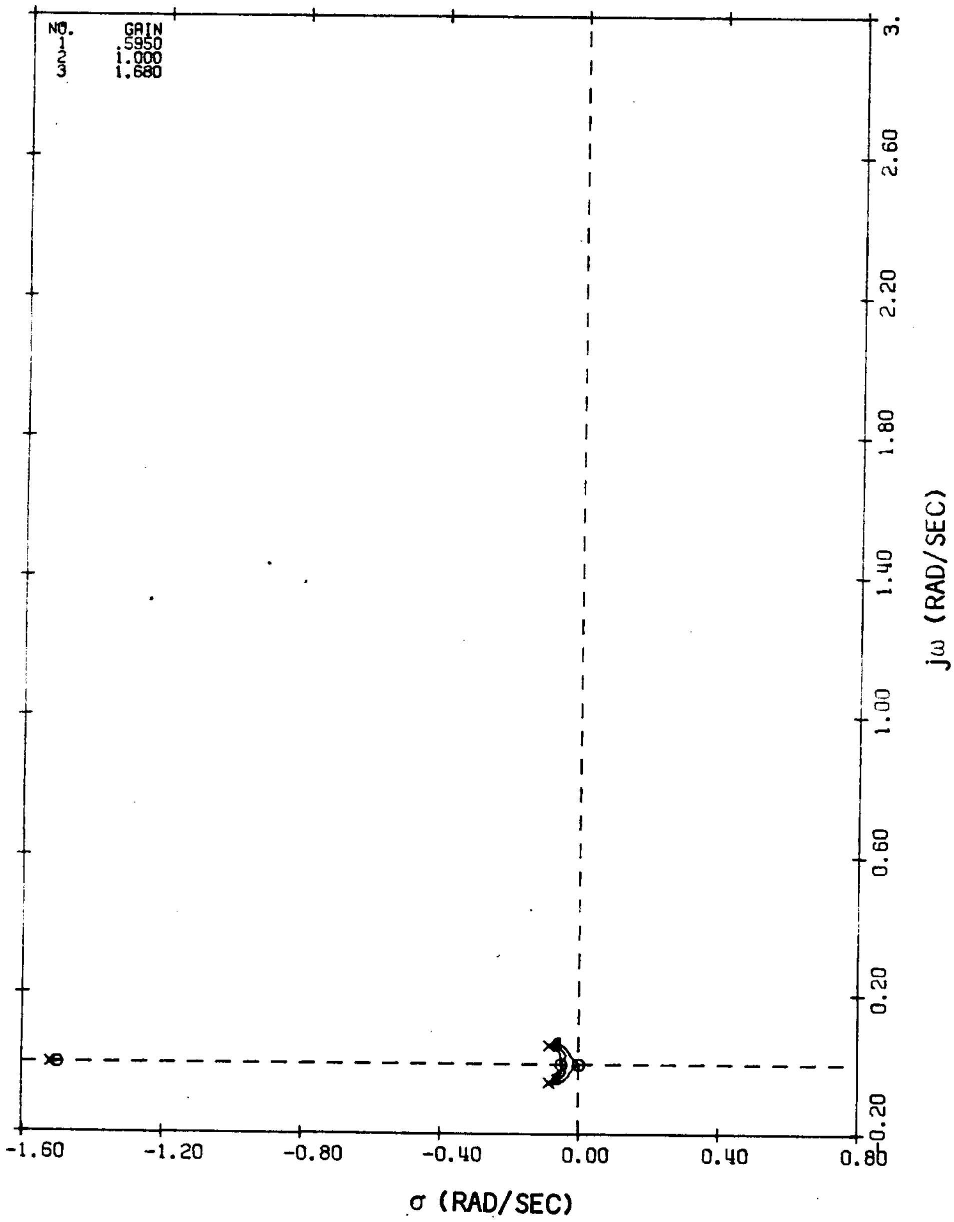


FIGURE 130 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

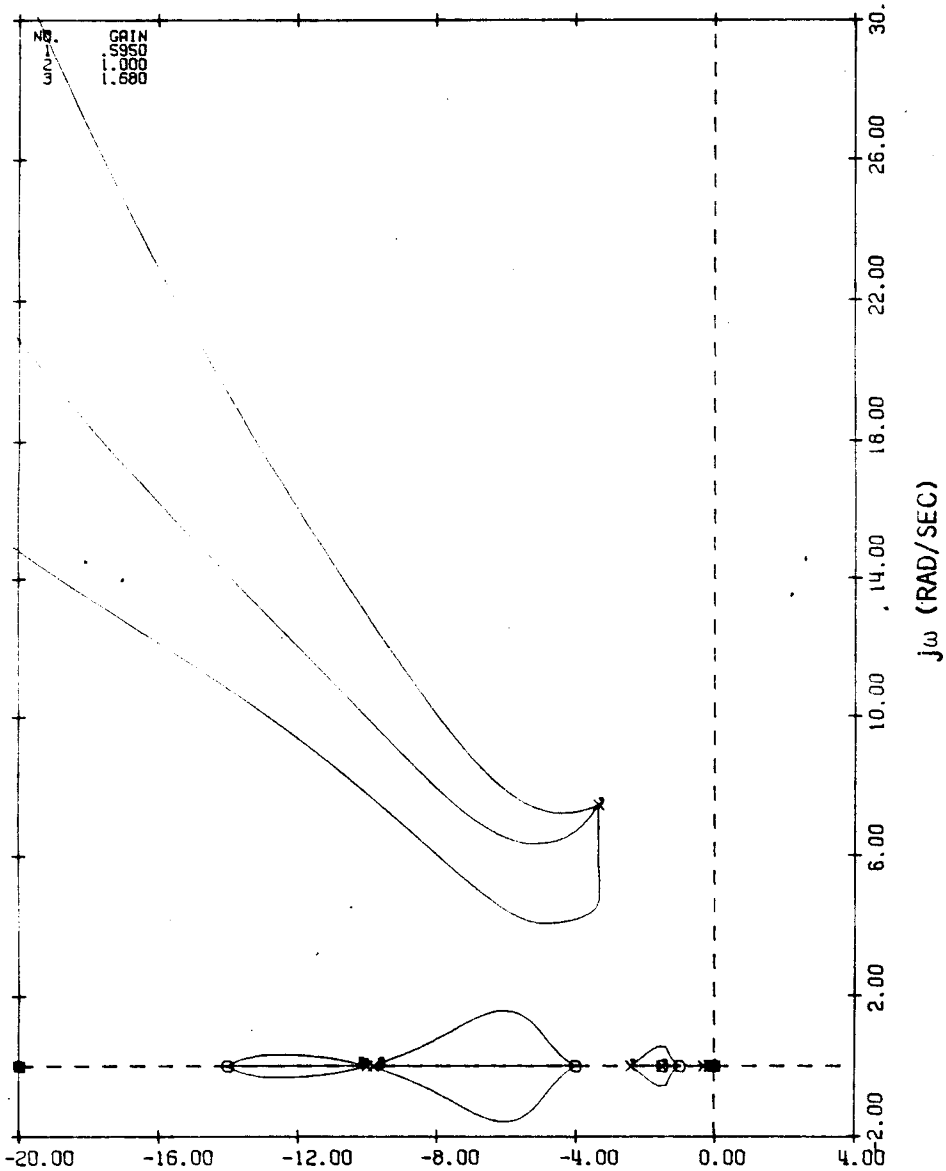


FIGURE 131

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

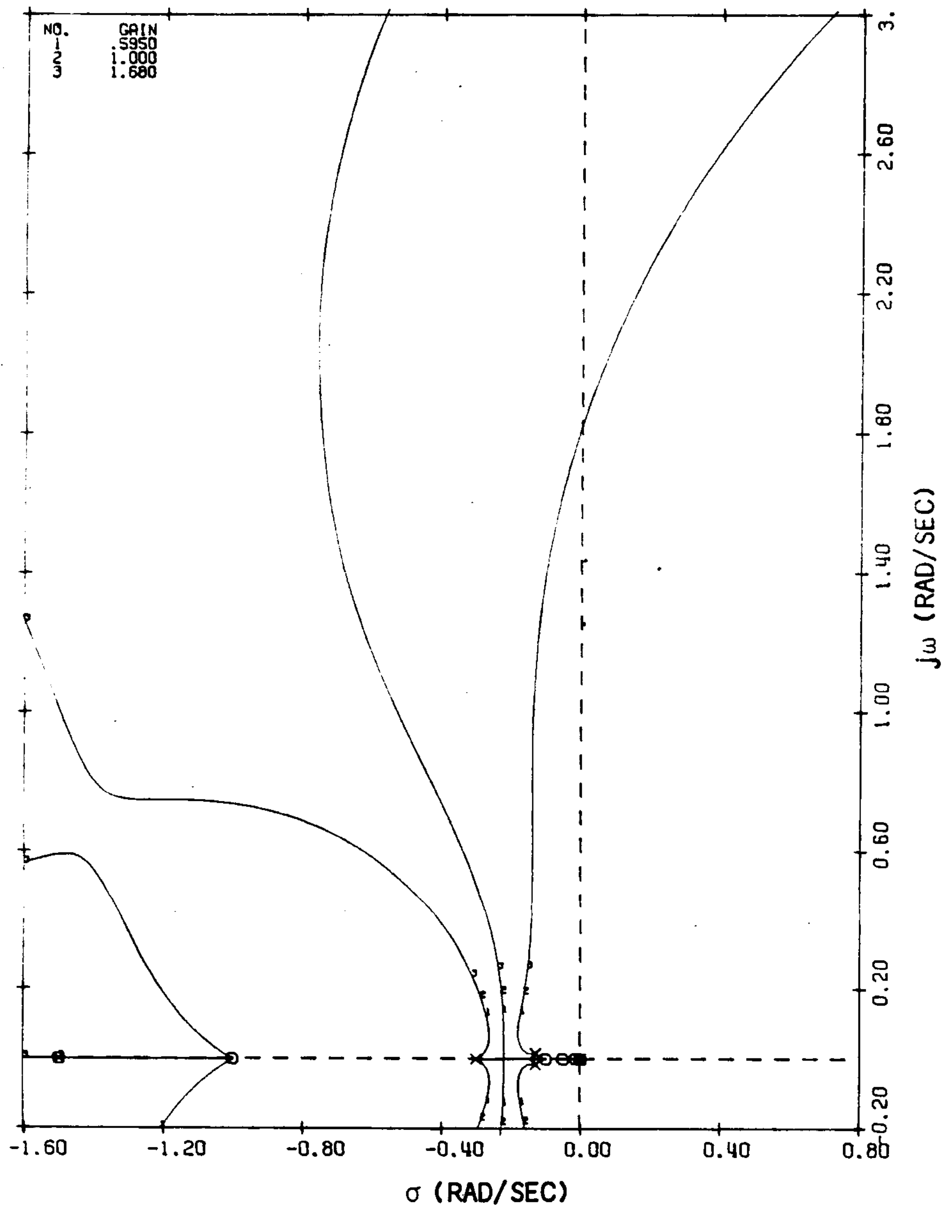


FIGURE 131 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. GLA TEST CONDITION

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

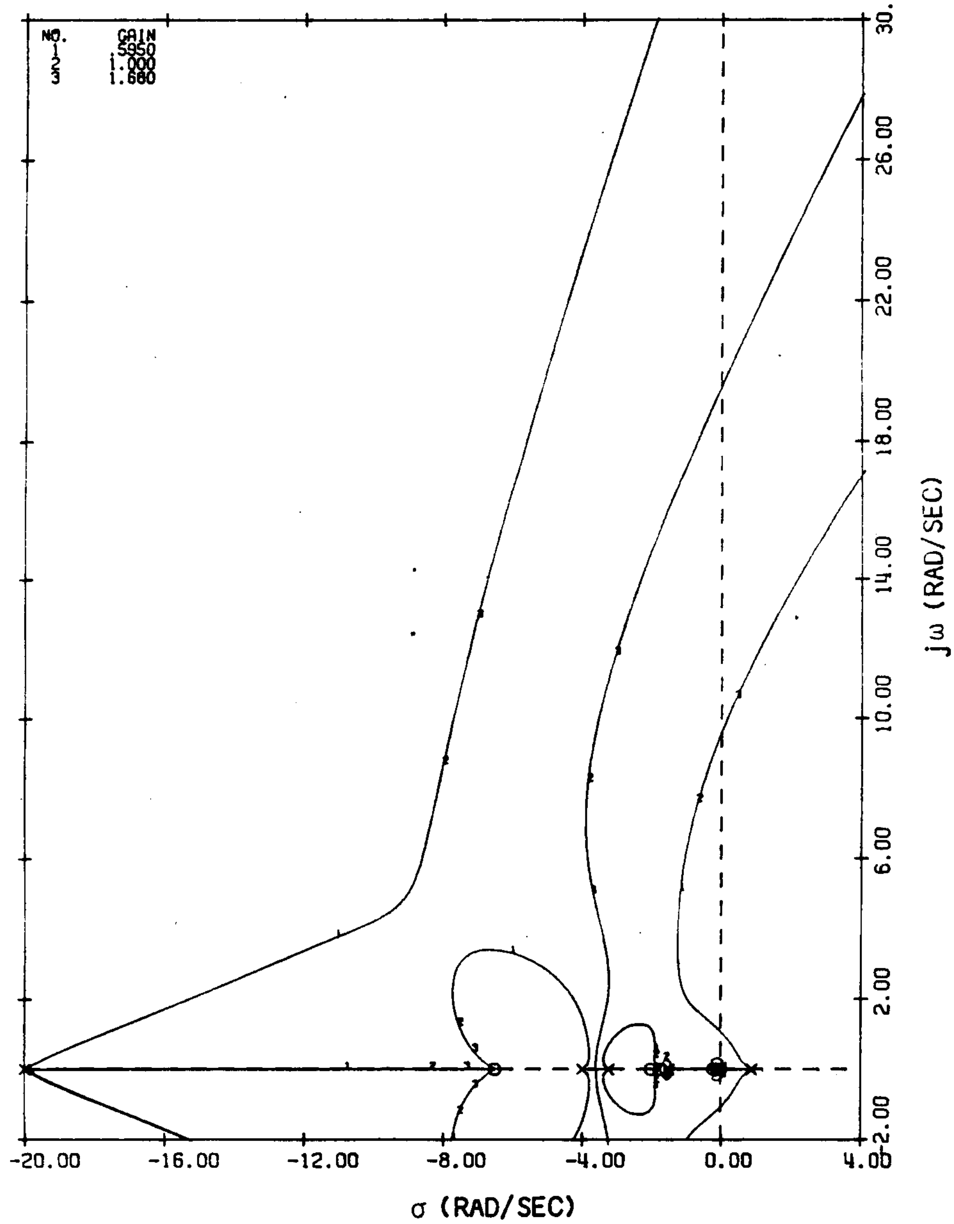


FIGURE 132

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- RSS
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

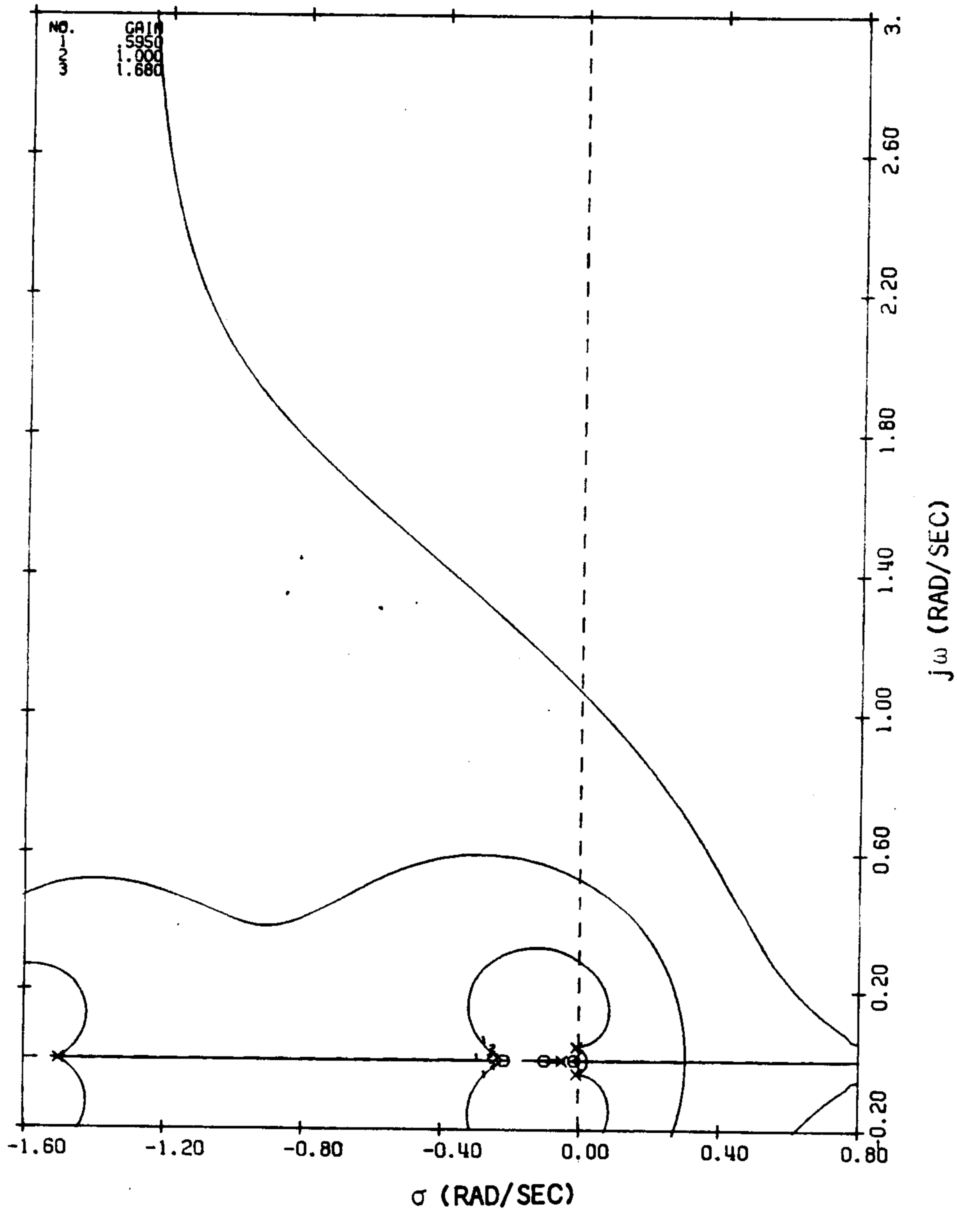


FIGURE 132 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

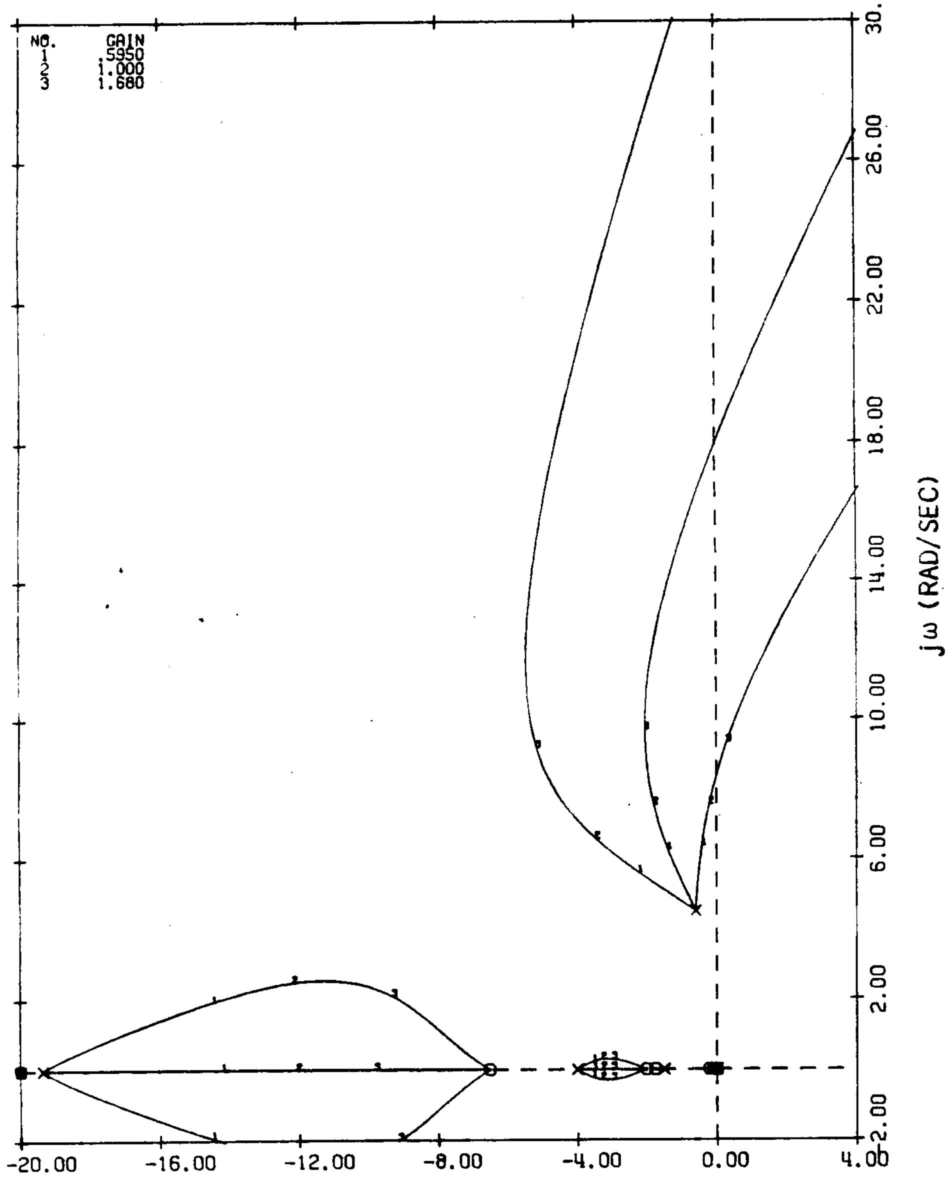


FIGURE 133

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

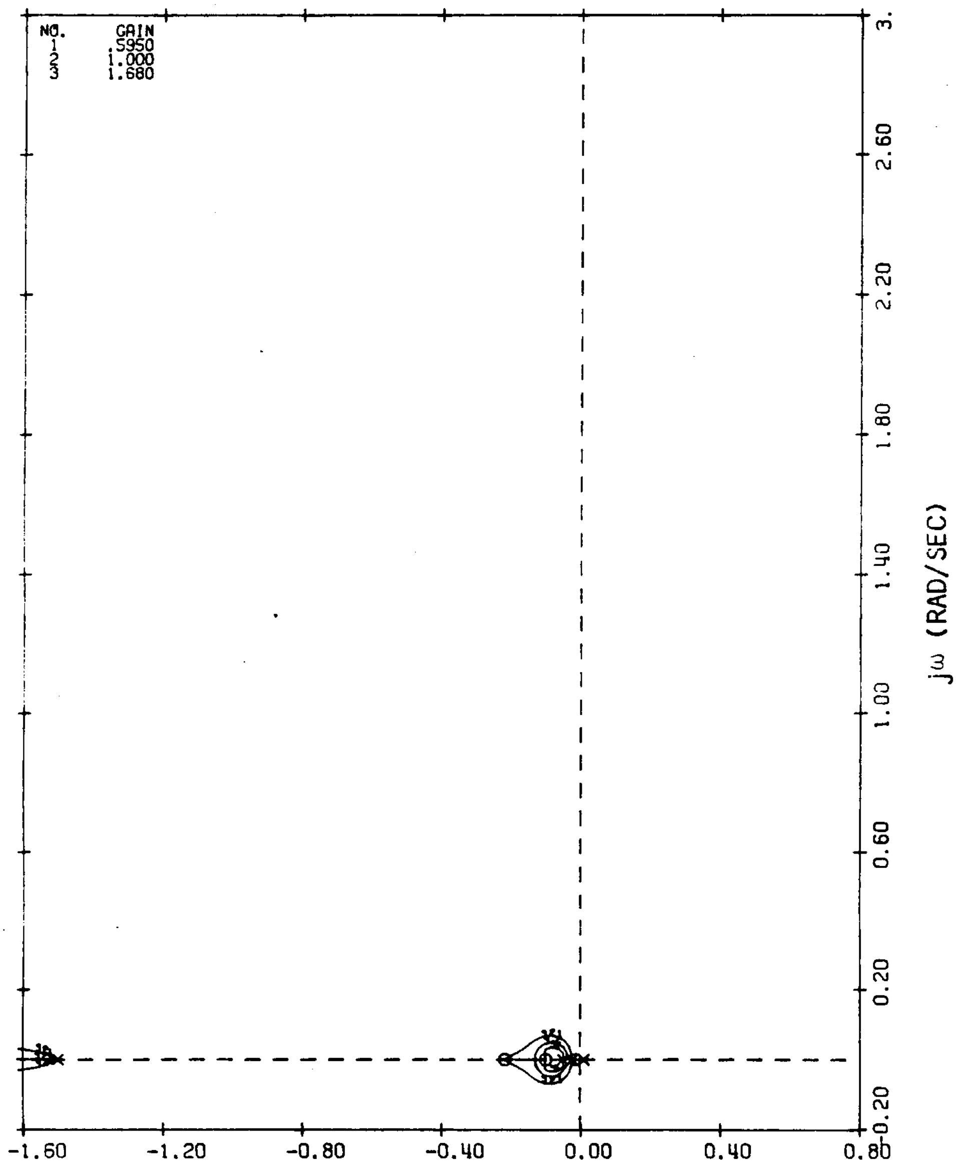


FIGURE 133 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

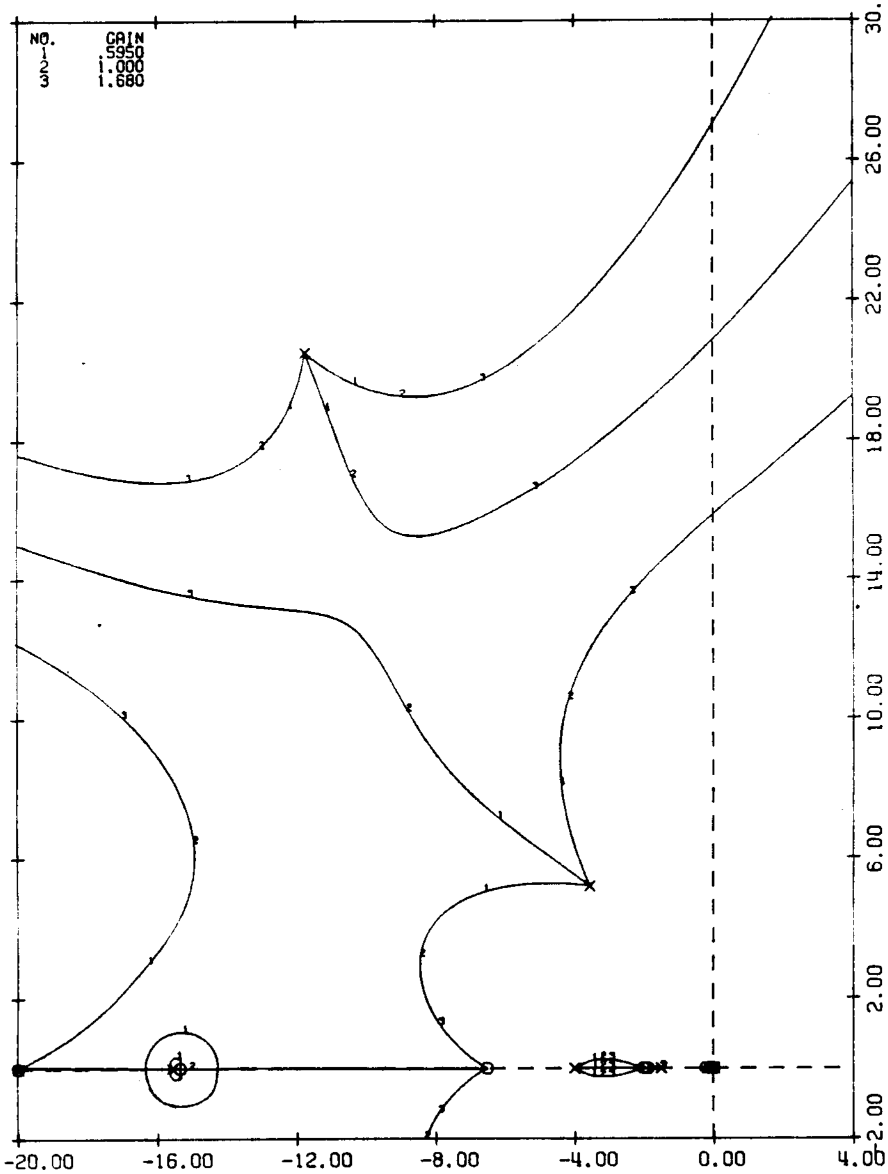


FIGURE 134

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

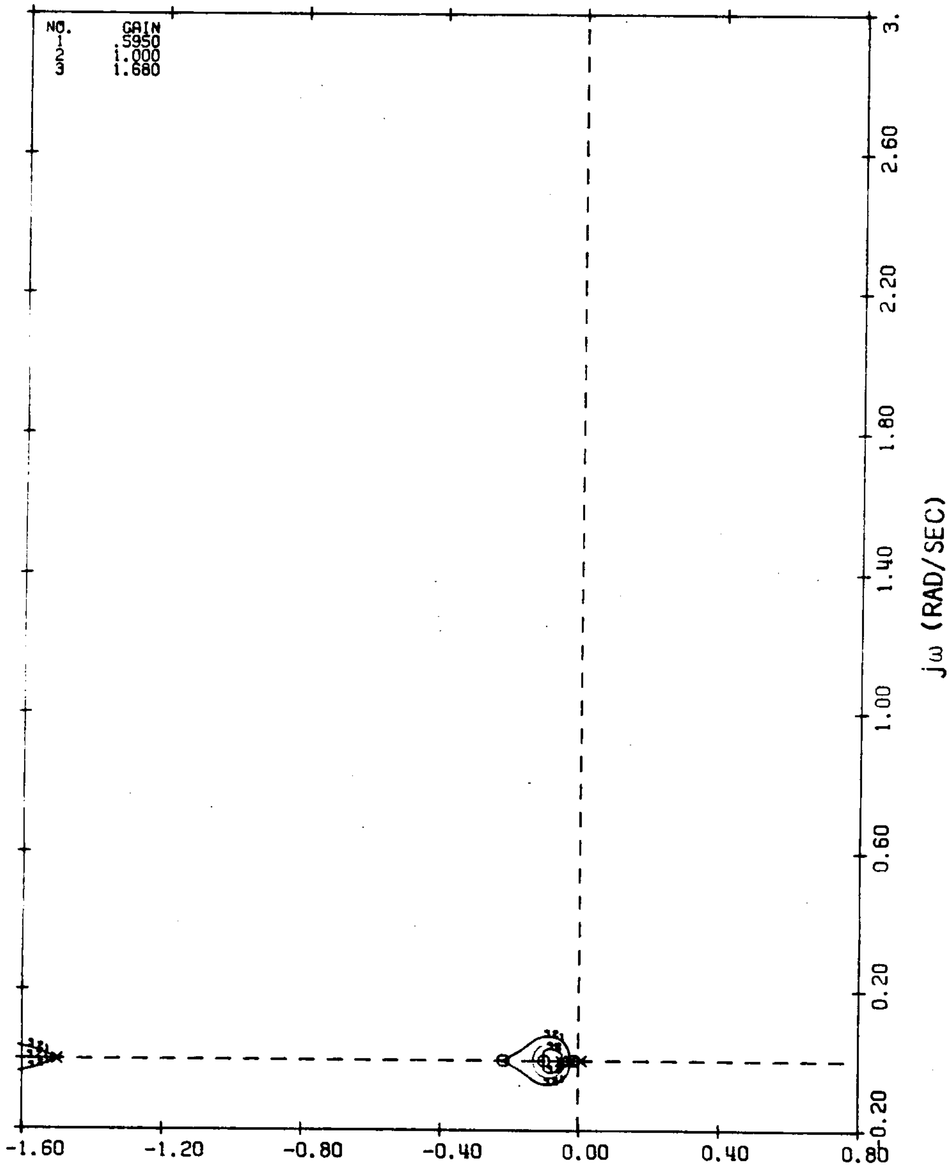


FIGURE 134 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

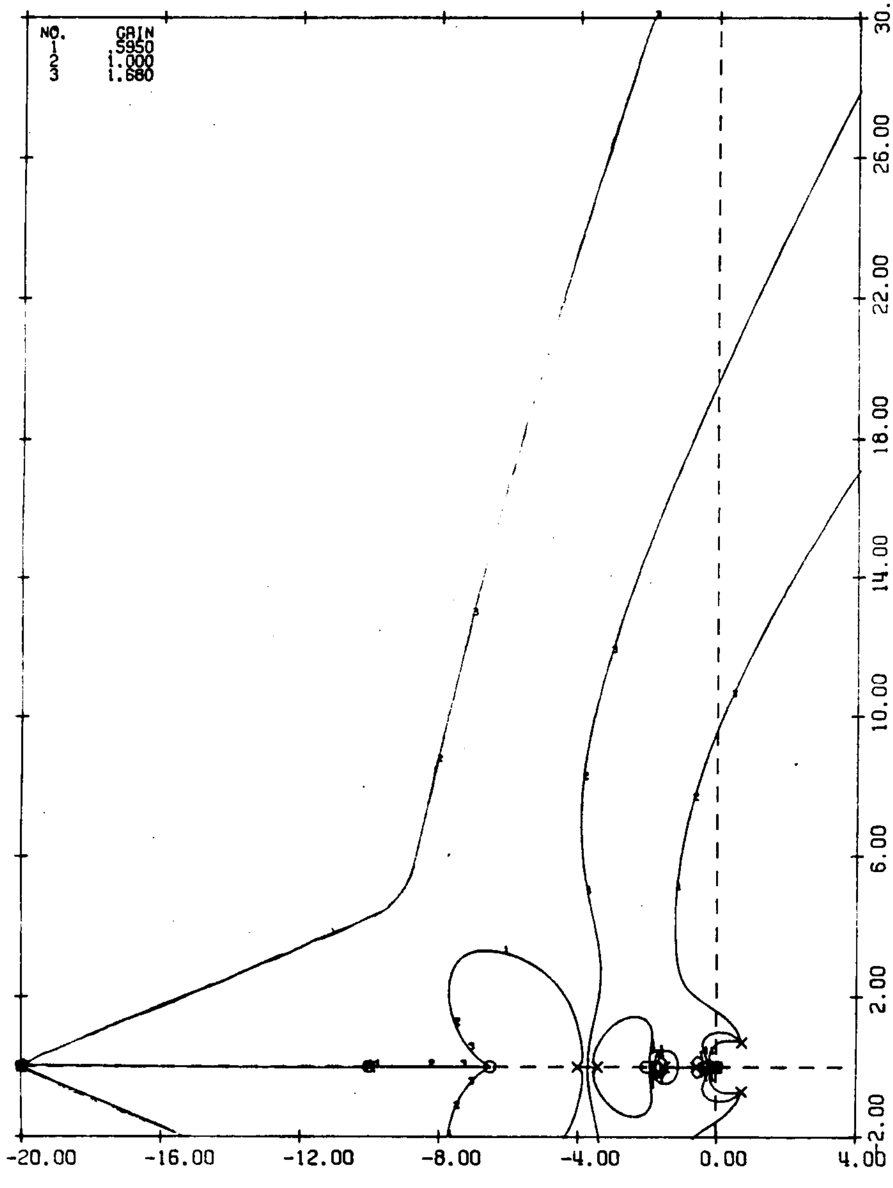


FIGURE 135

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

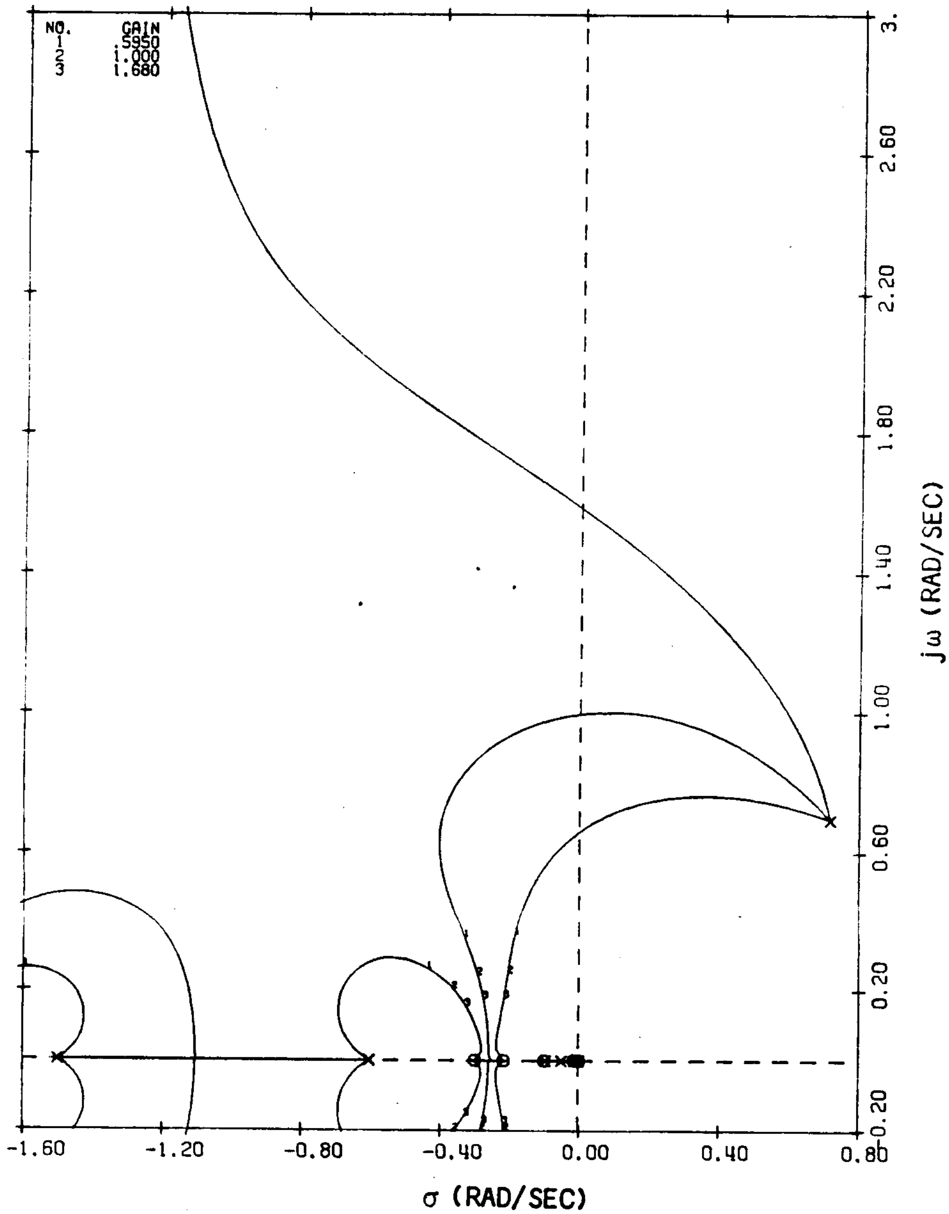


FIGURE 135 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

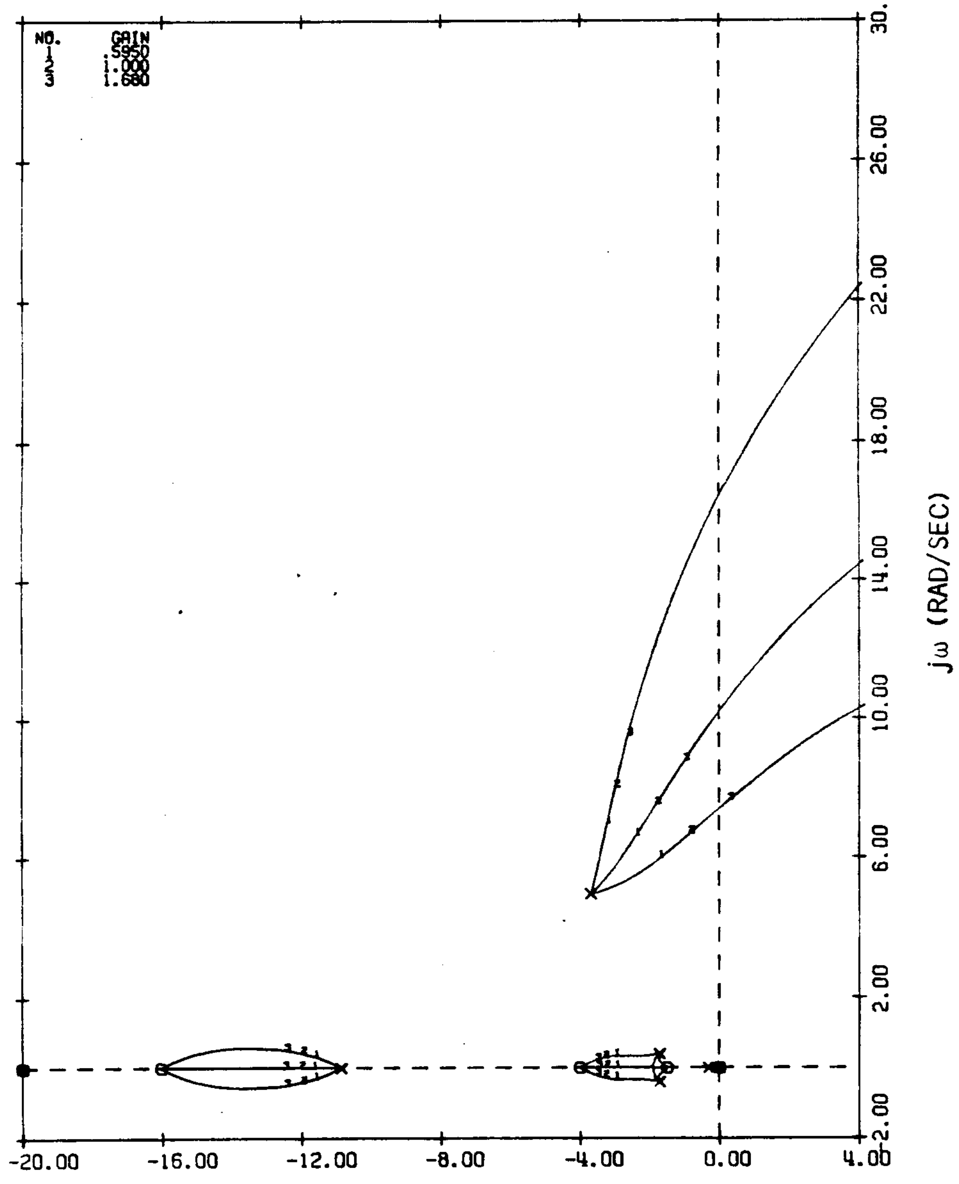


FIGURE 136

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

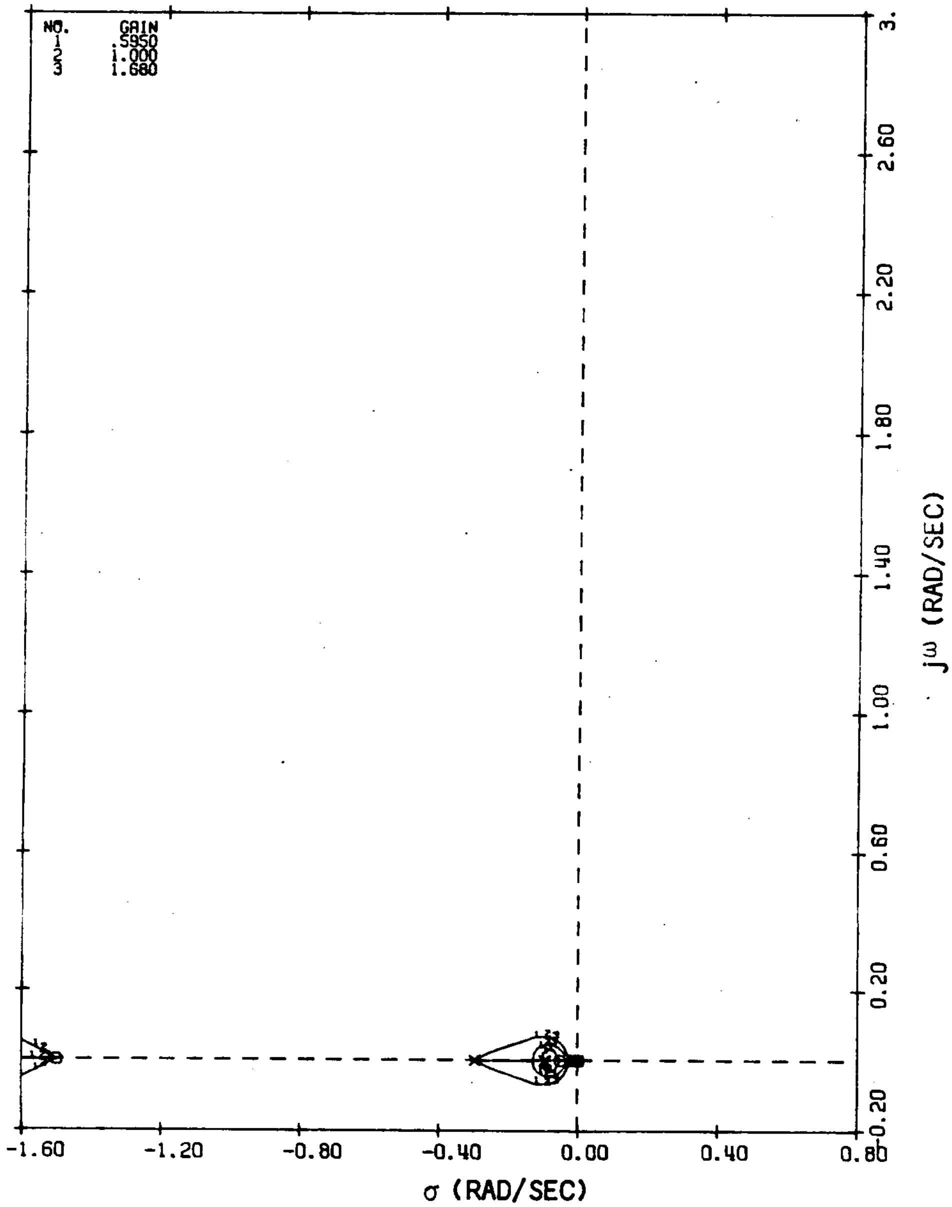


FIGURE 136 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

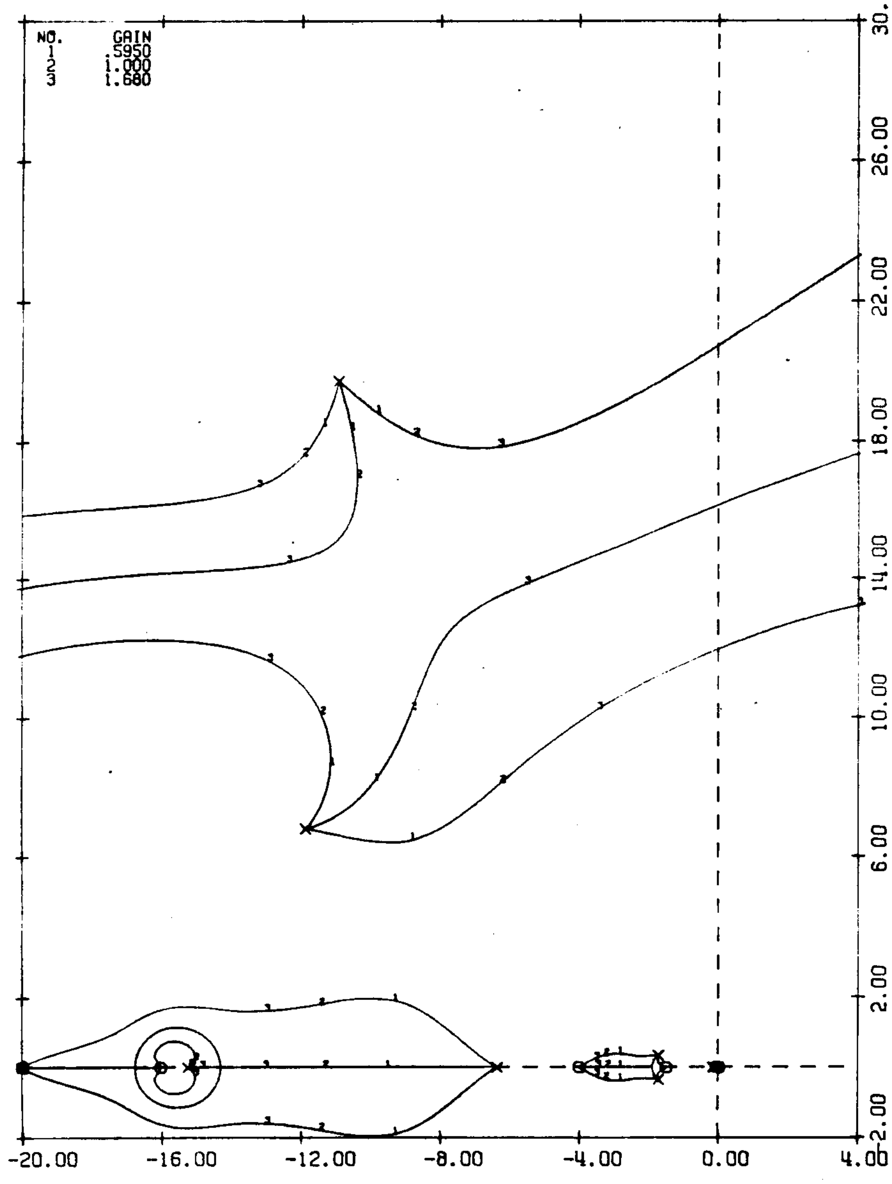


FIGURE 137

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

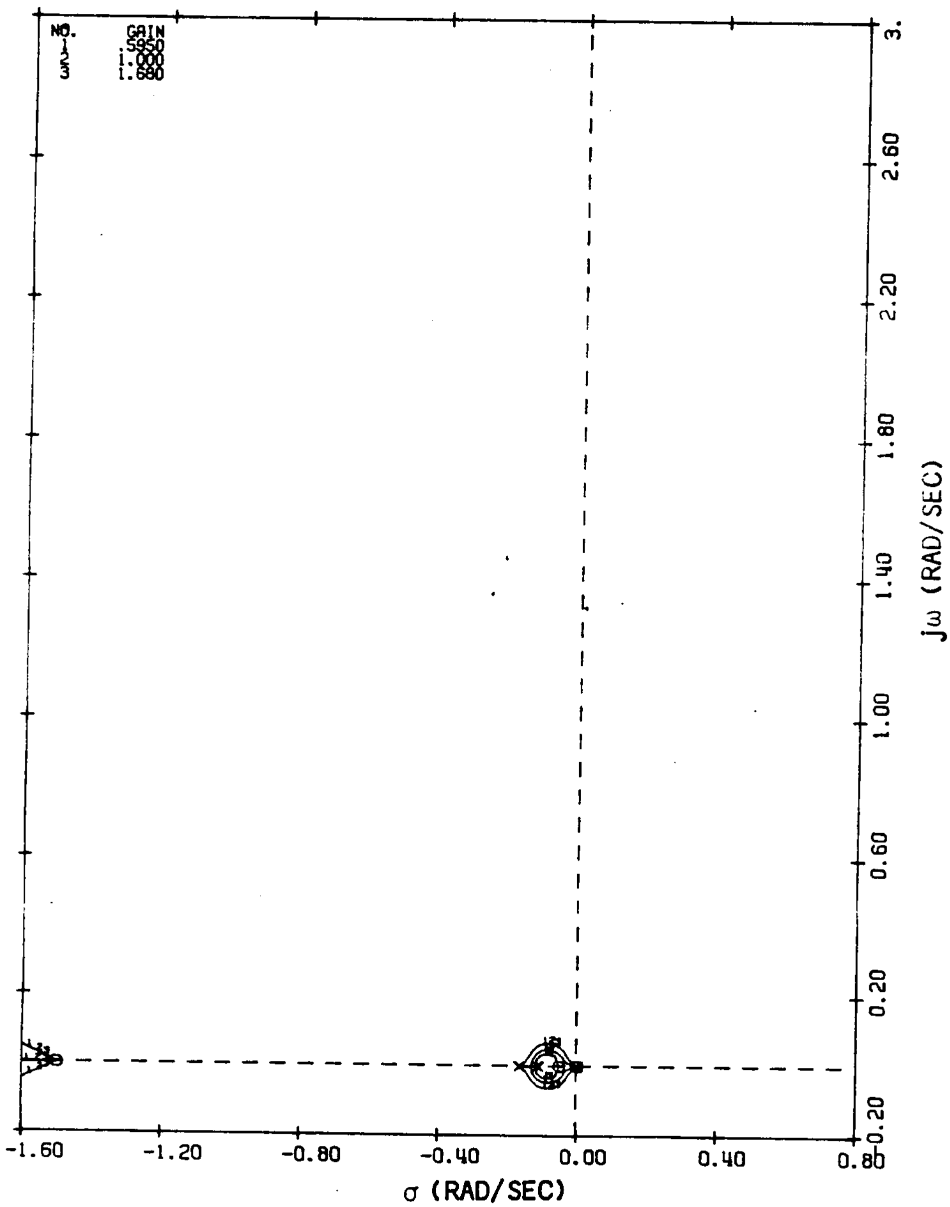


FIGURE 137 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

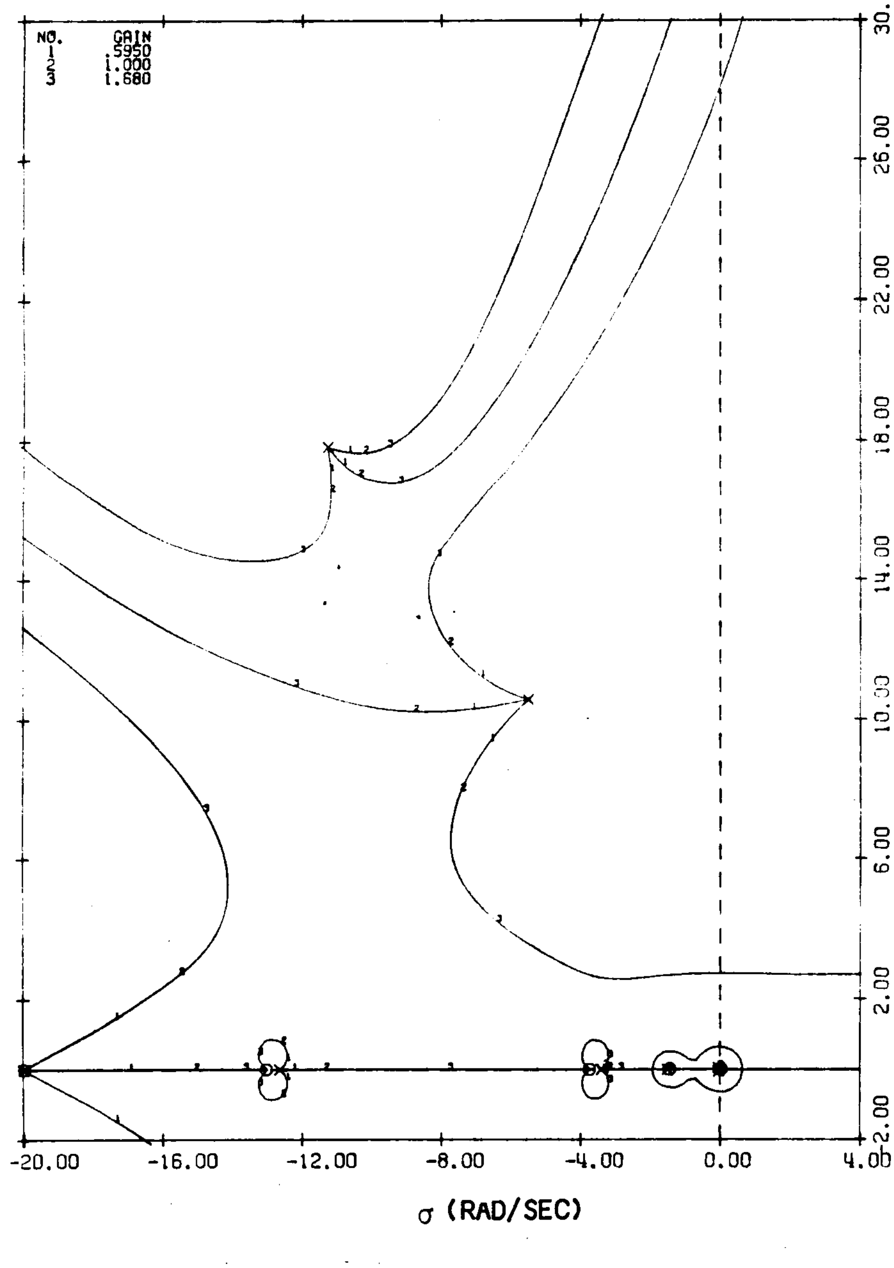


FIGURE 138

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

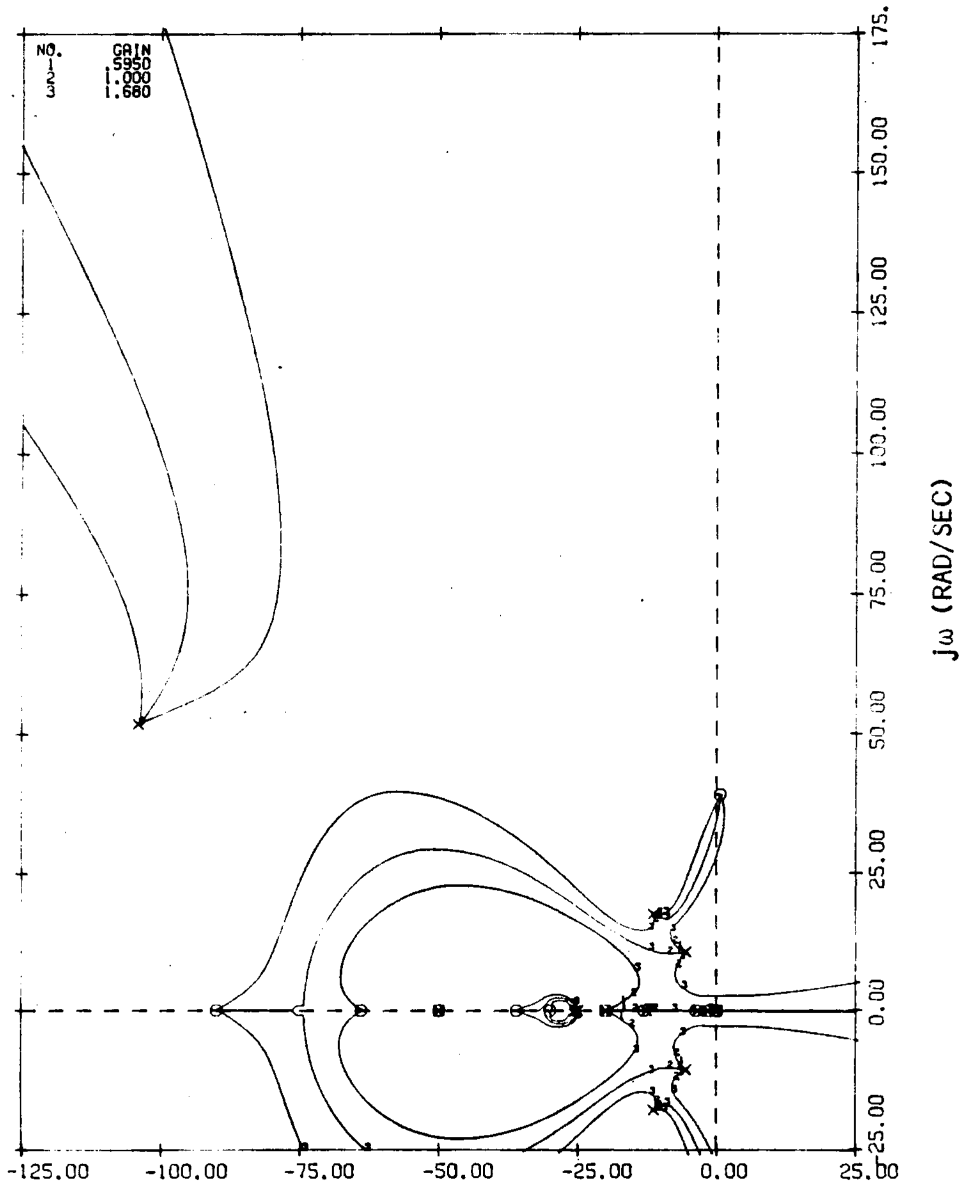


FIGURE 138 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

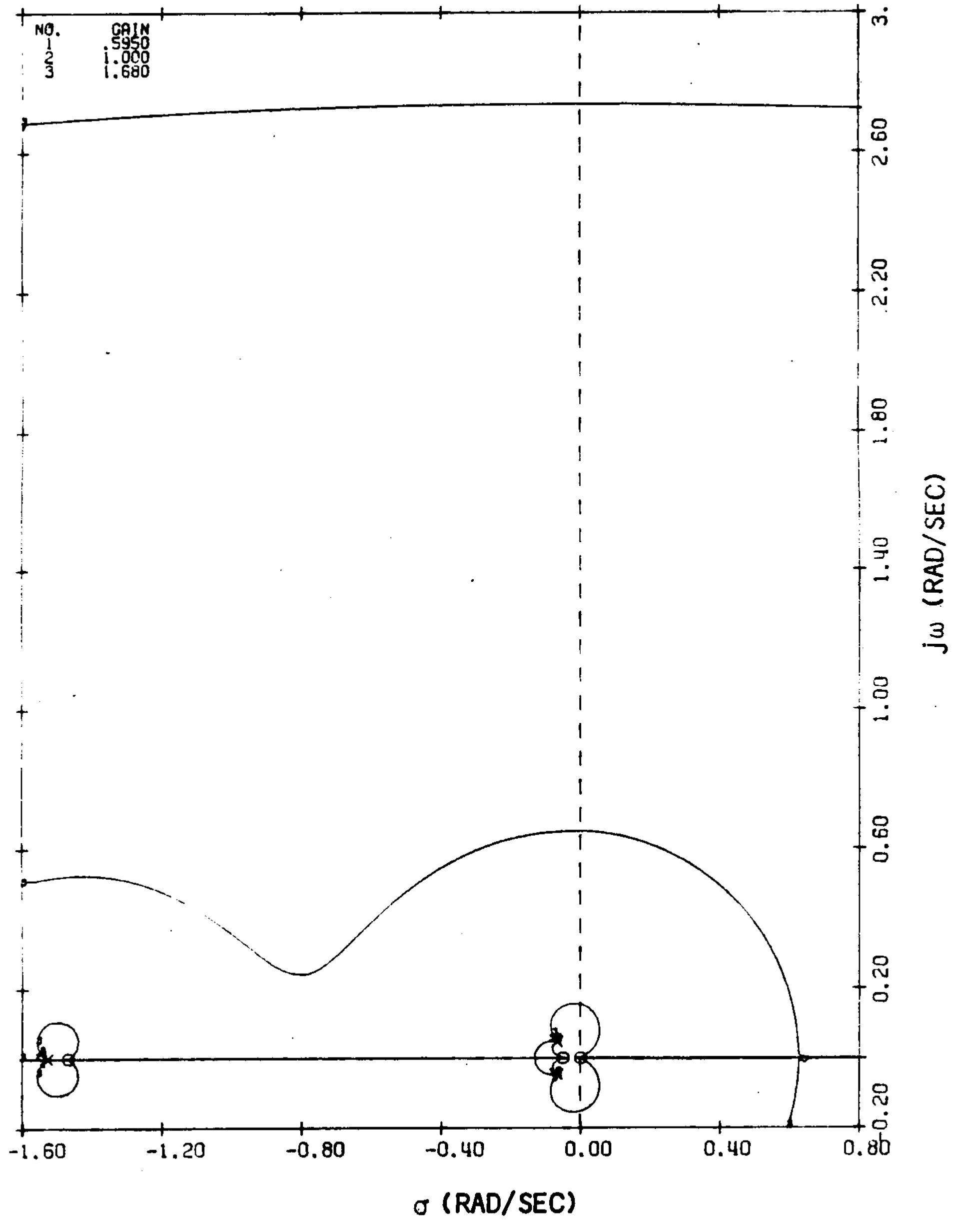


FIGURE 138 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

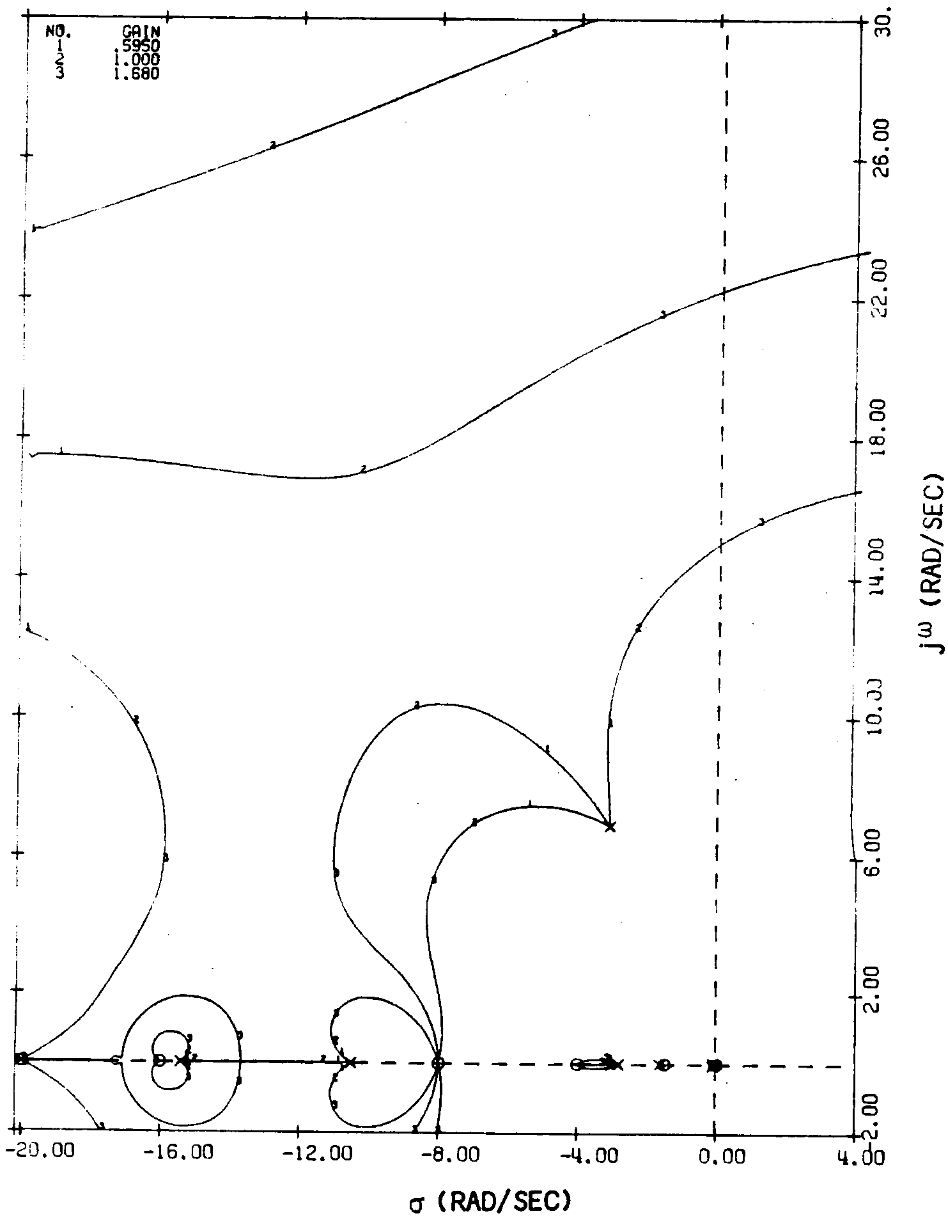


FIGURE 139

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

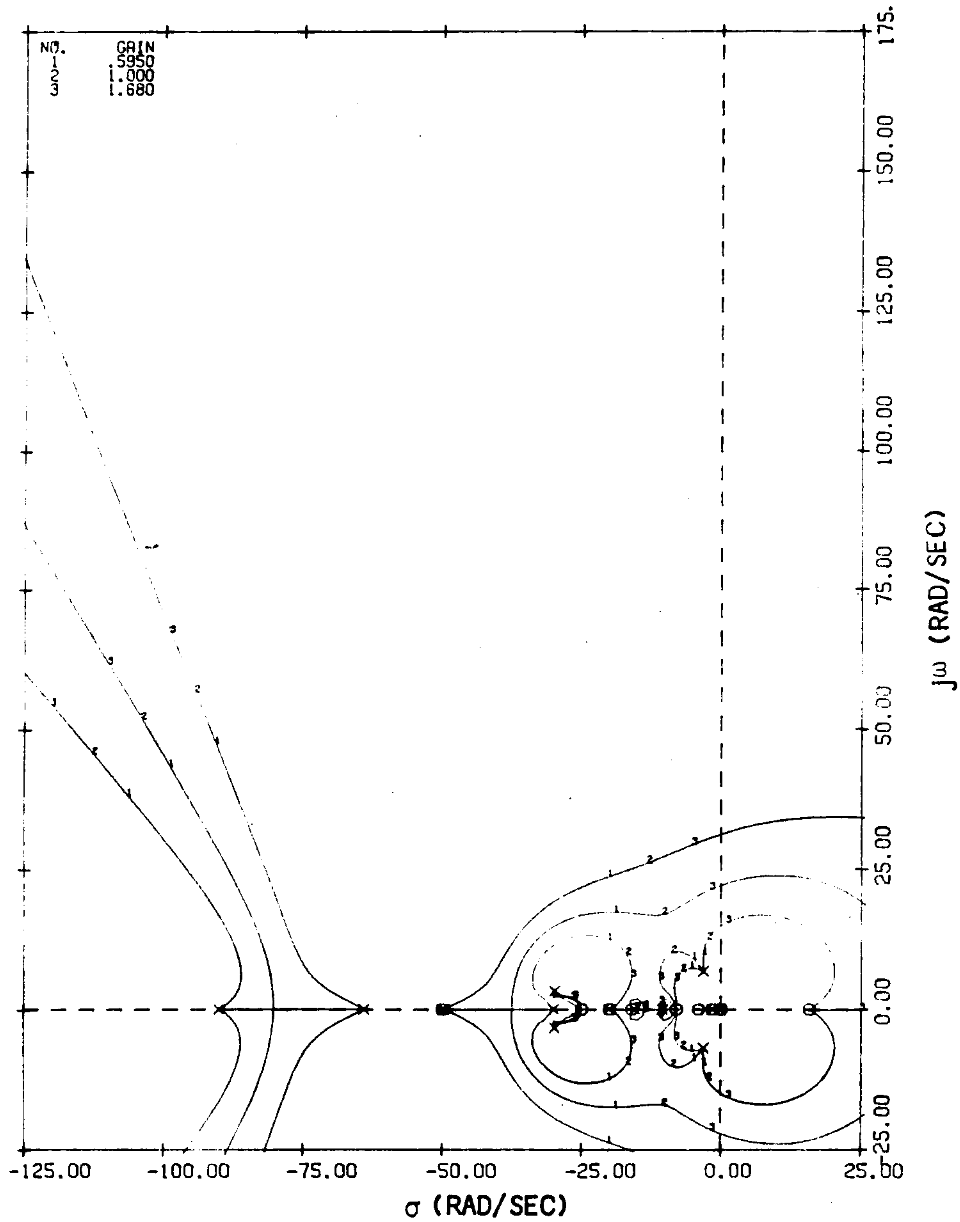


FIGURE 139 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

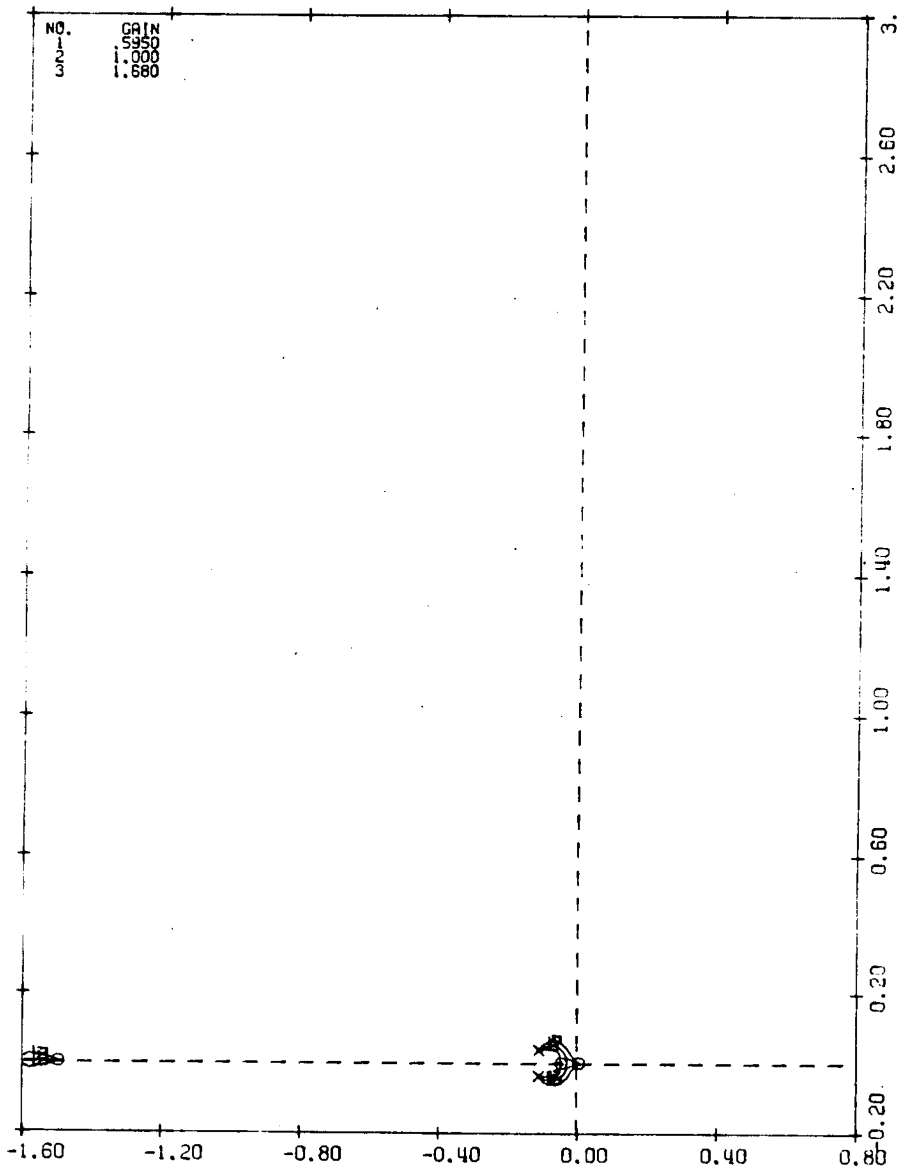


FIGURE 139 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. GLA TEST CONDITION

APPENDIX E

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

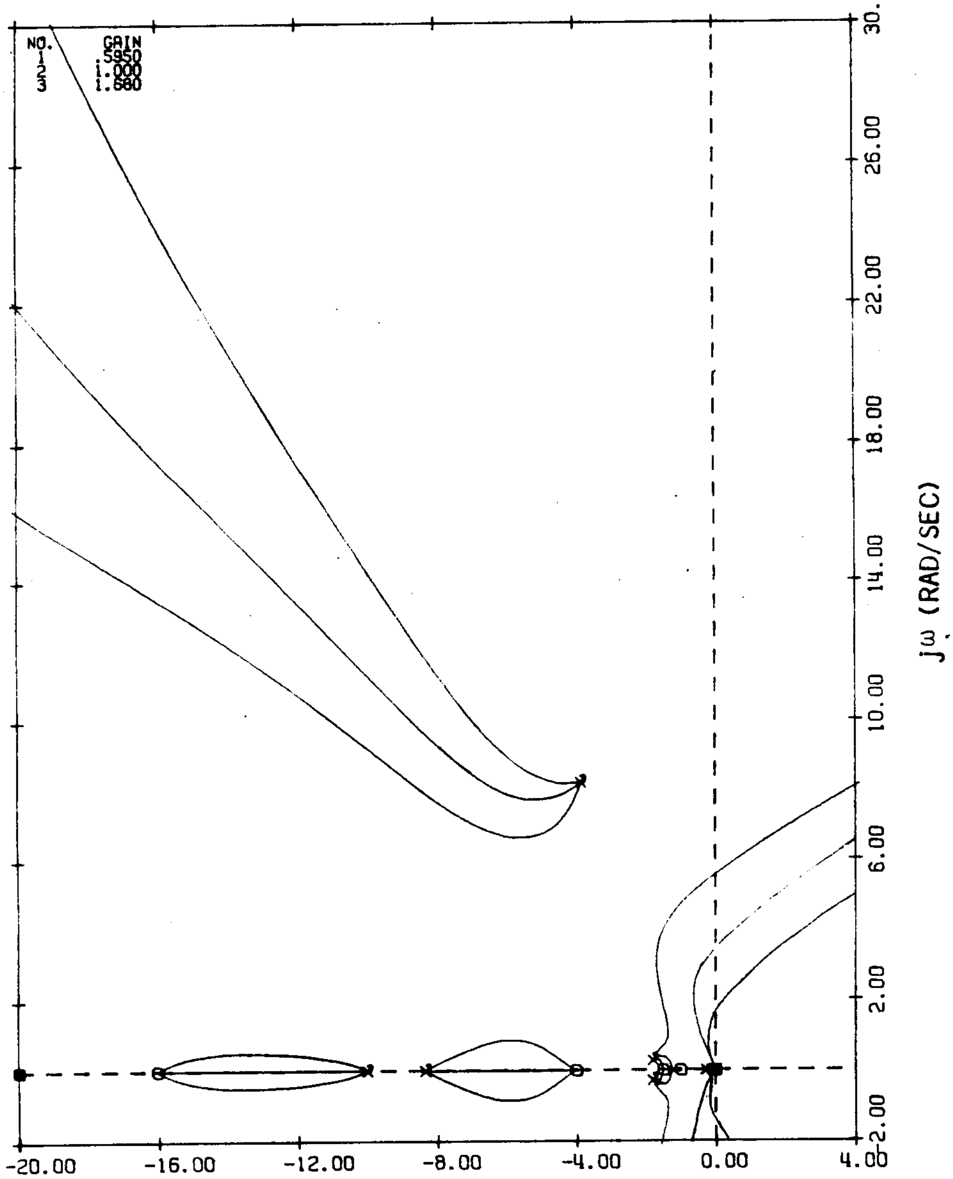


FIGURE 140

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION

ORIGINAL PAGE IS
OF POOR QUALITY

- GLA TEST
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

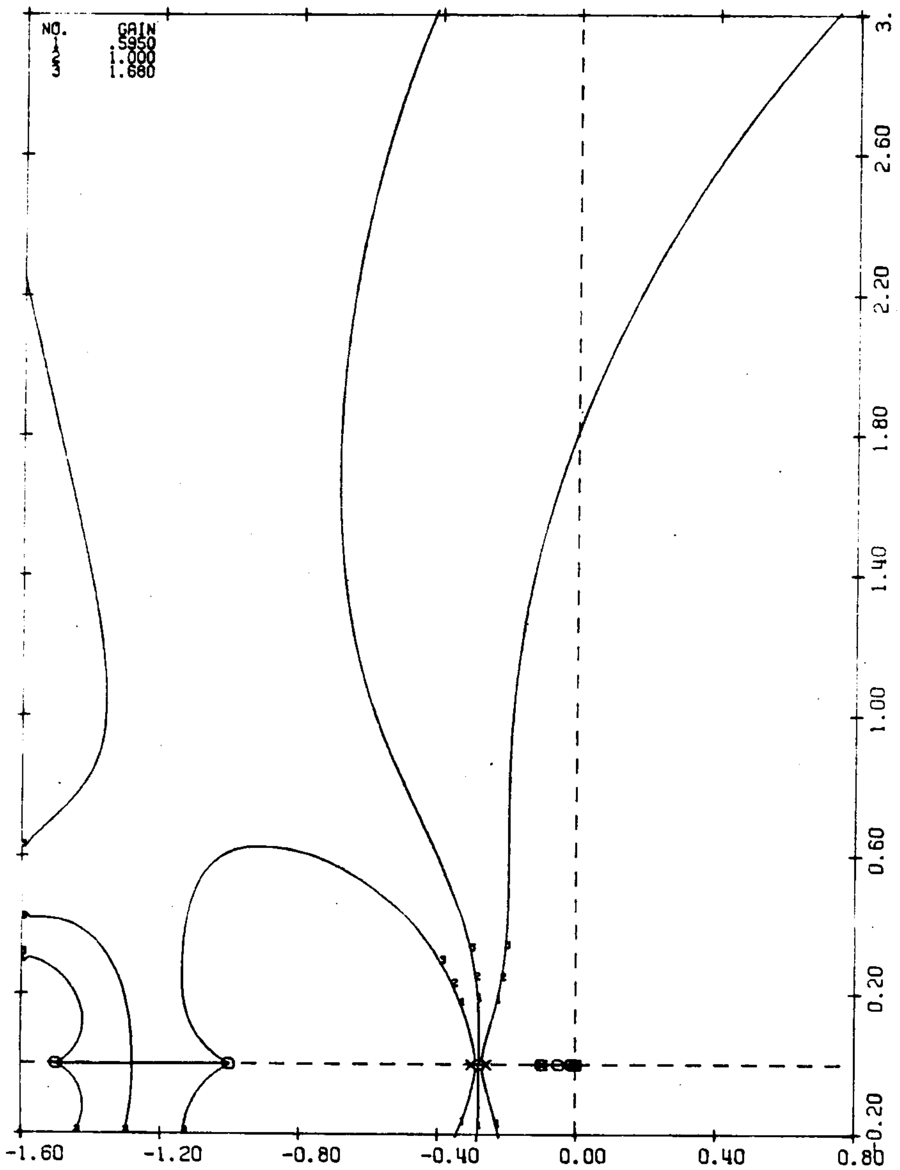


FIGURE 140 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. GLA TEST CONDITION

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

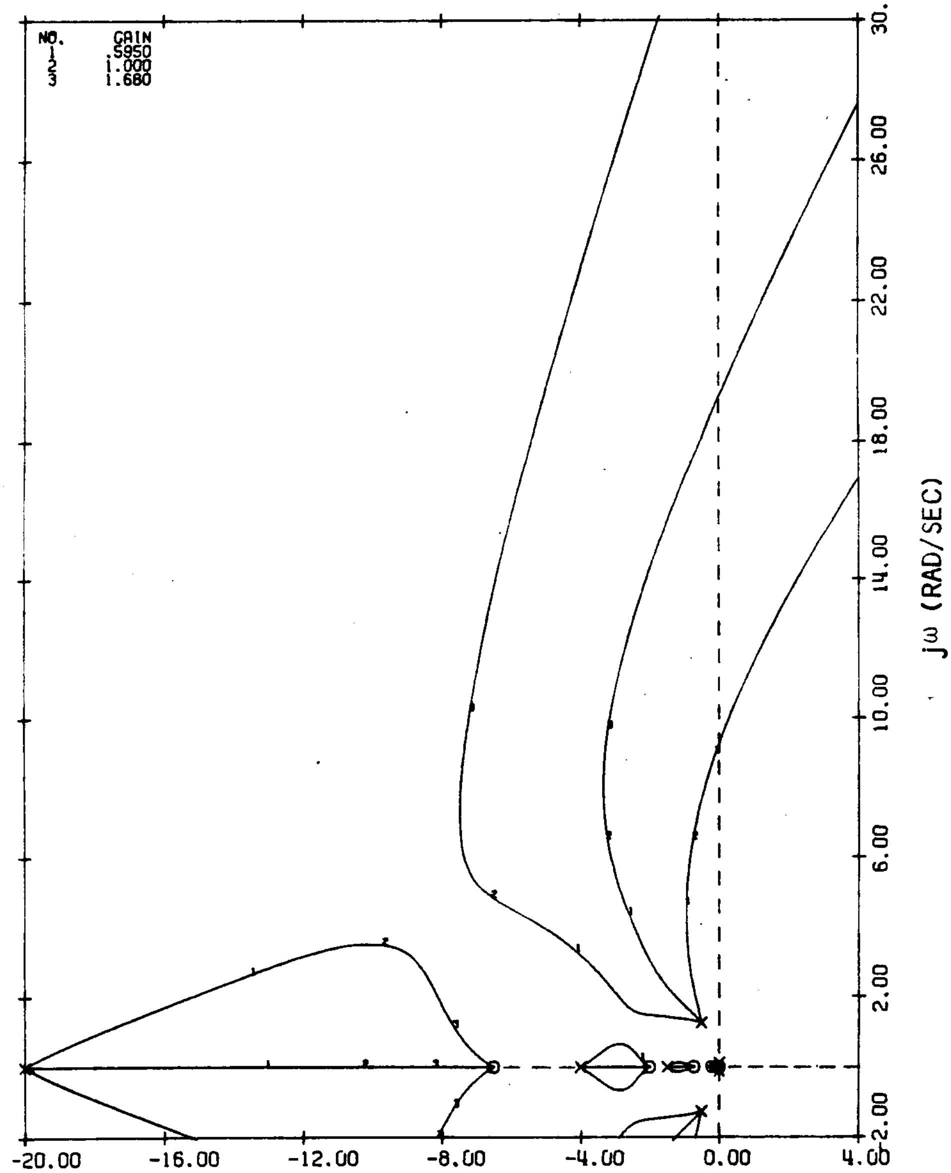


FIGURE 141

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

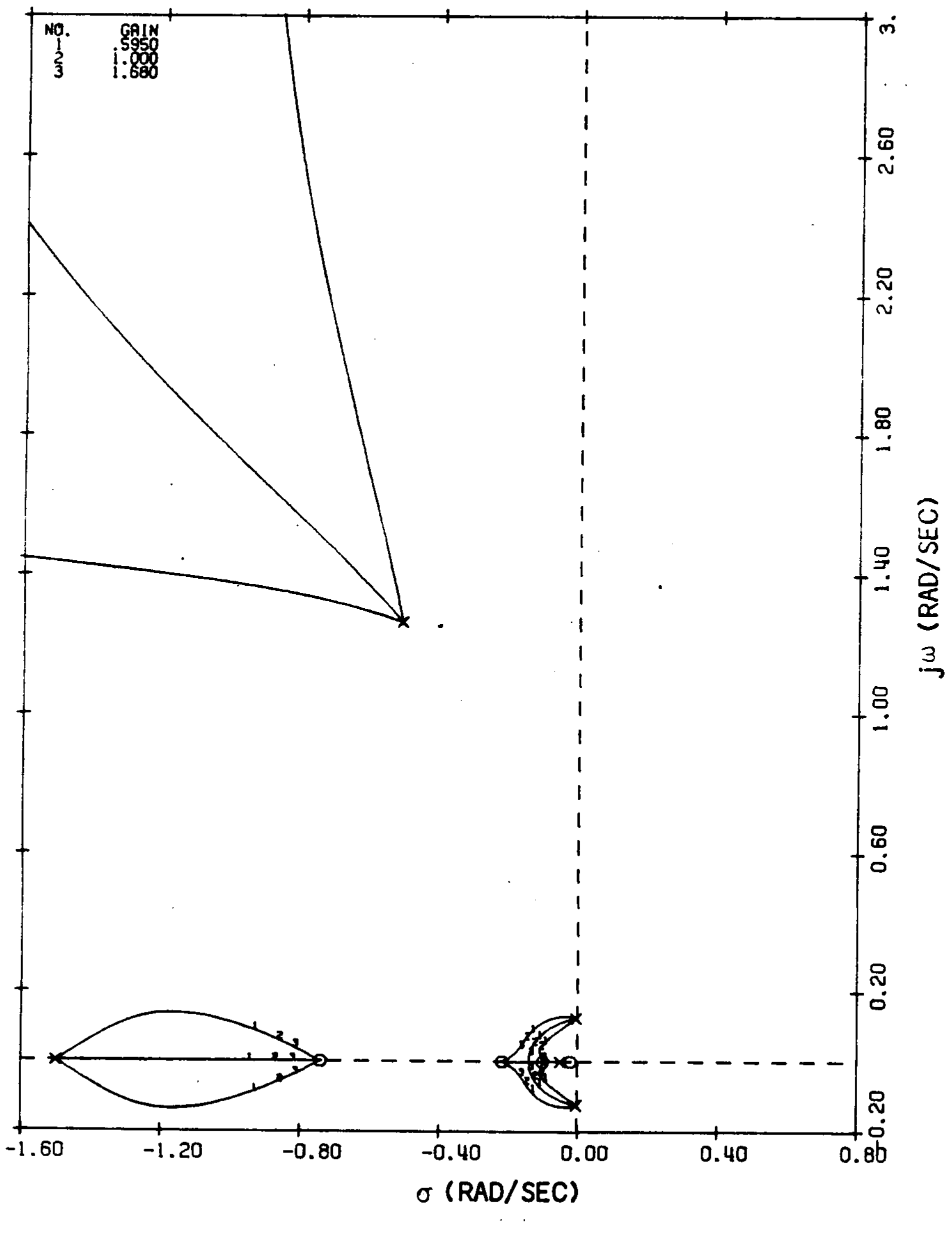


FIGURE 141 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

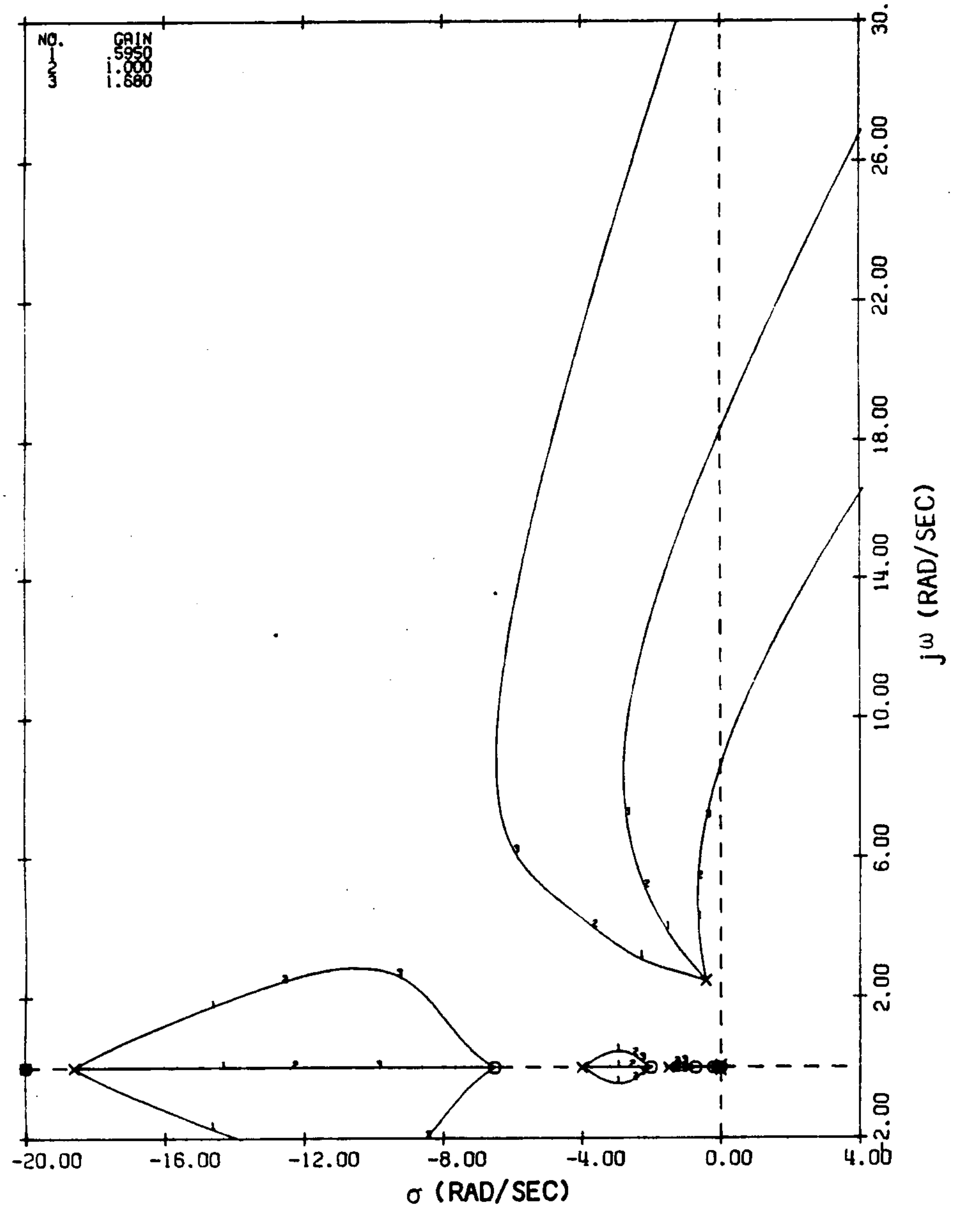


FIGURE 142

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

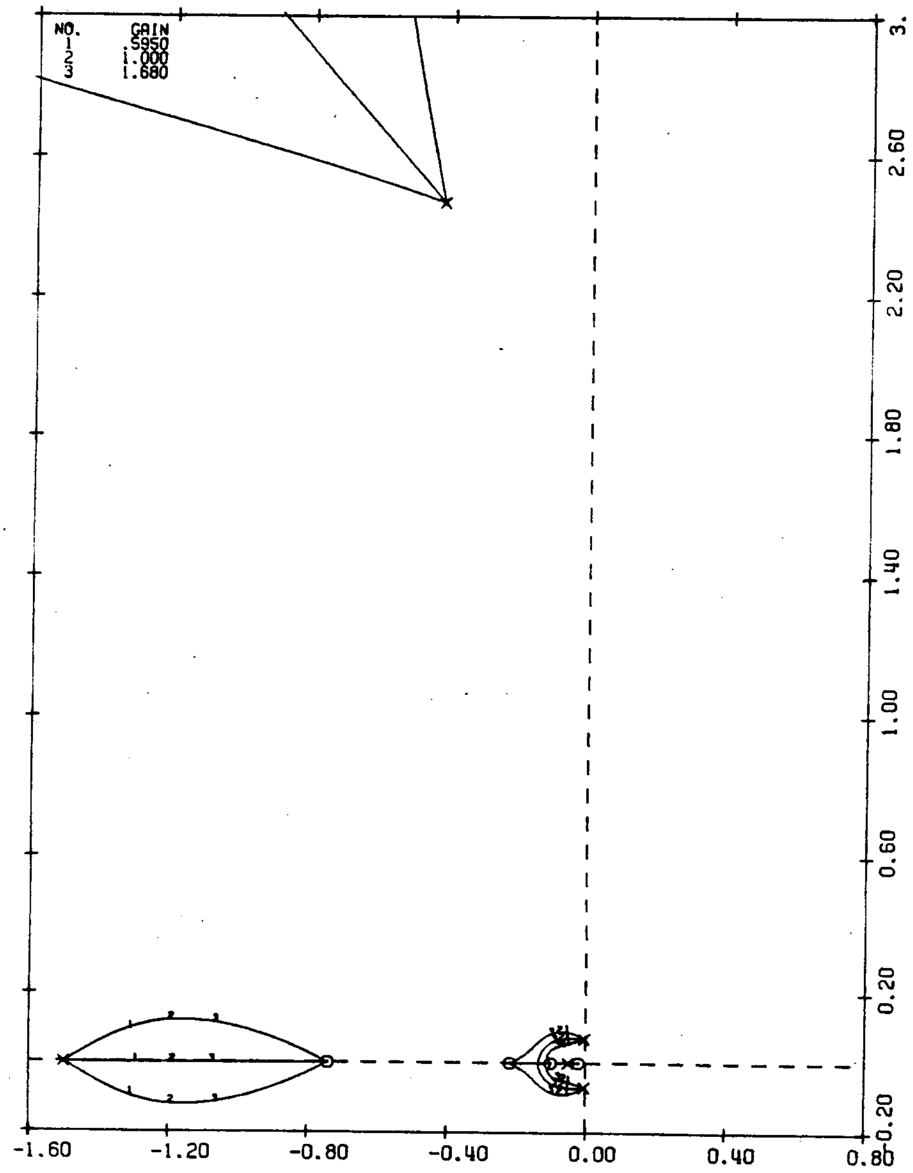


FIGURE 142 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

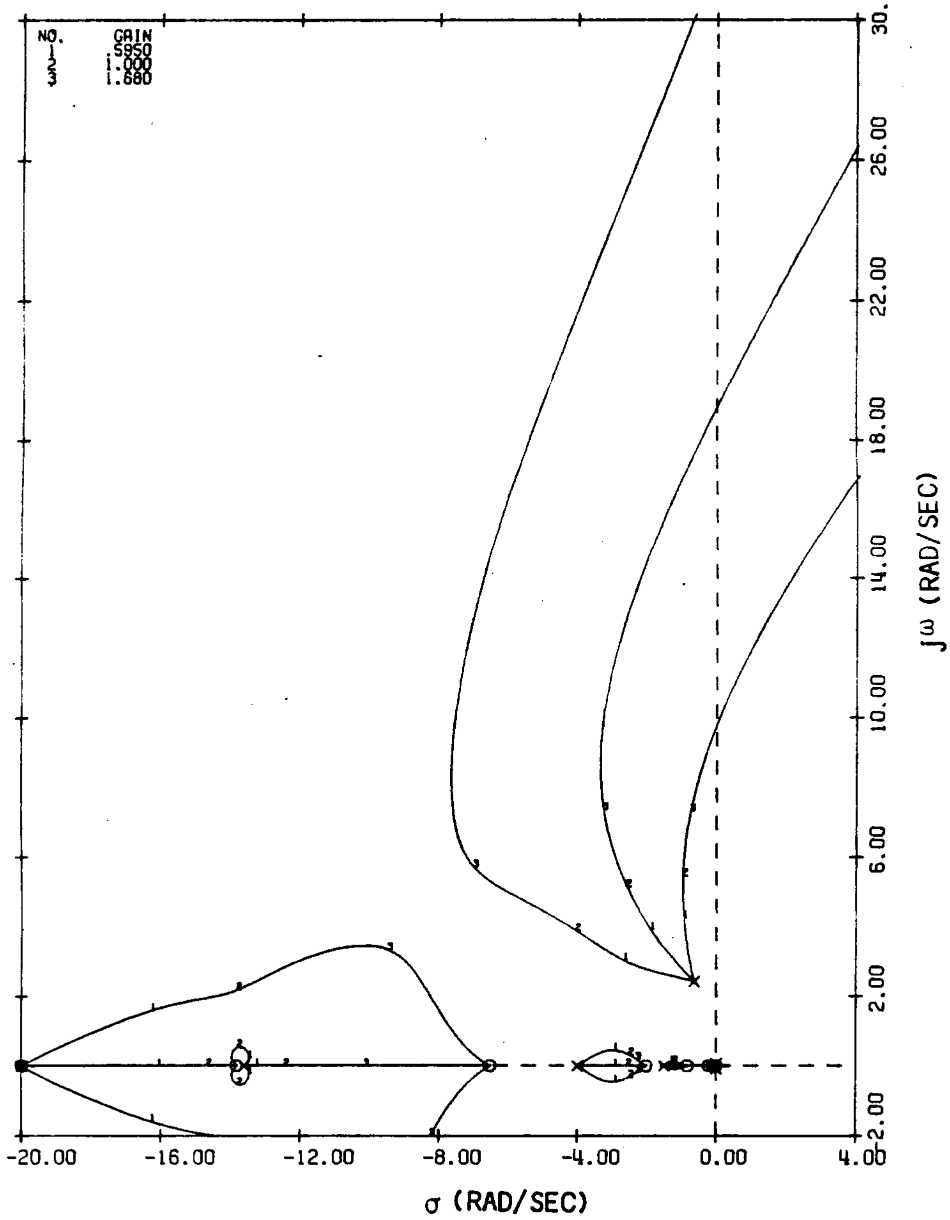


FIGURE 143

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

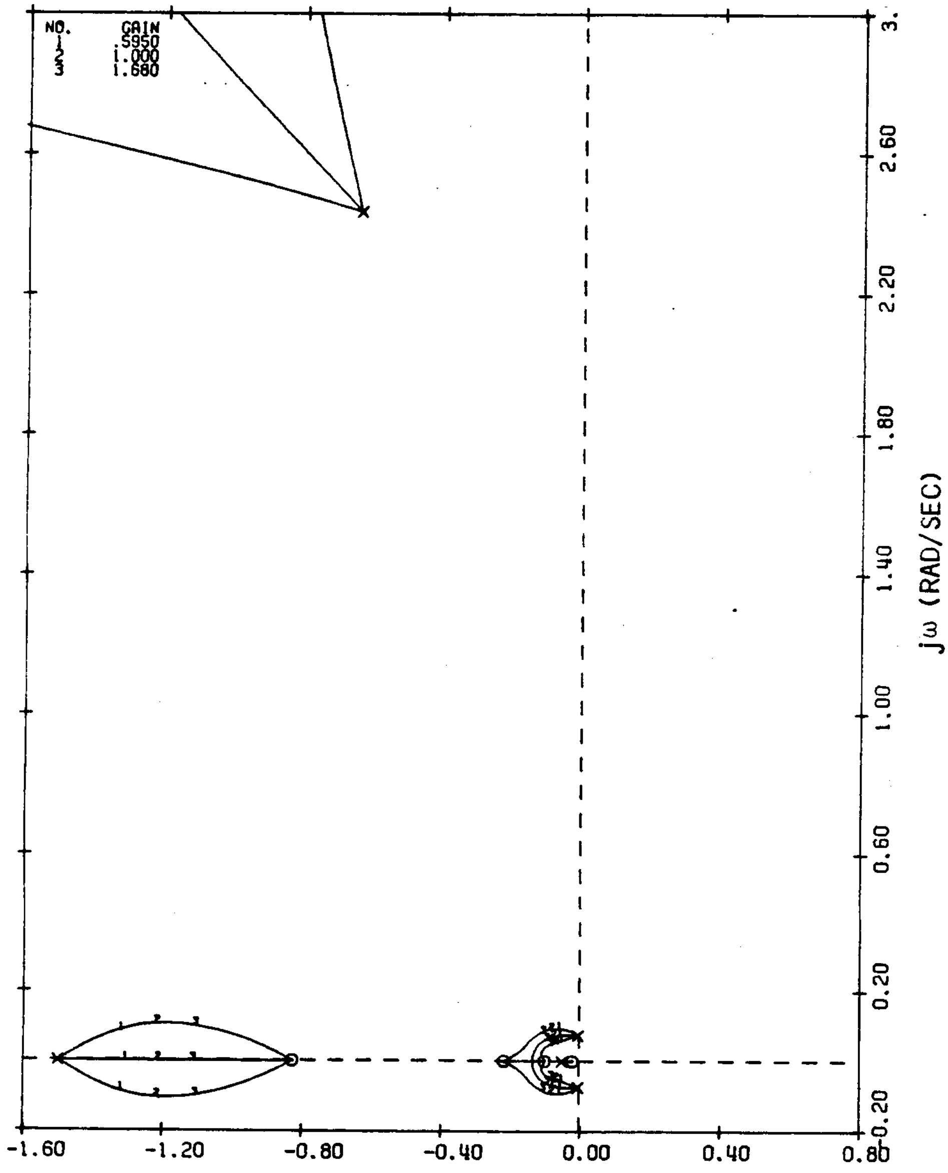


FIGURE 143 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

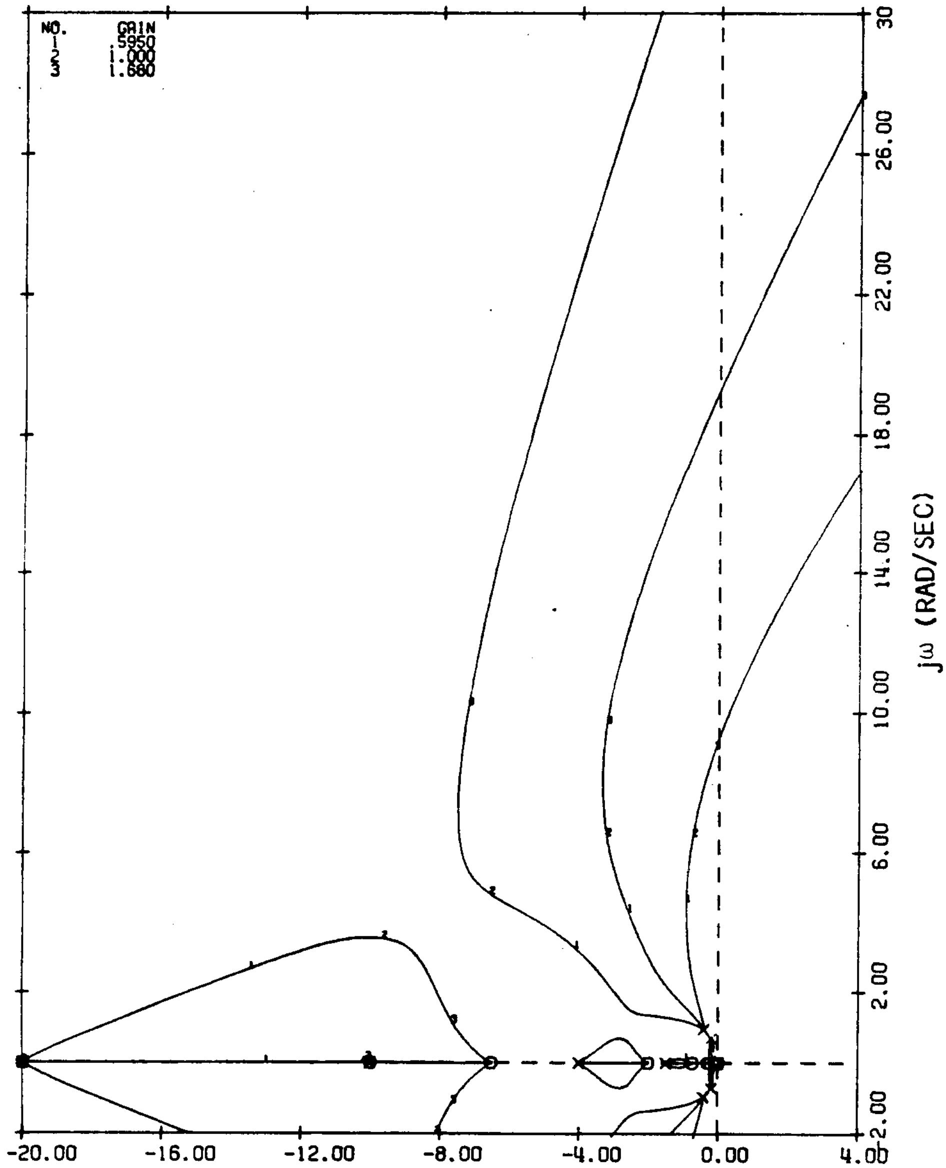


FIGURE 144

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

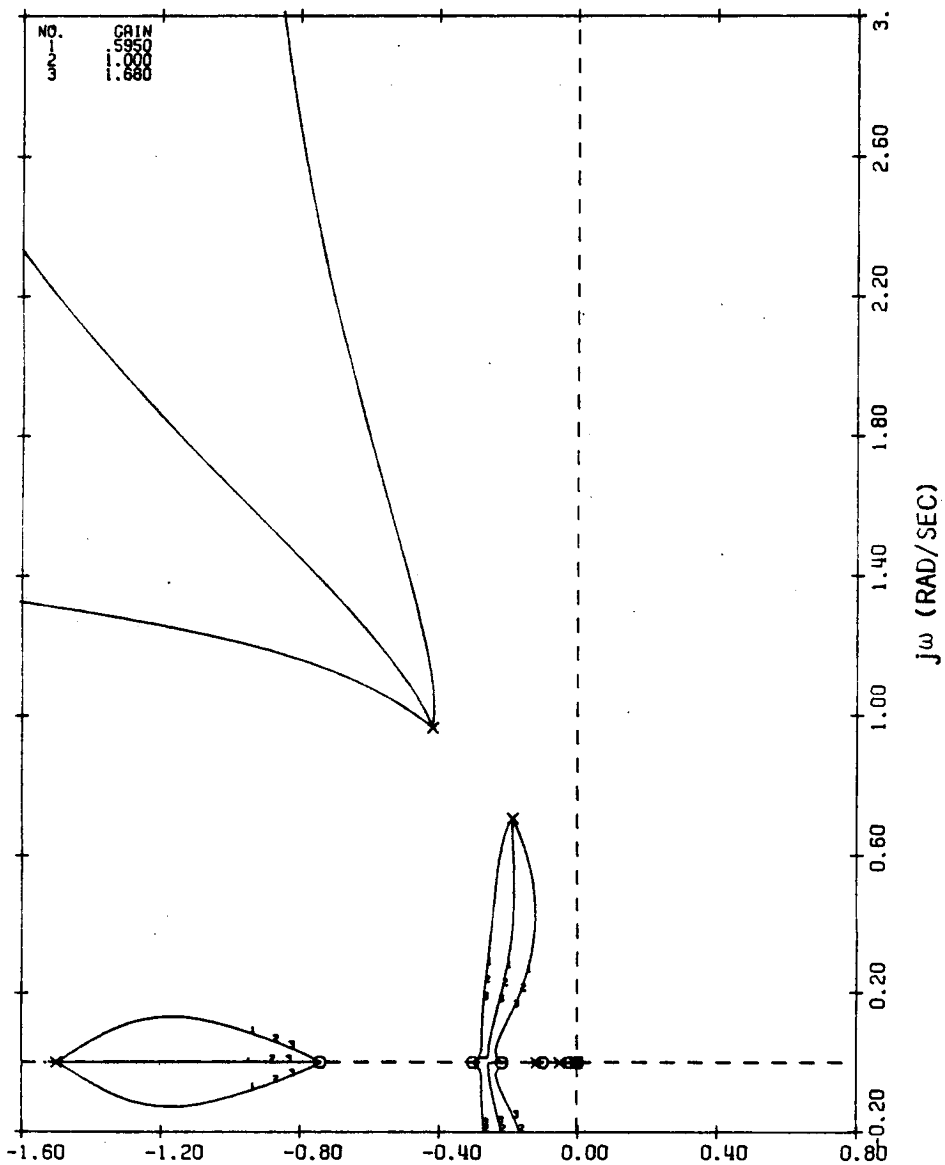


FIGURE 144 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

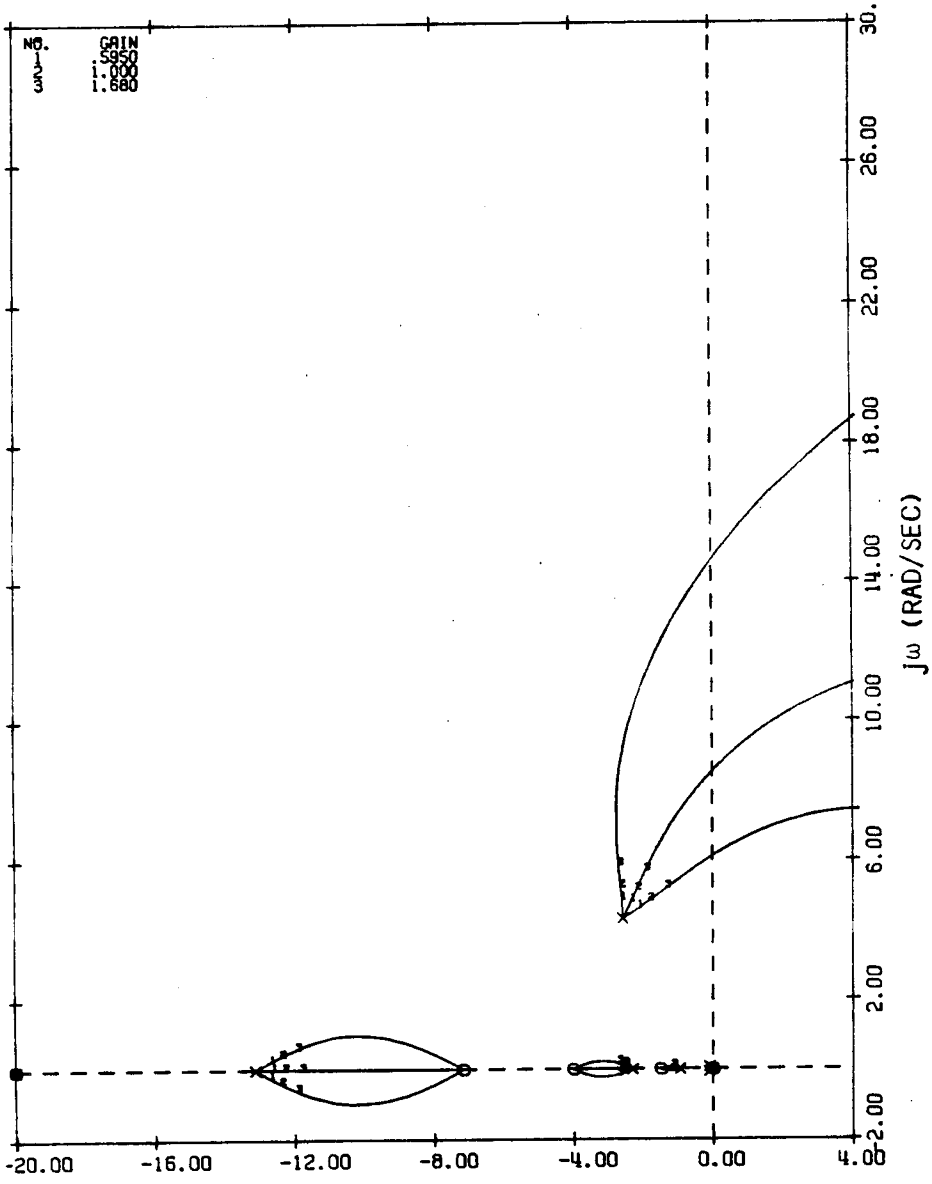


FIGURE 145

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

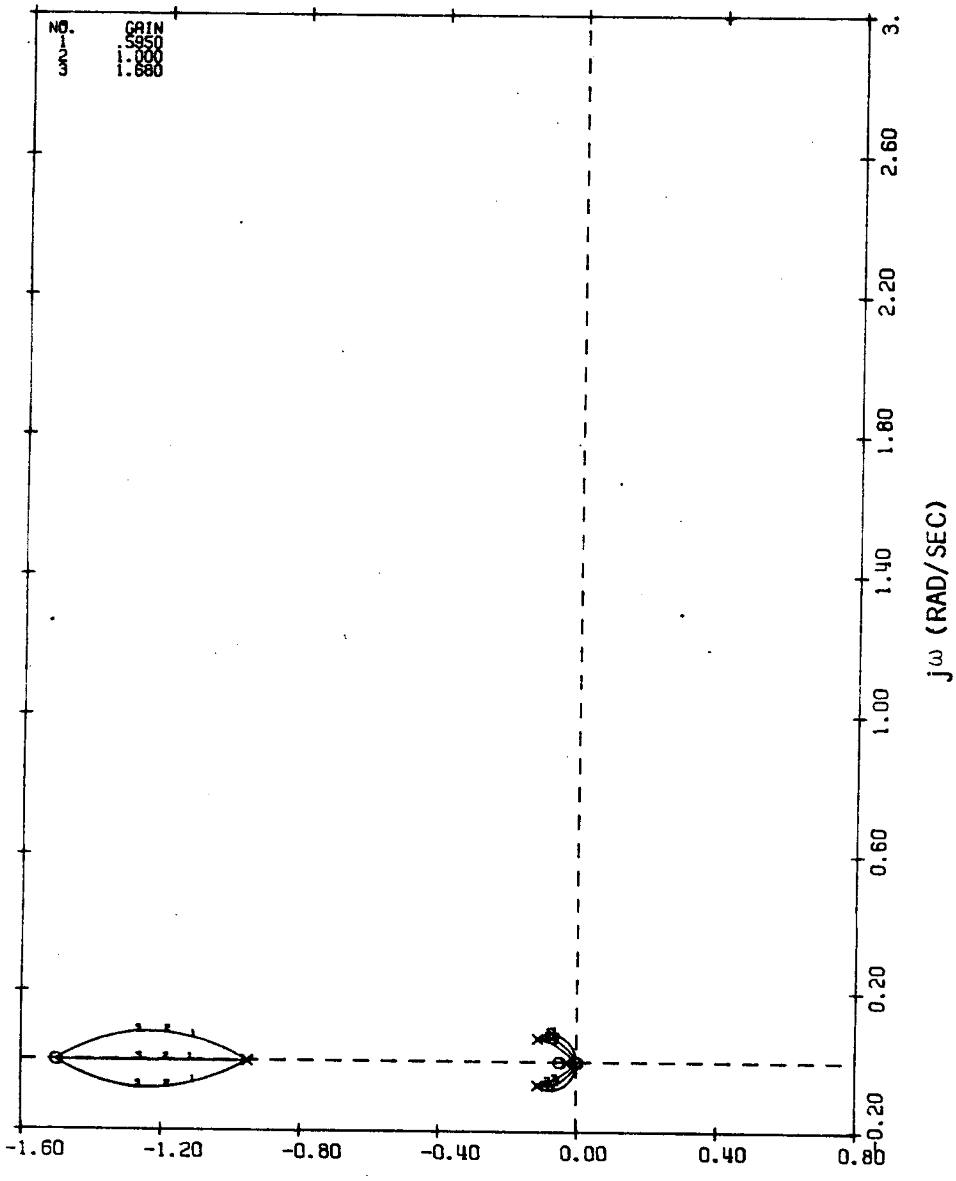


FIGURE 145 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

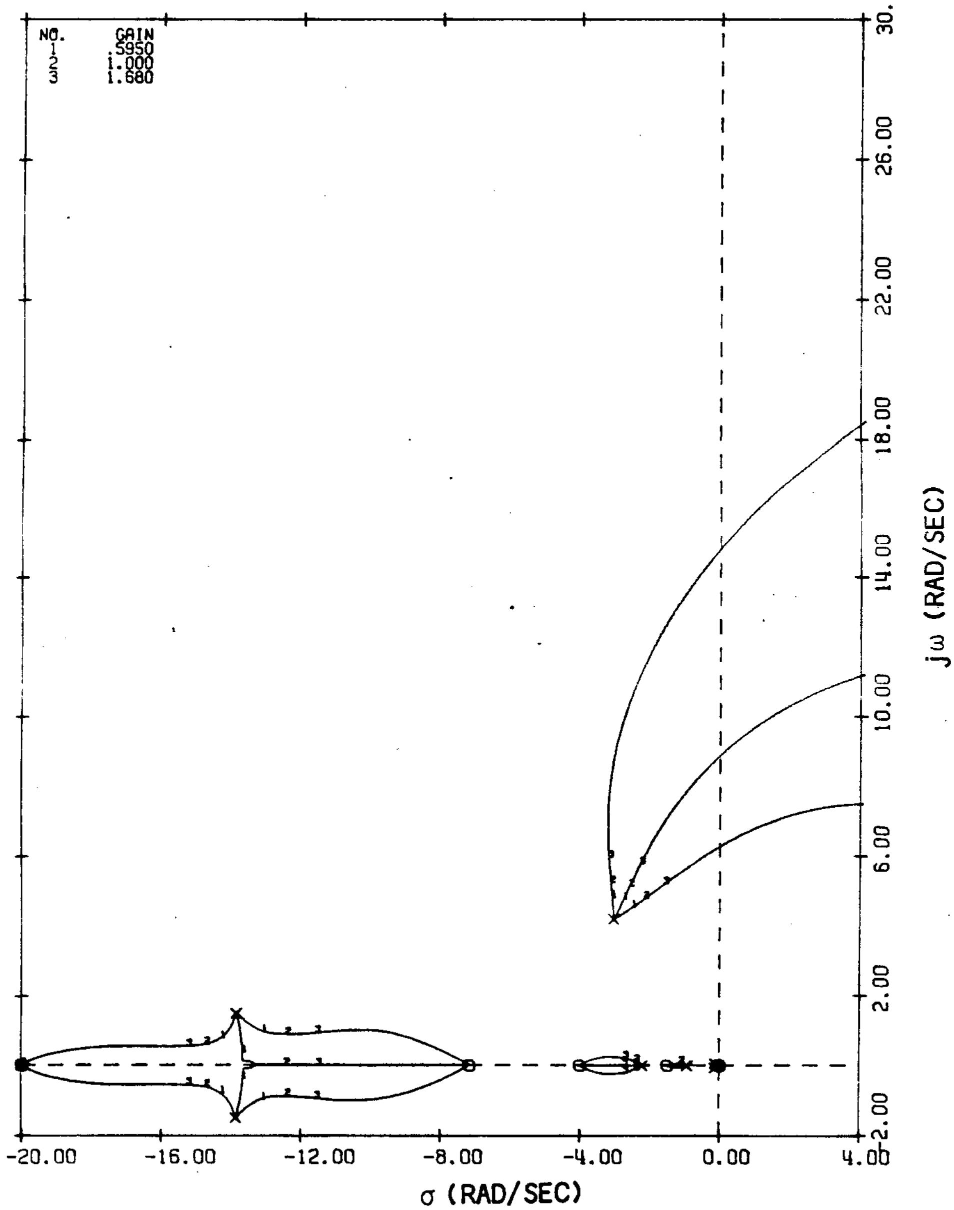


FIGURE 146

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

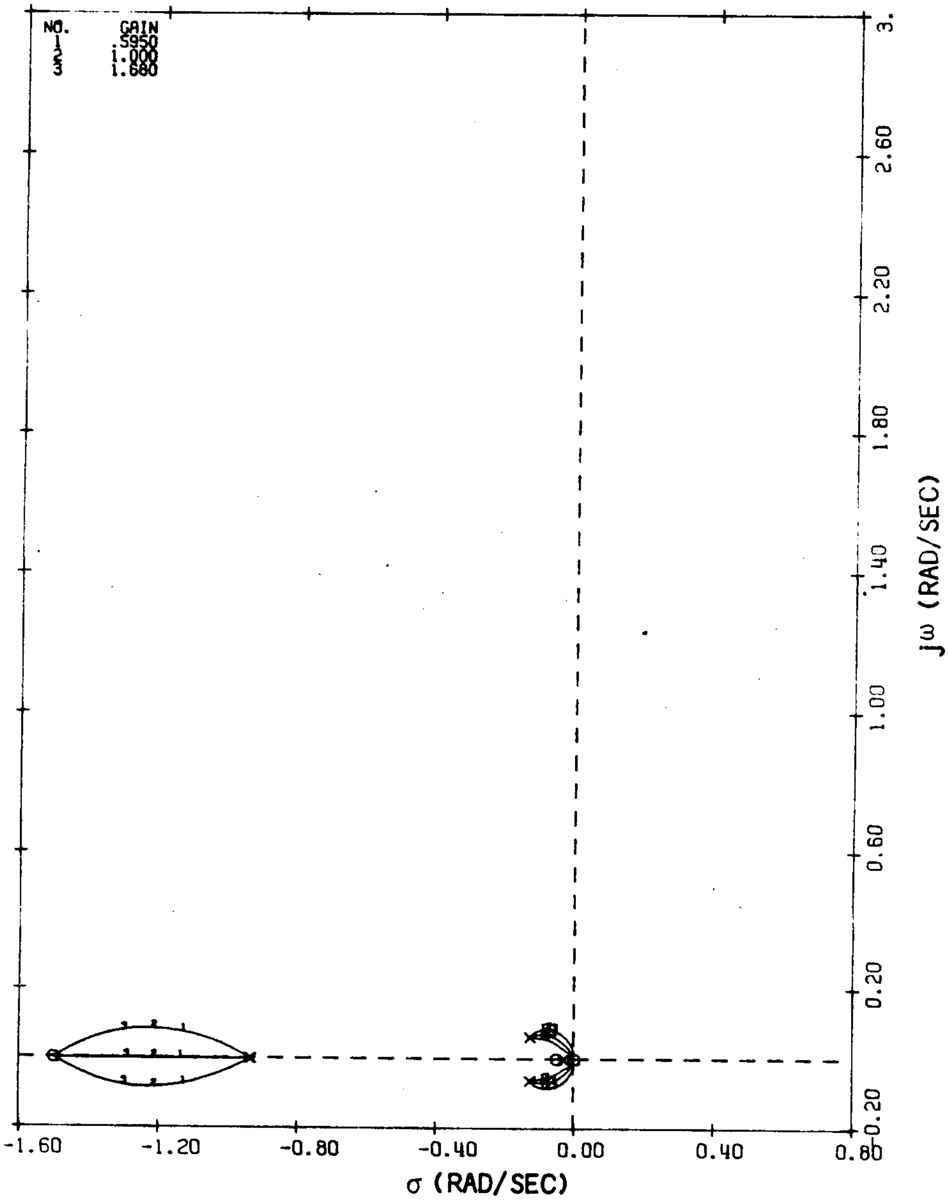


FIGURE 146 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

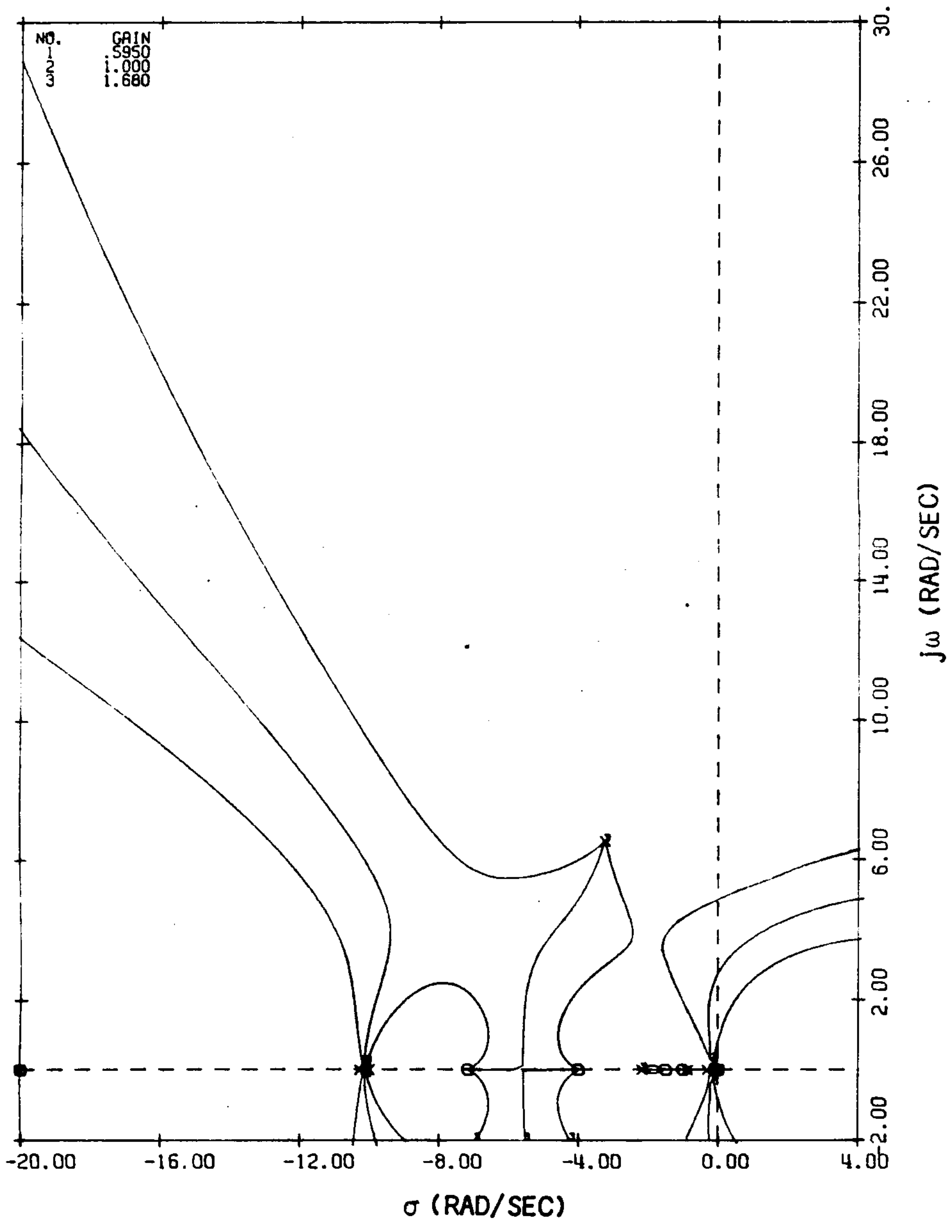


FIGURE 147

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

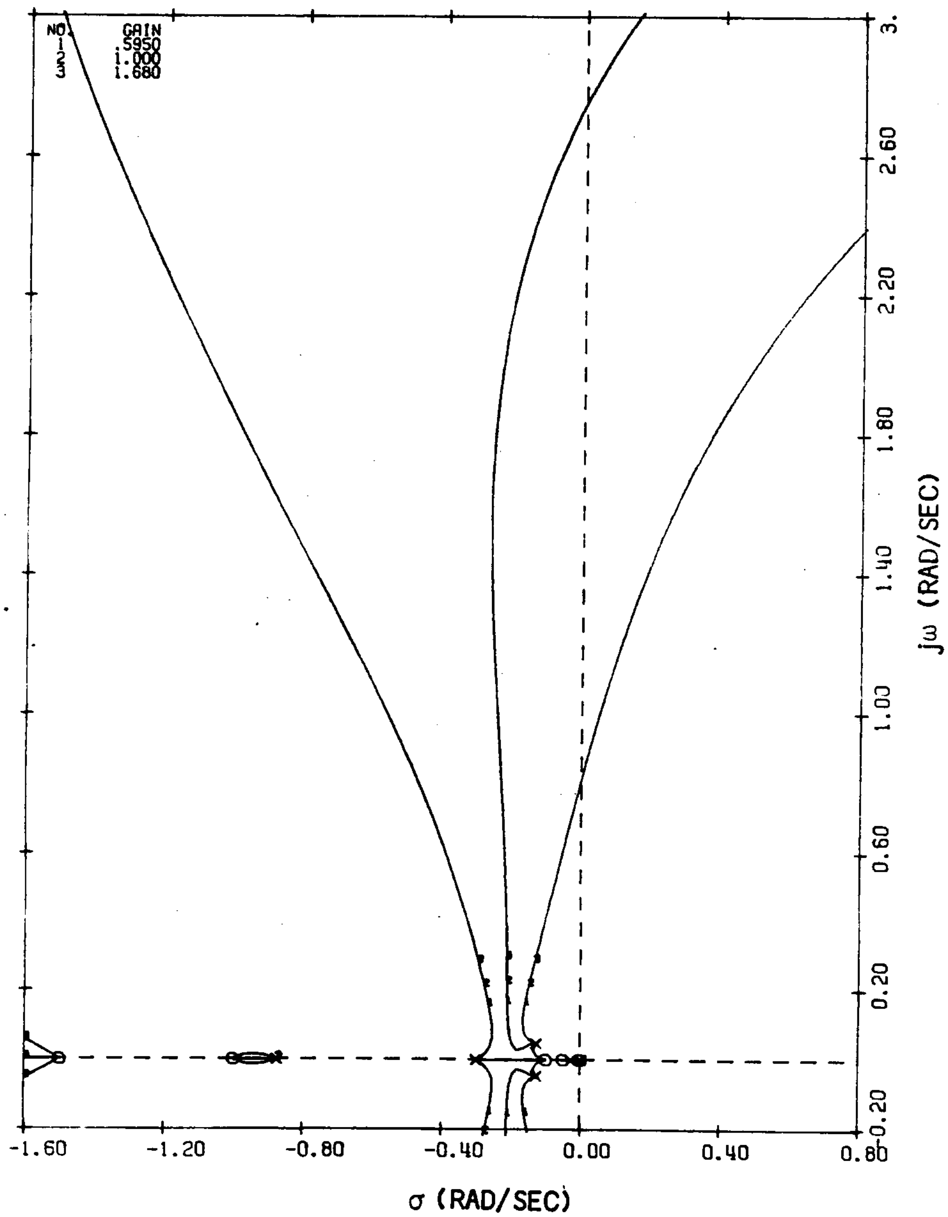


FIGURE 147 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. LAUNCH CONDITION

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

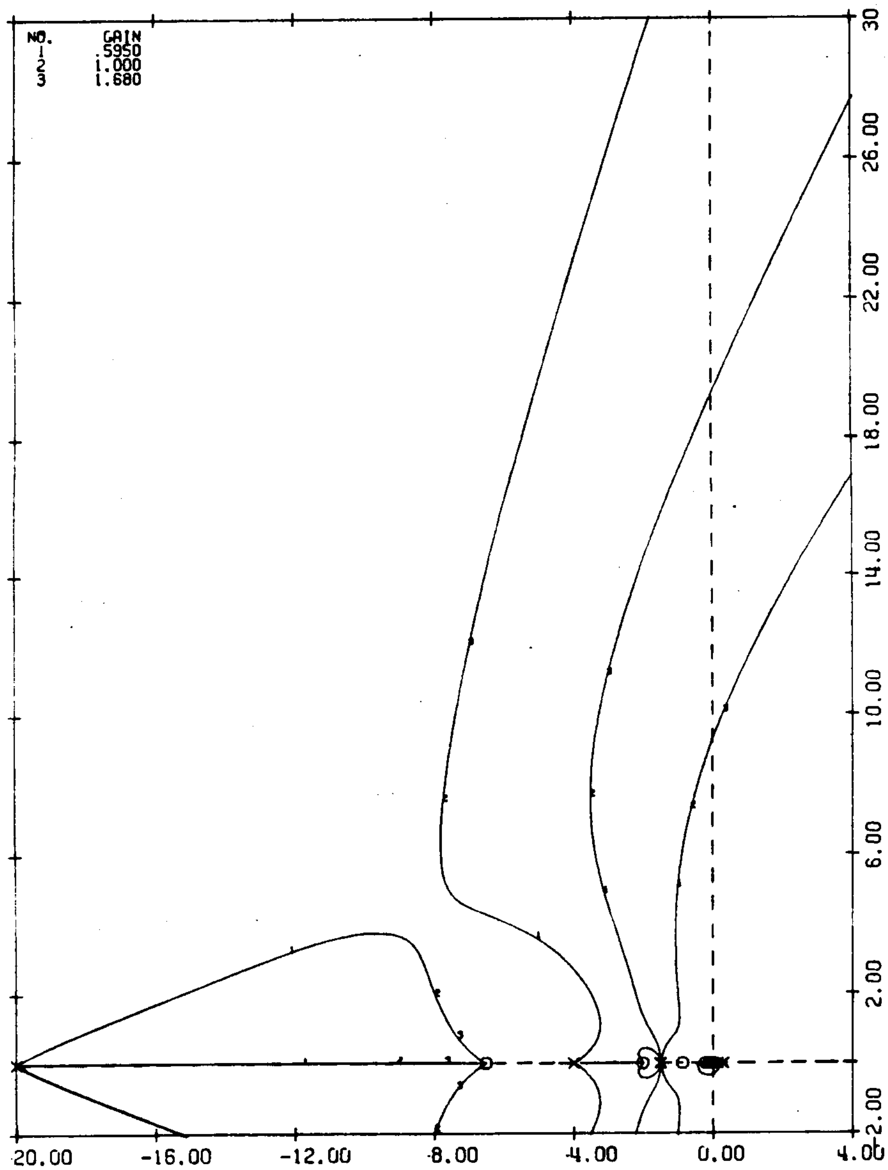


FIGURE 148

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- RSS
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

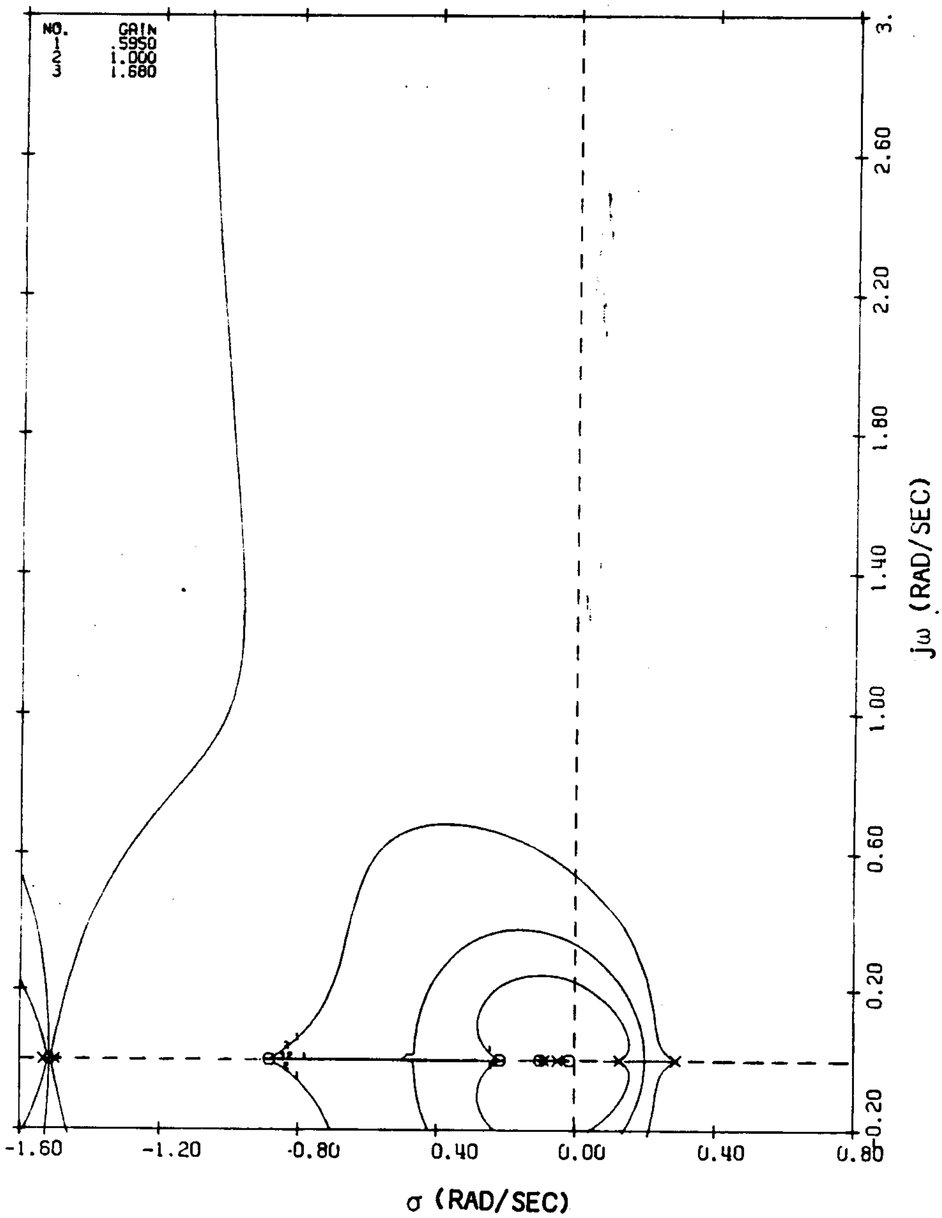


FIGURE 148 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

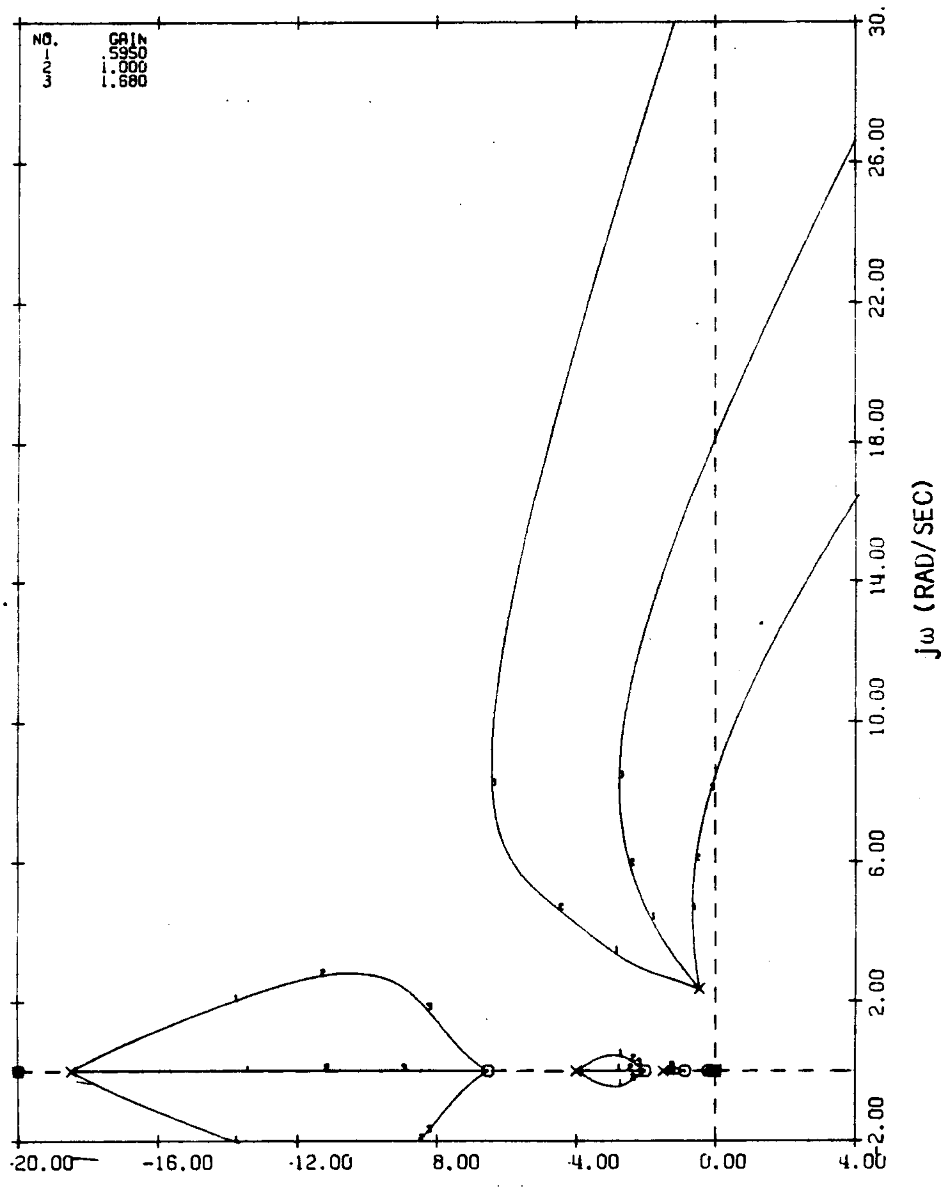


FIGURE 149

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH PCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

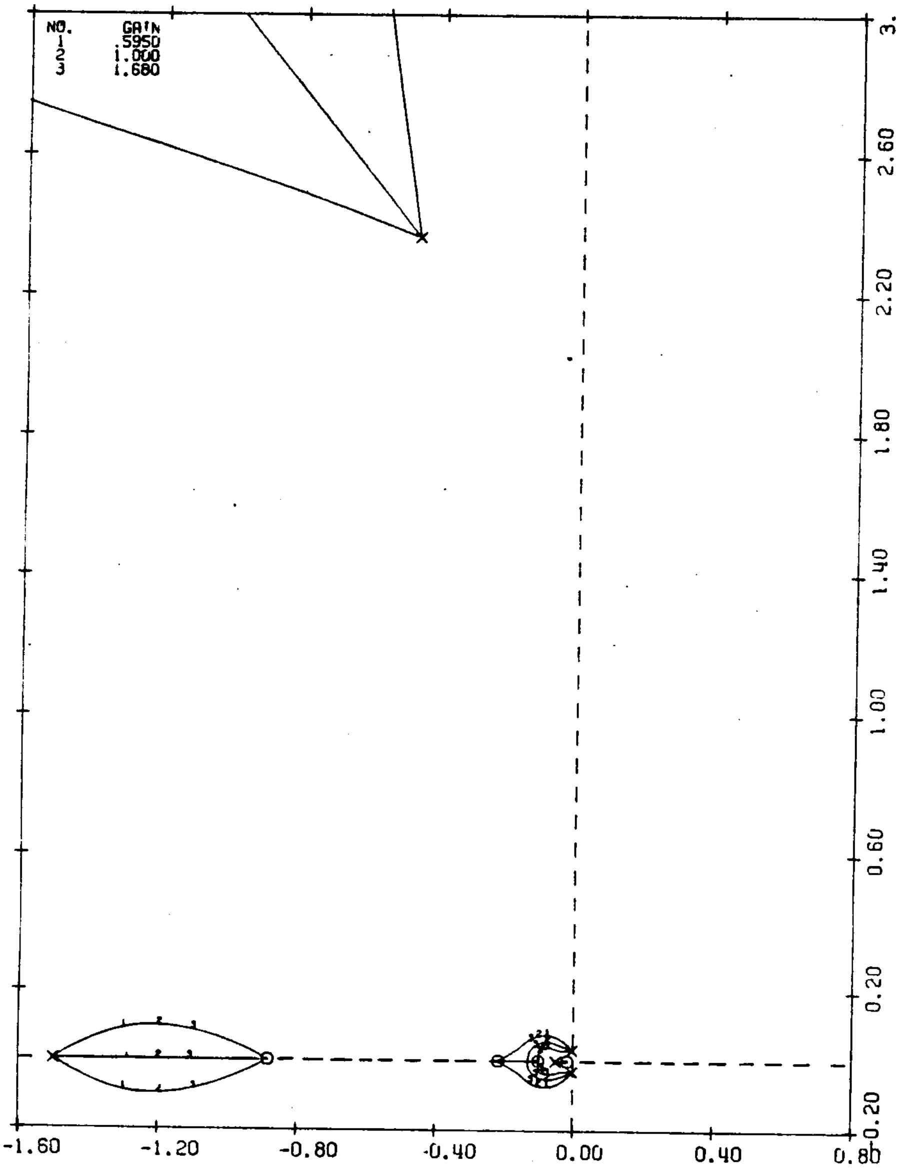


FIGURE 149 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

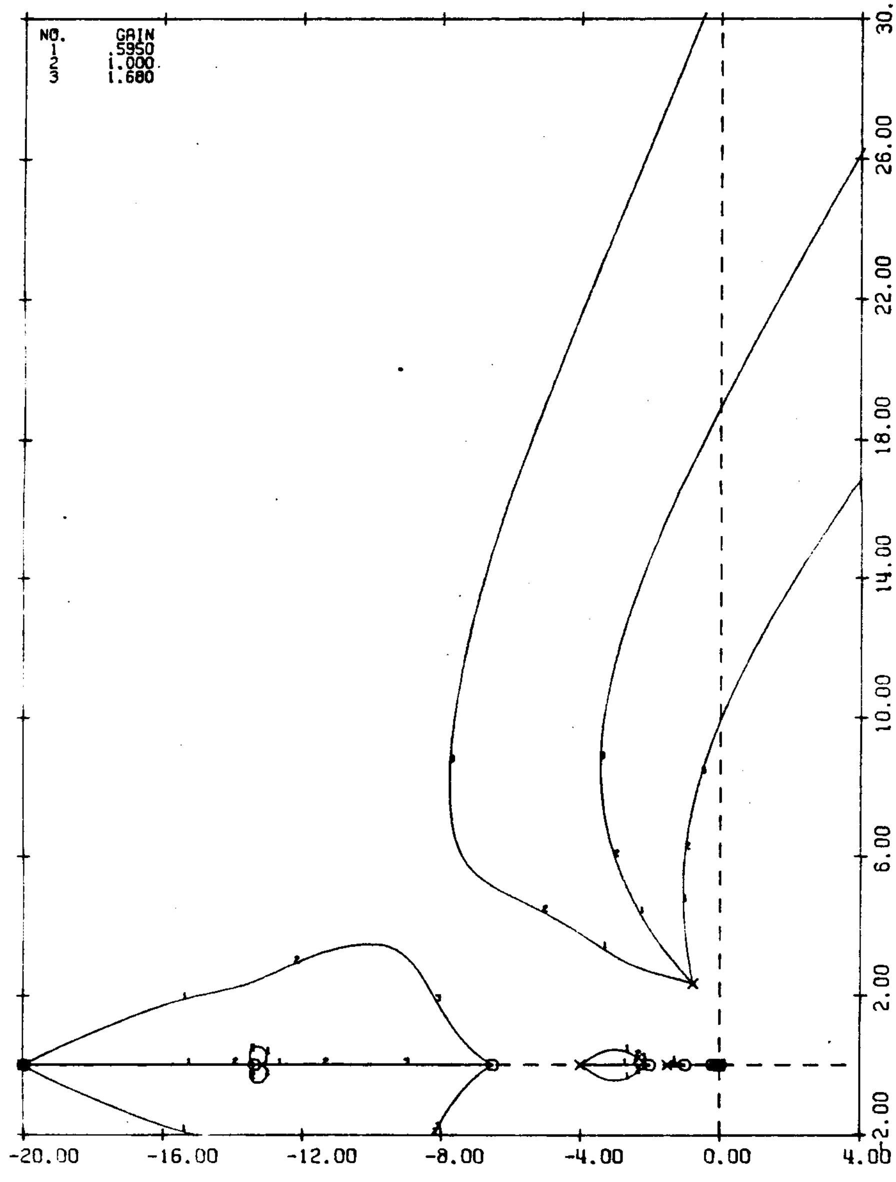


FIGURE 150

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

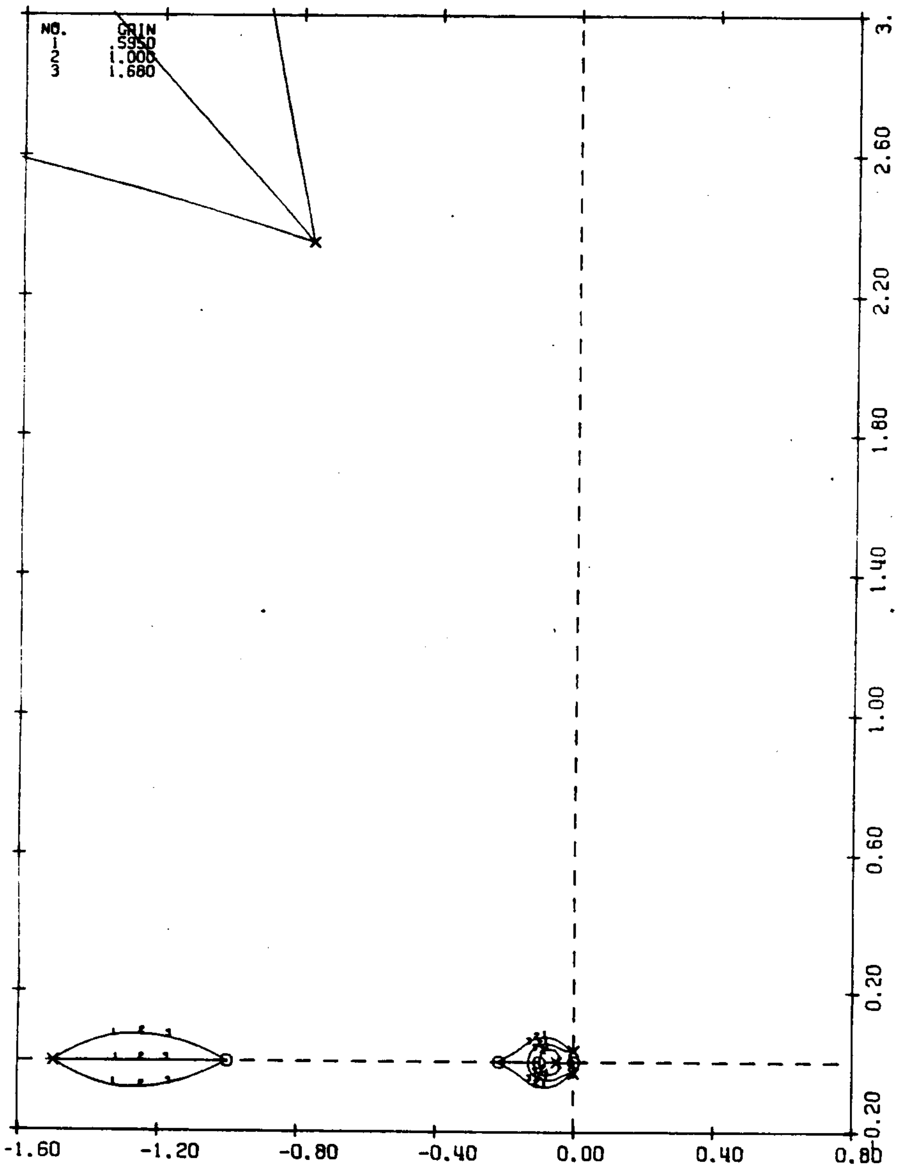


FIGURE 150 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

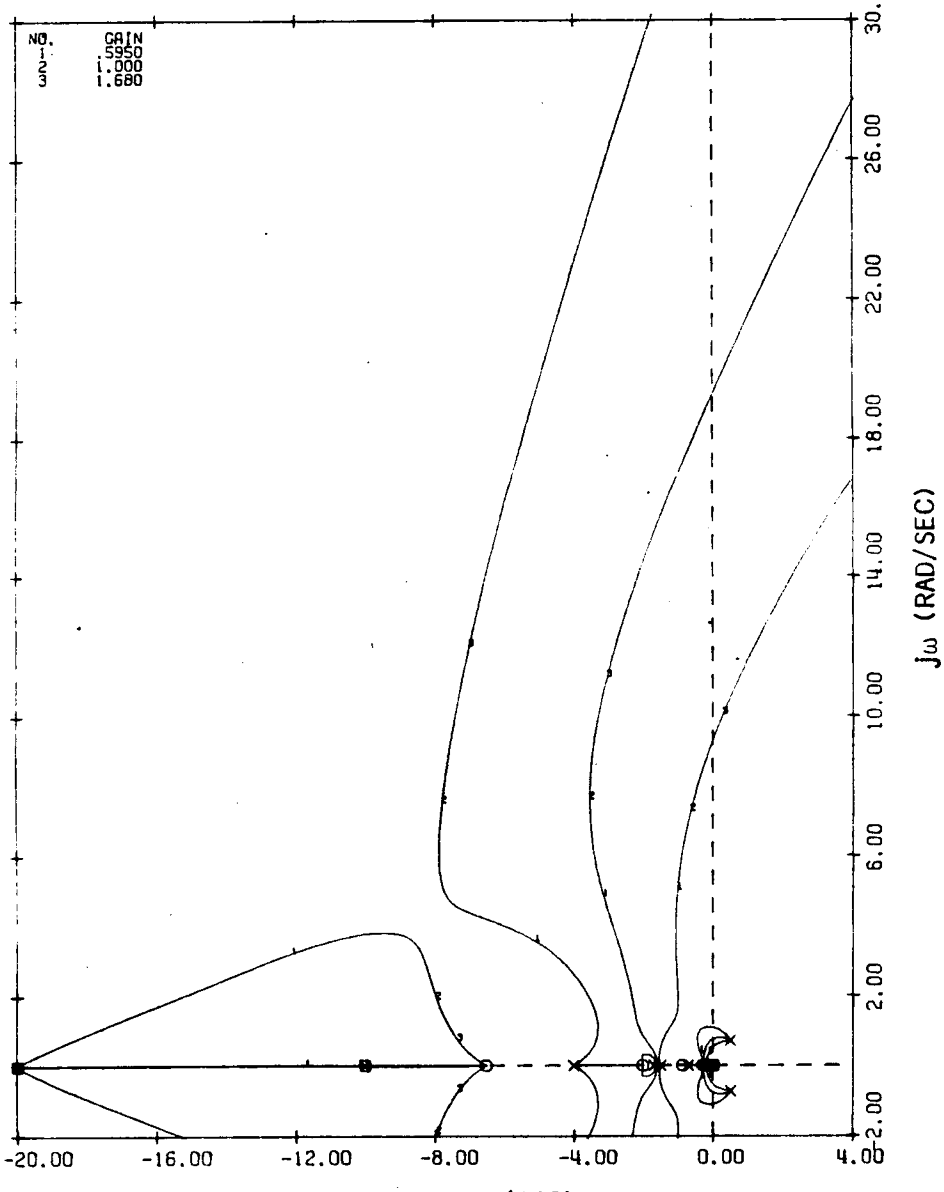


FIGURE 151

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- RSS WITH BCS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

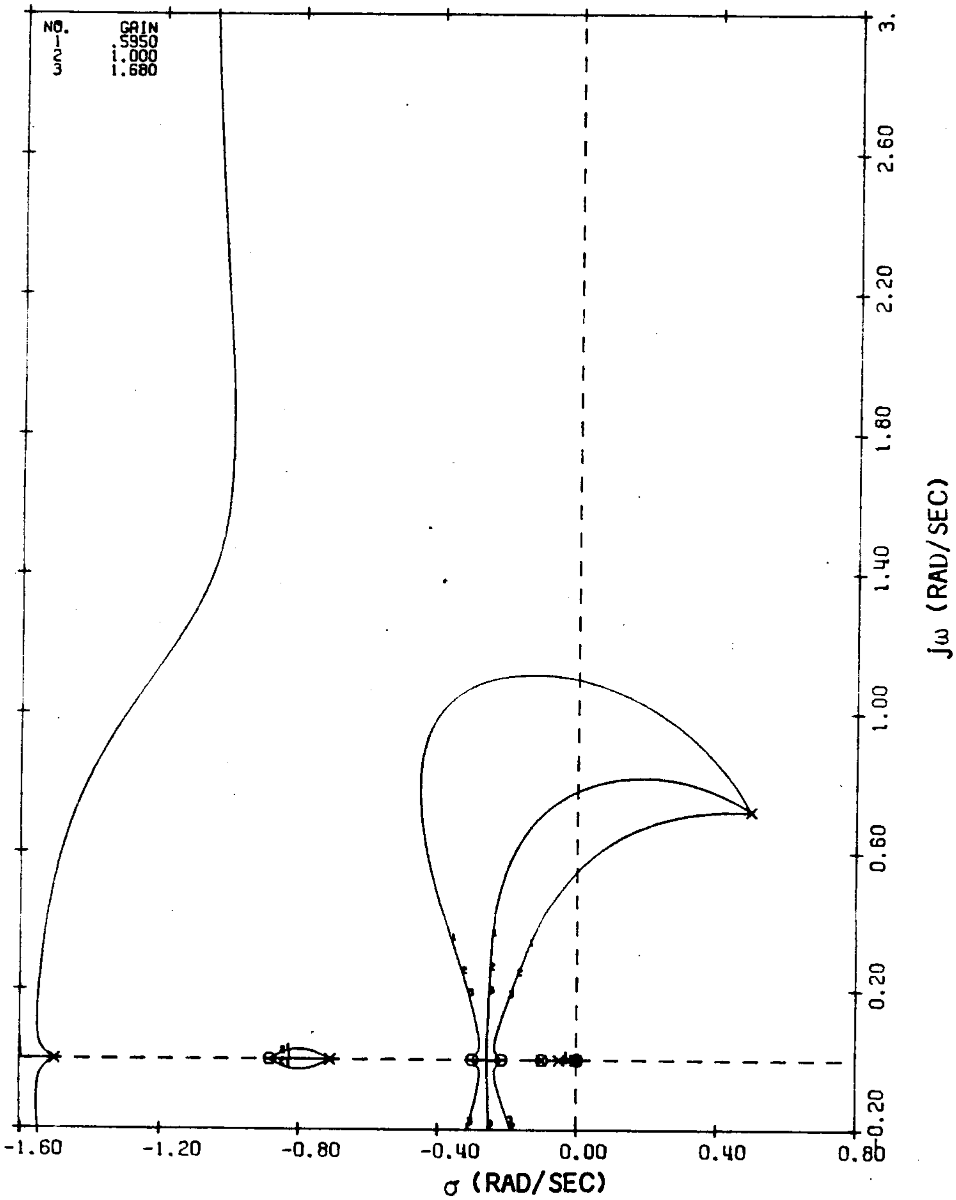


FIGURE 151 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

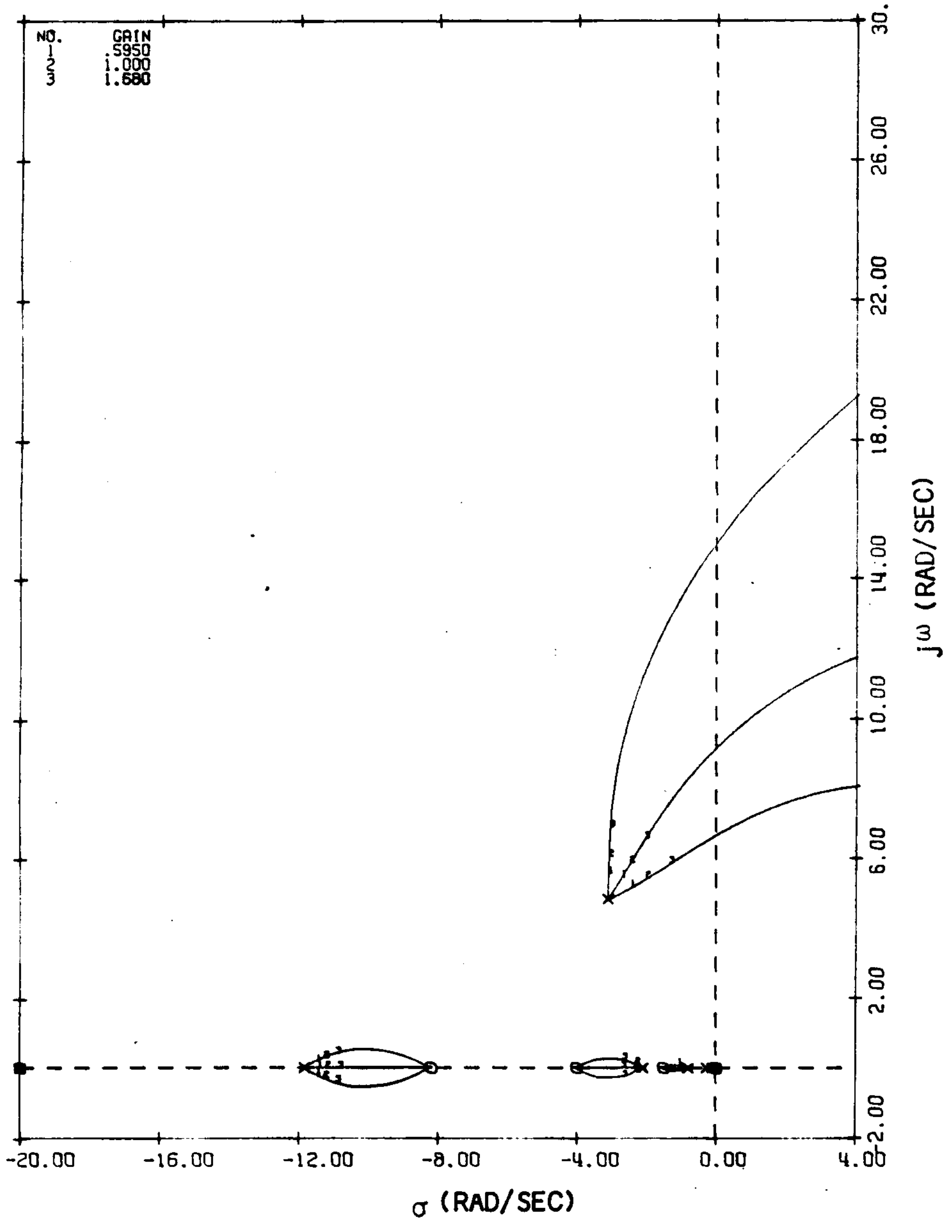


FIGURE 152

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

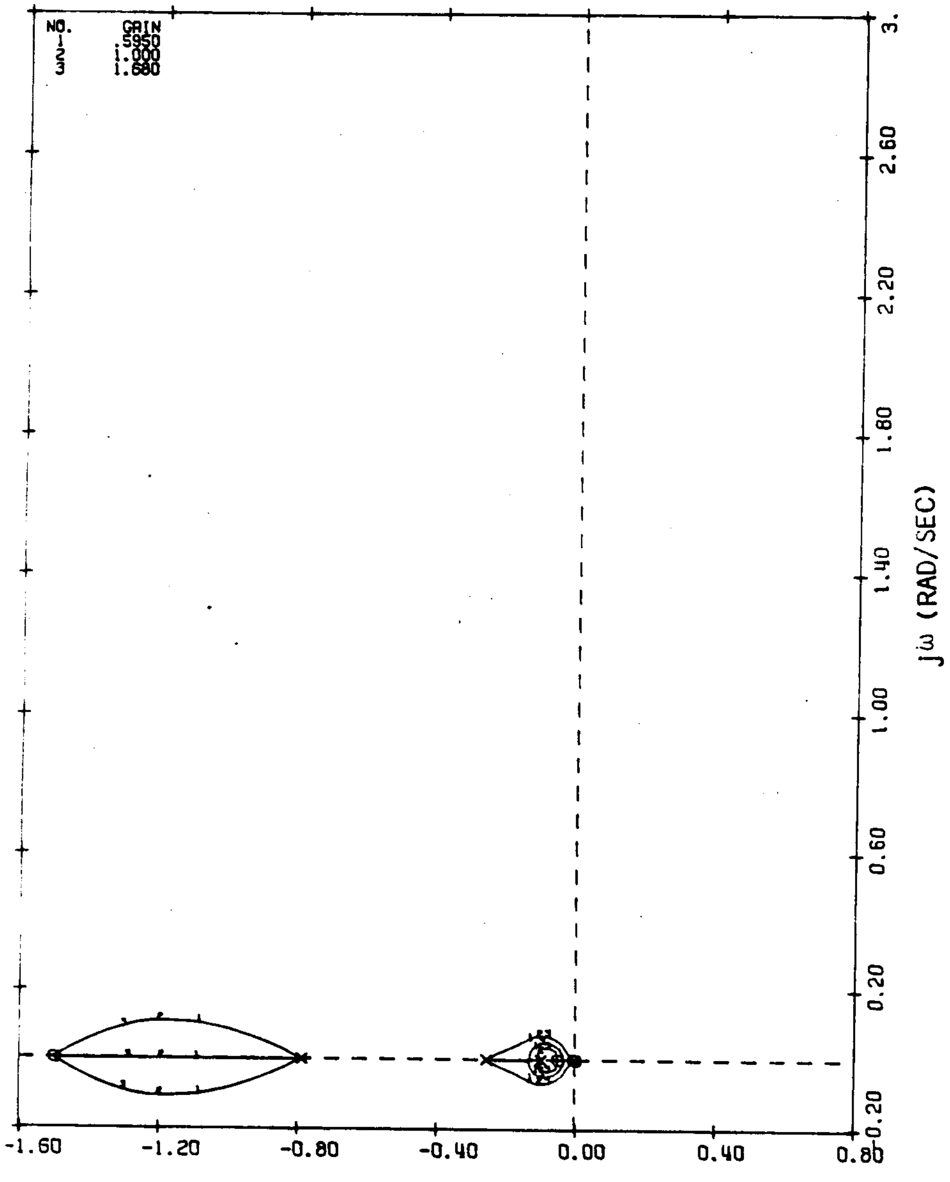


FIGURE 152 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

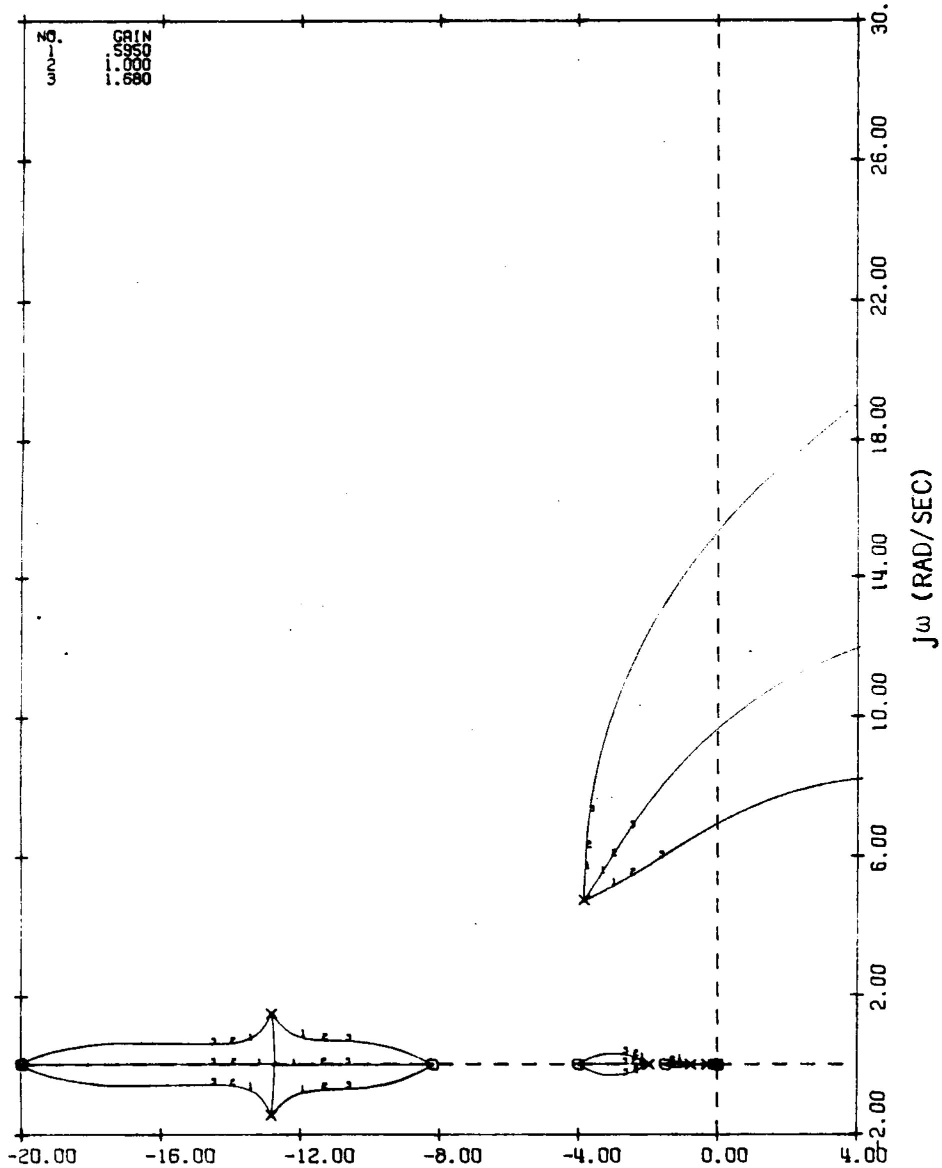


FIGURE 153

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

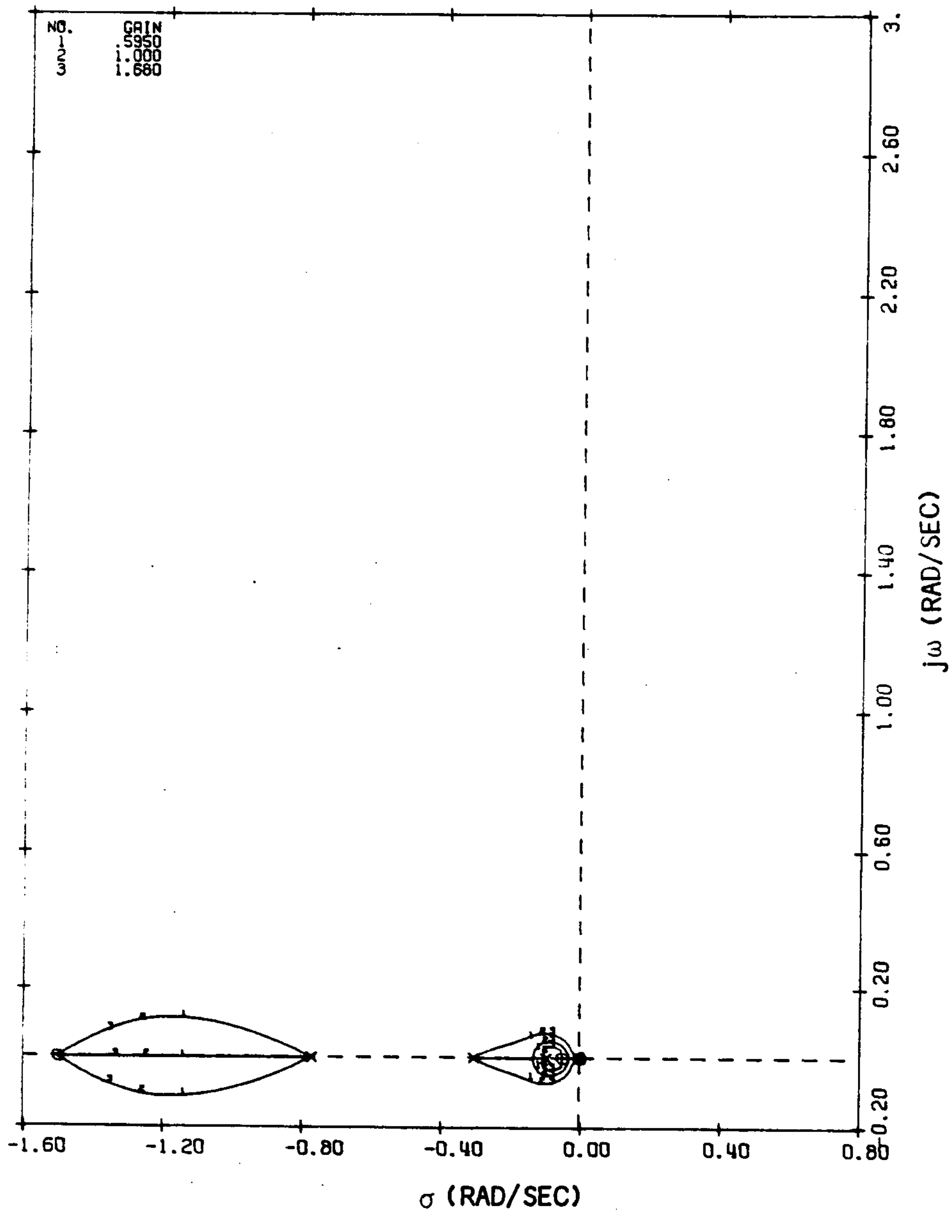


FIGURE 153 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

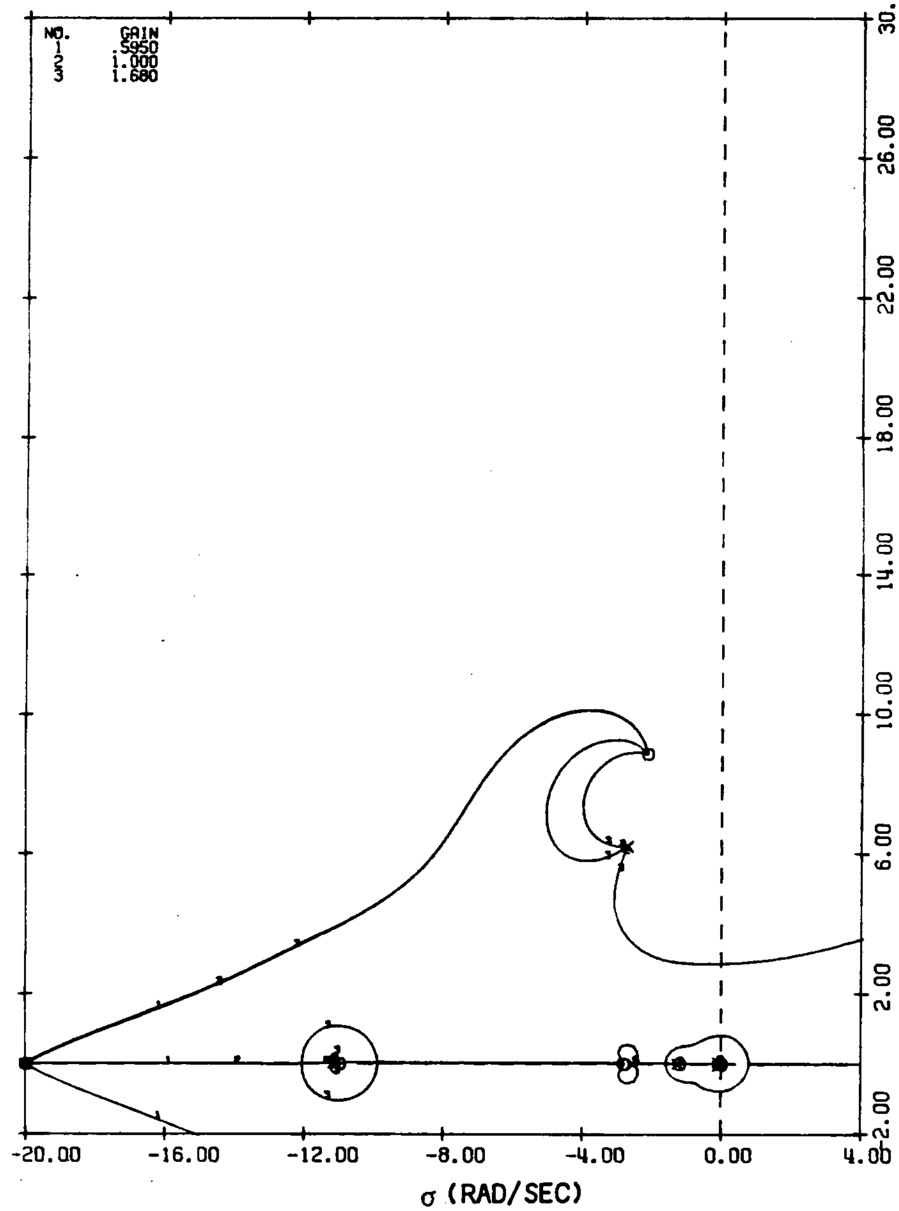


FIGURE 154

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

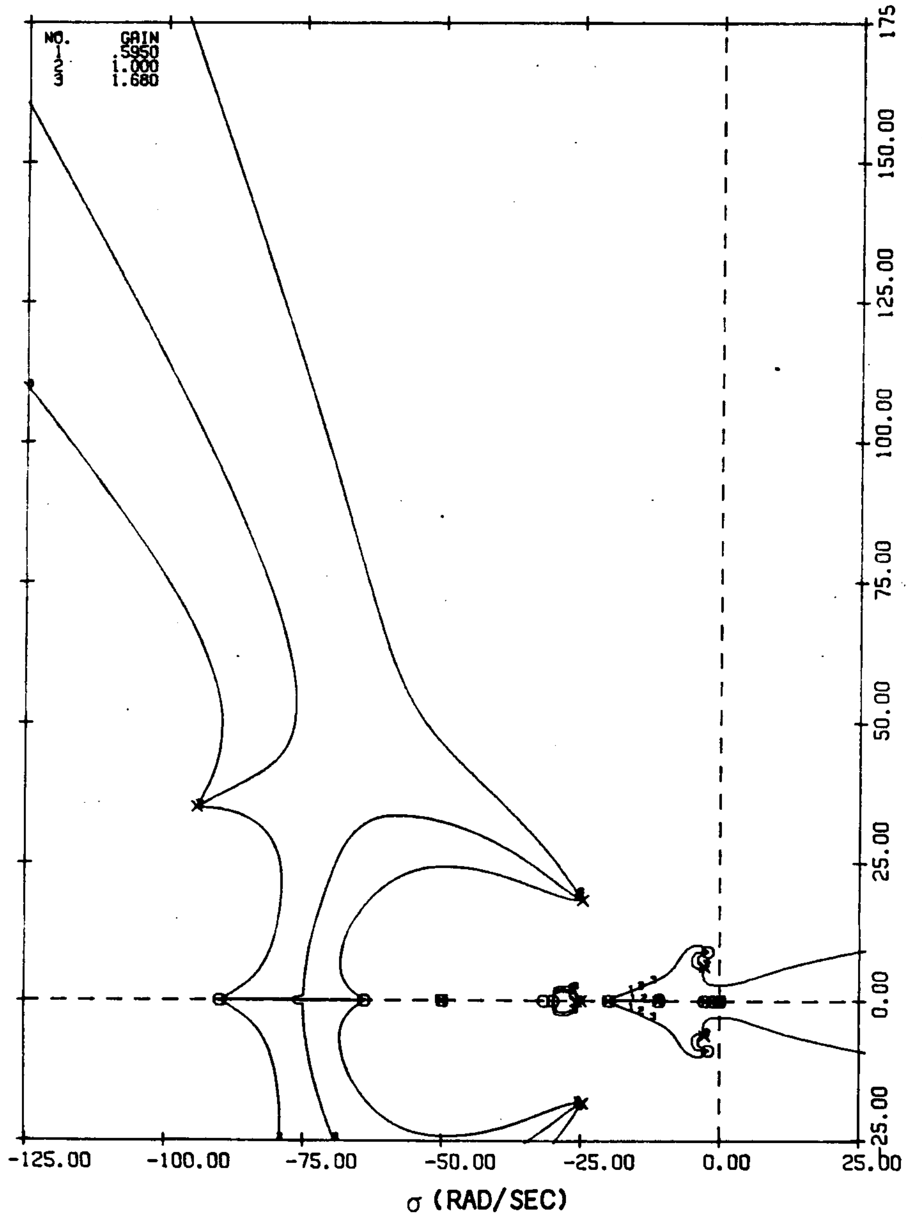


FIGURE 154 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

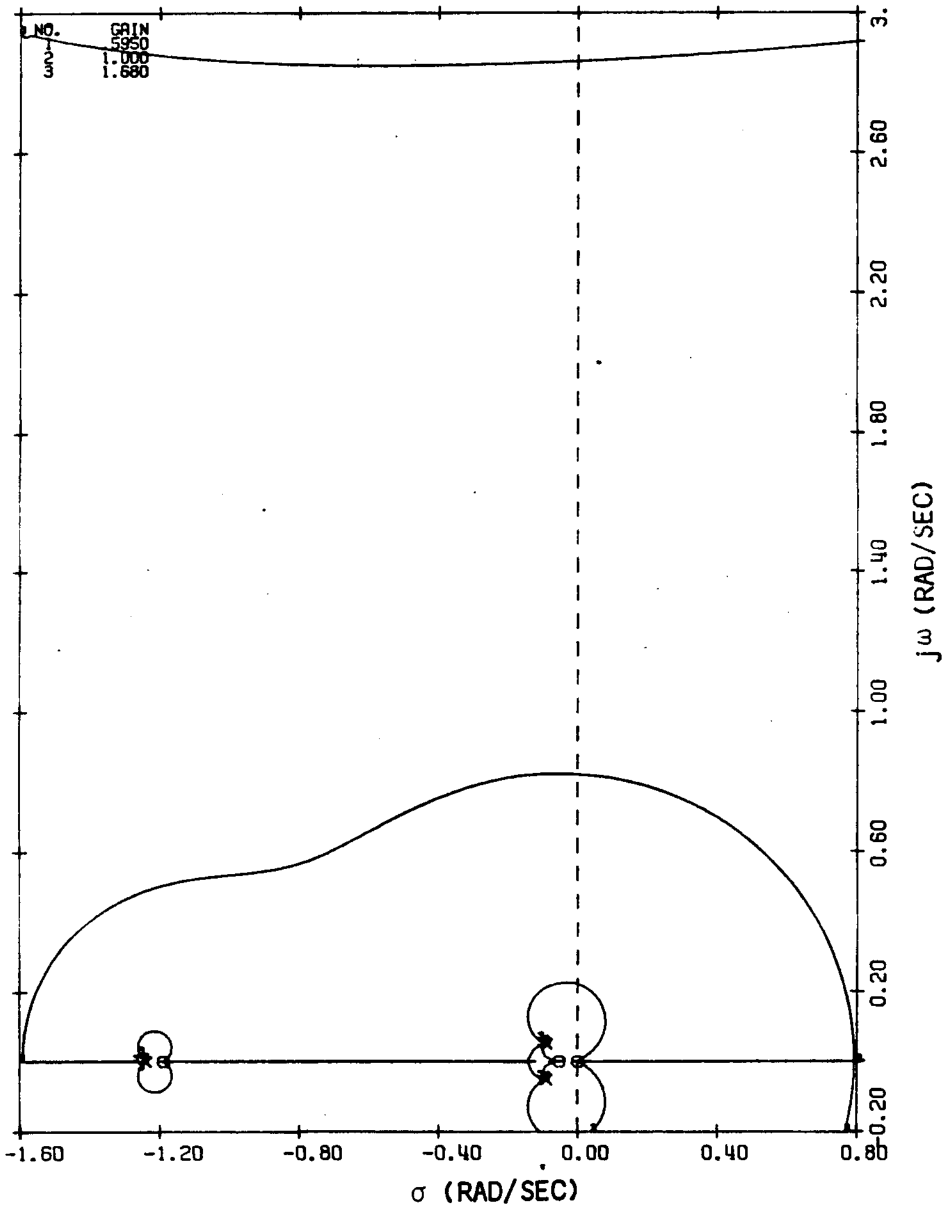


FIGURE 154 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

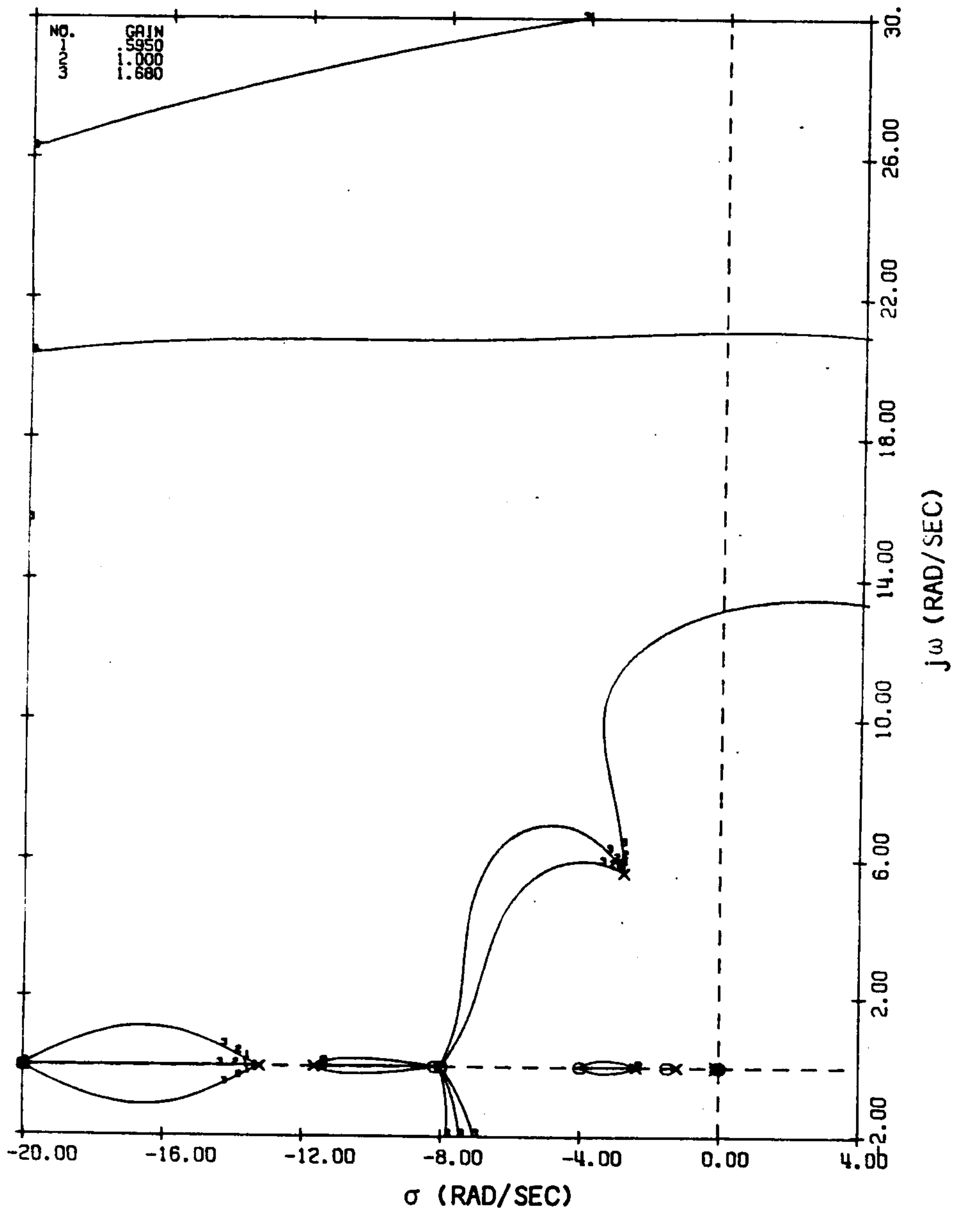


FIGURE 155

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

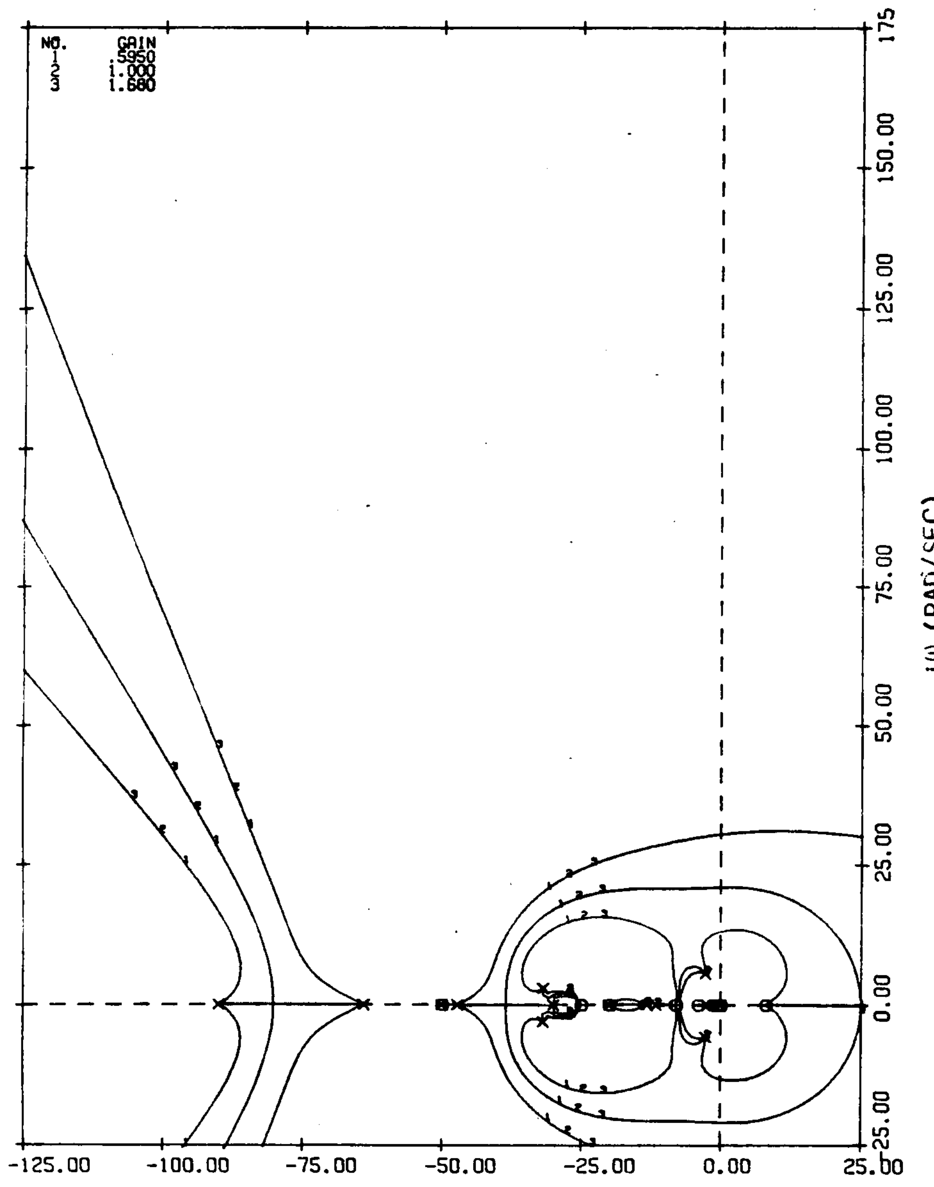


FIGURE 155 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

APPENDIX E

- LAUNCH
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

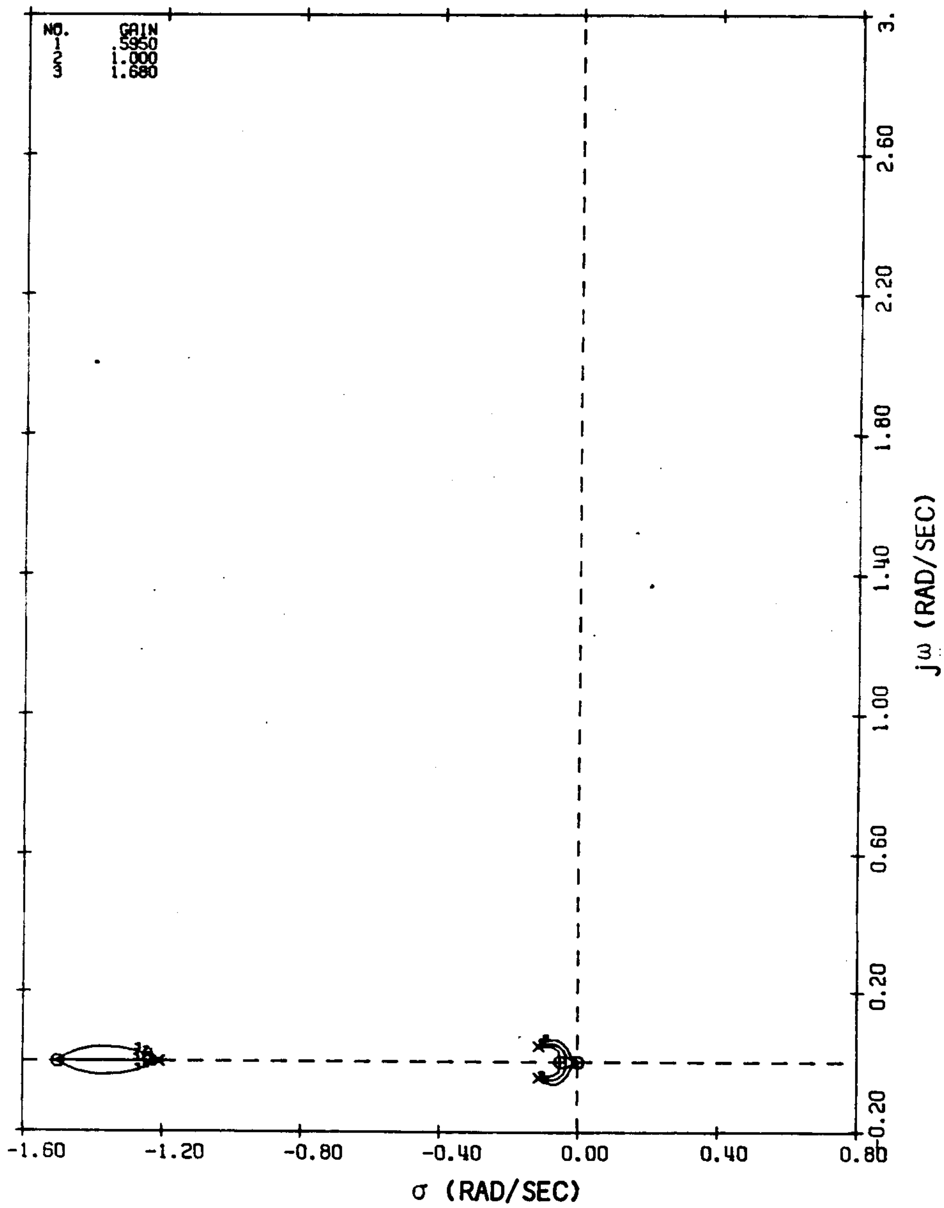


FIGURE 155 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

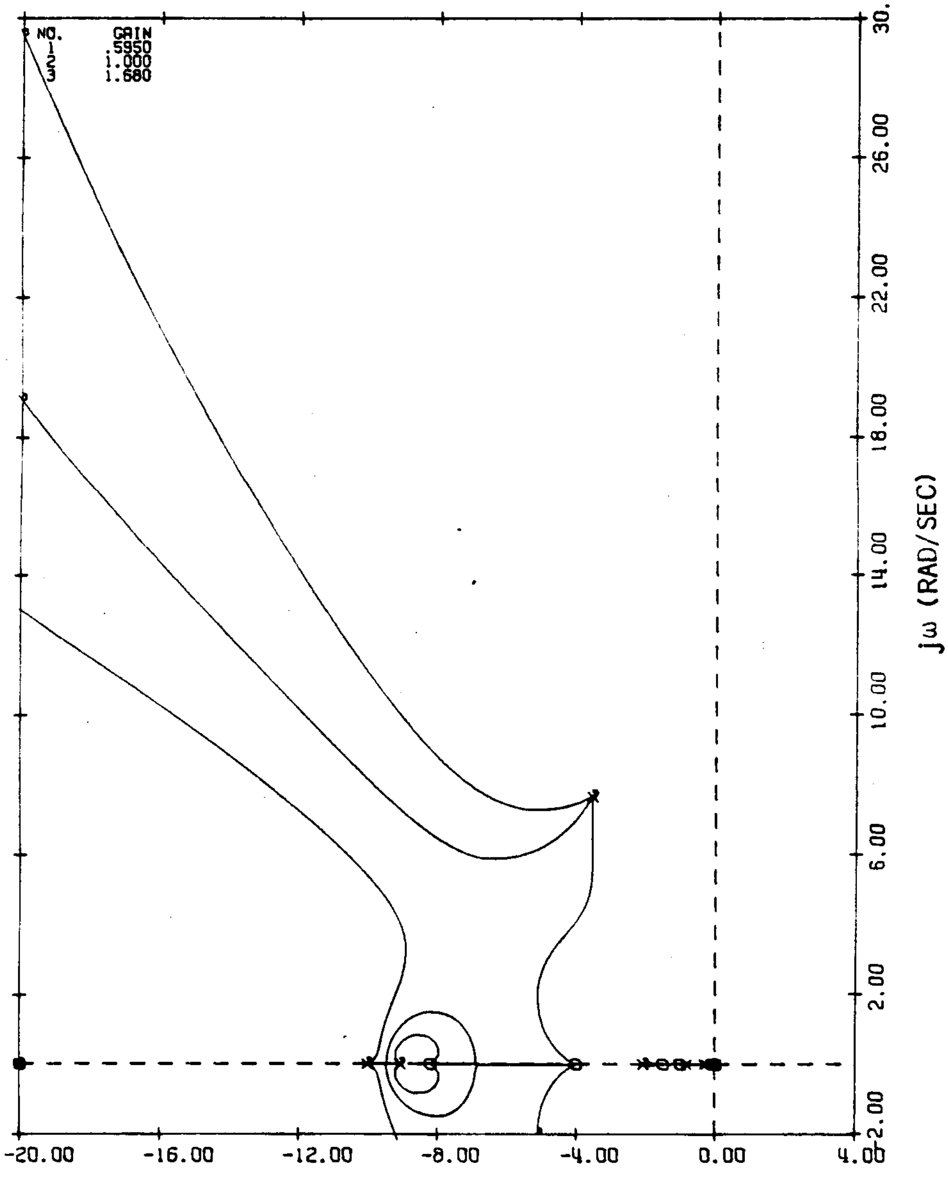


FIGURE 156

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION

- LAUNCH
- BCS WITH RSS CLOSED
- MACH: 0.40
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

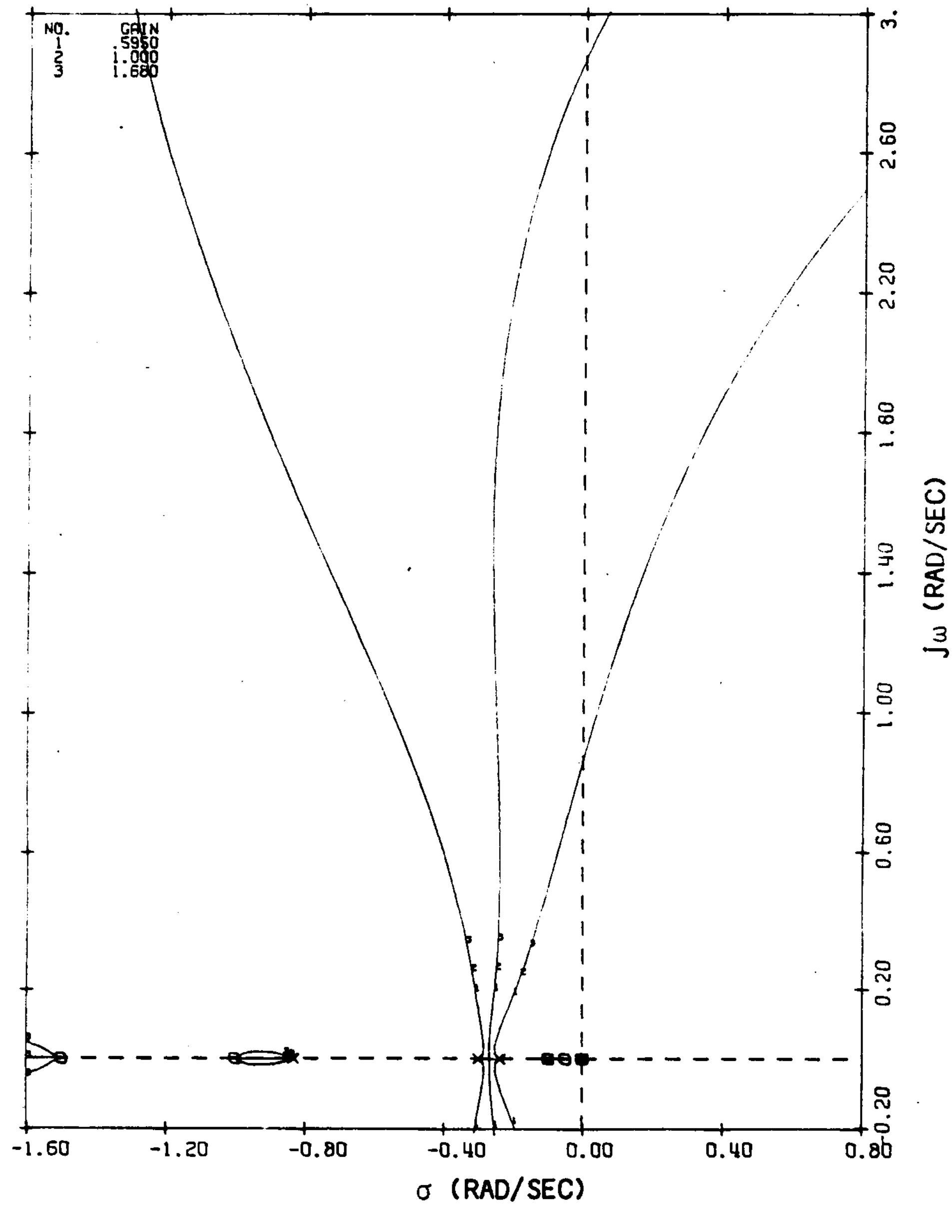


FIGURE 156 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. LAUNCH CONDITION

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

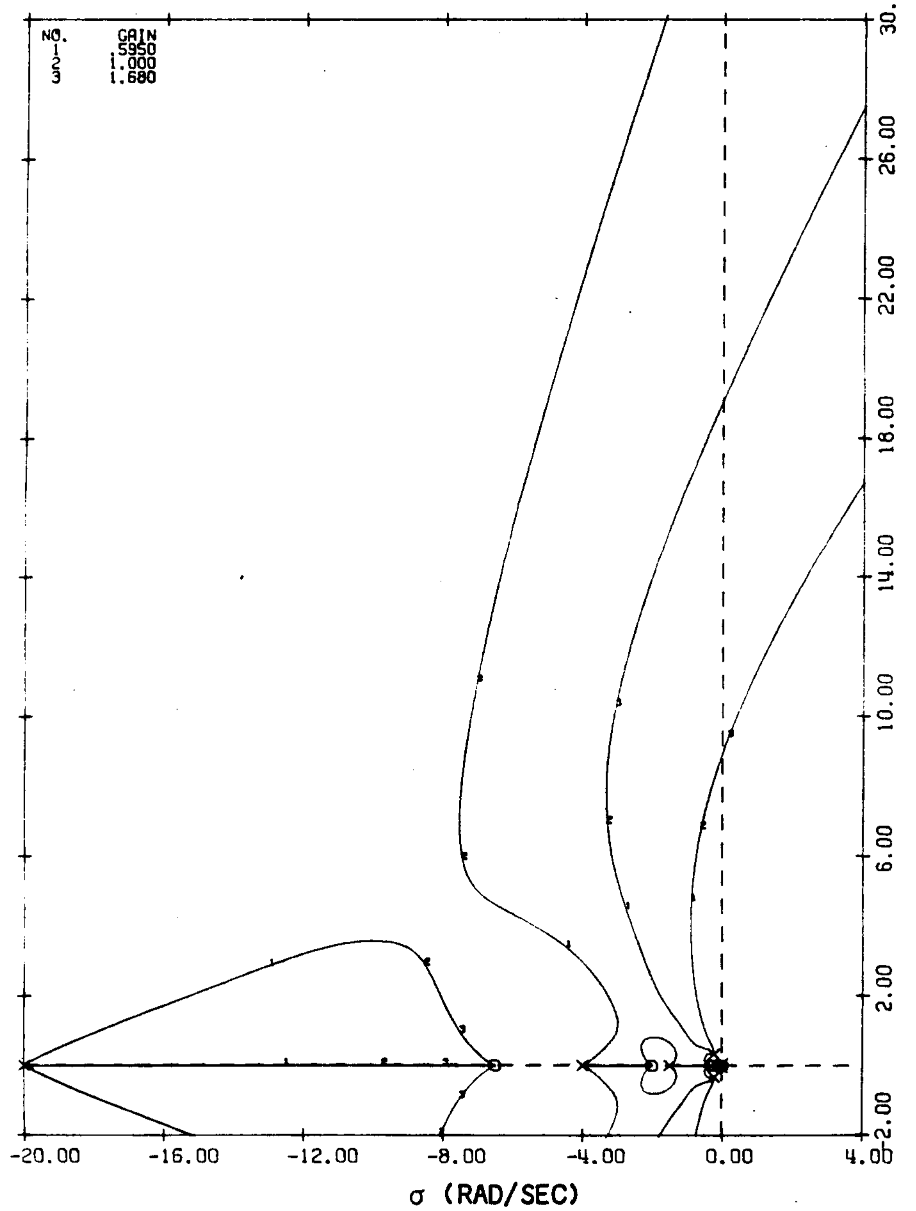


FIGURE 157

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

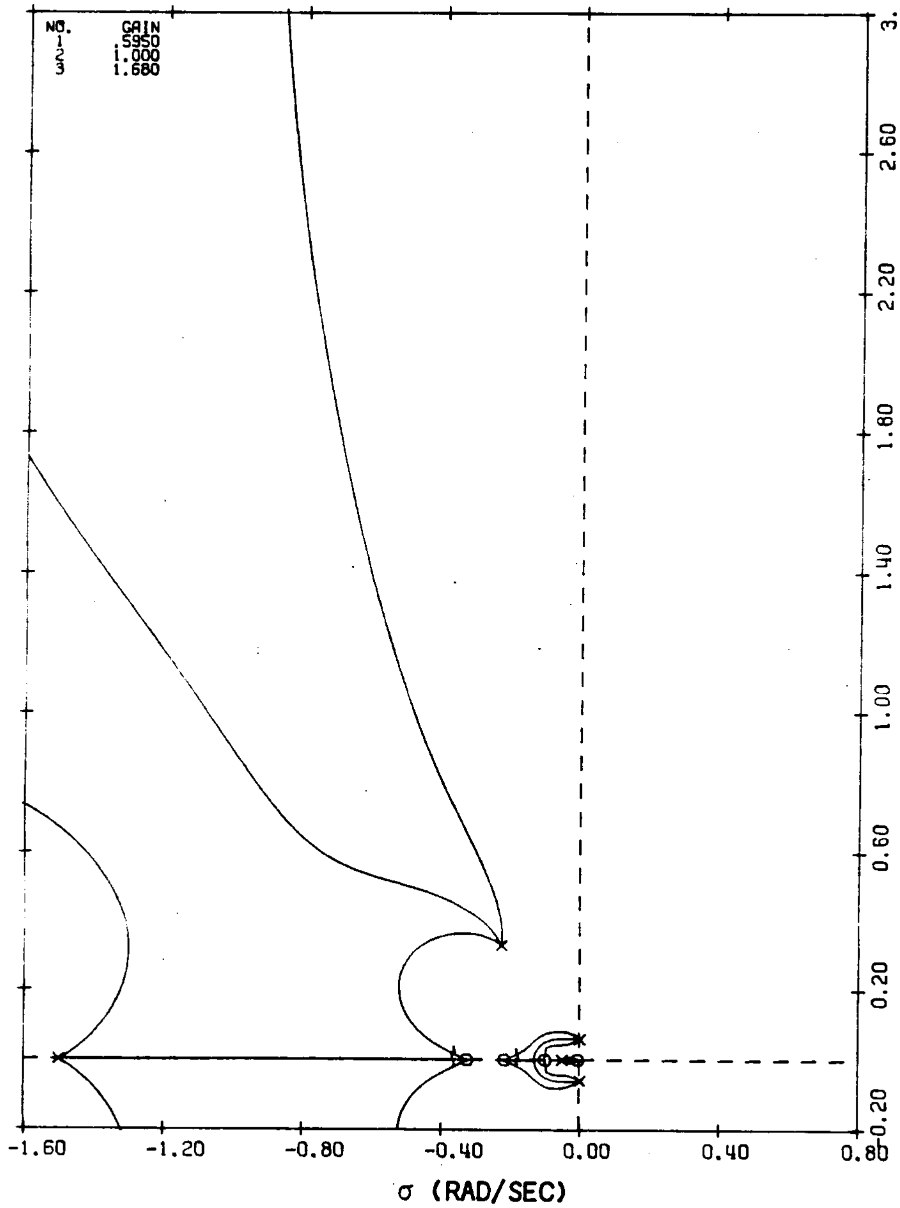


FIGURE 157 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

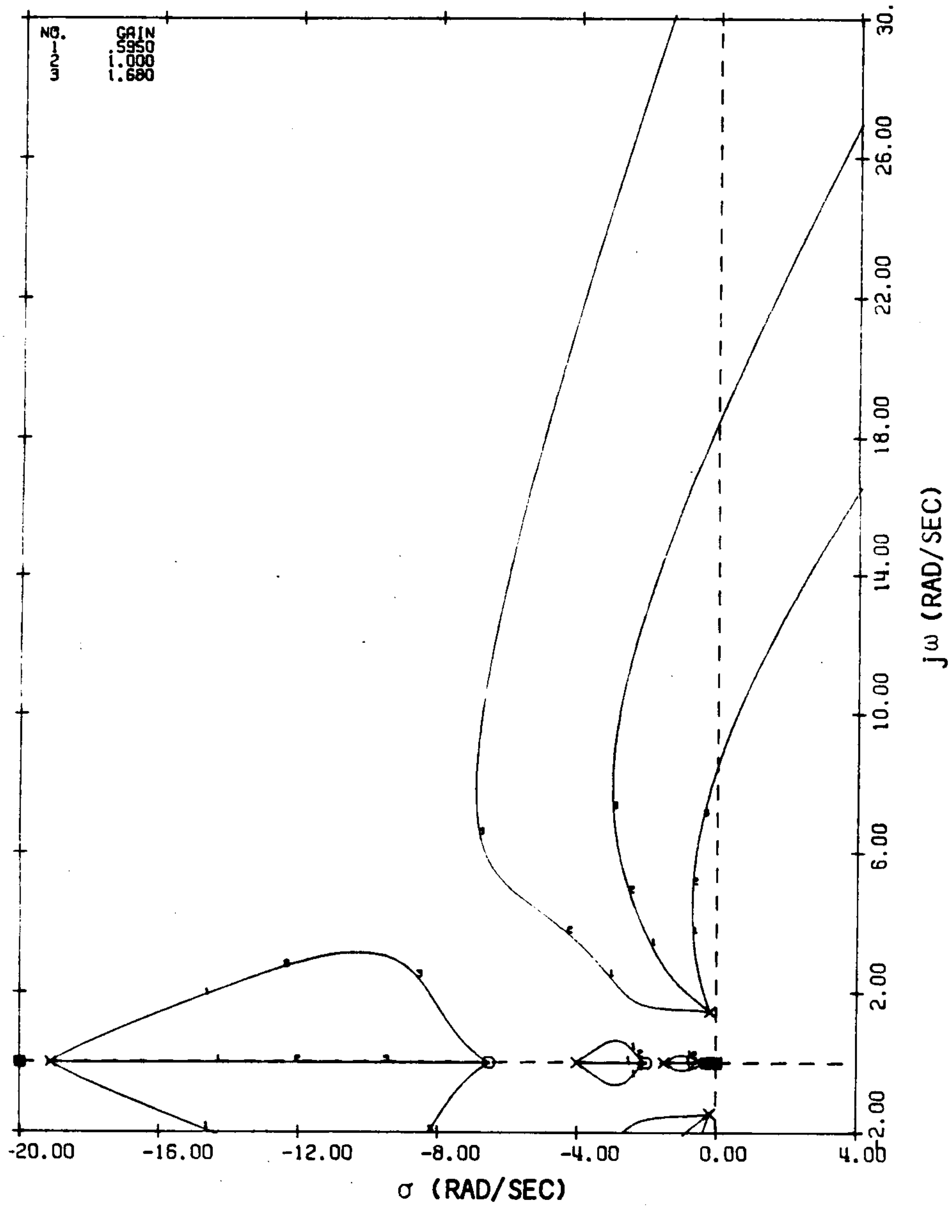


FIGURE 158

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

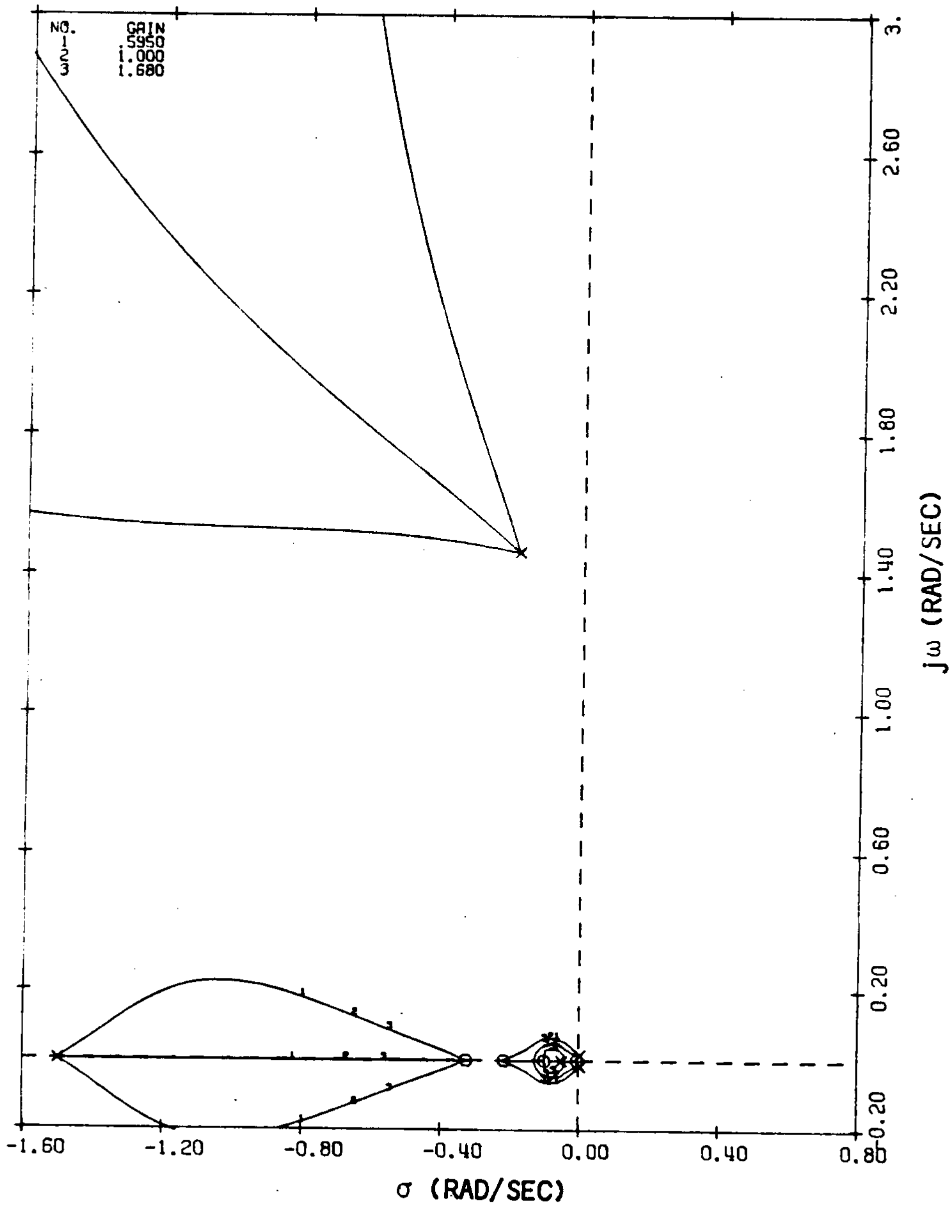


FIGURE 158 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

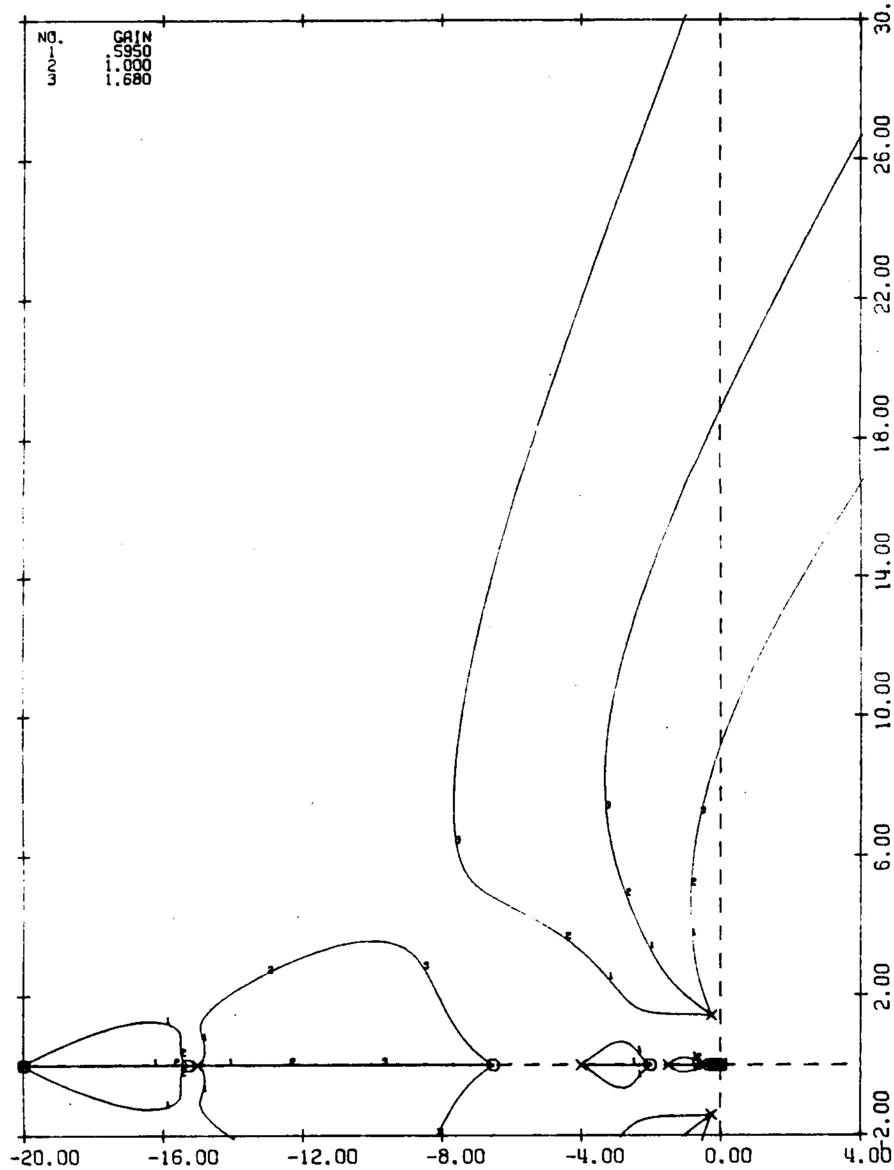


FIGURE 159

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

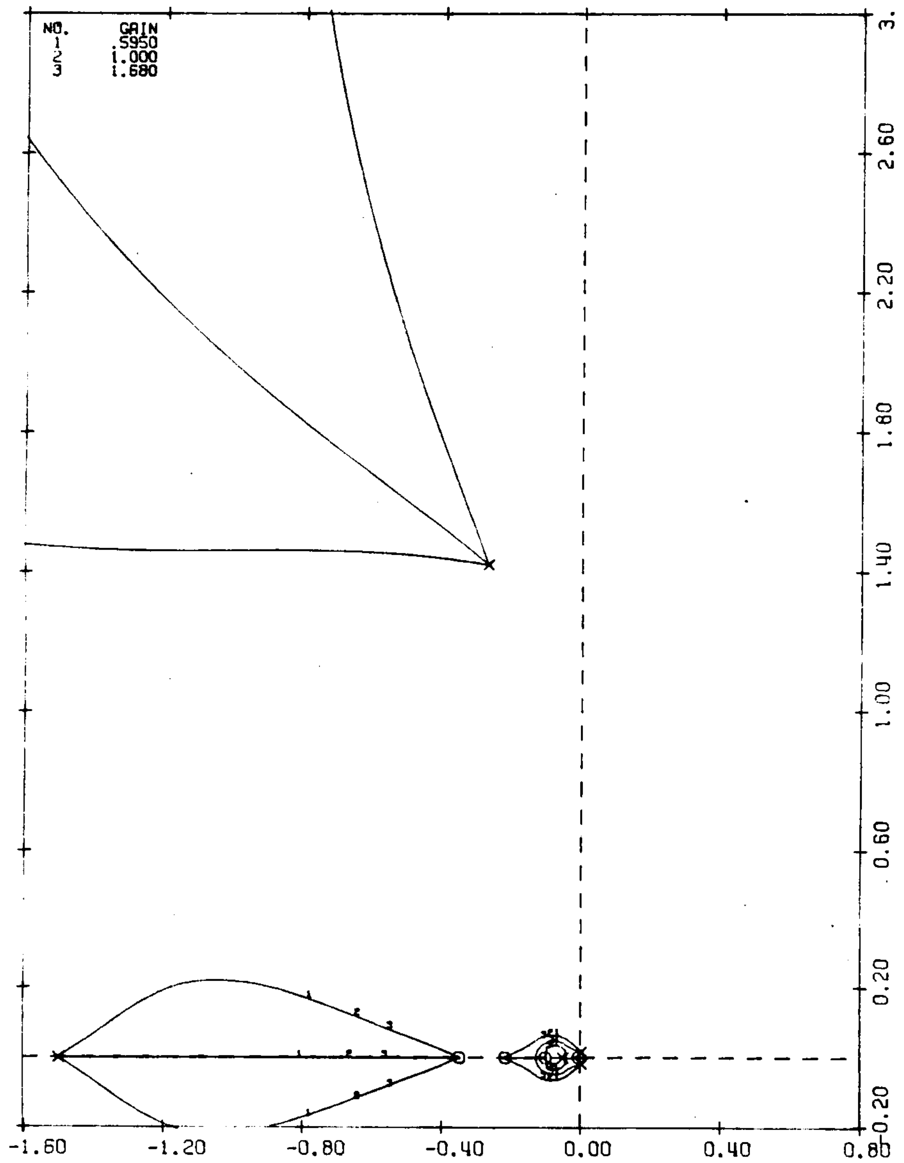


FIGURE 159 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

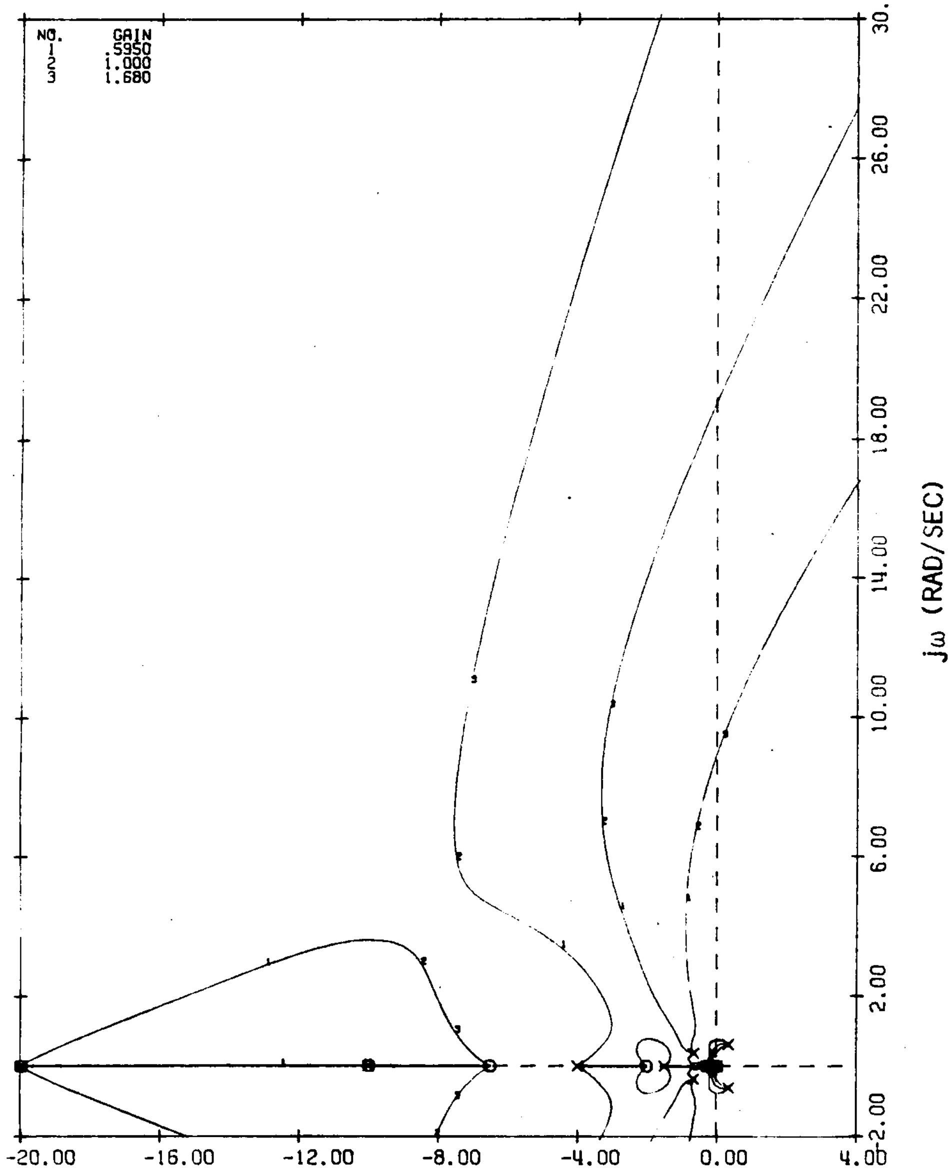


FIGURE 160

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

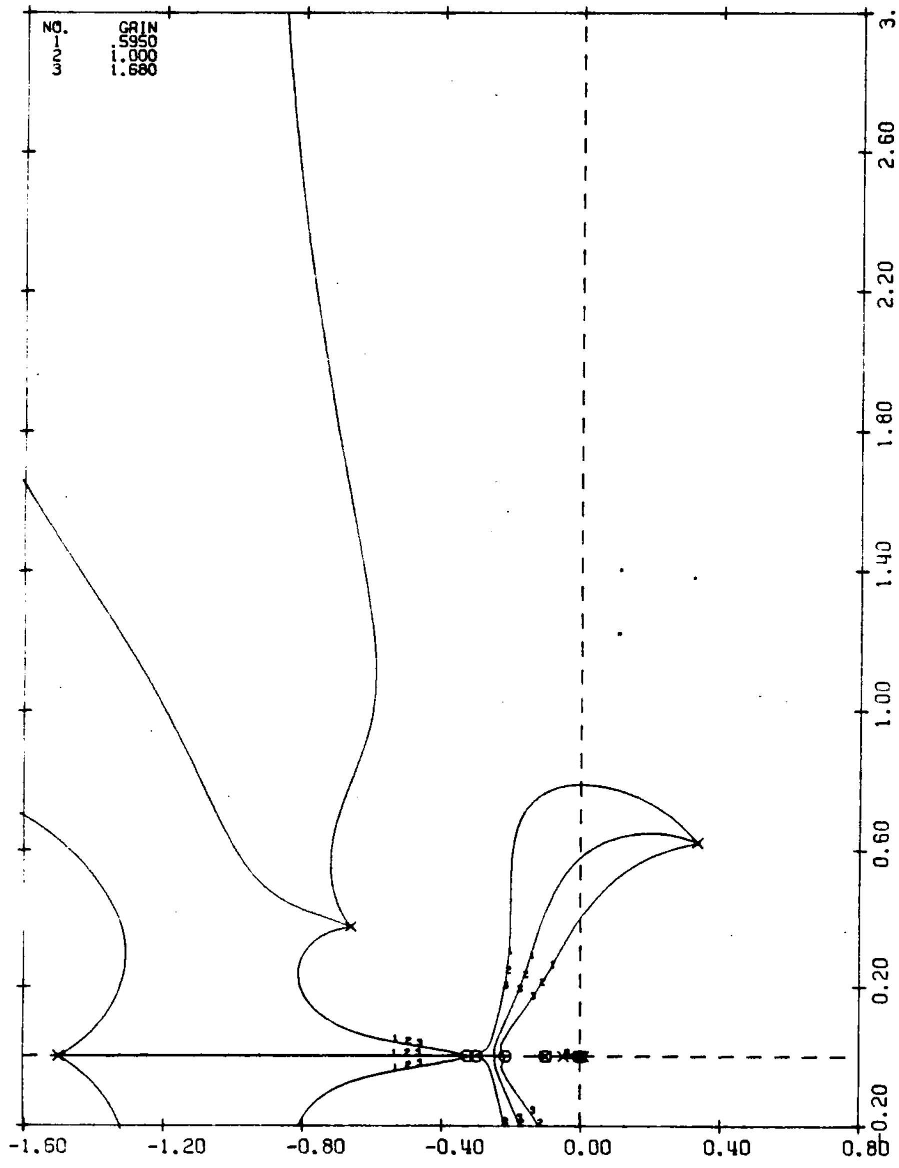


FIGURE 160 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

C-4

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

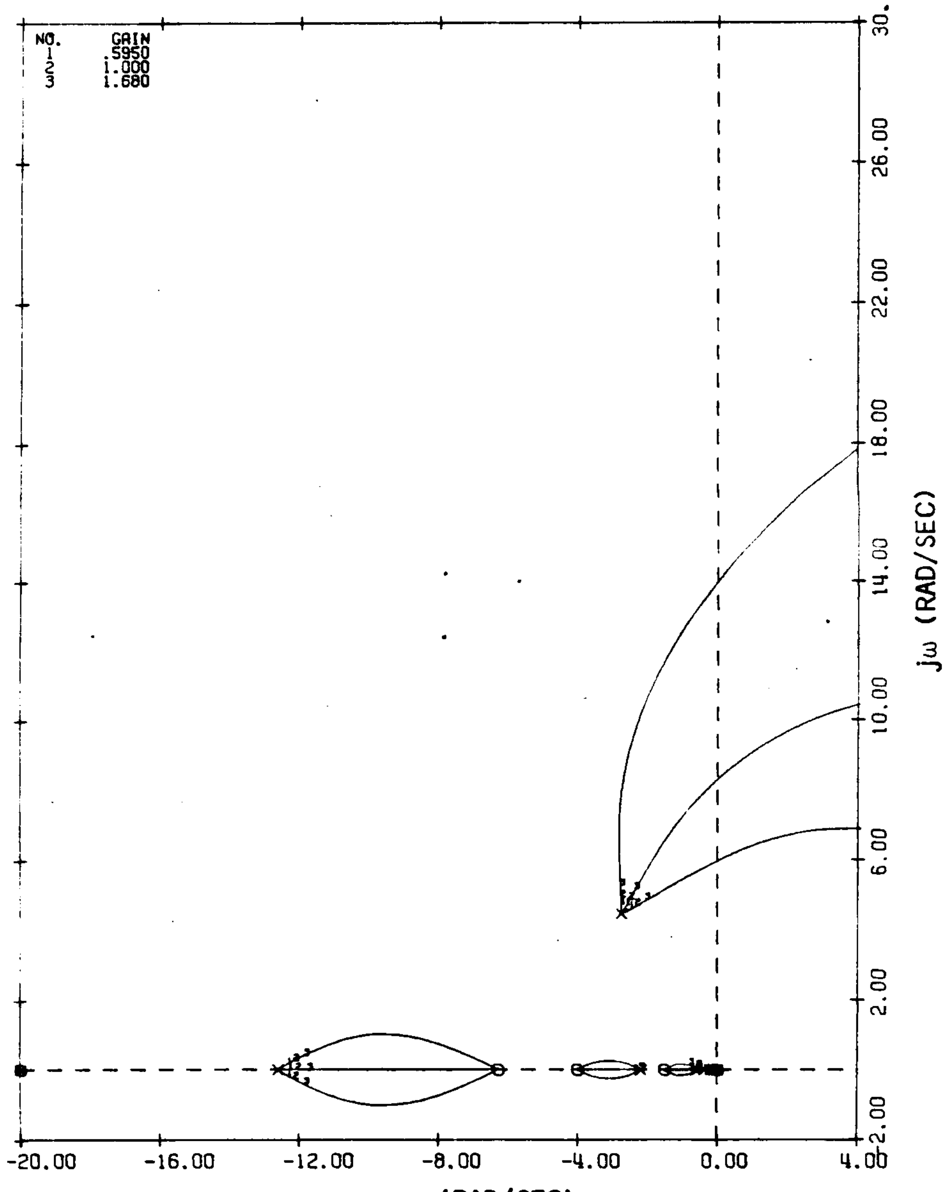


FIGURE 161

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

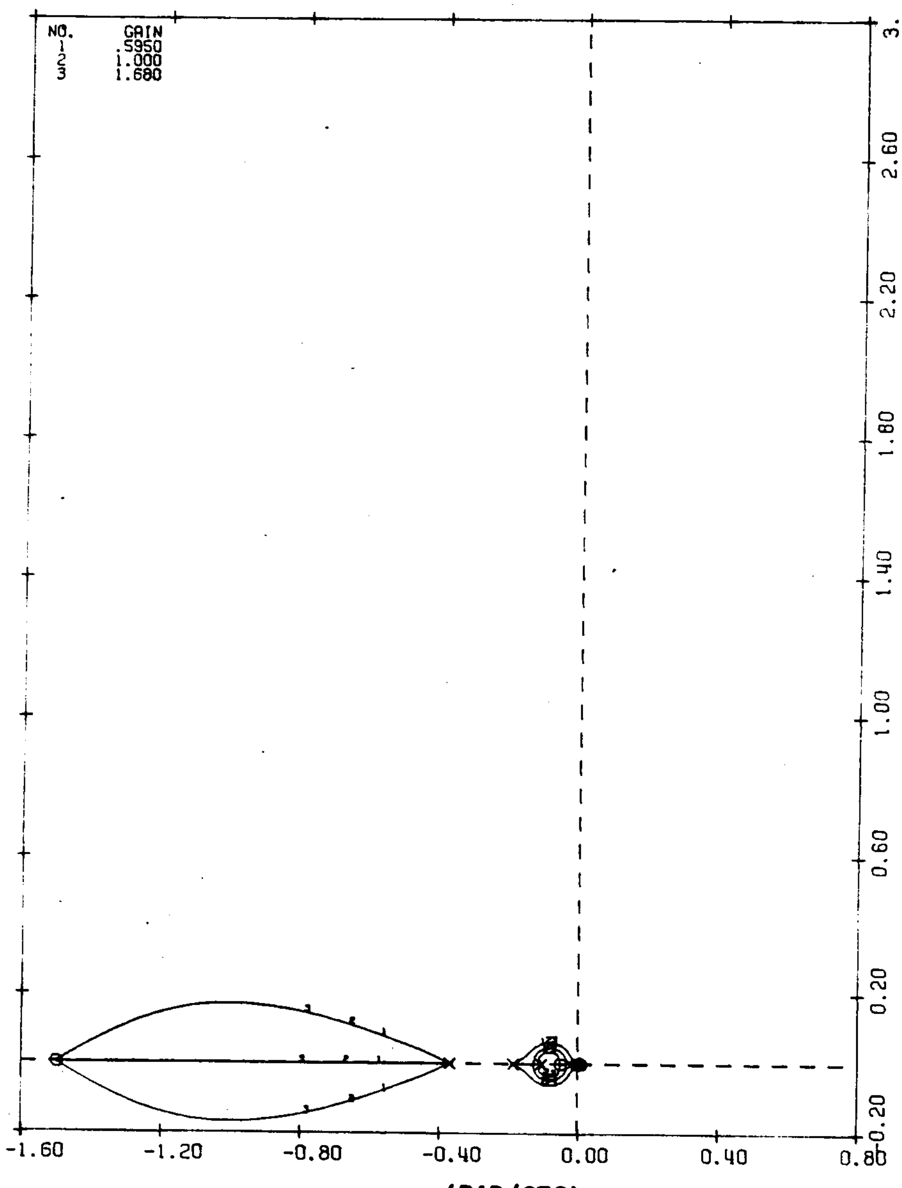


FIGURE 161 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

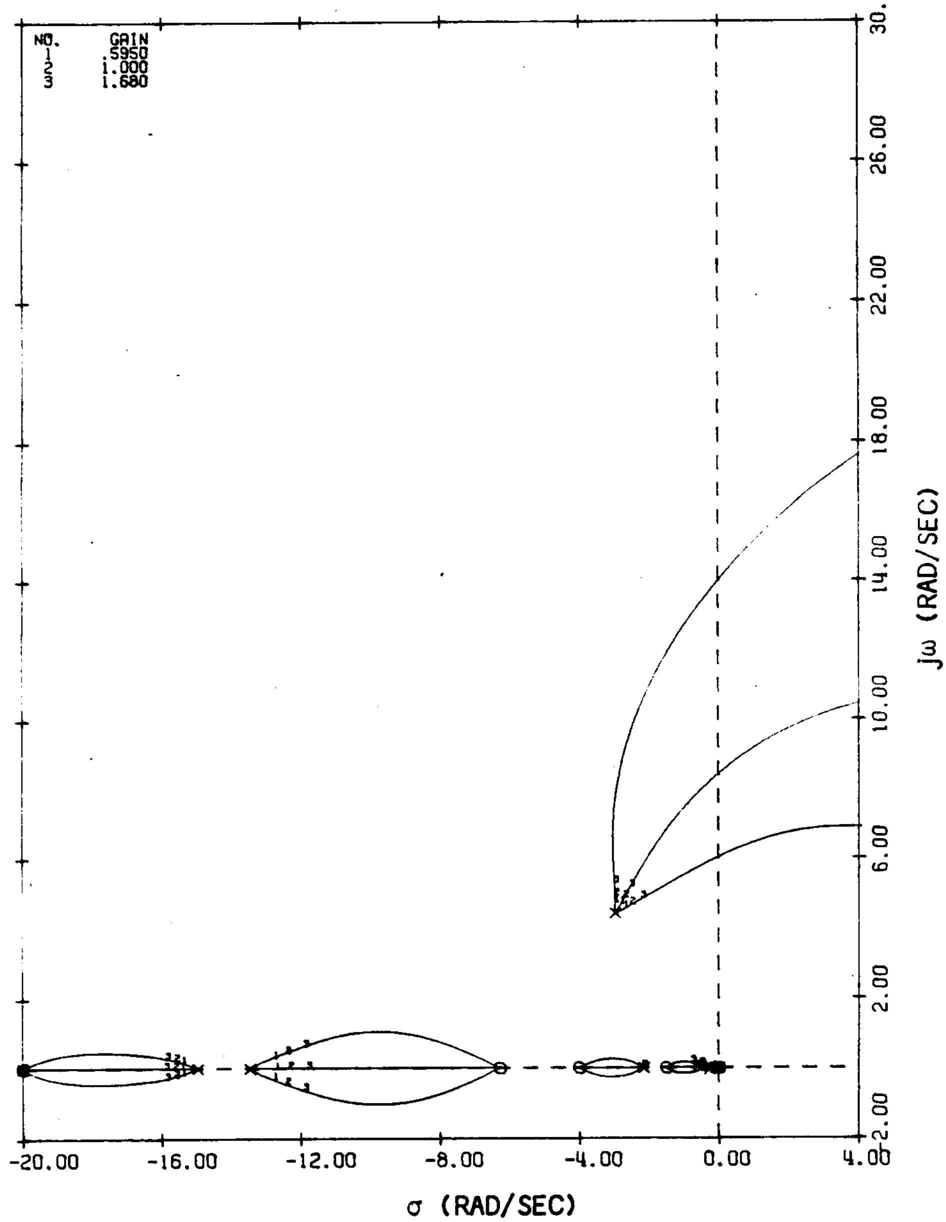


FIGURE 162

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

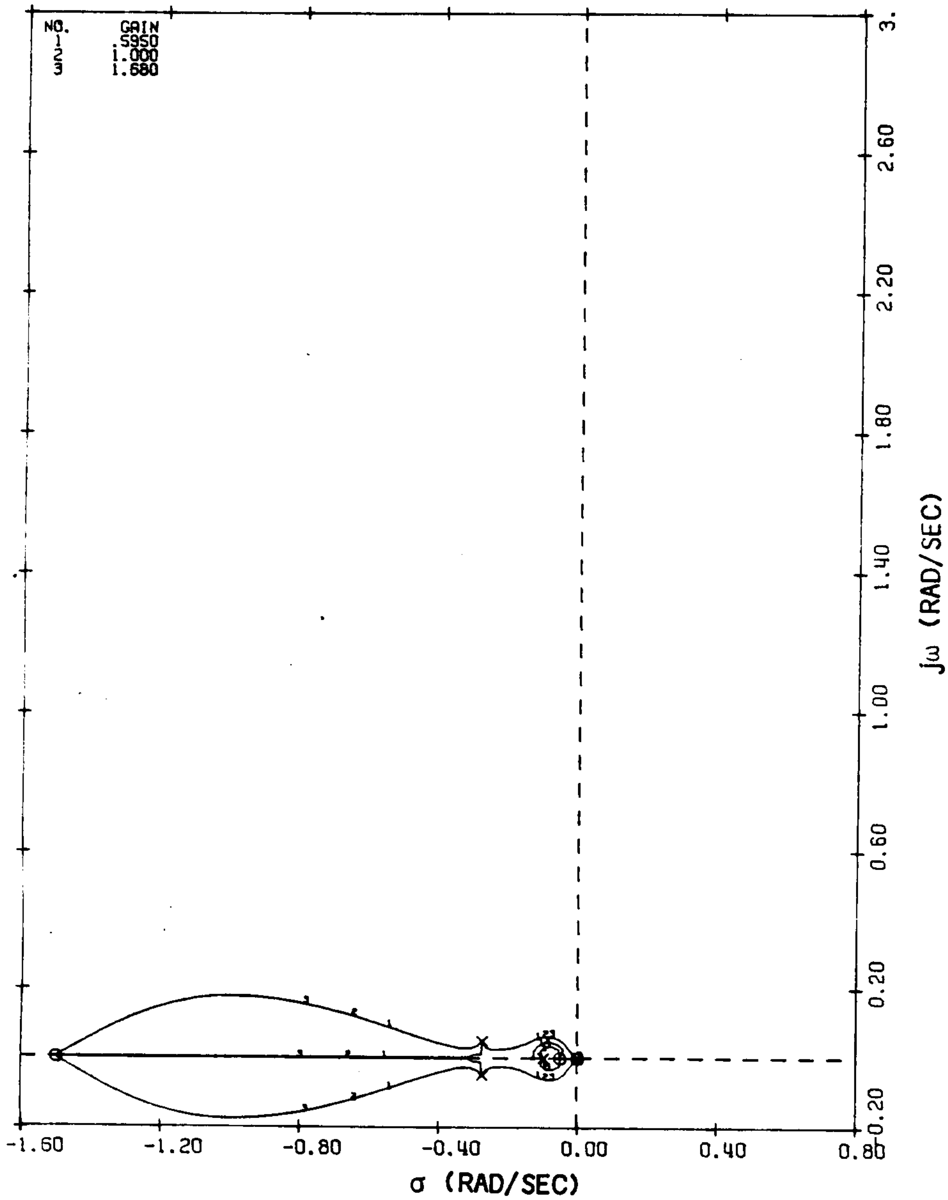


FIGURE 162 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

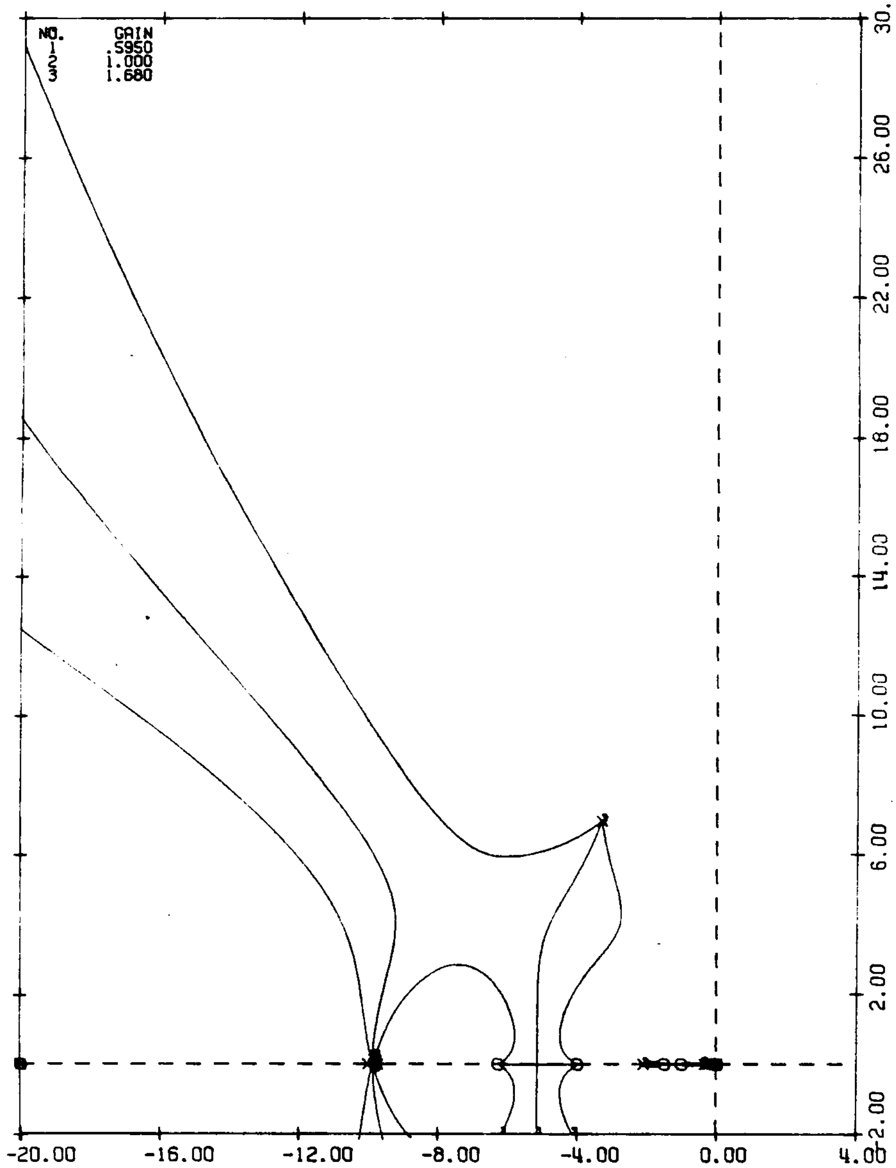


FIGURE 163

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

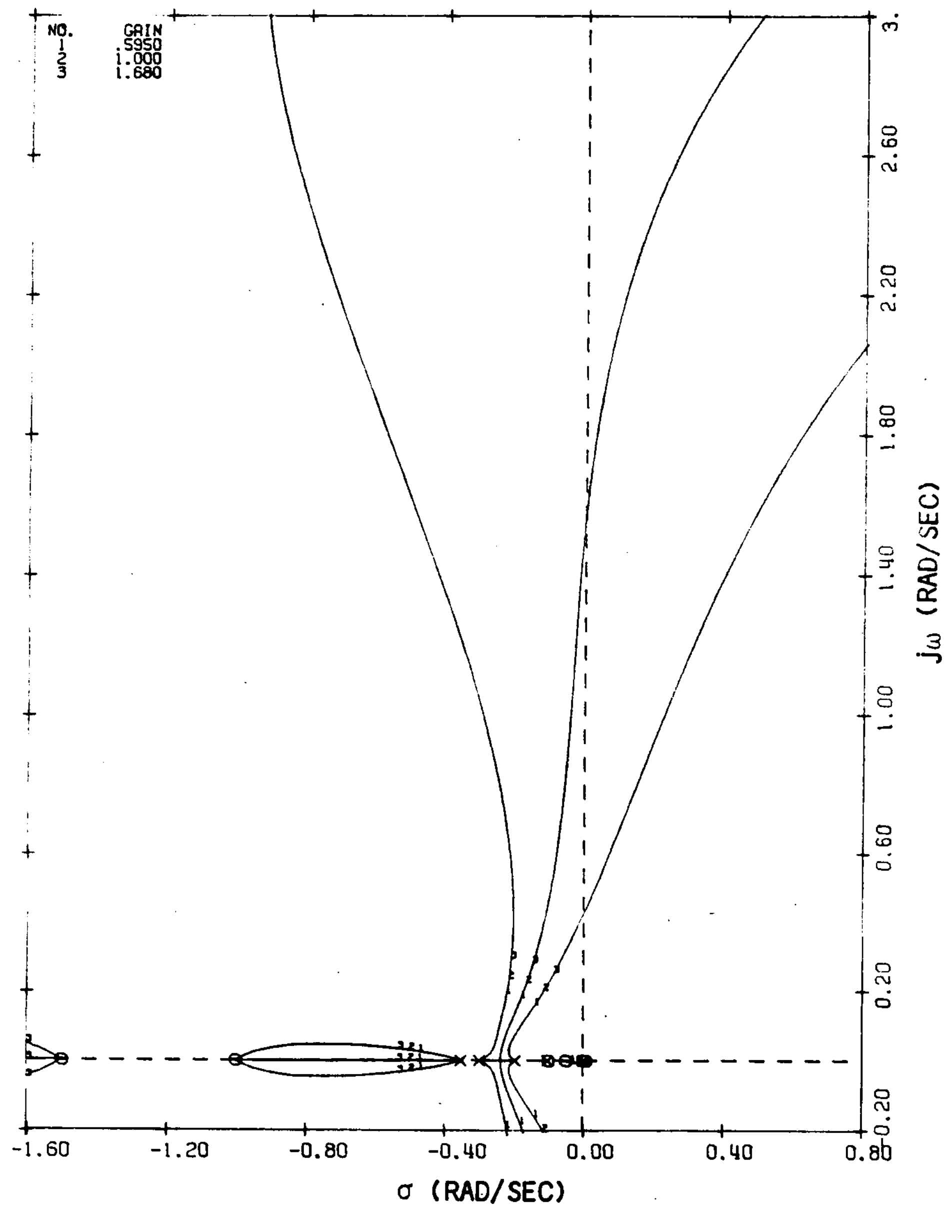


FIGURE 163 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

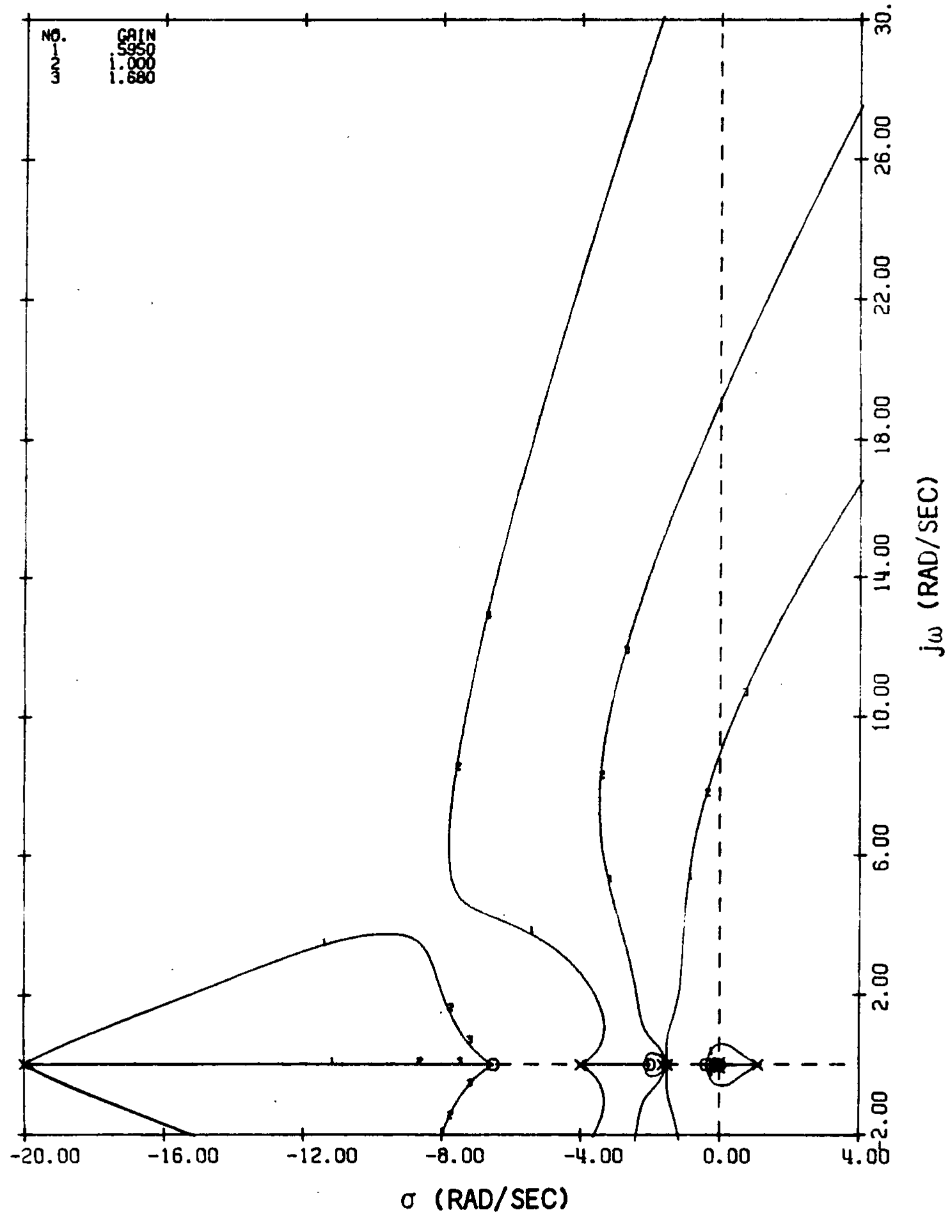


FIGURE 164

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

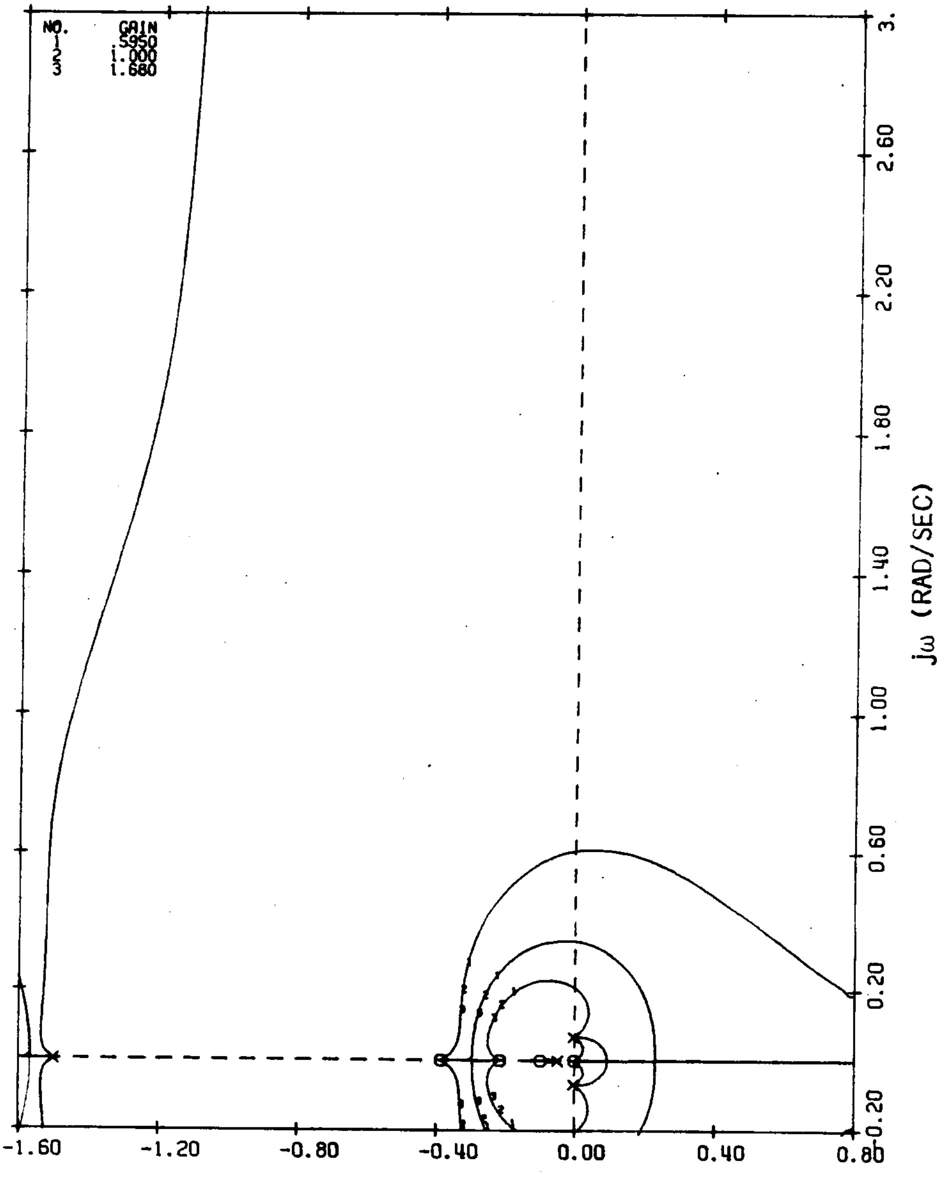


FIGURE 164 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

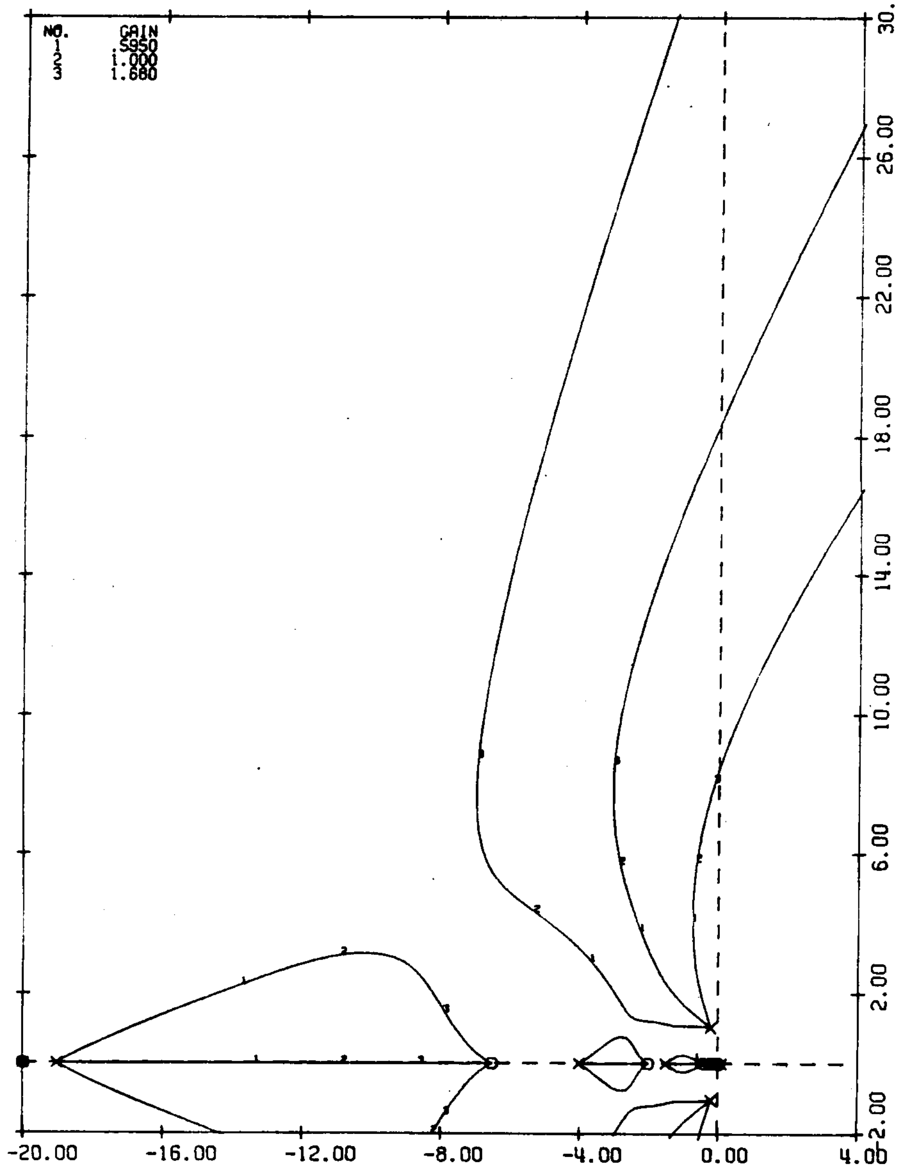


FIGURE 165

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- RSS WITH PCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

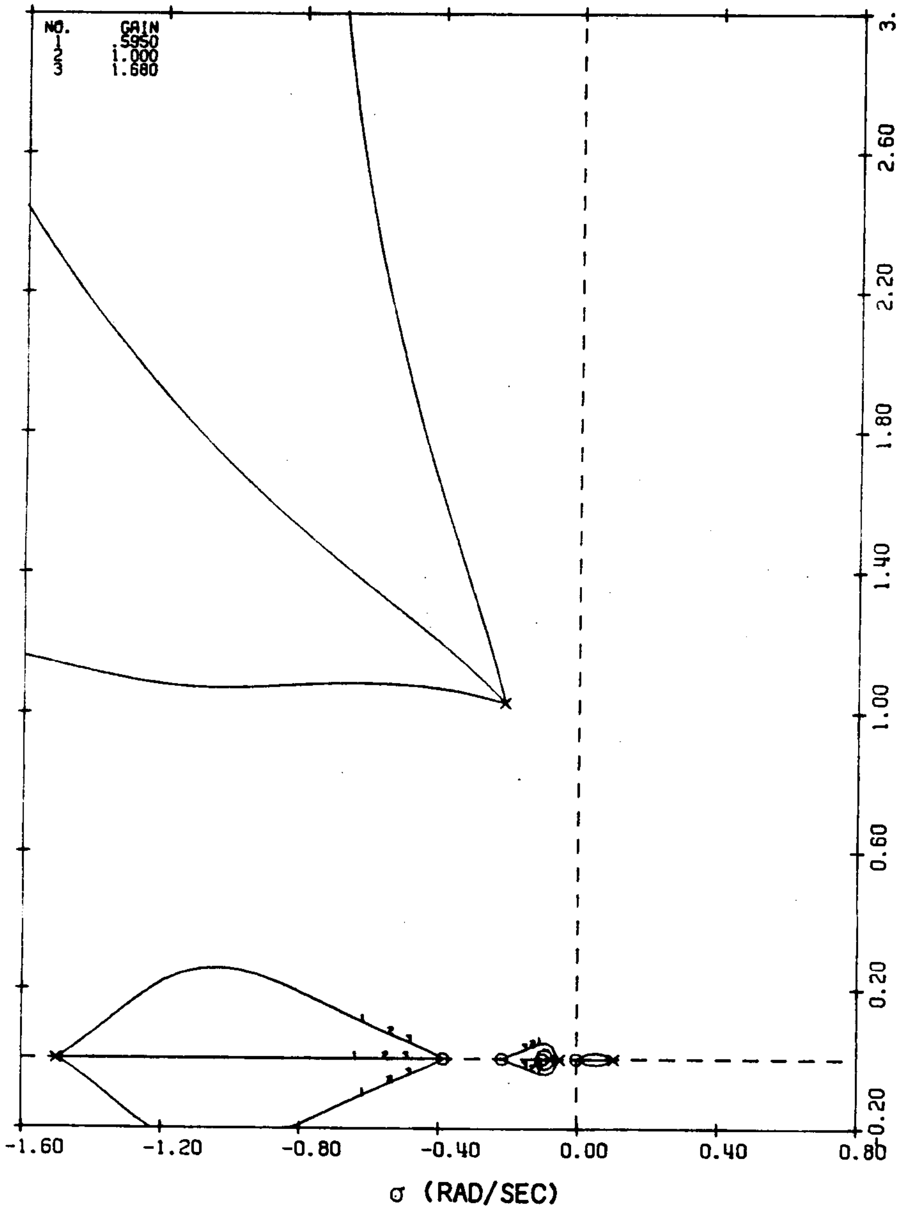


FIGURE 165 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

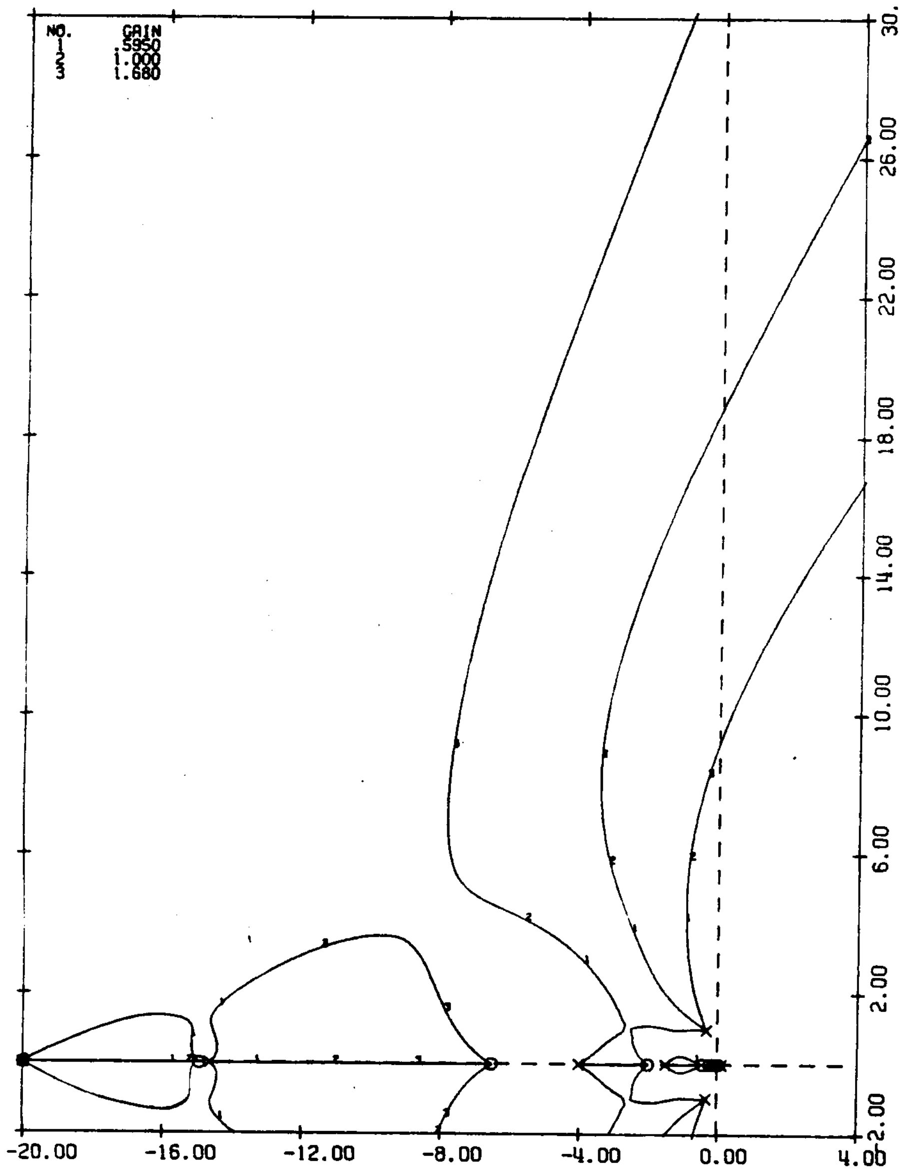


FIGURE 166

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

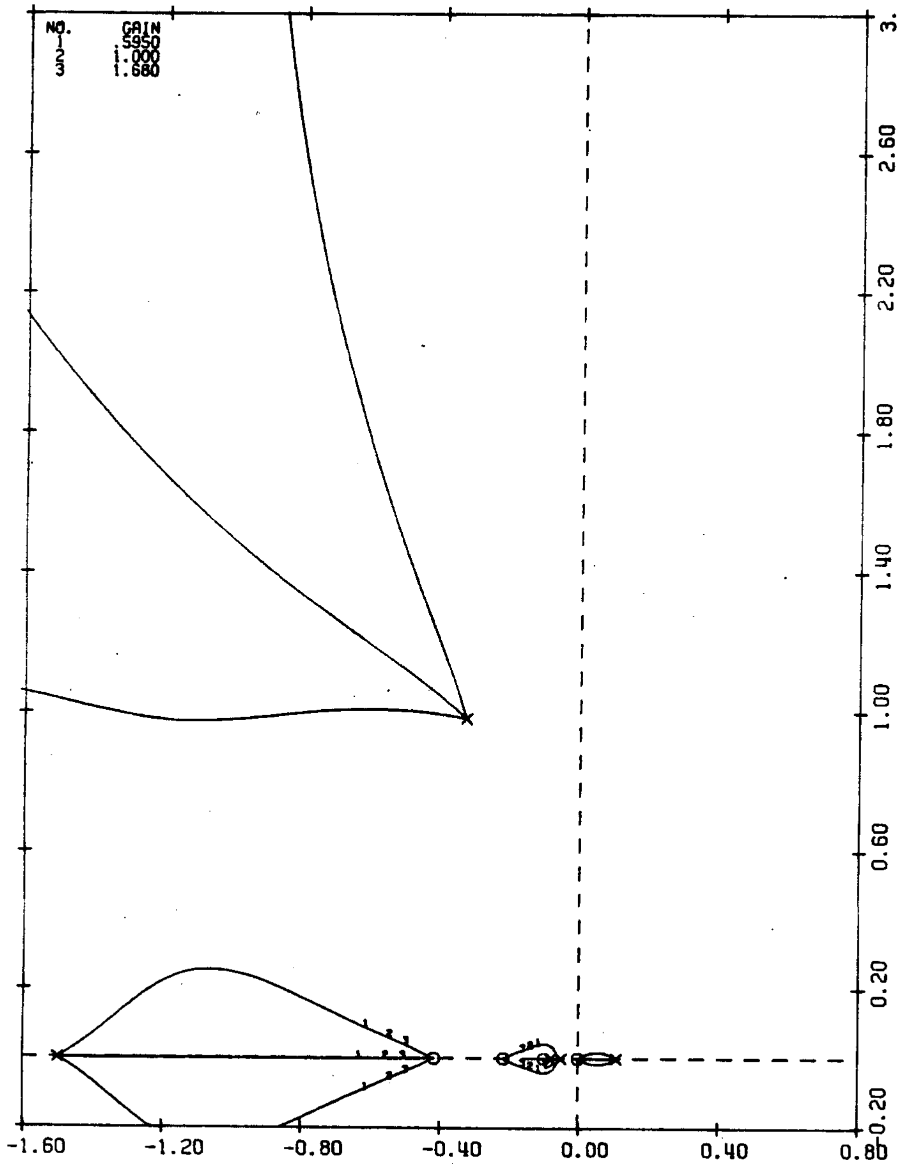


FIGURE 166 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

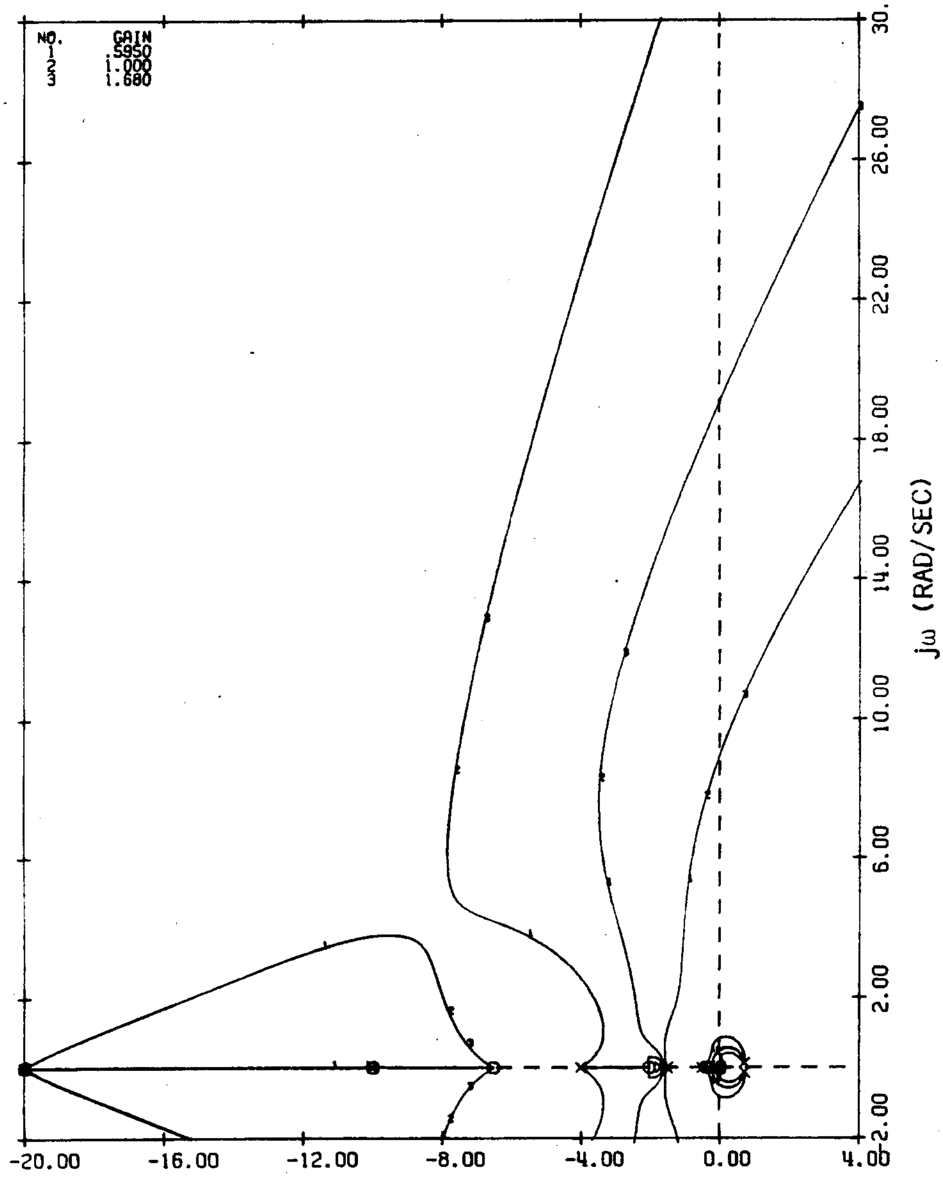


FIGURE 167

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- RSS WITH BCS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

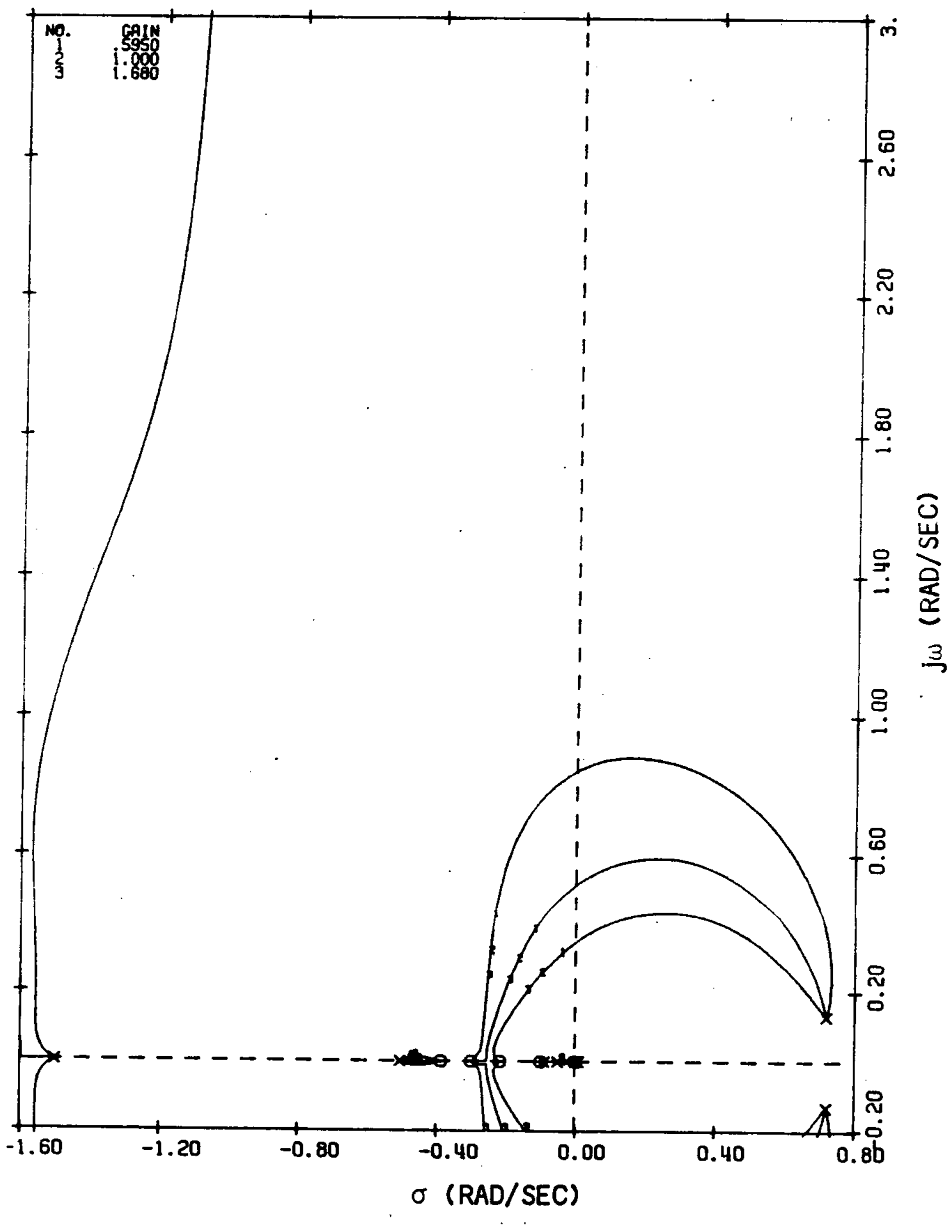


FIGURE 167 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

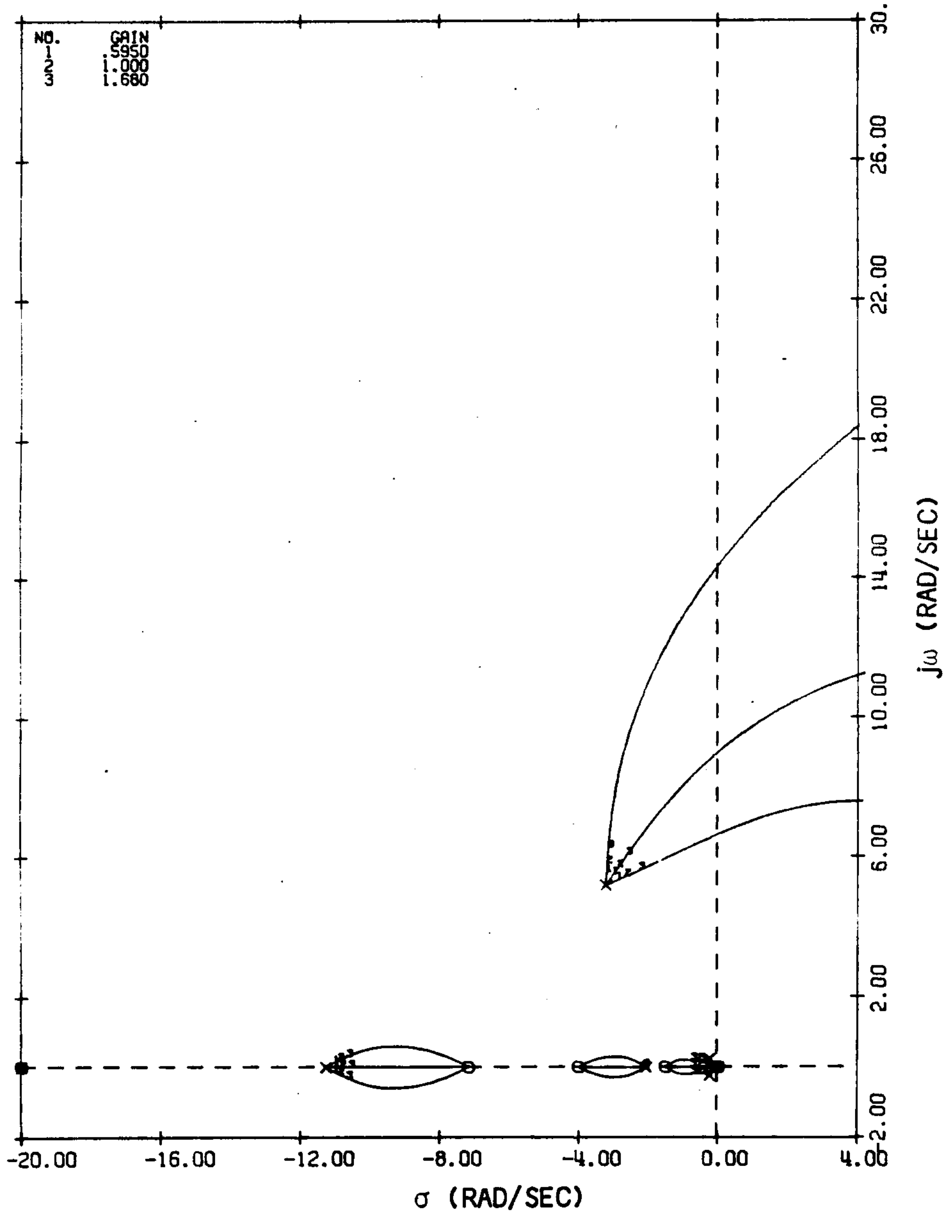


FIGURE 168

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- PCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

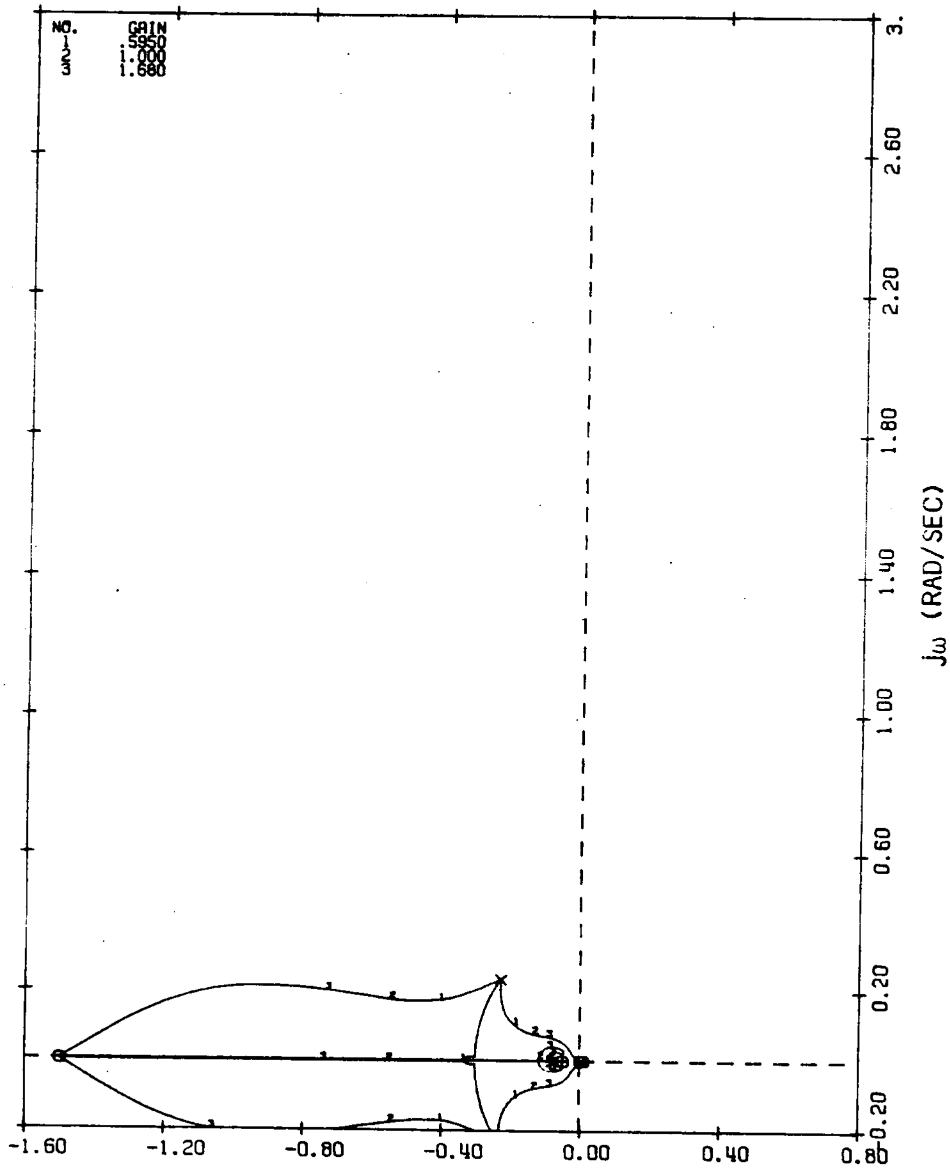


FIGURE 168 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

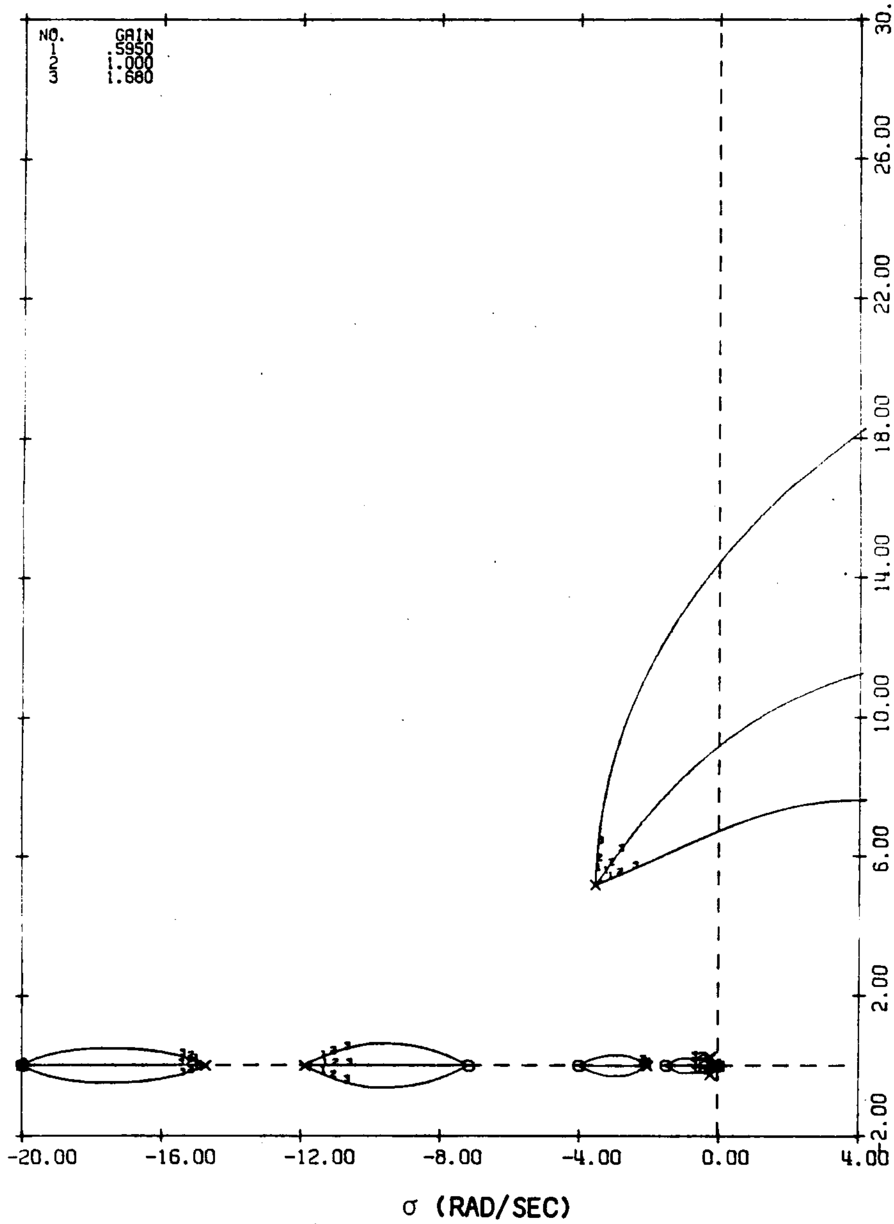


FIGURE 169

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

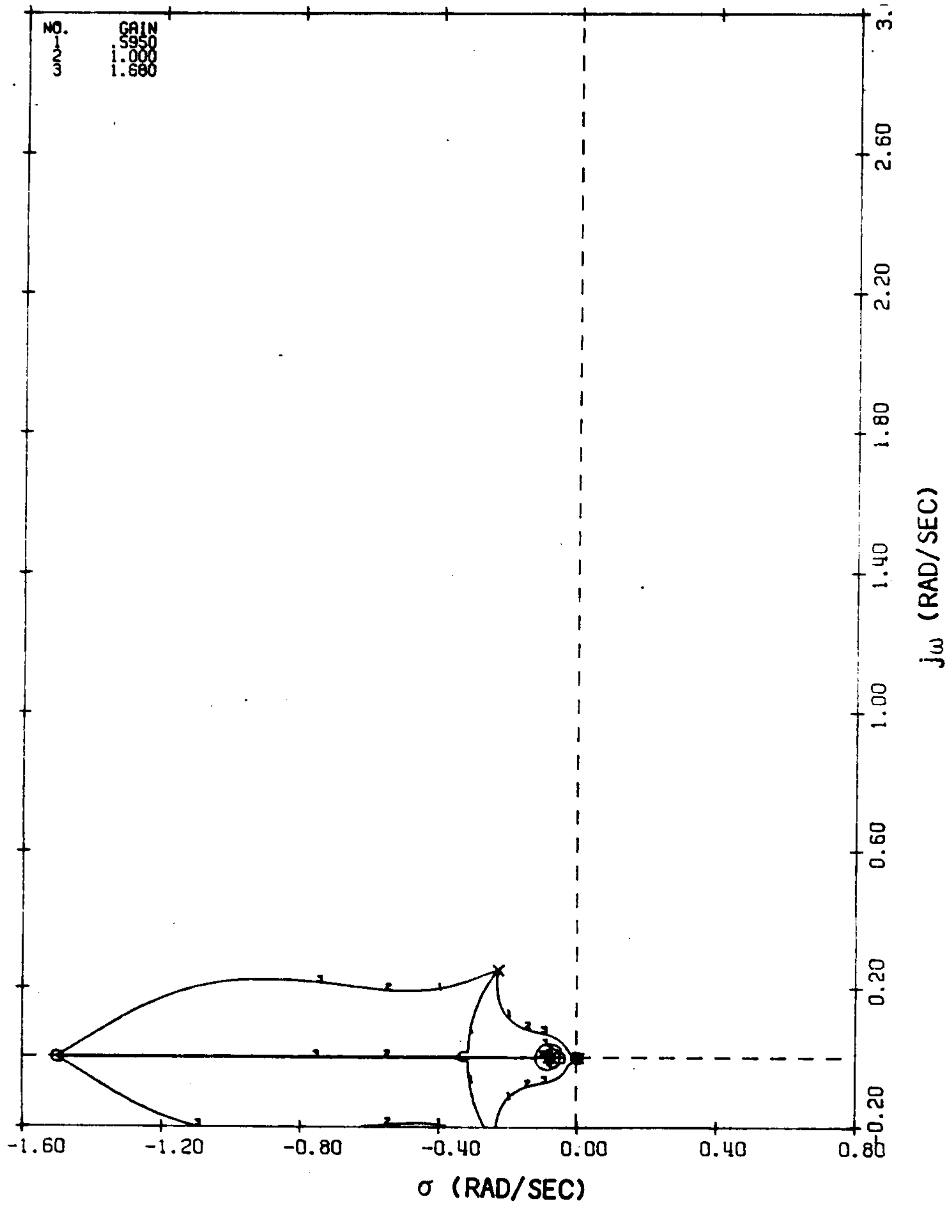


FIGURE 169 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

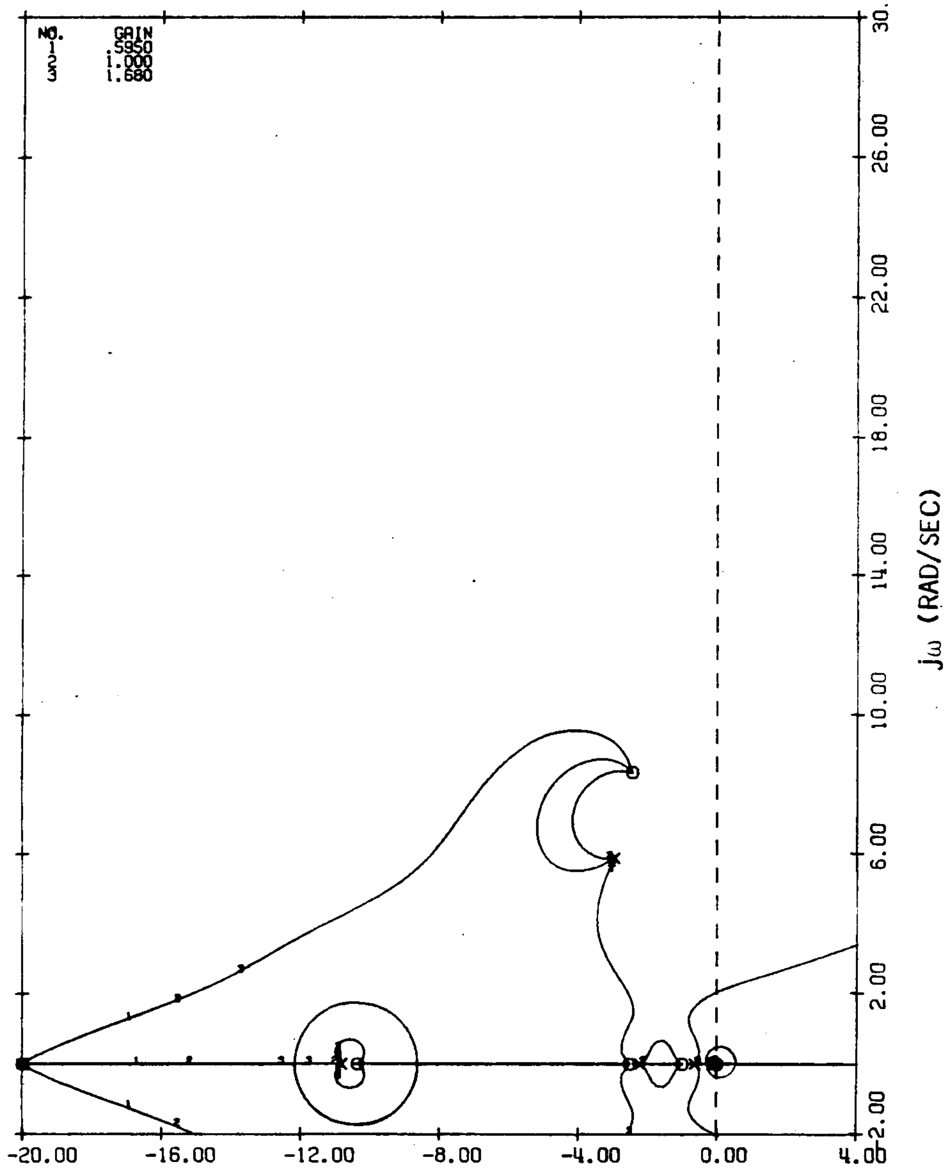


FIGURE 170

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

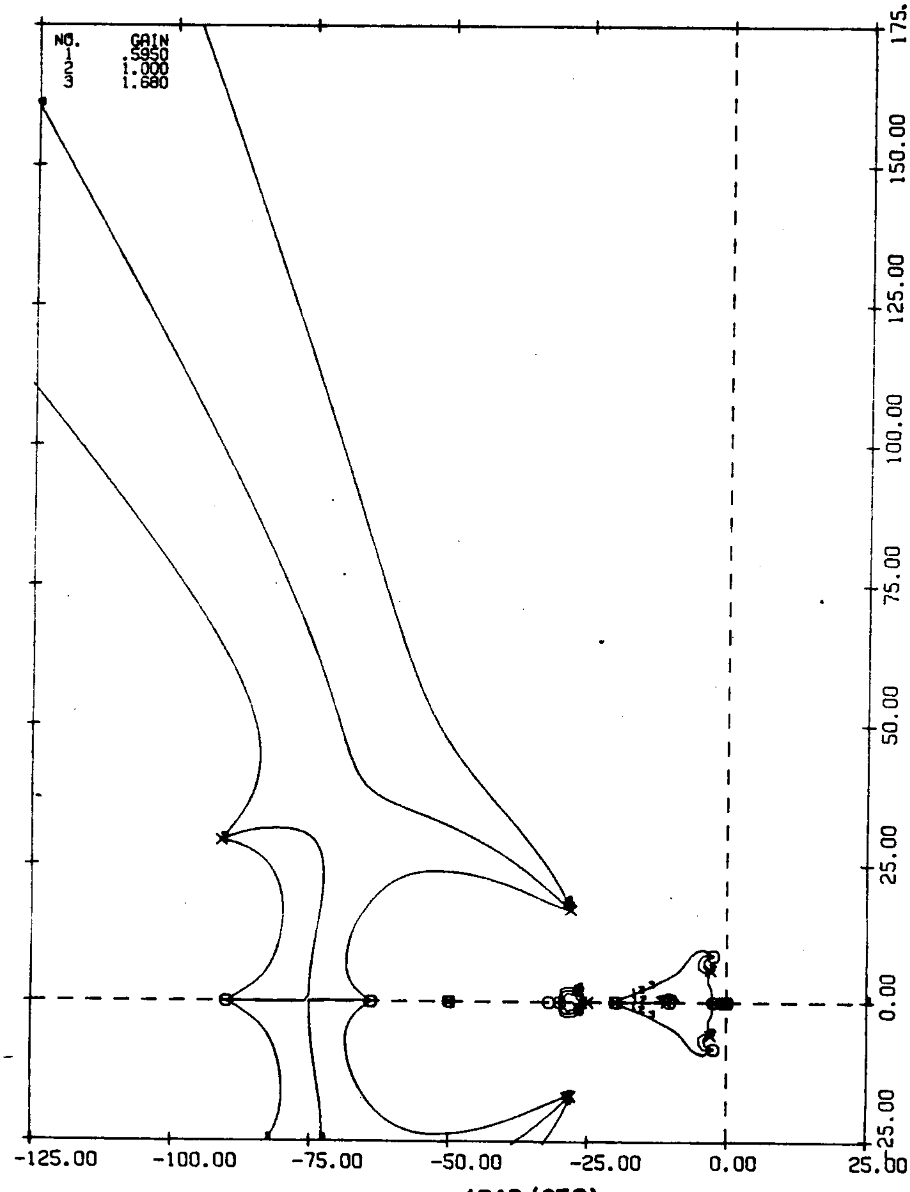


FIGURE 170 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

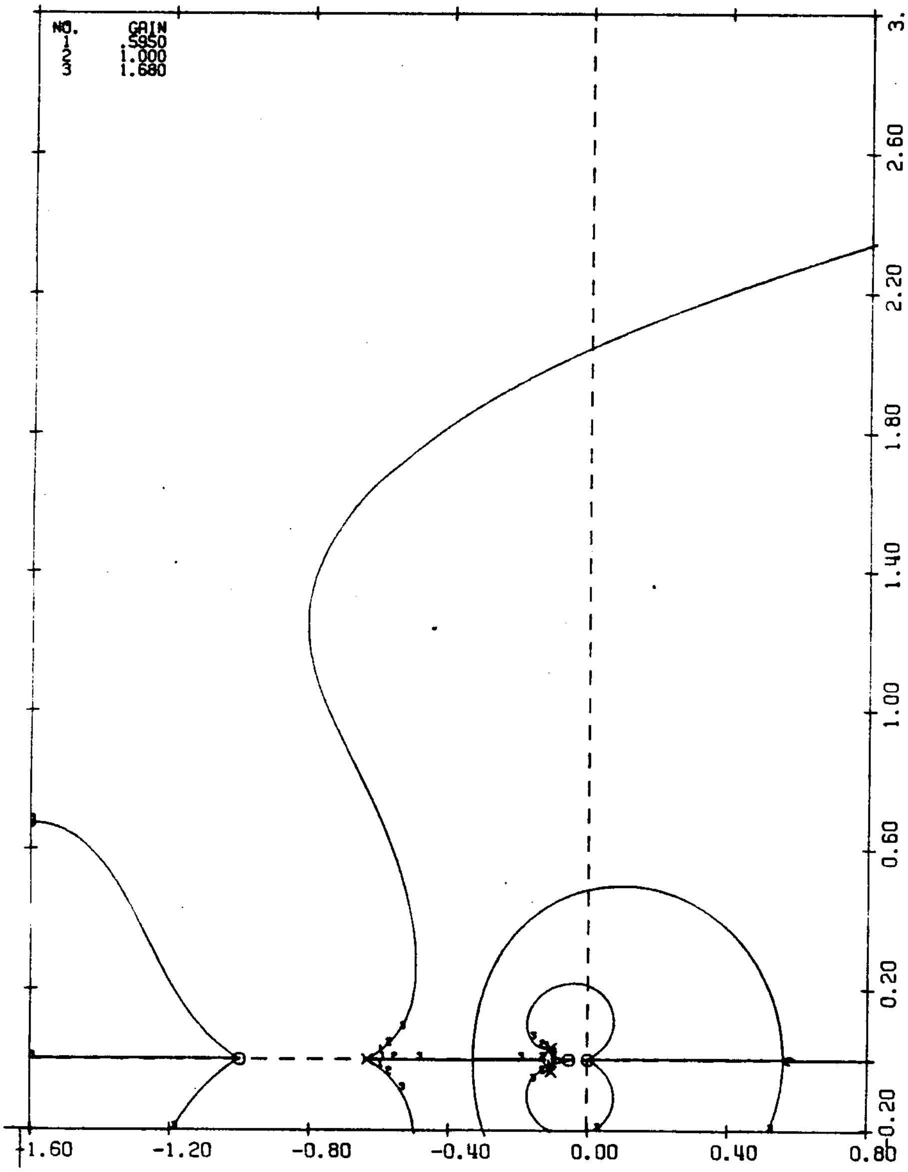


FIGURE 170 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

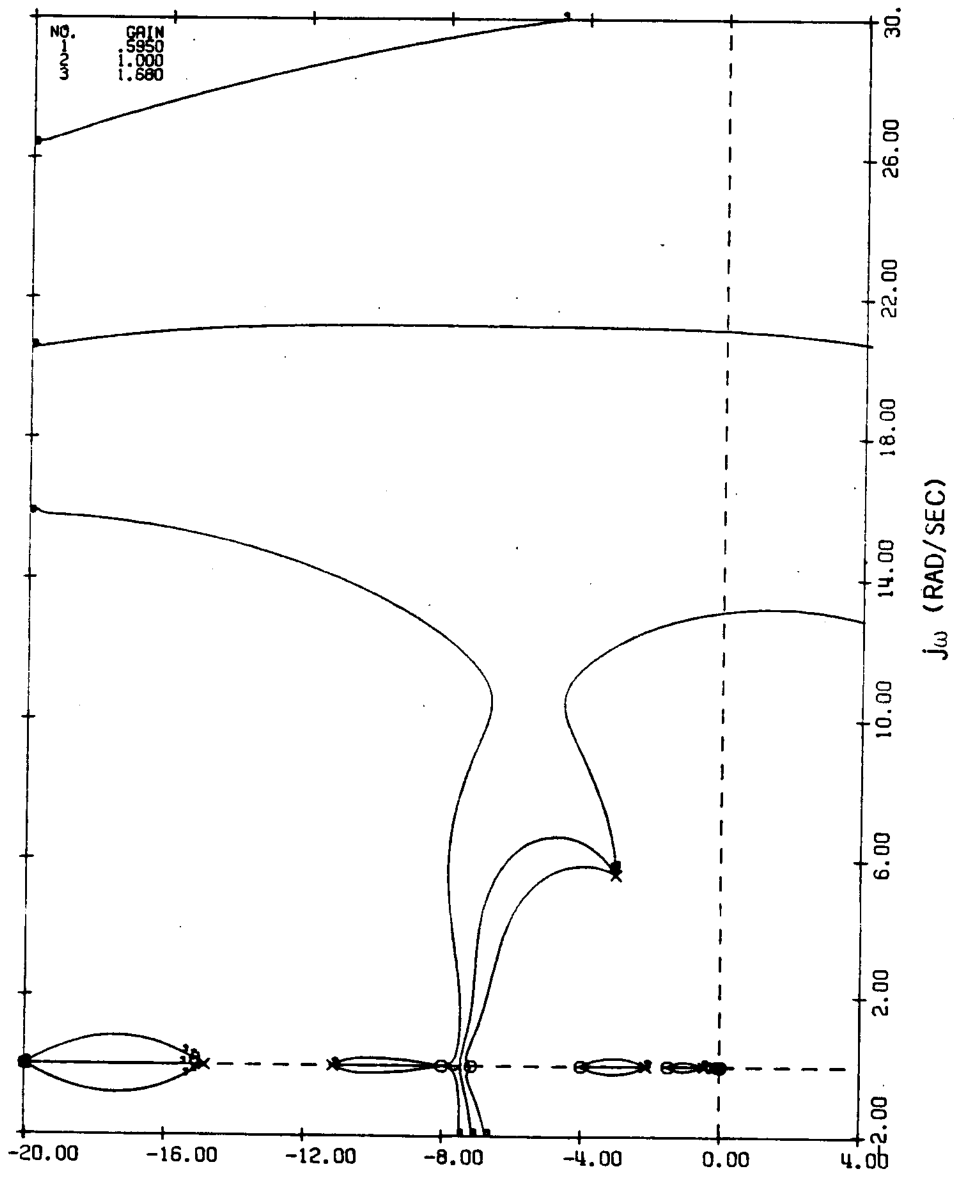


FIGURE 171

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- HIGH ALTITUDE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

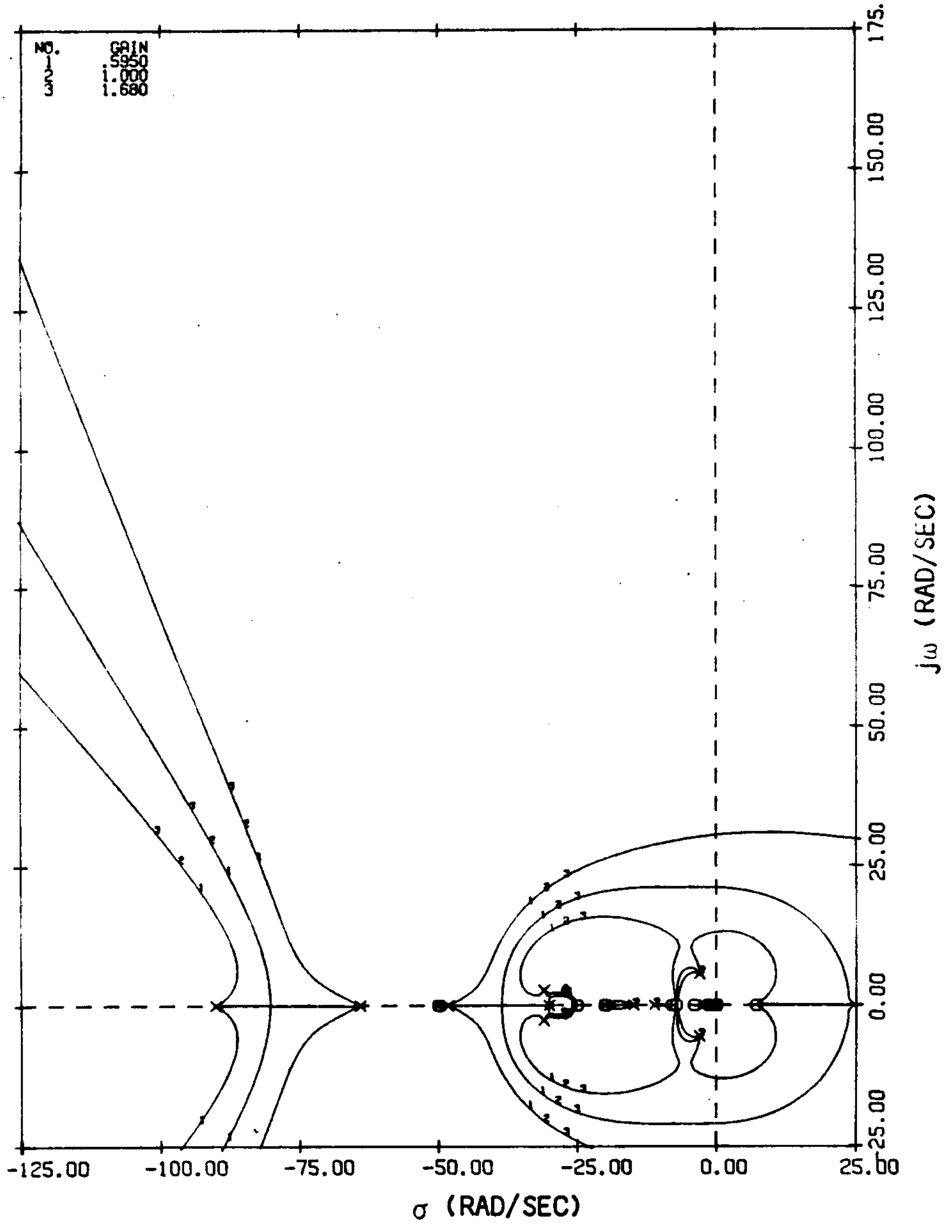


FIGURE 171 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

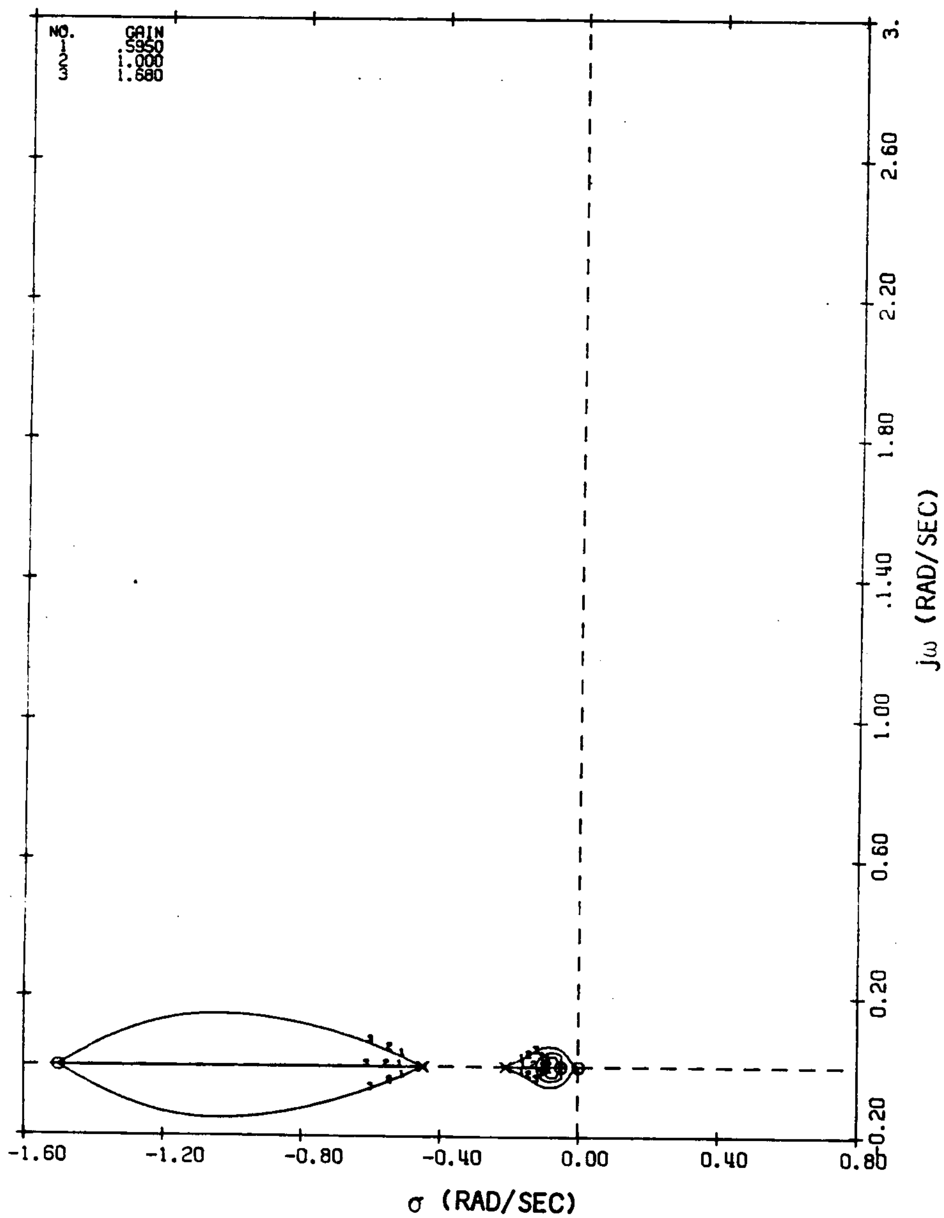


FIGURE 171 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

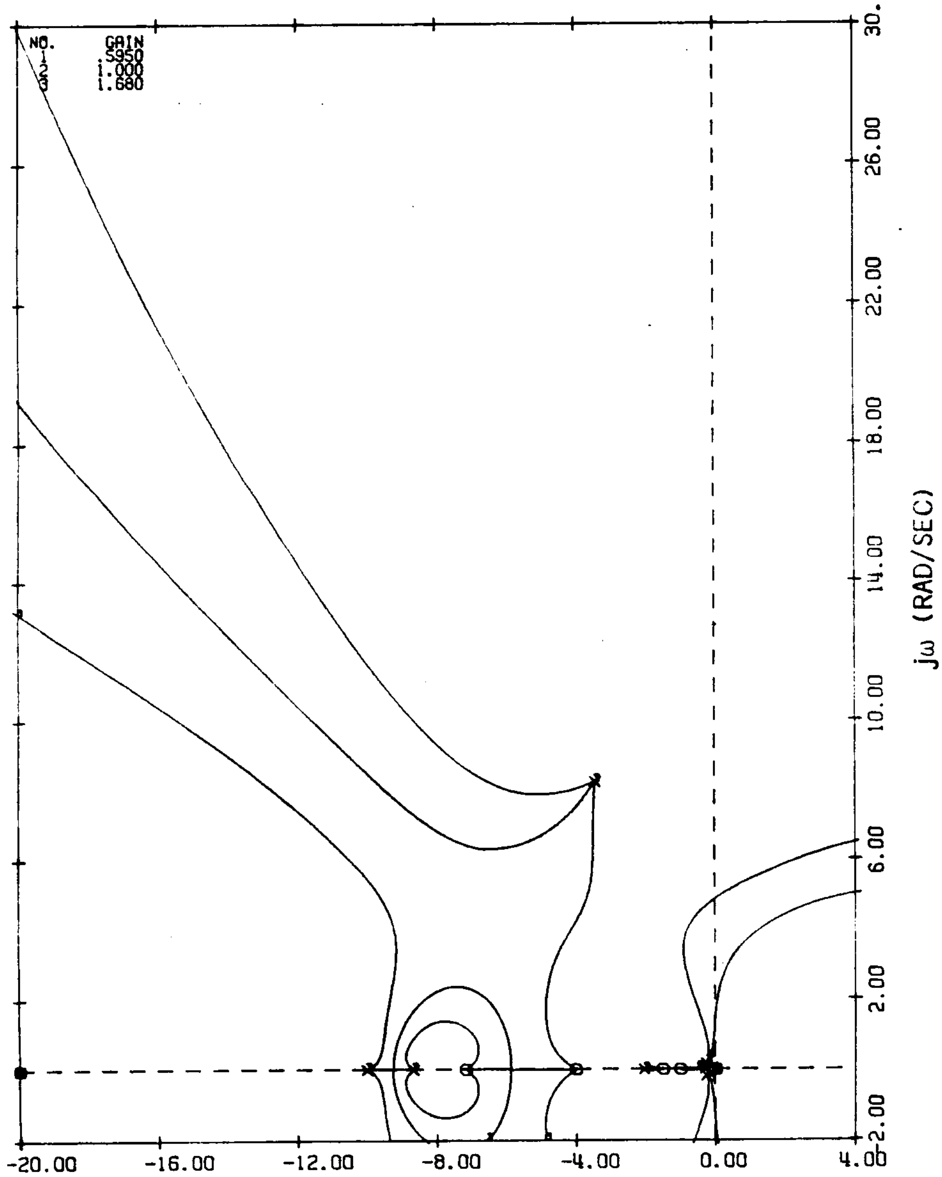


FIGURE 172

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

- HIGH ALTITUDE
- BCS WITH RSS CLOSED
- MACH: 0.70
- ALTITUDE: 50,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

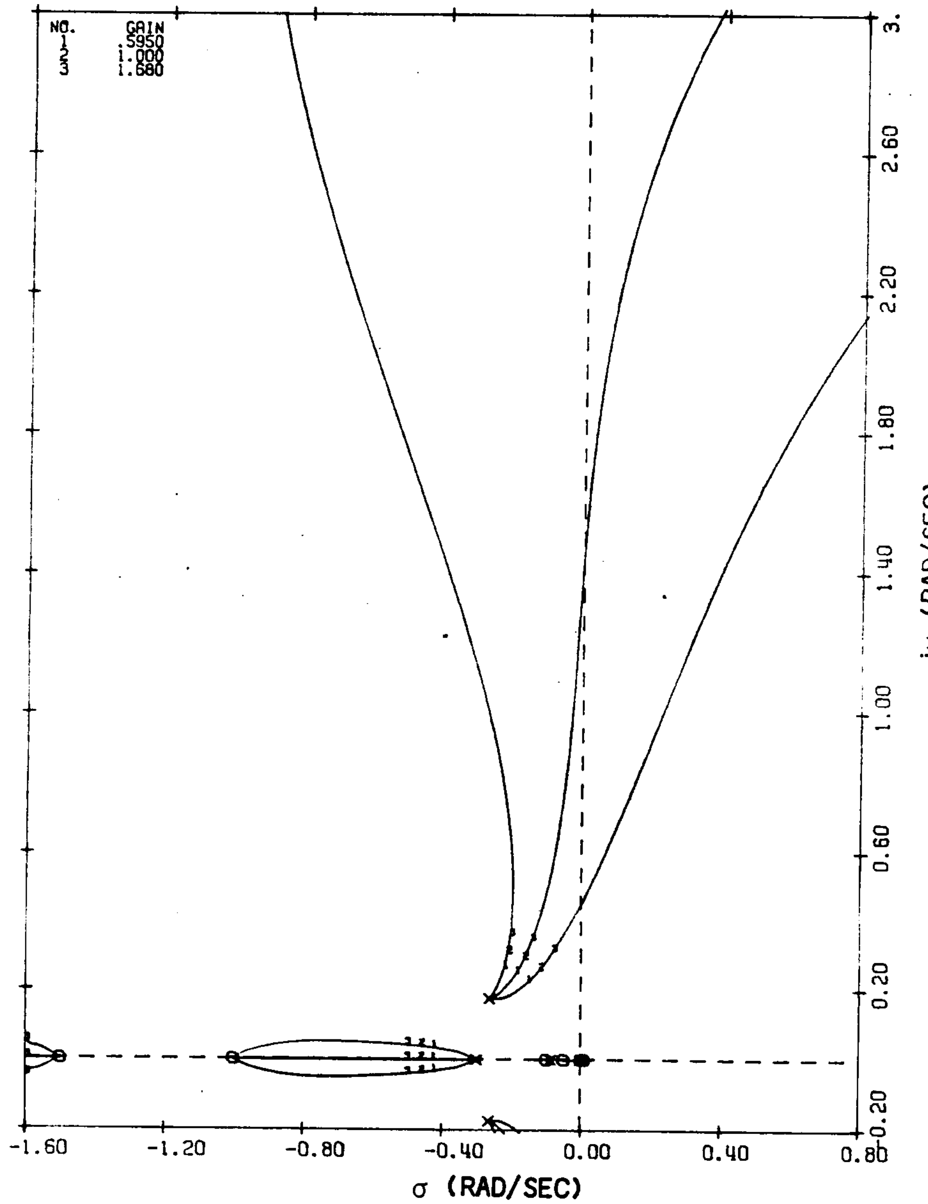


FIGURE 172 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. HIGH ALTITUDE CONDITION

APPENDIX E

- CRUISE
- RSS
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

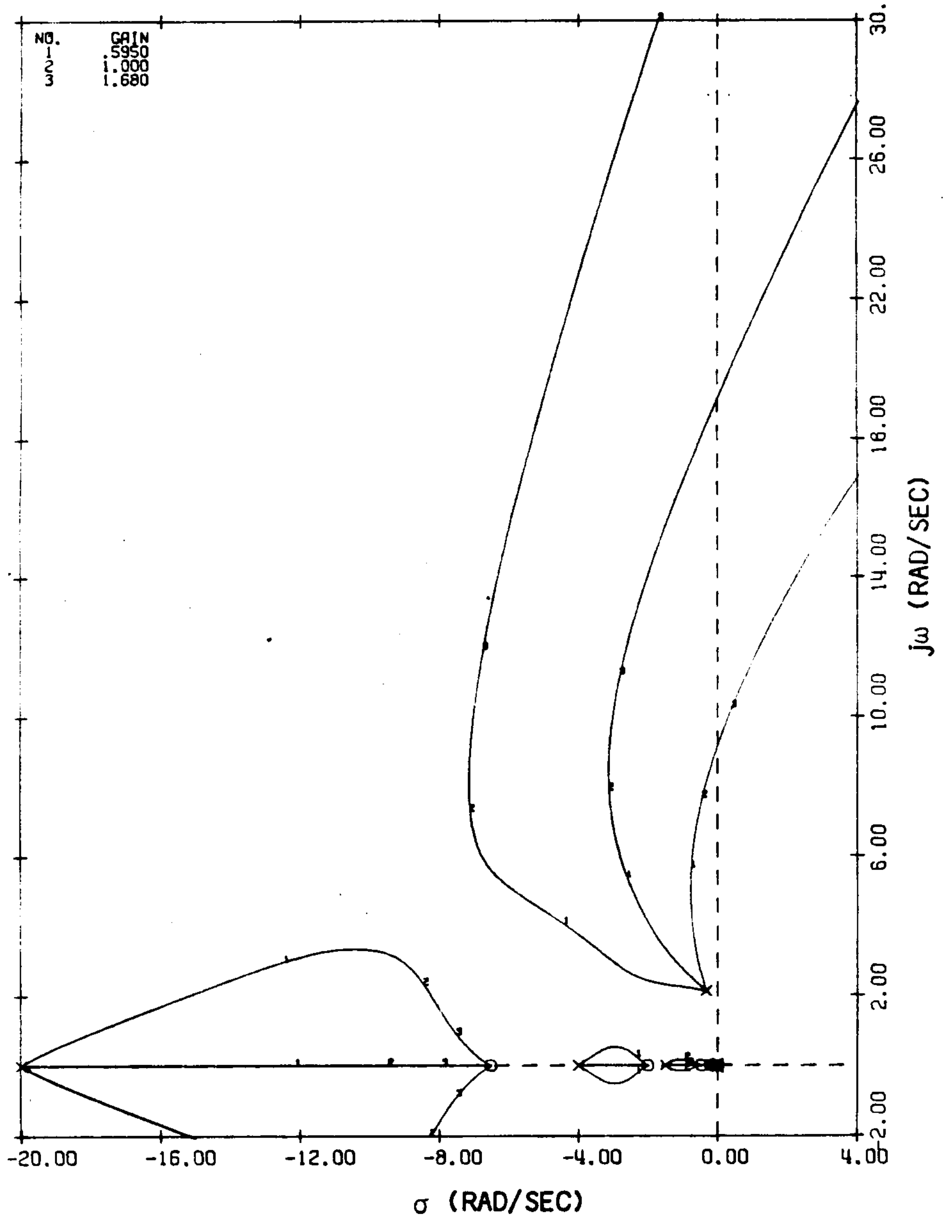


FIGURE 173

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- RSS
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

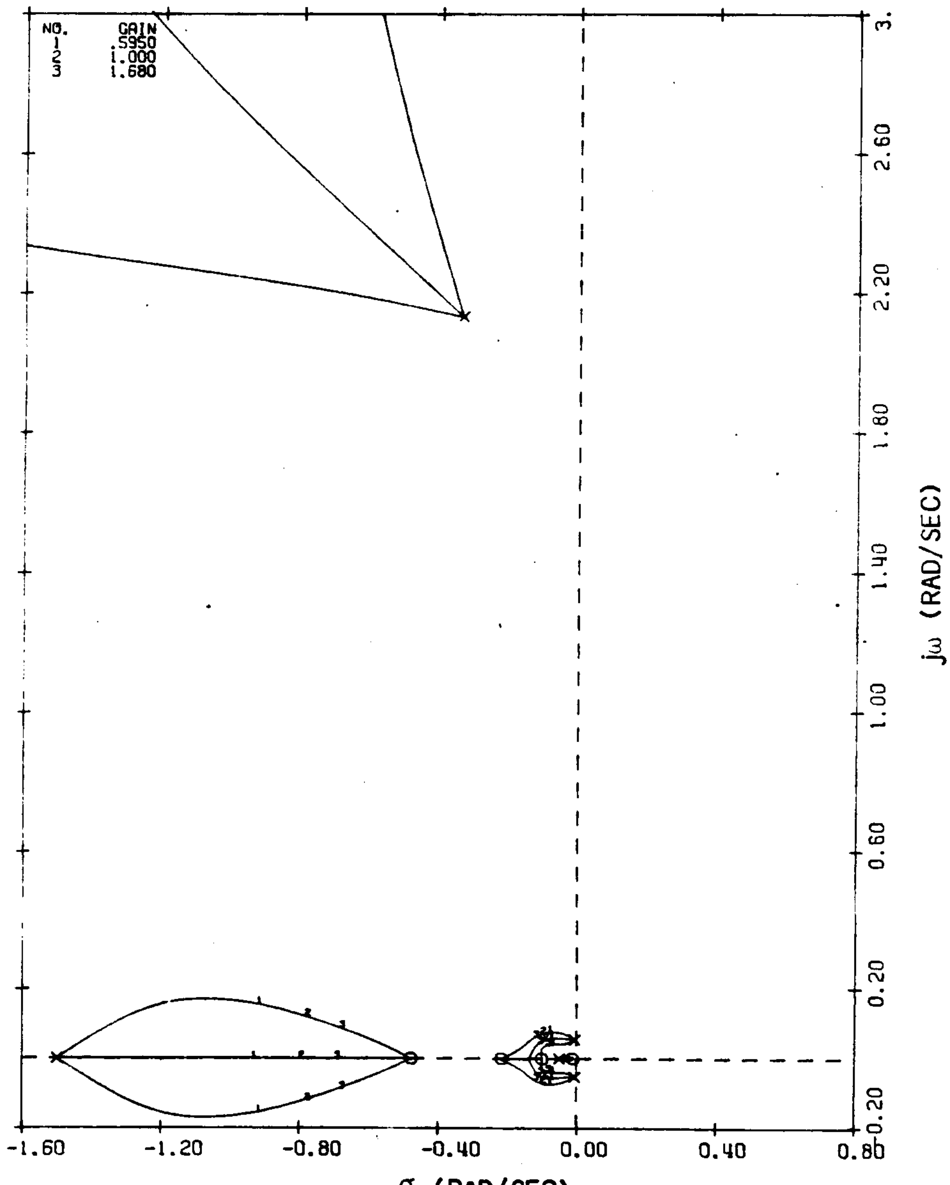


FIGURE 173 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- RSS WITH PCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

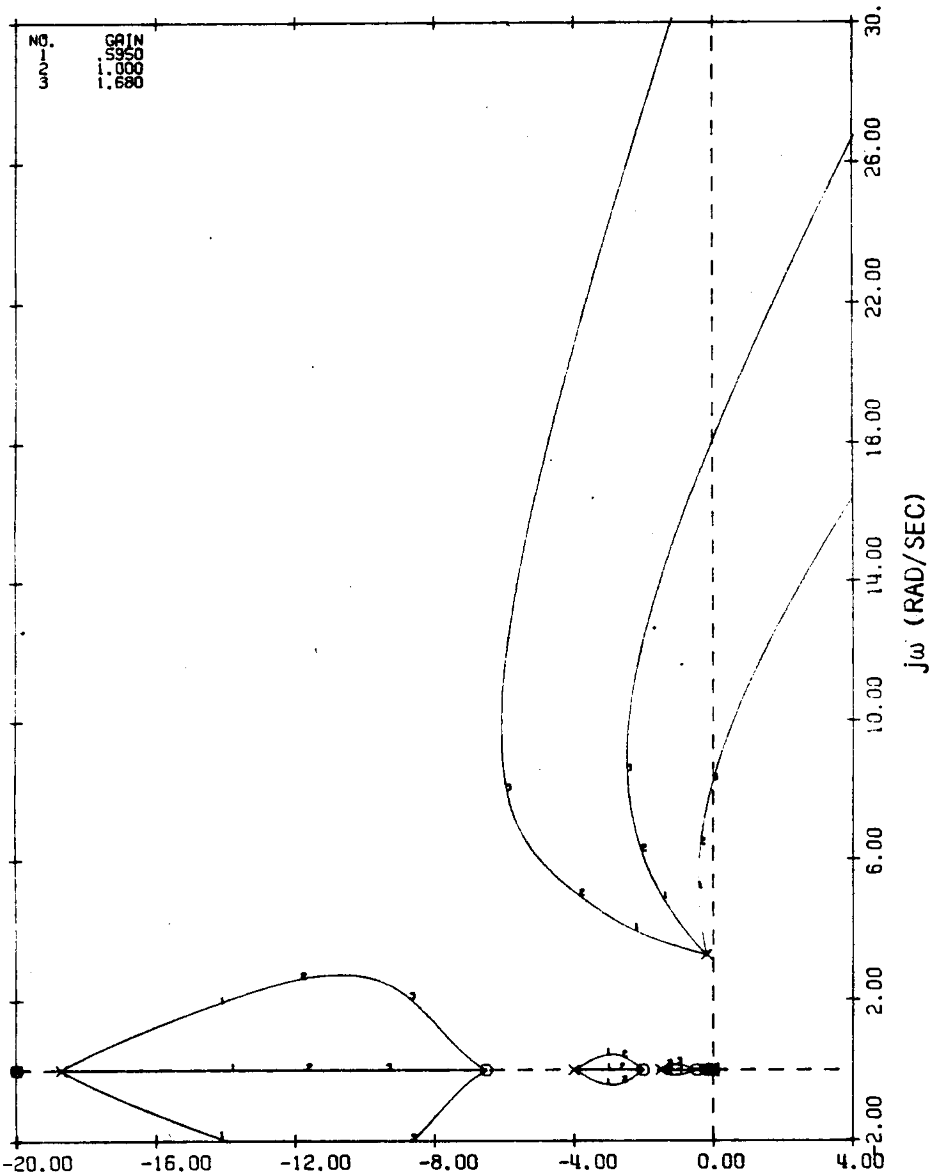


FIGURE 174

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

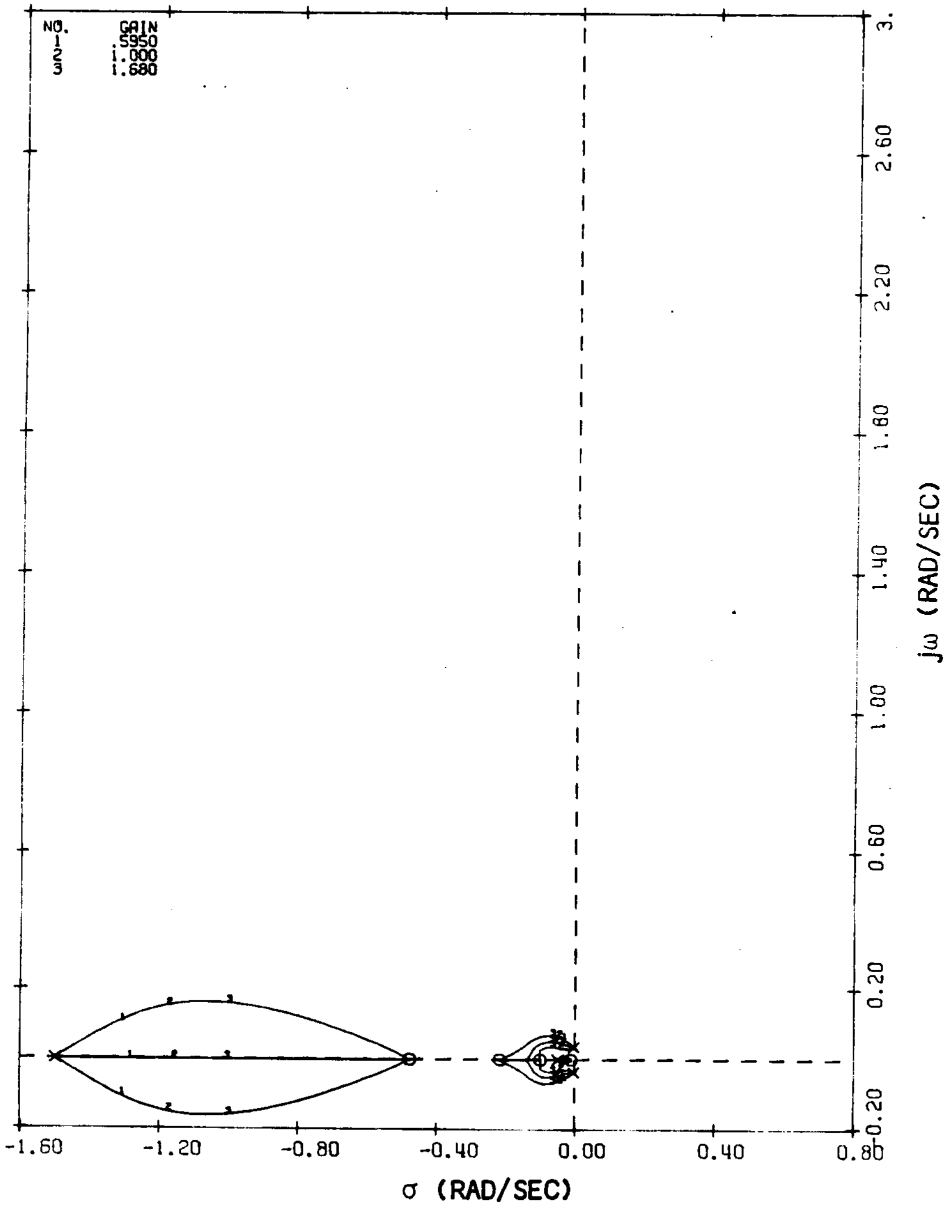


FIGURE 174 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

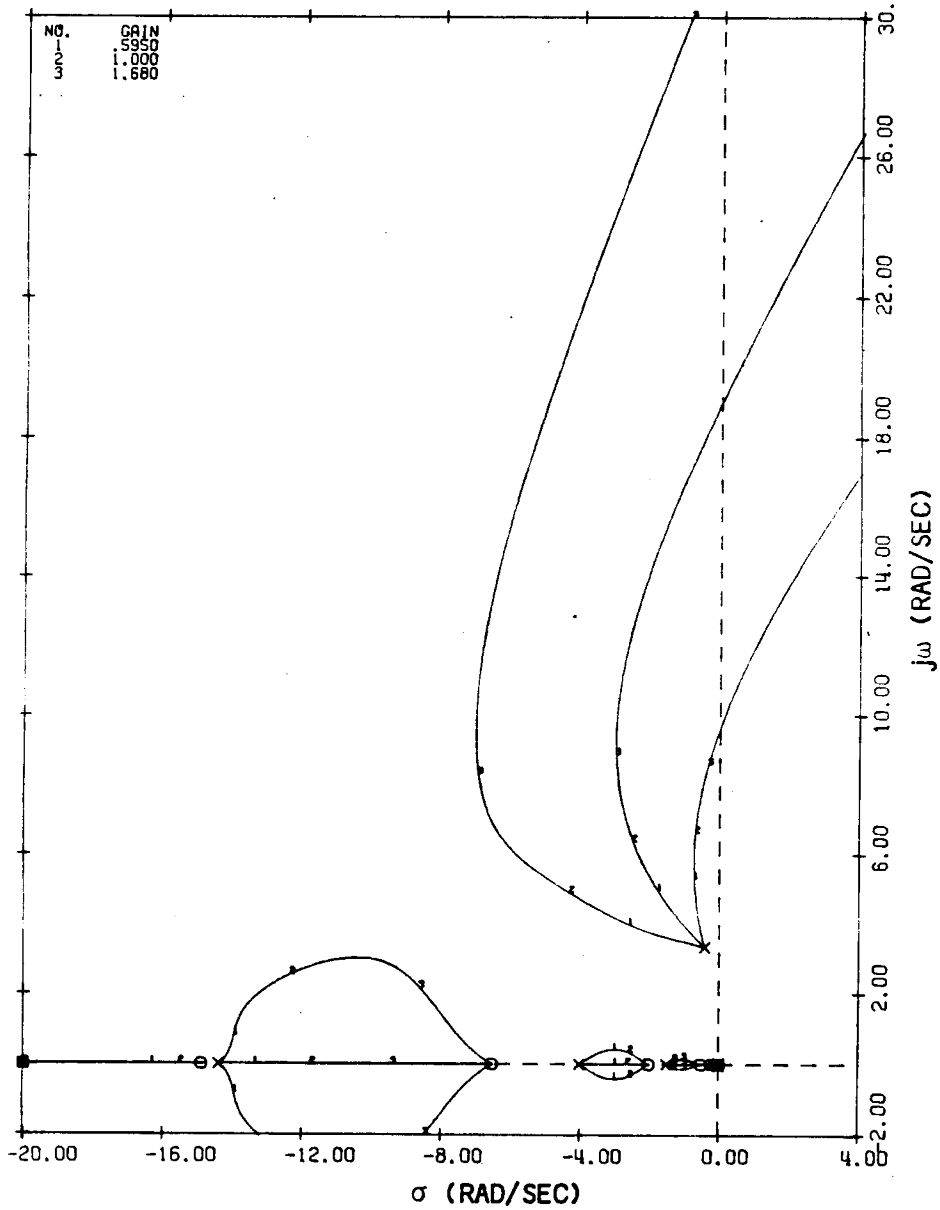


FIGURE 175

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

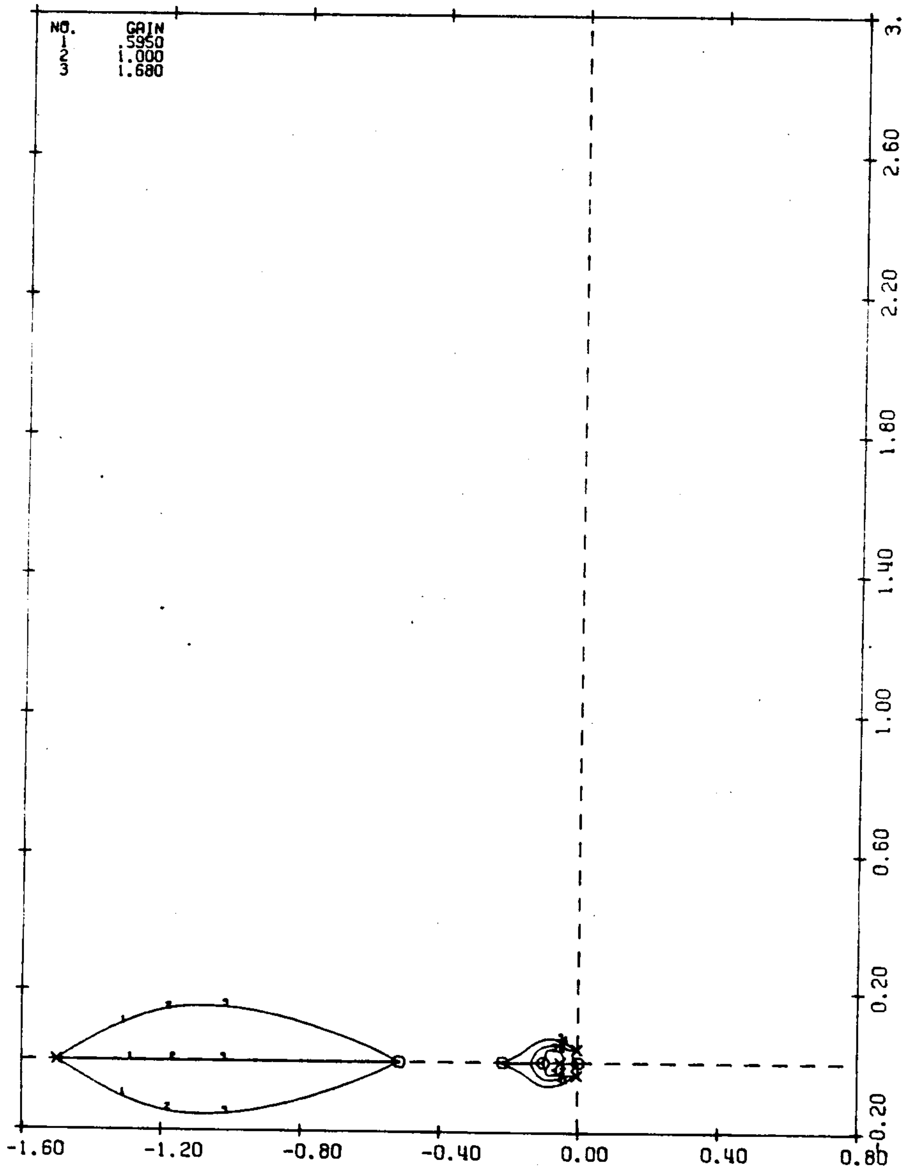


FIGURE 175 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH BCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

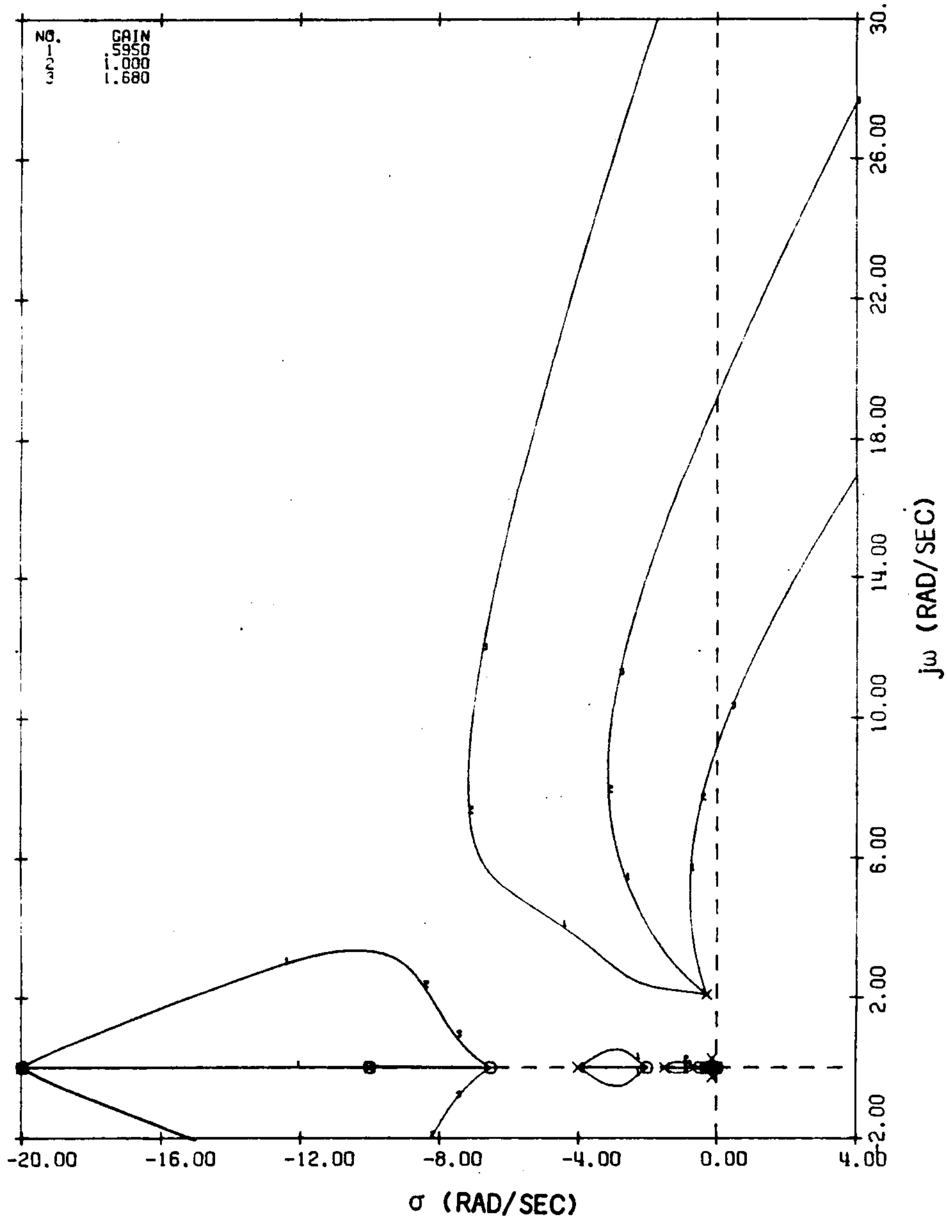


FIGURE 176

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- RSS WITH BCS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

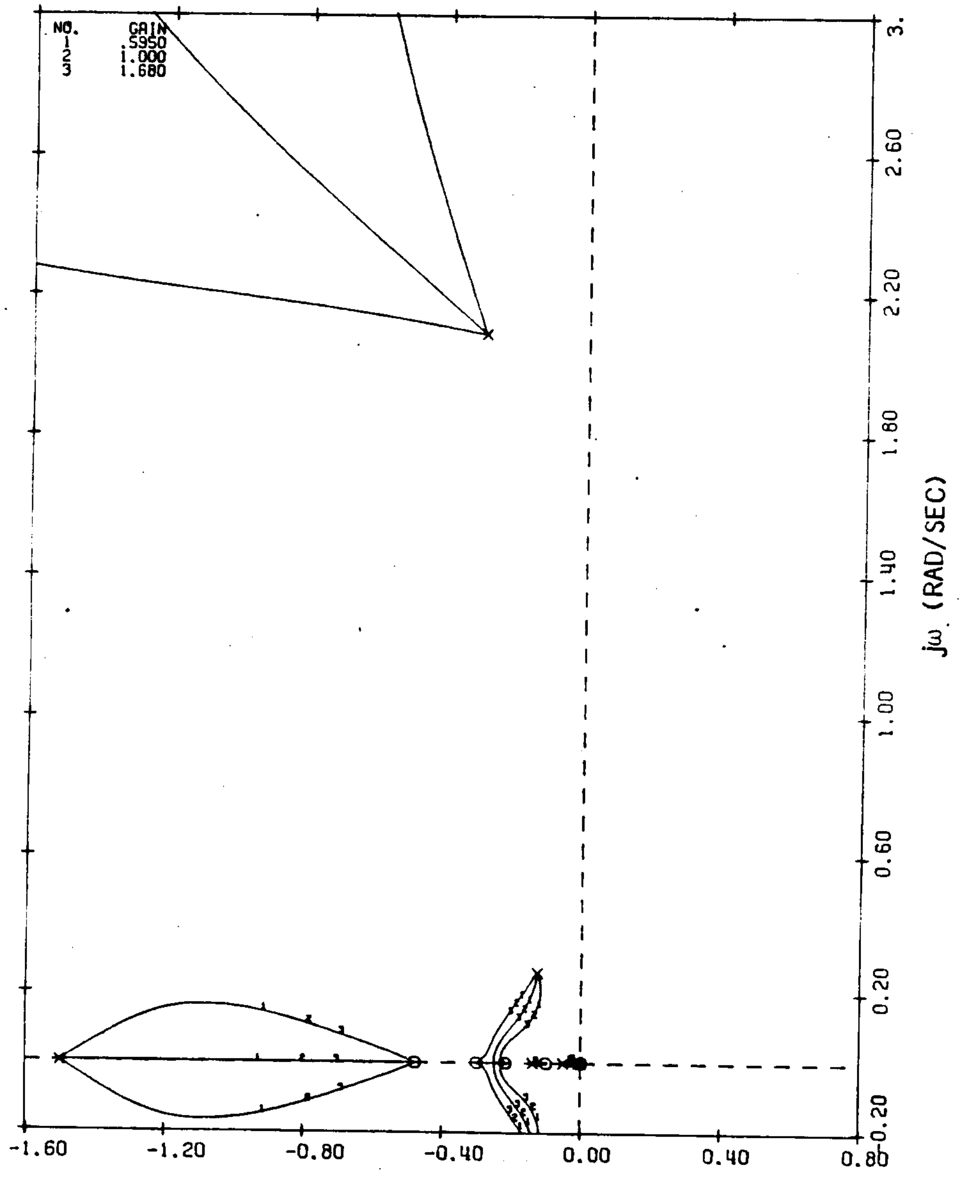


FIGURE 176 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- PCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

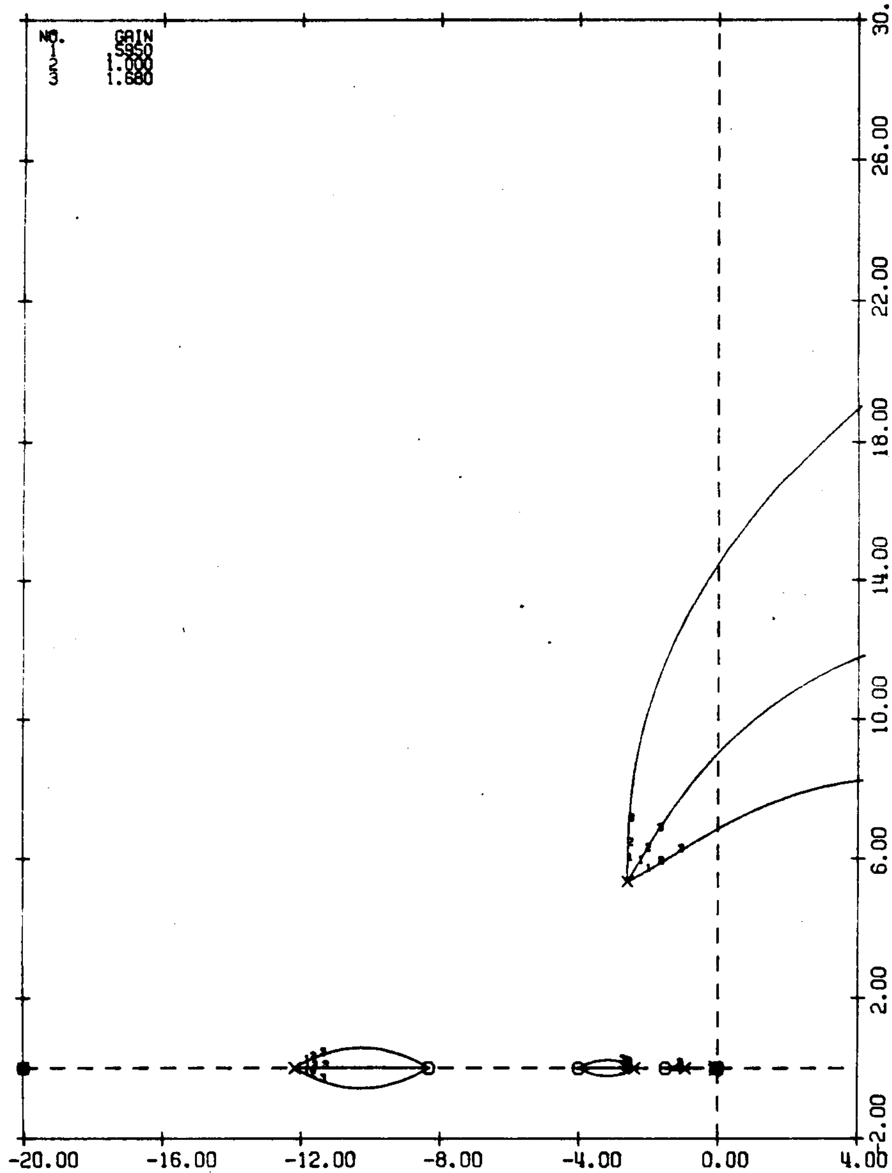


FIGURE 177

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- PCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

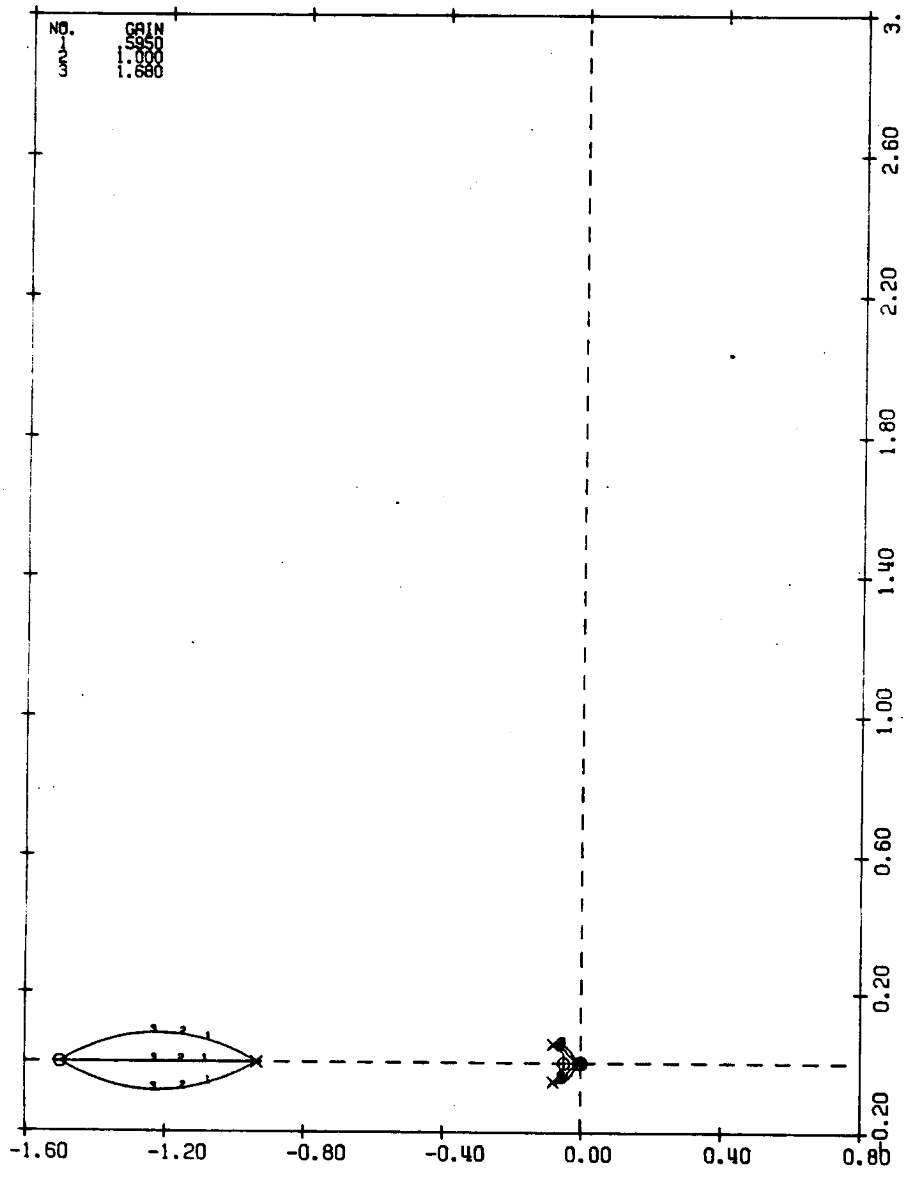


FIGURE 177 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

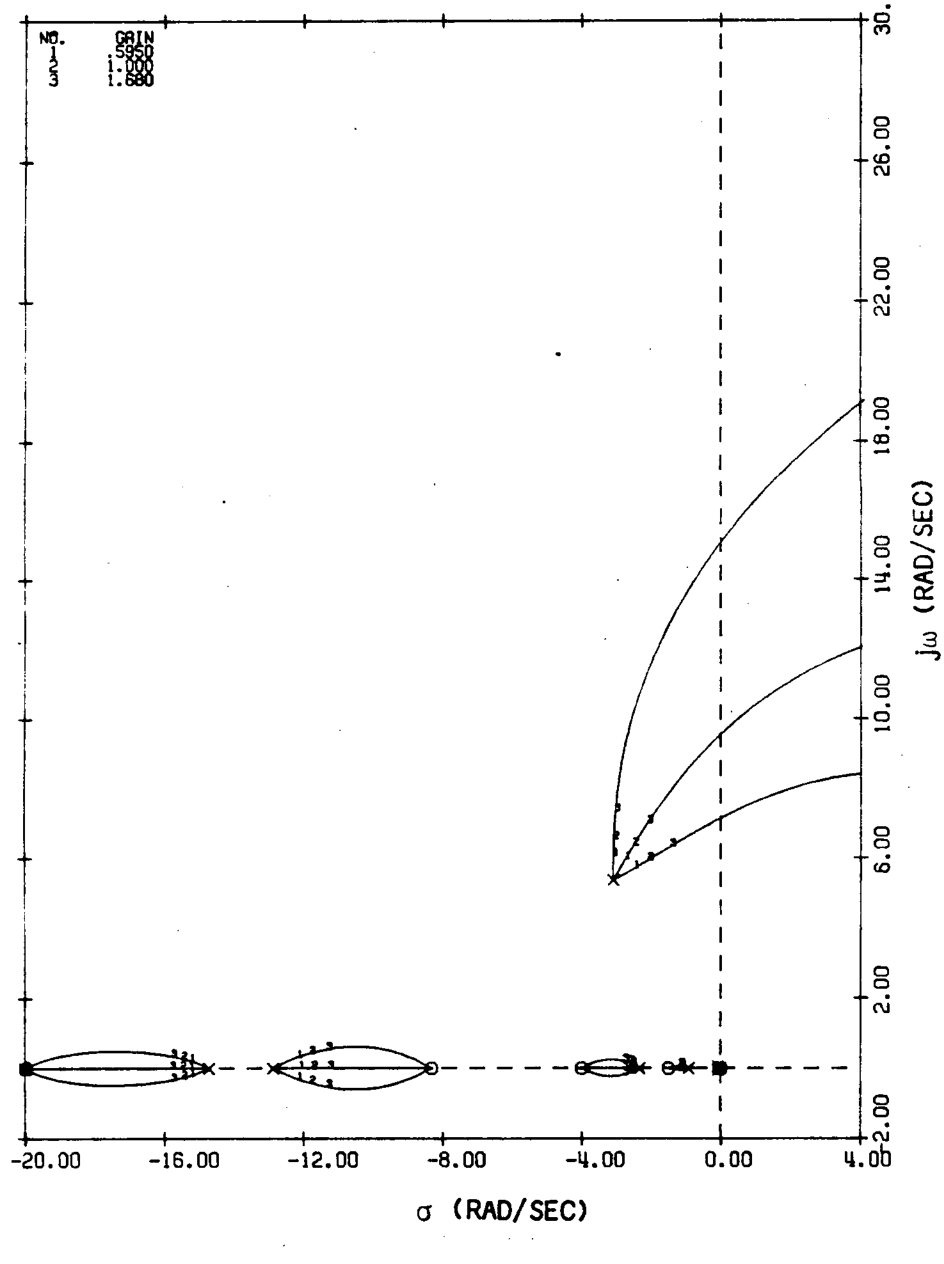


FIGURE 178

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

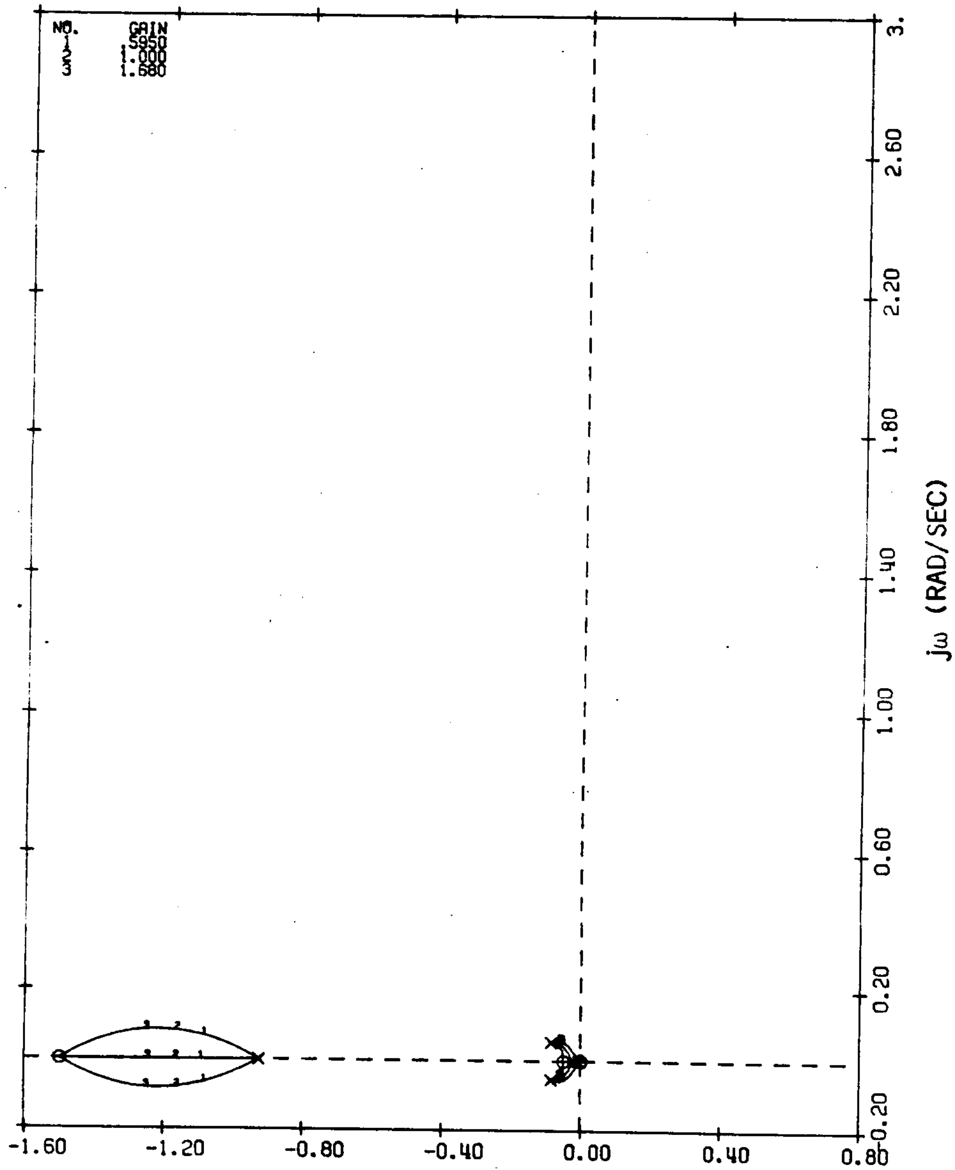


FIGURE 178 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- BCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

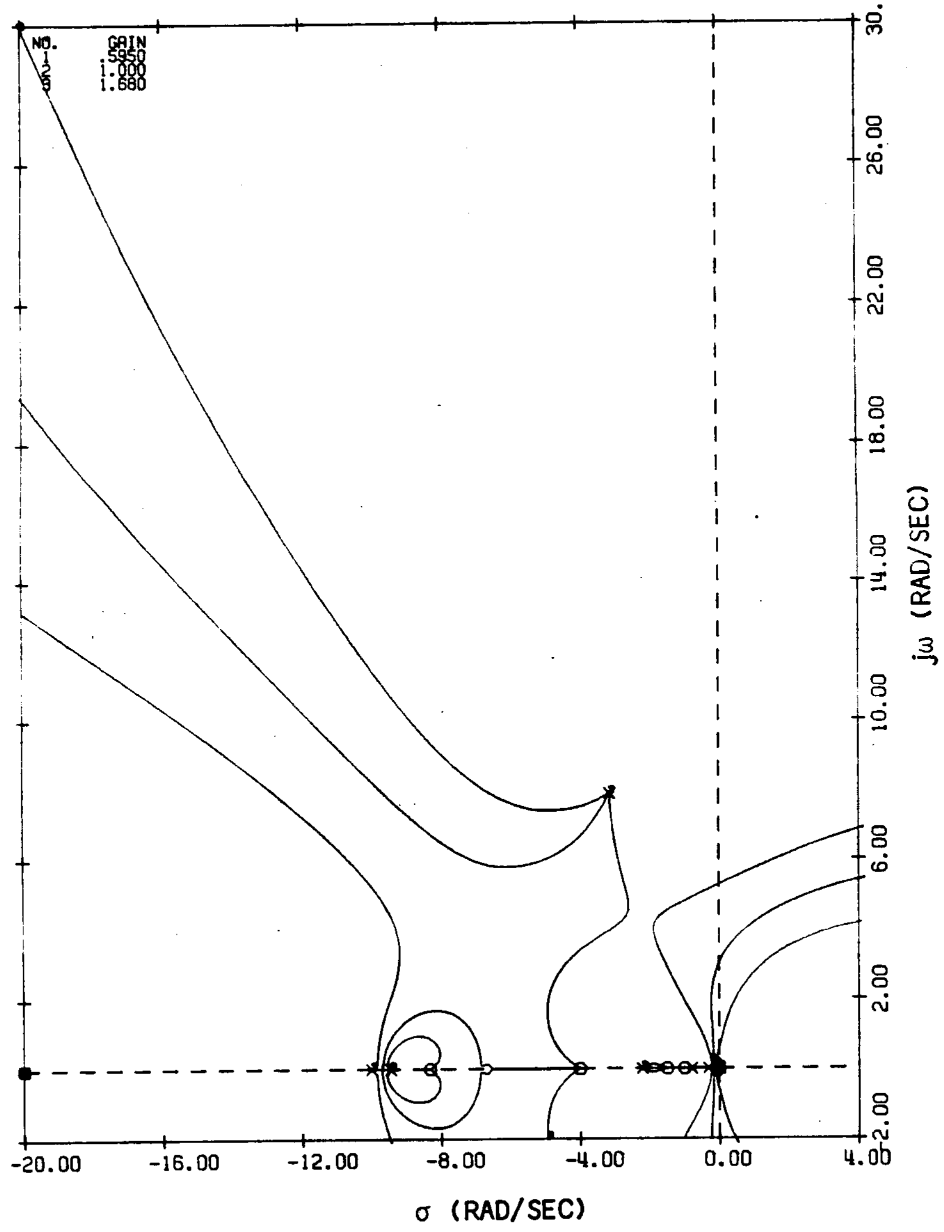


FIGURE 179

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- BCS WITH RSS CLOSED
- 1.0g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

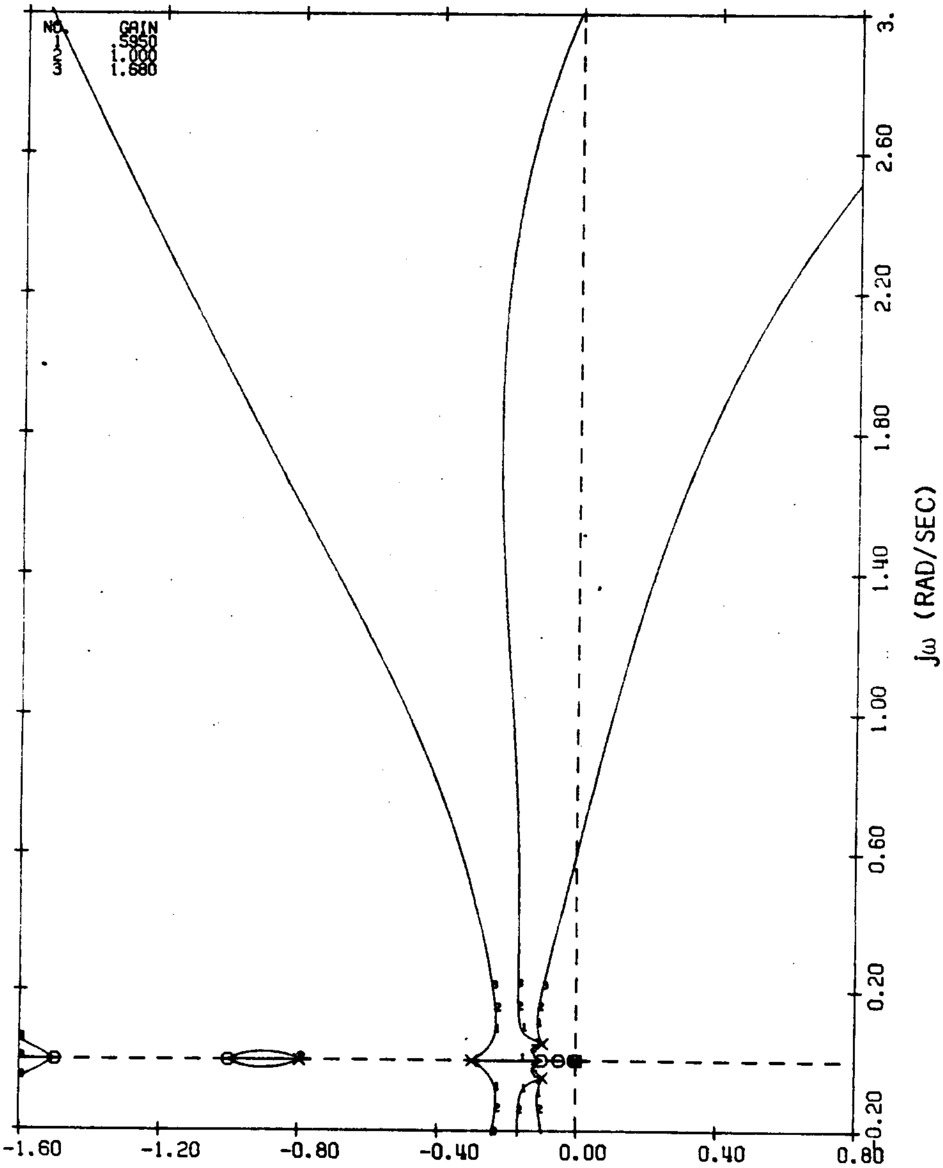


FIGURE 179 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

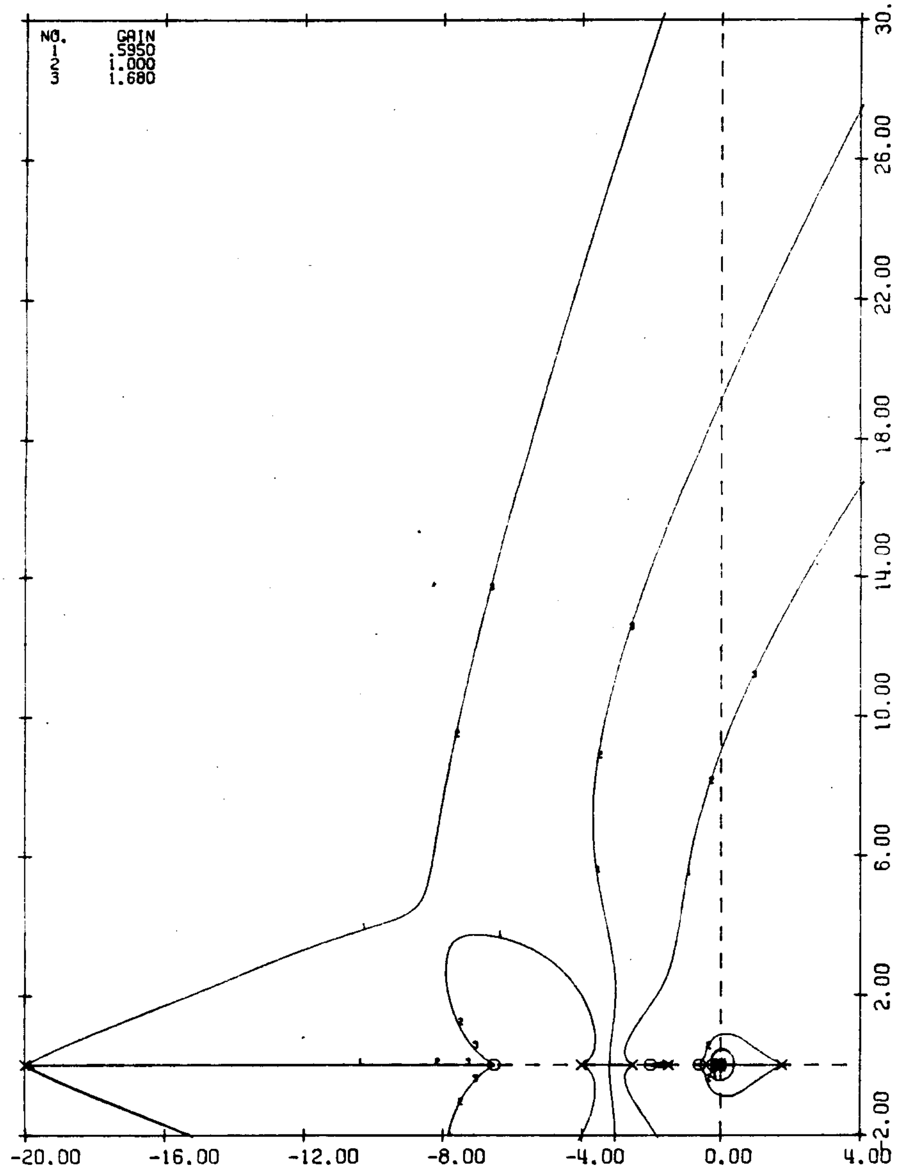


FIGURE 180

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. CRUISE CONDITION

- CRUISE
- RSS
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

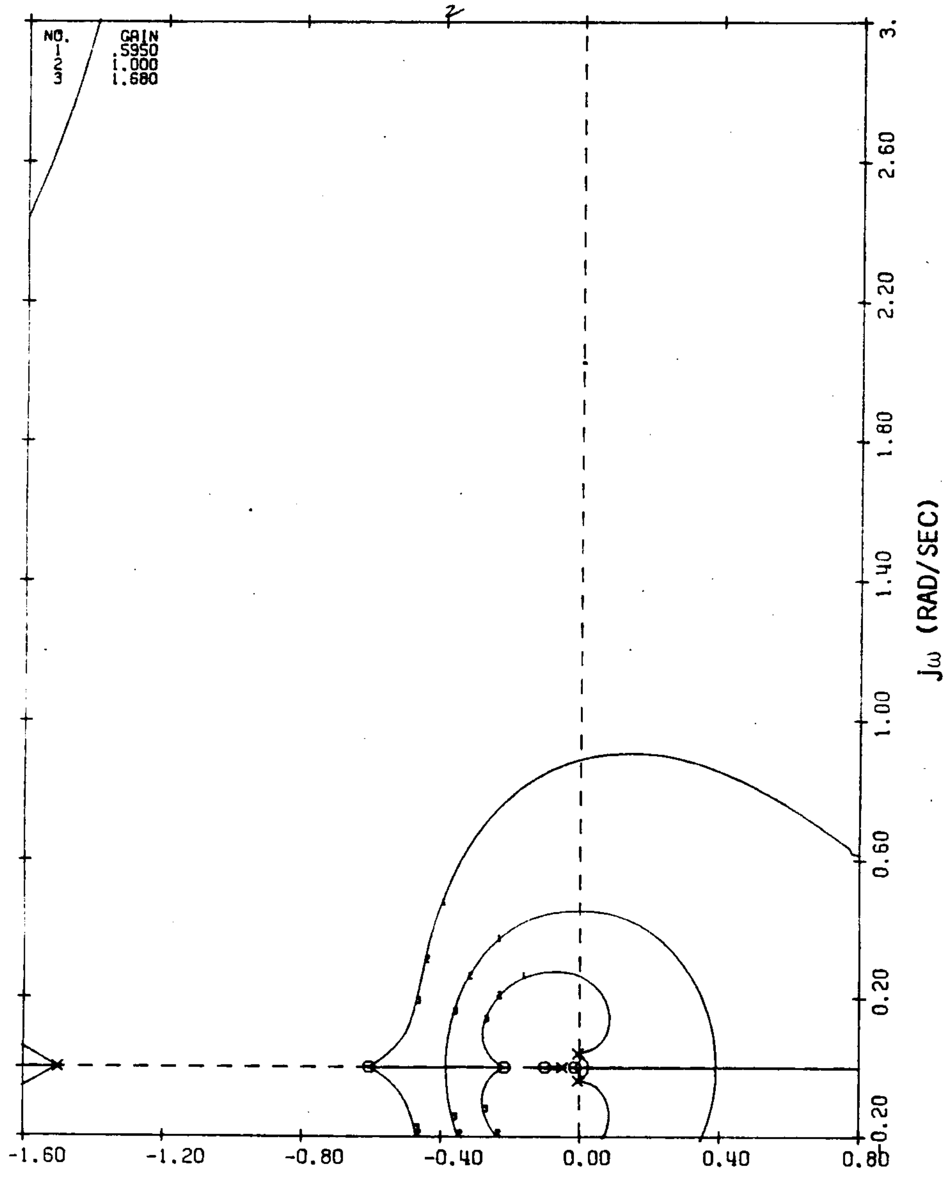


FIGURE 180 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

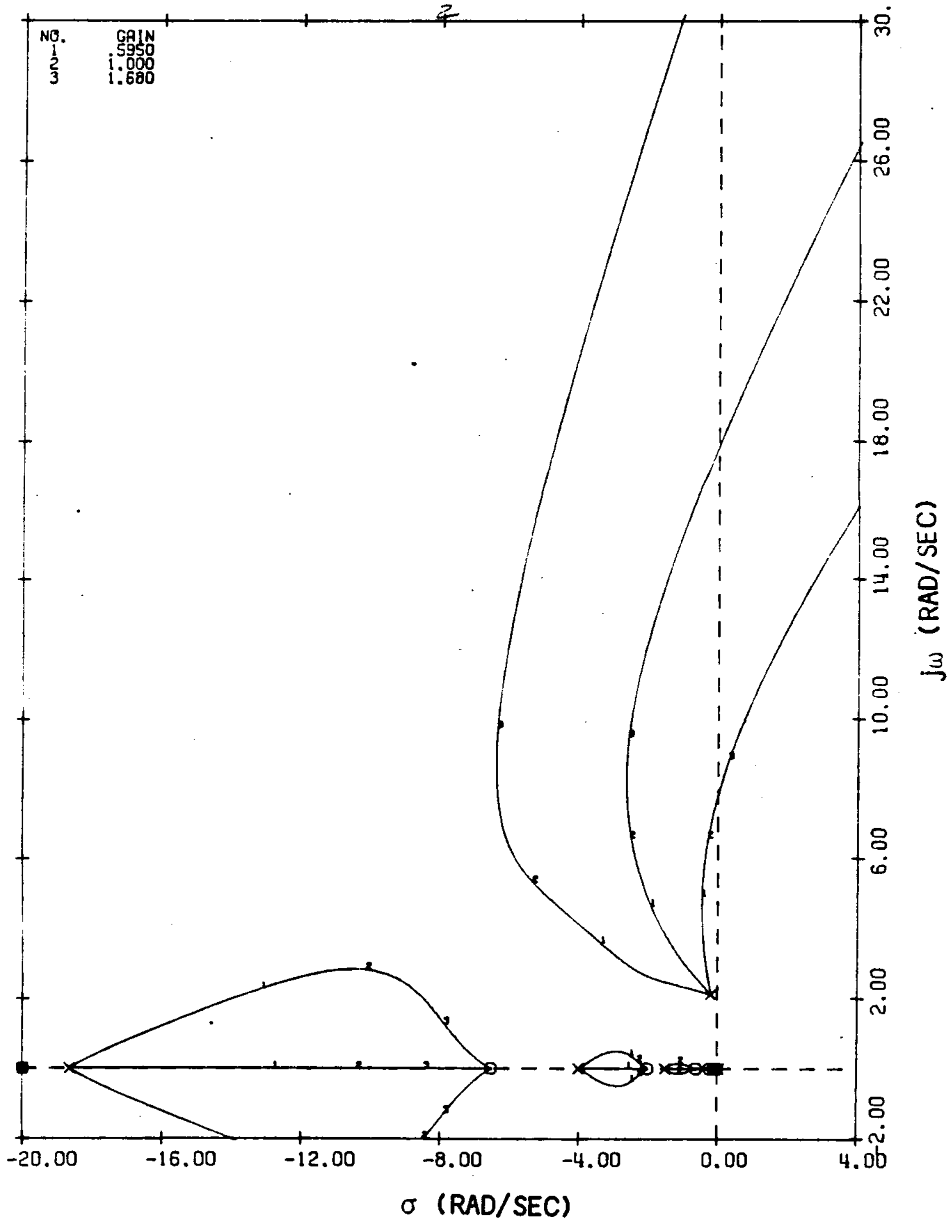


FIGURE 181

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH PCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

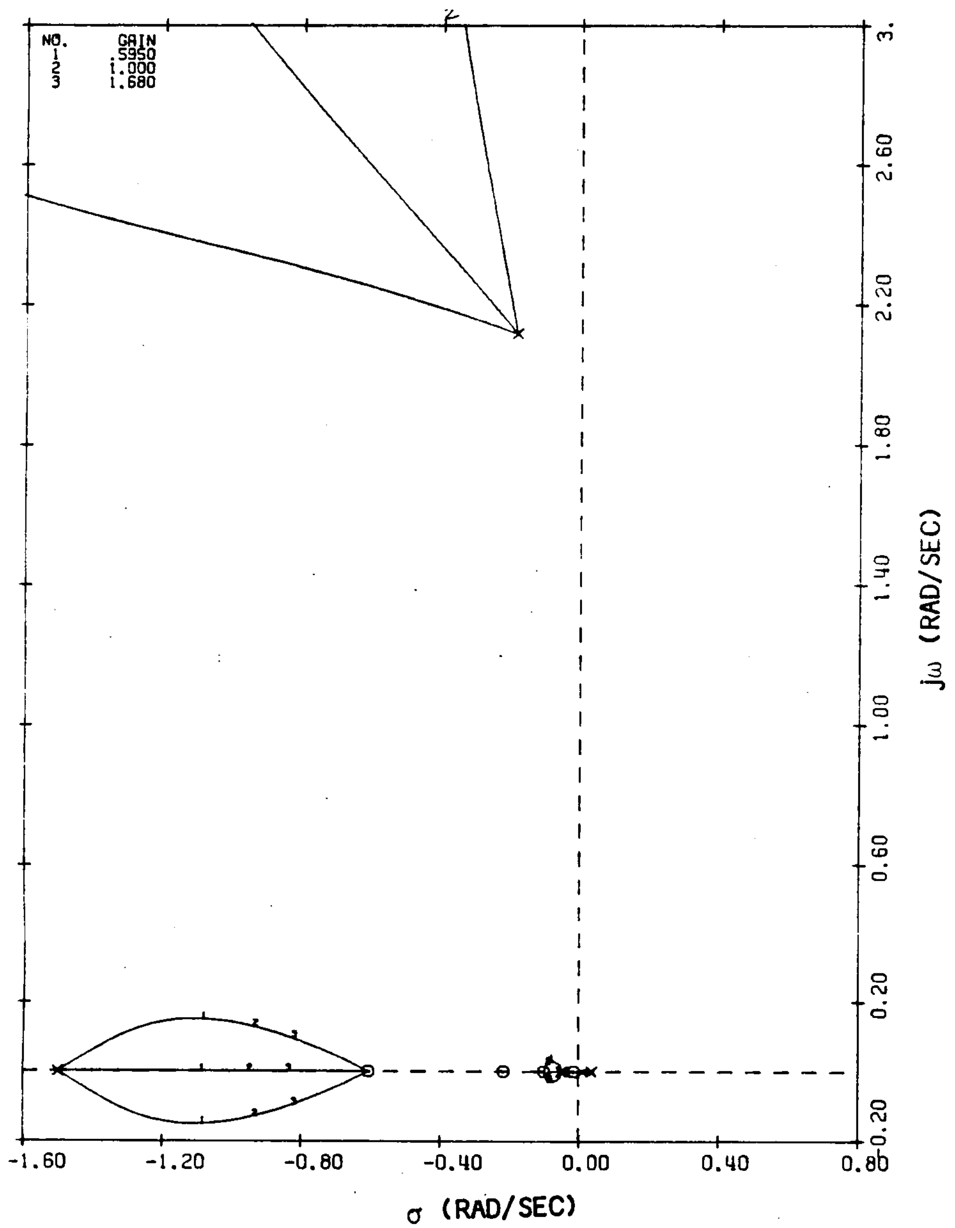


FIGURE 181 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

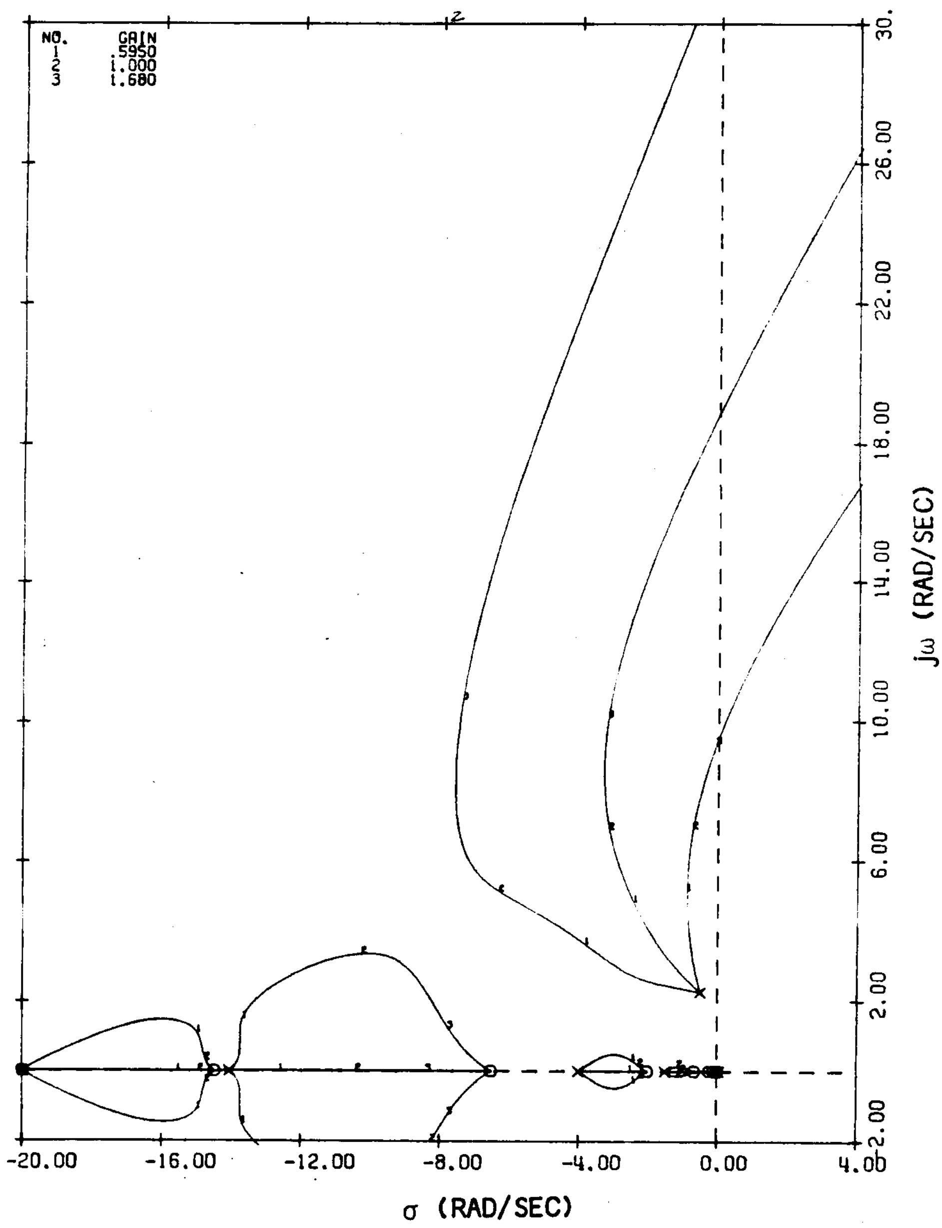


FIGURE 182

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH PCS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

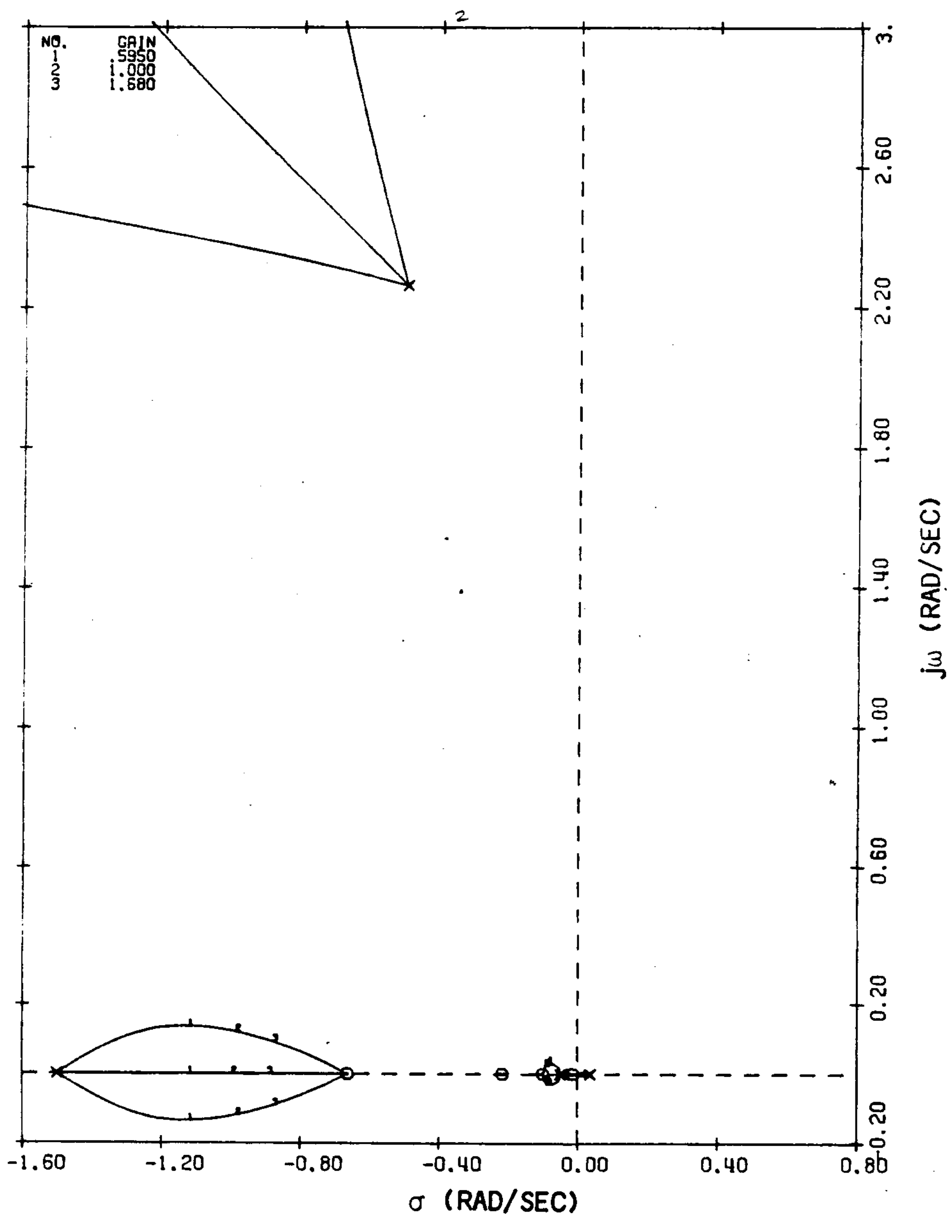


FIGURE 182 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- RSS WITH BCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

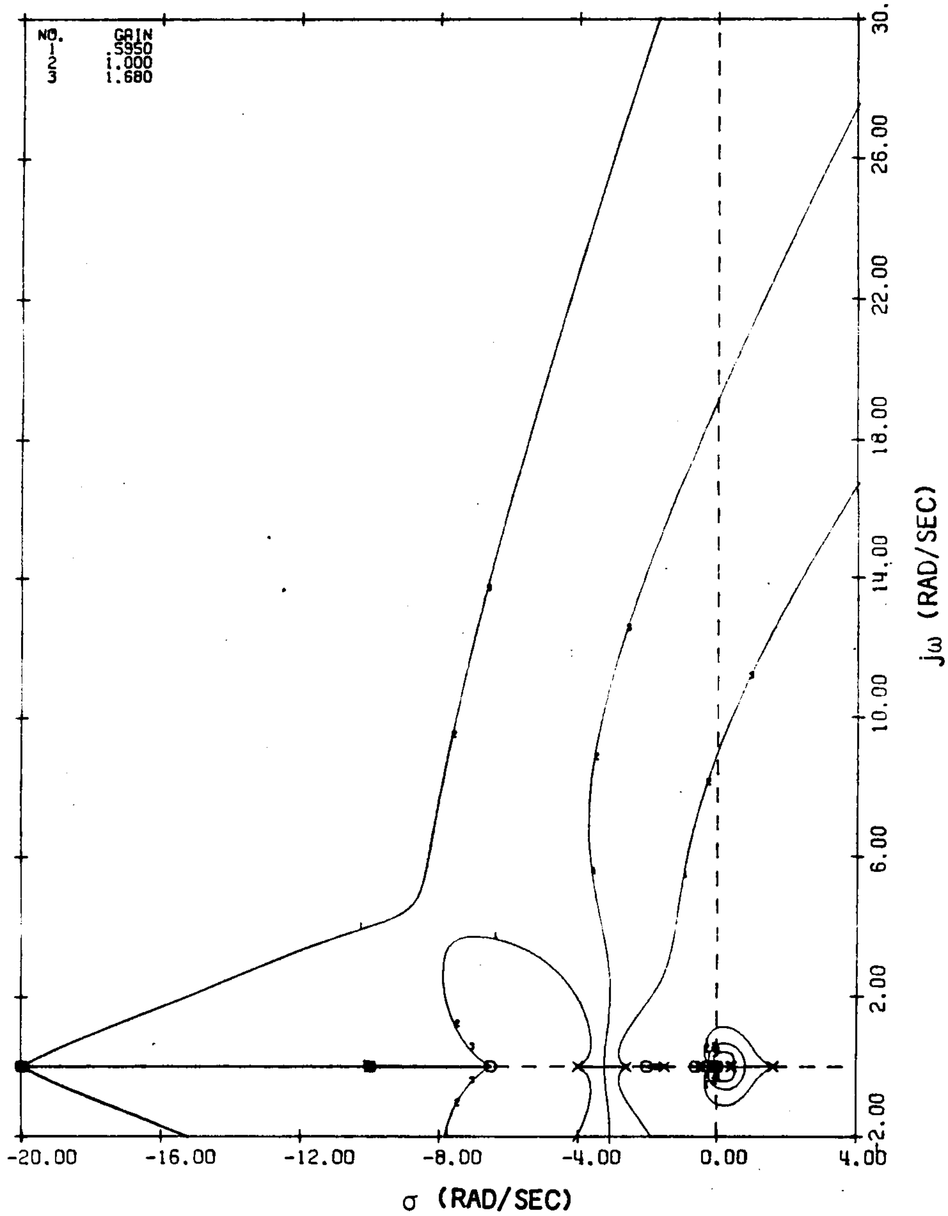


FIGURE 183

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- RSS WITH BCS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

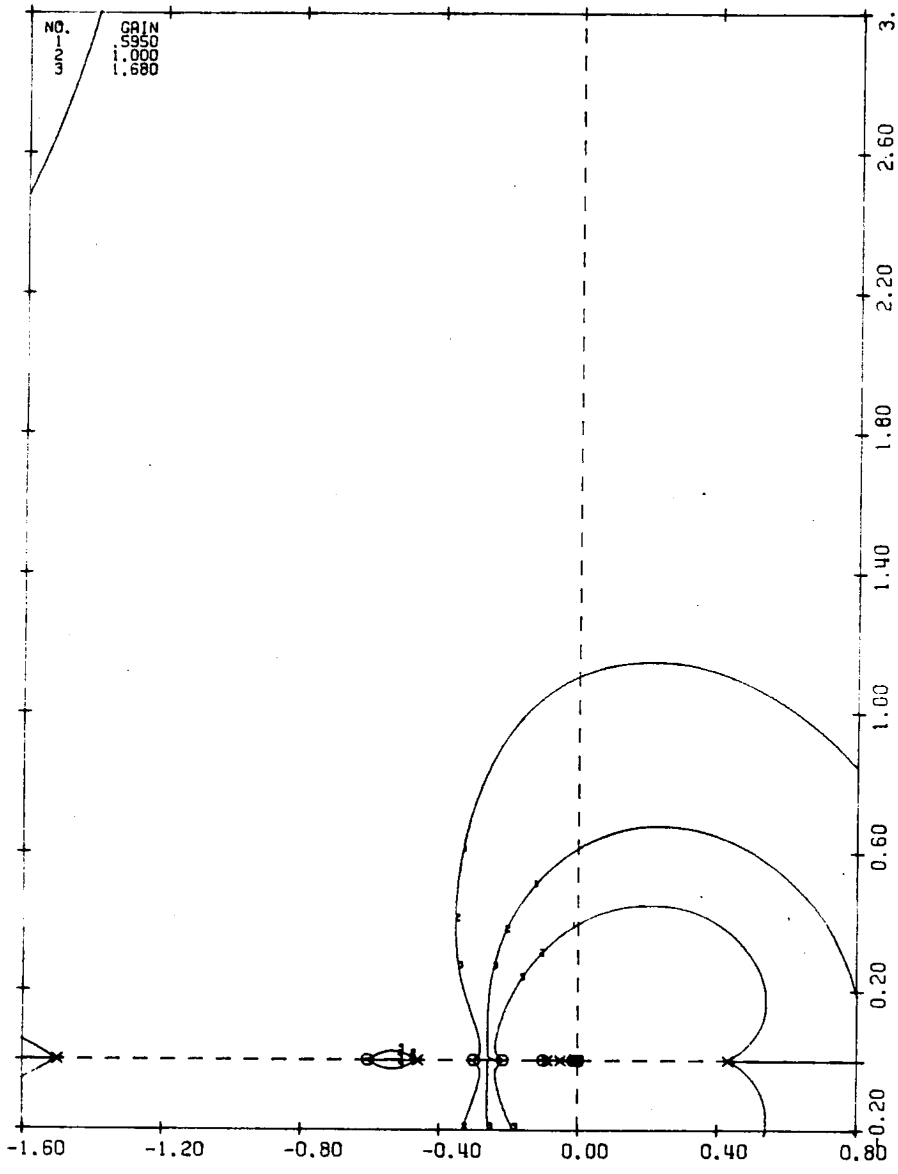


FIGURE 183 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- PCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

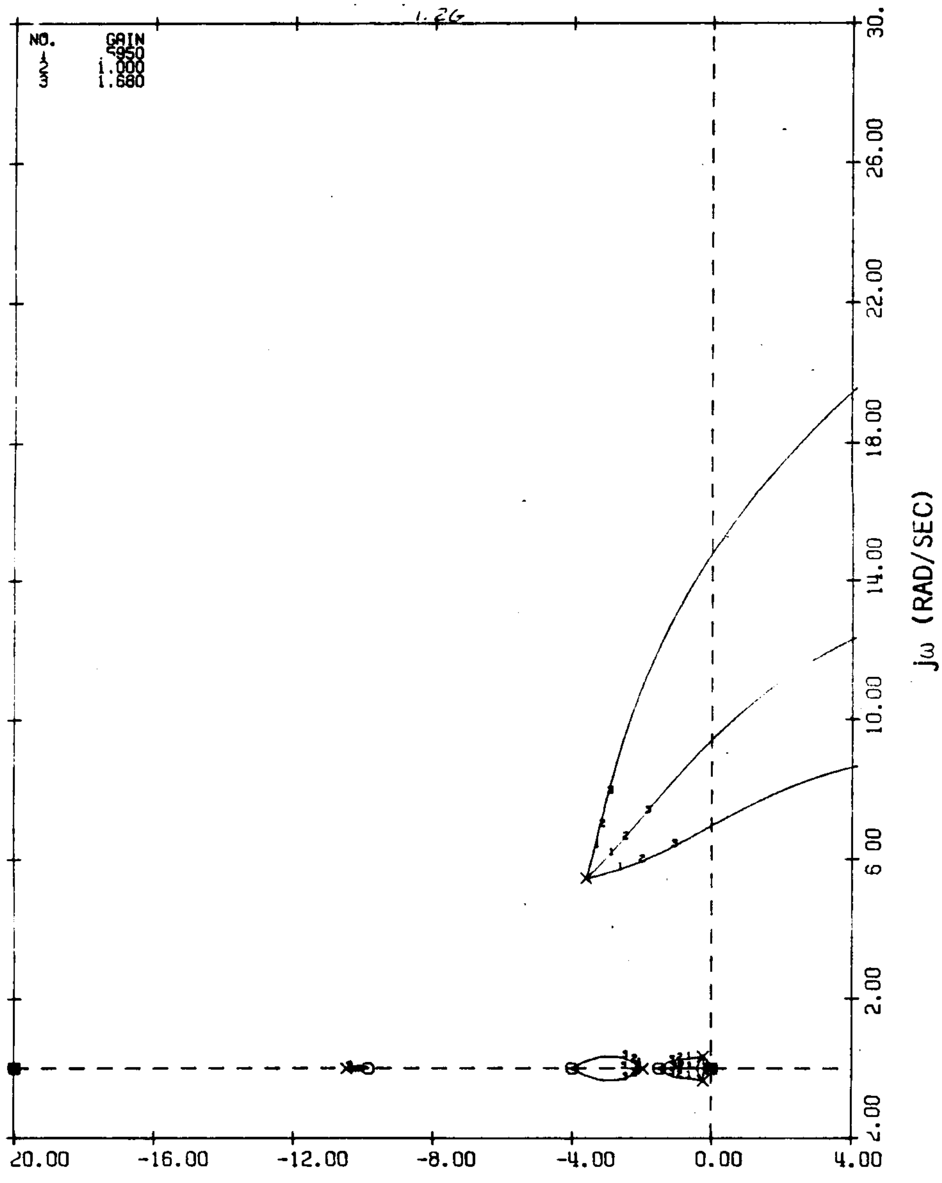


FIGURE 184

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- PCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

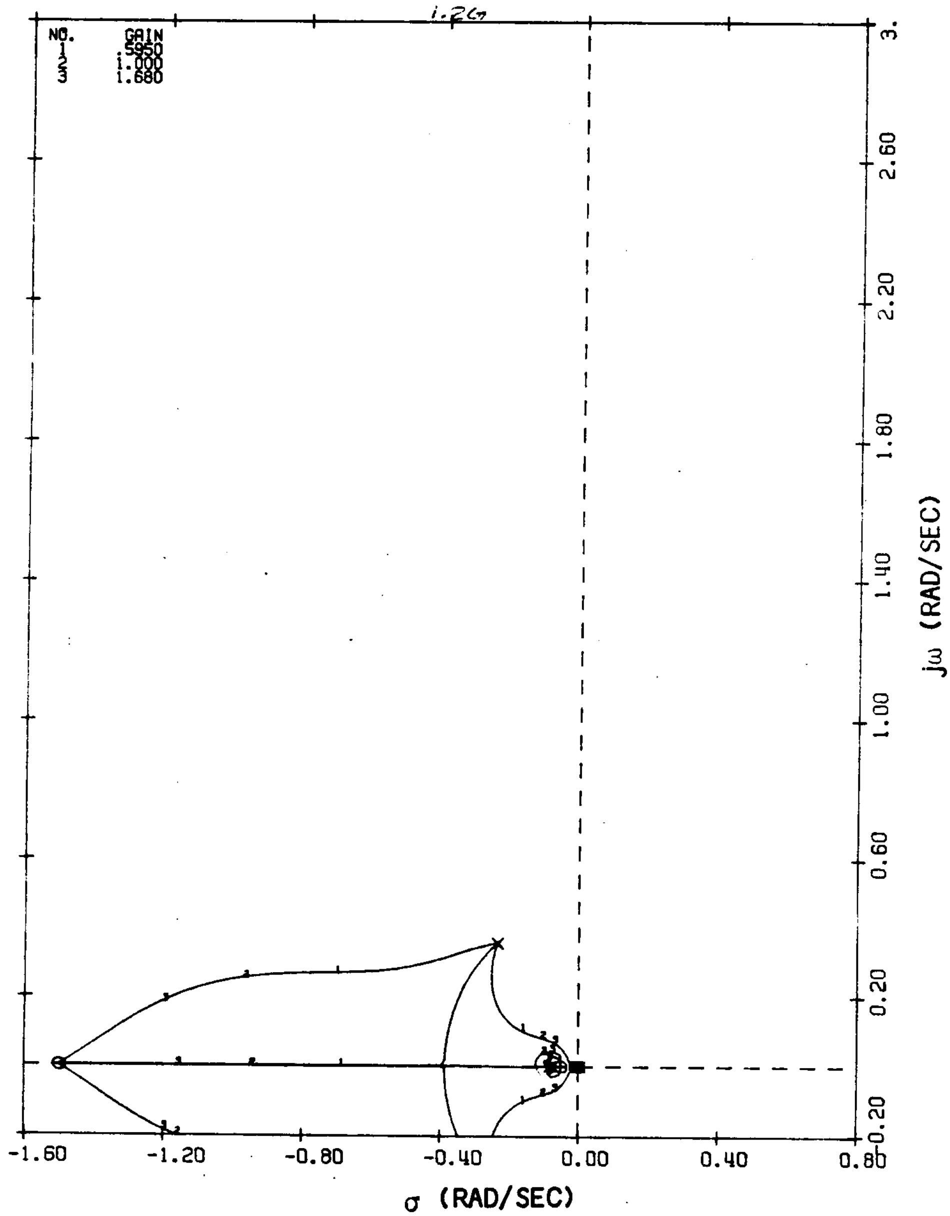


FIGURE 184 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

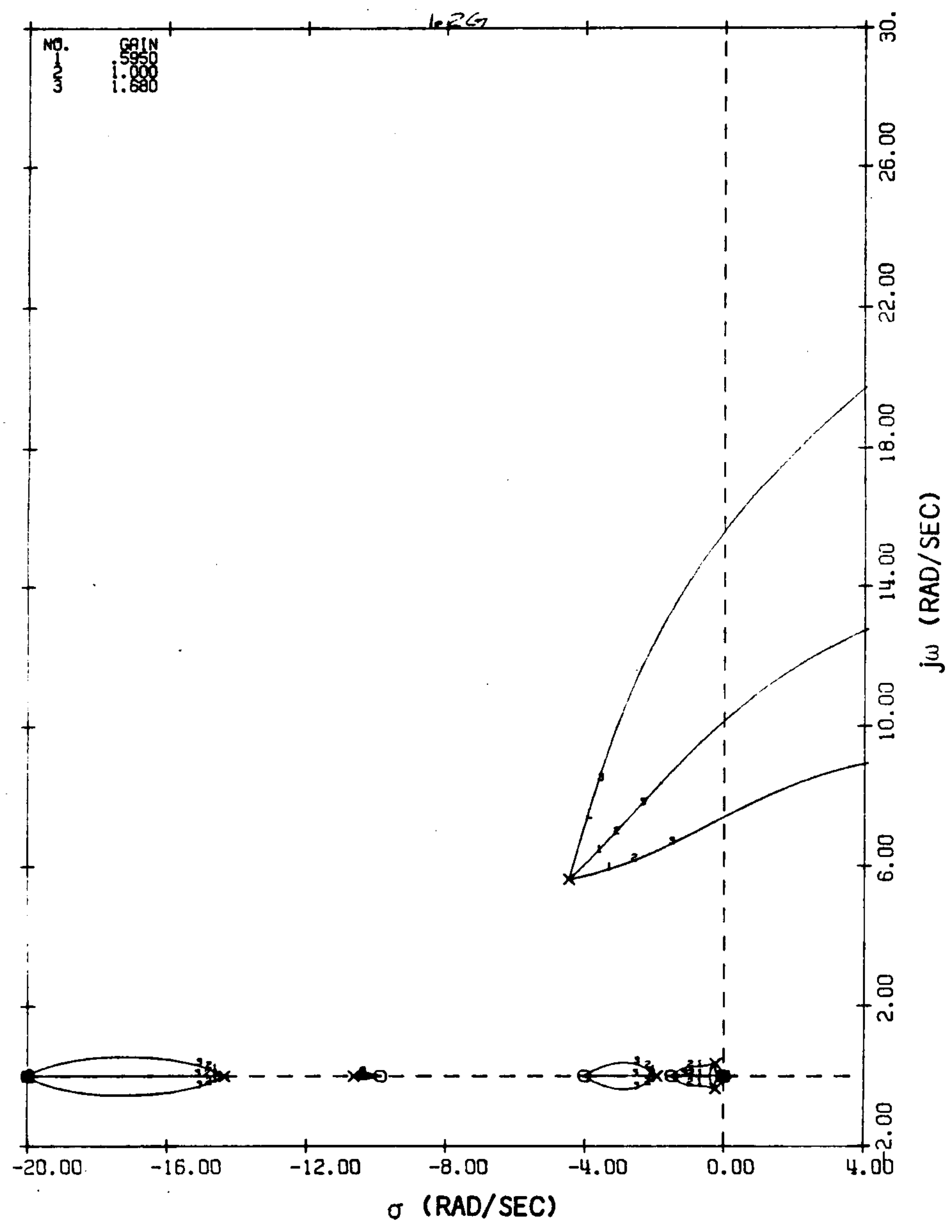


FIGURE 185

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- PCS WITH RSS AND GLA CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

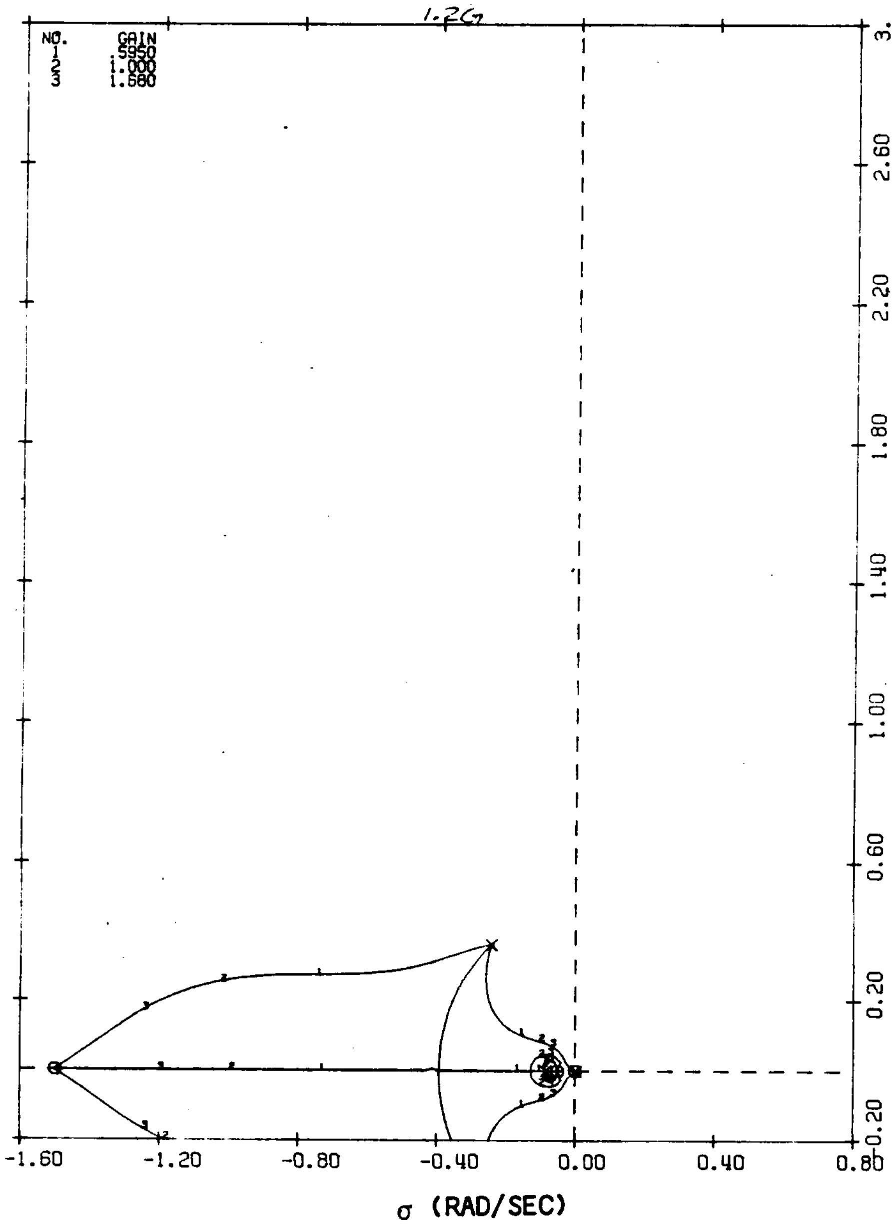


FIGURE 185 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

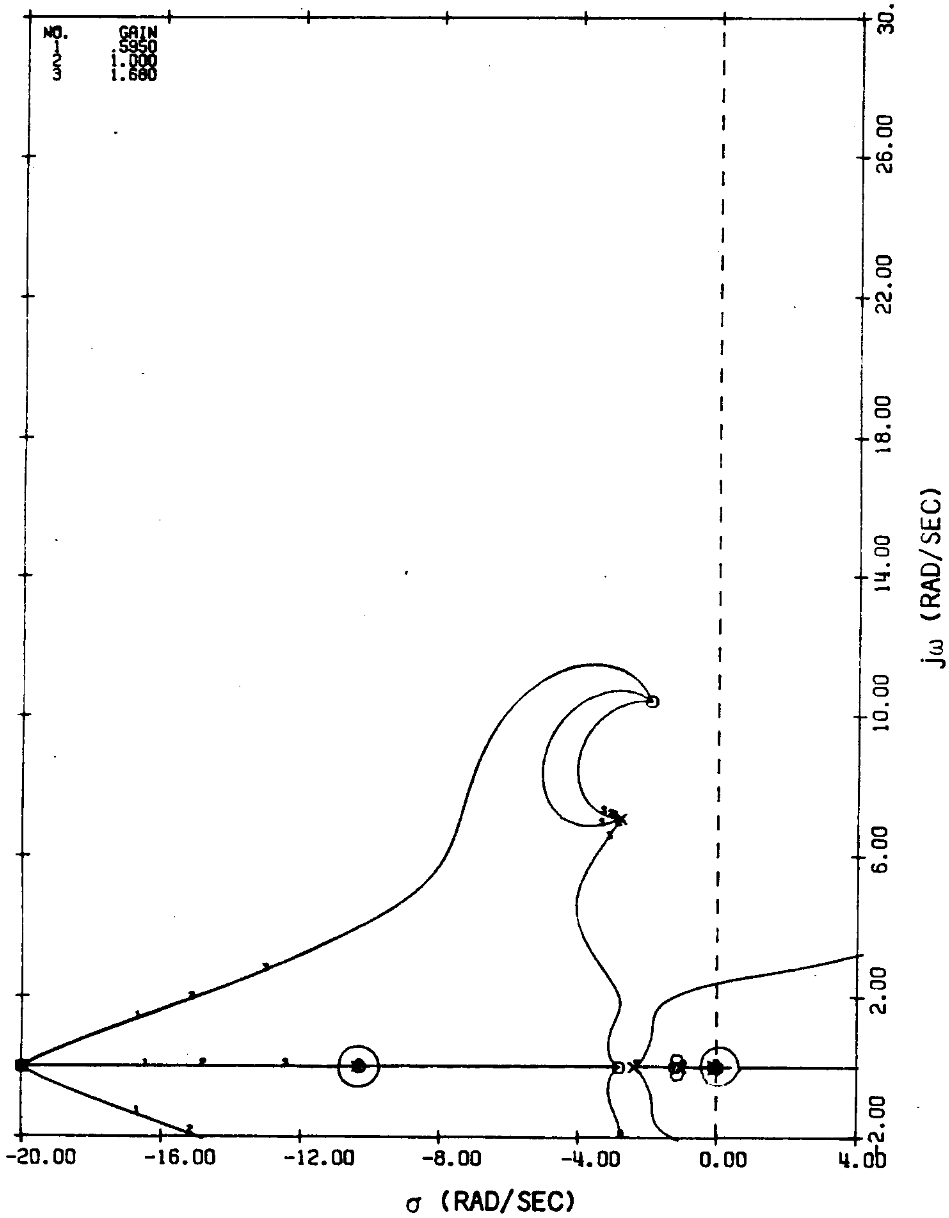


FIGURE 186

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

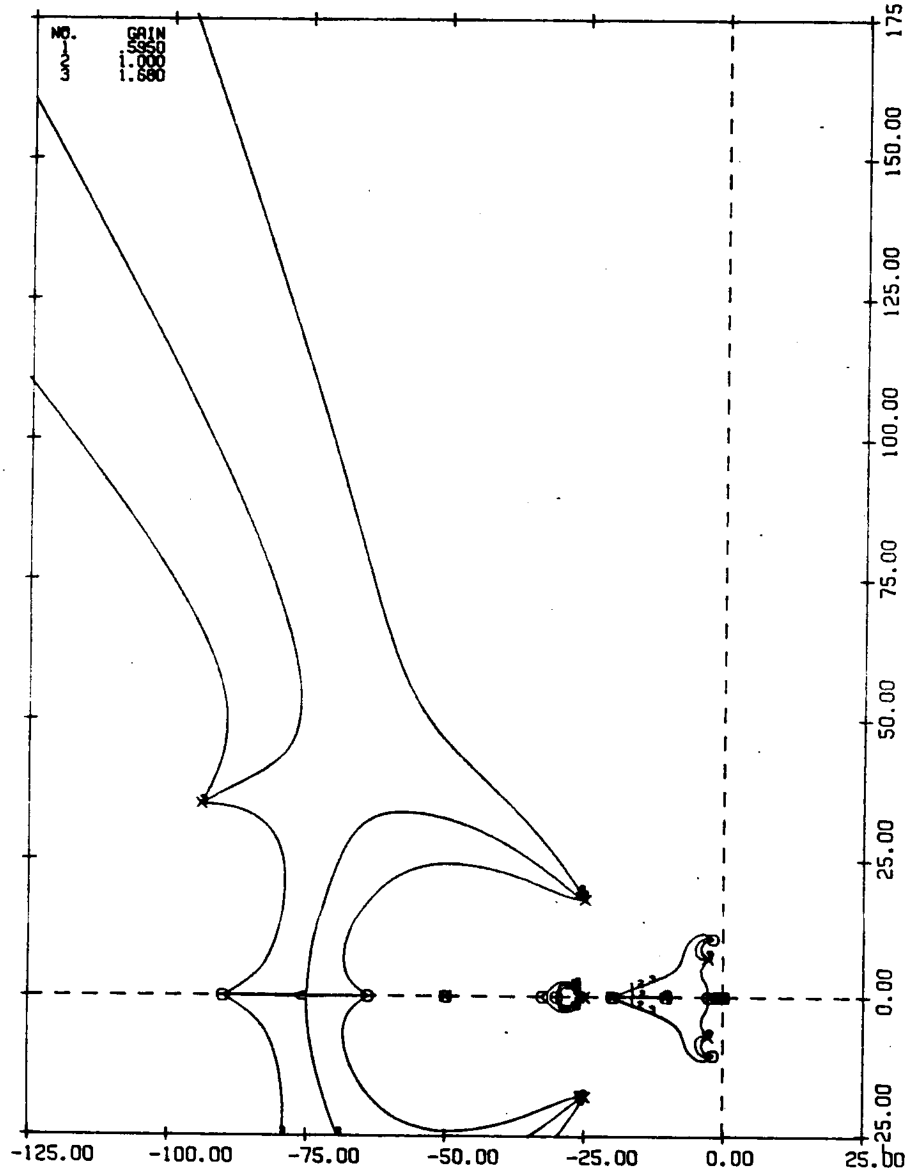


FIGURE 186 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

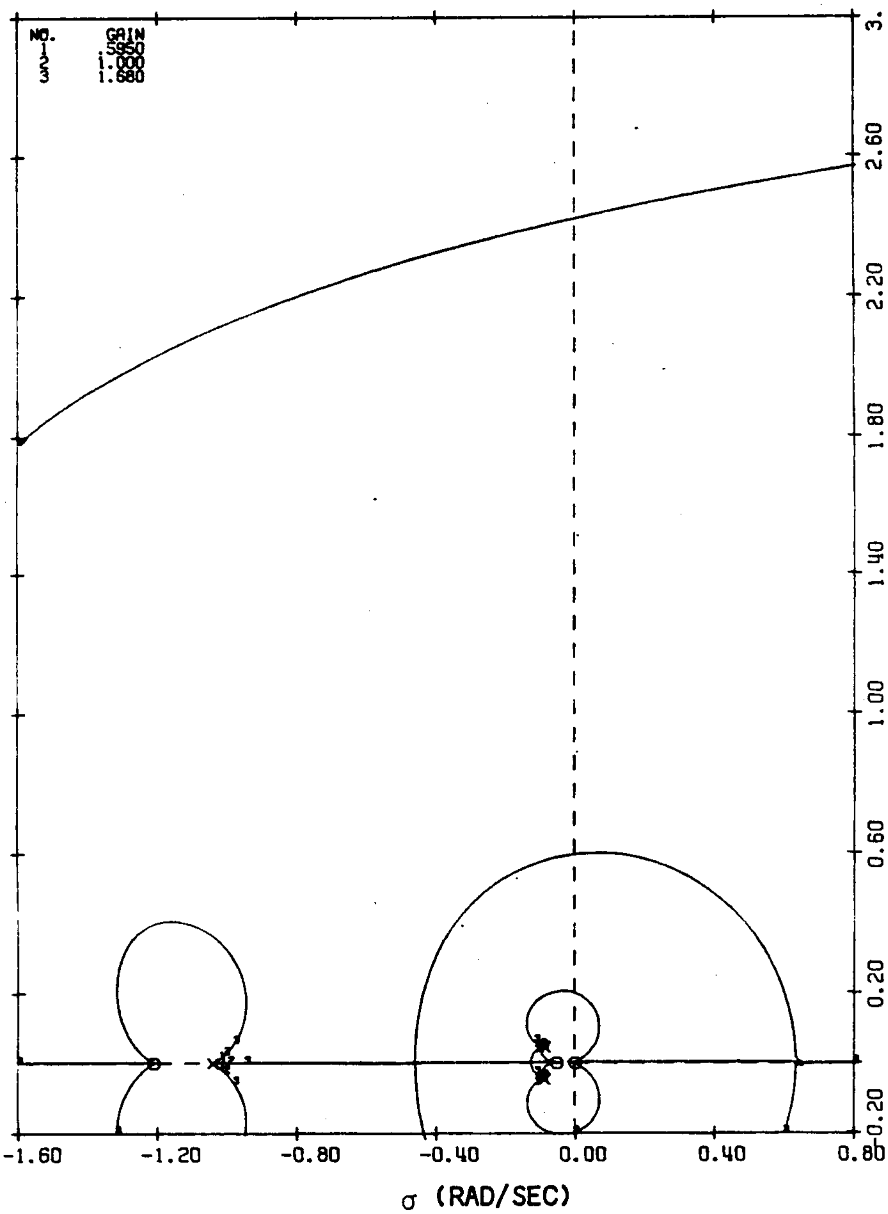


FIGURE 186 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

APPENDIX E

- CRUISE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

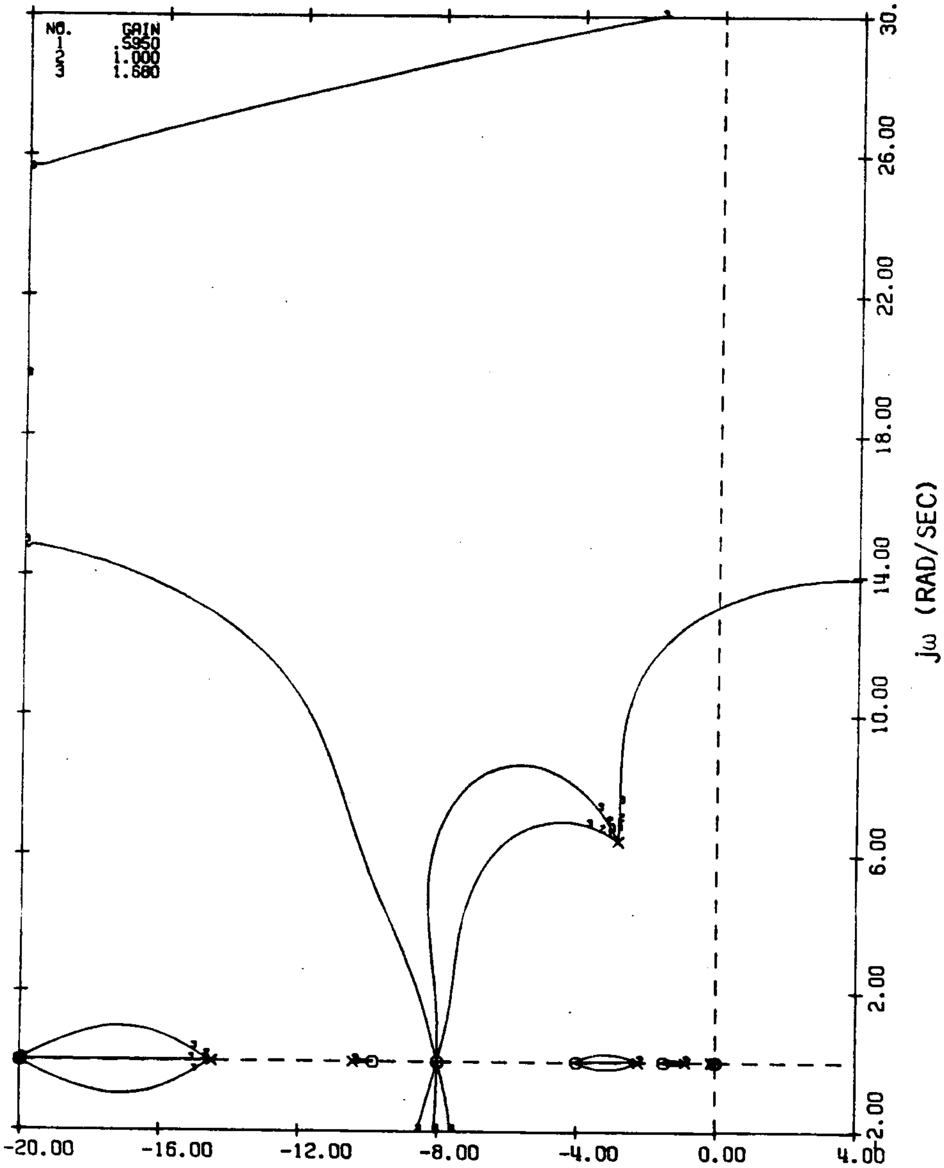


FIGURE 187

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

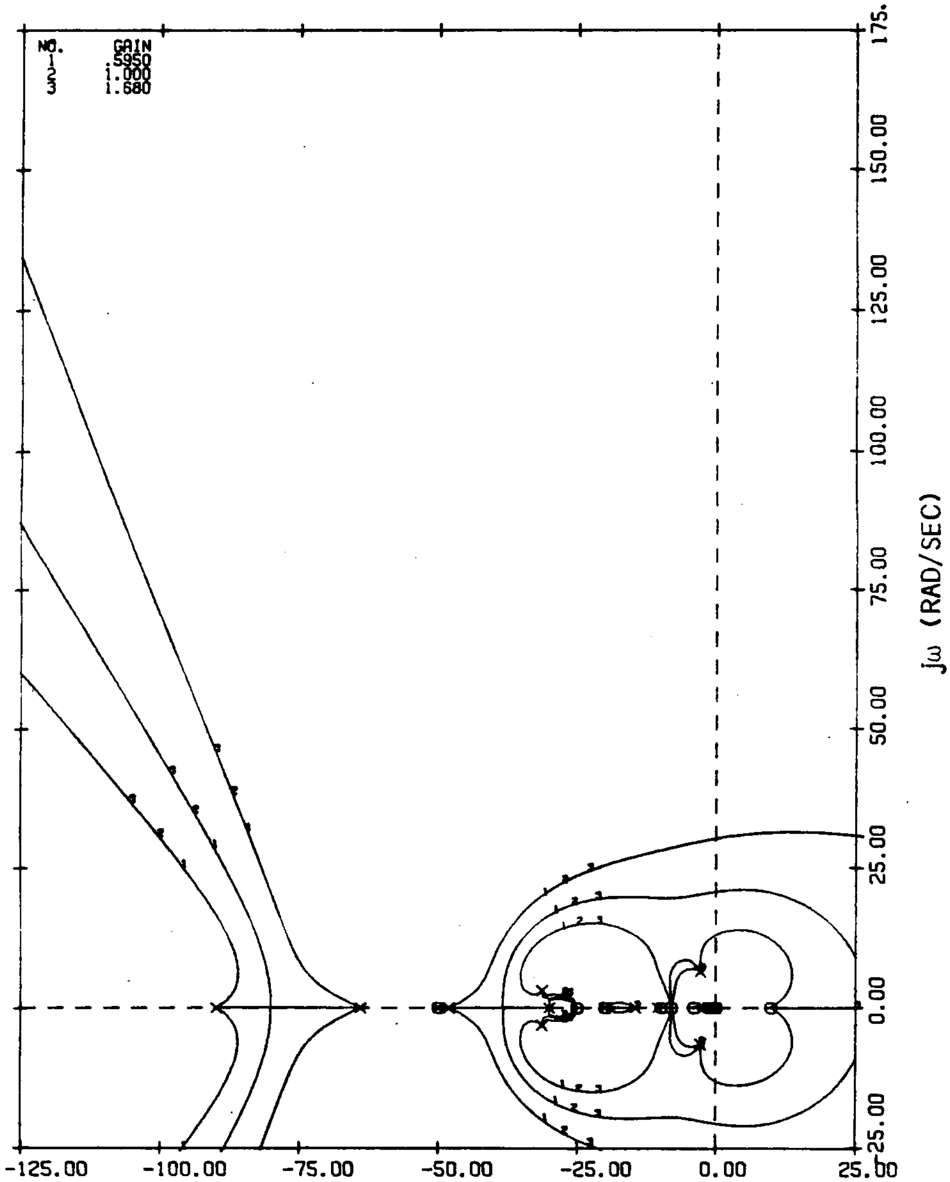


FIGURE 187 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

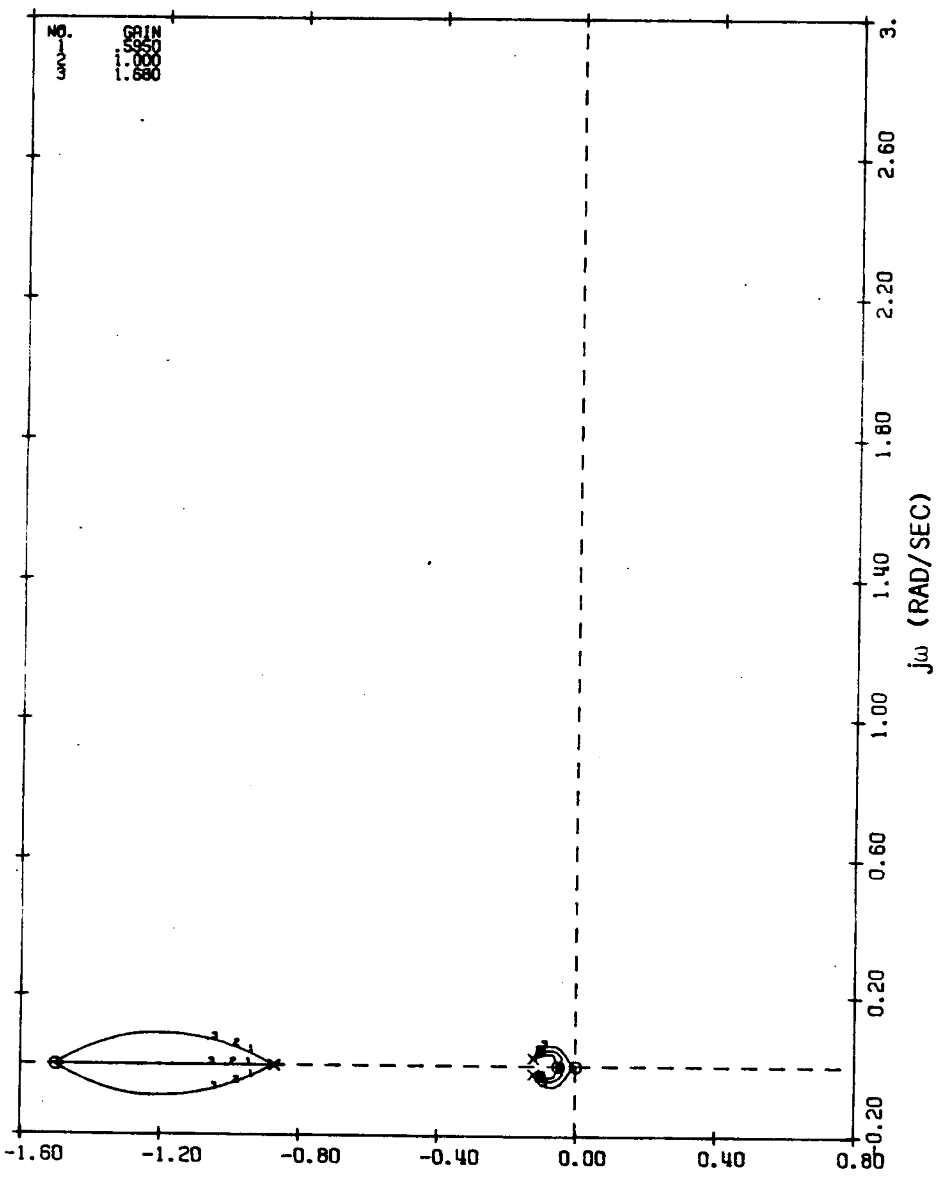


FIGURE 187 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- BCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

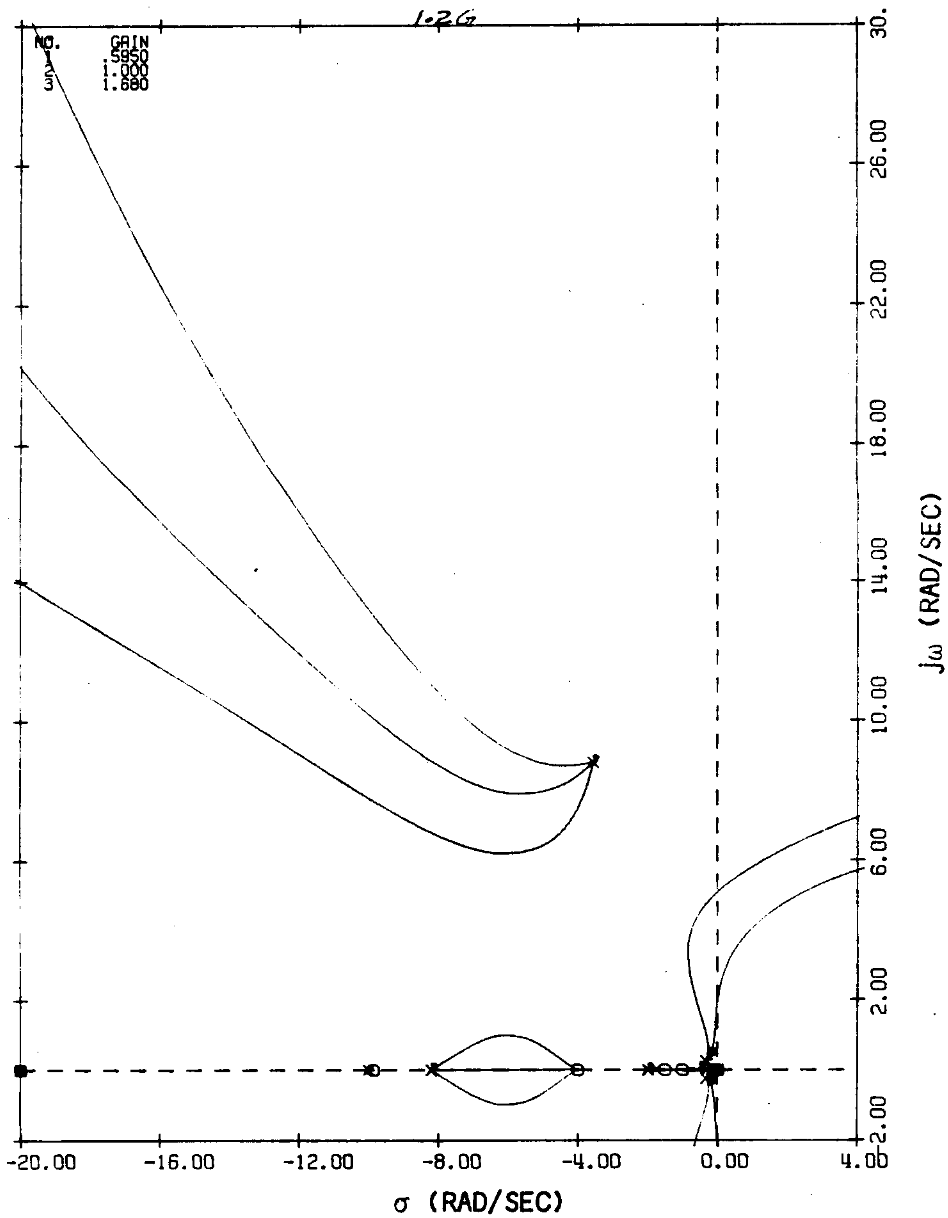


FIGURE 188

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION

- CRUISE
- BCS WITH RSS CLOSED
- 1.2g FLIGHT
- MACH: 0.80
- ALTITUDE: 46,800 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

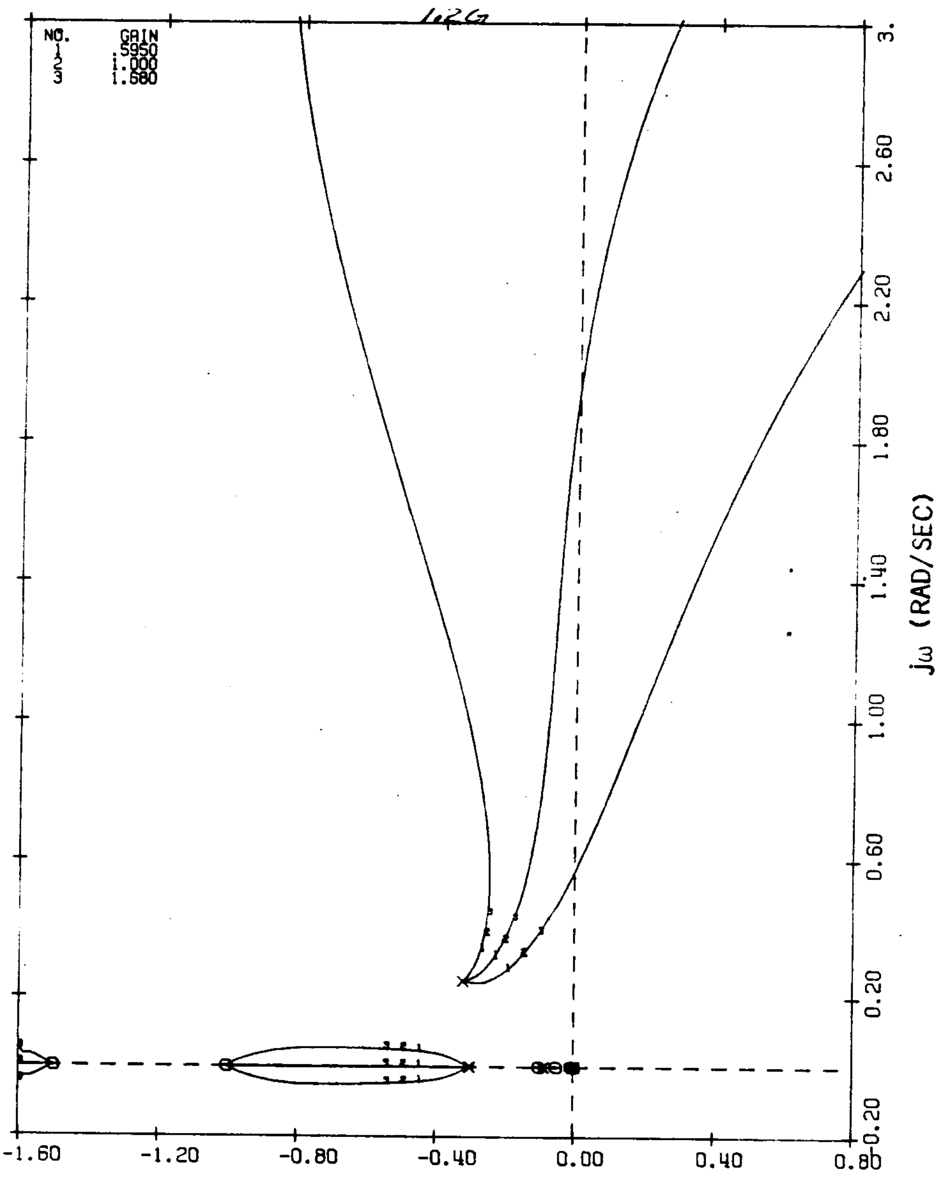


FIGURE 188 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. CRUISE CONDITION

- MAXIMUM Q (V_d)
- RSS
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

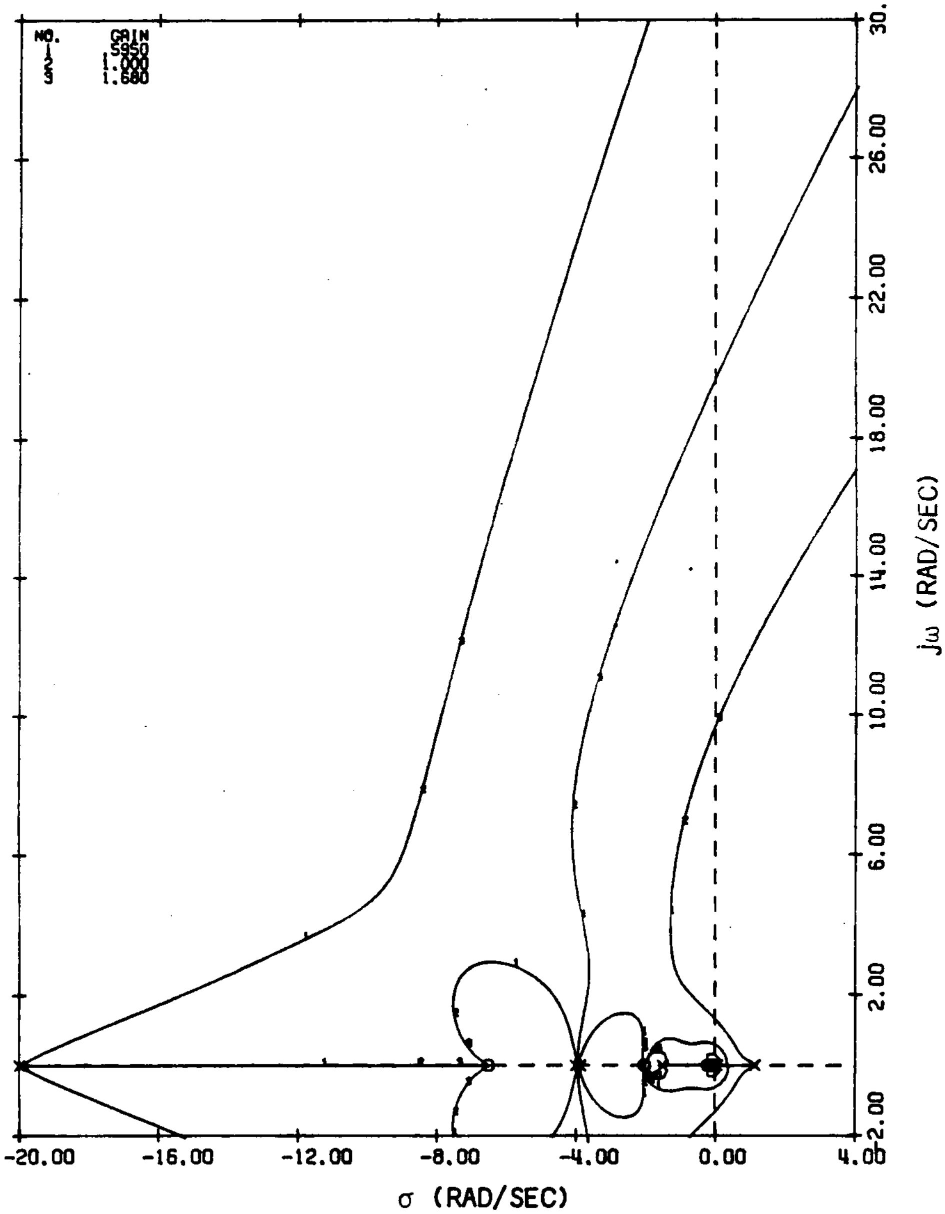


FIGURE 189

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

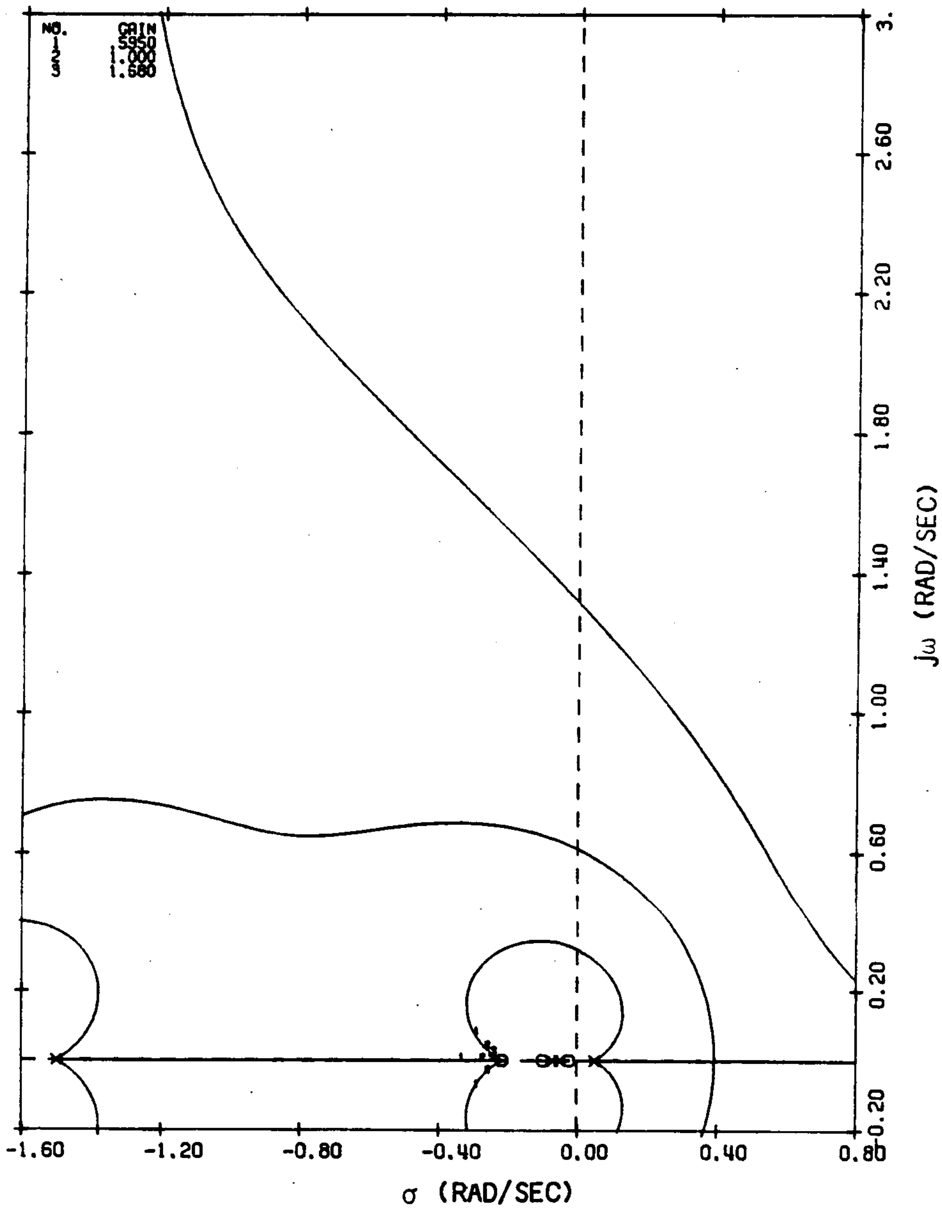


FIGURE 189 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

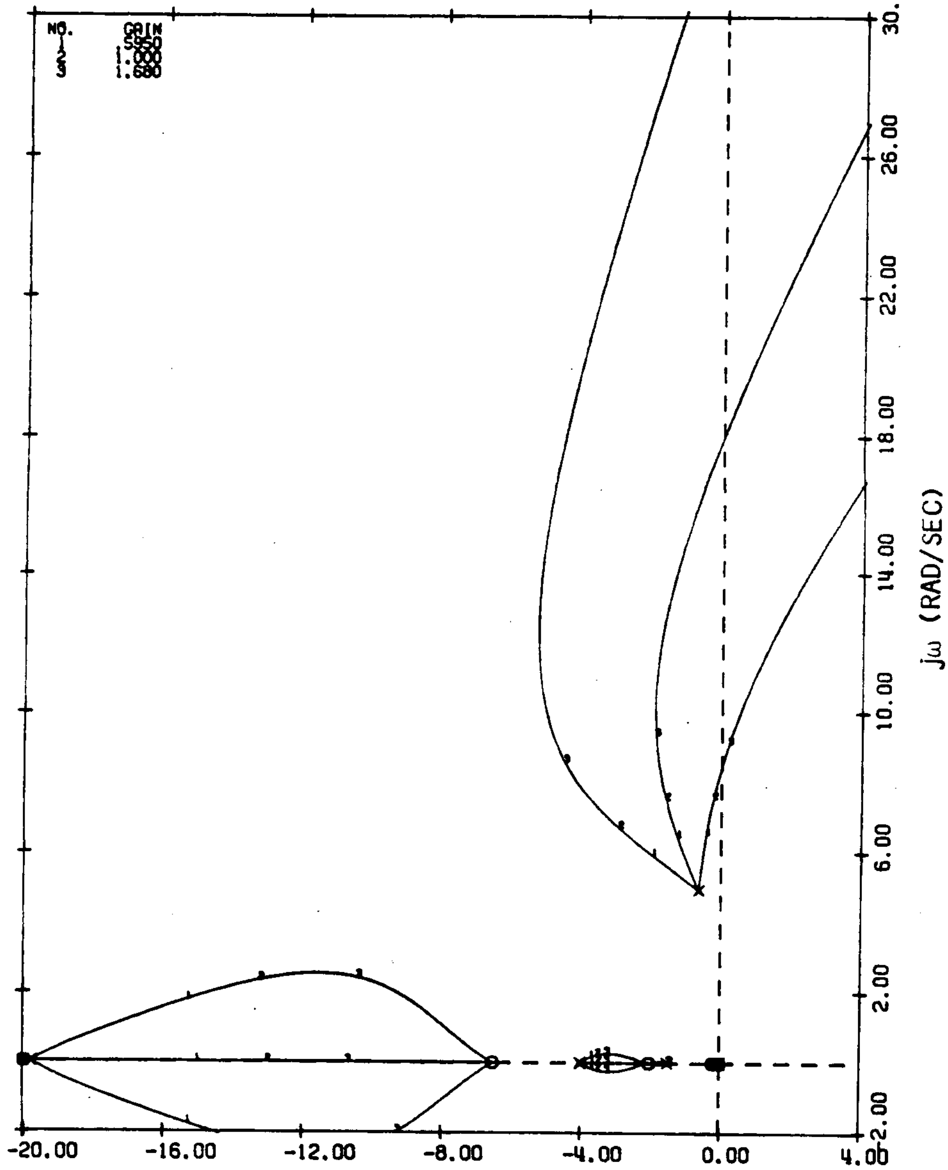


FIGURE 190

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

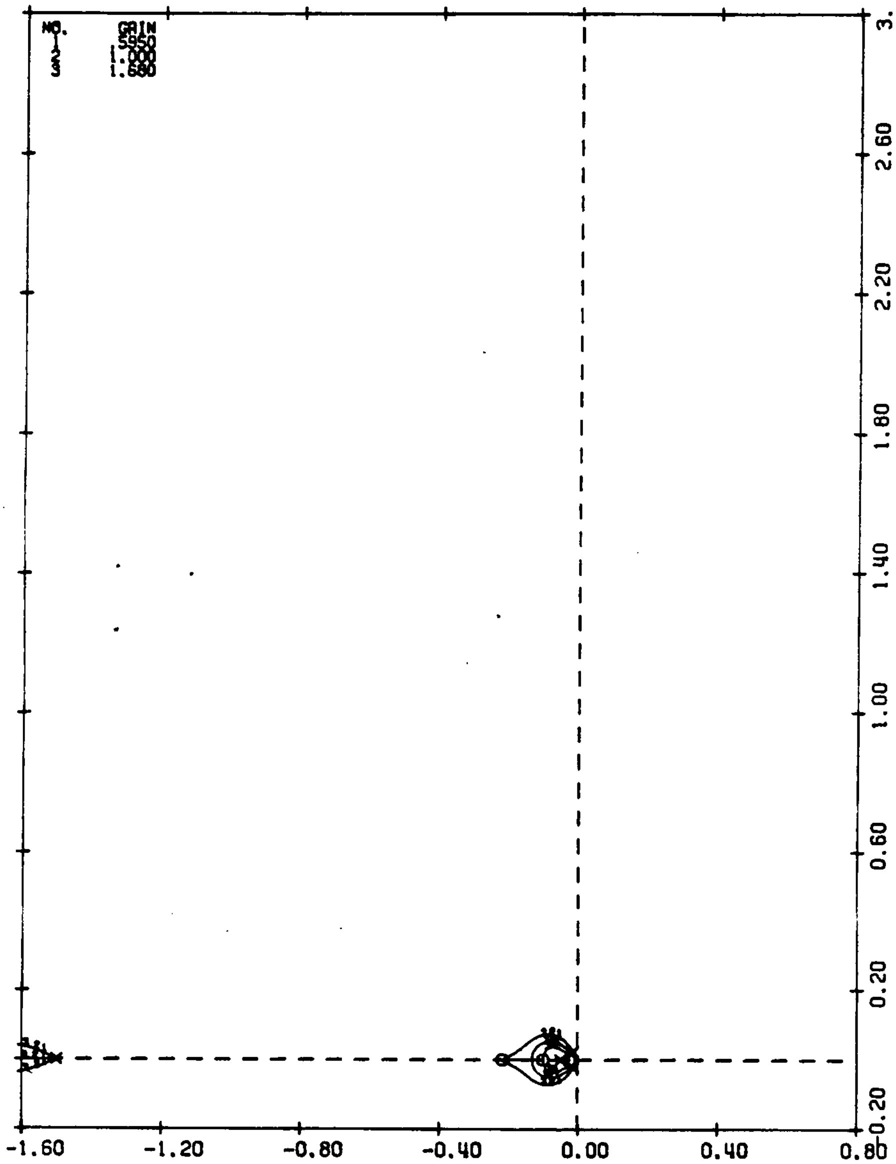


FIGURE 190 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

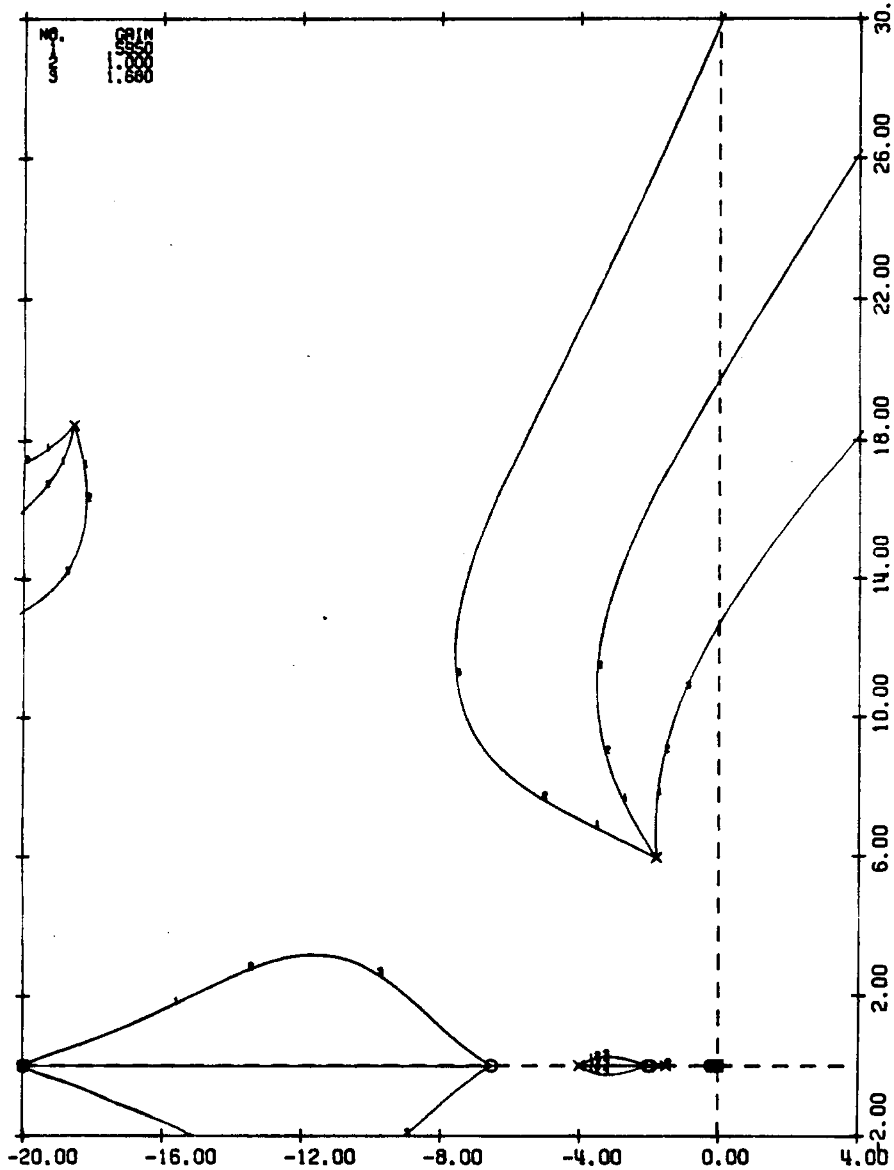


FIGURE 191

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

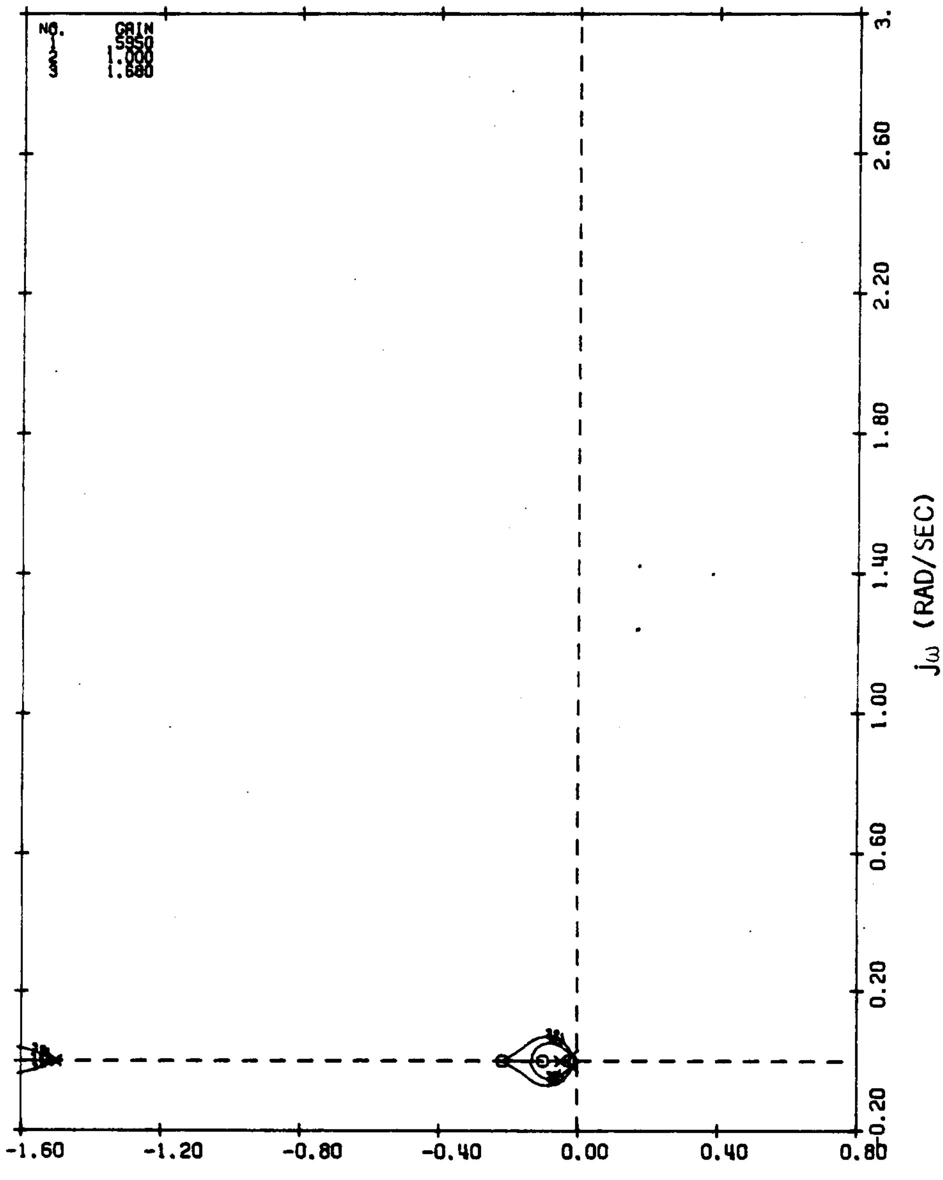


FIGURE 191 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

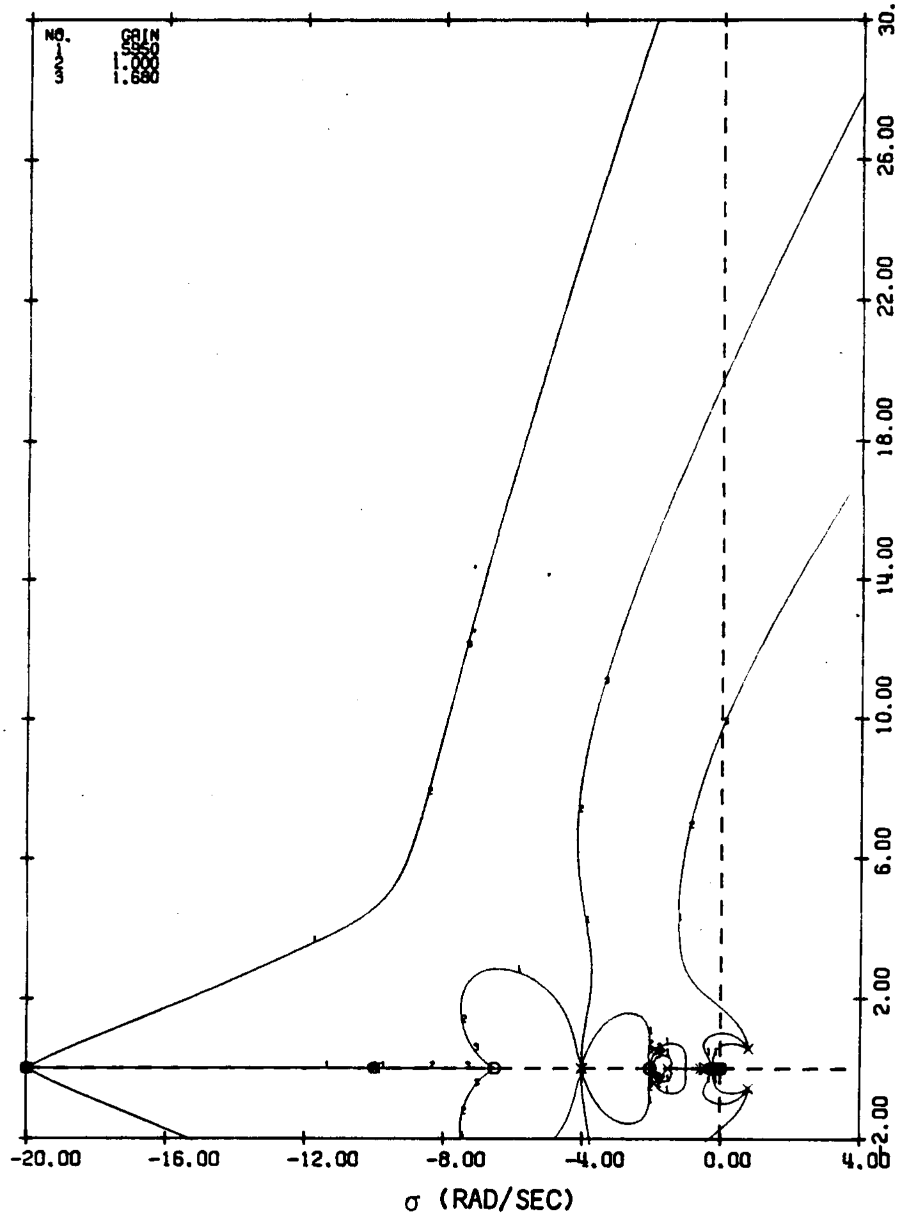


FIGURE 192

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

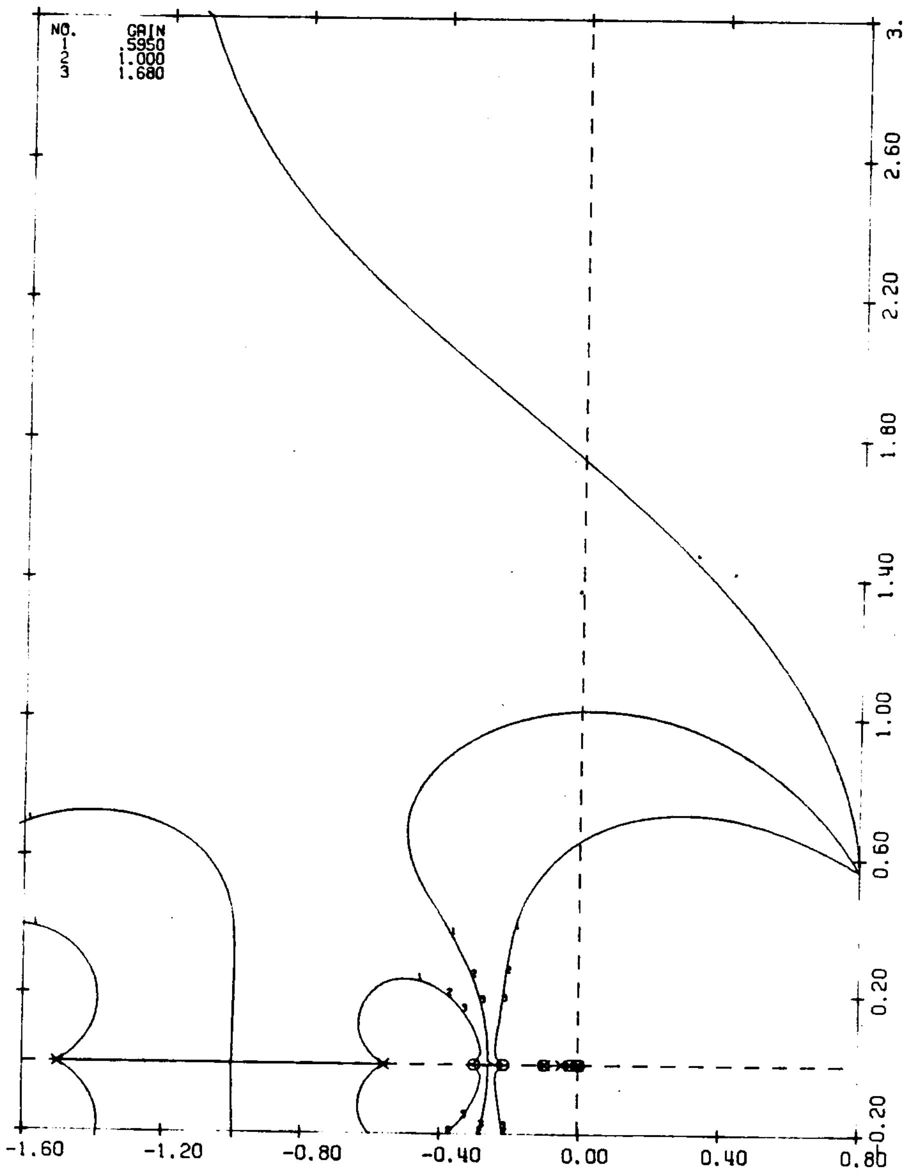


FIGURE 192 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

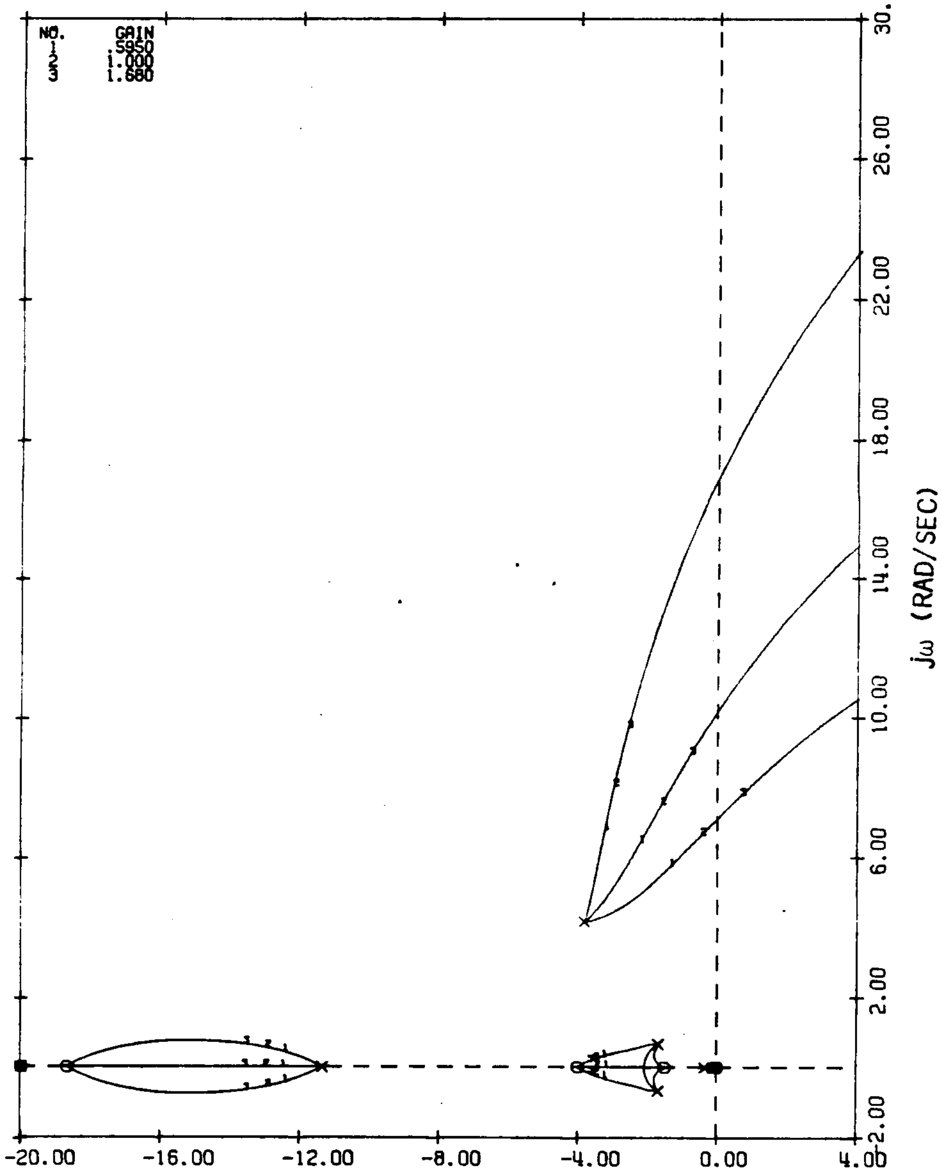


FIGURE 193

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

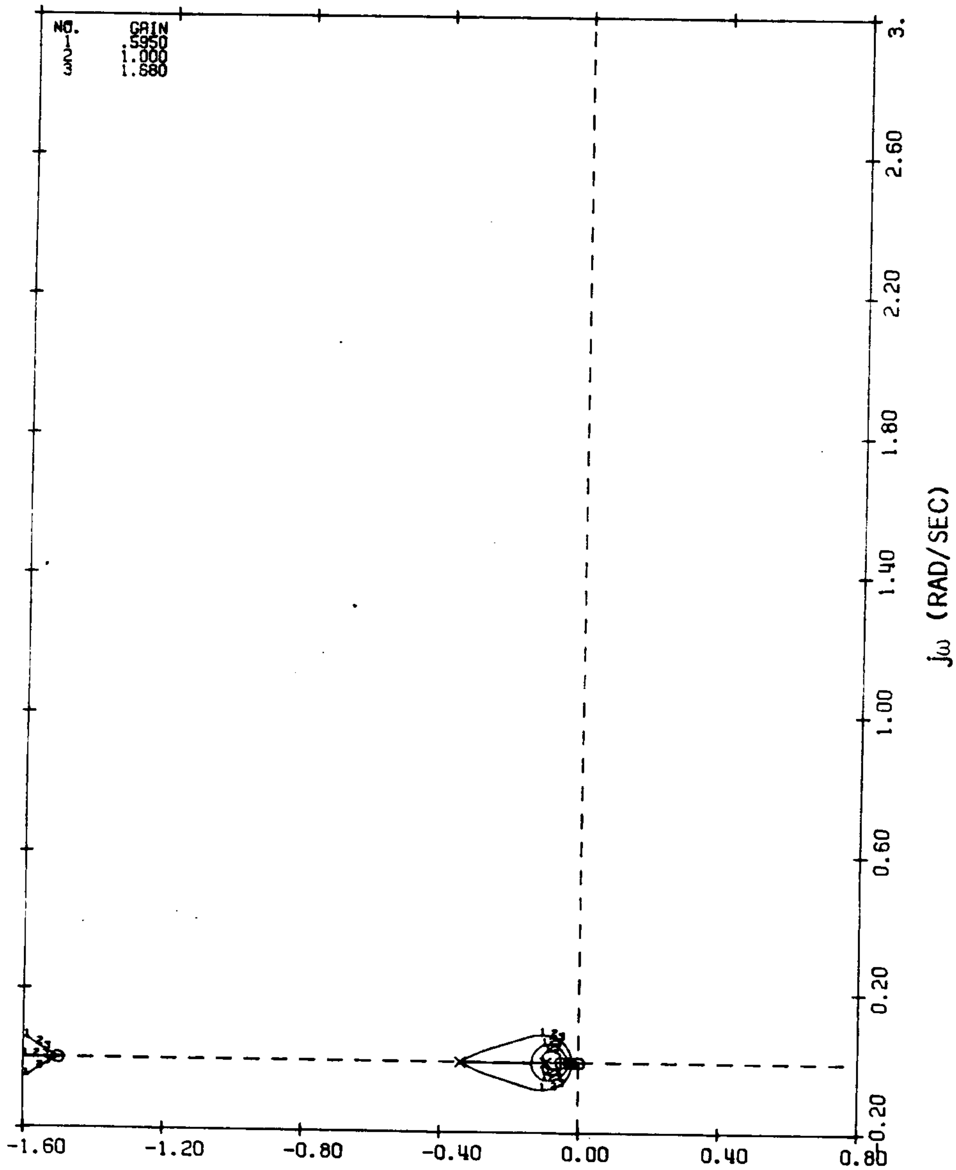


FIGURE 193 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

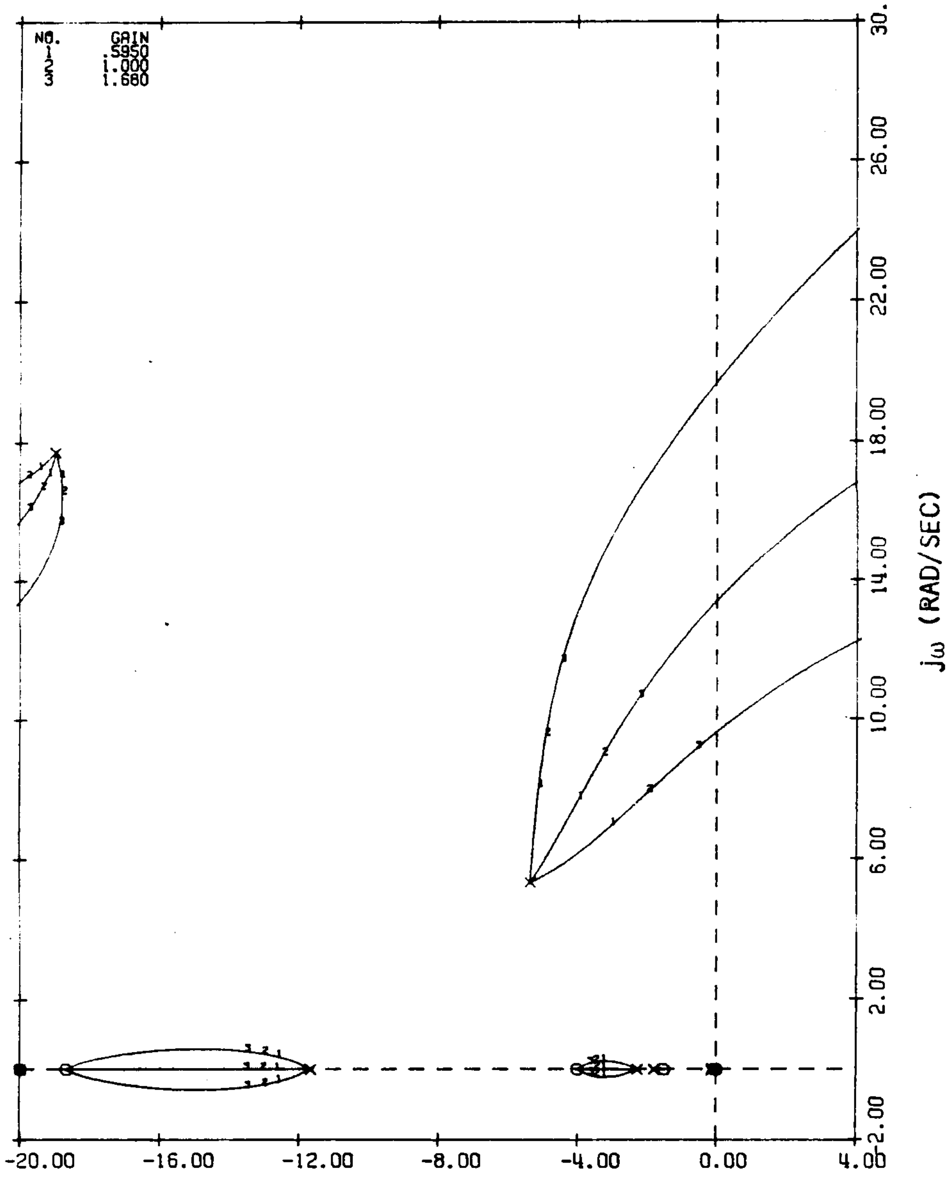


FIGURE 194

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

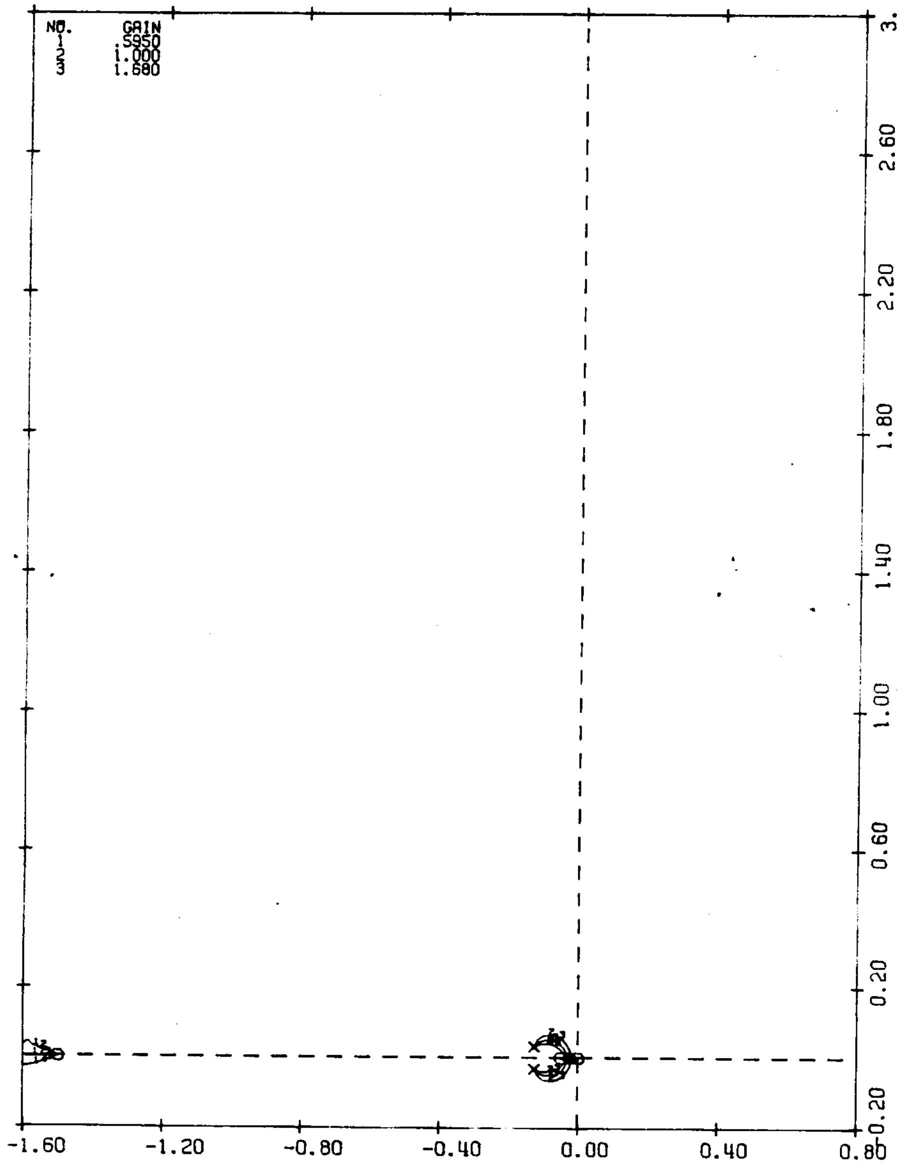


FIGURE 194 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

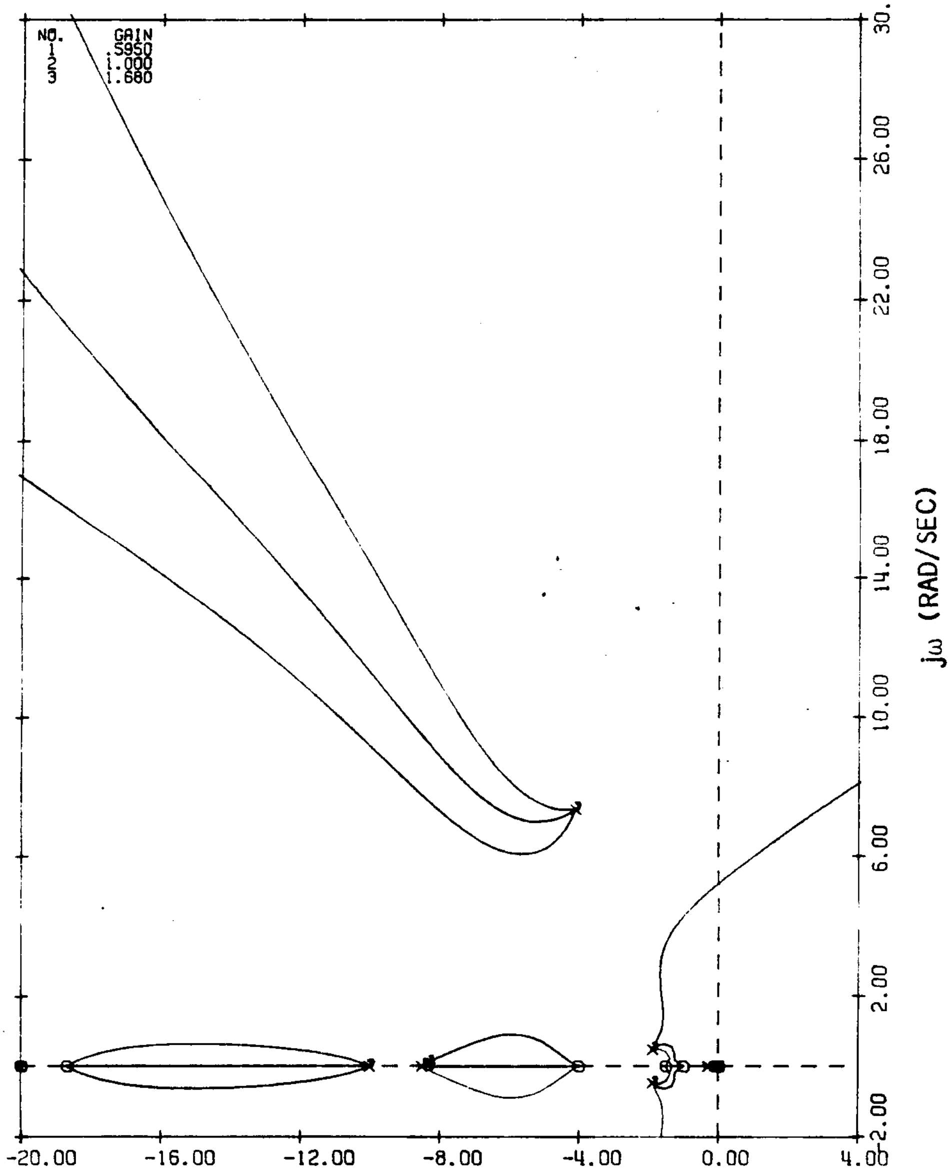


FIGURE 195

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2500 LBS.
- C.G.: 20% MAC

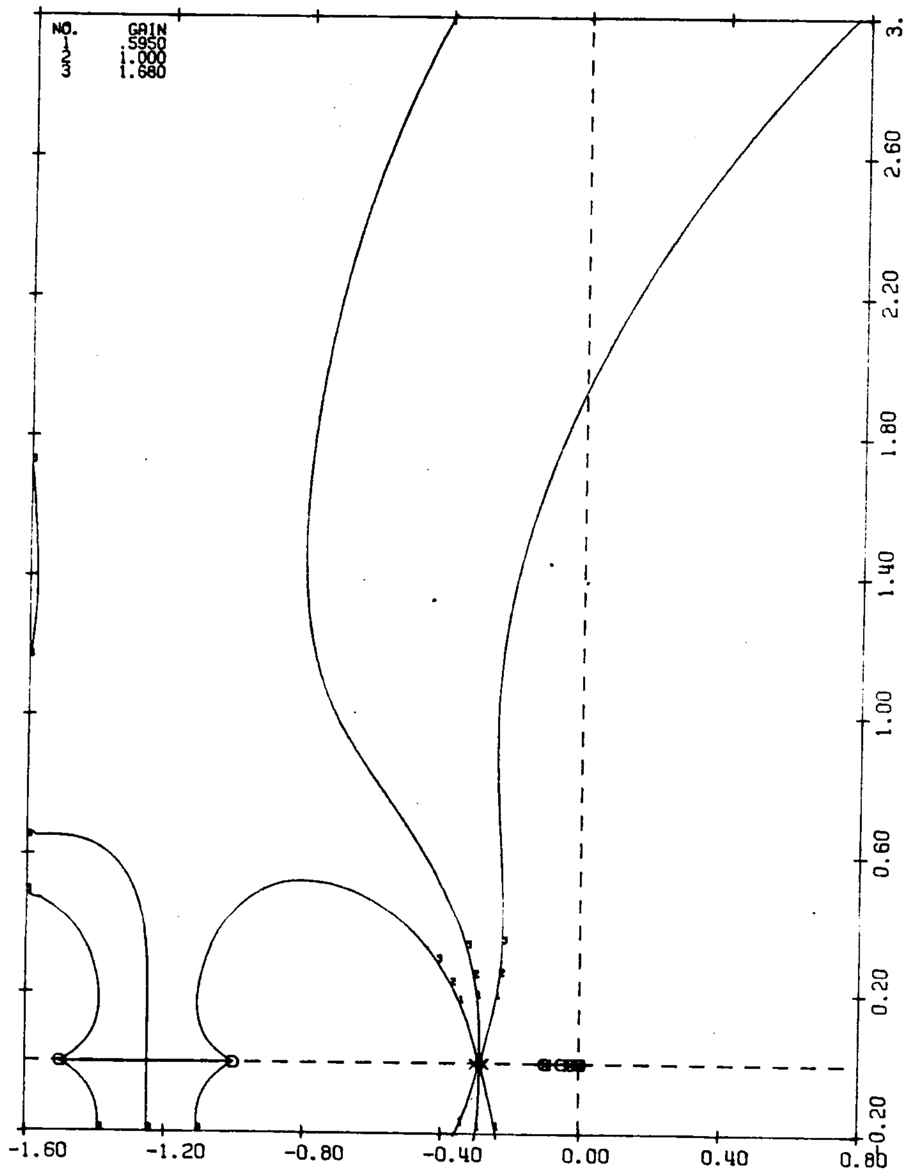


FIGURE 195 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR FORWARD C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

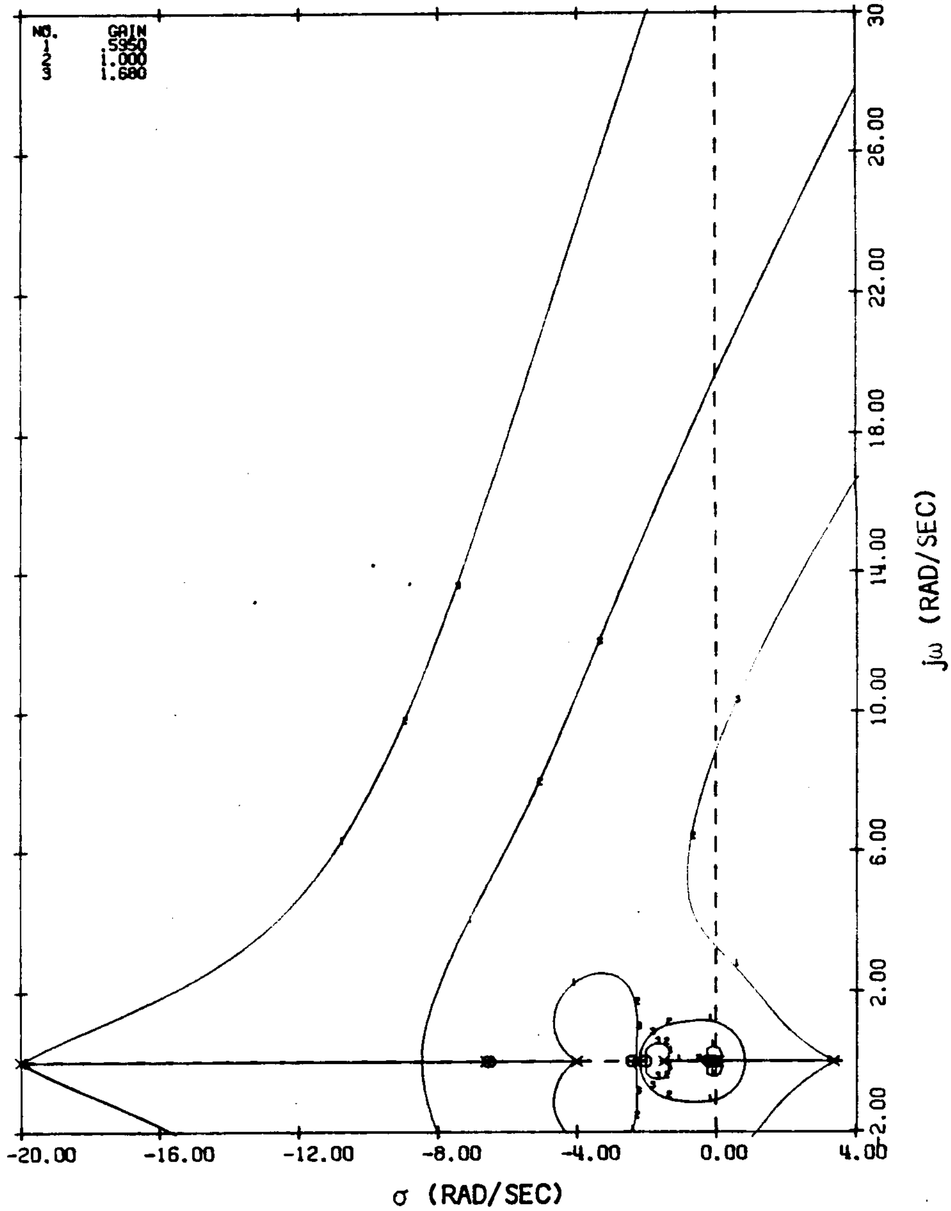


FIGURE 196

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

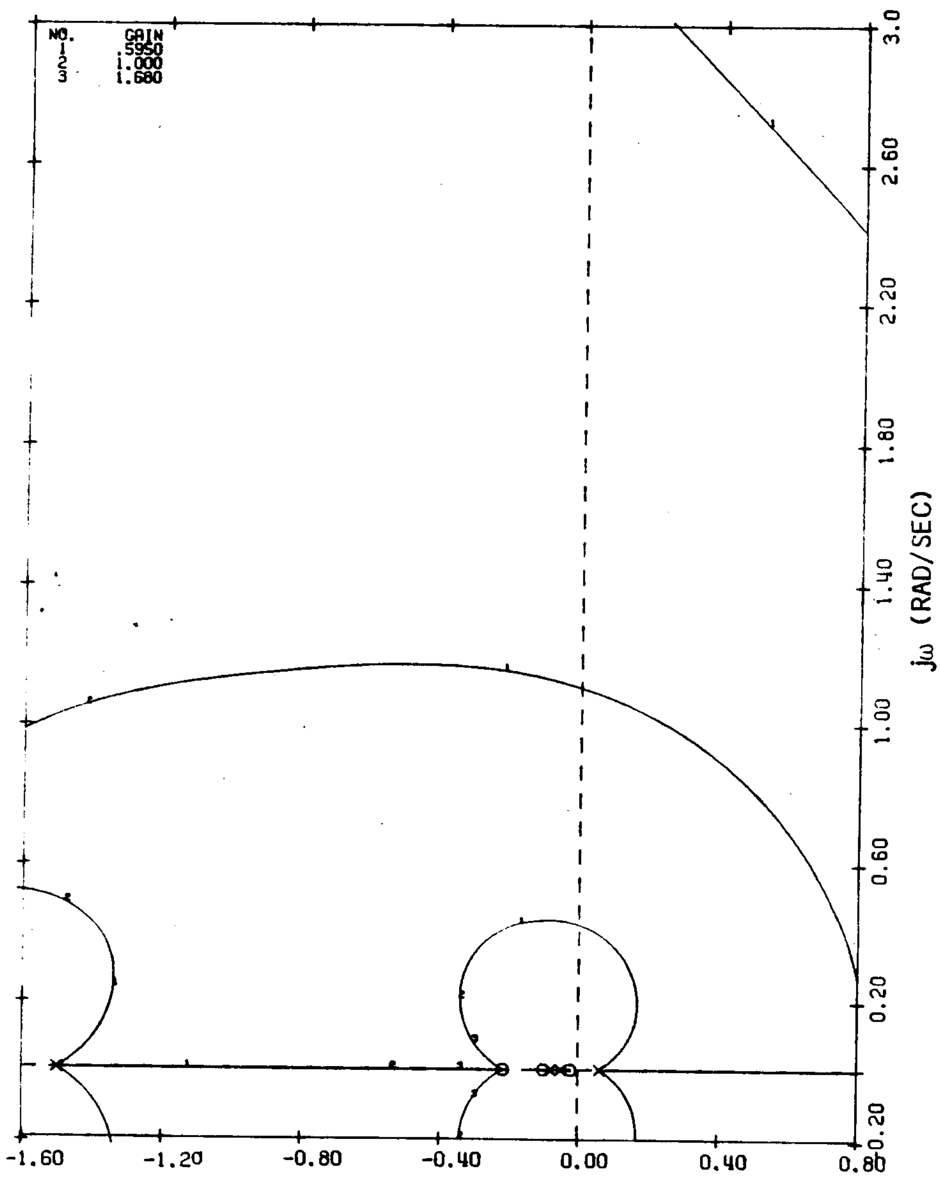


FIGURE 196 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BASIC AIRPLANE FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

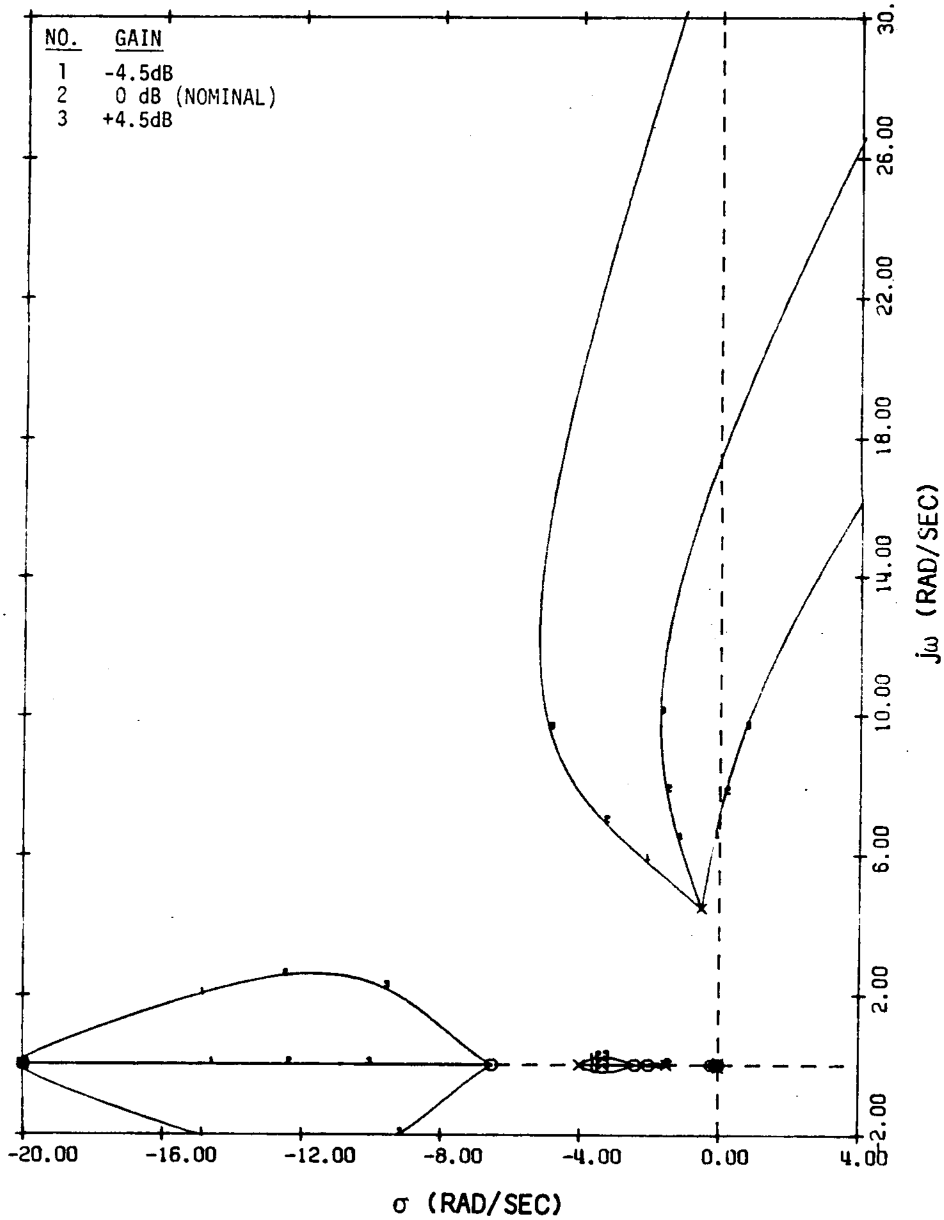


FIGURE 197

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

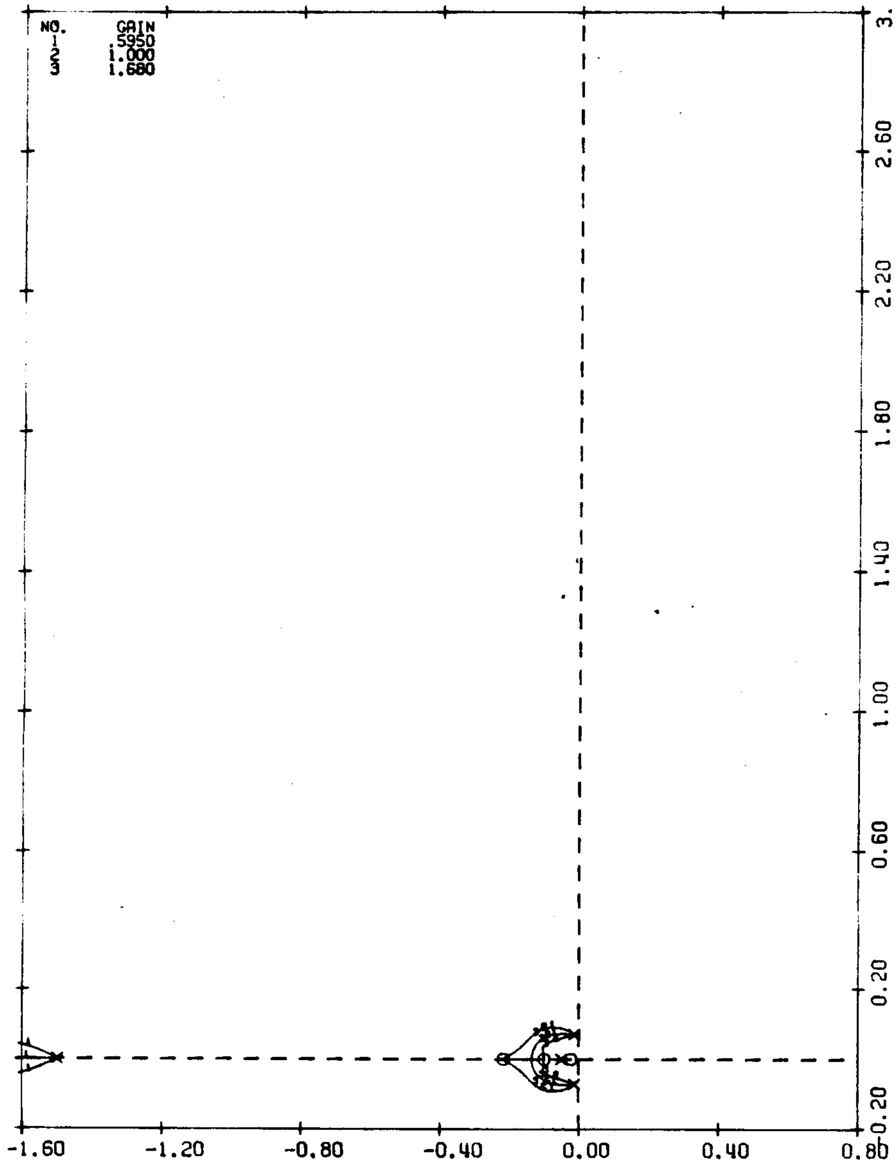


FIGURE 197 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

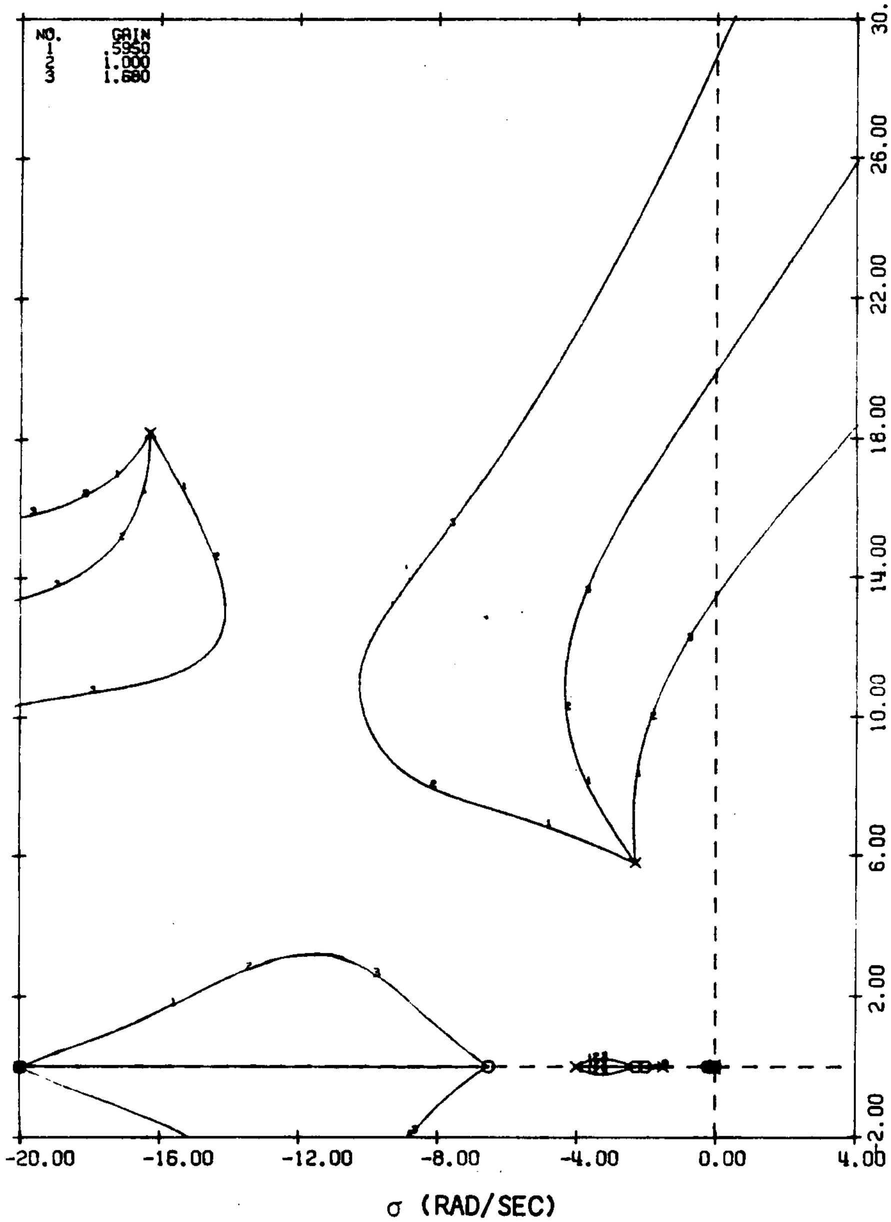


FIGURE 198

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS WITH PCS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

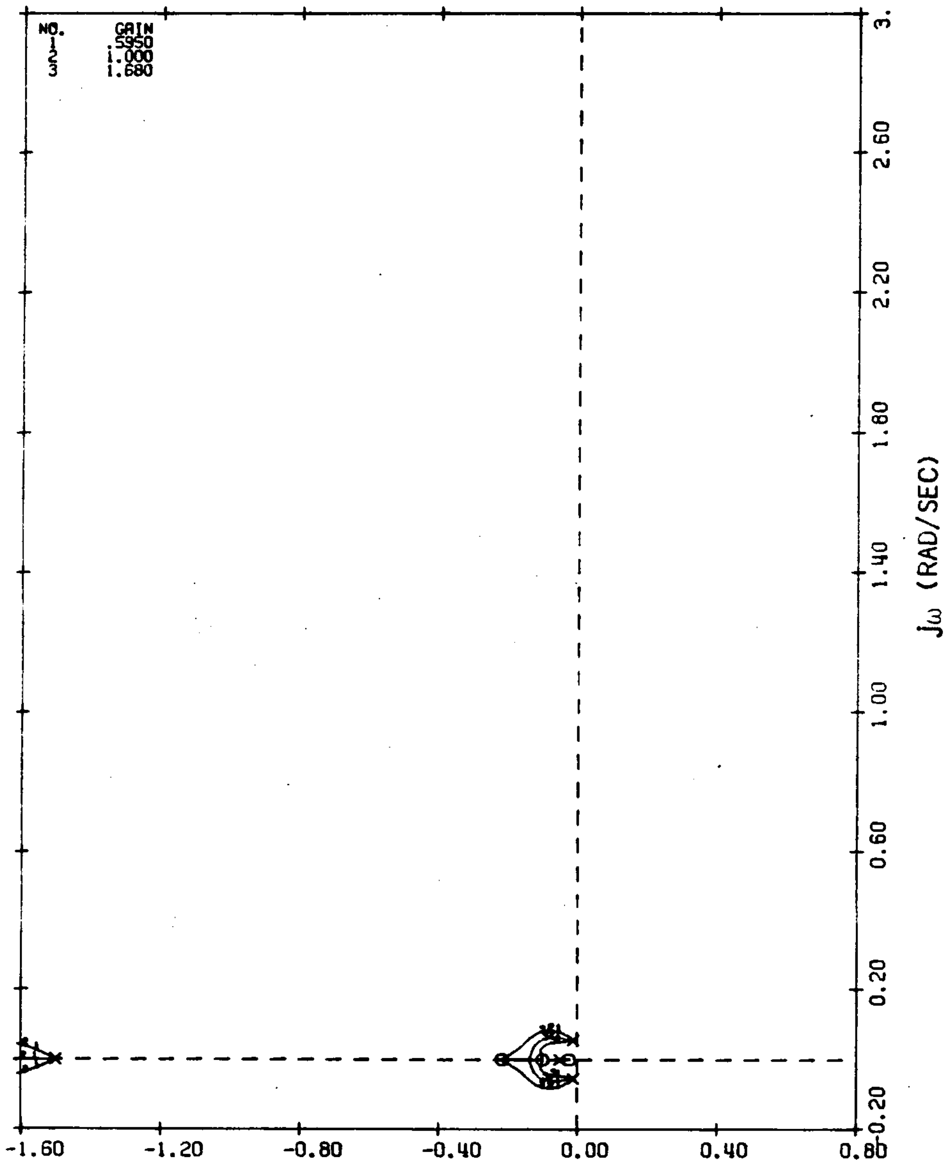


FIGURE 198 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH PCS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

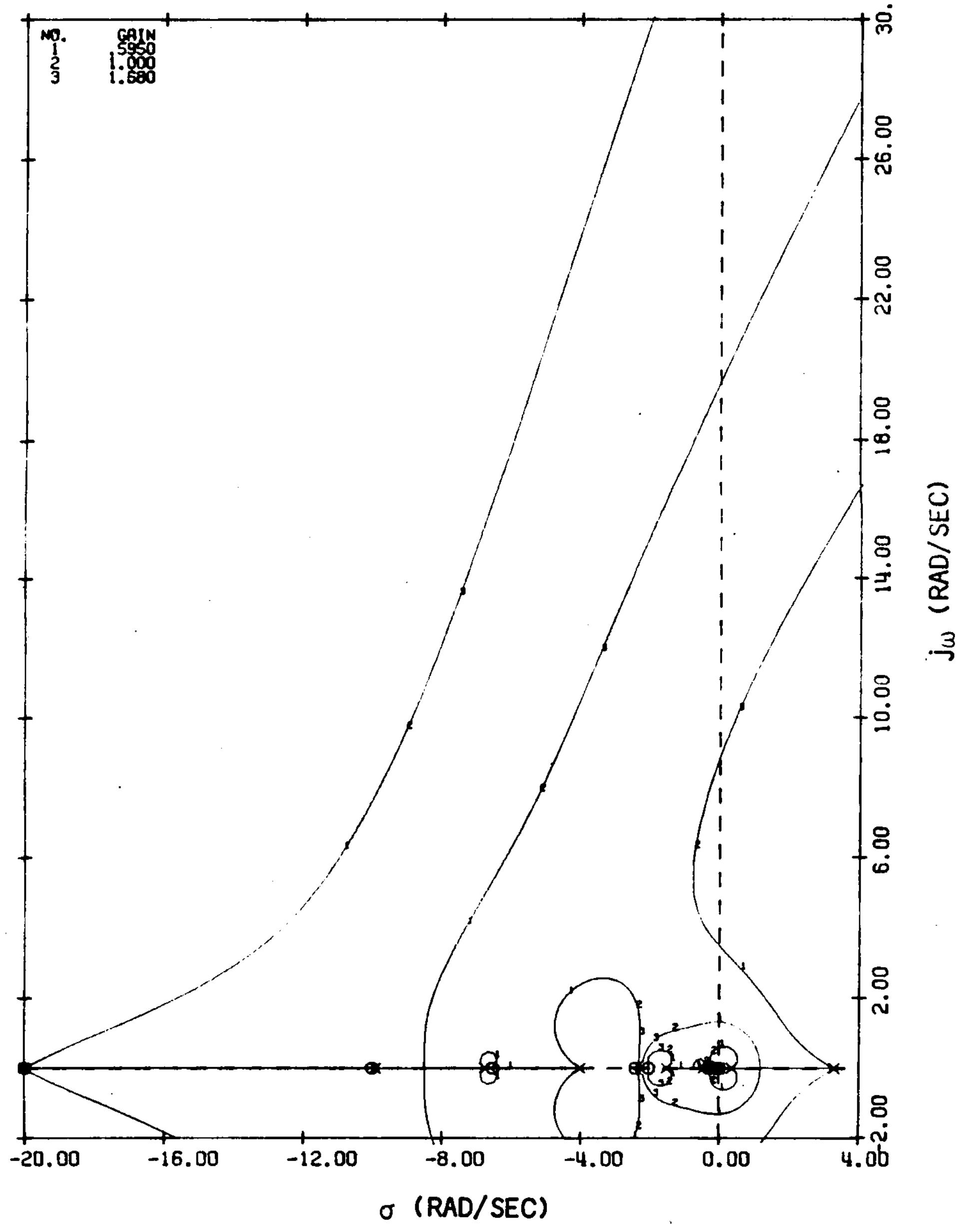


FIGURE 199

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- RSS WITH BCS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

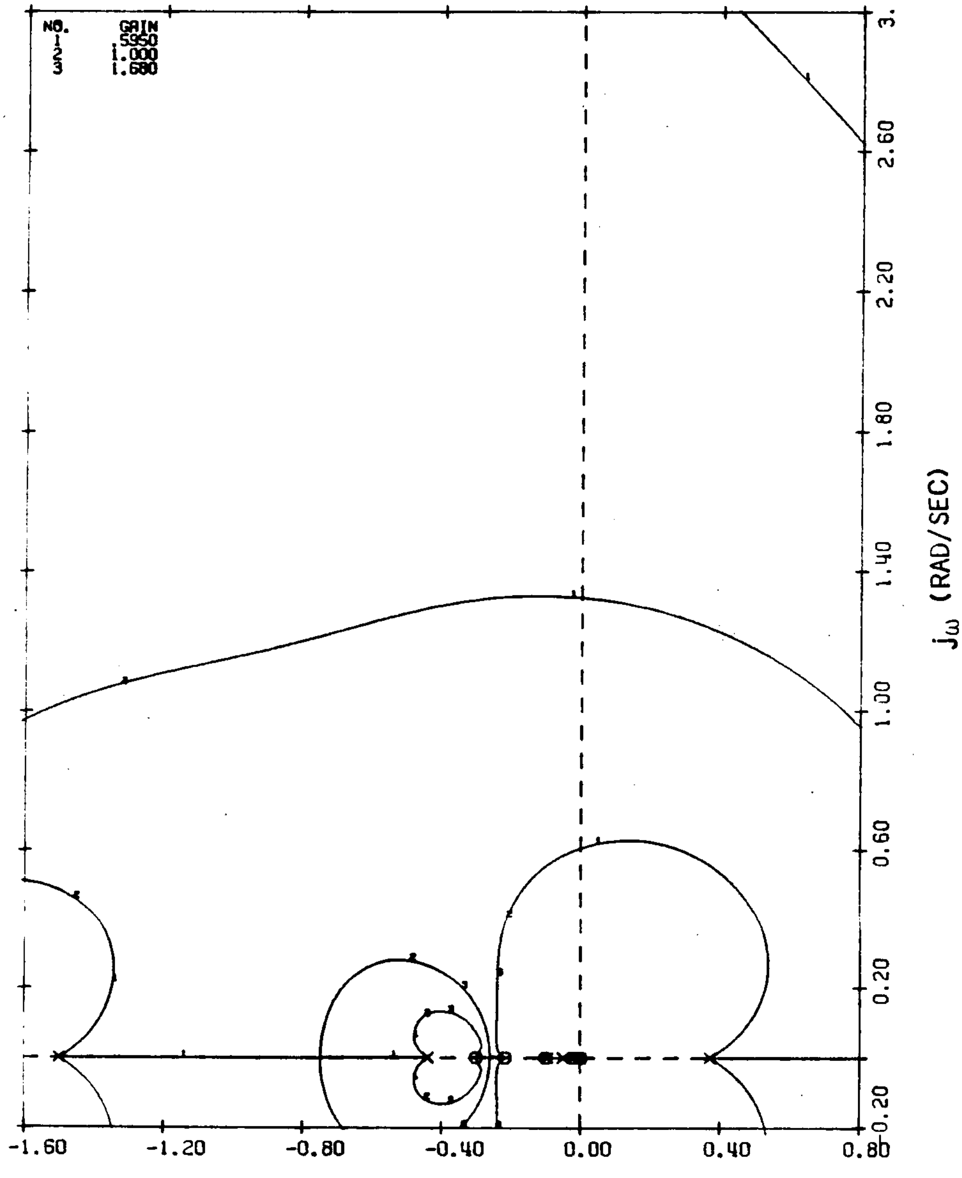


FIGURE 199 (CONCLUDED)

DAST ARW-2 RSS SYSTEM GAIN/PHASE ROOT LOCI WITH BCS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

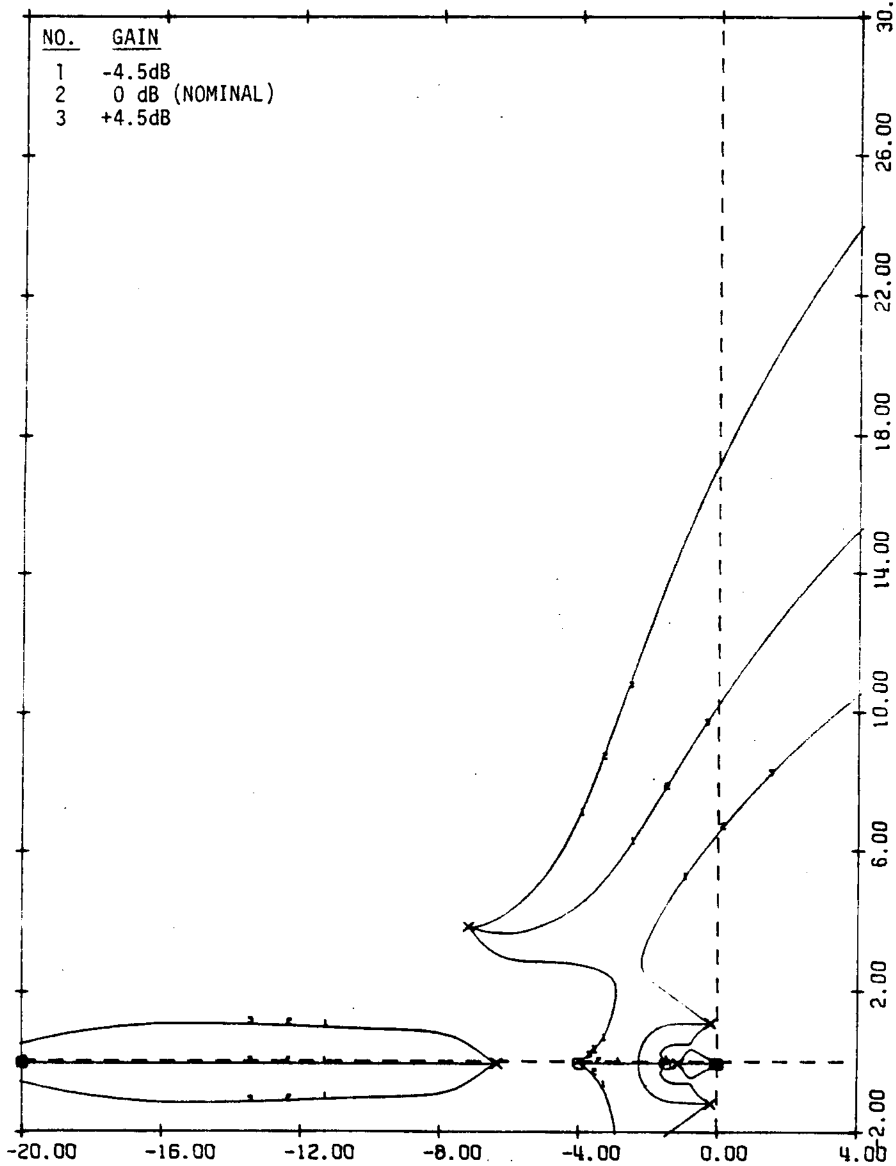


FIGURE 200

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

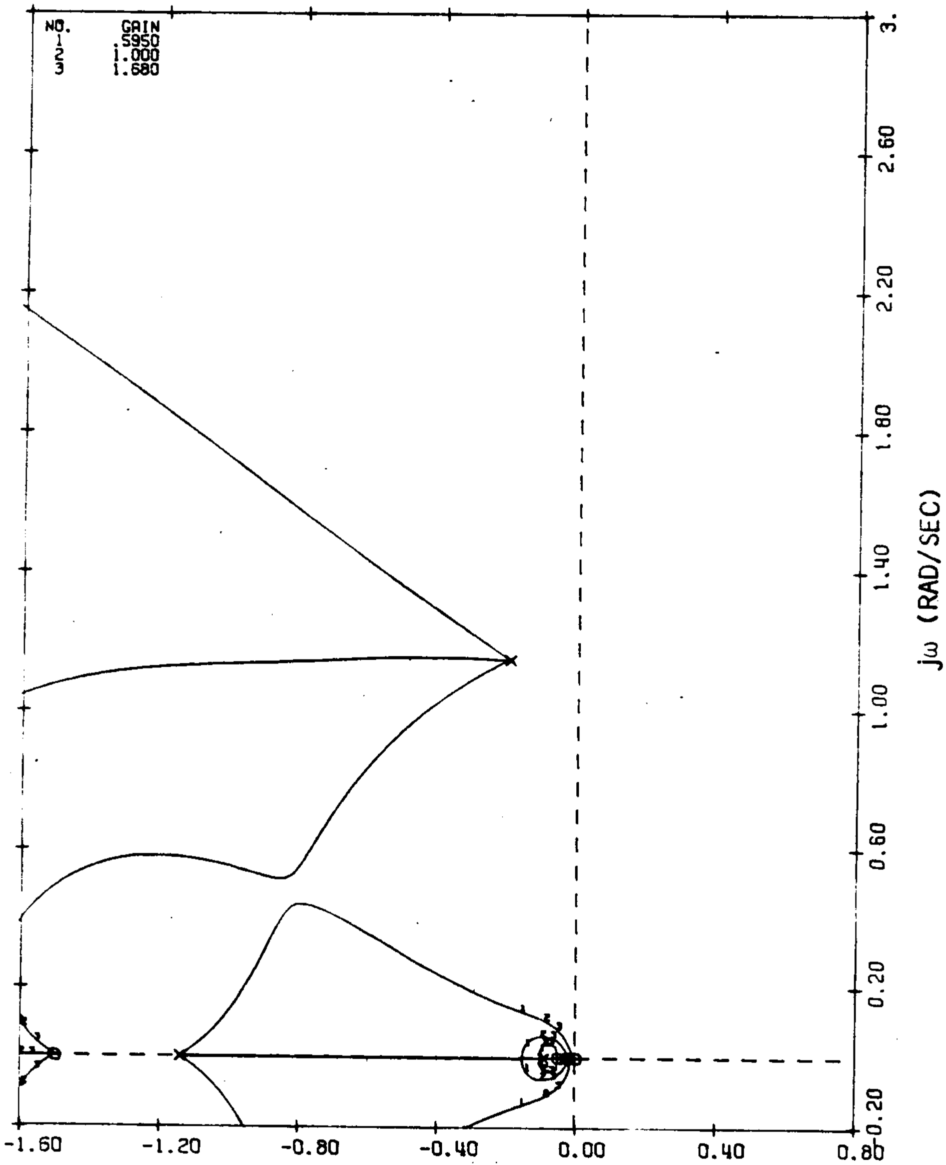


FIGURE 200 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

APPENDIX E

- MAXIMUM Q (V_d)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

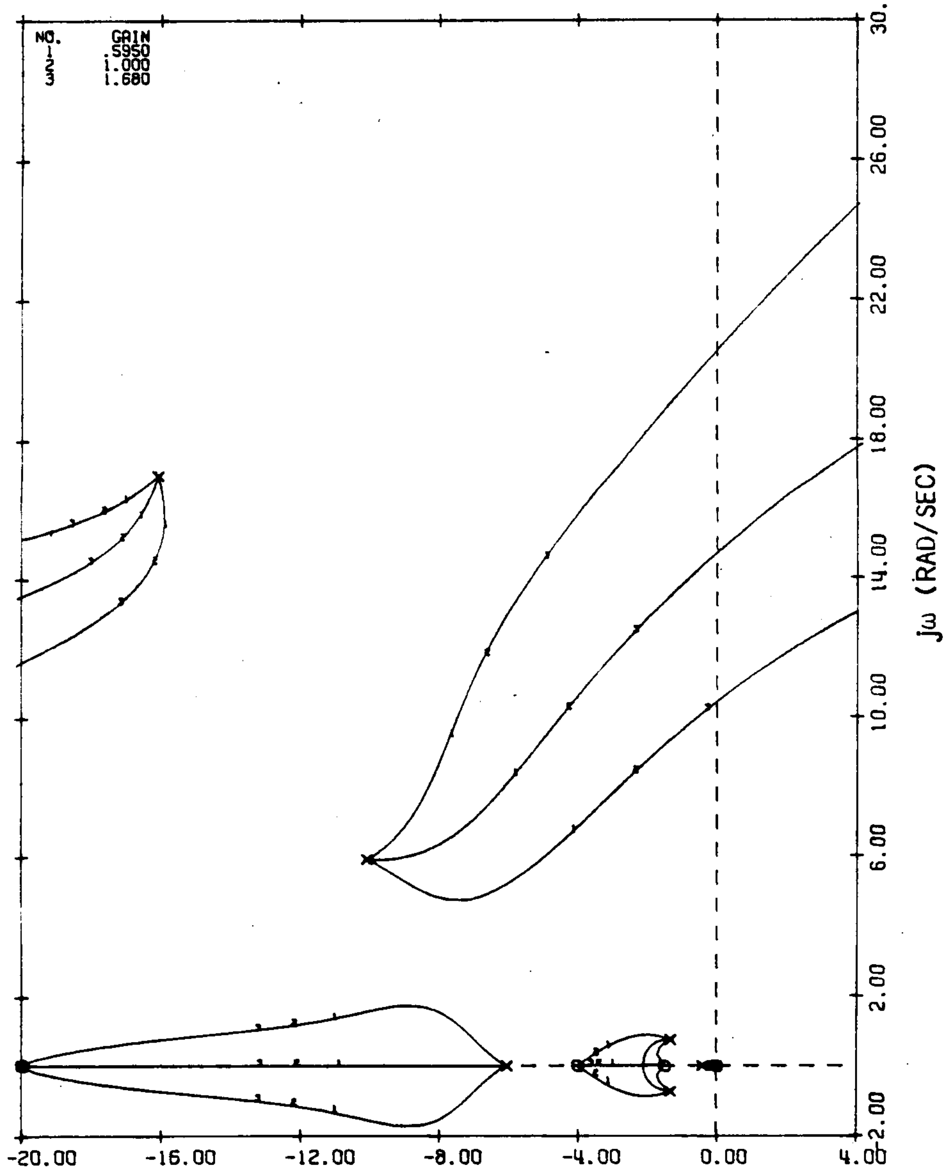


FIGURE 201

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- PCS WITH RSS AND GLA CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

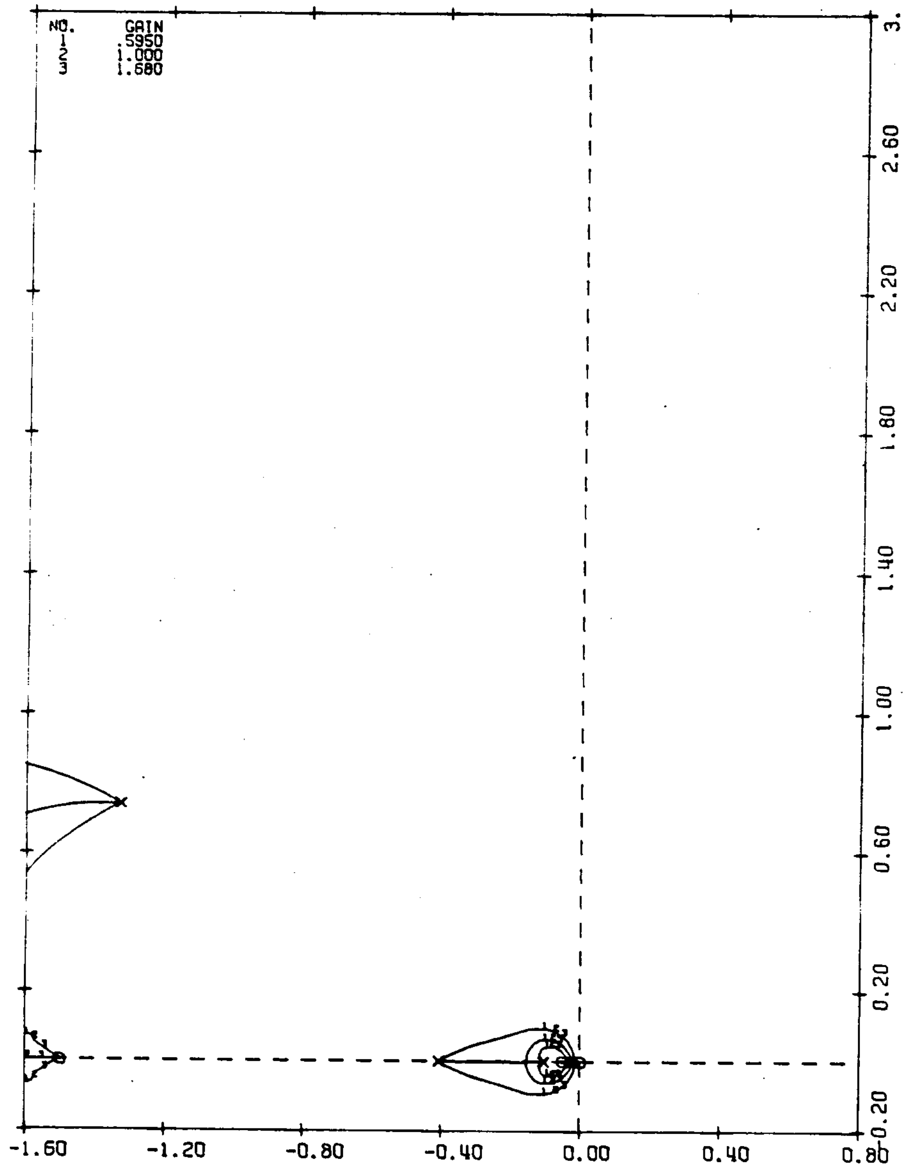


FIGURE 201 (CONCLUDED)

DAST ARW-2 PCS GAIN/PHASE ROOT LOCI WITH RSS AND GLA CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

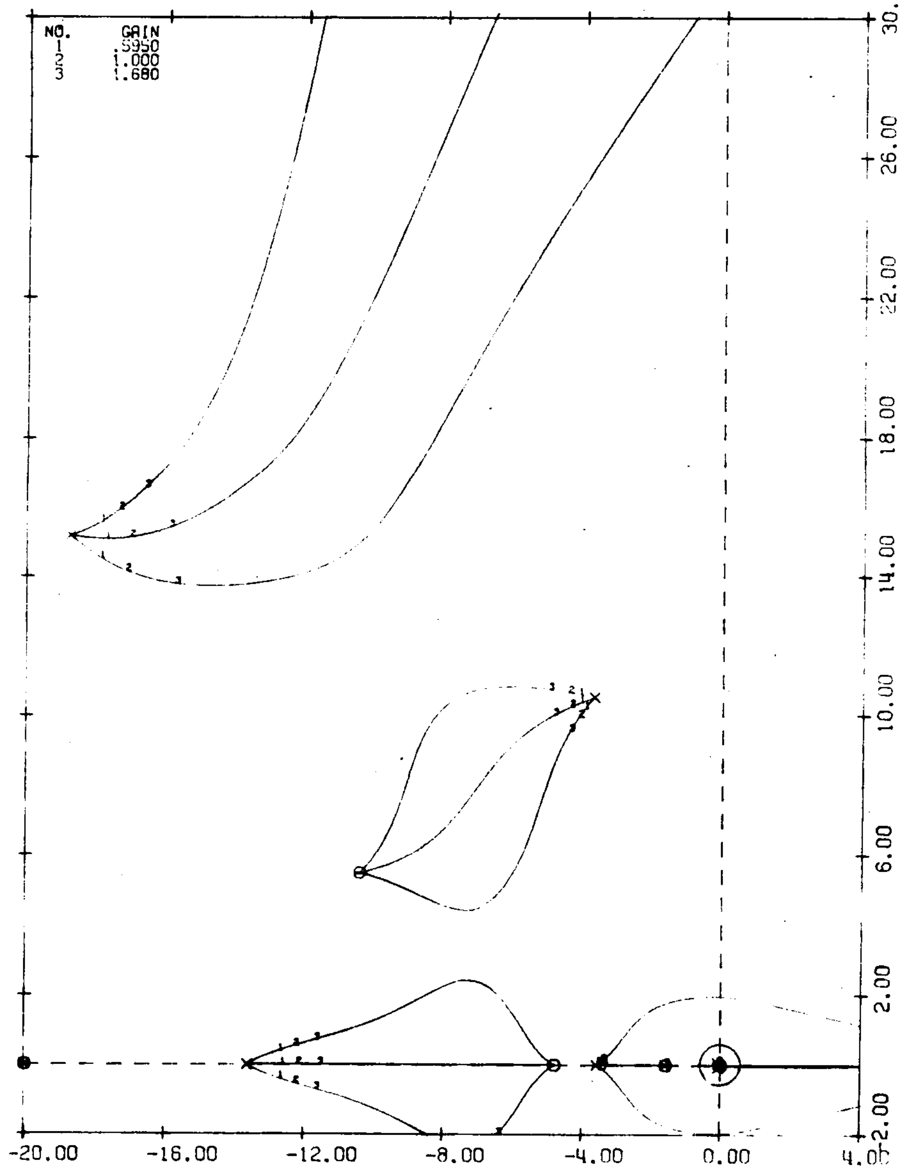


FIGURE 202

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

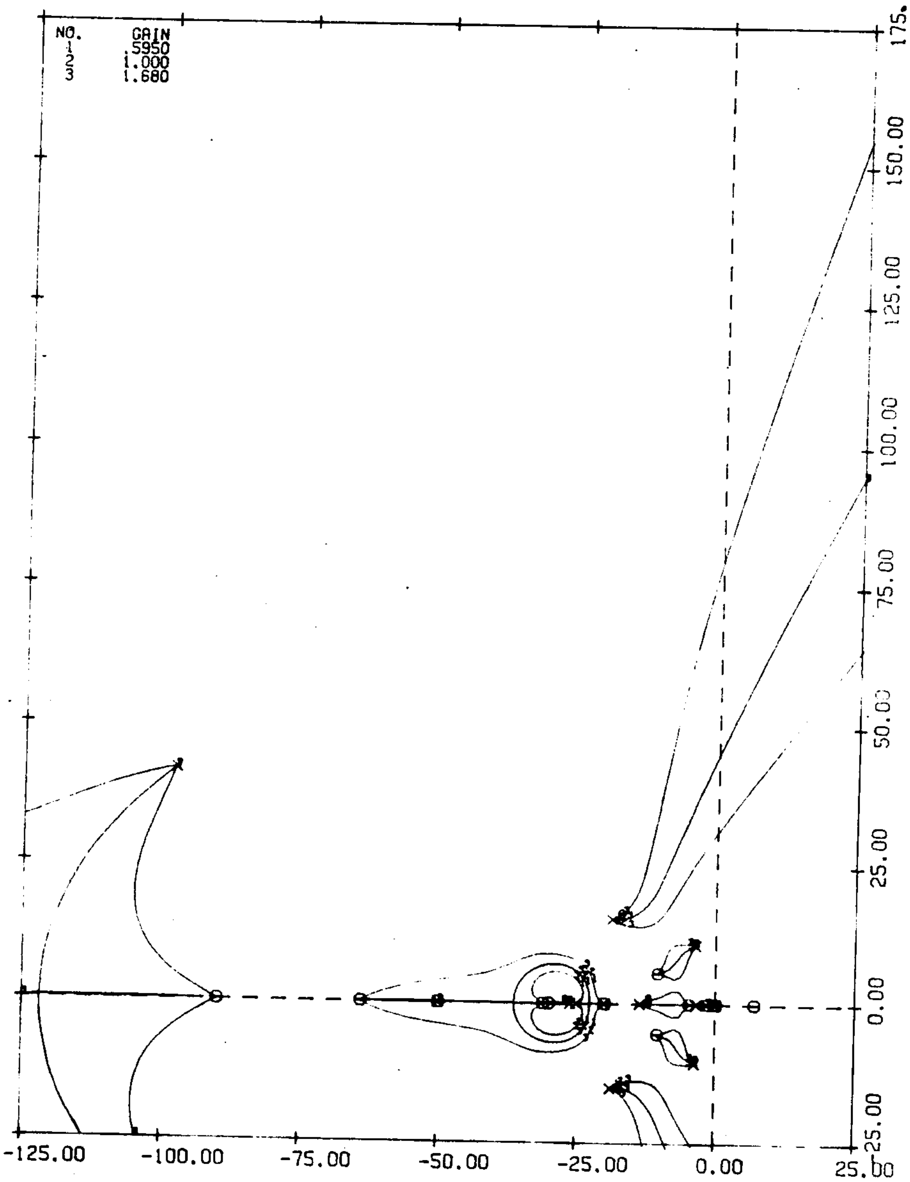


FIGURE 202 (CONTINUED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- GLA AILERON WITH RSS, PCS AND GLA STABILIZER CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

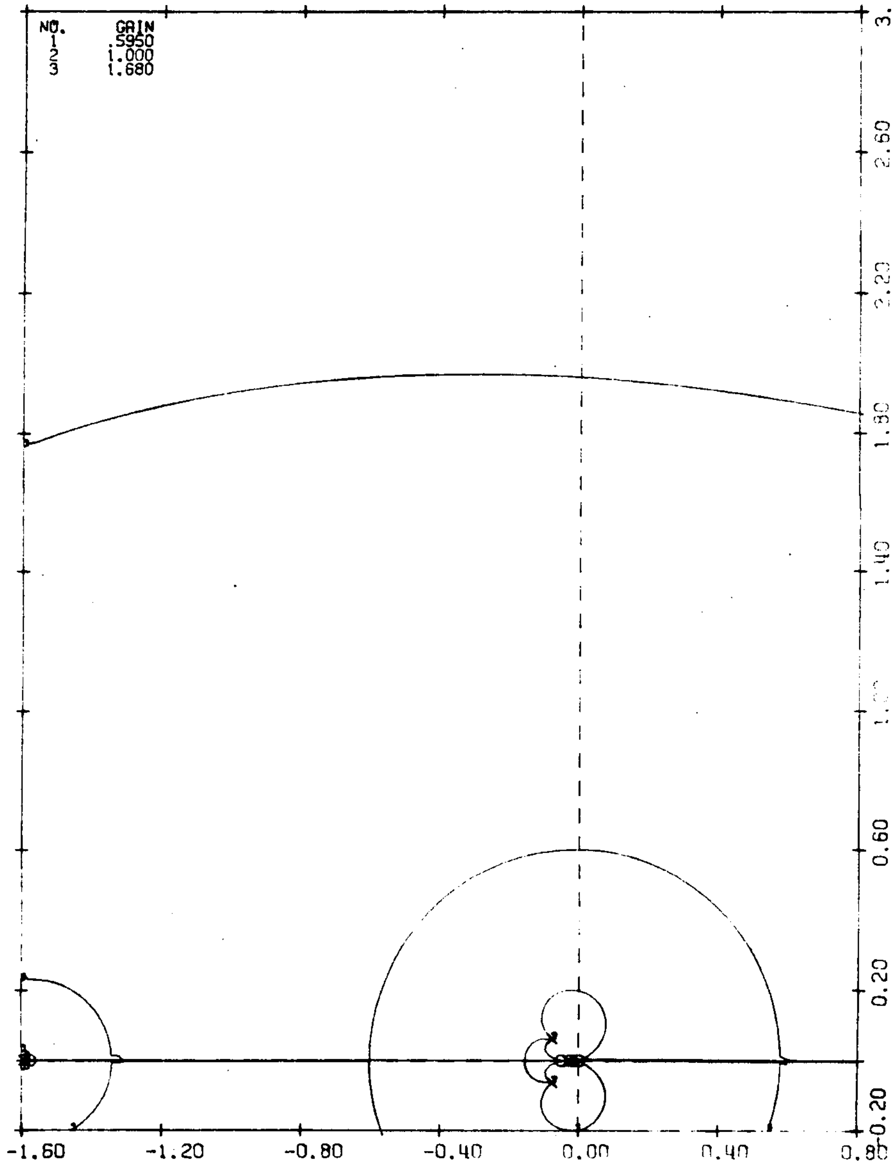


FIGURE 202 (CONCLUDED)

DAST ARW-2 GLA AILERON LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA STABILIZER LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

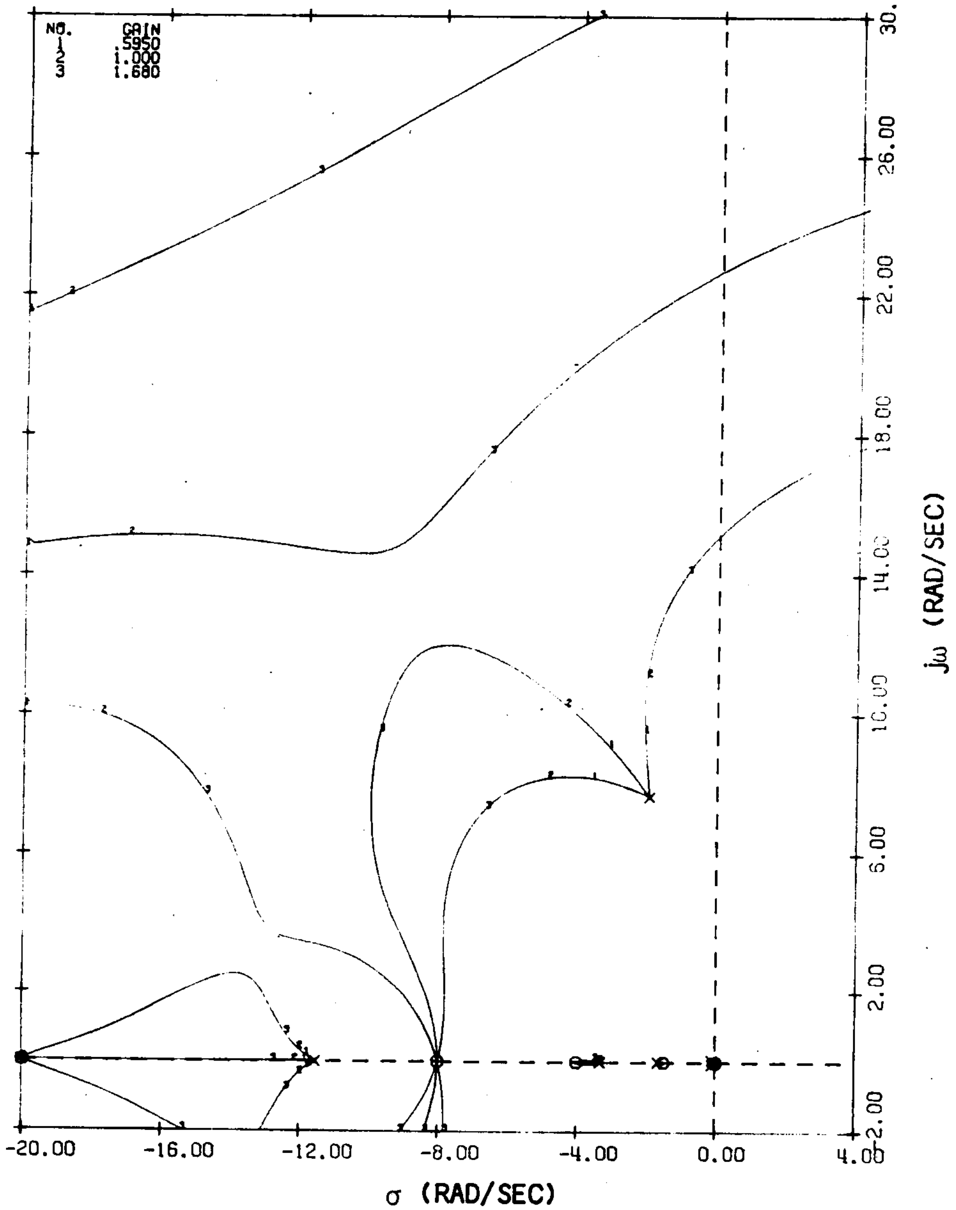


FIGURE 203

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

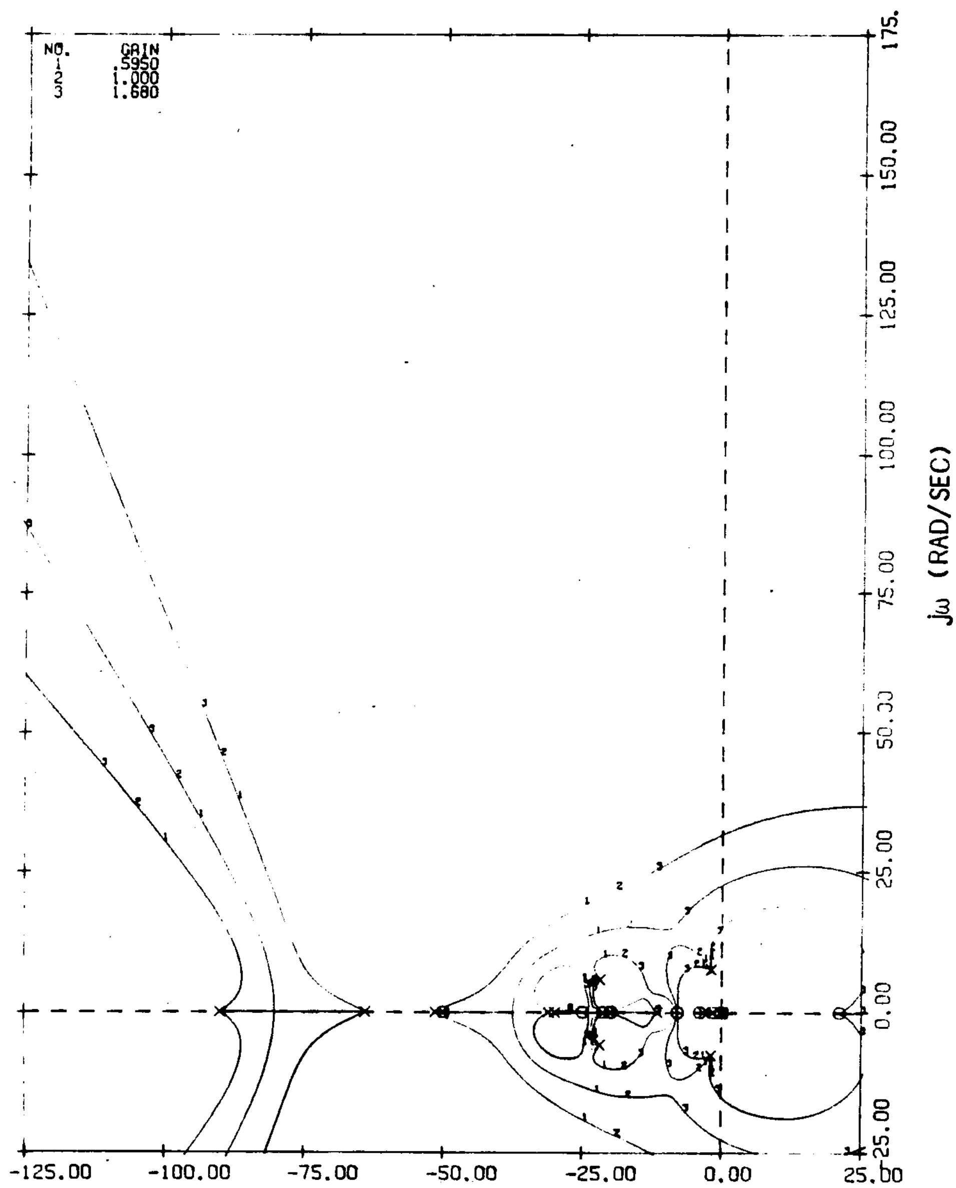


FIGURE 203 (CONTINUED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- GLA STABILIZER WITH RSS, PCS AND GLA AILERON CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

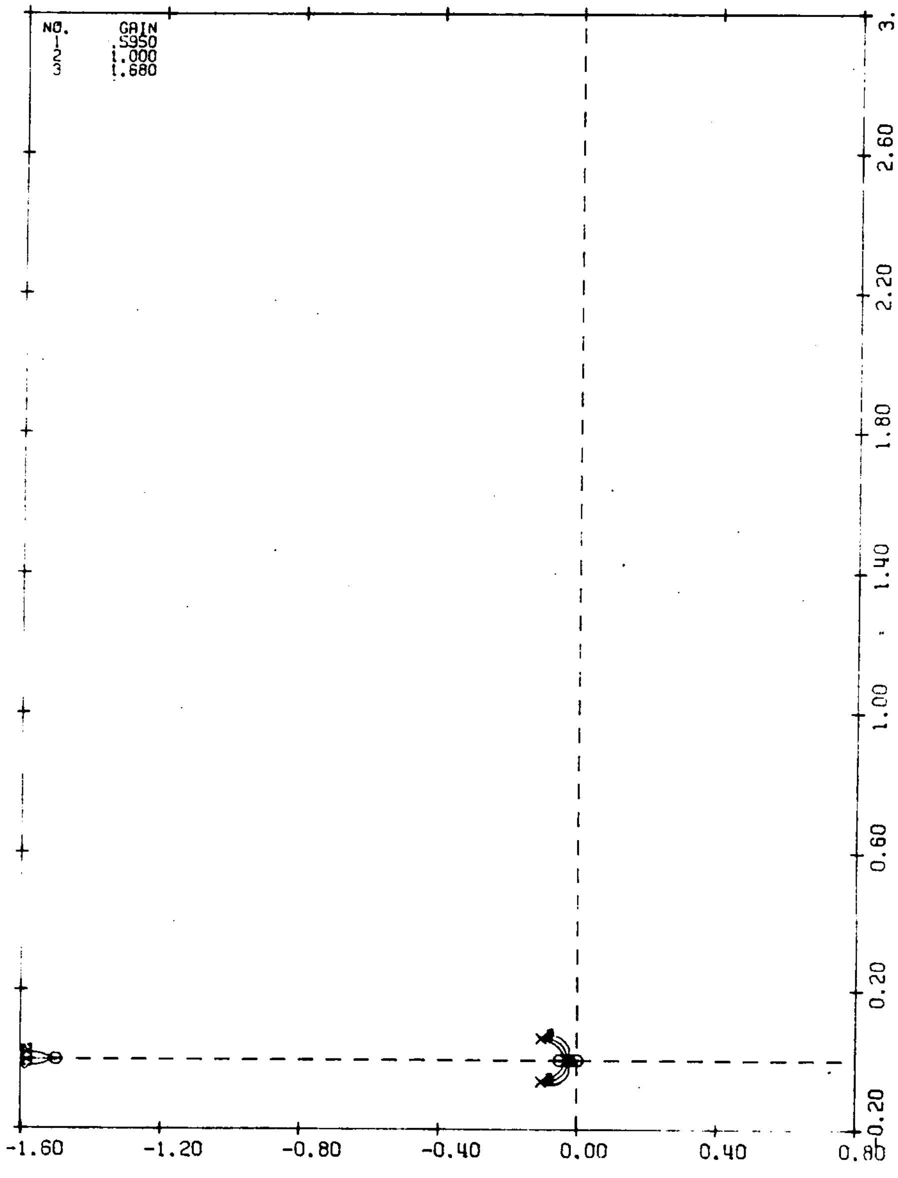


FIGURE 203 (CONCLUDED)

DAST ARW-2 GLA STABILIZER LOOP GAIN/PHASE ROOT LOCI WITH RSS, PCS AND GLA AILERON LOOPS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC

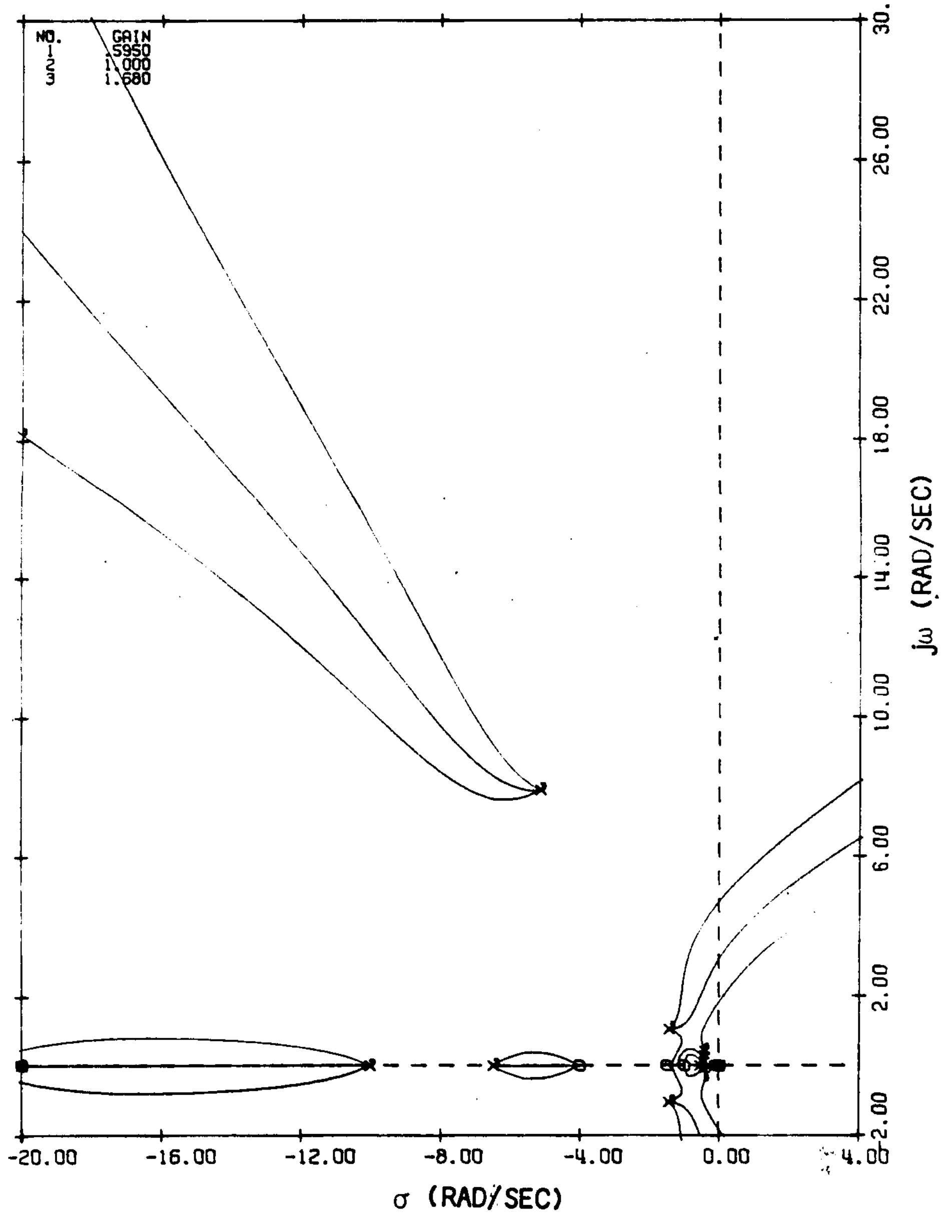
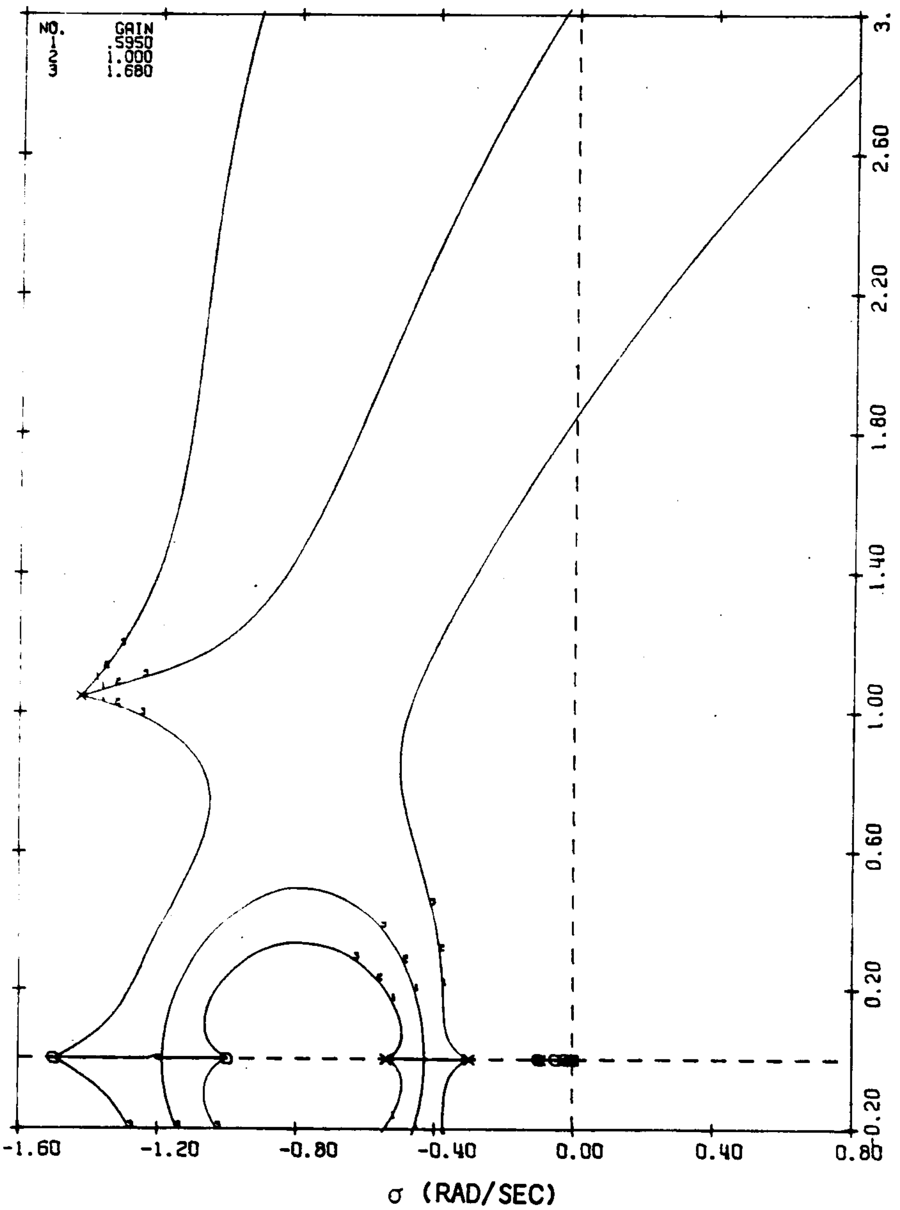


FIGURE 204

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

- MAXIMUM Q (V_d)
- BCS WITH RSS CLOSED
- MACH: 0.86
- ALTITUDE: 15,000 FT.
- GROSS WEIGHT: 2200 LBS.
- C.G.: 33% MAC



[redacted]

FIGURE 204 (CONCLUDED)

DAST ARW-2 BCS SYSTEM GAIN/PHASE ROOT LOCI WITH RSS CLOSED FOR AFT C.G. MAXIMUM DYNAMIC PRESSURE CONDITION

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15. Supplementary Notes

16. Abstract

A study was conducted under Drones for Aerodynamic and Structural Testing (DAST) program to accomplish the final design and hardware fabrication for four active control systems compatible with and ready for installation in the NASA Aeroelastic Research Wing No. 2 (ARW-2) and Firebee II drone flight test vehicle. The wing structure was designed so that Active Control Systems (ACS) are required in the normal flight envelope by integrating control system design with aerodynamics and structure technologies. The DAST ARW-2 configuration uses flutter suppression, relaxed static stability and gust and maneuver load alleviation ACS systems, and an automatic flight control system. Performance goals and criteria were applied to individual systems and the systems collectively to assure that vehicle stability margins, flutter margins, flying qualities and load reductions were achieved.

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