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VOLUME II

FINAL REPORT

CHARACTERISTICS OF HINGELESS ROTORS WITH HUB MOMENT FEEDBACK CONTROLS INCLUDING EXPERIMENTAL ROTOR FREQUENCY RESPONSE

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INTRODUCTION

This volume constitutes a test data report for Phase 2 of the Lockheed/AMRDL High Advance Ratio Research Program. Four distinct types of tests were conducted and the data from each are presented in separate appendices. As a convenience to those who would utilize the test results, all of the data which were discussed in the main body of the report (Volume 1) are also presented herein.

TABLE OF CONTENTS

(VOLUME 2)

Section		Page
	INTRODUCTION	iii
	LIST OF FIGURES	vii
	LIST OF TABLES	xvi
	APPENDIX	
C	EXPERIMENTAL ROTOR TRANSFER FUNCTIONS	C-1
D	EXPERIMENTAL TRANSFER FUNCTIONS FROM WHICH TOTAL PITCH LOOP AND TOTAL ROLL LOOP STABILITIES WERE DETERMINED	D-1
E	EXPERIMENTAL CLOSED LOOP STEADY STATE AND FREQUENCY RESPONSE DATA	E-1
F	OPEN LOOP STEADY STATE ROTOR RESPONSE DATA	F-1

LIST OF FIGURES
(APPENDICES C, D, E AND F)

Figure	Title	Page
C1	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .29$, 800 rpm (P = 1.33)	C-19
C2	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .29$, 800 rpm (P = 1.33)	C-20
C3	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .40$, 800 rpm (P = 1.33)	C-21
C4	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .40$, 800 rpm (P = 1.33)	C-22
C5	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .54$, 800 rpm (P = 1.33)	C-23
C6	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .54$, 800 rpm (P = 1.33)	C-24
C7	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .66$, 800 rpm (P = 1.33)	C-25
C8	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .66$, 800 rpm (P = 1.33)	C-26
C9	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .29$, 800 rpm (P = 1.33)	C-27
C10	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .29$, 800 rpm (P = 1.33)	C-28
C11	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .40$, 800 rpm (P = 1.33)	C-29
C12	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .40$, 800 rpm (P = 1.33)	C-30
C13	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .54$, 800 rpm (P = 1.33)	C-31
C14	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .54$, 800 rpm (P = 1.33)	C-32
C15	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .66$, 800 rpm (P = 1.33)	C-33
C16	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .66$, 800 rpm (P = 1.33)	C-34

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
C17	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)	C-35
C18	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)	C-36
C19	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)	C-37
C20	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)	C-38
C21	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)	C-39
C22	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)	C-40
C23	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)	C-41
C24	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)	C-42
C25	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)	C-43
C26	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)	C-44
C27	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)	C-45
C28	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)	C-46
C29	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)	C-47
C30	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)	C-48
C31	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)	C-49
C32	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)	C-50
C33	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)	C-51
C34	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)	C-52

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
C35	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)	C-53
C36	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)	C-54
C37	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)	C-55
C38	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)	C-56
C39	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)	C-57
C40	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)	C-58
C41	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)	C-59
C42	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)	C-60
C43	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)	C-61
C44	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)	C-62
C45	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)	C-63
C46	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)	C-64
C47	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)	C-65
C48	Rotor Lateral Frequency Response to Collective Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)	C-66
C49	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)	C-67
C50	Rotor Lateral Frequency Response to Collective Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)	C-68
C51	Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)	C-69
C52	Rotor Lateral Frequency Response to Collective Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)	C-70

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
C53	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)	C-71
C54	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)	C-72
C55	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)	C-73
C56	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)	C-74
C57	Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)	C-75
C58	Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)	C-76
C59	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)	C-77
C60	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)	C-78
C61	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)	C-79
C62	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)	C-80
C63	Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)	C-81
C64	Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)	C-82
D1	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .29$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg	D-2
D2	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .29$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg	D-3
D3	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .29$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-4
D4	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .29$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-5

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
D5	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg	D-6
D6	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg	D-7
D7	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-8
D8	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-9
D9	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg	D-10
D10	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg	D-11
D11	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-12
D12	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-13
D13	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg	D-14
D14	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg	D-15
D15	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s, \delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-16

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
D16	Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-17
D17	Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-18
D18	Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-19
D19	Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-20
D20	Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-21
D21	Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg	D-22
D22	Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg	D-23
E1	Closed Loop Rotor Longitudinal Frequency Response to θ_o , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-2
E2	Closed Loop Rotor Lateral Frequency Response to θ_o , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-3
E3	Closed Loop Rotor Longitudinal Frequency Response to θ_o , $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-4
E4	Closed Loop Rotor Lateral Frequency Response to θ_o , $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-5
E5	Closed Loop Rotor Longitudinal Frequency Response to $\bar{\theta}_s$, $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-6
E6	Closed Loop Rotor Lateral Frequency Response to $\bar{\theta}_s$, $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-7

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
E7	Closed Loop Rotor Longitudinal Frequency Response to $\bar{\theta}_s$, $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-8
E8	Closed Loop Rotor Lateral Frequency Response to $\bar{\theta}_s$, $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg	E-9
E9	Closed Loop Rotor Longitudinal Frequency Response to θ_{long} , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-10
E10	Closed Loop Rotor Lateral Frequency Response to θ_{long} , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-11
E11	Closed Loop Rotor Longitudinal Frequency Response to θ_{long} , $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-12
E12	Closed Loop Rotor Lateral Frequency Response to θ_{long} , $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-13
E13	Closed Loop Rotor Longitudinal Frequency Response to θ_{lat} , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-14
E14	Closed Loop Rotor Lateral Frequency Response to θ_{lat} , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-15
E15	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 2.5$	E-16
E16	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 5.0$	E-17
E17	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 2.5$	E-18
E18	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 5.0$	E-19
E19	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 2.5$	E-20
E20	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 5.0$	E-21

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
E21	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 2.5$	E-22
E22	Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 5.0$	E-23
E23	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = 32$ deg	E-24
E24	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 42$ deg	E-25
E25	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = 10$ deg	E-26
E26	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 21.5$ deg	E-27
E27	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = -3.5$ deg	E-28
E28	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg	E-29
E29	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = -3$ deg	E-30
E30	Closed Loop Steady State Rotor Response to θ_{long} , $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 13$ deg	E-31
E31	Closed Loop Rotor Pitching Moment Response to α , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg	E-32
E32	Closed Loop Rotor Rolling Moment Response to α , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg	E-33
E33	Closed Loop Rotor Pitching Moment Response to θ_o , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg	E-34
E34	Closed Loop Rotor Rolling Moment Response to θ_o , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg	E-35
E35	Closed Loop Rotor Pitching Moment Response to θ_{long} , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg	E-36
E36	Closed Loop Rotor Rolling Moment Response to θ_{long} , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg	E-37

LIST OF FIGURES (CONT'D)
(APPENDICES C, D, E AND F)

Figure	Title	Page
E37	Closed Loop Rotor Pitching Moment Response to θ_{lat} , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg	E-38
E38	Closed Loop Rotor Rolling Moment Response to θ_{lat} , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg	E-39
E39	Closed Loop Rotor Moment Responses to α , 300 rpm ($P = 2.32$), $A/L = 5.0$, $\Delta = 0$ deg	E-40
E40	Closed Loop Rotor Moment Responses to θ_o , 300 rpm ($P = 2.32$), $A/L = 5.0$, $\Delta = 0$ deg	E-41
E41	Closed Loop Rotor Moment Responses to θ_{long} , 300 rpm ($P = 2.32$), $A/L = 5.0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-42
E42	Closed Loop Rotor Moment Responses to θ_{lat} , 300 rpm ($P = 2.32$), $A/L = 5.0$, $\Delta = 0$ deg, $\Gamma = 0$ deg	E-43
F1	Open Loop Rotor Moment Responses to θ_o , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-2
F2	Open Loop Rotor Lift Response to θ_o , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-3
F3	Open Loop Rotor Pitching Moment Response to α , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-4
F4	Open Loop Rotor Rolling Moment Response to α , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-5
F5	Open Loop Rotor Lift Response to α , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-6
F6	Open Loop Rotor Pitching Moment Response to θ_s , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-7
F7	Open Loop Rotor Rolling Moment Response to θ_s , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-8
F8	Open Loop Rotor Lift Response to θ_s , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-9
F9	Open Loop Rotor Pitching Moment Response to θ_c , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-10
F10	Open Loop Rotor Rolling Moment Response to θ_c , 1200 rpm ($P = 1.17$), $\gamma = 5.0$	F-11

LIST OF TABLES

Table		Page
VIII	ROTOR FREQUENCY RESPONSE TO COLLECTIVE PITCH	C-2
IX	ROTOR FREQUENCY RESPONSE TO LONGITUDINAL CYCLIC PITCH	C-7
X	ROTOR FREQUENCY RESPONSE TO LATERAL CYCLIC PITCH	C-13

APPENDIX C

EXPERIMENTAL ROTOR TRANSFER FUNCTIONS

All of the rotor transfer functions which were obtained during the Phase 2 test are contained within this appendix. In addition to plotted data, the derivatives are also expressed in coefficient form and tabulated (Tables VIII, IX and X. The moments were transferred to the center of rotation (for transfer procedure see page 84 of Ref. 1) and nondimensionalized as follows.

$$\frac{c_m}{a\sigma} = \frac{M_R (@ 0 \text{ in.})}{\pi R^3 \rho (\Omega_R)^2 a\sigma}$$

$$\frac{c_l}{a\sigma} = \frac{L_R (@ 0 \text{ in.})}{\pi R^3 \rho (\Omega_R)^2 a\sigma}$$

Values of $a = 5.73$ and $\rho = 0.002378 \text{ slugs/ft}^3$ have been assumed for the calculations.

The tabulated phase data are expressed in radians in the range 0 to -2π .

TABLE VIII
 ROTOR FREQUENCY RESPONSE TO COLLECTIVE PITCH

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_0 a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_0 a \sigma}$	c_l Phase (rad)
300	0.78	3.13	0.100	0.03760	-6.2662	0.08553	-3.1533
		6.27	0.200	0.03845	-6.2252	0.08840	-3.1777
		12.54	0.399	0.03987	-6.0601	0.09462	-3.2301
		18.80	0.599	0.05072	-5.9535	0.10174	-3.3315
		25.11	0.800	0.06291	-5.9297	0.11085	-3.4334
		31.38	0.999	0.09410	-6.0458	0.12015	-3.6711
		37.65	1.199	0.15781	-0.1520	0.15774	-4.2030
		43.92	1.399	0.15171	-0.8412	0.09658	-4.8204
		50.20	1.599	0.14091	-1.2785	0.05092	-5.2307
		56.47	1.799	0.11452	-1.2574	0.03692	-4.8534
		62.63	1.995	0.10502	-1.6505	0.02234	-3.5070
		68.86	2.193	0.07296	-1.9103	0.04508	-3.0940
		75.14	2.393	0.05153	-1.5361	0.06464	-3.4511
		81.41	2.593	0.07678	-1.3972	0.08051	-3.5284
		87.71	2.793	0.10196	-1.5945	0.10325	-3.7376
		93.95	2.992	0.12746	-1.8628	0.11549	-3.9199
		100.21	3.191	0.17201	-2.3129	0.15195	-4.1834
		106.46	3.390	0.20078	-3.0373	0.18797	-4.7281
		112.64	3.587	0.14911	-3.7716	0.15060	-5.3358
		118.91	3.787	0.09320	-4.2394	0.07980	-5.6856
1.07	1.07	3.13	0.100	0.06506	-6.2601	0.13489	-3.1637
		6.26	0.199	0.06411	-6.2411	0.13673	-3.1891
		12.54	0.399	0.06674	-6.1154	0.14501	-3.2819
		18.81	0.599	0.08342	-5.0017	0.15447	-3.3953
		25.11	0.800	0.11328	-6.0423	0.17135	-3.5467
		31.37	0.999	0.16044	-6.2149	0.19800	-3.8056
		37.64	1.199	0.21935	-0.3714	0.19139	-4.3253
		43.90	1.398	0.20787	-0.9608	0.11649	-4.8440
		50.19	1.599	0.17357	-1.3398	0.05197	-5.1820
		56.46	1.798	0.17001	-1.3500	0.03779	-5.0120
		62.61	1.994	0.13639	-1.7128	0.02739	-2.9112
		68.86	2.193	0.09964	-1.8932	0.07504	-3.1082
		75.12	2.392	0.07998	-1.5775	0.10178	-3.4482
		81.37	2.591	0.11250	-1.4899	0.11860	-3.5596
		87.66	2.792	0.14687	-1.6340	0.13355	-3.7951
		93.92	2.991	0.19342	-1.8840	0.15619	-3.8655
		100.18	3.190	0.24474	-2.3873	0.21051	-4.2032
		106.46	3.390	0.26749	-3.0835	0.24636	-4.7631
		112.64	3.587	0.19958	-3.8017	0.19799	-5.3562
		118.91	3.787	0.13089	-4.2314	0.13599	-5.6779
		137.73	4.386	0.03143	-4.6477	0.03970	-5.7552

TABLE VIII (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_0 a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_0 a \sigma}$	c_l Phase (rad)
300	1.44	3.13	0.100	0.13200	-6.2721	0.25609	-3.2592
		6.27	0.200	0.13614	-6.2645	0.25904	-3.2705
		12.53	0.399	0.14739	-6.2284	0.26170	-3.4227
		18.80	0.599	0.17411	-6.2288	0.25972	-3.5663
		25.11	0.800	0.21649	-0.0190	0.27073	-3.7236
		31.37	0.999	0.28079	-0.2539	0.27970	-4.0283
		37.64	1.199	0.36299	-0.6942	0.25355	-4.5747
		43.91	1.398	0.31471	-1.0914	0.14249	-4.8411
		50.19	1.598	0.29039	-1.4213	0.05883	-5.2442
		56.47	1.799	0.26037	-1.4236	0.03255	-4.4027
		62.62	1.994	0.21205	-1.7297	0.06405	-2.9343
		68.88	2.194	0.17560	-1.8481	0.15890	-3.1619
		75.14	2.393	0.16457	-1.6834	0.19399	-3.5513
		81.39	2.592	0.19546	-1.7542	0.22101	-3.7613
		87.68	2.792	0.22754	-1.8548	0.22197	-3.9745
		93.92	2.991	0.29082	-2.0584	0.24144	-4.0236
		100.21	3.191	0.35602	-2.5436	0.30976	-4.3175
		106.46	3.390	0.36624	-3.1514	0.34116	-4.7924
		112.64	3.587	0.28303	-3.7521	0.28229	-5.2891
		118.91	3.787	0.18524	-4.1036	0.19824	-5.5666
		137.73	4.386	0.05151	-4.4149	0.06774	-5.6228
550	0.58	3.40	0.059	0.04607	-6.2528	0.05119	-3.1962
		6.28	0.109	0.04788	-6.2678	0.05248	-3.2938
		12.53	0.218	0.05278	-6.2684	0.05463	-3.4642
		18.81	0.327	0.06311	-0.0589	0.05764	-3.7187
		25.10	0.437	0.07782	-0.2718	0.05855	-4.0956
		21.94	0.382	0.07034	-0.1351	0.05980	-3.8820
		28.25	0.491	0.08394	-0.4355	0.05676	-4.3368
		31.38	0.546	0.08461	-0.6303	0.05067	-4.6057
		37.64	0.655	0.07767	-1.0600	0.03189	-5.2763
		50.20	0.873	0.04980	-1.3780	0.00311	-6.1990
		62.62	1.089	0.04241	-1.4791	0.00937	-2.4520
		75.12	1.306	0.03109	-1.4948	0.02010	-2.9760
		87.71	1.525	0.02610	-1.5474	0.02732	-3.1676
		100.21	1.743	0.03130	-1.2644	0.02905	-3.4512
		112.64	1.959	0.04360	-1.4827	0.03251	-3.4914
		125.17	2.177	0.05700	-1.8260	0.04442	-3.6332
		137.73	2.395	0.06939	-2.4288	0.05468	-4.0261

TABLE VIII (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_0 a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_0 a \sigma}$	c_l Phase (rad)
550	0.79	3.14	0.055	0.07549	-6.2780	0.07986	-3.2217
		6.27	0.109	0.07662	-6.2771	0.07966	-3.3083
		12.54	0.218	0.08526	-0.0032	0.09317	-3.4066
		18.80	0.327	0.10495	-0.1029	0.09058	-3.7781
		15.67	0.273	0.09375	-0.0320	0.08689	-3.6167
		25.12	0.437	0.13006	-0.3652	0.09307	-4.2117
		31.39	0.546	0.13557	-0.7902	0.07617	-4.7890
		37.65	0.655	0.12149	-1.2302	0.04959	-5.5203
		50.20	0.873	0.07251	-1.5353	0.00869	-0.5204
		65.92	1.146	0.10735	-3.4779	0.07419	-6.1693
		75.14	1.307	0.04039	-1.5565	0.03039	-2.8415
		87.68	1.525	0.03410	-1.5476	0.04439	-3.1346
		100.21	1.743	0.04636	-1.2762	0.04419	-3.4723
		112.64	1.959	0.06320	-1.5102	0.04865	-3.5069
		125.22	2.178	0.08117	-1.6819	0.06288	-3.6636
		137.67	2.394	0.09458	-2.4768	0.07706	-4.0039
	0.96	3.13	0.055	0.09578	-0.0488	0.09355	-3.2777
		6.27	0.109	0.10132	-0.0127	0.09718	-3.3286
		12.54	0.218	0.11569	-0.0274	0.10507	-3.5076
		18.81	0.327	0.14360	-0.1462	0.11471	-3.8078
		25.11	0.437	0.17652	-0.4409	0.11714	-4.2693
		31.36	0.545	0.17335	-0.8921	0.09037	-4.8671
		37.65	0.655	0.15020	-1.2931	0.05692	-5.5664
		50.19	0.873	0.09417	-1.5206	0.01155	-0.4192
		62.62	1.089	0.07312	-1.6591	0.02329	-2.1181
		75.14	1.307	0.05293	-1.6572	0.04263	-2.6914
		87.71	1.525	0.04294	-1.5717	0.06533	-3.1331
		100.21	1.743	0.05879	-1.3629	0.06158	-3.5370
		112.64	1.959	0.07753	-1.5909	0.06339	-3.5791
		125.17	2.177	0.09873	-1.9096	0.07979	-3.6942
		137.73	2.395	0.11139	-2.4206	0.09481	-3.9646

TABLE VIII (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_0 \text{ a}\sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_0 \text{ a}\sigma}$	c_l Phase (rad)
800	0.29	3.20	.038	.02500	-.0700	.01125	-3.2722
		6.38	.076	.02402	-.1230	.01025	-3.3820
		12.76	.153	.02550	-.2370	.01025	-3.6452
		19.14	.222	.02625	-.4020	.00950	-3.8502
		22.38	.267	.02621	-.5000	.00757	-4.1200
		25.54	.305	.02576	-.6052	.00620	-4.3102
		28.74	.343	.02431	-.8150	.00422	-4.5710
		31.92	.381	.02321	-.8602	.00362	-4.6702
		38.27	.457	.01725	-1.1550	.00266	-1.5280
		44.75	.534	.01354	-.8020	.00537	-3.1300
		63.85	.762	.01300	-1.0240	.00358	-2.7812
		70.28	.836	.01133	-.8020	.00503	-3.1612
		76.62	.915	.01504	-.8070	.00326	-3.2460
		89.50	1.068	.01730	-1.1770	.00304	-2.6302
		102.33	1.221	.01382	-1.4147	.00077	-2.4217
		115.16	1.374	.01116	-1.4522	.01280	-3.0083
		127.70	1.524	.01156	-1.2070	.01243	-3.3102
		140.90	1.682	.01402	-1.3072	.01342	-3.3227
		154.00	1.838	.01616	-1.5200	.01556	-3.4382
	0.40	3.13	.037	.03414	-.0300	.01057	-3.2580
		6.27	.075	.03348	-.0840	.01871	-3.3852
		12.54	.150	.03564	-.1070	.01844	-3.6700
		18.80	.224	.03704	-.3700	.01700	-4.0050
		25.13	.300	.04023	-.6300	.01453	-4.4070
		31.35	.374	.03588	-.8050	.00071	-5.0002
		37.62	.440	.02055	-1.1040	.00460	-6.1672
		43.88	.524	.02102	-1.1100	.00313	-2.0430
		50.18	.598	.01547	-1.2832	.00501	-2.3442
		62.58	.747	.01781	-1.1500	.00627	-.2380
		74.98	.825	.02103	-.8730	.00478	-3.3200
		87.75	1.047	.02053	-1.2810	.00720	-2.3102
		100.05	1.194	.01782	-1.5320	.01106	-2.3700
		112.60	1.344	.01367	-1.4400	.01835	-2.0200
		125.20	1.404	.01522	-1.3022	.01040	-3.2780
		137.80	1.645	.01780	-1.4480	.01753	-3.3180
		150.30	1.764	.02088	-1.5560	.01071	-3.3372

TABLE VIII (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_0 a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_0 a \sigma}$	c_l Phase (rad)
800	0.54	3.13	0.037	0.05568	-0.0432	0.03281	-3.2797
		6.27	0.075	0.05597	-0.0896	0.03255	-3.4098
		12.54	0.150	0.05962	-0.2160	0.03256	-3.7153
		18.82	0.225	0.06517	-0.4108	0.03098	-4.0874
		25.09	0.300	0.06534	-0.7021	0.02545	-4.6098
		31.35	0.374	0.05864	-1.0046	0.01780	-5.1389
		37.67	0.450	0.04659	-1.2919	0.00987	-6.0610
		50.19	0.599	0.02564	-1.4412	0.00601	-1.8362
		62.58	0.747	0.02625	-1.3827	0.00801	-2.1997
		75.16	0.897	0.02682	-1.0526	0.00677	-2.9527
		87.51	1.045	0.03017	-1.4700	0.00905	-2.1581
		100.05	1.194	0.02252	-1.6438	0.01627	-2.3016
		112.60	1.344	0.01851	-1.4293	0.02488	-3.0096
		125.16	1.494	0.02176	-1.3406	0.02424	-3.2995
		137.79	1.645	0.02670	-1.4129	0.02551	-3.2949
		150.32	1.794	0.03221	-1.6419	0.02948	-3.4437
	0.66	3.13	0.037	0.07457	-0.0191	0.04416	-3.2578
		6.24	0.074	0.07413	-0.1171	0.04268	-3.4436
		12.54	0.150	0.08064	-0.2259	0.04301	-3.7262
		18.81	0.225	0.08752	-0.4566	0.04131	-4.1447
		25.09	0.300	0.08981	-0.7775	0.03510	-4.6903
		31.35	0.374	0.07760	-1.1022	0.02477	-5.2411
		37.67	0.450	0.05906	-1.3825	0.01354	-6.0873
		50.27	0.600	0.02905	-1.4974	0.00726	-1.9870
62.58		0.747	0.03129	-1.4514	0.01029	-2.1295	
75.16		0.897	0.03286	-1.1944	0.00717	-2.5667	
87.51		1.045	0.03394	-1.5729	0.01330	-2.1359	
100.37		1.198	0.02556	-1.6874	0.02022	-2.3085	
113.01		1.349	0.02050	-1.3462	0.03256	-2.9761	
125.16		1.494	0.02814	-1.2613	0.03244	-3.2419	
137.79		1.645	0.03210	-1.3925	0.02971	-3.3260	
150.32		1.794	0.03889	-1.6446	0.03525	-3.4418	

TABLE IX

ROTOR FREQUENCY RESPONSE TO LONGITUDINAL CYCLIC PITCH

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_s a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_s a \sigma}$	c_l Phase (rad)
300	0.78	3.14	0.100	0.03343	-0.0109	0.07261	-3.1598
		6.28	0.200	0.03297	-6.2745	0.07358	-3.1557
		12.53	0.399	0.03122	-6.1578	0.07963	-3.1804
		18.82	0.599	0.03758	-5.9161	0.08932	-3.2738
		25.10	0.799	0.05214	-5.8399	0.10137	-3.3953
		31.38	0.999	0.08100	-5.9424	0.11934	-3.5904
		37.64	1.199	0.14035	-0.0104	0.15244	-4.0961
		43.92	1.399	0.14496	-0.6737	0.10924	-4.6929
		50.21	1.599	0.12346	-1.1133	0.06044	-5.0719
		56.48	1.799	0.11109	-1.2111	0.04103	-4.9944
		62.63	1.995	0.08414	-1.5669	0.00899	-4.2400
		68.85	2.193	0.06945	-1.7163	0.03194	-3.3502
		75.12	2.392	0.05789	-1.5251	0.04576	-3.4882
		81.37	2.591	0.07590	-1.4068	0.06275	-3.5614
		87.68	2.792	0.09961	-1.6211	0.08307	-3.7651
		93.95	2.992	0.12784	-1.9126	0.09804	-3.9413
		100.18	3.190	0.16732	-2.3591	0.13603	-4.2193
		106.42	3.389	0.18049	-3.1097	0.16241	-4.8479
		112.68	3.589	0.12634	-3.7838	0.12820	-5.4441
		118.91	3.787	0.07621	-4.2160	0.08706	-5.8047
	1.07	3.14	0.100	0.05729	-0.0160	0.10489	-3.1738
		6.27	0.200	0.05693	-6.2827	0.10677	-3.1737
		12.53	0.399	0.05529	-6.2417	0.11413	-3.2649
		18.81	0.599	0.05978	-5.9710	0.11678	-3.3277
		25.11	0.800	0.08631	-6.0457	0.13848	-3.5428
		31.37	0.999	0.12701	-6.1777	0.16282	-3.8323
		37.65	1.199	0.19382	-0.3295	0.17671	-4.3534
		43.92	1.399	0.18079	-0.9029	0.11132	-4.8742
		50.19	1.598	0.15623	-1.2957	0.05763	-5.3004
		56.47	1.799	0.14607	-1.3555	0.03688	-5.2652
		62.62	1.994	0.12094	-1.7133	0.01992	-3.3013
		68.86	2.193	0.08600	-1.8103	0.05178	-3.1700
		75.12	2.392	0.07323	-1.6060	0.07086	-3.4255
		81.37	2.591	0.09587	-1.4893	0.09297	-3.6029
		87.66	2.792	0.12182	-1.6582	0.10612	-3.8509
		93.92	2.991	0.15257	-1.9559	0.11696	-4.0018
		100.18	3.190	0.20197	-2.3762	0.16321	-4.2151
		106.45	3.390	0.21471	-3.0753	0.19416	-4.7994
		112.64	3.587	0.15513	-3.7541	0.15663	-5.3949
		118.91	3.787	0.09648	-4.1597	0.10911	-5.7298
137.73	4.386	0.00995	-4.1818	0.02937	-5.6246		

TABLE IX (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_s a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_s a \sigma}$	c_l Phase (rad)
300	1.44	3.13	0.100	0.11748	-0.0223	0.17856	-3.2042
		6.28	0.200	0.12384	-0.0137	0.18815	-3.2620
		12.54	0.399	0.12820	-0.0083	0.18964	-3.4285
		18.82	0.599	0.14560	-0.0254	0.19357	-3.6153
		25.12	0.800	0.17631	-0.1077	0.19636	-3.8117
		31.40	1.000	0.22367	-0.3460	0.20278	-4.1223
		37.64	1.199	0.28663	-0.7891	0.18456	-4.7433
		43.89	1.398	0.25135	-1.2102	0.10305	-5.1558
		50.20	1.599	0.22643	-1.5086	0.04961	-5.7590
		56.47	1.799	0.20663	-1.5403	0.01589	-5.8212
		62.62	1.994	0.15477	-2.1115	0.05671	-4.1075
		68.88	2.194	0.12376	-1.9759	0.11166	-3.0822
		75.12	2.392	0.11195	-1.7656	0.14452	-3.4986
		81.37	2.591	0.13311	-1.7548	0.16205	-3.7966
		87.68	2.792	0.15870	-1.8933	0.16889	-4.0571
		93.95	2.992	0.19493	-2.0853	0.16540	-4.1793
		100.18	3.190	0.24251	-2.5275	0.20826	-4.3987
		106.50	3.392	0.24676	-3.1742	0.23288	-4.8927
		112.68	3.589	0.19132	-3.7805	0.20081	-5.3917
		118.91	3.787	0.11682	-4.2623	0.13922	-5.7707
		137.73	4.386	0.00193	-2.7861	0.02951	-5.8937
550	0.43	3.13	0.055	0.02542	-6.2169	0.03943	-3.1794
		6.27	0.109	0.02641	-6.1803	0.04024	-3.2464
		12.53	0.218	0.03058	-6.1128	0.04229	-3.3827
		15.67	0.273	0.03352	-6.1074	0.04355	-3.4669
		18.82	0.327	0.03743	-6.1309	0.04506	-3.5570
		21.95	0.382	0.04280	-6.1391	0.04719	-3.6957
		25.12	0.437	0.04865	-6.2676	0.04884	-3.8514
		31.36	0.545	0.05809	-0.3228	0.04657	-4.2758
		37.64	0.655	0.05910	-0.7207	0.03506	-4.7846
		43.90	0.764	0.04765	-0.9319	0.02021	-4.5349
		50.19	0.873	0.04301	-1.0456	0.01375	-4.9417
		57.72	1.004	0.04377	-1.0793	0.00924	-4.8791
		62.62	1.089	0.03881	-1.2292	0.00479	-4.4249
		75.14	1.307	0.03402	-1.3478	0.00816	-3.4615
		87.68	1.525	0.02832	-1.4089	0.01405	-3.4694
		100.21	1.743	0.03008	-1.4014	0.01542	-3.6387
		112.64	1.959	0.03548	-1.5392	0.01907	-3.6066
		125.22	2.178	0.04466	-1.8537	0.02773	-3.7369
		137.67	2.394	0.05013	-2.4001	0.03342	-4.0926

TABLE IX (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_s a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_s a \sigma}$	c_l Phase (rad)
550	0.58	3.14	0.055	0.03602	-6.2564	0.04981	-3.2128
		6.28	0.109	0.03698	-6.1979	0.04997	-3.2646
		12.57	0.218	0.04190	-6.1654	0.05220	-3.4351
		18.82	0.327	0.05248	-6.2109	0.05609	-3.6653
		25.09	0.436	0.06700	-0.1308	0.05803	-4.0073
		21.95	0.382	0.06020	-0.0148	0.05786	-3.8192
		28.25	0.491	0.07369	-0.2915	0.05778	-4.2310
		31.41	0.546	0.07524	-0.4970	0.05268	-4.4712
		37.66	0.655	0.07206	-0.8891	0.03774	-5.0081
		50.19	0.873	0.04964	-1.1959	0.01183	-5.2468
		62.61	1.089	0.04264	-1.3543	0.00223	-3.7964
		75.12	1.306	0.03698	-1.4234	0.01011	-3.1136
		87.68	1.525	0.02892	-1.4553	0.01943	-3.2863
		100.18	1.742	0.03486	-1.3660	0.02146	-3.5213
		112.64	1.959	0.04275	-1.5609	0.02662	-3.5615
		125.17	2.177	0.05250	-1.8656	0.03495	-3.7334
		137.73	2.395	0.05695	-2.3983	0.03917	-4.0502
	0.79	3.13	0.054	0.05964	-6.2627	0.07042	-3.2217
		6.28	0.109	0.06256	-6.2279	0.07242	-3.2892
		12.56	0.218	0.07165	-6.2311	0.07618	-3.4855
		18.78	0.327	0.09004	-0.0498	0.08248	-3.7687
		25.35	0.441	0.11306	-0.3116	0.08465	-4.1861
		31.41	0.546	0.11522	-0.7427	0.06923	-4.7262
		37.67	0.655	0.10434	-1.1490	0.04655	-5.3659
		50.19	0.873	0.06823	-1.4066	0.01176	-5.9297
		62.62	1.089	0.05428	-1.5629	0.00810	-1.9648
		75.14	1.307	0.04163	-1.5865	0.02020	-2.7317
		87.68	1.525	0.03439	-1.5349	0.03320	-3.1864
		100.21	1.743	0.04564	-1.3714	0.03368	-3.5344
		112.64	1.959	0.05582	-1.5467	0.03539	-3.5462
		125.22	2.178	0.06995	-1.9003	0.04764	-3.7177
		137.73	2.395	0.07470	-2.4063	0.05577	-3.9578

TABLE IX (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_s a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_s a \sigma}$	c_l Phase (rad)
550	0.96	6.24	0.106	0.08430	-6.2458	0.08577	-6.2475
		12.56	0.218	0.09603	-6.2648	0.09065	-6.2632
		18.77	0.326	0.11984	-6.3969	0.09642	-6.3964
		25.08	0.436	0.14711	-6.4059	0.10130	-6.2659
		31.36	0.545	0.14585	-6.8703	0.07927	-6.3851
		37.63	0.654	0.12674	-1.2281	0.05200	-5.4424
		50.18	0.873	0.08208	-1.4498	0.01324	-5.1660
		62.63	1.089	0.06432	-1.6252	0.01636	-1.4648
		75.14	1.307	0.05013	-1.6495	0.03055	-2.5719
		87.68	1.525	0.03886	-1.5984	0.04998	-3.1595
		100.21	1.743	0.05182	-1.4145	0.04481	-3.6039
		112.64	1.959	0.06704	-1.5175	0.04589	-3.6125
		125.26	2.179	0.08106	-1.9394	0.05764	-3.7579
		137.79	2.396	0.08964	-2.4260	0.06694	-4.0129
800	0.29	3.20	.036	.02723	-.0040	.02160	-3.2460
		6.38	.076	.02772	-.0120	.02187	-3.3360
		12.70	.153	.03010	-.0710	.02205	-3.5672
		19.16	.220	.03307	-.1020	.02235	-3.8652
		22.37	.267	.03574	-.2050	.02167	-4.0532
		25.56	.305	.03685	-.4150	.02071	-4.2500
		28.78	.344	.03675	-.5500	.01808	-4.4722
		31.93	.381	.03473	-.6702	.01617	-4.6302
		33.60	.401	.03033	-.6232	.00936	-5.0852
		44.72	.534	.02403	-.8090	.00670	-4.7116
		51.12	.610	.02233	-.8820	.00424	-5.0522
		63.61	.763	.02274	-1.1170	.00032	-5.1062
		76.72	.916	.02202	-1.1582	.00184	-2.8222
		89.53	1.069	.02320	-1.2310	.00341	-2.6740
		102.30	1.221	.02105	-1.4020	.00827	-2.7630
		115.20	1.375	.02017	-1.4812	.00975	-3.2602
		128.02	1.528	.01997	-1.5350	.00971	-3.4242
		140.82	1.681	.02000	-1.6110	.01055	-3.4170

TABLE IX (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_s a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_s a \sigma}$	c_l Phase (rad)
800	0.40	3.10	0.037	0.03544	-6.2786	0.02589	-3.2464
		6.27	0.075	0.03515	-0.0207	0.02523	-3.3590
		12.54	0.150	0.03849	-0.0837	0.02604	-3.6132
		18.80	0.224	0.04346	-0.2219	0.02657	-3.9330
		25.05	0.299	0.04602	-0.4050	0.02446	-4.3321
		31.42	0.375	0.04368	-0.7393	0.01897	-4.7280
		37.67	0.450	0.03840	-1.0018	0.01256	-5.2261
		43.88	0.524	0.03050	-1.0080	0.00733	-4.9355
		50.11	0.598	0.02449	-1.1234	0.00344	-5.2226
		62.46	0.745	0.02628	-1.1661	0.00101	-5.4675
		75.16	0.897	0.02477	-1.1494	0.00192	-2.9576
		87.51	1.045	0.02527	-1.2139	0.00413	-2.8500
		100.37	1.198	0.02173	-1.4759	0.01000	-2.4038
		112.60	1.344	0.02010	-1.4773	0.01333	-3.1379
		125.66	1.500	0.02003	-1.4489	0.01305	-3.3519
		137.79	1.645	0.02199	-1.5049	0.01341	-3.4215
	0.54	3.13	0.037	0.04736	-0.0180	0.03255	-3.2621
		6.26	0.075	0.04945	-0.0335	0.03335	-3.3650
		12.55	0.150	0.05436	-0.1350	0.03348	-3.6941
		18.80	0.224	0.05941	-0.3121	0.03325	-4.0332
		25.03	0.299	0.06407	-0.6041	0.02948	-4.5506
		31.42	0.375	0.05695	-0.9200	0.02185	-5.0225
		37.67	0.450	0.04687	-1.1896	0.01351	-5.7132
		50.19	0.599	0.02639	-1.2679	0.00215	-0.0342
		62.58	0.747	0.02854	-1.3592	0.00250	-1.4283
		75.34	0.899	0.02823	-1.1736	0.00203	-2.3113
		87.75	1.047	0.02718	-1.3594	0.00752	-2.2072
		100.05	1.194	0.02121	-1.5299	0.01539	-2.3510
		112.60	1.344	0.02055	-1.3823	0.01774	-2.9711
		125.16	1.494	0.02265	-1.3326	0.01596	-3.2315
		138.40	1.652	0.02724	-1.4441	0.01908	-3.3134

TABLE IX (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_s a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_s a \sigma}$	c_l Phase (rad)
800	0.66	3.13	0.037	0.06204	-0.0073	0.03926	-3.2508
		6.26	0.075	0.06300	-0.0606	0.03878	-3.4039
		12.54	0.150	0.06787	-0.1364	0.03825	-3.7063
		18.85	0.225	0.07435	-0.3905	0.03785	-4.1040
		25.15	0.300	0.07790	-0.6765	0.03413	-4.5863
		31.38	0.375	0.06762	-0.9779	0.02449	-5.0695
		37.53	0.448	0.05306	-1.2332	0.01376	-5.6365
		50.19	0.595	0.03035	-1.3296	0.00262	-0.1920
		62.71	0.748	0.03022	-1.4205	0.00429	-1.5389
		74.98	0.895	0.03093	-1.2670	0.00322	-2.3729
		87.51	1.045	0.03079	-1.4204	0.00868	-2.2504
		100.37	1.198	0.02406	-1.6196	0.01480	-2.3137
		112.60	1.344	0.02168	-1.4157	0.02147	-2.9923
		124.67	1.488	0.02481	-1.3615	0.01989	-3.2853
		137.19	1.637	0.03127	-1.4398	0.02281	-3.3072

TABLE X
 ROTOR FREQUENCY RESPONSE TO LATERAL CYCLIC PITCH

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_c a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_c a \sigma}$	c_l Phase (rad)
300	0.78	3.13	0.100	0.06393	-3.1850	0.00753	-2.8050
		6.26	0.199	0.06397	-3.2019	0.00666	-2.7076
		12.54	0.399	0.06535	-3.2058	0.01140	-1.9909
		18.80	0.599	0.07718	-3.2477	0.02350	-1.9286
		25.11	0.800	0.09176	-3.4043	0.03805	-2.1406
		31.37	0.999	0.11341	-3.6493	0.06627	-2.3580
		37.64	1.199	0.14182	-4.0989	0.11031	-2.8340
		43.90	1.398	0.11136	-4.8404	0.12306	-3.6522
		50.19	1.599	0.05765	-5.0073	0.08904	-4.0923
		56.46	1.798	0.03420	-5.1159	0.07643	-4.3954
		62.62	1.994	0.01689	-4.8264	0.07604	-4.5377
		68.86	2.193	0.01487	-4.4435	0.06015	-4.7211
		75.12	2.392	0.02214	-3.7431	0.05467	-4.8375
		81.39	2.592	0.03499	-3.6994	0.05563	-4.9502
		87.66	2.792	0.04535	-3.8203	0.05885	-5.1745
		93.92	2.991	0.06337	-3.8391	0.06015	-5.2924
		100.18	3.190	0.08598	-4.1729	0.07047	-5.5602
		106.42	3.389	0.10544	-4.7964	0.07776	-6.1919
		112.60	3.586	0.08173	-5.4026	0.05399	-6.5378
		118.91	3.787	0.05660	-5.7796	0.03286	-6.9426
		137.73	4.386	0.01293	-5.6153	0.00789	-5.9065
	1.07	3.13	0.100	0.07565	-3.1692	0.00257	-2.5395
		6.28	0.200	0.07552	-3.2067	0.00662	-1.8453
		12.53	0.399	0.07673	-3.1988	0.01573	-1.7556
		18.80	0.599	0.09320	-3.2321	0.02994	-1.8919
		25.12	0.800	0.11231	-3.4068	0.04788	-2.0009
		31.38	0.999	0.13711	-3.6910	0.07303	-2.3303
		37.64	1.199	0.16554	-4.1813	0.13012	-2.9045
		43.91	1.398	0.12482	-4.8620	0.13753	-3.6599
		50.19	1.599	0.07525	-5.0964	0.11259	-4.0748
		56.46	1.798	0.03852	-5.0422	0.08885	-4.3320
		62.62	1.994	0.02617	-4.9283	0.08264	-4.5712
		68.88	2.194	0.01698	-4.4321	0.07569	-4.7919
		75.12	2.392	0.02734	-3.8161	0.06754	-4.9340
		81.37	2.591	0.04226	-3.7737	0.06722	-5.0707
		87.66	2.792	0.05578	-3.8927	0.06781	-5.3177
		93.92	2.991	0.07762	-4.0759	0.06840	-5.4899
		100.18	3.190	0.10511	-4.3590	0.08363	-5.7354
		106.42	3.389	0.12137	-4.9618	0.08780	-6.0789
		112.64	3.587	0.09327	-5.5706	0.06106	-6.7453
		118.91	3.787	0.06156	-5.9302	0.03543	-6.1747
		137.67	4.384	0.00492	-5.6639	0.00872	-4.9273

TABLE X (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_c a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_c a \sigma}$	c_l Phase (rad)
300	1.44	3.13	0.100	0.10636	-3.1734	0.02070	-0.3595
		6.28	0.200	0.10678	-3.2109	0.02575	-0.8769
		12.54	0.400	0.10982	-3.2332	0.03394	-1.4942
		18.81	0.599	0.12960	-3.3282	0.04973	-1.9307
		25.10	0.799	0.15378	-3.5151	0.06952	-2.2117
		31.39	1.000	0.17991	-3.8870	0.10452	-2.4051
		37.64	1.199	0.19927	-4.2698	0.15218	-3.0160
		43.93	1.399	0.14547	-4.8191	0.15669	-3.6662
		50.20	1.599	0.10739	-5.0506	0.14765	-4.0294
		56.46	1.798	0.05540	-5.1077	0.12544	-4.3881
		62.62	1.994	0.04472	-4.9652	0.12159	-4.6923
		68.88	2.194	0.02735	-4.4394	0.10630	-4.8474
		75.14	2.393	0.03583	-3.9497	0.08115	-5.0269
		81.39	2.592	0.05349	-3.9833	0.08557	-5.1428
		87.68	2.792	0.06867	-4.0612	0.08464	-5.3194
		93.95	2.992	0.08924	-4.2423	0.08377	-5.5360
		100.21	3.191	0.12386	-4.5459	0.04594	-5.8343
		106.46	3.390	0.13983	-5.1309	0.09577	-0.1666
		112.64	3.587	0.11598	-5.6697	0.07132	-0.7725
		118.91	3.787	0.08267	-6.0435	0.04500	-1.2529
		137.67	4.384	0.00750	-6.2246	0.01278	-4.4571
550	0.43	3.13	0.055	0.04576	-3.2101	0.01450	-3.0238
		6.28	0.109	0.04625	-3.2372	0.01529	-2.9058
		12.55	0.218	0.04844	-3.4479	0.01975	-2.7541
		15.67	0.273	0.05032	-3.5446	0.02332	-2.7237
		18.79	0.327	0.05277	-3.6563	0.02811	-2.7369
		25.10	0.437	0.05811	-3.9709	0.04143	-2.9140
		31.38	0.546	0.05620	-4.4422	0.05472	-3.3318
		37.65	0.655	0.04240	-4.9433	0.05593	-3.8266
		43.91	0.764	0.02643	-5.2033	0.04662	-4.1192
		50.20	0.873	0.01526	-5.0380	0.03712	-4.2870
		57.73	1.004	0.01236	-4.8719	0.03160	-4.4083
		62.62	1.089	0.00845	-4.8933	0.02970	-4.5043
		75.14	1.307	0.00653	-4.2227	0.02540	-4.6019
		87.68	1.525	0.00715	-3.5787	0.02353	-4.7263
		100.21	1.743	0.01350	-3.5481	0.02331	-4.7563
		112.64	1.959	0.01734	-3.6495	0.02517	-4.8435
		125.22	2.178	0.02468	-3.8459	0.02997	-5.1173
		125.17	2.177	0.02465	-3.8427	0.02887	-5.1149

TABLE X (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_c a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_c a \sigma}$	c_l Phase (rad)
550	0.58	3.13	0.055	0.05045	-3.2128	0.01229	-2.9317
		6.28	0.109	0.05140	-3.2828	0.01346	-2.7734
		6.28	0.109	0.05120	-3.2803	0.01381	-2.7987
		12.55	0.218	0.05410	-3.4319	0.01896	-2.5843
		18.79	0.327	0.05938	-3.6436	0.02953	-2.5861
		25.12	0.437	0.06592	-3.9657	0.04522	-2.8024
		31.36	0.545	0.06295	-4.4545	0.05936	-3.2590
		37.64	0.655	0.04909	-4.9530	0.06157	-3.7502
		50.20	0.873	0.01901	-5.2026	0.04385	-4.2422
		62.62	1.089	0.00835	-5.1214	0.03479	-4.5150
		75.14	1.307	0.00575	-4.1402	0.02864	-4.6510
		87.68	1.525	0.00787	-3.5151	0.02587	-4.8011
		100.21	1.743	0.01509	-3.5608	0.02396	-4.8172
		112.64	1.959	0.01940	-3.7544	0.02581	-4.9448
		125.17	2.177	0.02613	-3.9449	0.02928	-5.1551
		137.67	2.394	0.03631	-4.4140	0.03257	-5.5170
	0.79	3.14	0.055	0.05847	-3.1988	0.01071	-2.9191
		6.25	0.109	0.06008	-3.2904	0.01265	-2.6013
		12.55	0.218	0.06379	-3.4255	0.01862	-2.4029
		18.82	0.327	0.07009	-3.6322	0.03108	-2.4321
		25.13	0.437	0.07976	-3.9750	0.05106	-2.6971
		31.40	0.546	0.07373	-4.4793	0.06620	-3.1877
		37.65	0.655	0.05805	-4.9812	0.06843	-3.6732
		50.19	0.873	0.02529	-5.3955	0.05153	-4.1702
62.62		1.089	0.00964	-5.5419	0.04137	-4.4555	
75.12		1.306	0.00338	-4.1086	0.03508	-4.6402	
87.68		1.525	0.00923	-3.3761	0.03099	-4.8471	
100.18		1.742	0.01907	-3.6112	0.02765	-4.9074	
112.68	1.960	0.02390	-3.7900	0.03029	-5.0066		
125.22	2.178	0.03013	-4.1579	0.03105	-5.2965		
137.73	2.395	0.03765	-4.6241	0.03216	-5.7491		

TABLE X (CONTINUED)

rpm	μ	ω (rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_c a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_c a \sigma}$	c_l Phase (rad)
550	0.96	3.13	0.054	0.06686	-3.2650	0.01298	-2.5714
		6.30	0.110	0.06913	-3.2522	0.01089	-2.0360
		12.54	0.218	0.07219	-3.4131	0.01970	-2.3793
		18.78	0.327	0.08072	-3.6024	0.03263	-2.3308
		25.12	0.437	0.09103	-3.9412	0.05339	-2.6443
		31.41	0.546	0.08105	-4.4253	0.06811	-3.1523
		37.66	0.655	0.06621	-4.8763	0.07264	-3.6069
		50.19	0.873	0.03078	-5.2307	0.05630	-4.1147
		62.62	1.089	0.01323	-5.4076	0.04639	-4.4361
		75.16	1.307	0.00478	-4.3221	0.03958	-4.6309
		87.68	1.525	0.00985	-3.4191	0.03417	-4.8636
		100.18	1.742	0.01847	-3.6063	0.02975	-4.9145
		112.68	1.960	0.02714	-3.8583	0.03324	-5.0596
		125.21	2.178	0.03414	-4.1572	0.03563	-5.3078
		137.73	2.395	0.04438	-4.6403	0.03830	-5.7815
800	0.29	3.20	.038	.03390	-3.2670	.01043	-3.1040
		6.38	.076	.03375	-3.4080	.02053	-3.0600
		12.78	.153	.03373	-3.7012	.02441	-3.0882
		19.17	.229	.03263	-4.0492	.03004	-3.2402
		25.52	.305	.02934	-4.4702	.03487	-3.5212
		31.93	.381	.02136	-4.8402	.03410	-3.8380
		38.31	.457	.01433	-5.1352	.02907	-4.1150
		44.75	.534	.00990	-5.3730	.02038	-4.2840
		51.17	.611	.00500	-4.9852	.02164	-4.3602
		63.85	.762	.00318	-4.7722	.01634	-4.4012
		76.81	.917	.00329	-4.0052	.01442	-4.4080
		89.50	1.068	.00410	-3.8400	.01425	-4.4000
		102.33	1.221	.00462	-4.0612	.01300	-4.3100
		115.08	1.374	.00350	-3.7022	.01706	-4.5082
		127.70	1.524	.00439	-3.7250	.01732	-4.7260
		140.90	1.682	.00606	-3.5730	.01650	-4.8632
		153.11	.992	.00410	-3.5652	.01401	-4.6052

TABLE X (CONTINUED)

rpm	μ	ω (rad/sec)	Ω	c_m θ_c aσ	c_m Phase (rad)	c_l θ_c aσ	c_l Phase (rad)
800	0.40	3.19	0.038	0.03544	-3.2667	0.01991	-3.0967
		6.27	0.075	0.03564	-3.3359	0.02101	-3.0715
		12.55	0.150	0.03616	-3.6577	0.02464	-3.0808
		18.81	0.225	0.03524	-3.9931	0.03027	-3.2119
		25.13	0.300	0.03215	-4.3928	0.03525	-3.4600
		31.32	0.374	0.02423	-4.7646	0.03607	-3.7572
		37.67	0.450	0.01682	-5.1121	0.03308	-4.0668
		50.03	0.597	0.00709	-5.0148	0.02437	-4.3042
		62.46	0.745	0.00338	-5.0224	0.01979	-4.5231
		75.34	0.899	0.00310	-4.0324	0.01620	-4.5999
		87.75	1.047	0.00554	-4.1540	0.01317	-4.3762
		100.37	1.198	0.00537	-4.1432	0.01192	-4.3384
		112.60	1.344	0.00347	-4.0291	0.01816	-4.6232
		125.16	1.494	0.00475	-3.8154	0.01650	-4.7400
		137.79	1.645	0.00701	-3.8501	0.01694	-4.8529
	0.54	3.13	0.037	0.03833	-3.2627	0.01891	-3.0692
		6.26	0.075	0.03872	-3.3745	0.01976	-3.0302
		12.52	0.149	0.03904	-3.6431	0.02398	-3.0209
		18.81	0.225	0.03834	-3.9902	0.03034	-3.1387
		25.07	0.299	0.03448	-4.4137	0.03593	-3.4060
		31.38	0.375	0.02523	-4.7880	0.03635	-3.7145
		37.71	0.450	0.01779	-5.0980	0.03351	-3.9995
		50.27	0.600	0.00936	-5.1966	0.02609	-4.2105
		62.58	0.747	0.00380	-5.3937	0.02193	-4.4341
		75.34	0.899	0.00286	-3.9732	0.01781	-4.5630
		87.75	1.047	0.00468	-3.6268	0.01463	-4.7416
		100.37	1.198	0.00446	-4.2791	0.01378	-4.3363
		112.60	1.344	0.00331	-4.0076	0.01866	-4.6750
		125.16	1.494	0.00612	-3.8644	0.01718	-4.7912
		137.79	1.645	0.00726	-3.9431	0.01664	-4.8750

TABLE X (CONTINUED)

rpm	μ	(rad/sec)	$\frac{\omega}{\Omega}$	$\frac{c_m}{\theta_c a \sigma}$	c_m Phase (rad)	$\frac{c_l}{\theta_c a \sigma}$	c_l Phase (rad)
800	0.66	3.14	0.037	0.04508	-3.2760	0.01644	-3.0061
		6.27	0.075	0.04456	-3.3933	0.01352	-2.9284
		12.55	0.150	0.04469	-3.6498	0.02353	-2.8226
		18.81	0.225	0.04421	-3.9790	0.03028	-3.0009
		25.15	0.300	0.03851	-4.4038	0.03624	-3.3596
		31.42	0.375	0.02730	-4.7673	0.03613	-3.6751
		37.67	0.450	0.01890	-5.0591	0.03287	-3.9599
		50.19	0.599	0.00955	-5.0890	0.02540	-4.1460
		62.46	0.749	0.00471	-5.1479	0.02108	-4.3230
		74.98	0.895	0.00275	-4.2550	0.01764	-4.4546
		87.75	1.047	0.00571	-3.9708	0.01325	-4.5672
		100.05	1.194	0.00646	-4.0808	0.01567	-4.3183
		112.60	1.344	0.00486	-3.9666	0.01790	-4.1563
		125.16	1.494	0.00601	-3.8533	0.01594	-4.7667
		137.79	1.645	0.00852	-4.1113	0.01528	-4.9500

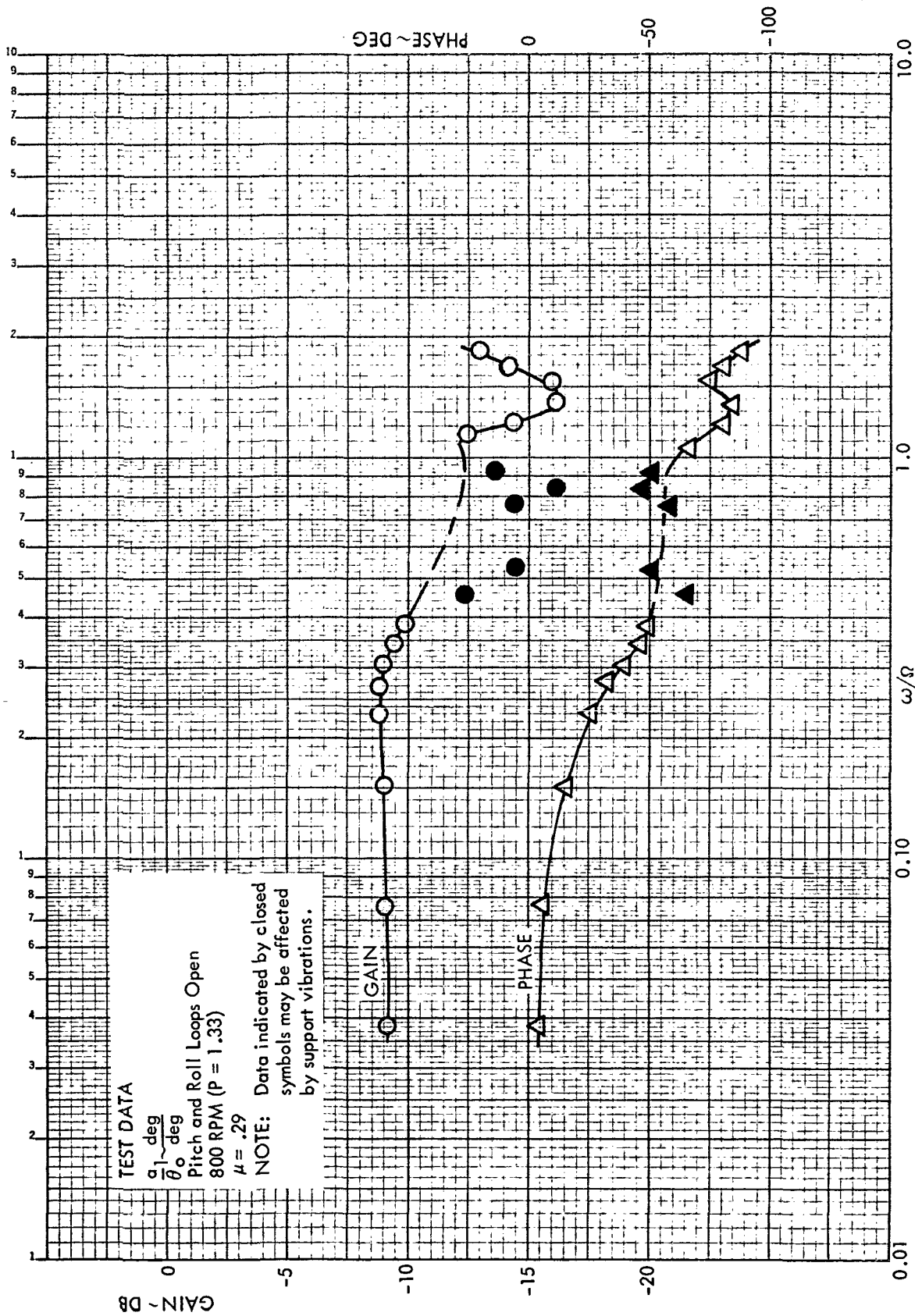


Figure C1. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)

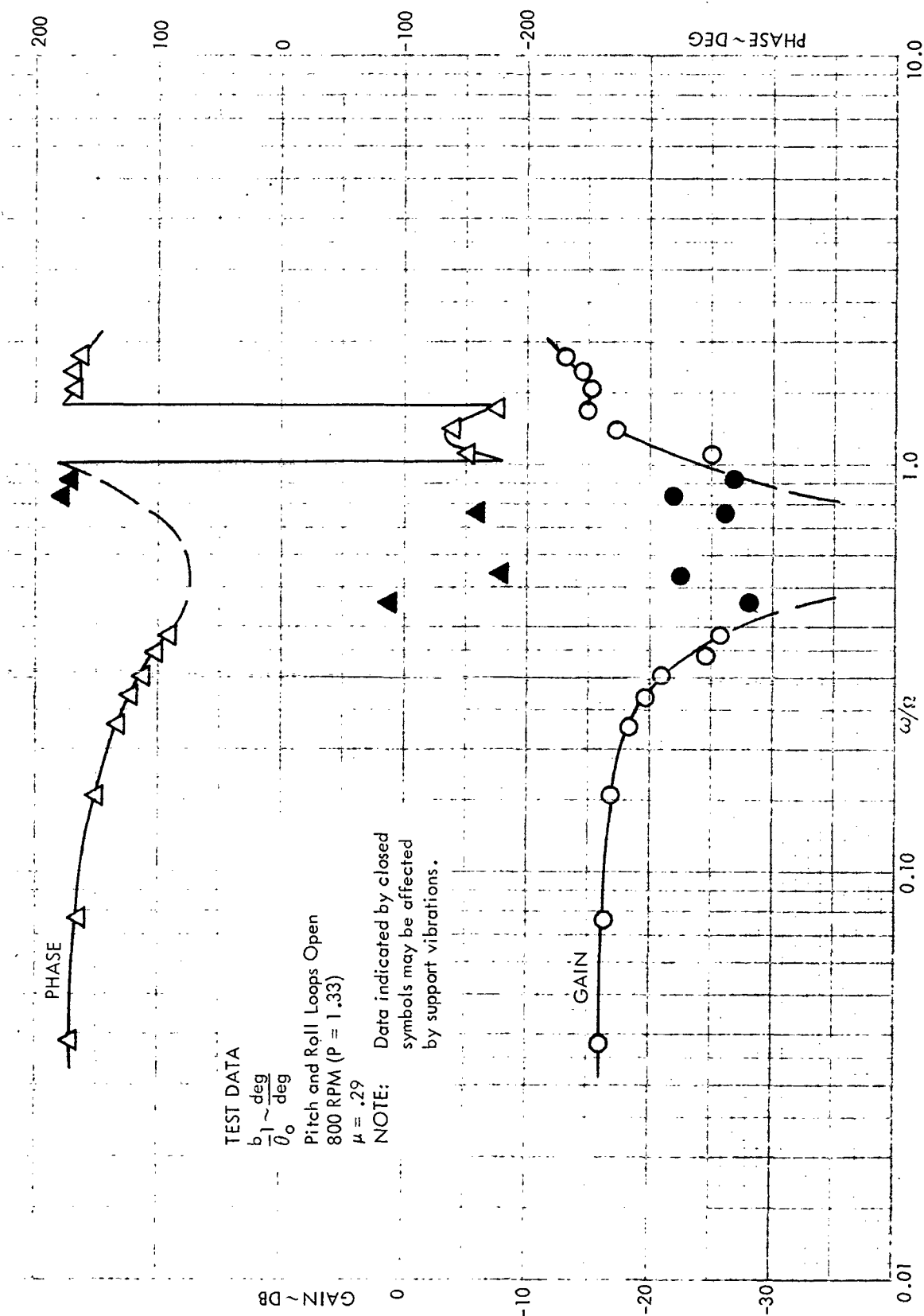


Figure C2. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)

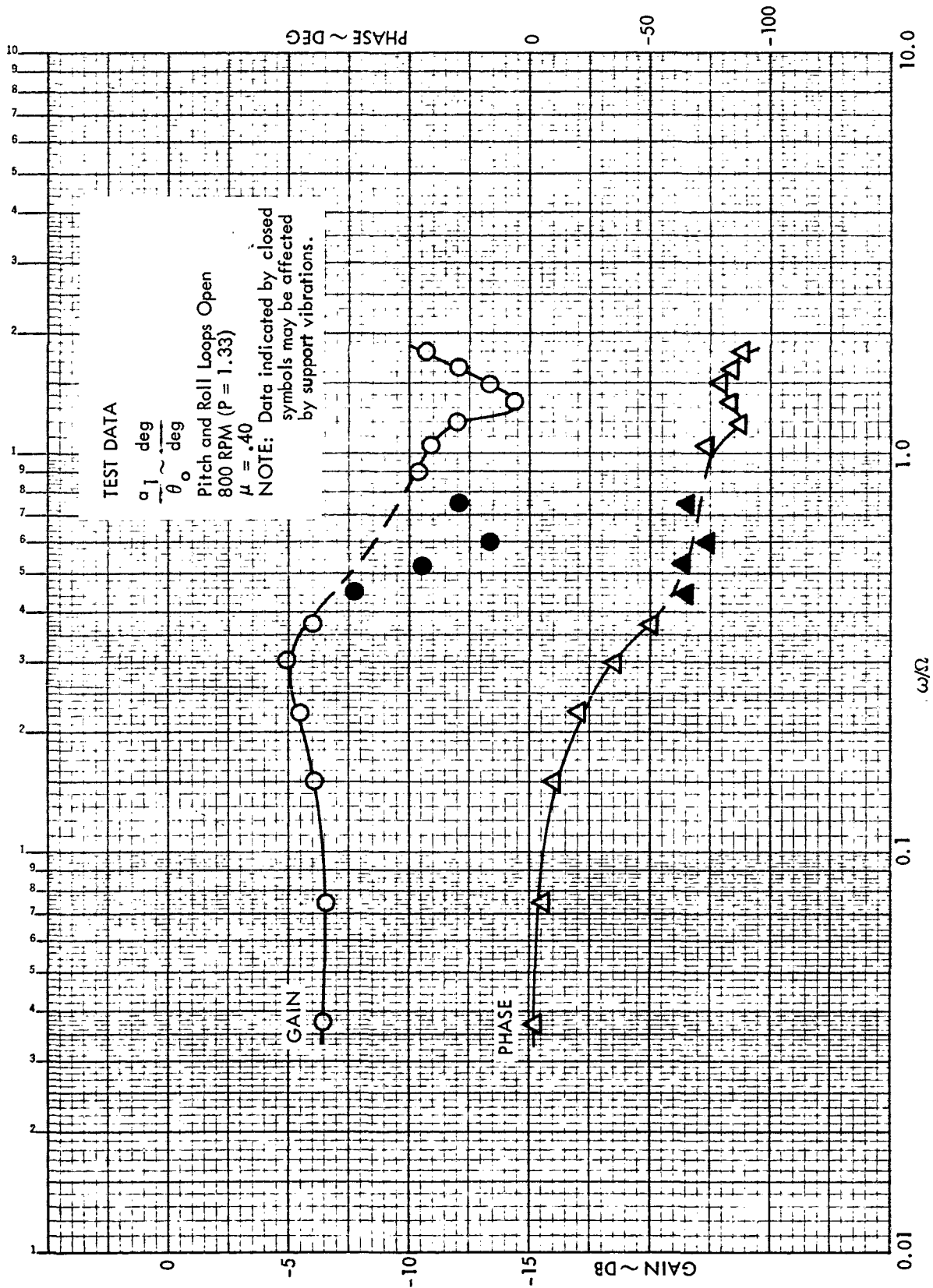


Figure C3. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)

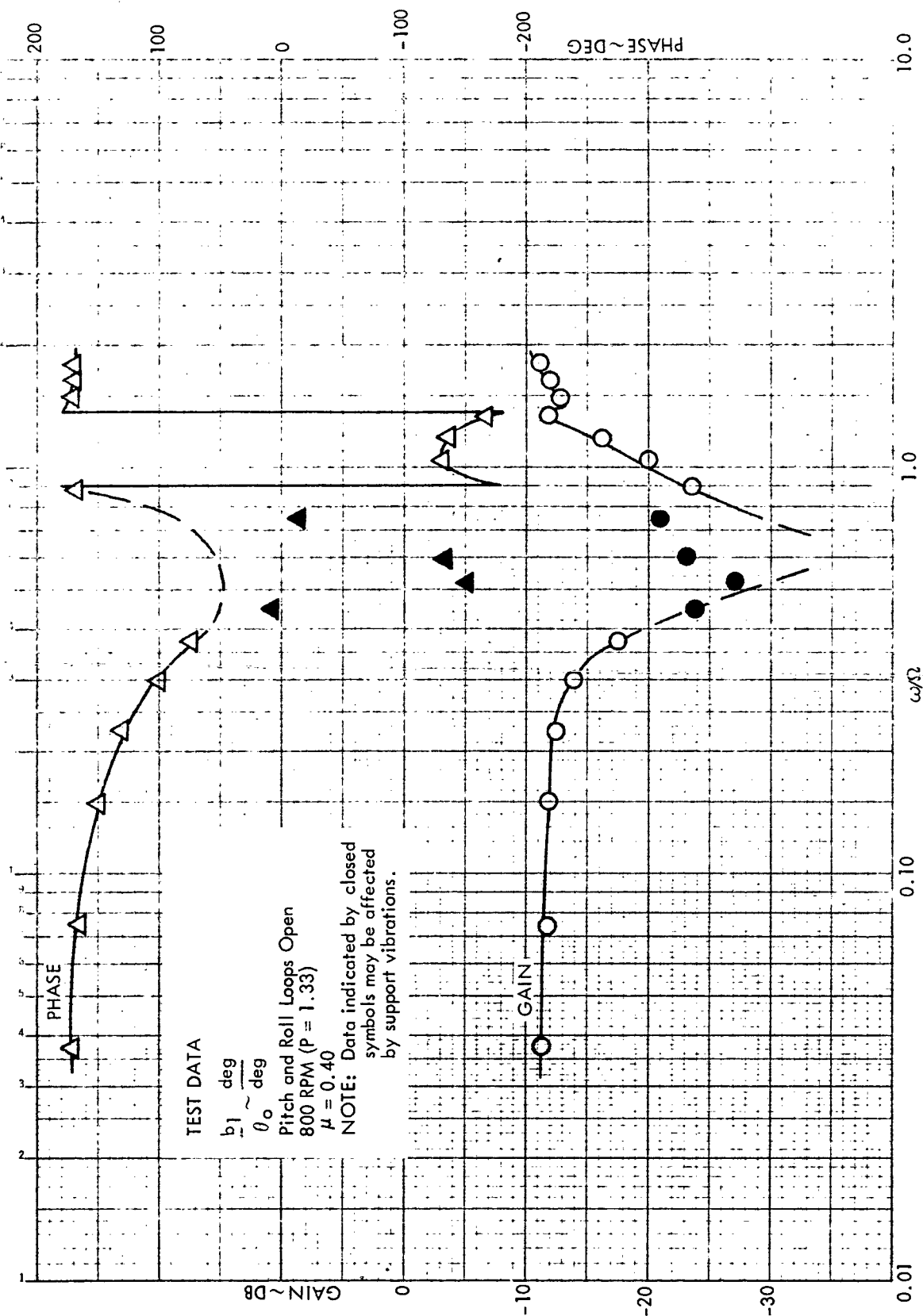


Figure C4. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)

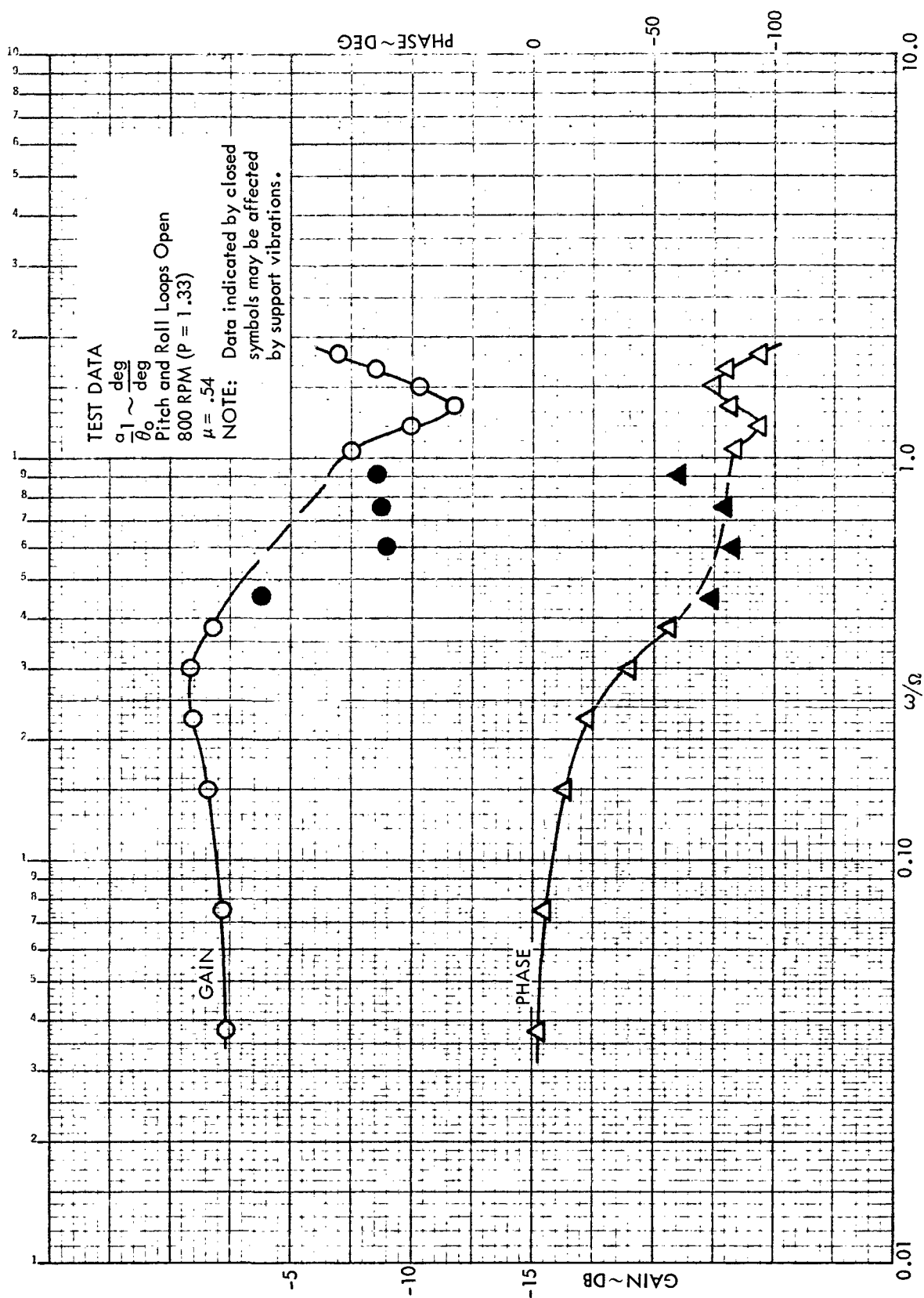


Figure C5. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)

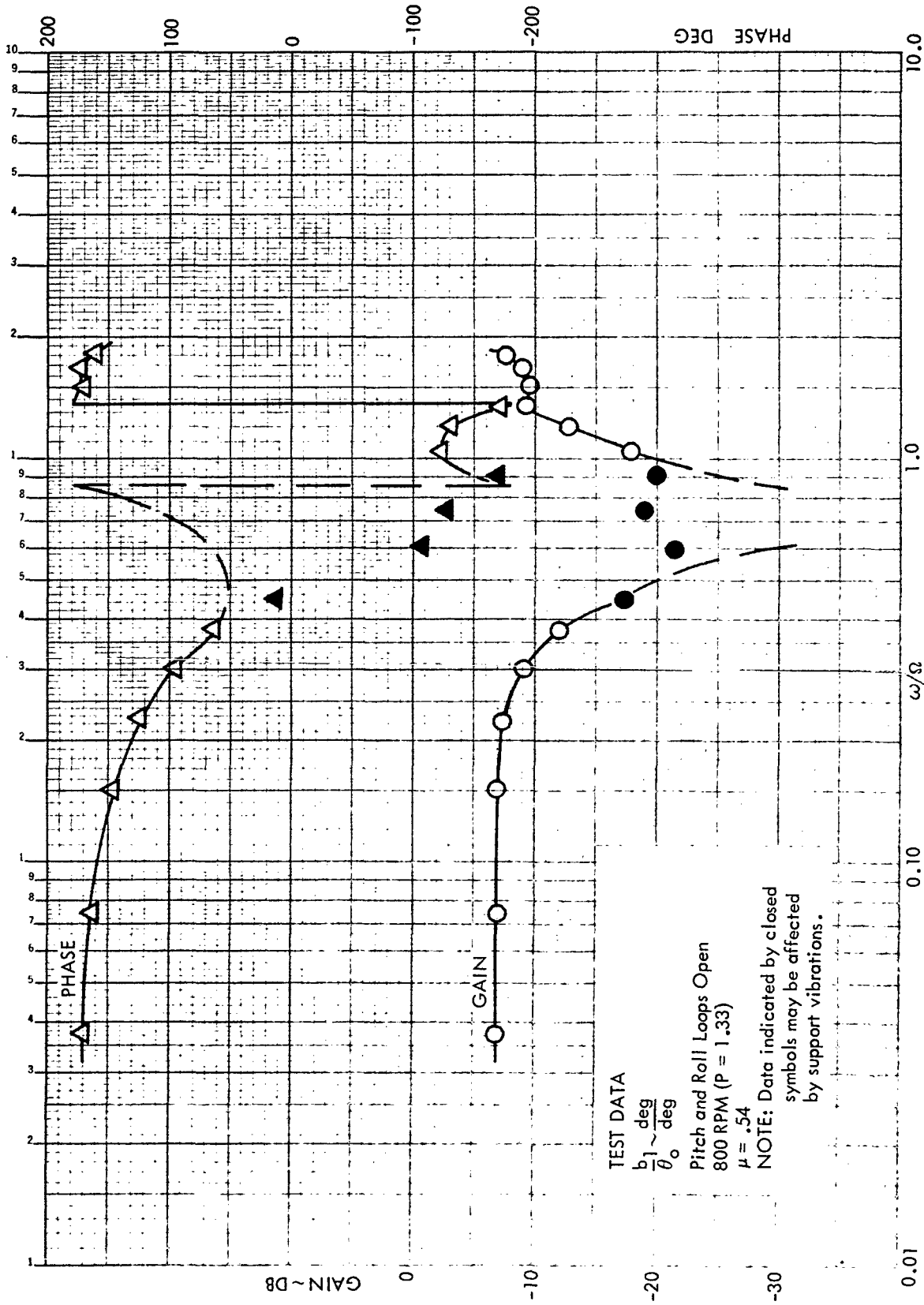


Figure C6. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)

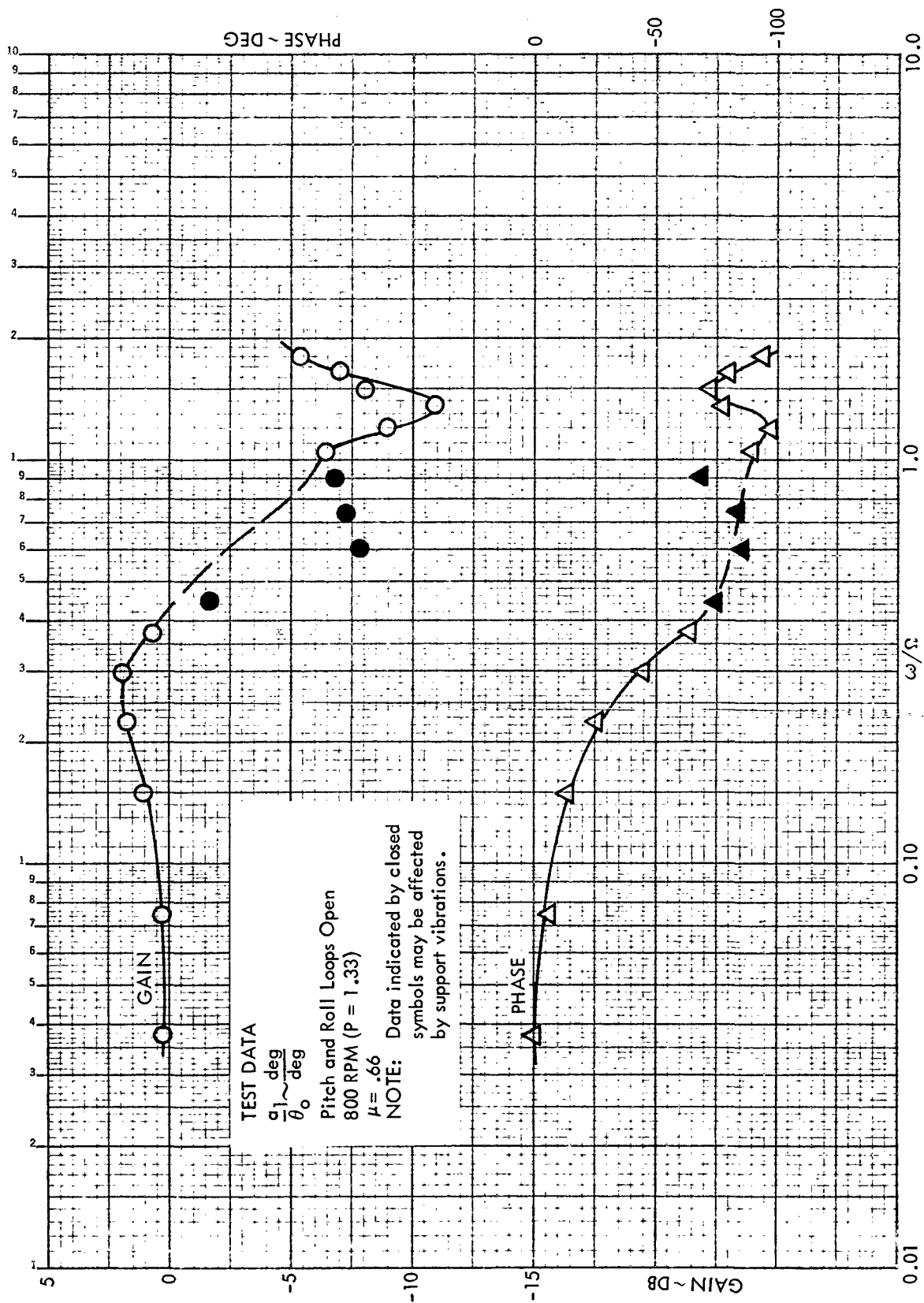


Figure C7. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)

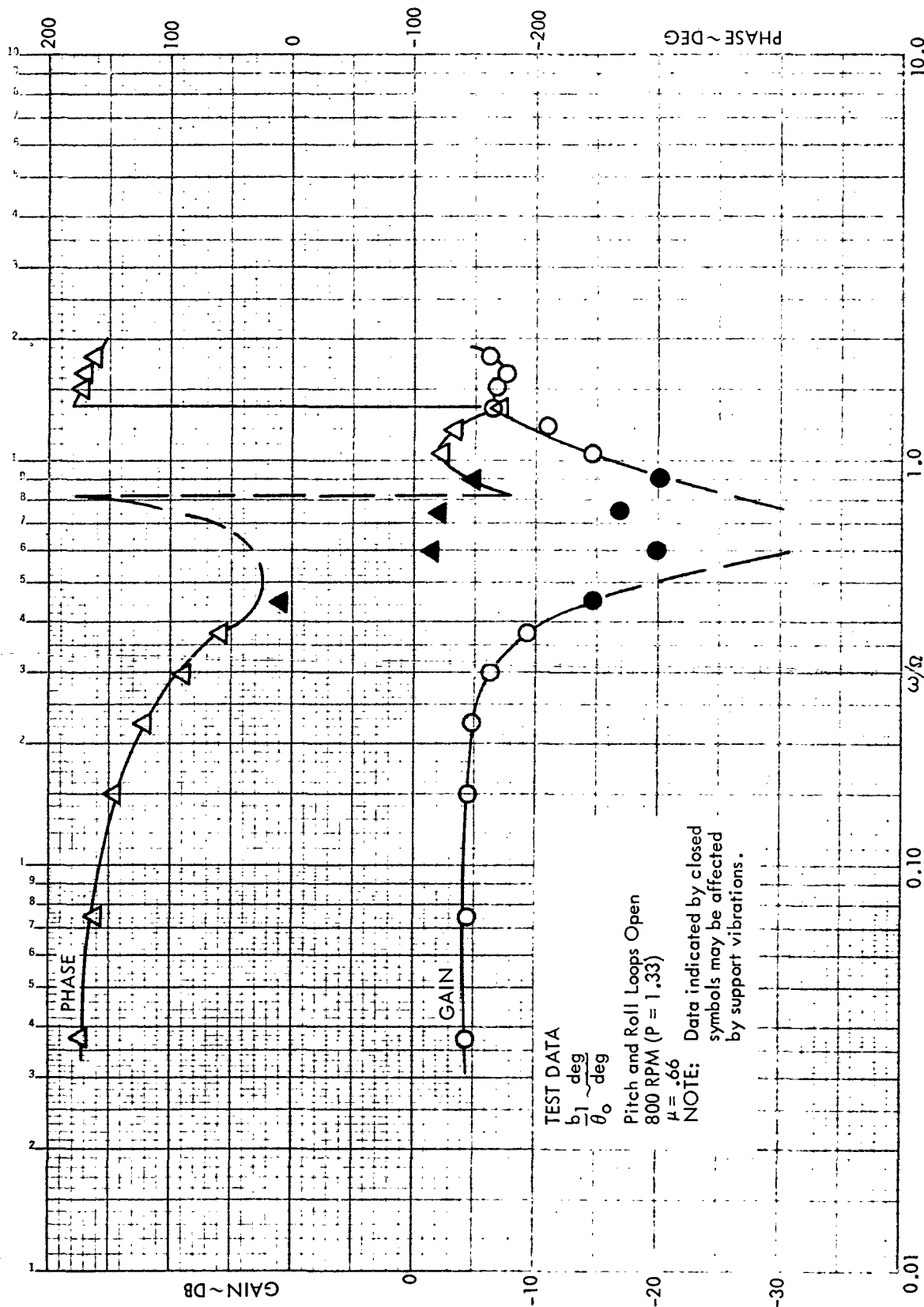


Figure C8. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)

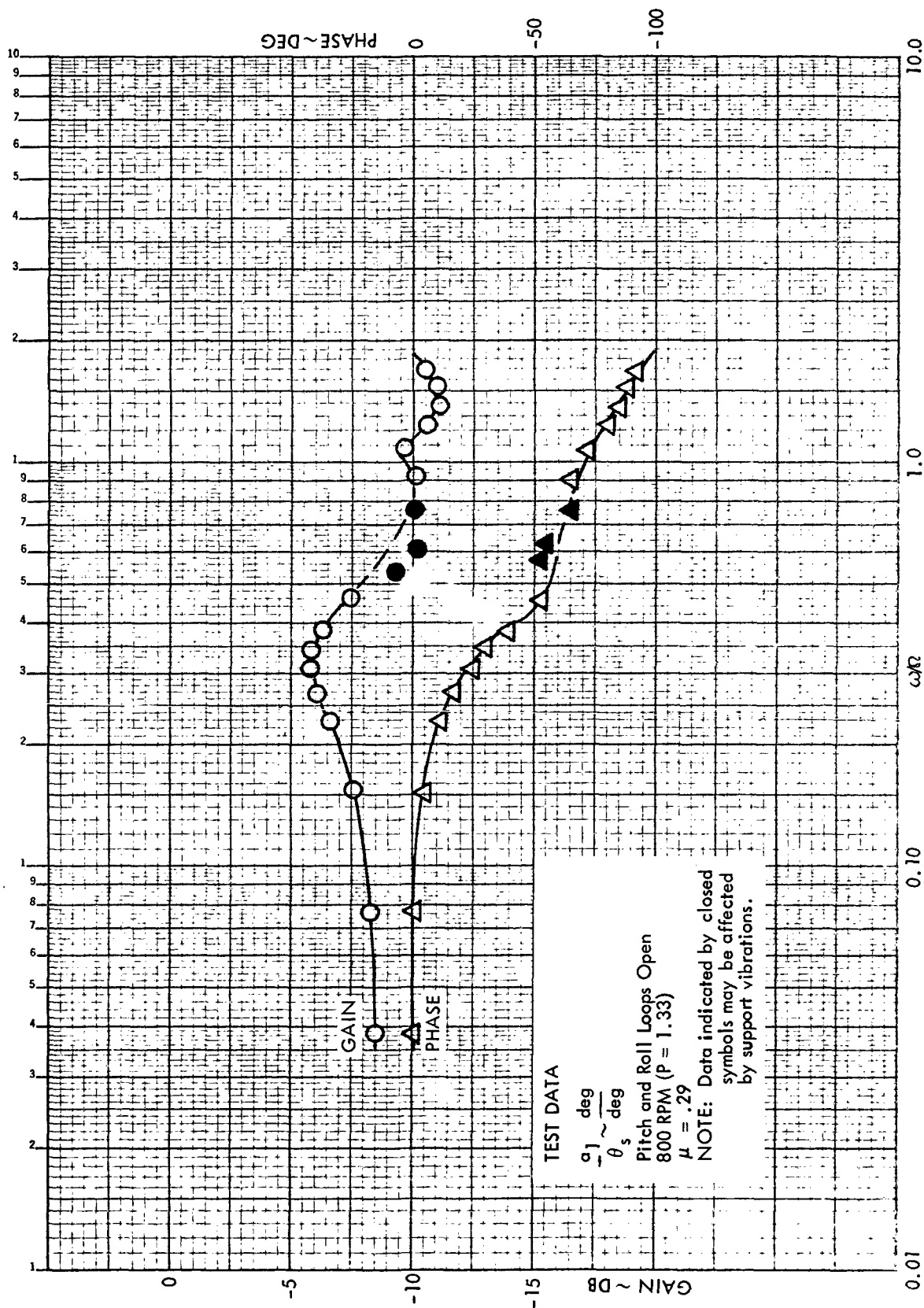


Figure C9. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)

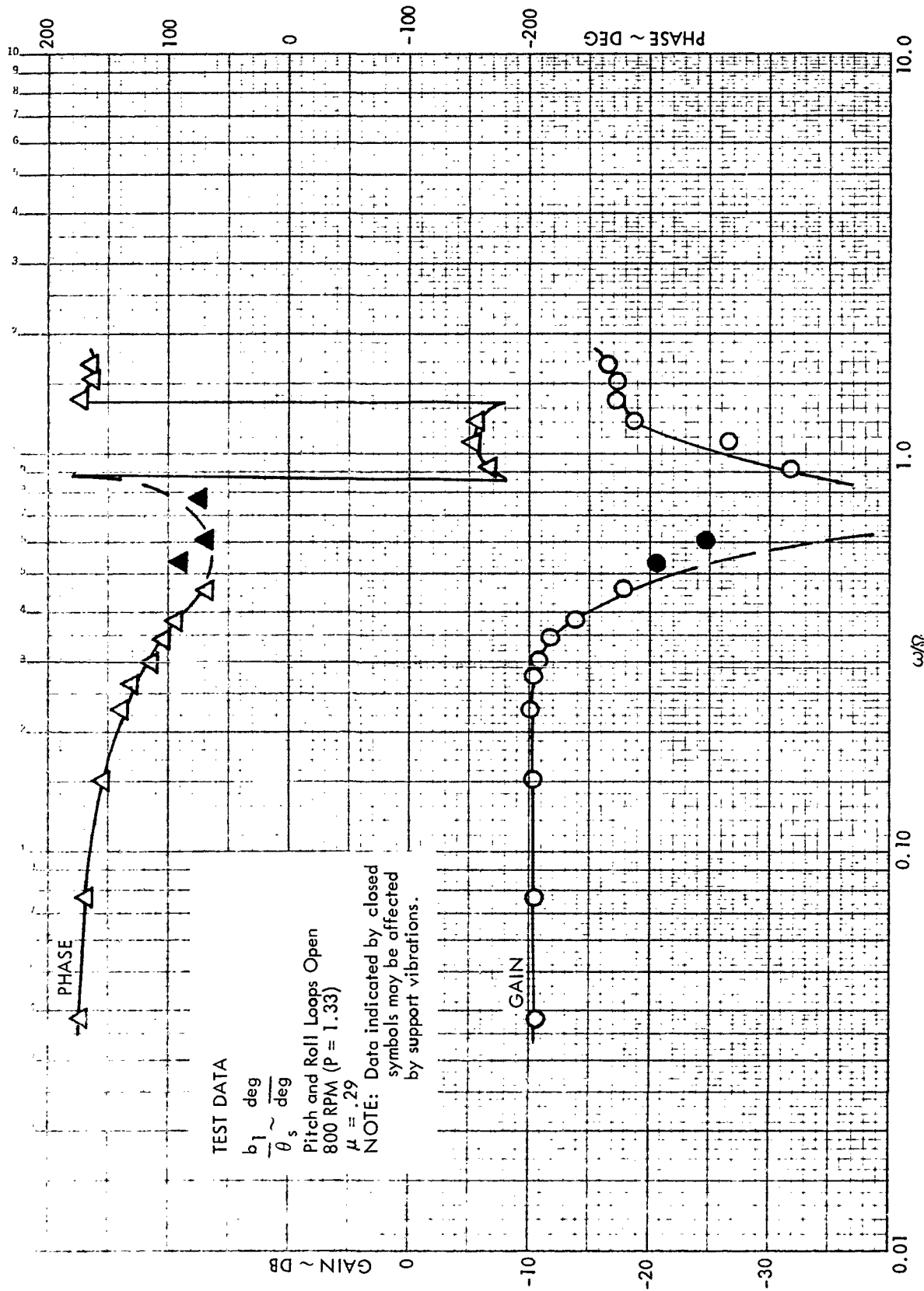


Figure C10. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)

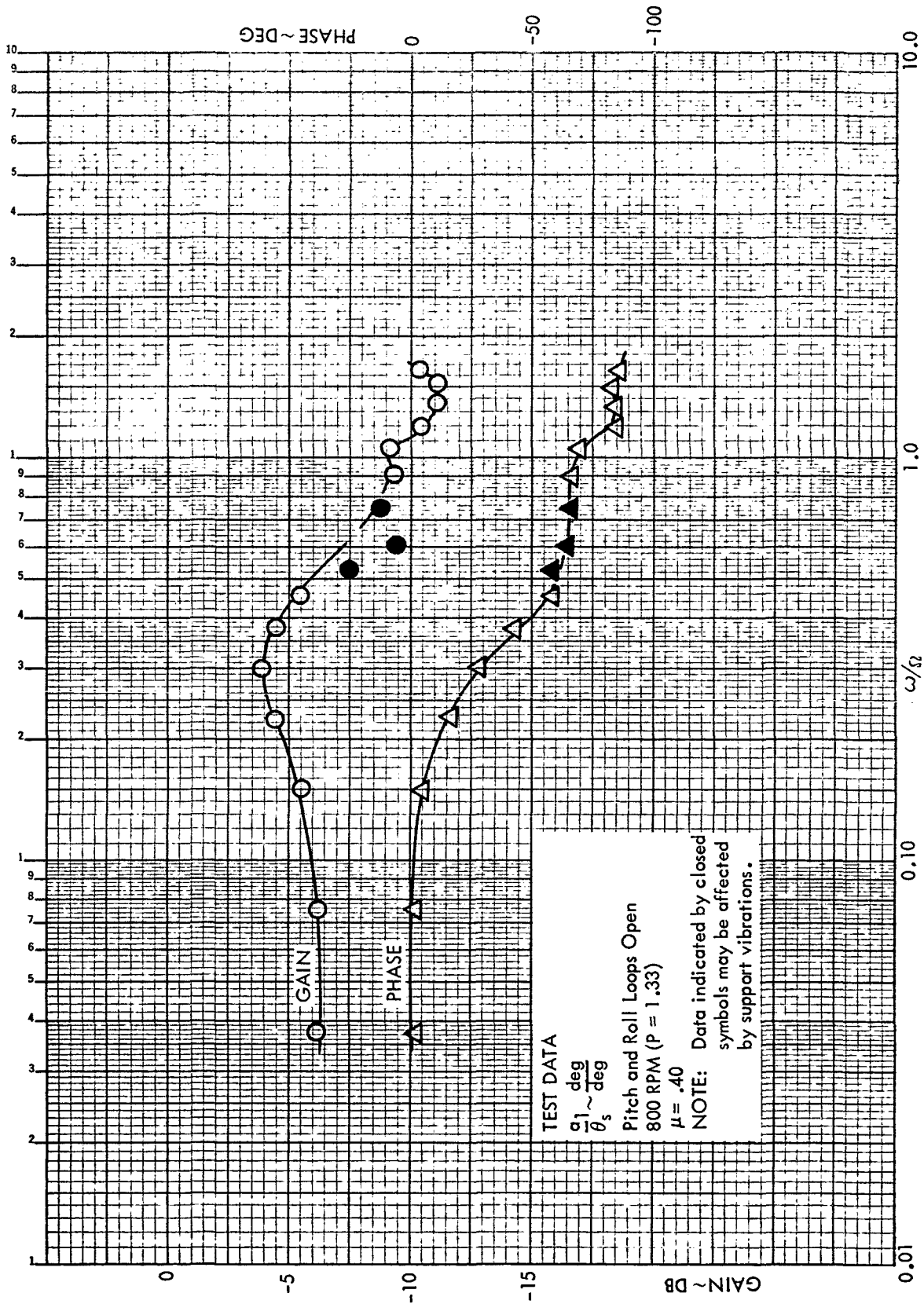


Figure C11. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)

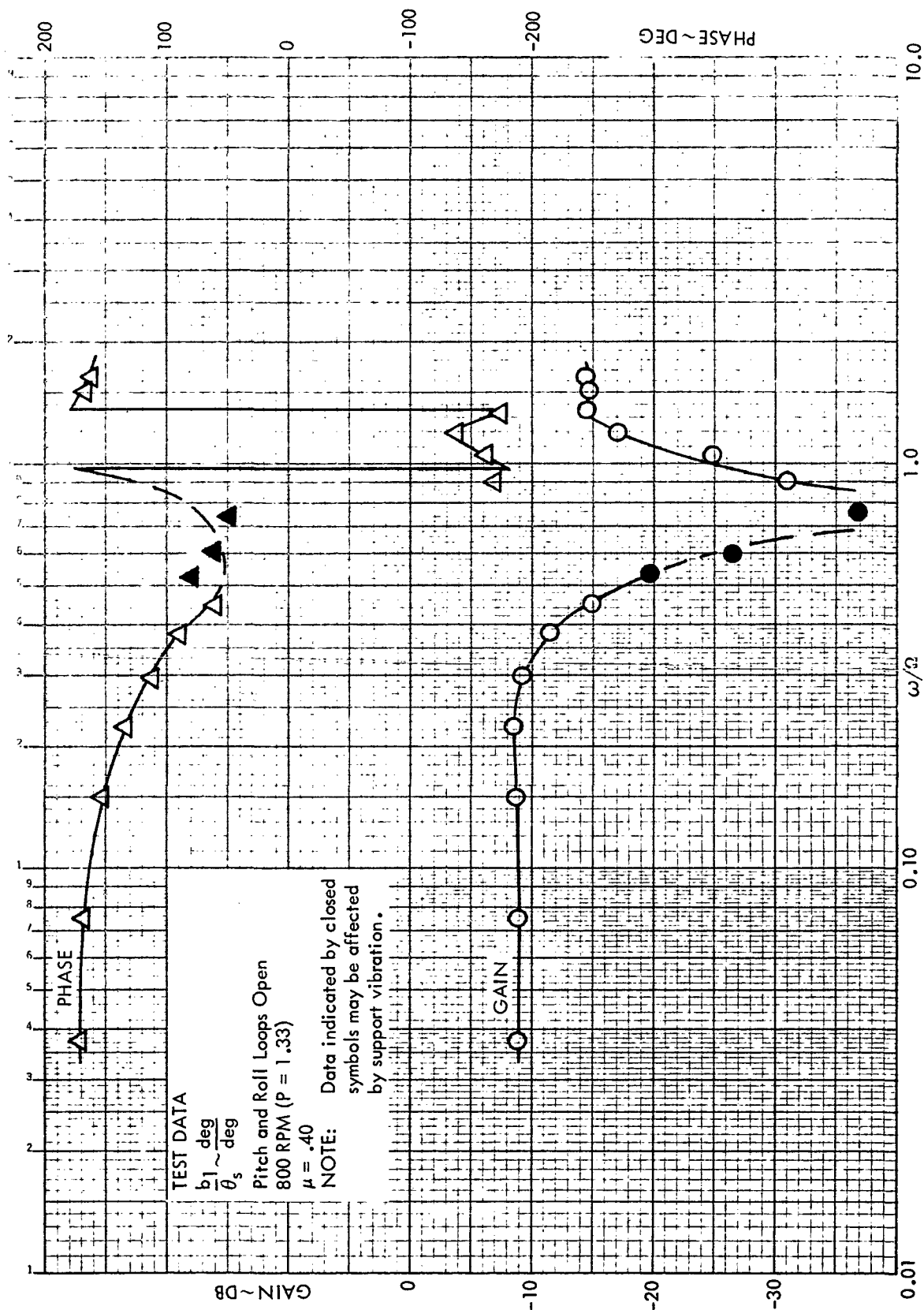


Figure C12. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)

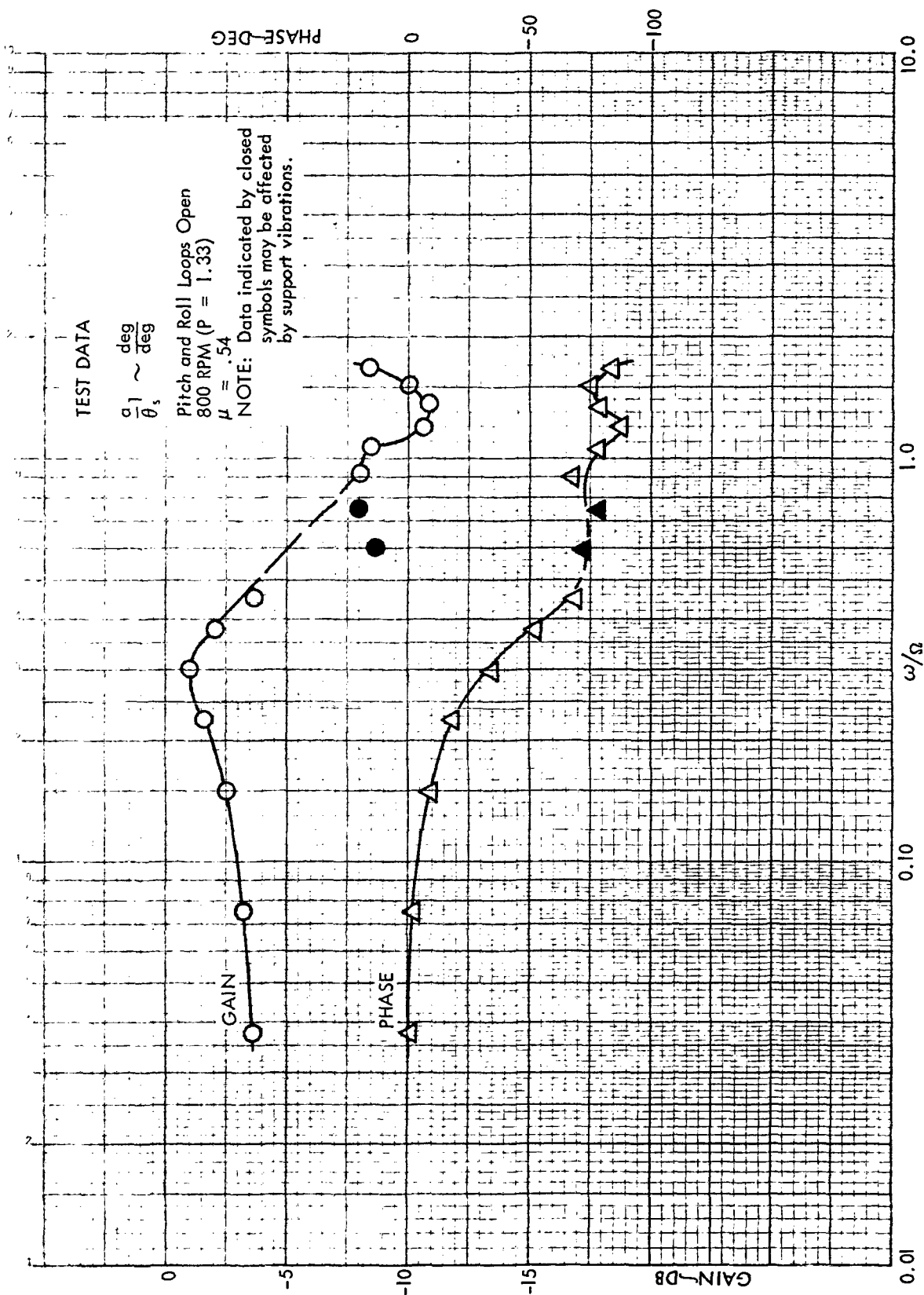


Figure CL3. Rotor Longitudinal Frequency Response to Longitudinal
Cyclic Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)

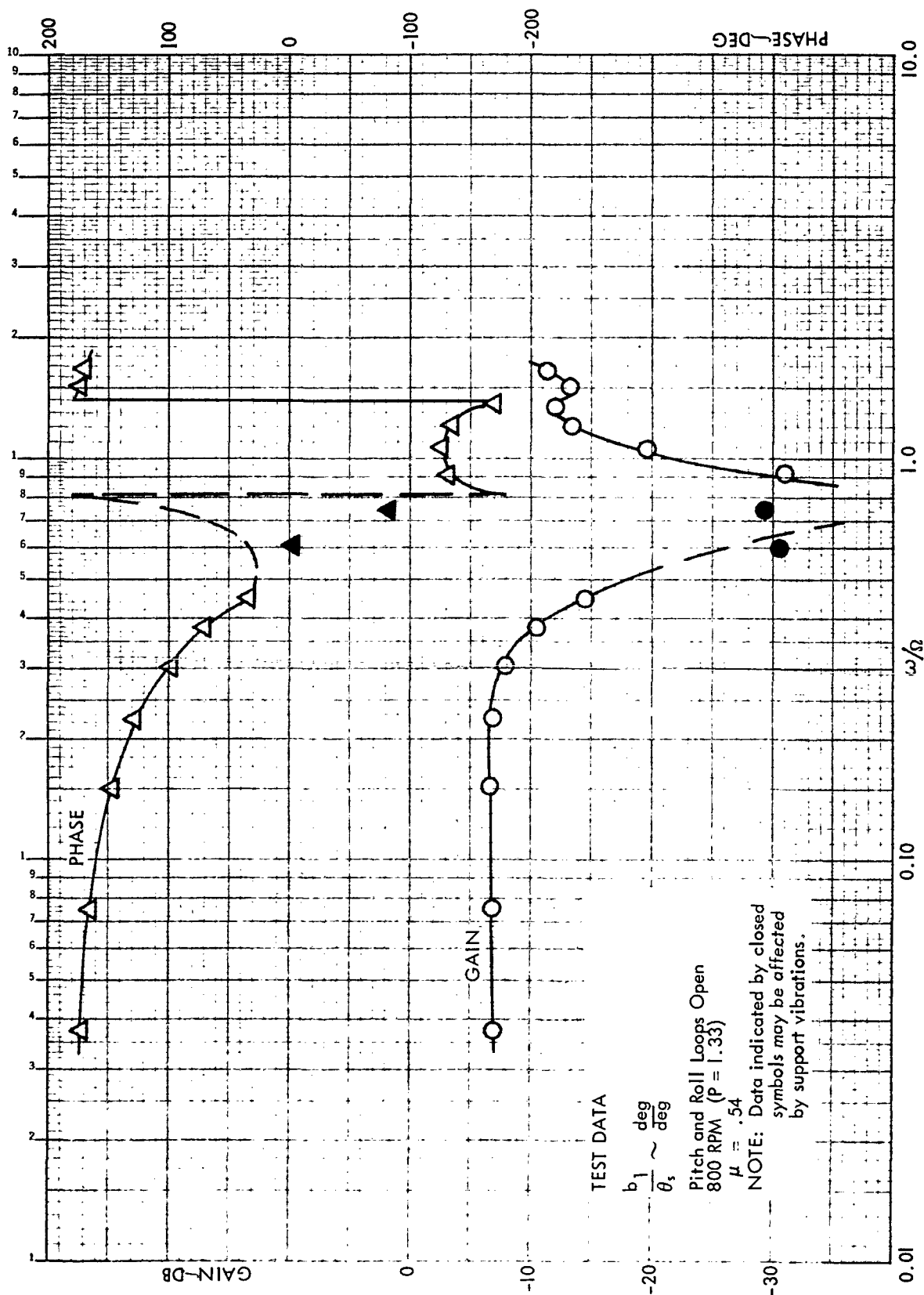


Figure CL4. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)

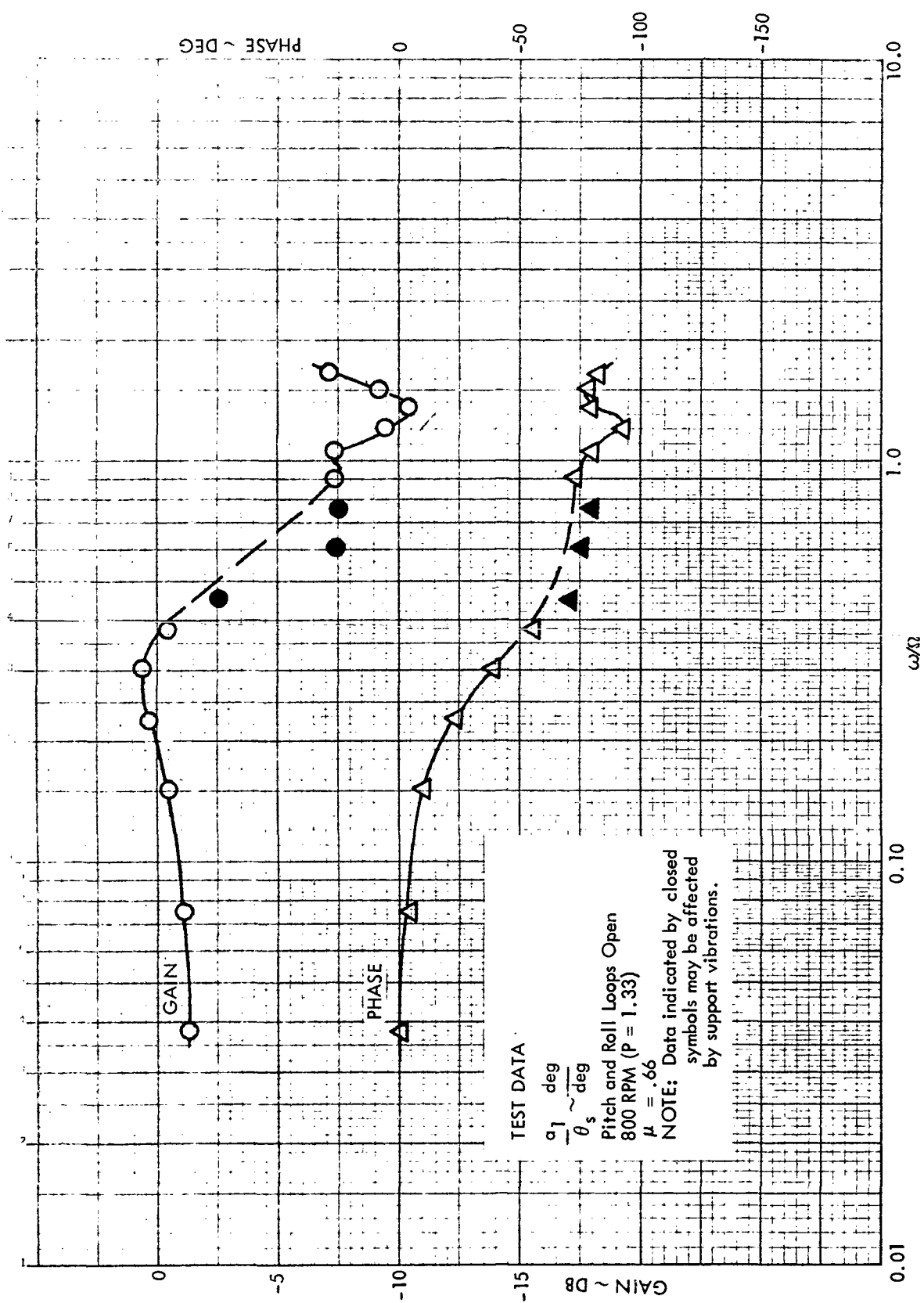


Figure C15. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)

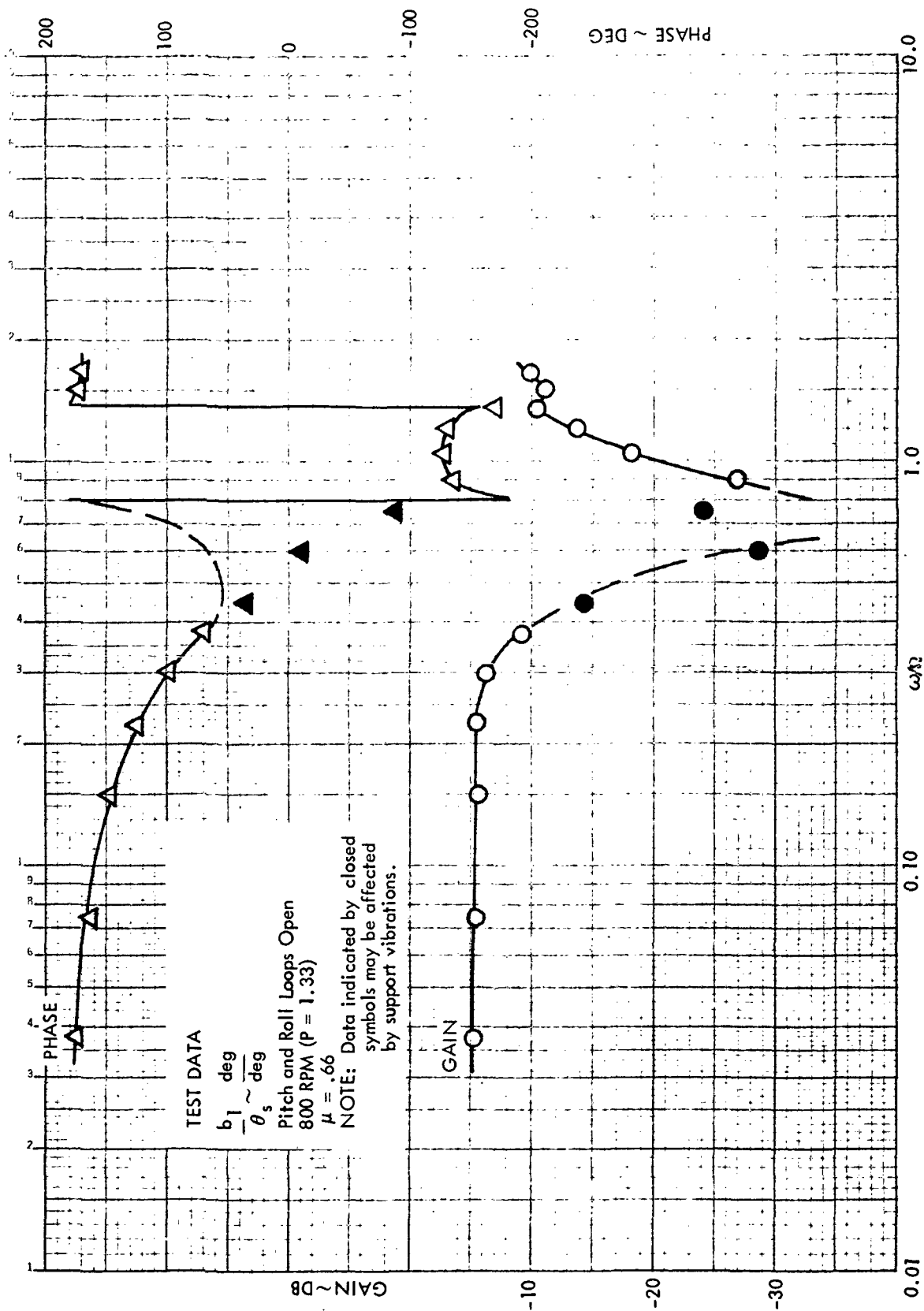


Figure C16. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)

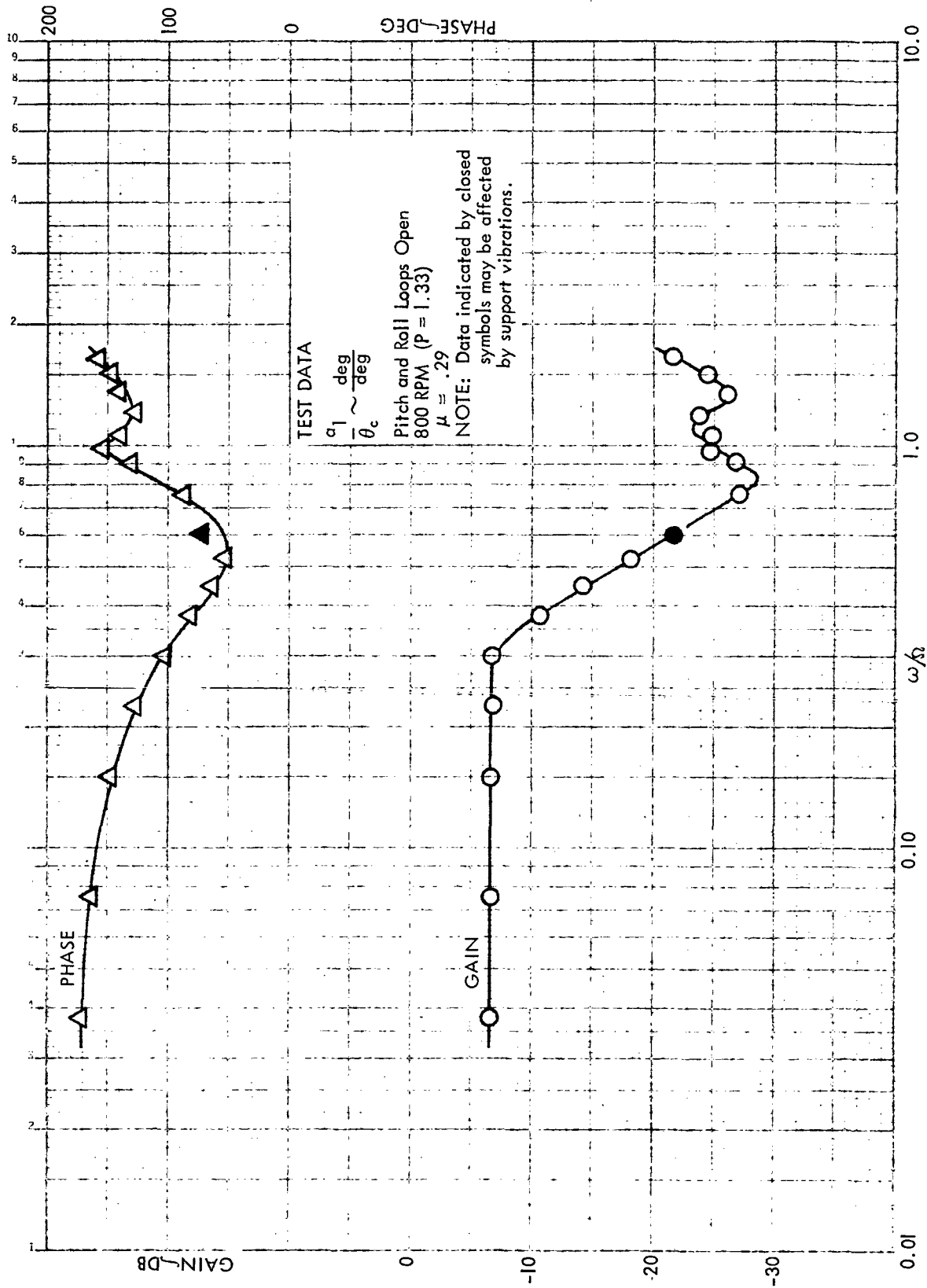


Figure C17. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)

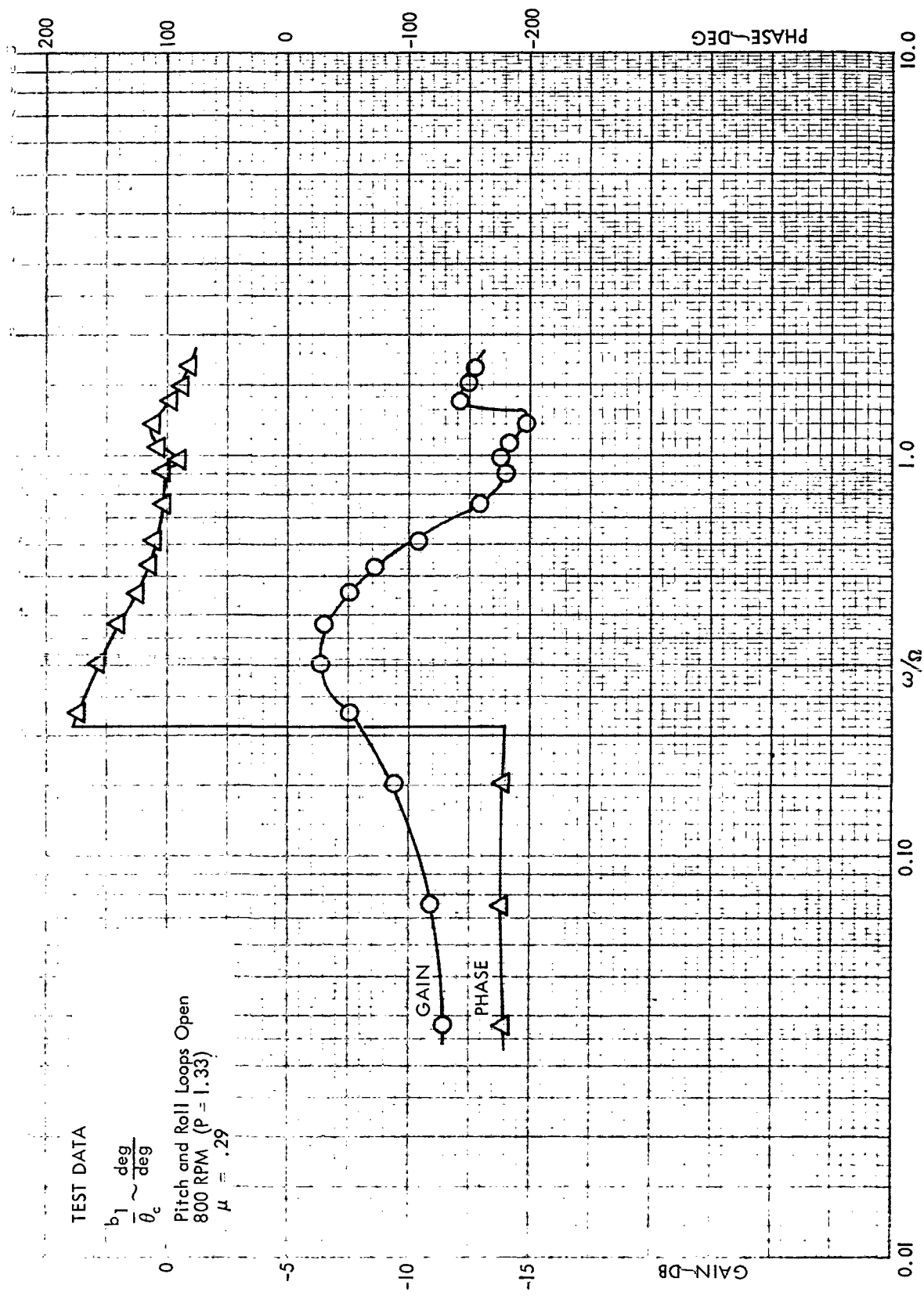


Figure C18. Rotor Lateral Frequency Response to Lateral
 Cyclic Pitch, $\mu = .29$, 800 rpm ($P = 1.33$)

10.0

1.0

 ω/Ω

0.01

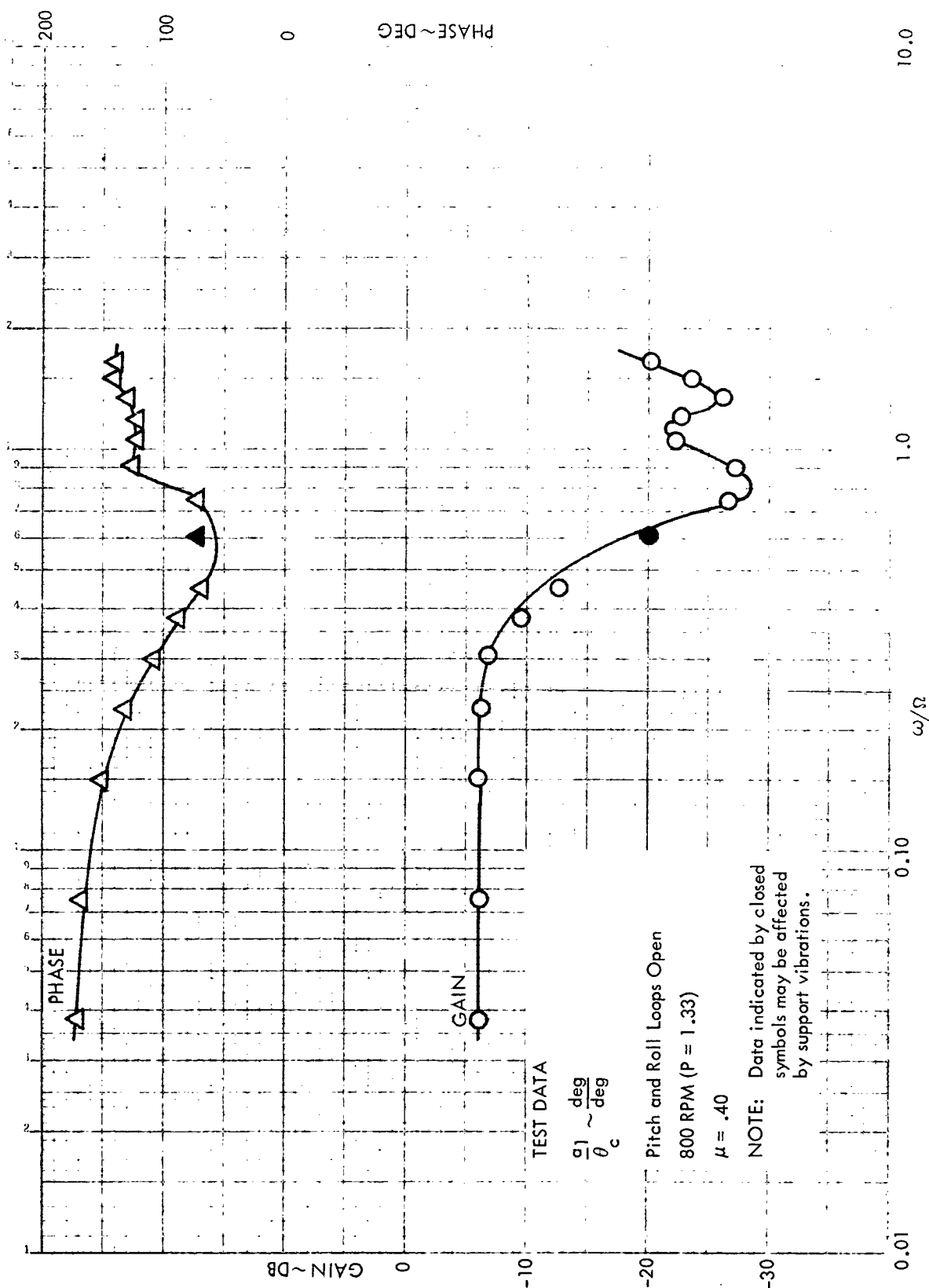


Figure C19. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)

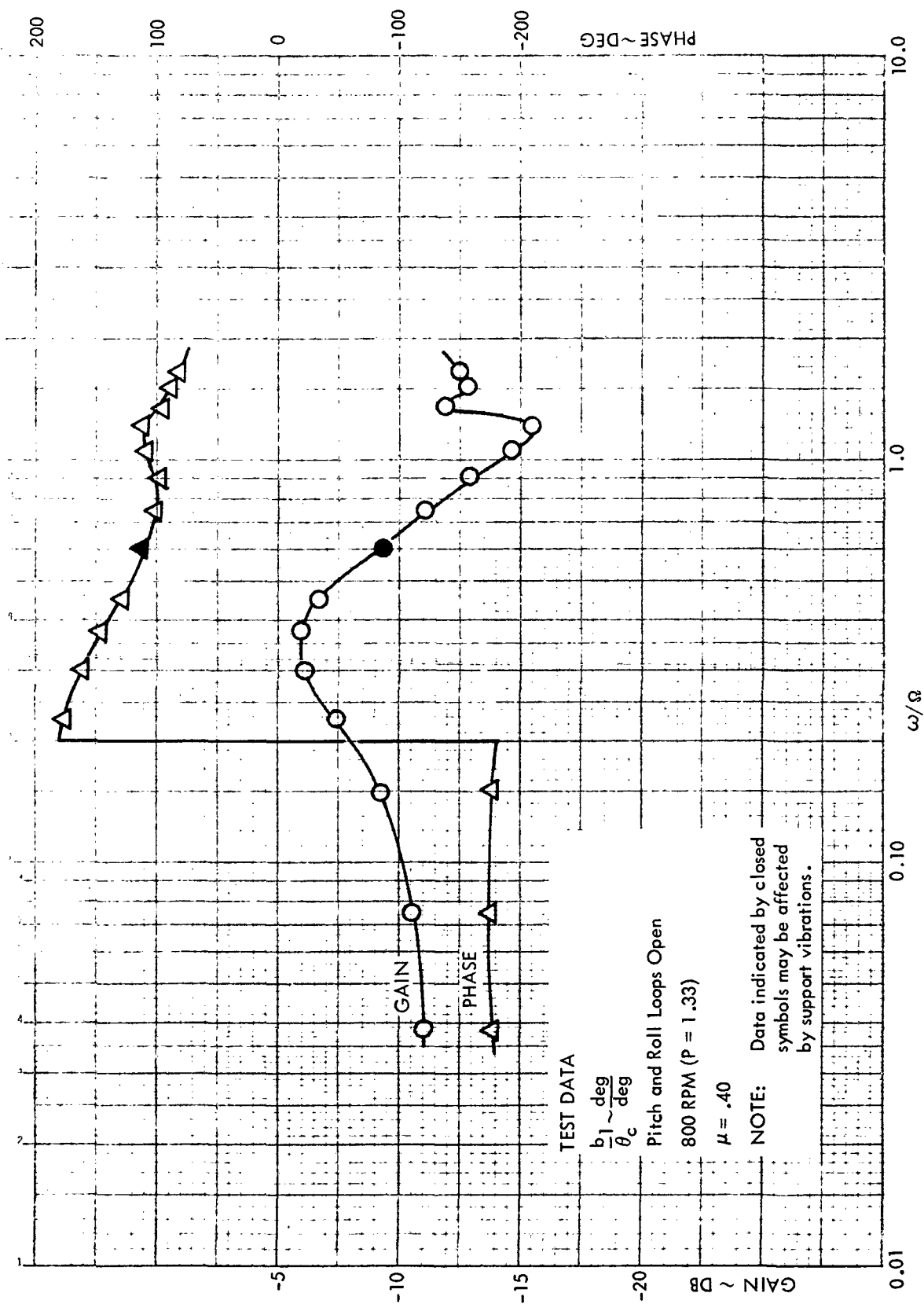


Figure C20. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .40$, 800 rpm ($P = 1.33$)

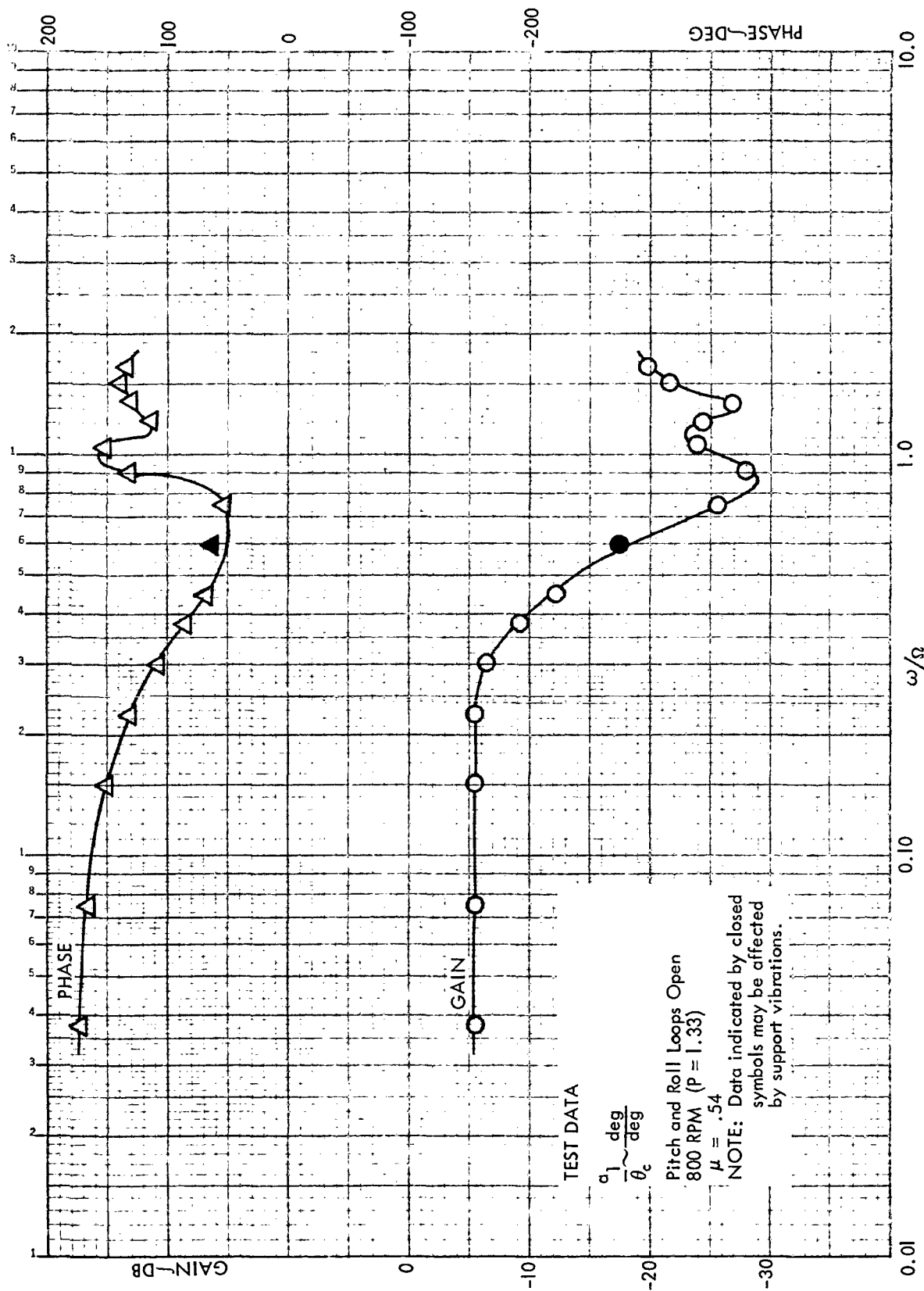


Figure C21. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)

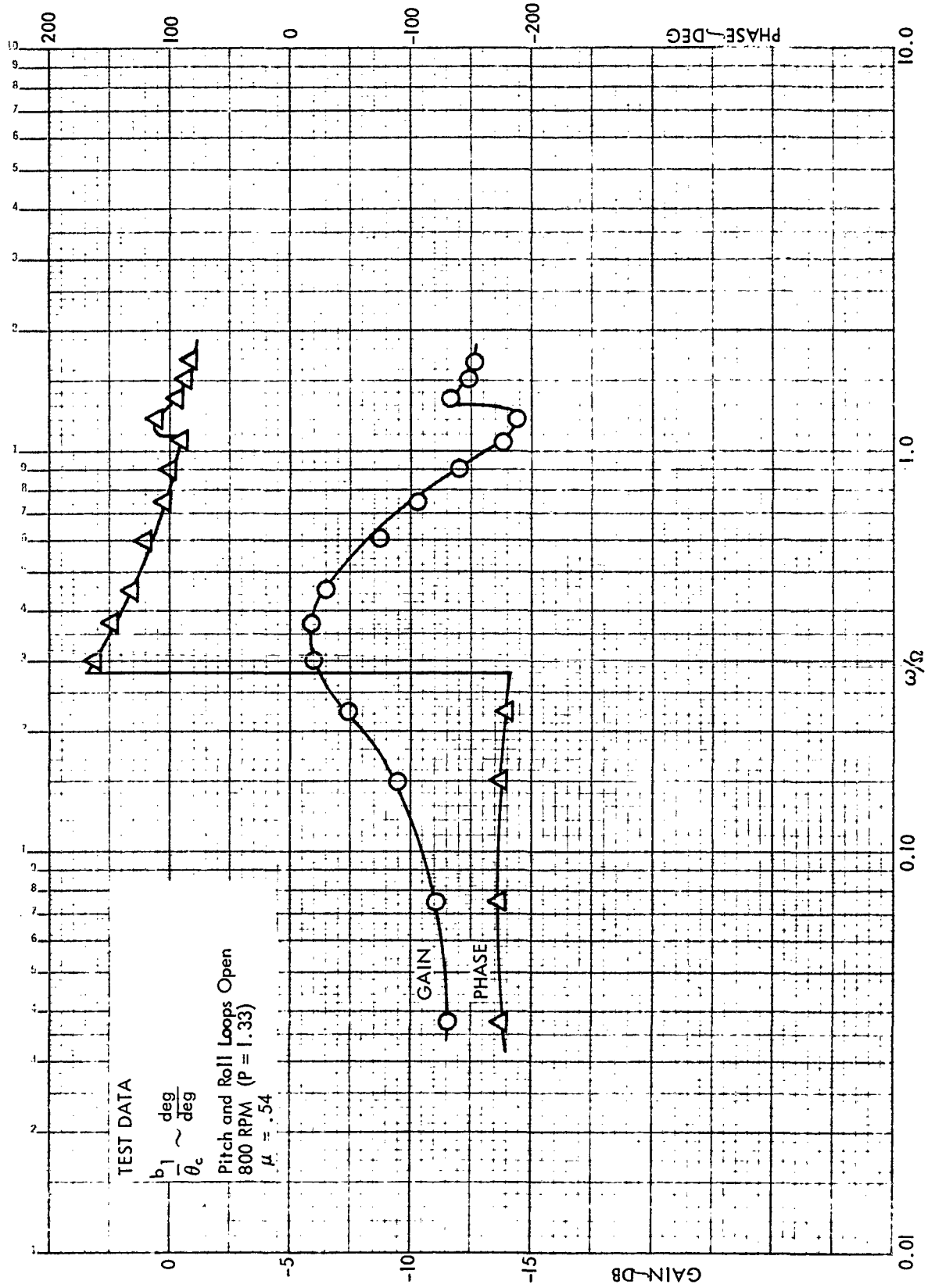


Figure C22. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .54$, 800 rpm ($P = 1.33$)

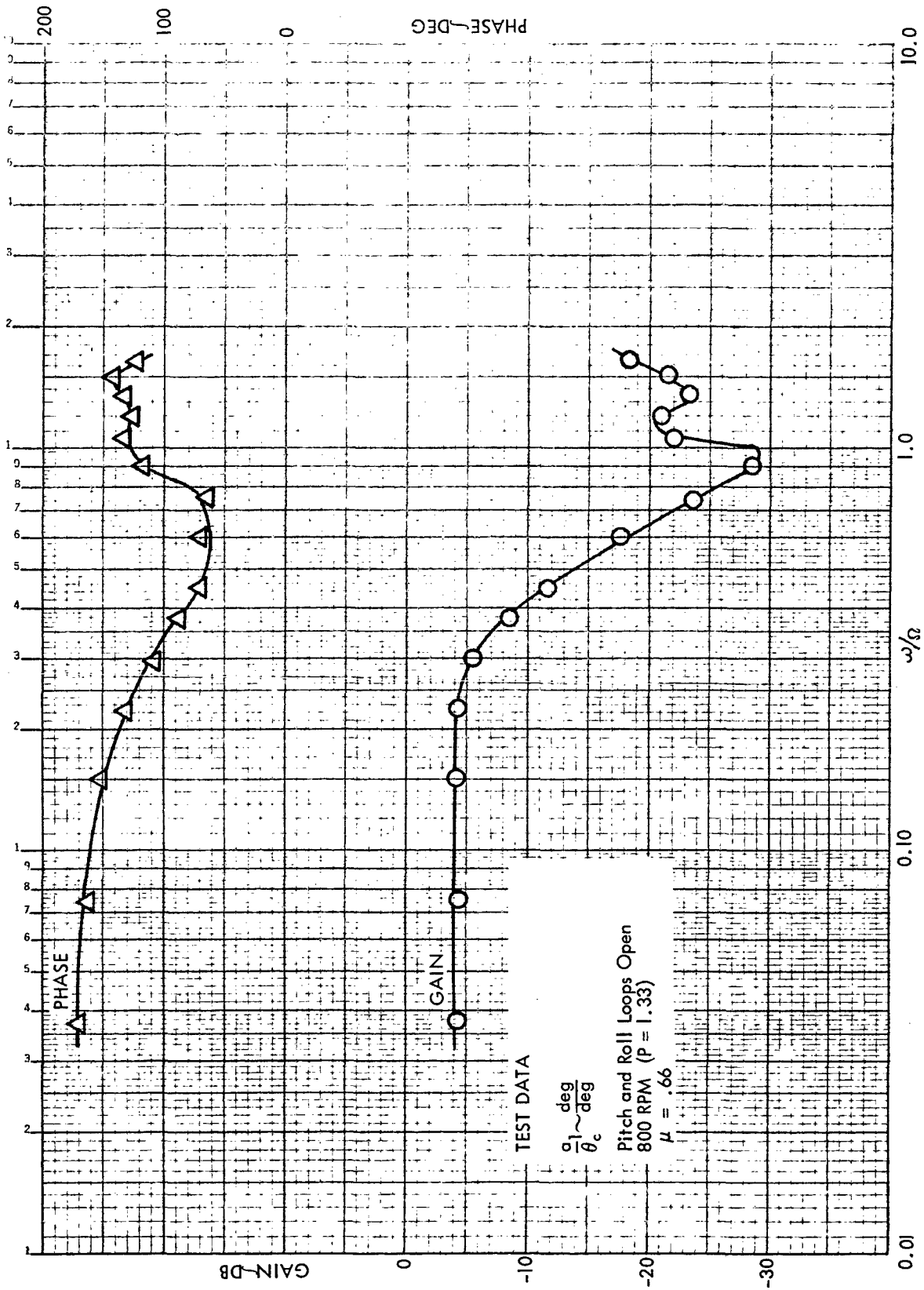


Figure C23. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)

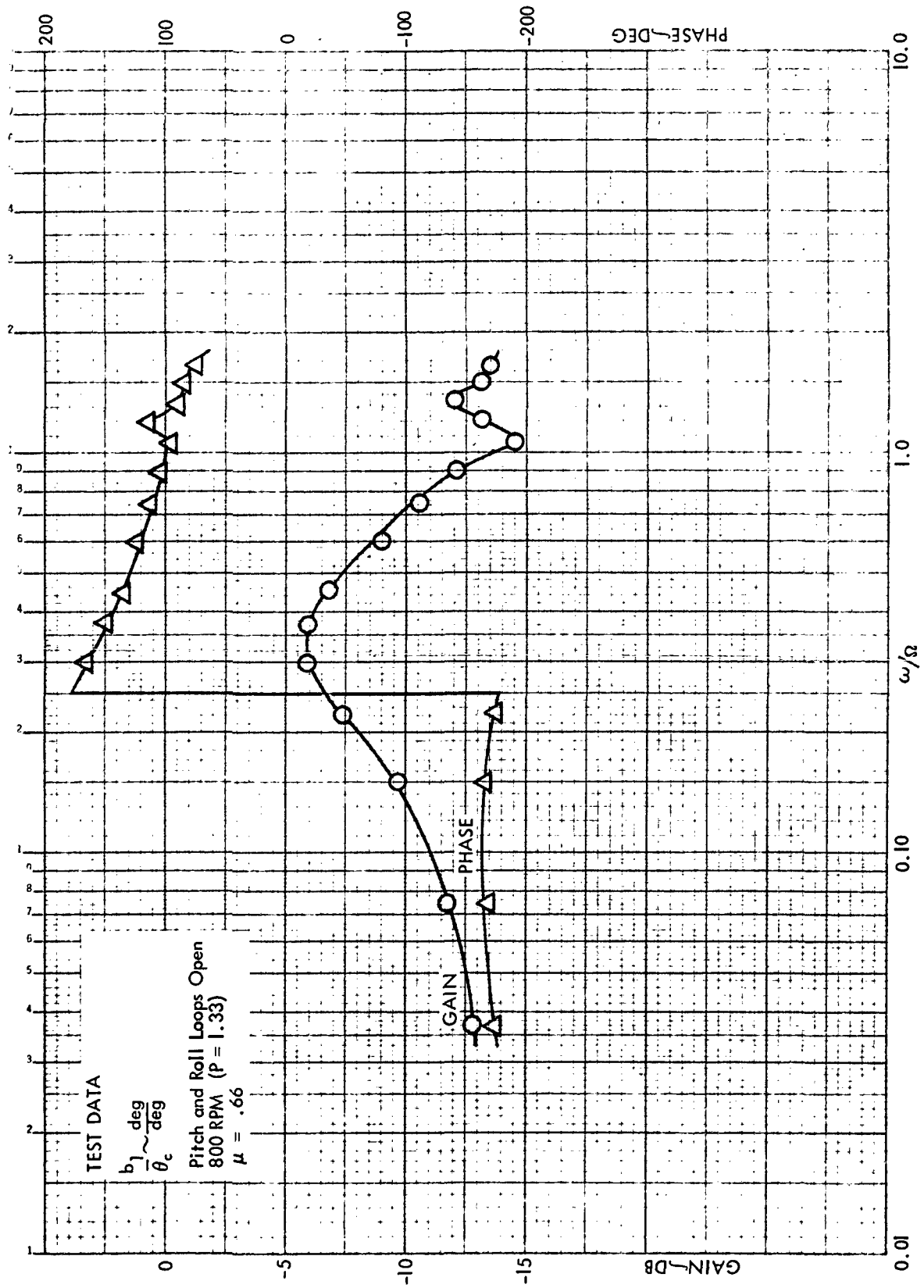


Figure C24. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .66$, 800 rpm ($P = 1.33$)

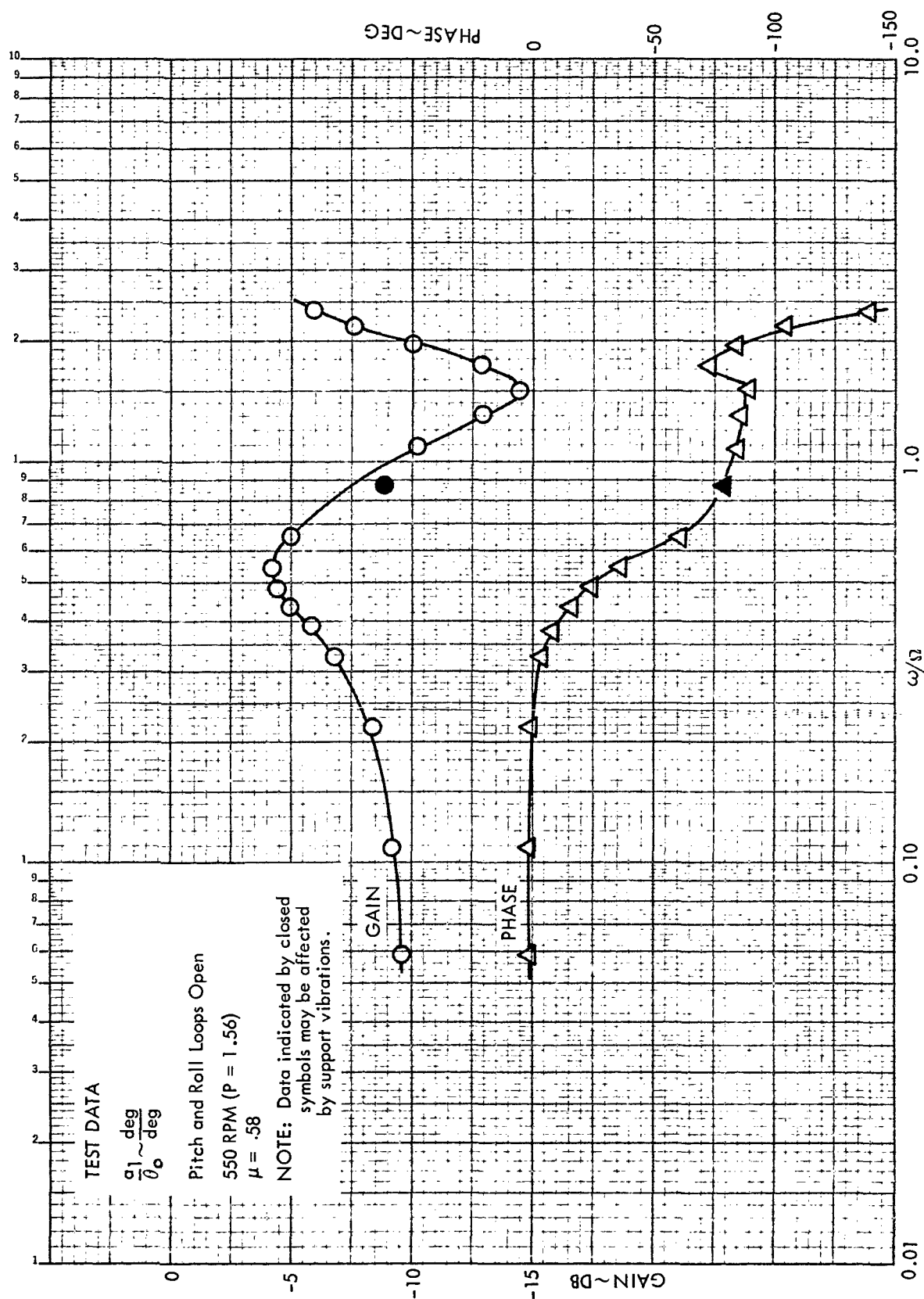


Figure C25. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)

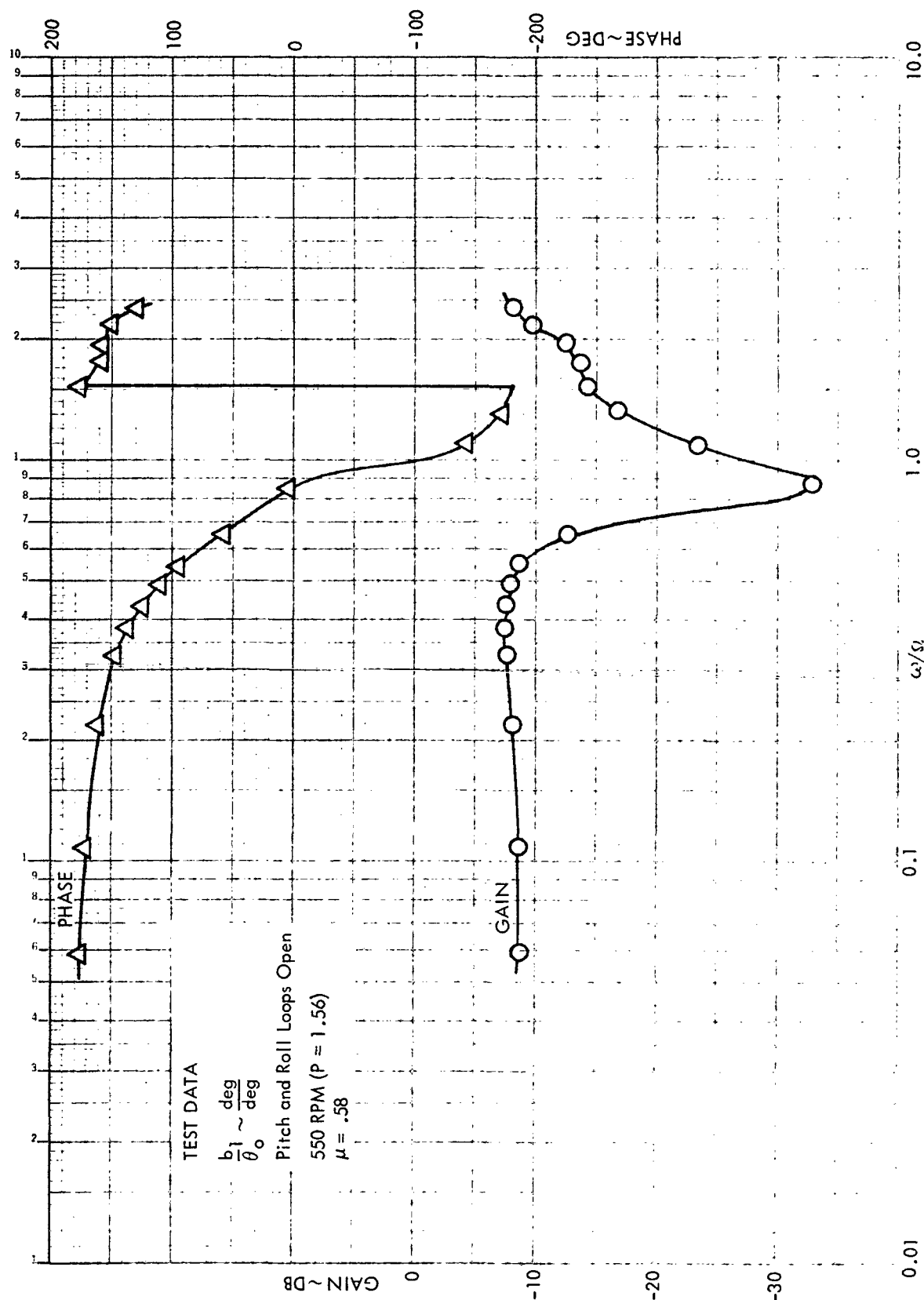


Figure C26. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)

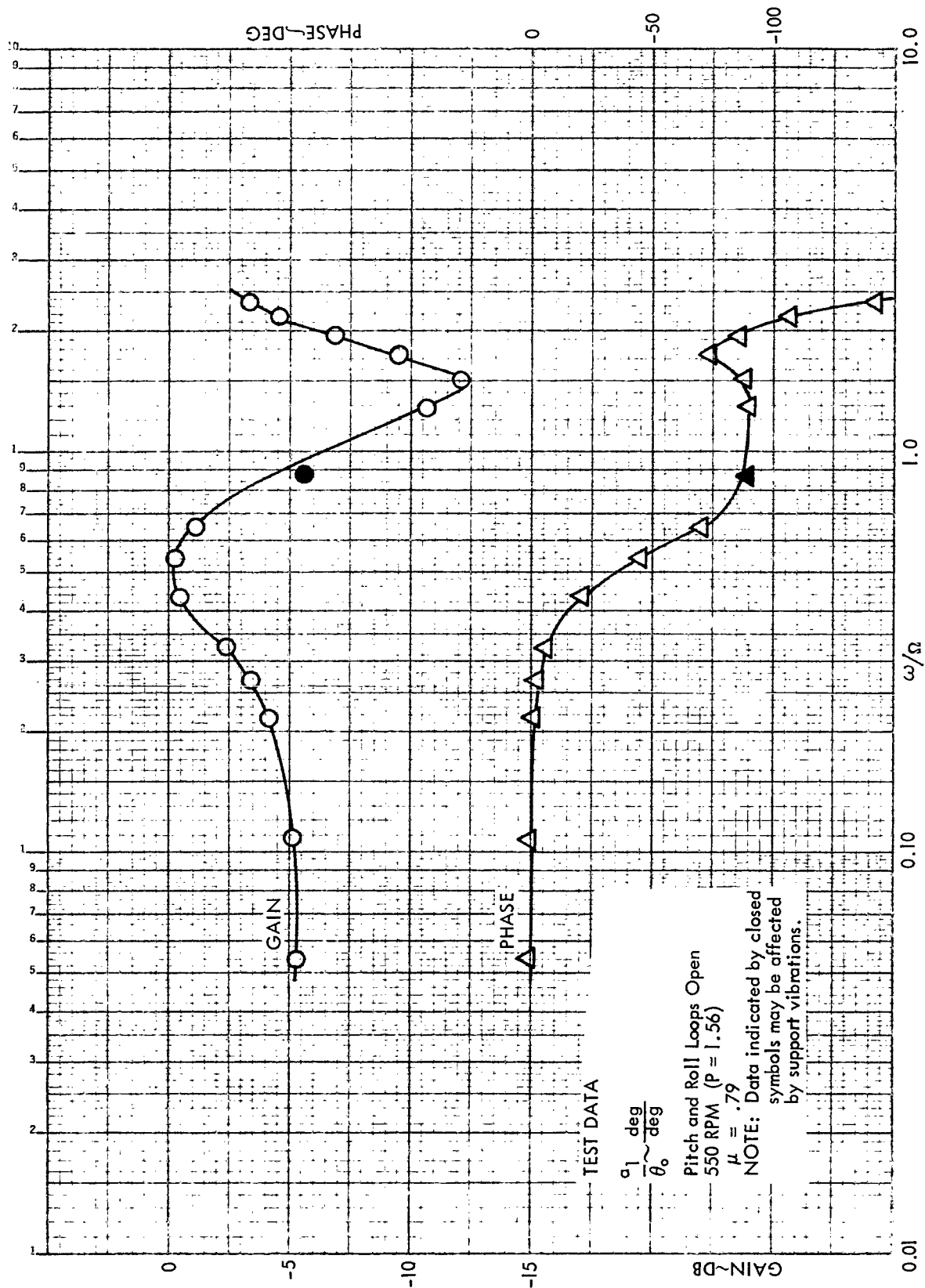


Figure C27. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)

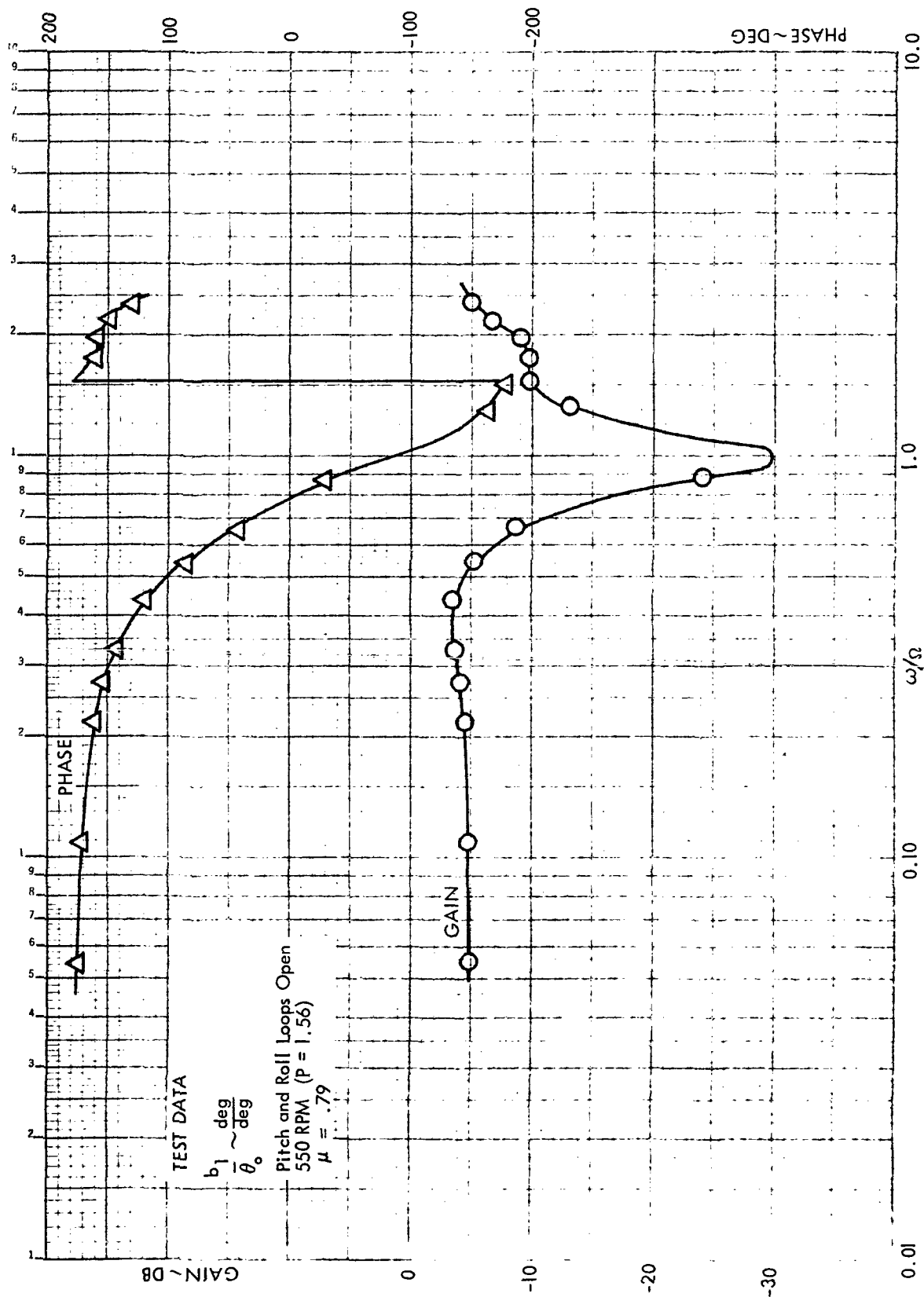


Figure C28. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)

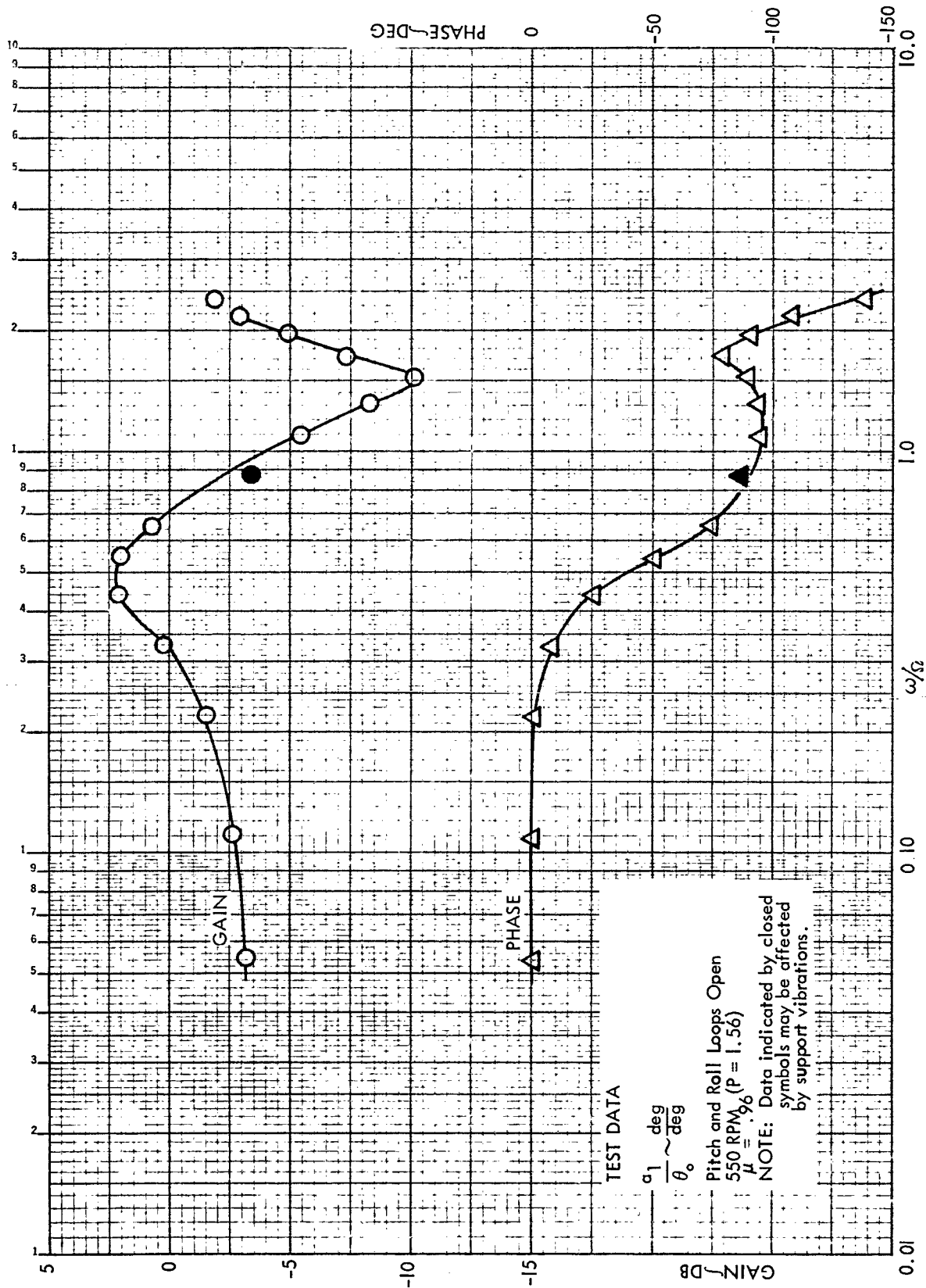


Figure C29. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)

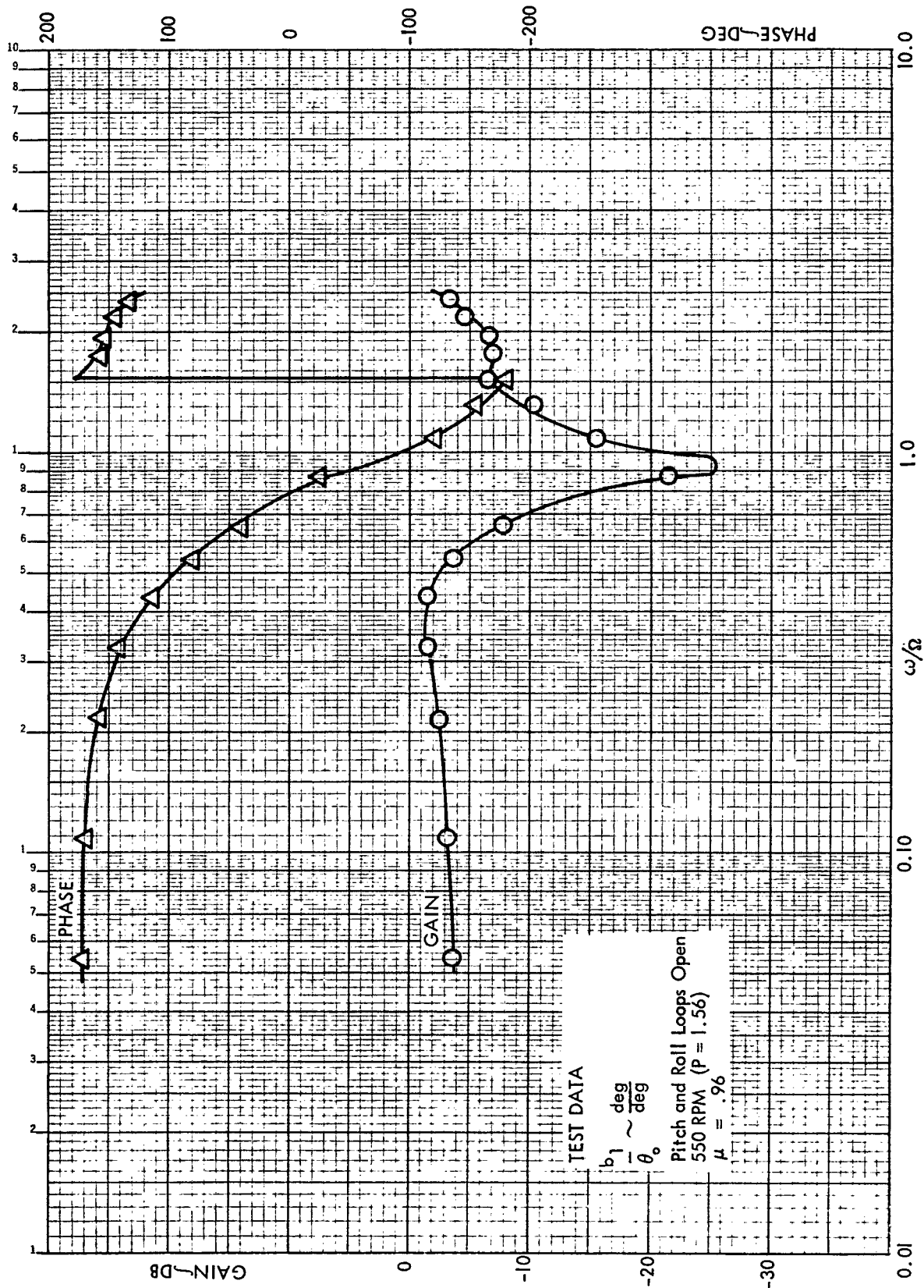


Figure C30. Rotor Lateral Frequency Response to Collective Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)

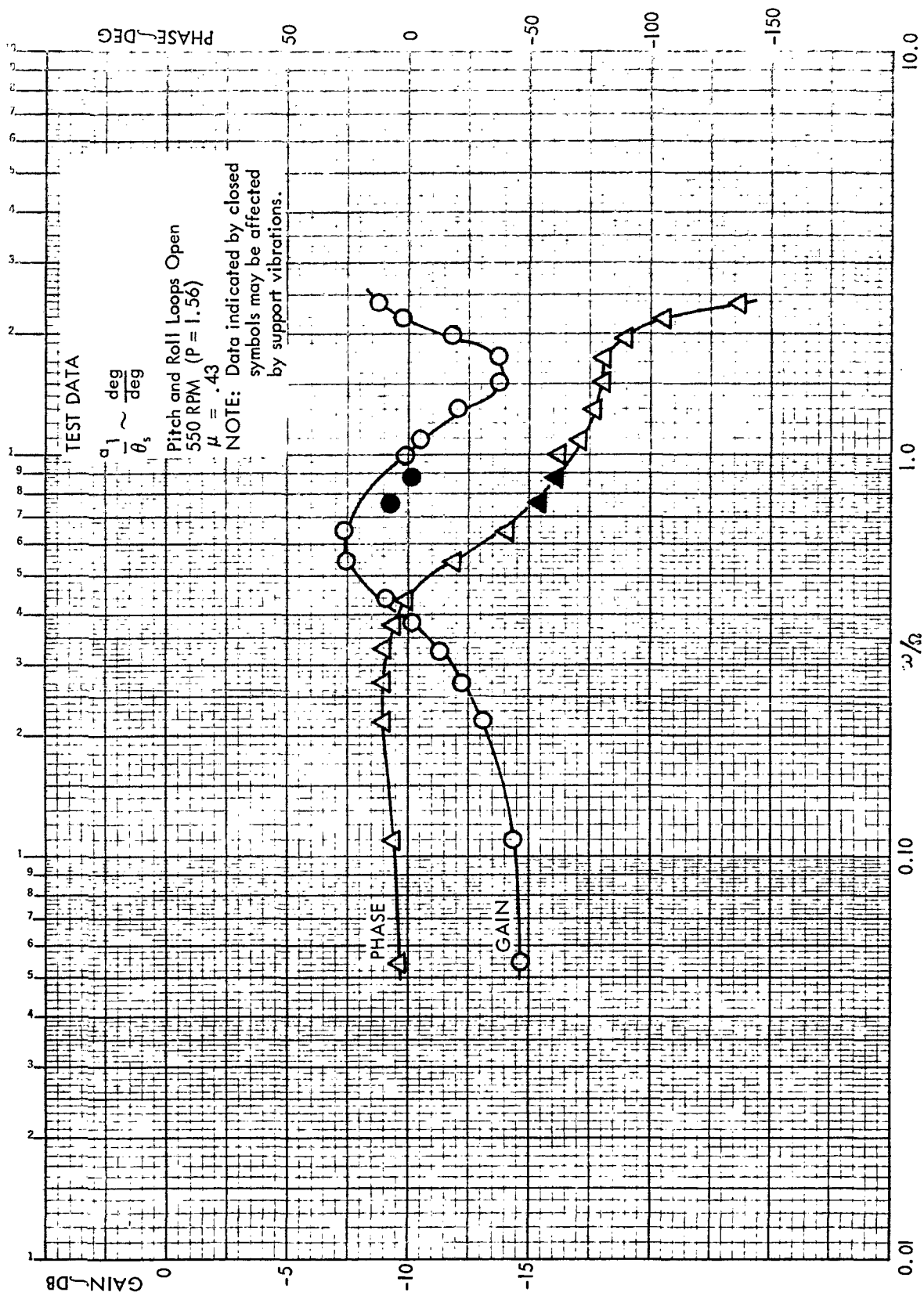


Figure C31. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)

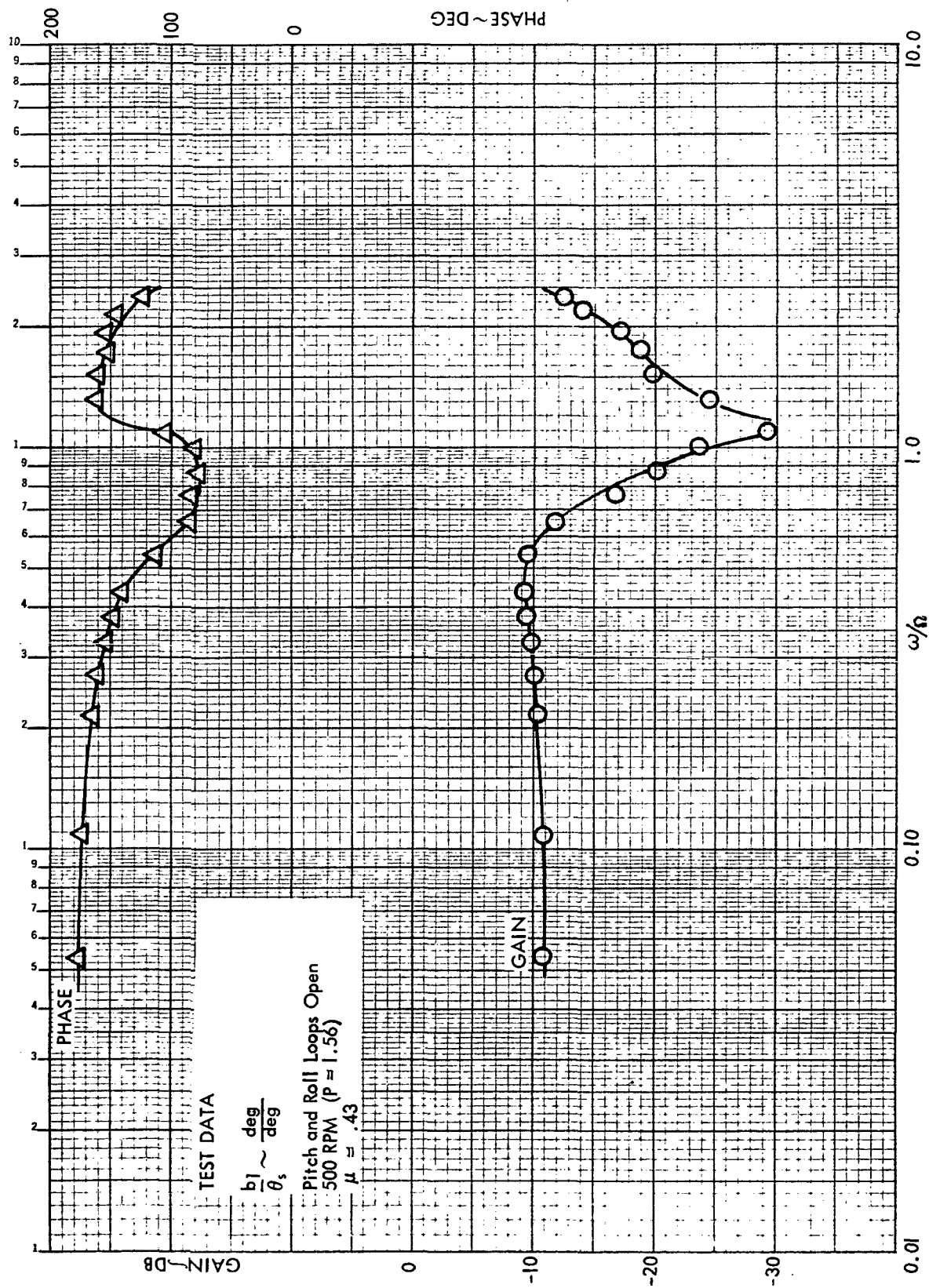


Figure C32. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)

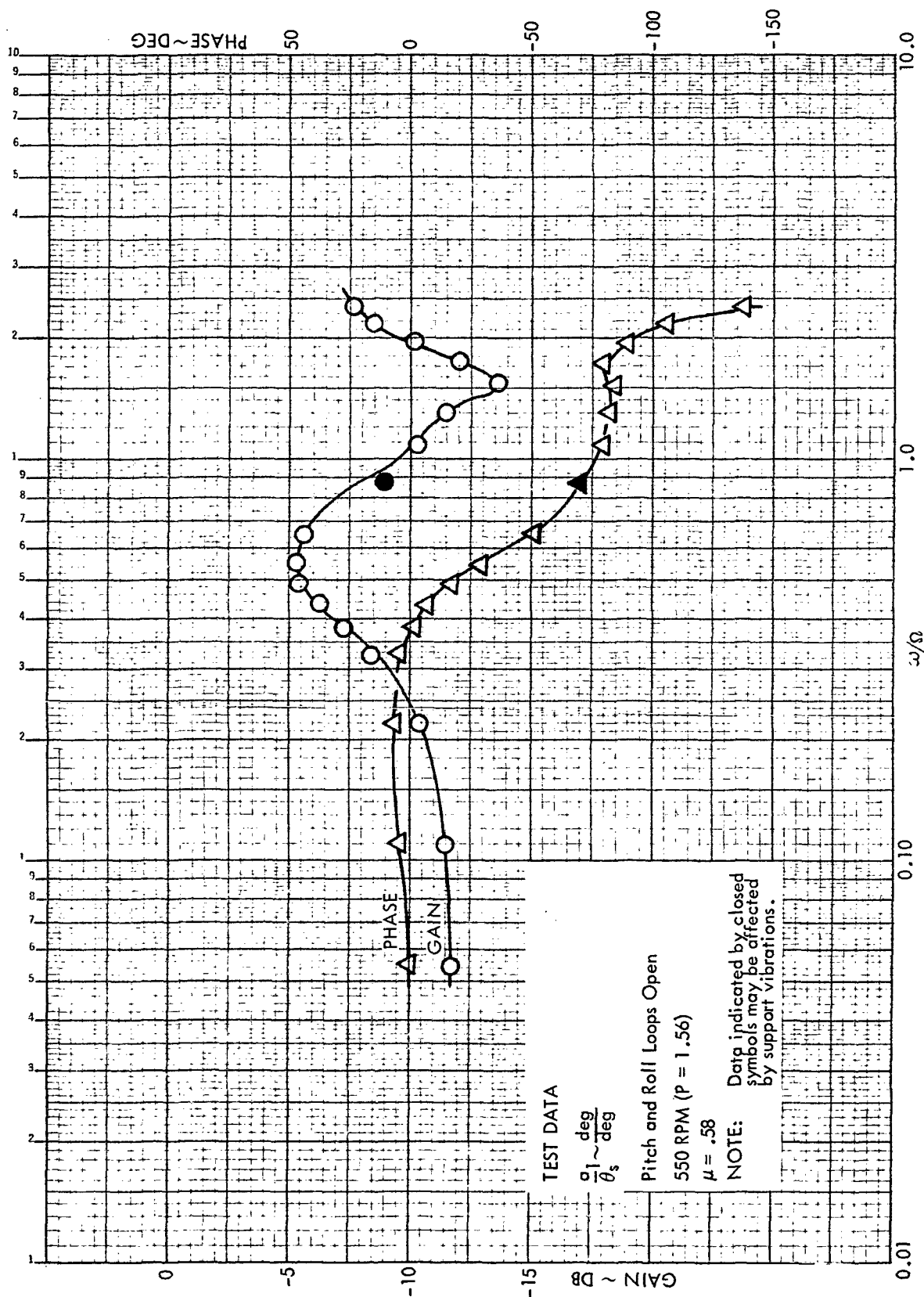


Figure C33. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)

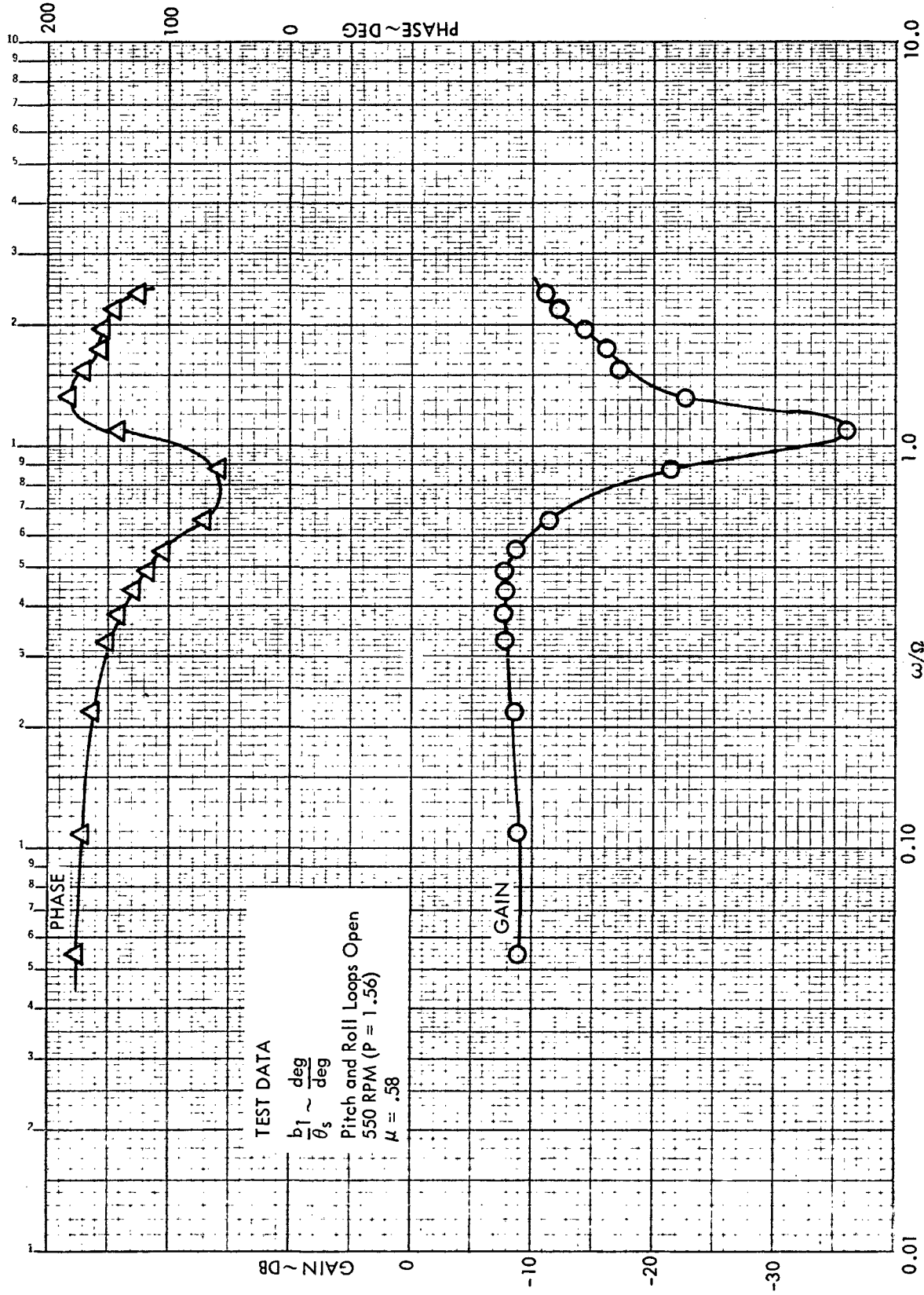


Figure C34. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)

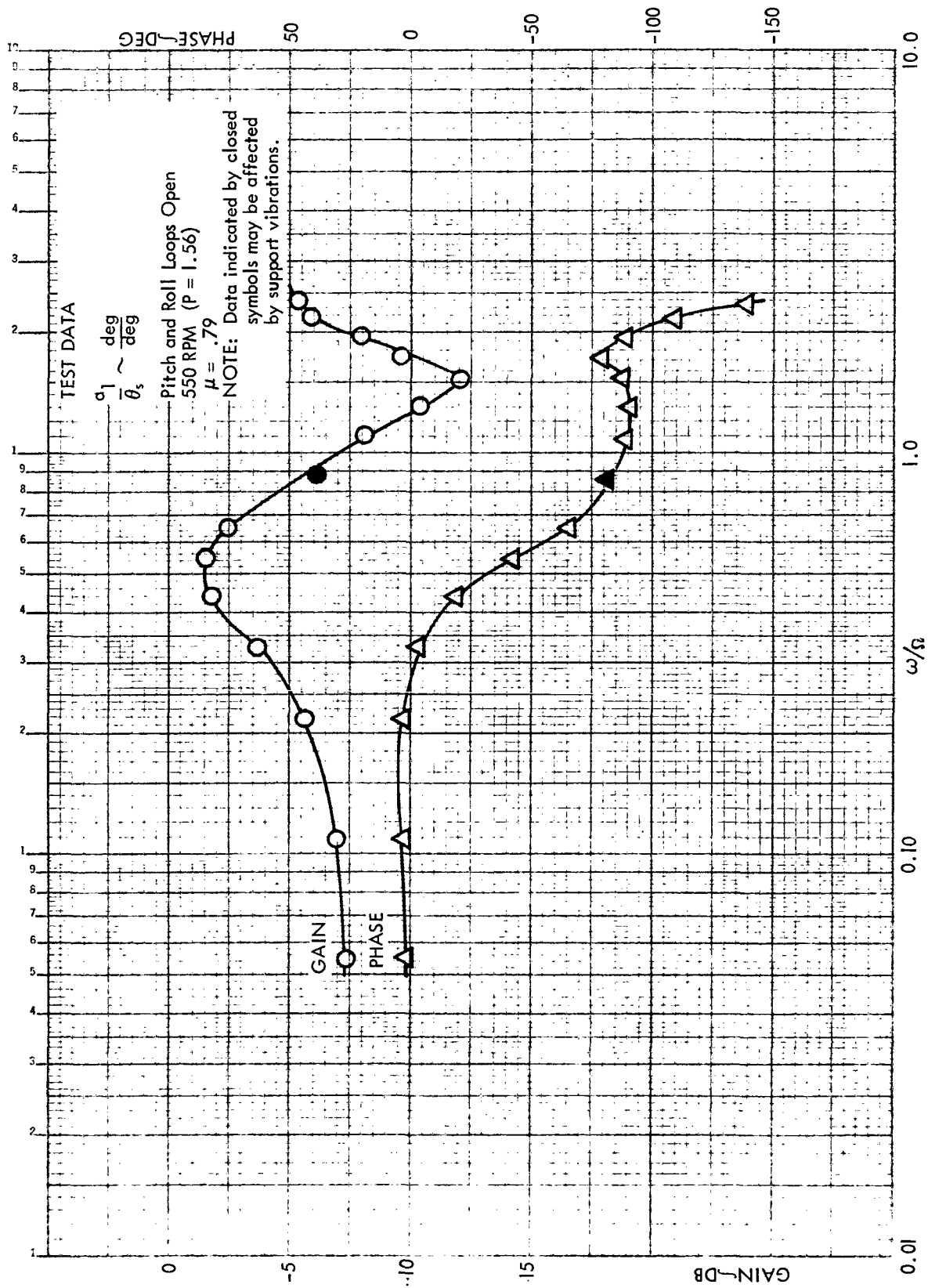


Figure C35. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)

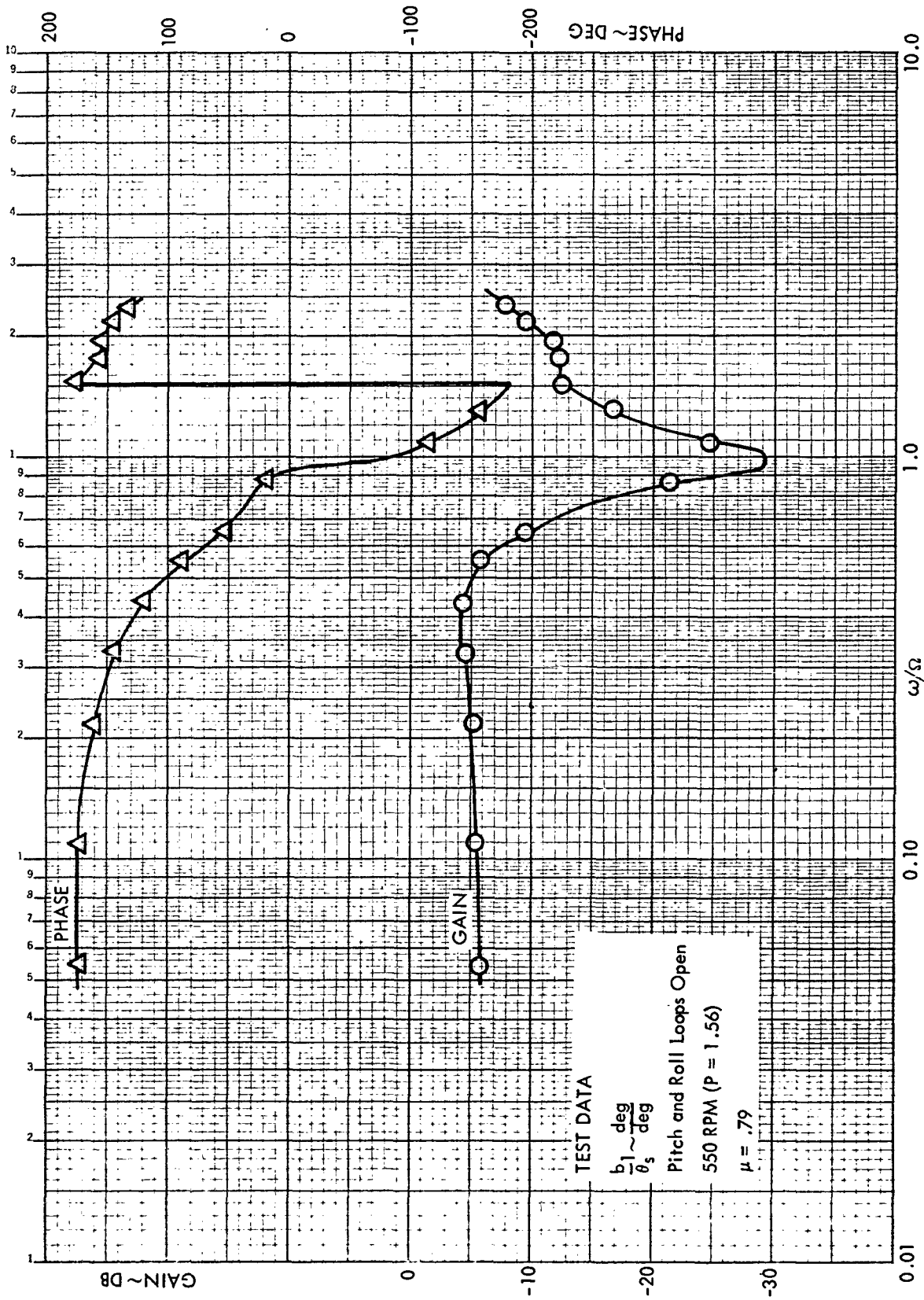


Figure C36. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .79$, 550 rpm ($p = 1.56$)

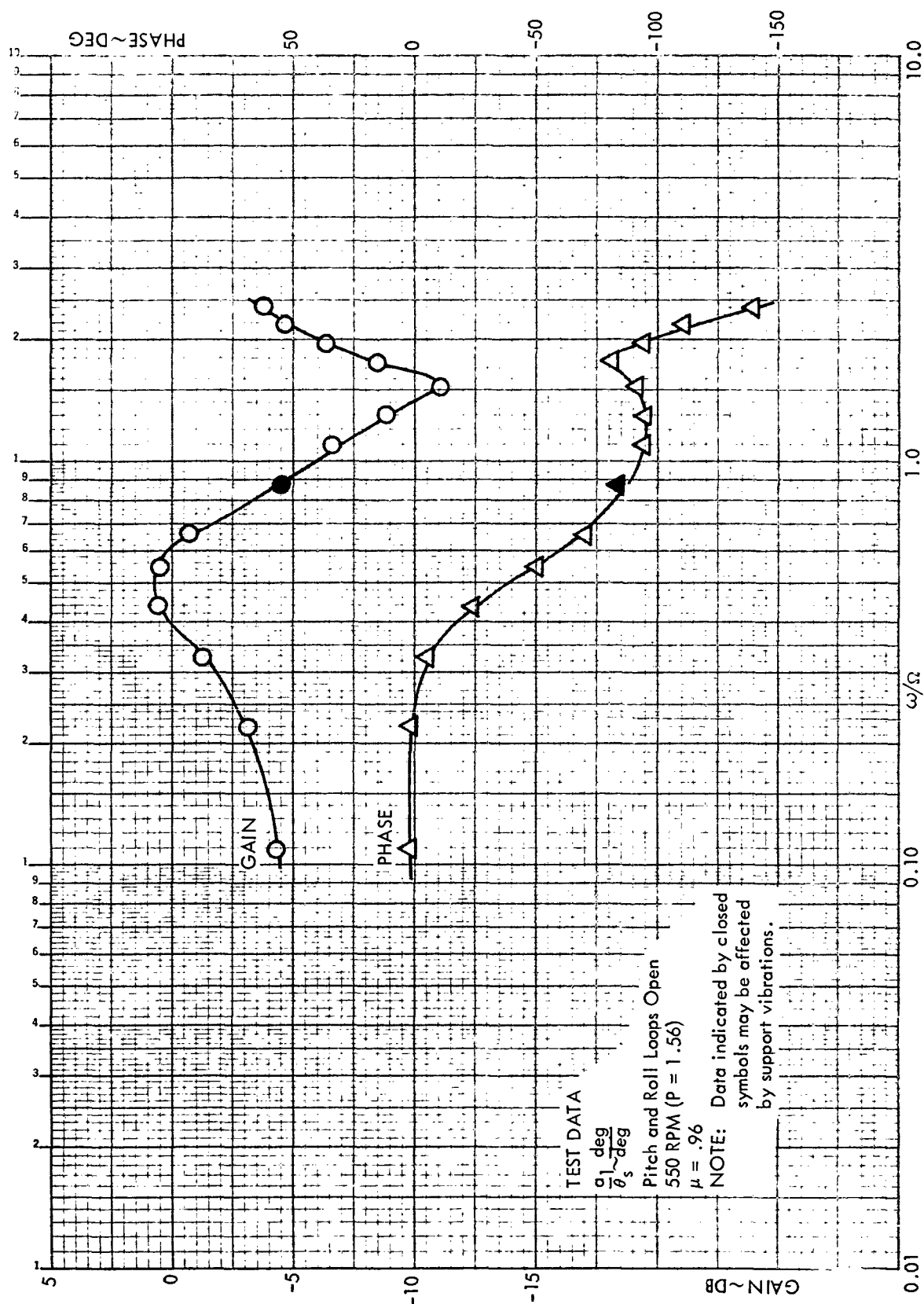


Figure C37. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)

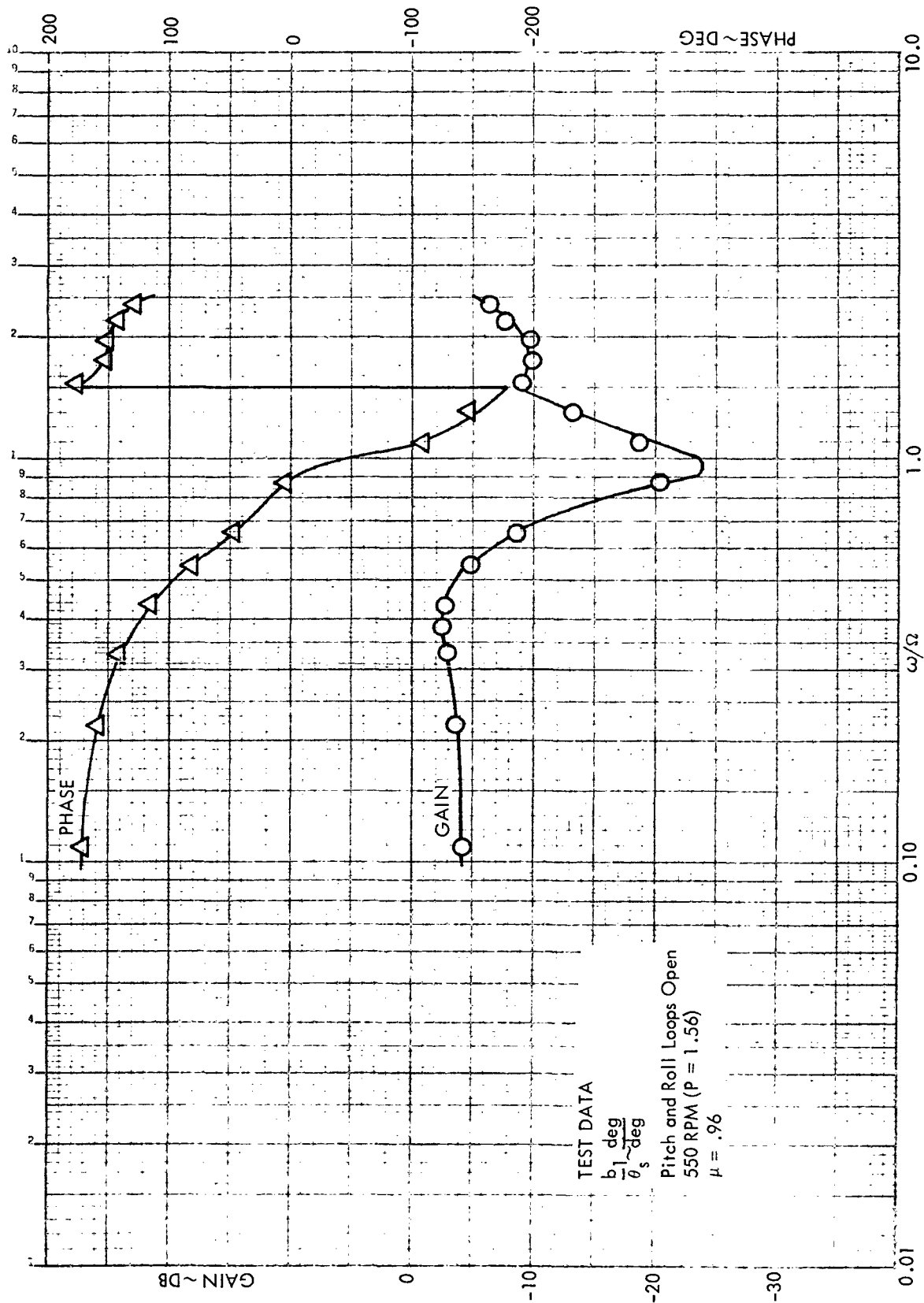


Figure C38. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)

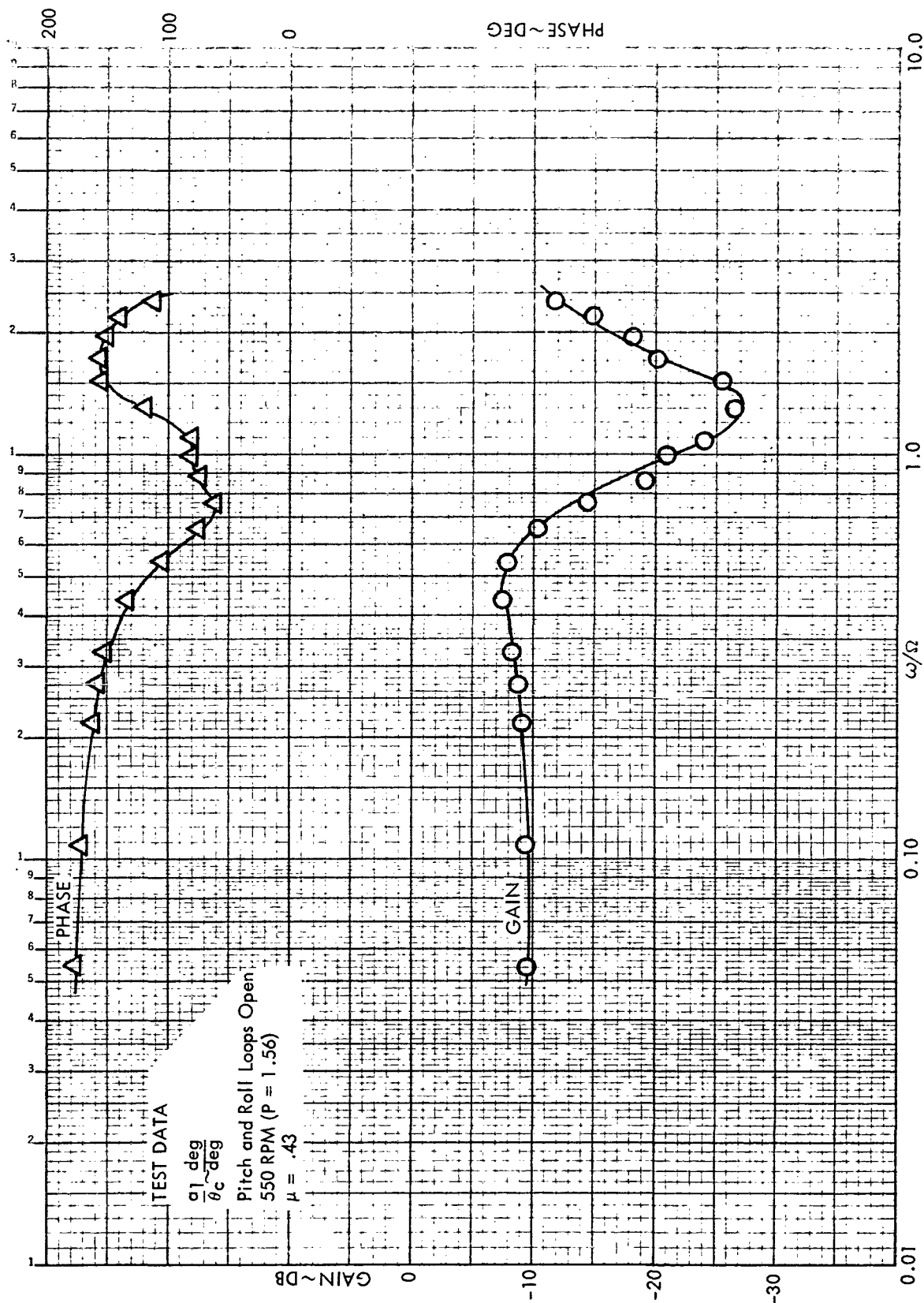


Figure C39. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)

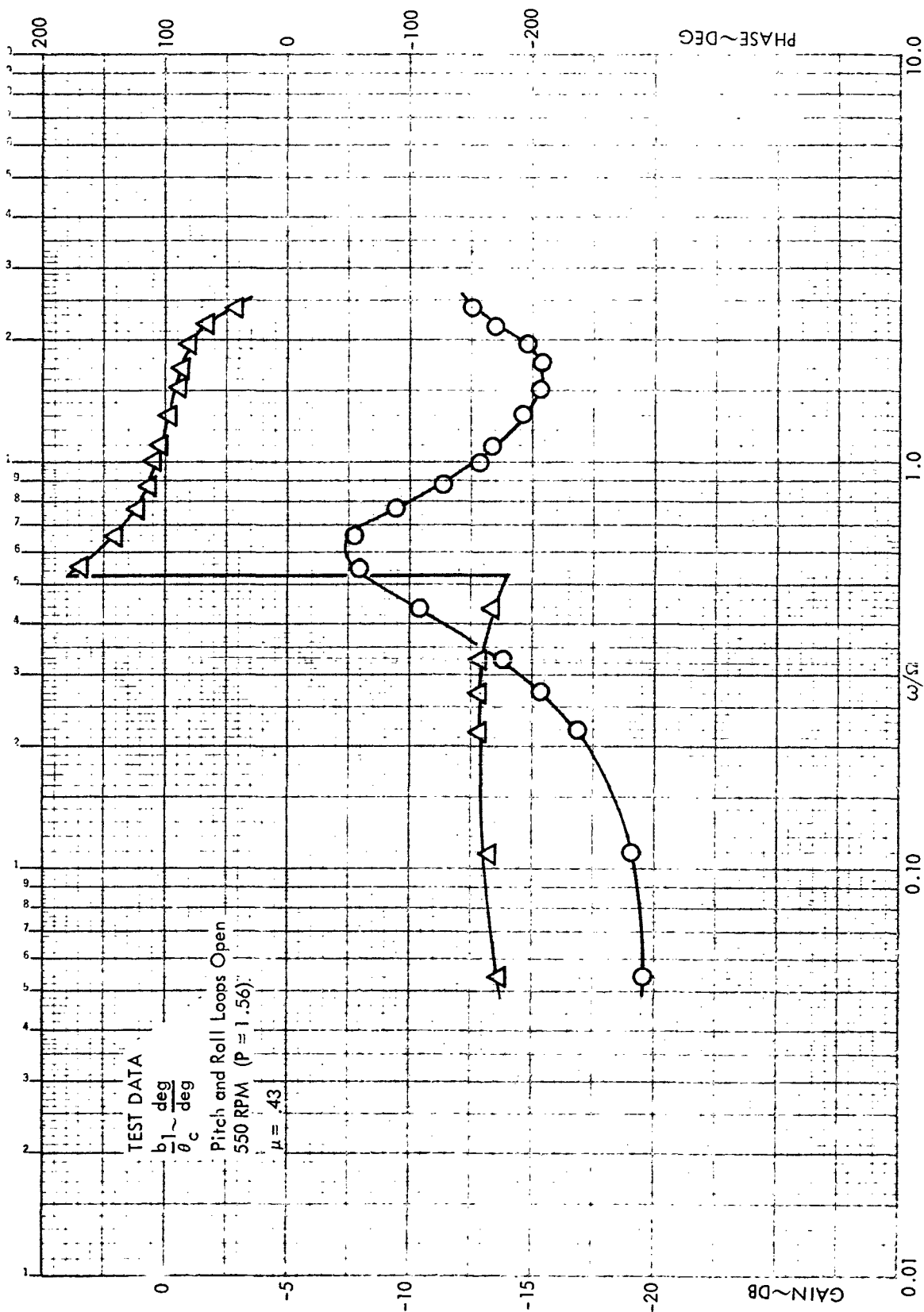


Figure C40. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .43$, 550 rpm ($P = 1.56$)

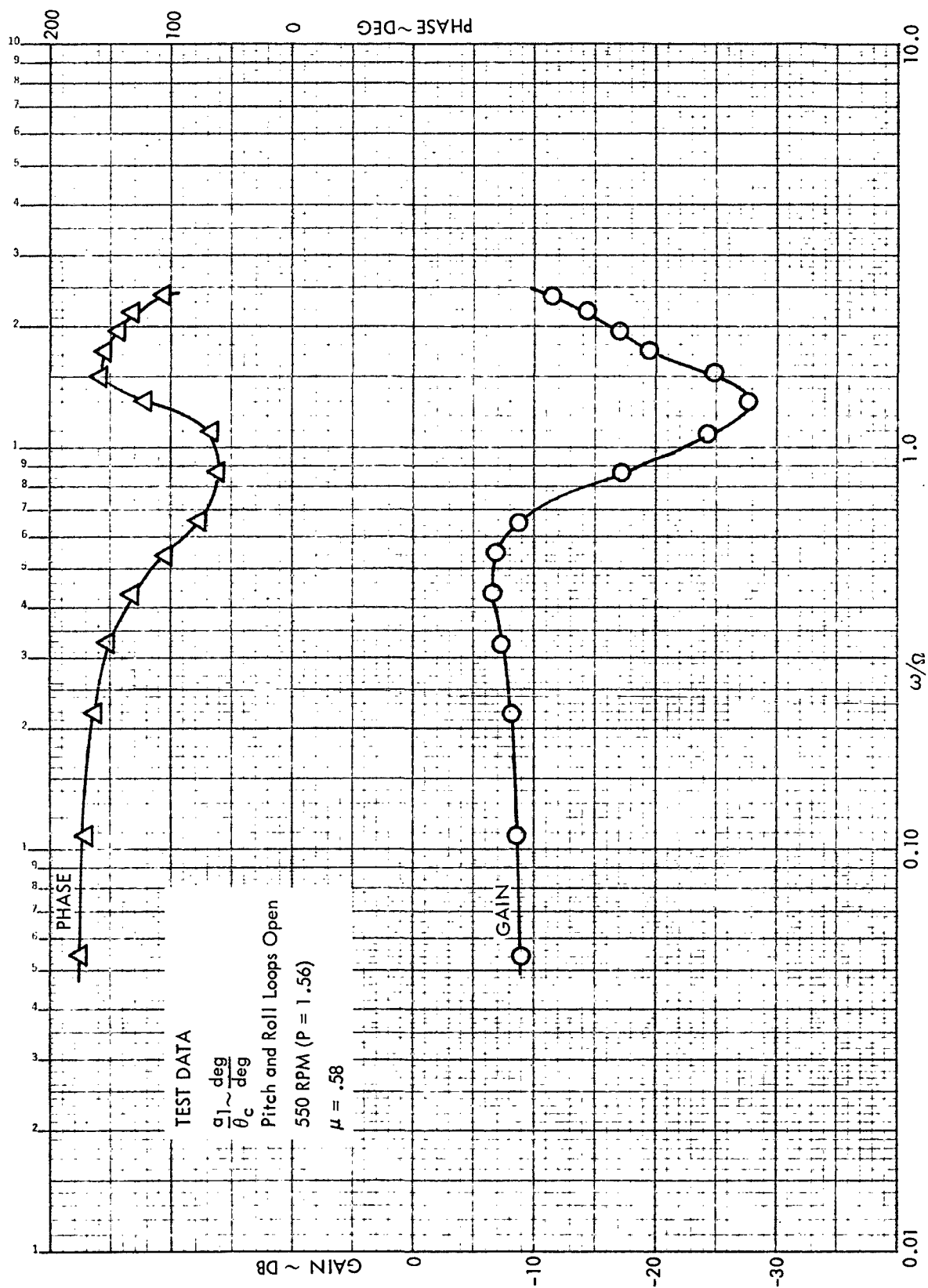


Figure C41. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)

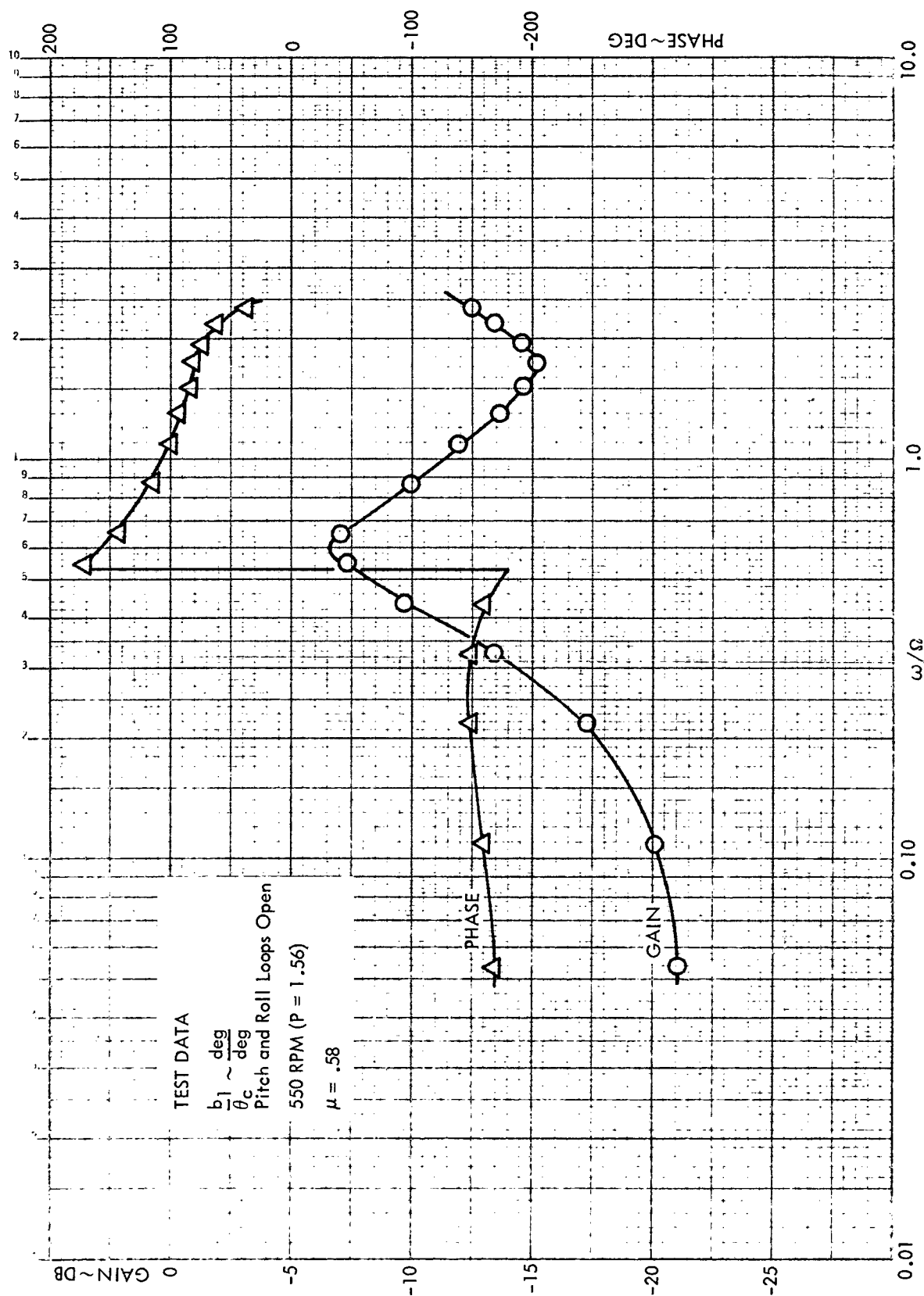


Figure C42. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .58$, 550 rpm ($P = 1.56$)

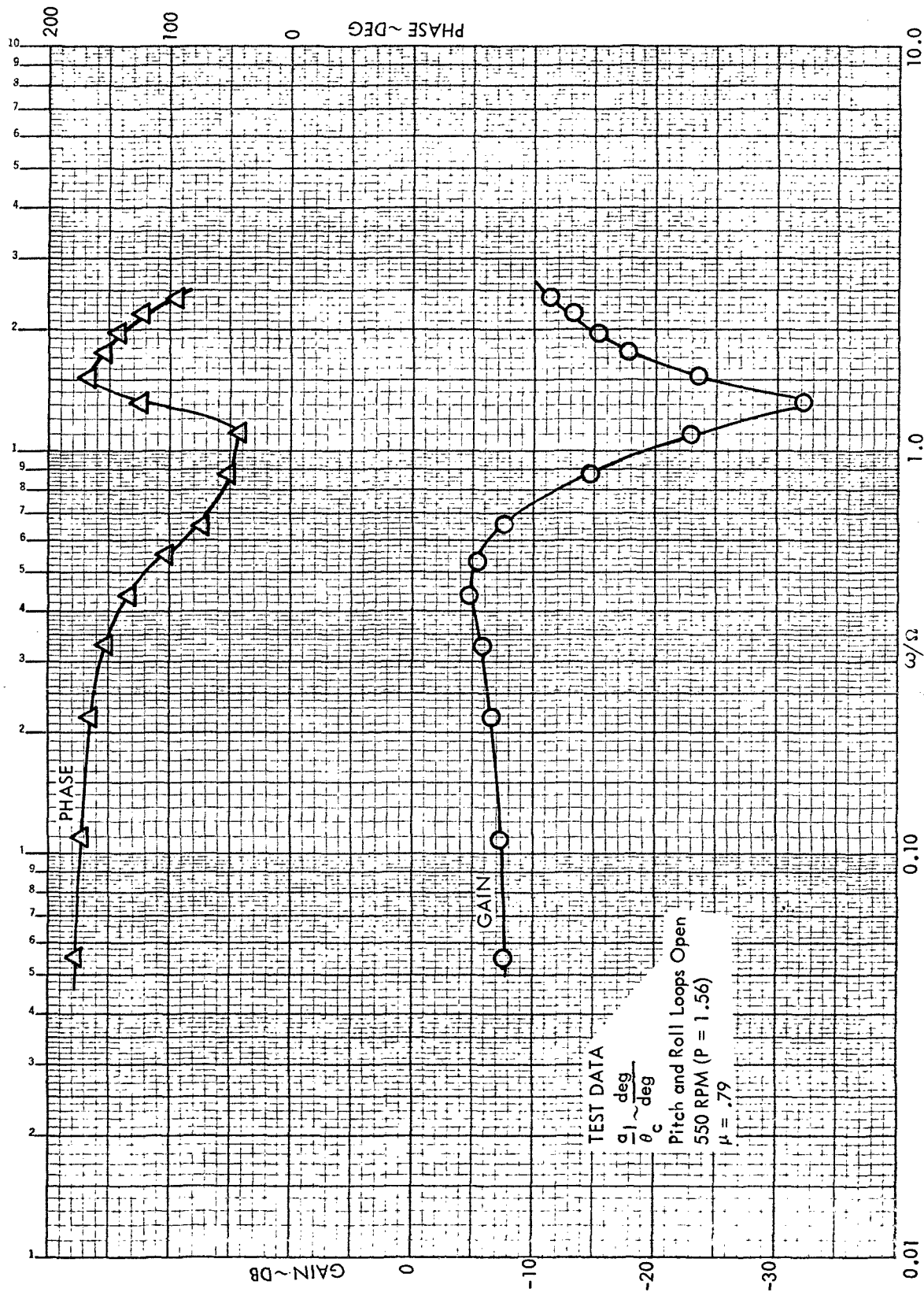


Figure C43. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)

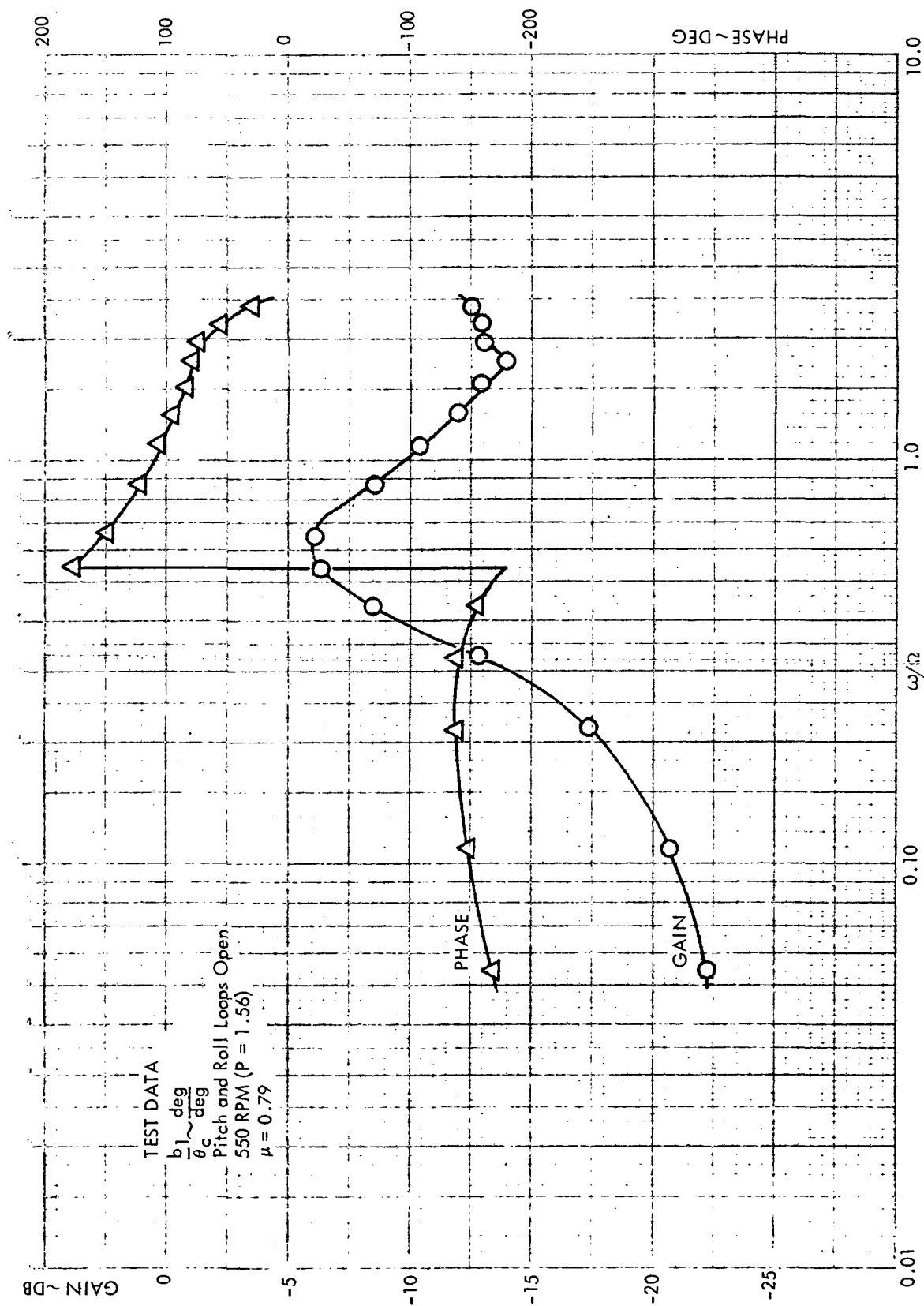


Figure C44. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .79$, 550 rpm ($P = 1.56$)

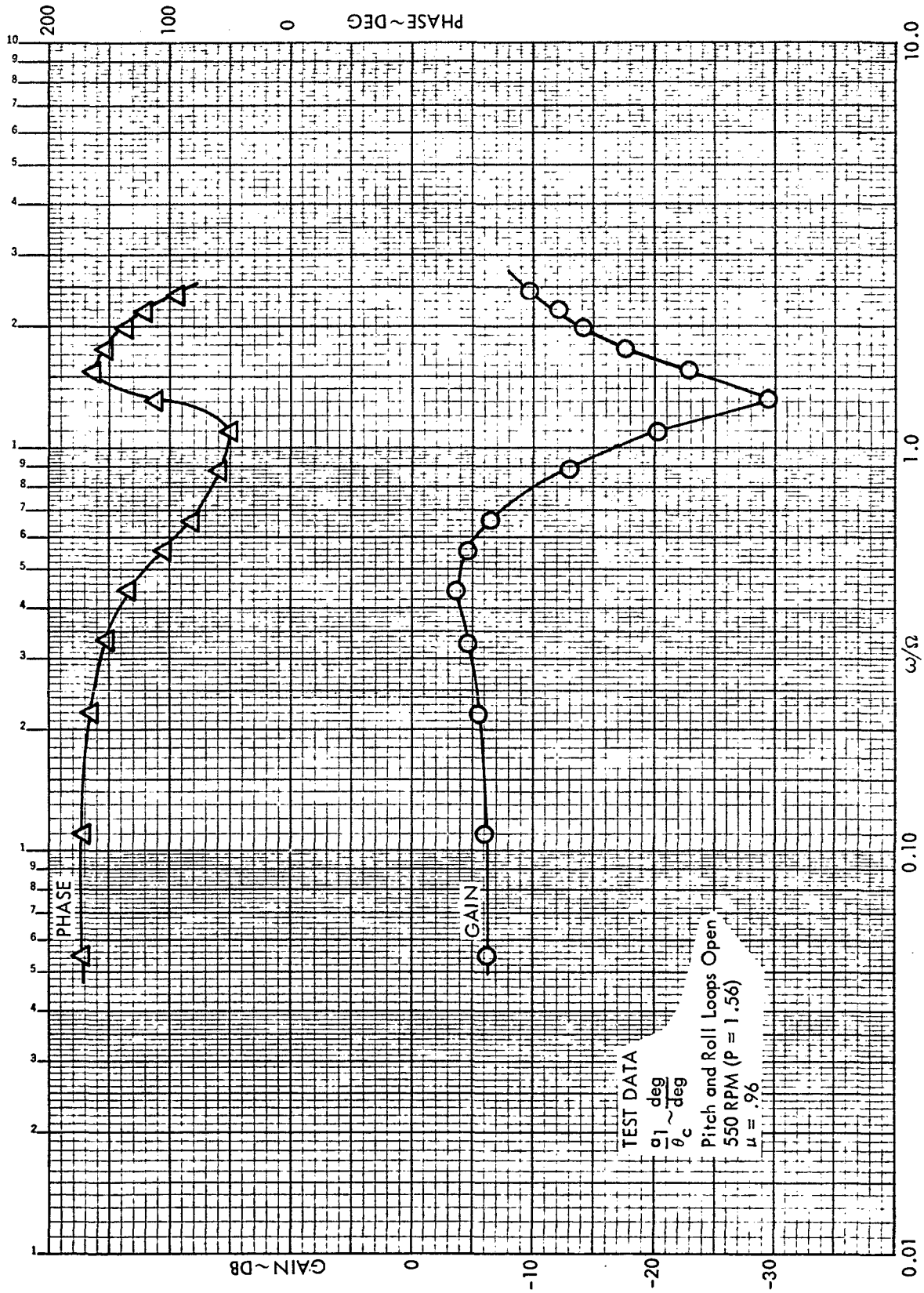


Figure C45. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)

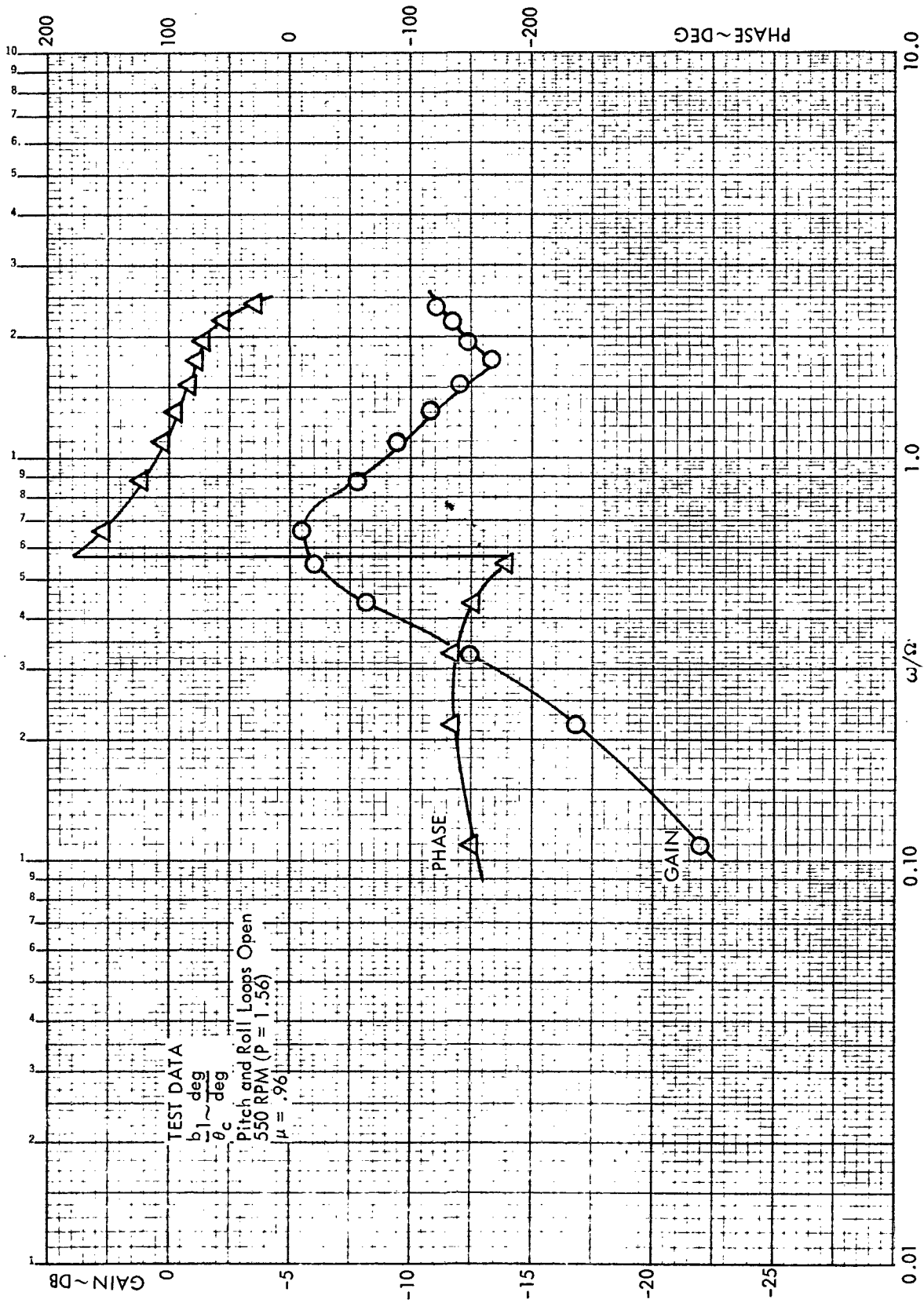


Figure C46. Rotcr Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .96$, 550 rpm ($P = 1.56$)

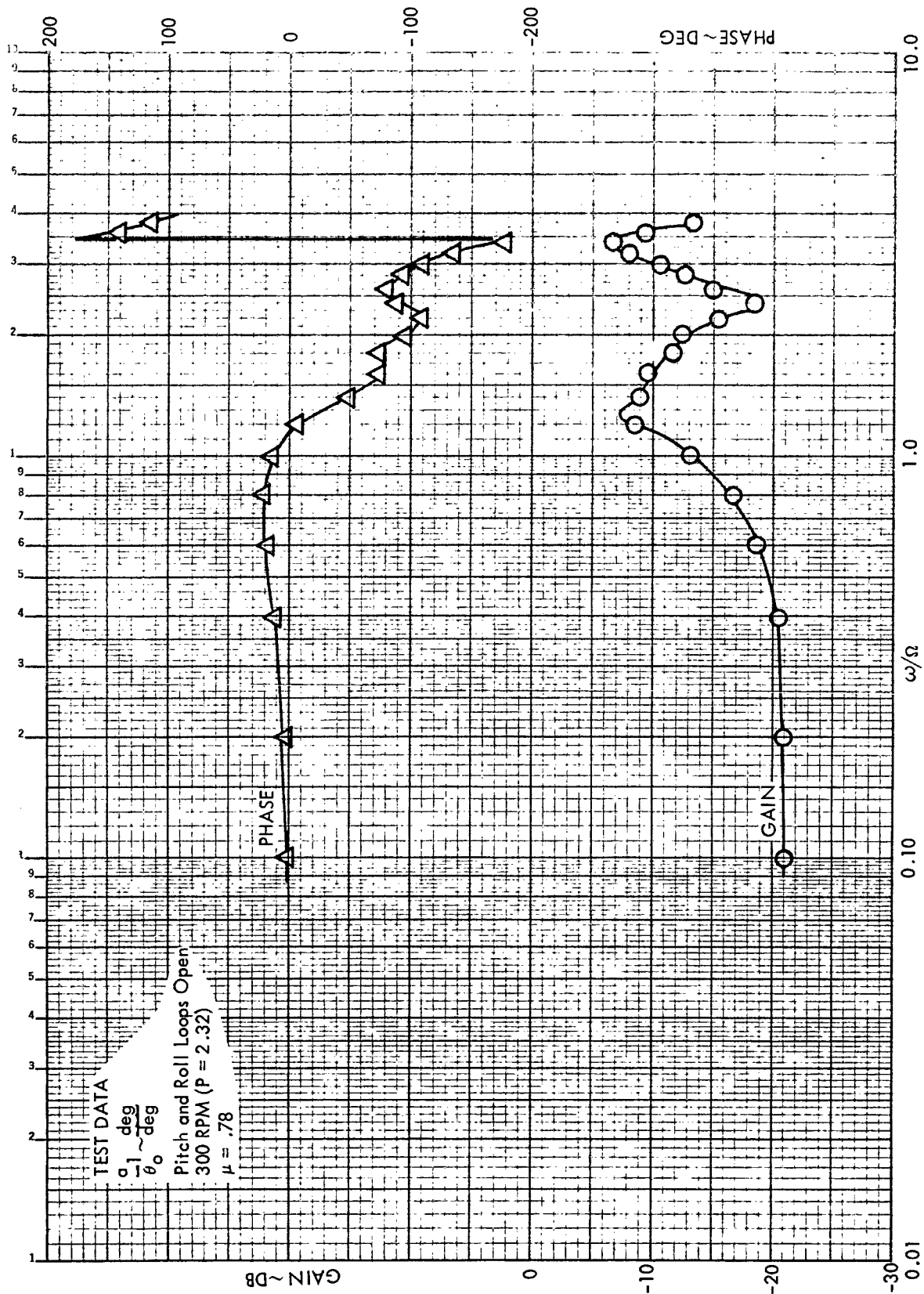


Figure C47. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)

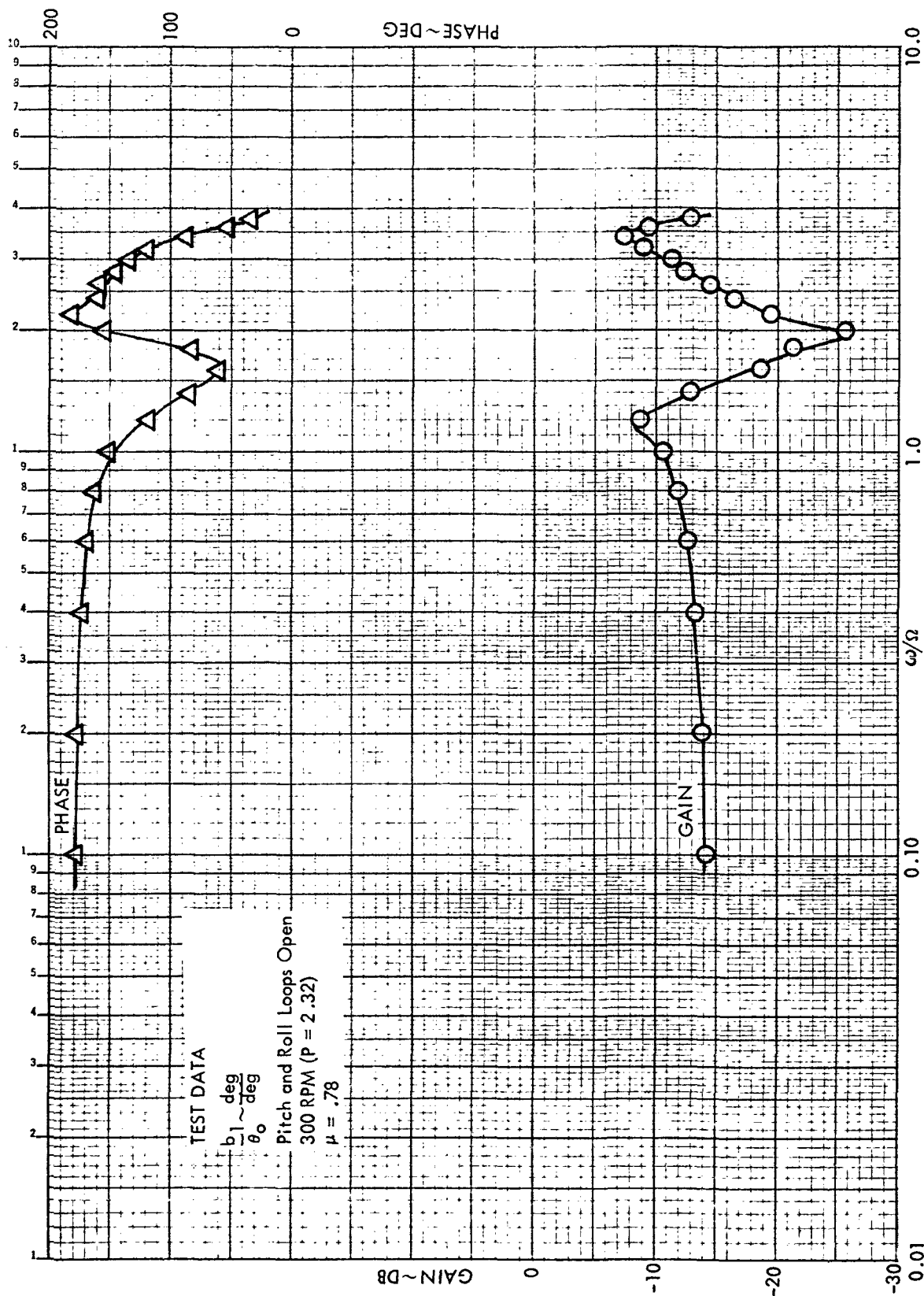


Figure C48. Rotor Lateral Frequency Response to Collective
 Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)

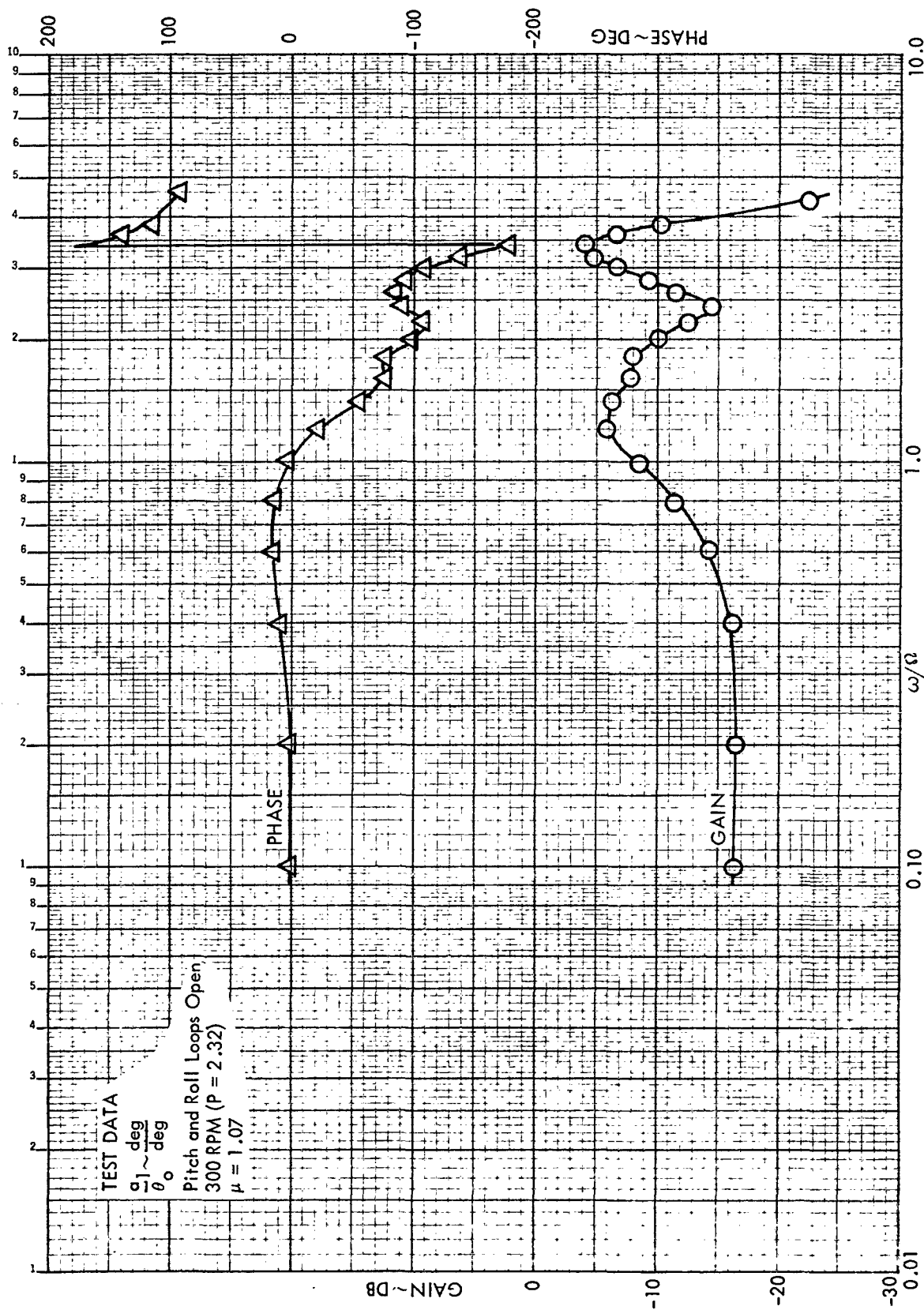


Figure C49. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)

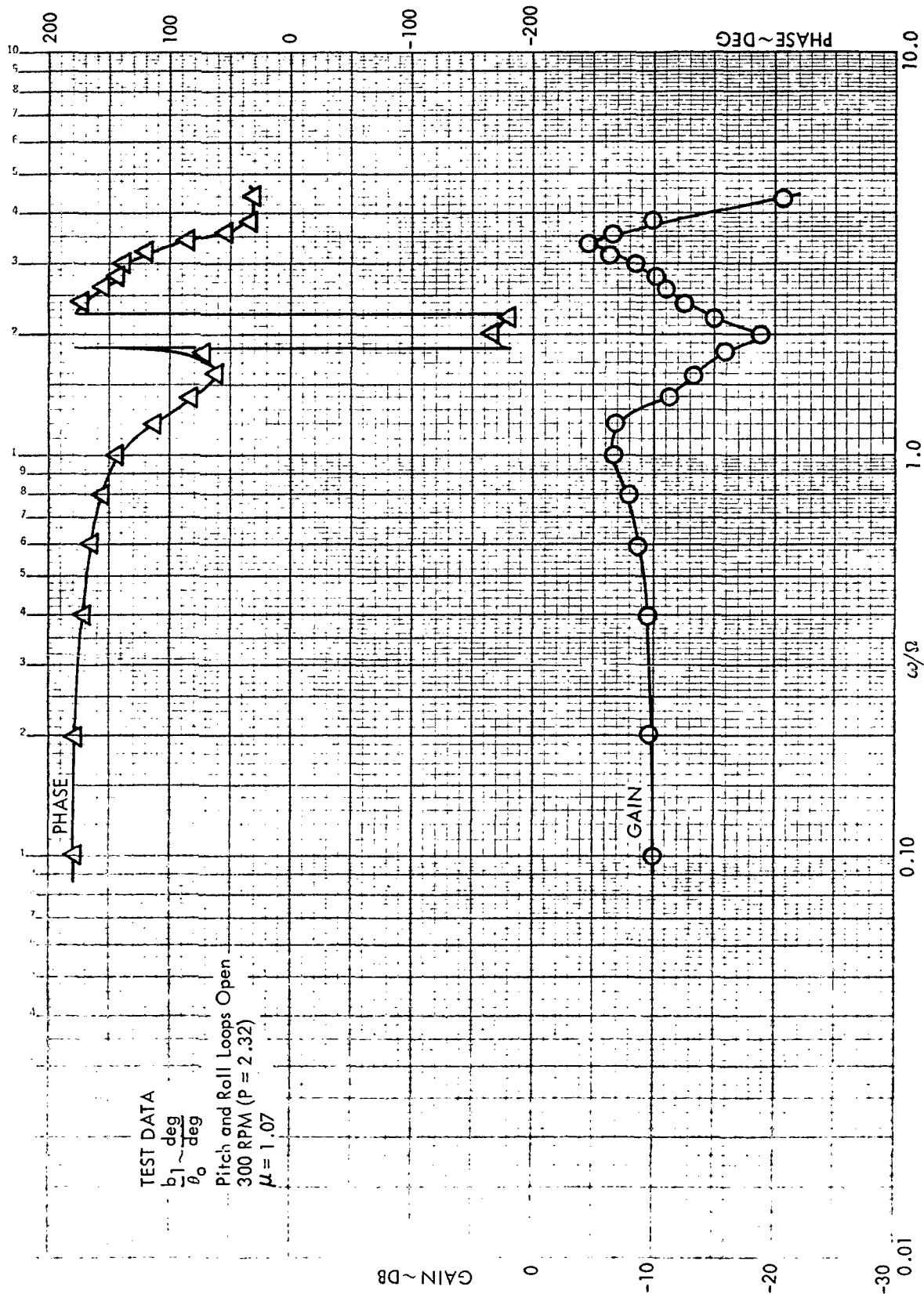


Figure C50. Rotor Lateral Frequency Response to Collective Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)



Figure C5L. Rotor Longitudinal Frequency Response to Collective Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)

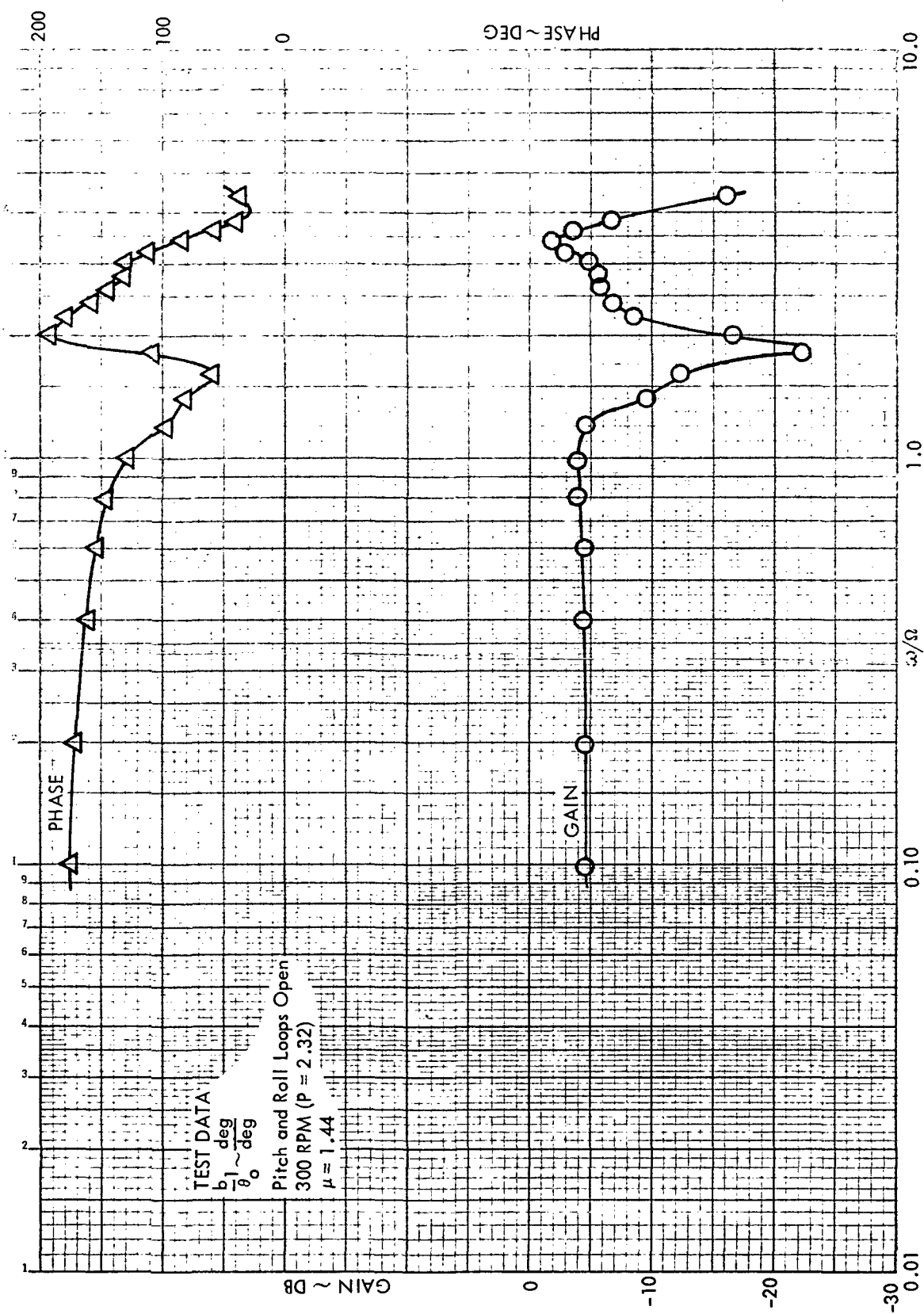


Figure C52. Rotor Lateral Frequency Response to Collective Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)

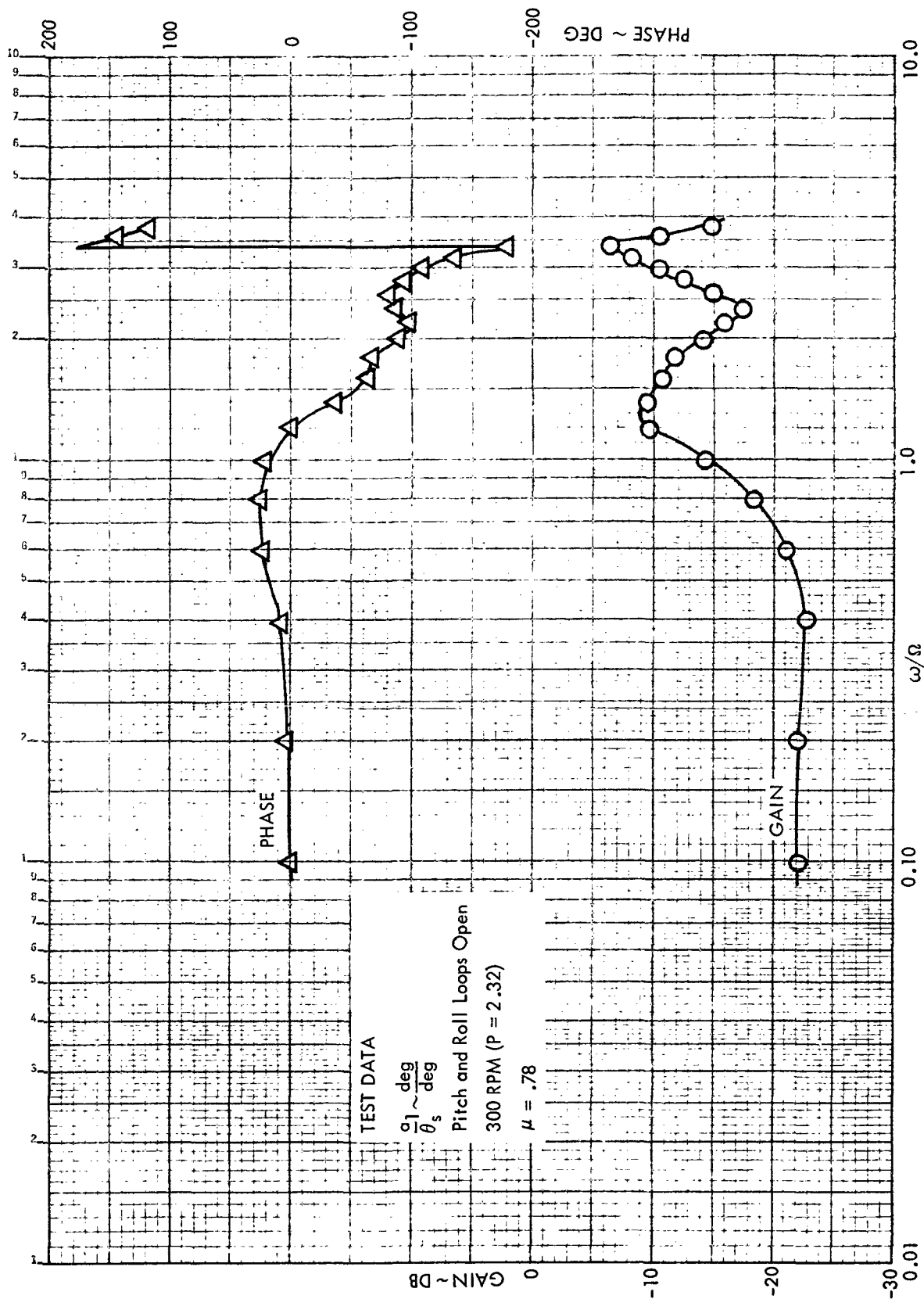


Figure C53. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)

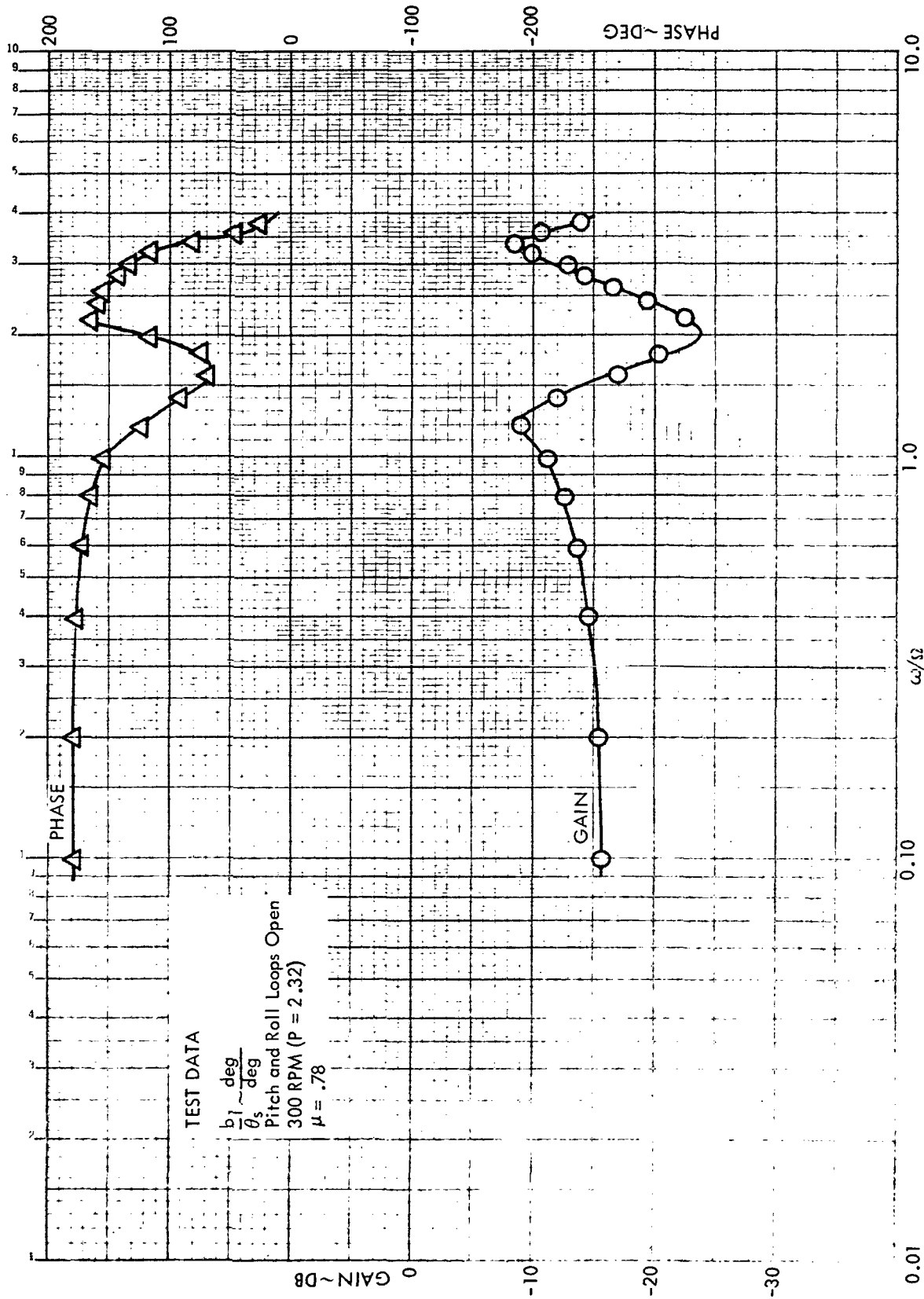


Figure C54. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)

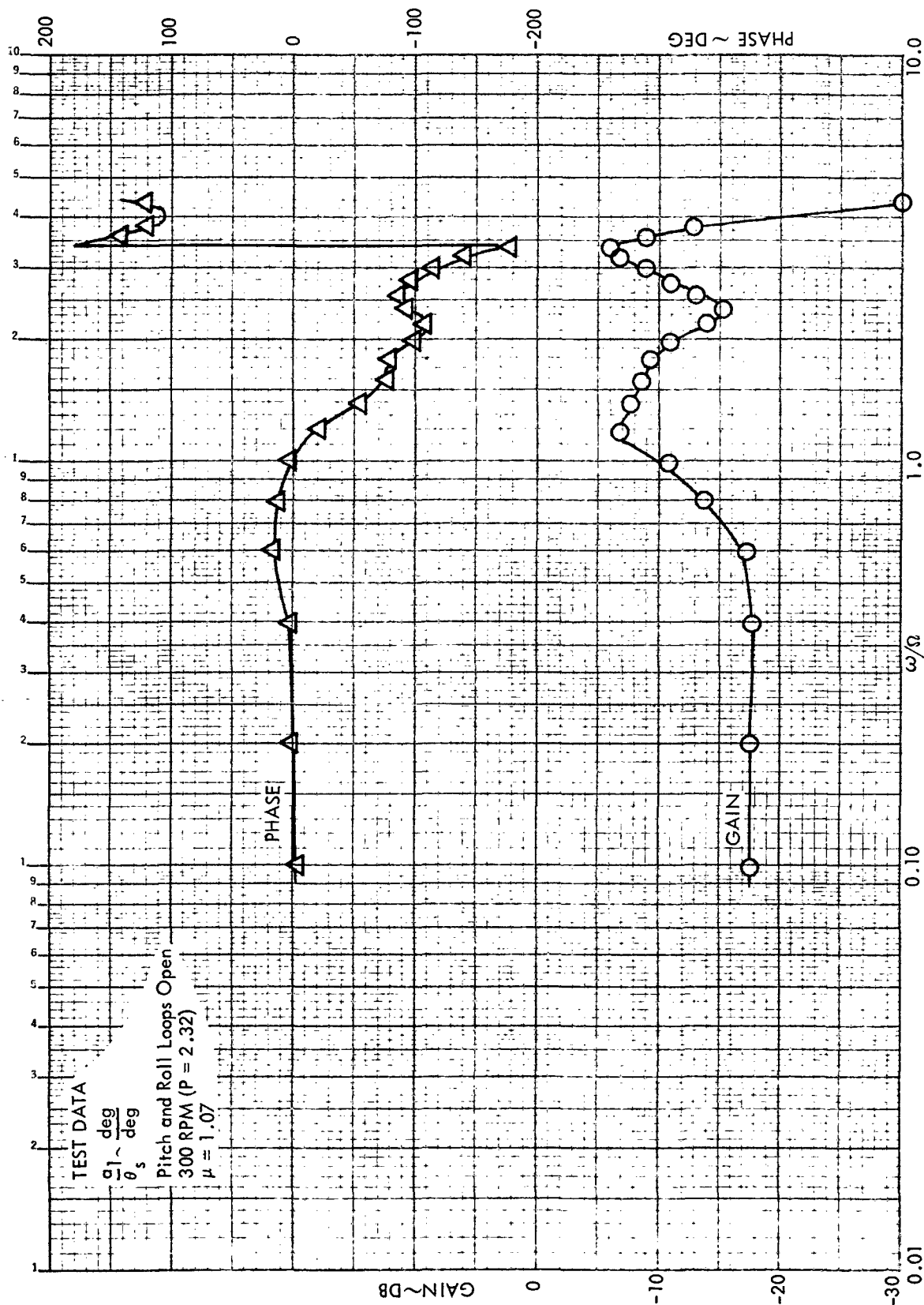


Figure C55. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)

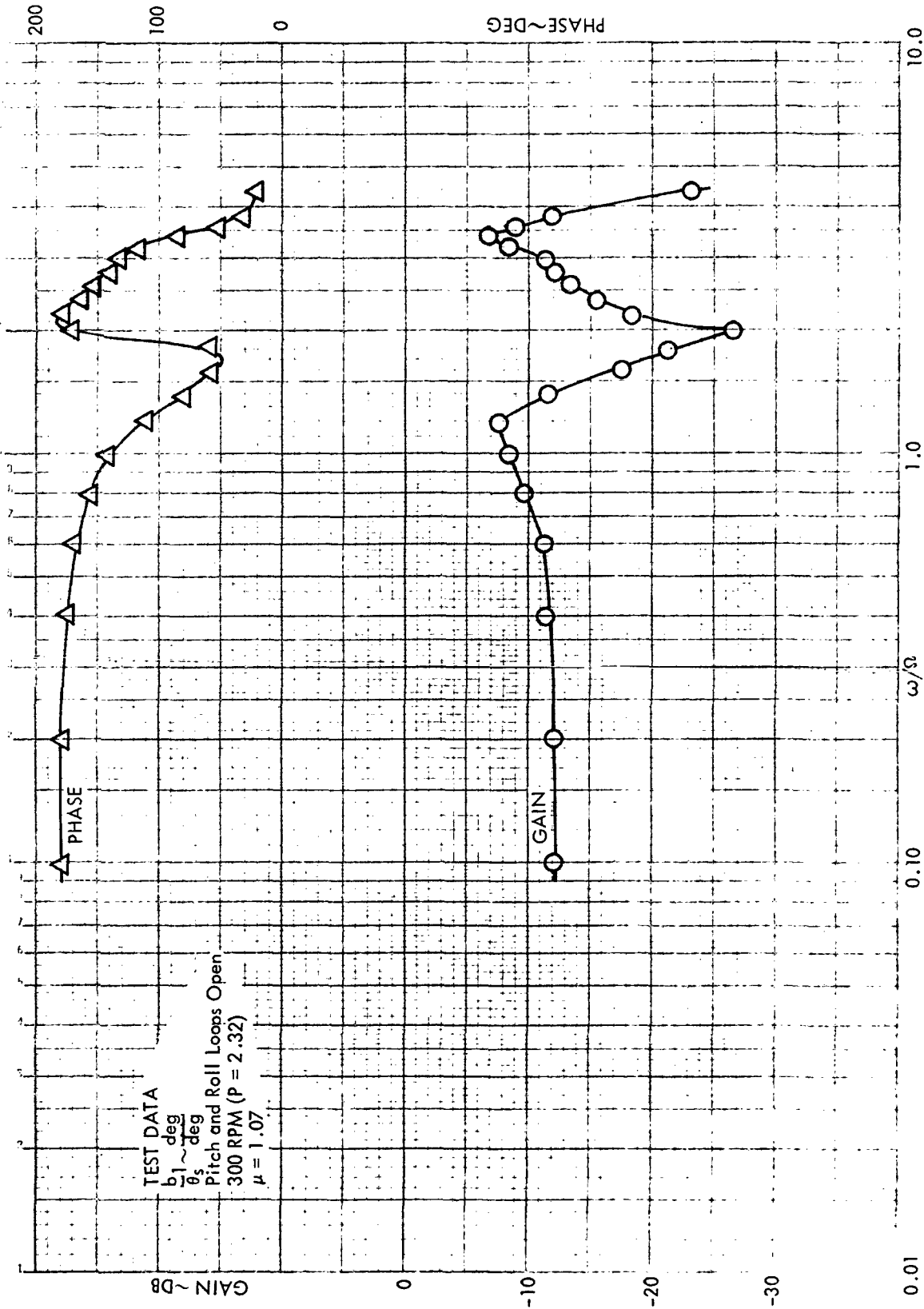


Figure C56. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)

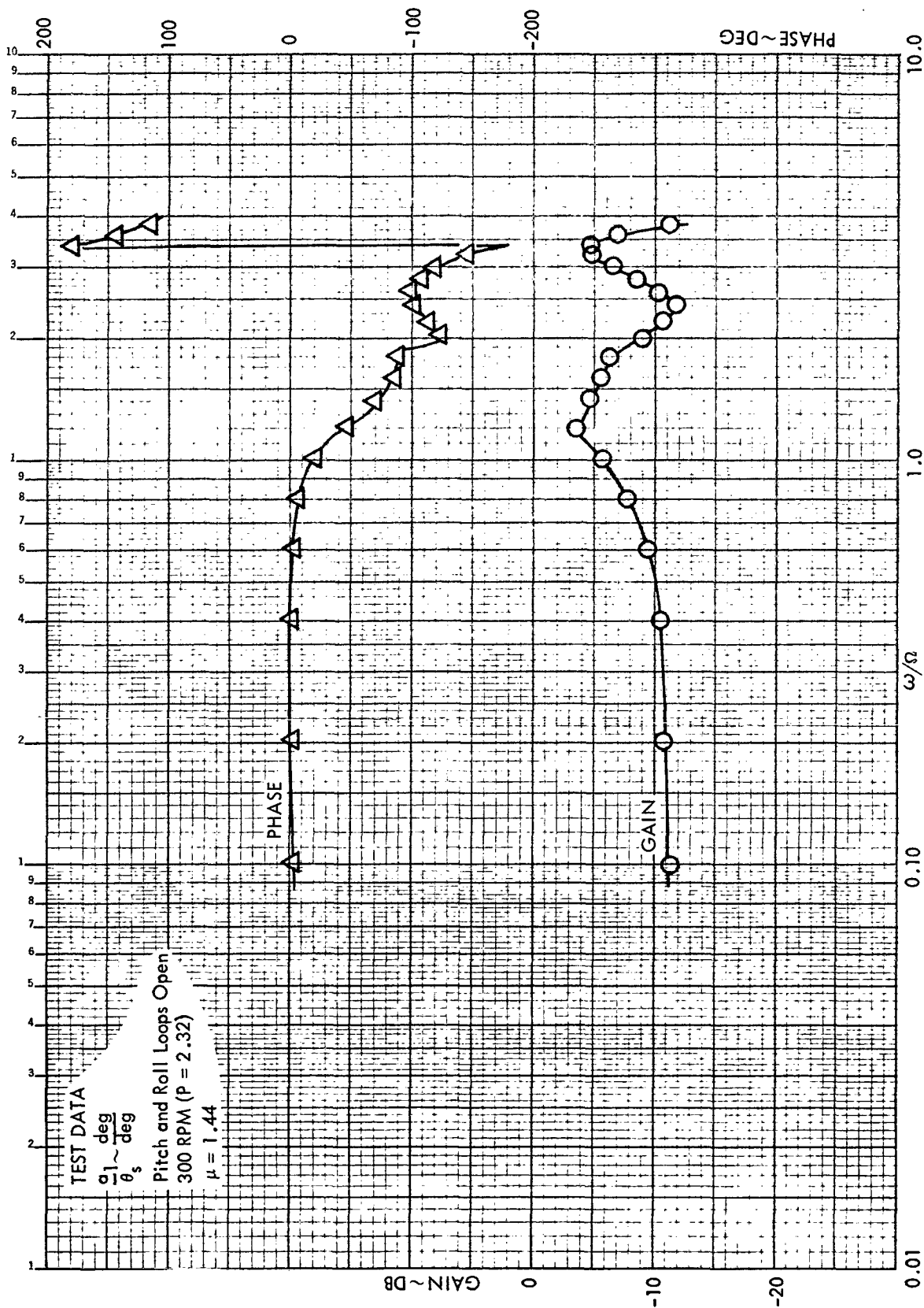


Figure C57. Rotor Longitudinal Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.44$, 300 rpm (P = 2.32)

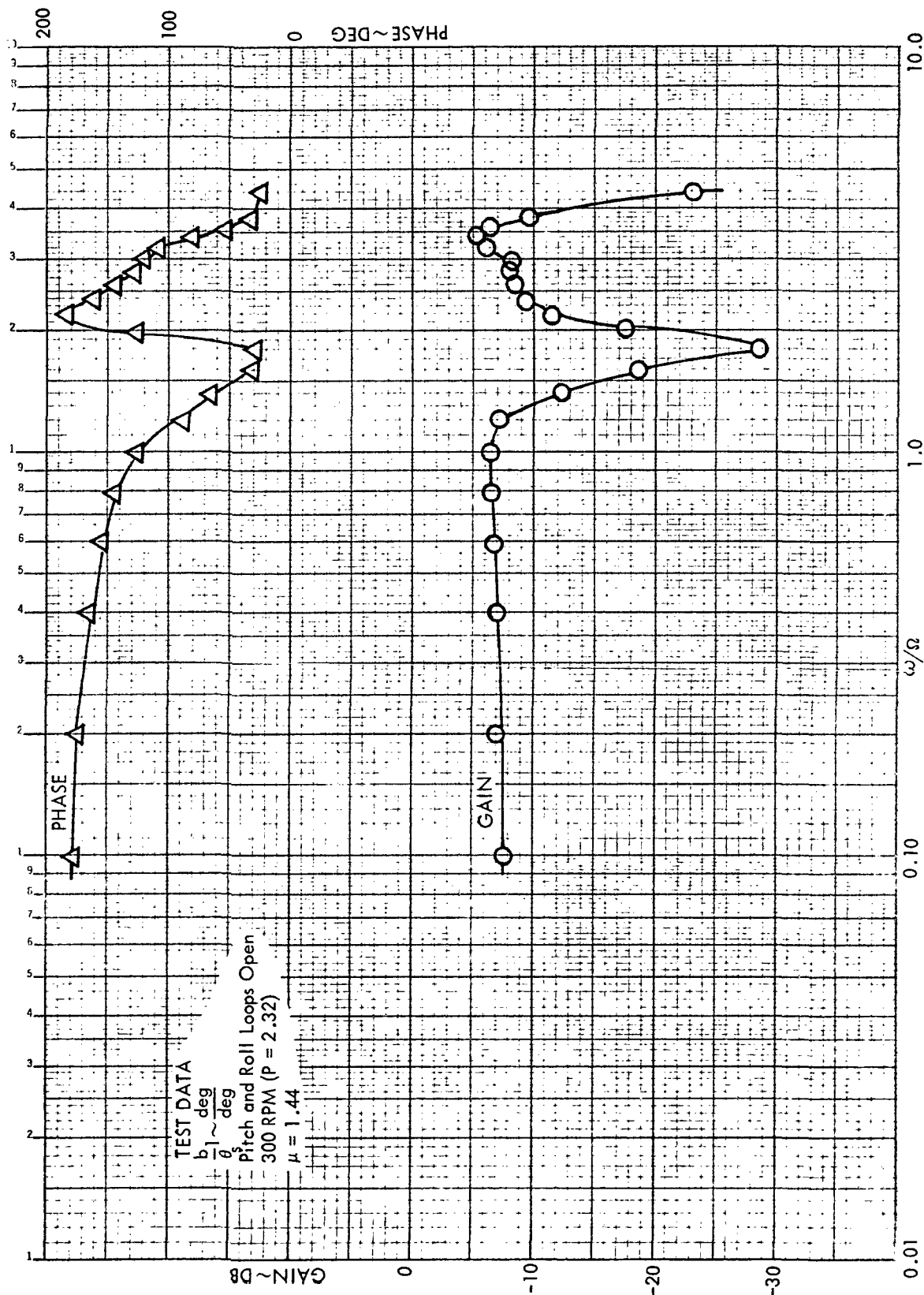


Figure C58. Rotor Lateral Frequency Response to Longitudinal Cyclic Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)

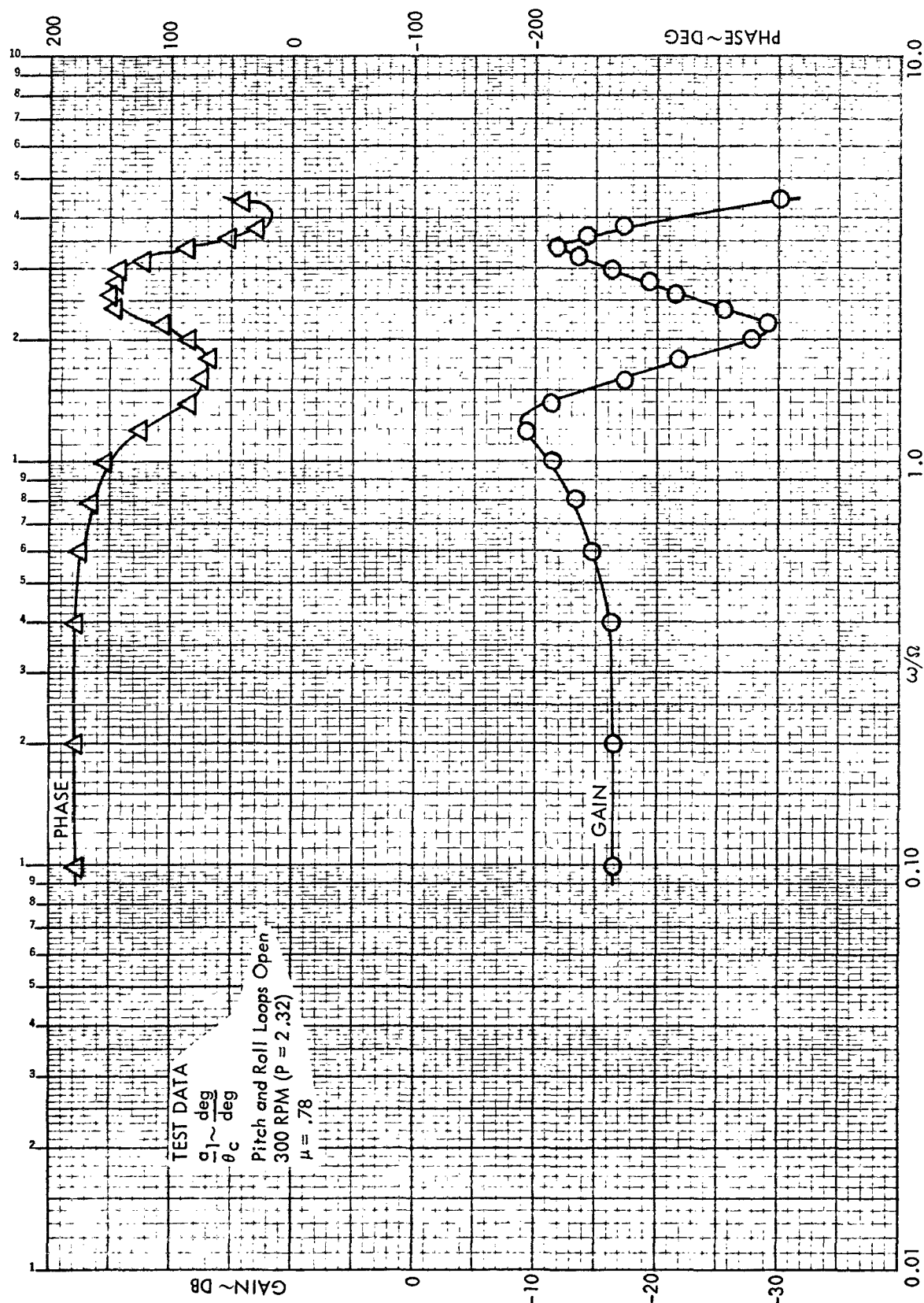


Figure C59. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)

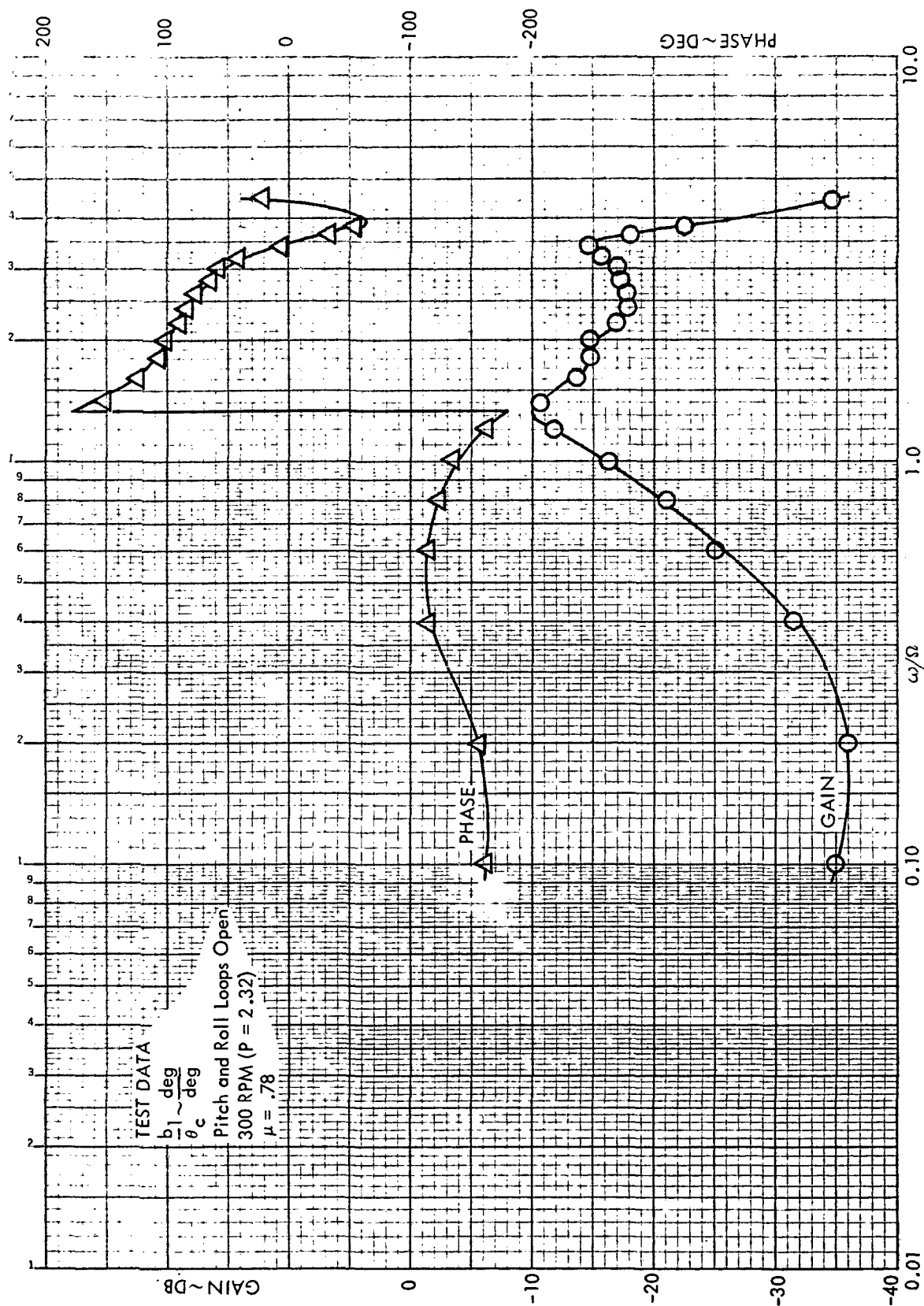


Figure C60. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = .78$, 300 rpm ($P = 2.32$)

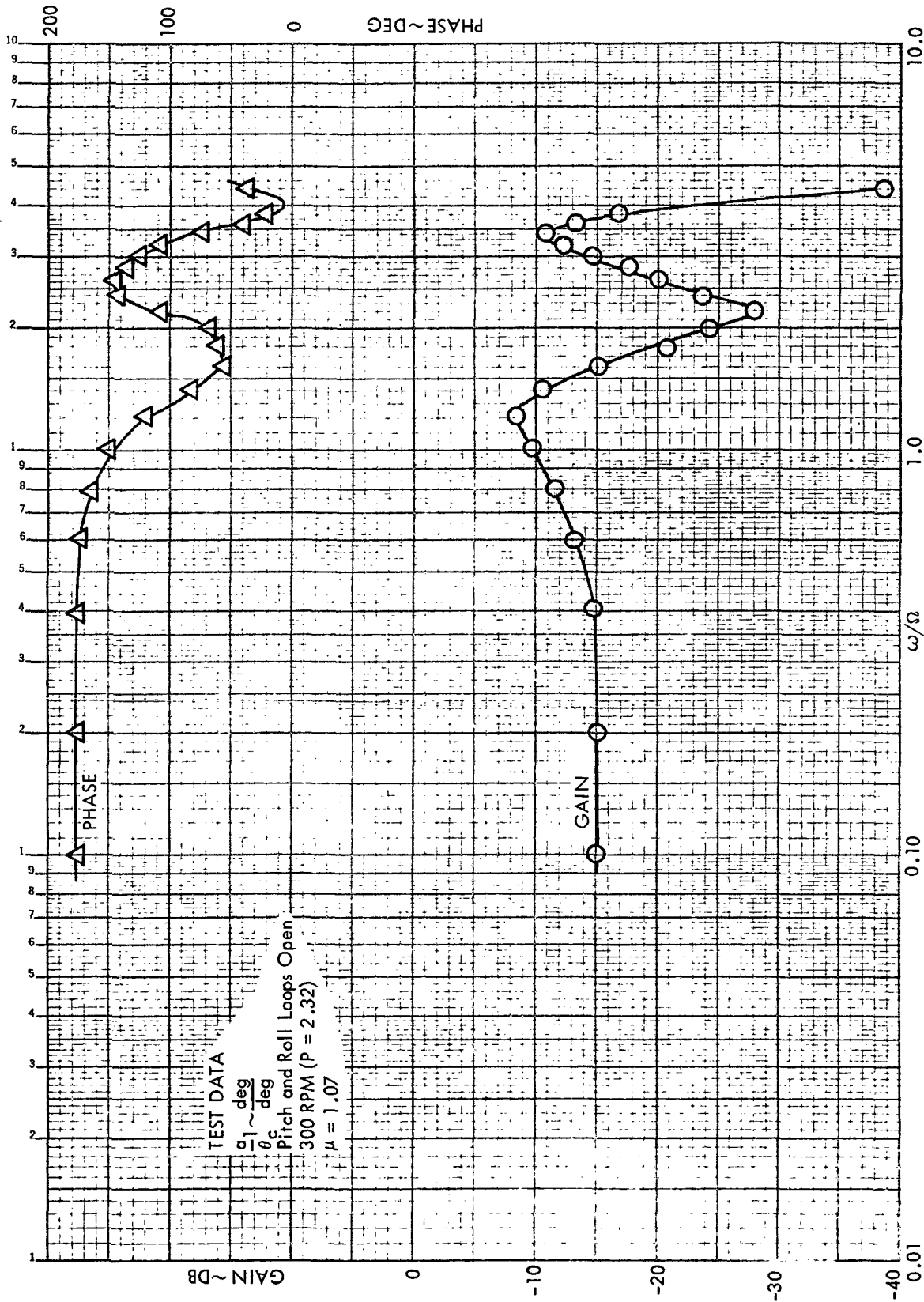


Figure C61. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)

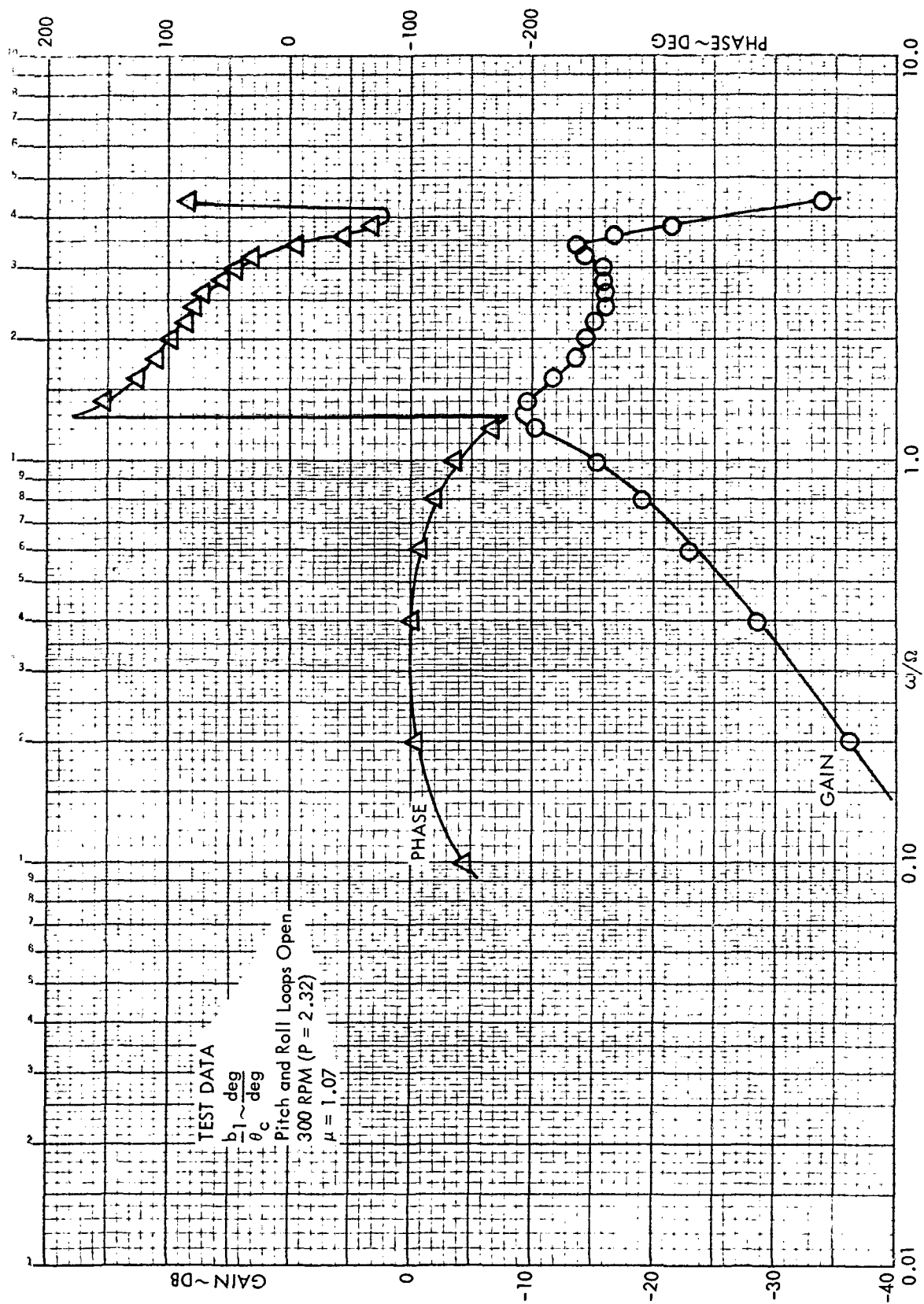


Figure C62. Rotor Lateral Frequency Response to Lateral
 Cyclic Pitch, $\mu = 1.07$, 300 rpm ($P = 2.32$)

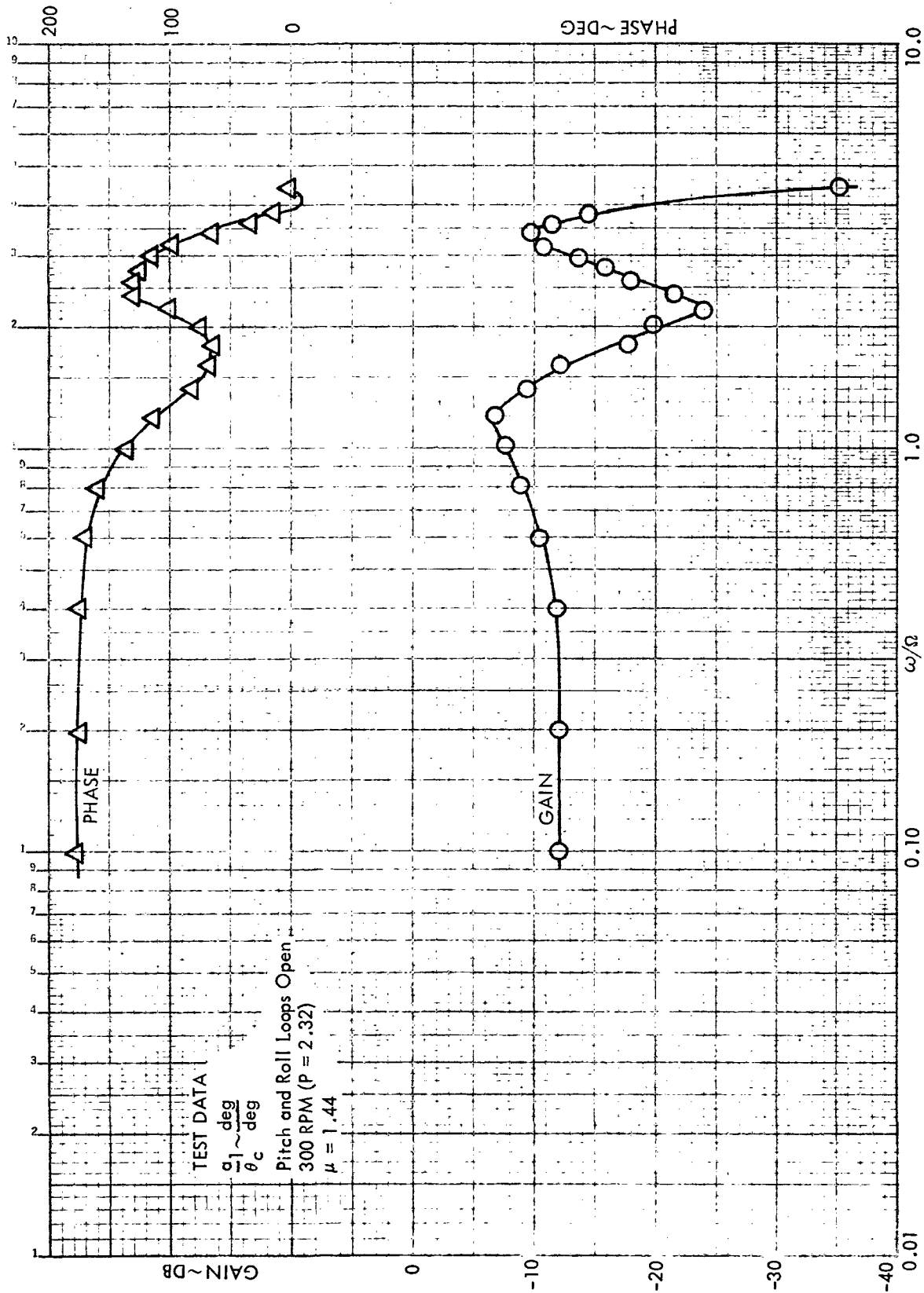


Figure C63. Rotor Longitudinal Frequency Response to Lateral Cyclic Pitch, $\mu = 1.44$, 300 rpm ($P = 2.32$)

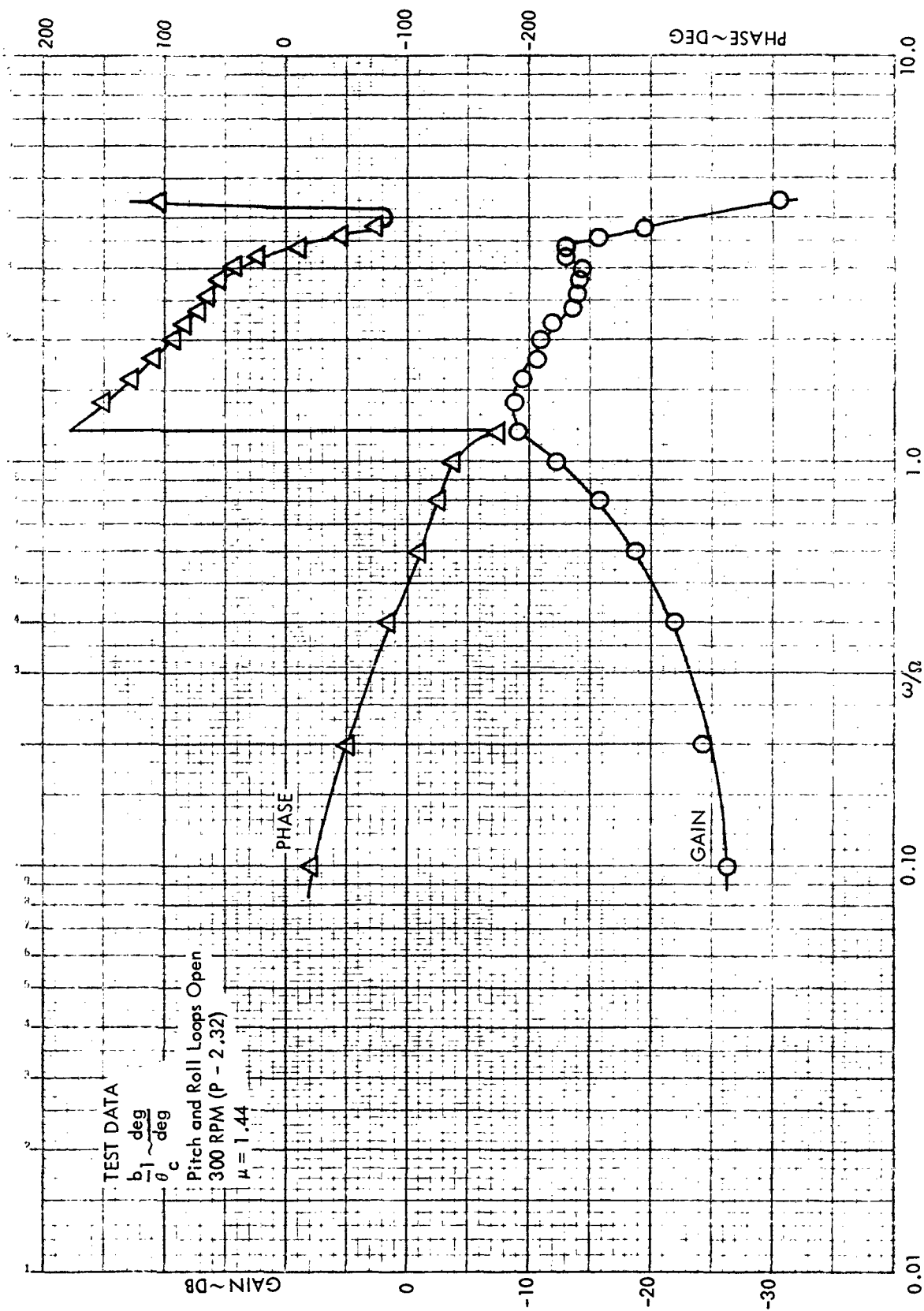


Figure C64. Rotor Lateral Frequency Response to Lateral Cyclic Pitch, $\mu = 1.44$, 300 rpm (P = 2.32)

APPENDIX D

EXPERIMENTAL TRANSFER FUNCTIONS FROM WHICH TOTAL PITCH LOOP AND
TOTAL ROLL LOOP STABILITIES WERE DETERMINED

The longitudinal transfer functions

$$\frac{a_1}{\bar{\theta}_s} \quad \text{and} \quad \frac{\delta_s}{\bar{\theta}_s}$$

which were used to determine total pitch loop stability margins are plotted in Figures D1 to D16. The lateral transfer functions

$$\frac{b_1}{\bar{\theta}_c} \quad \text{and} \quad \frac{\delta_c}{\bar{\theta}_c}$$

used for similar total roll loop stability measurements are shown in Figures D17 to D22.

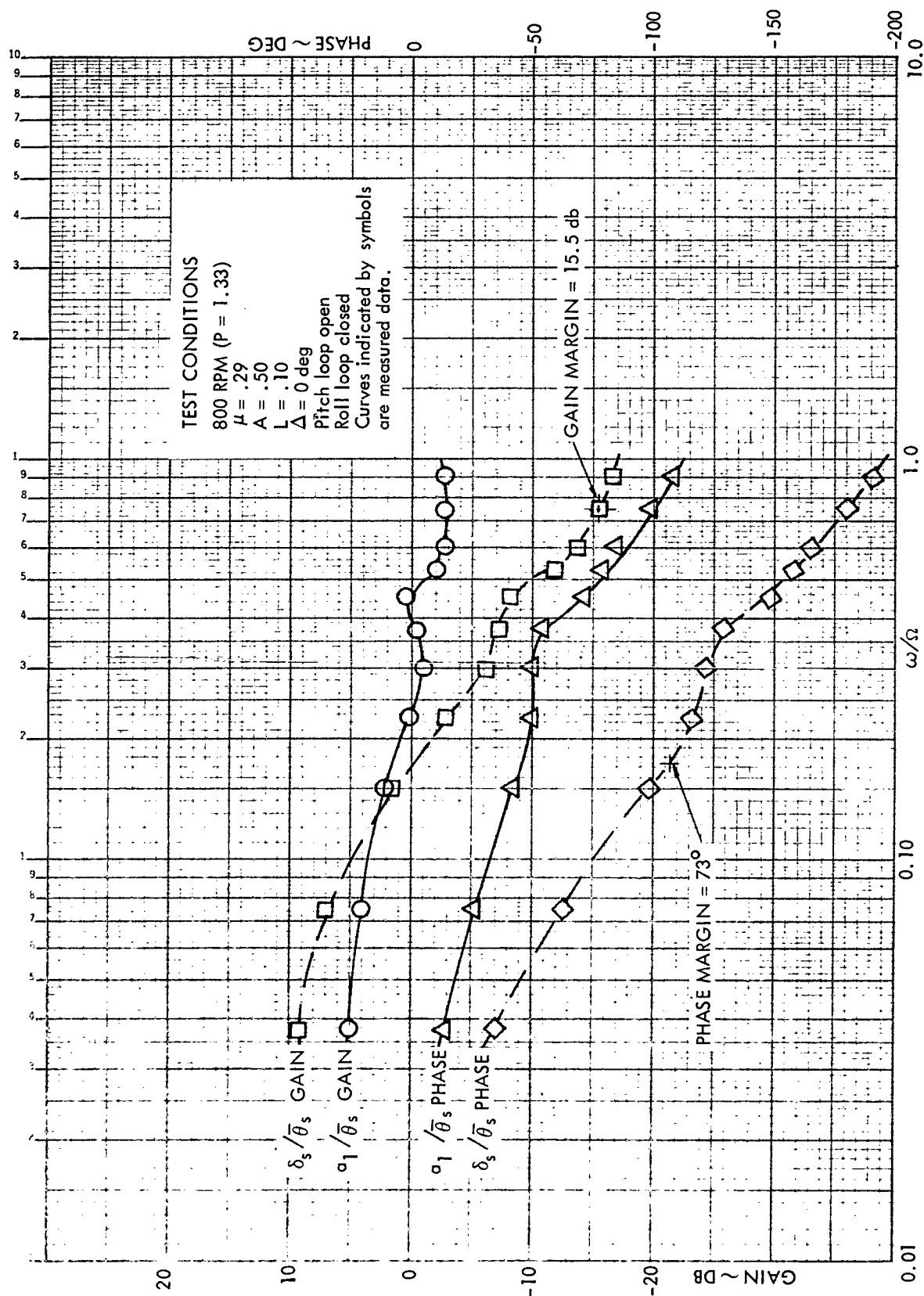


Figure D1. Longitudinal Transfer Functions (a_1/θ_s , δ_s/θ_s), Pitch Loop Open, Roll Loop Closed,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg

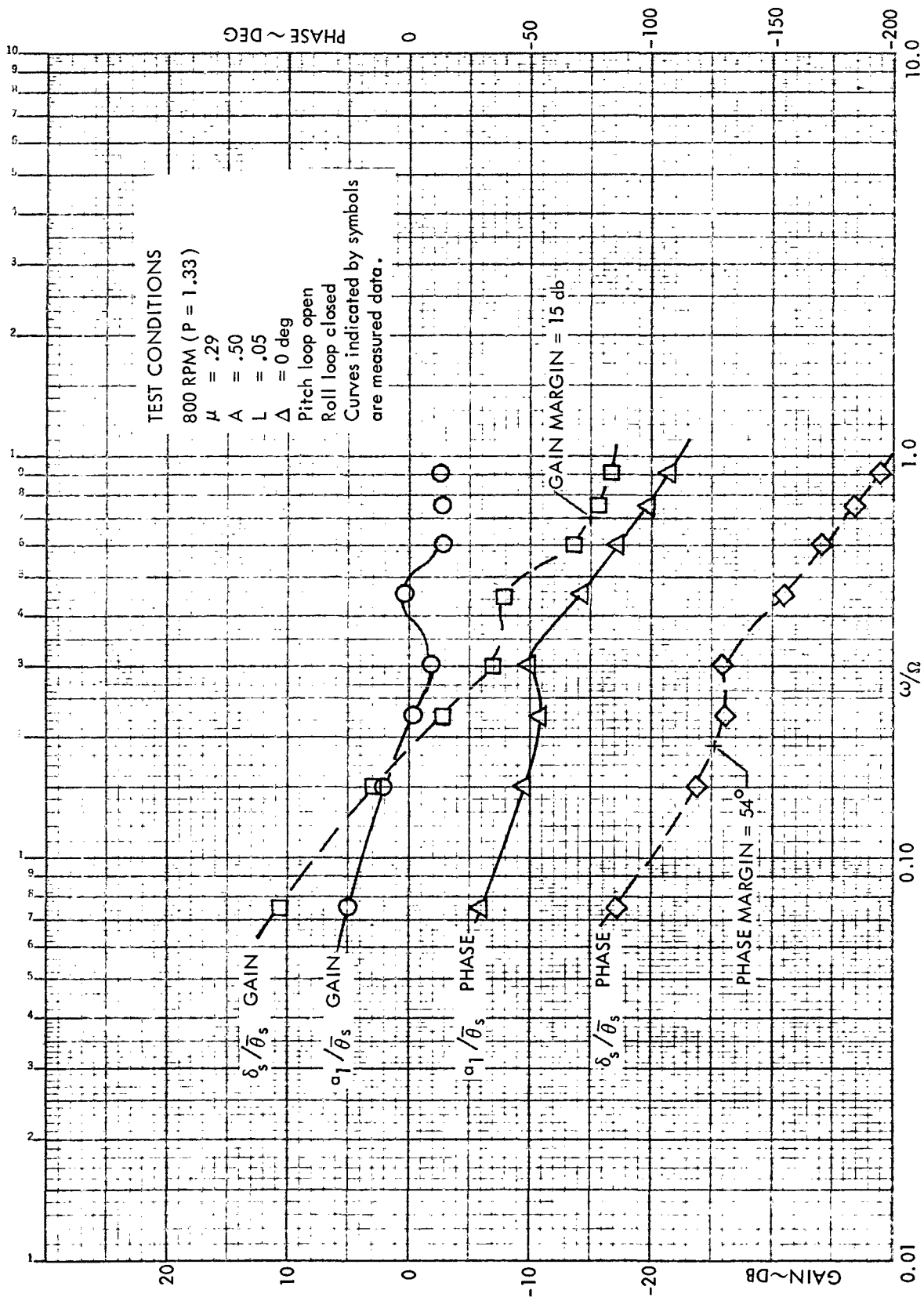


Figure D2. Longitudinal Transfer Functions ($a_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0 \text{ deg}$

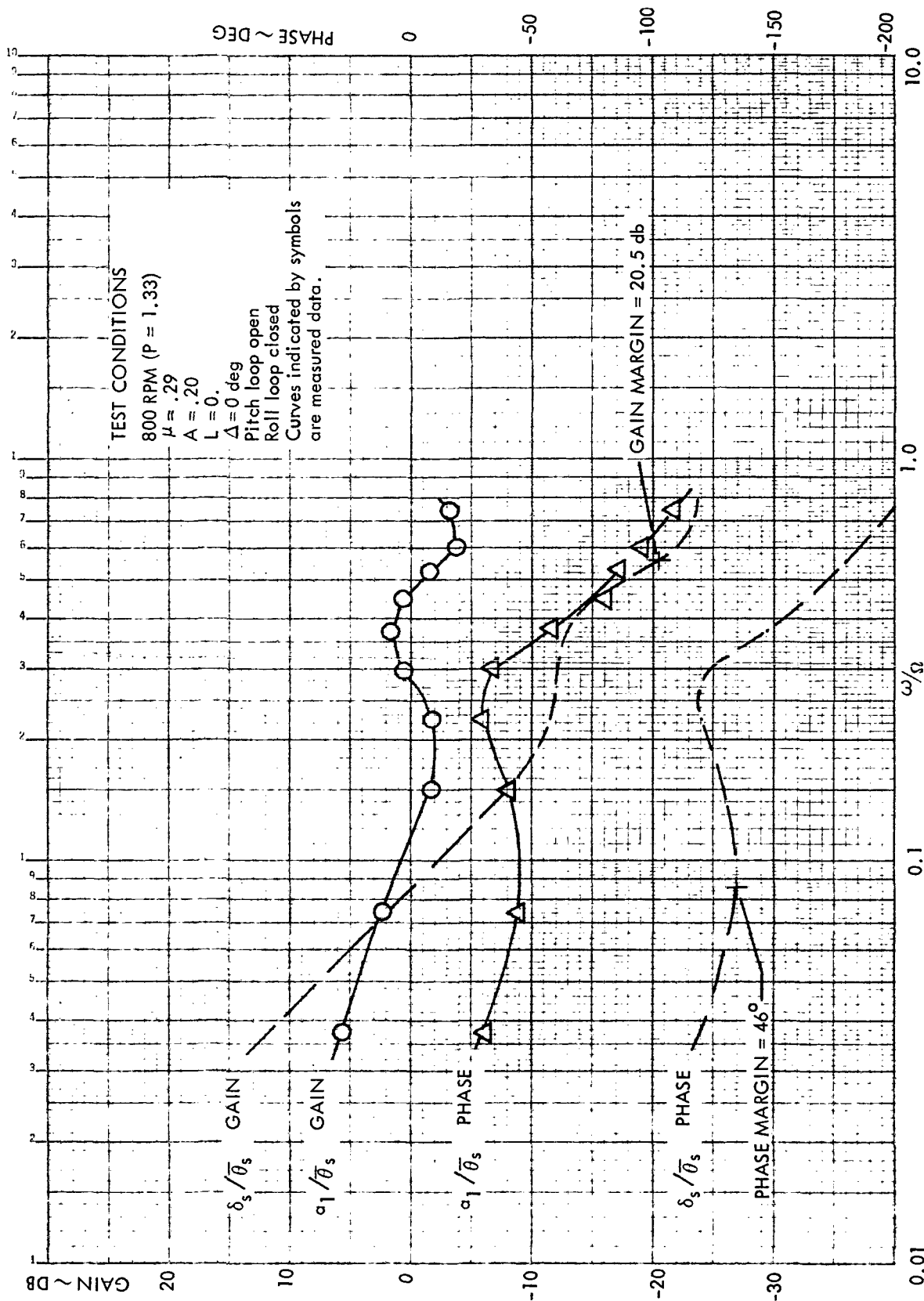


Figure D3. Longitudinal Transfer Functions ($\alpha_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg

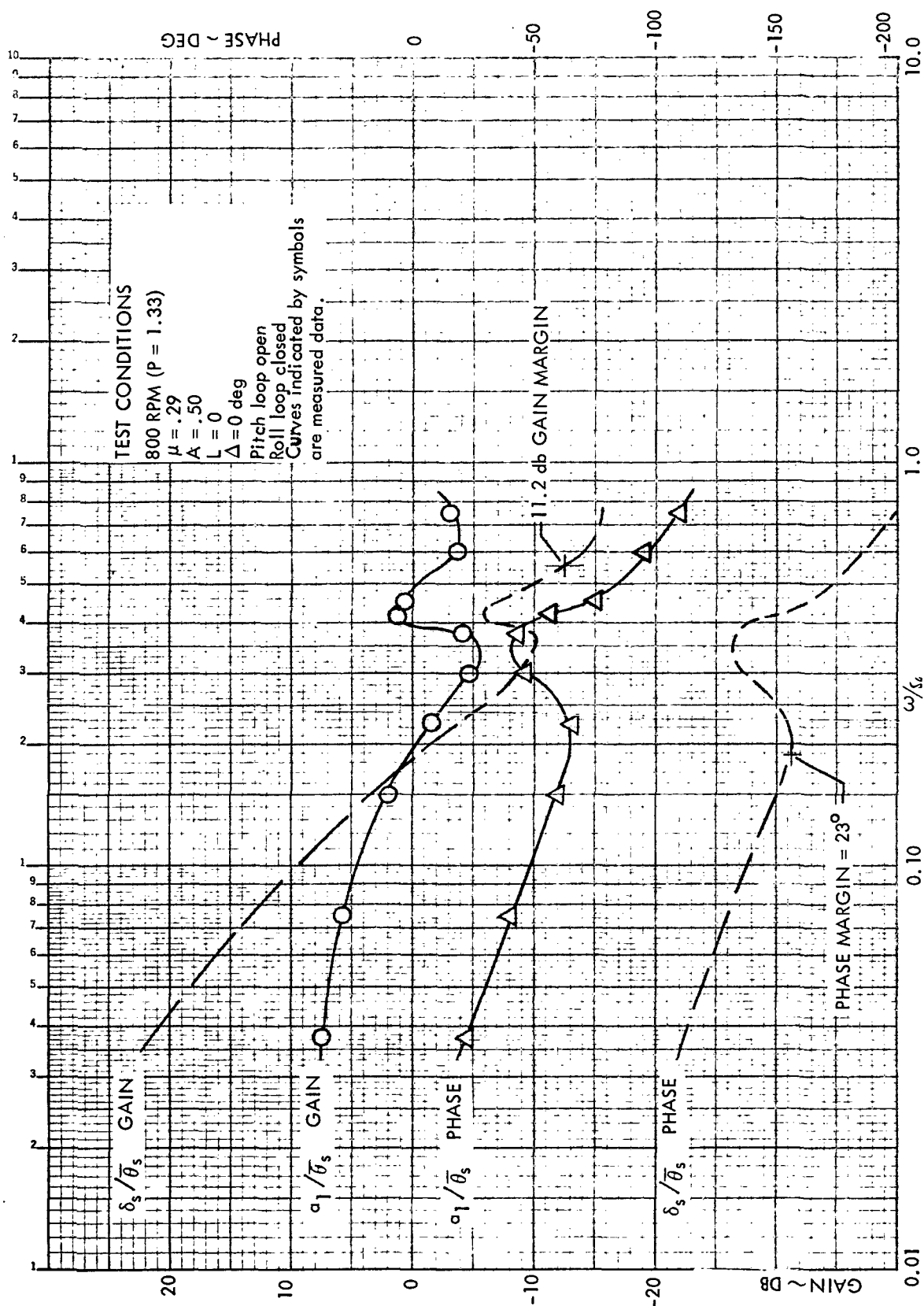


Figure D4. Longitudinal Transfer Functions ($a_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .29$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg

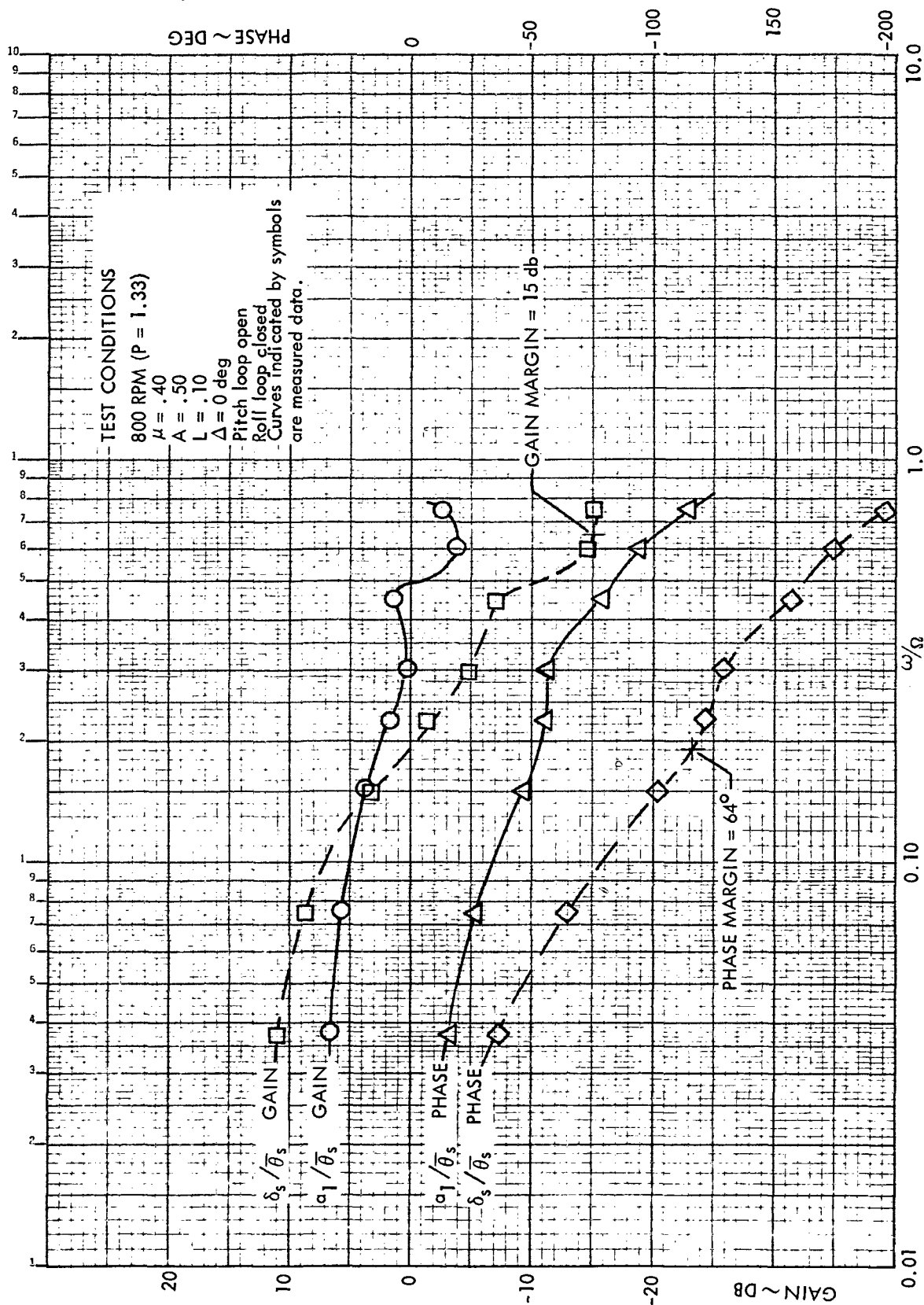


Figure D5. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg

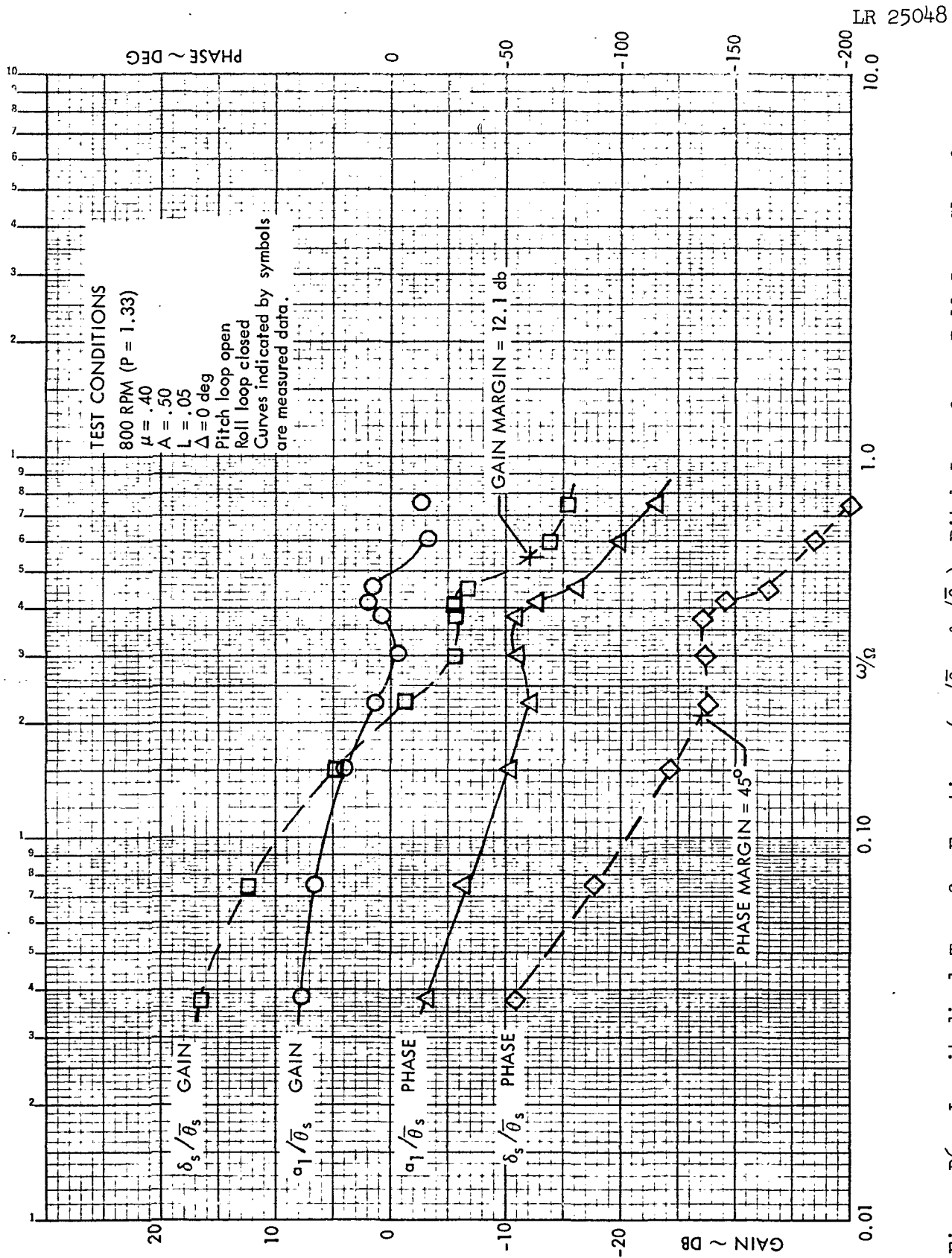


Figure D6. Longitudinal Transfer Functions ($a_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg

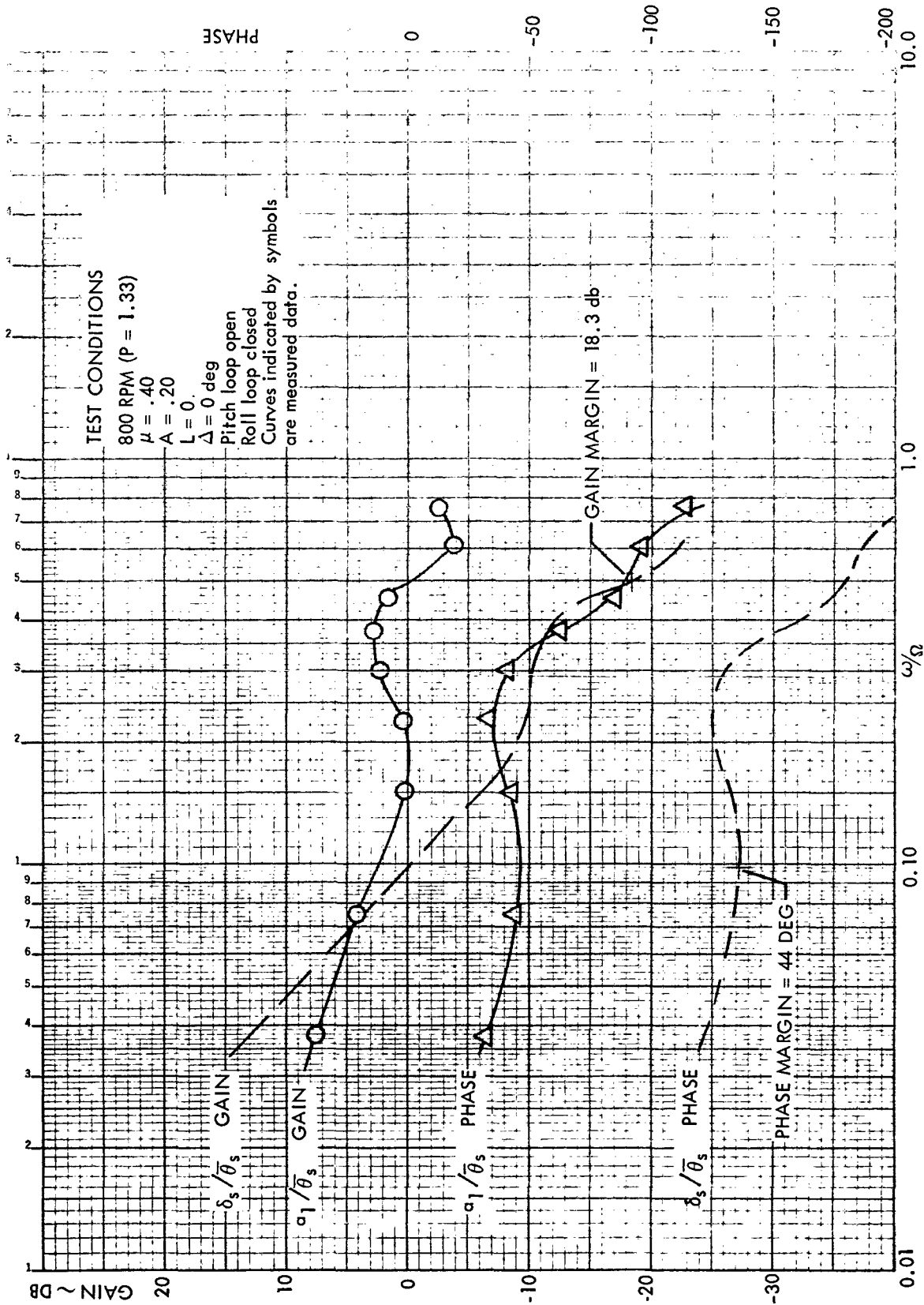


Figure D7. Longitudinal Transfer Functions ($a_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .40$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg

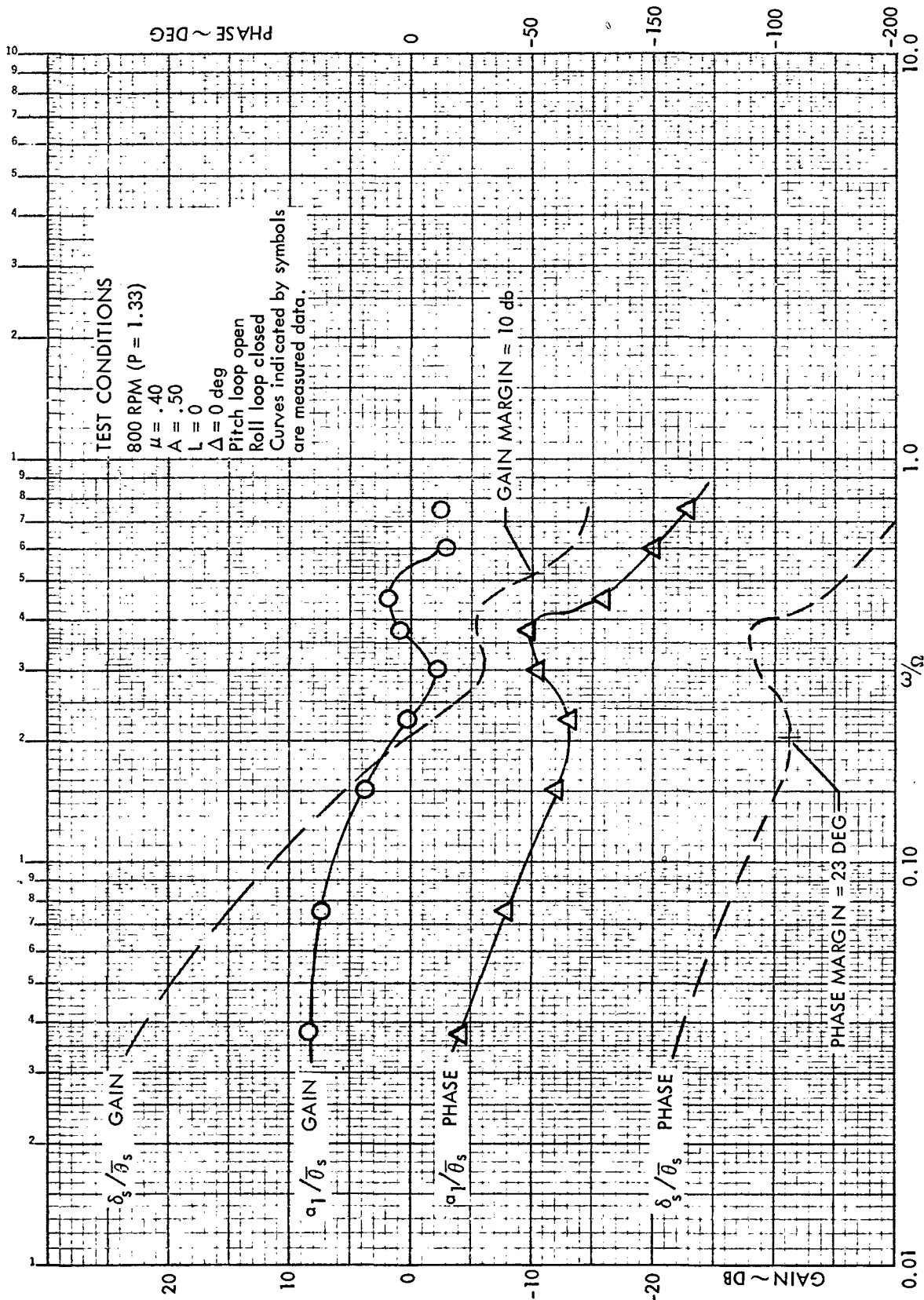


Figure D8. Longitudinal Transfer Functions ($a_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,

$\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg

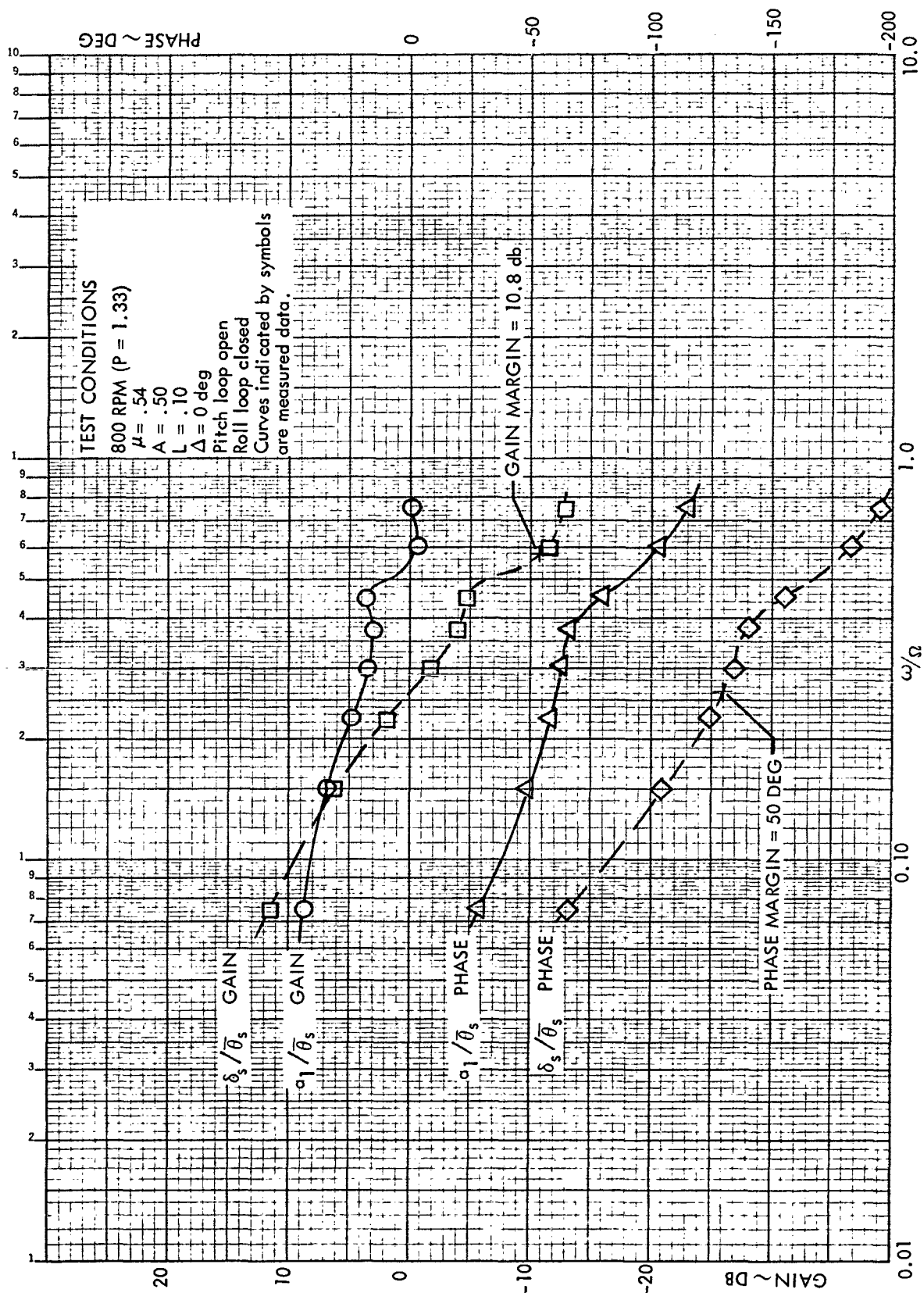


Figure D9. Longitudinal Transfer Functions ($\sigma_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg

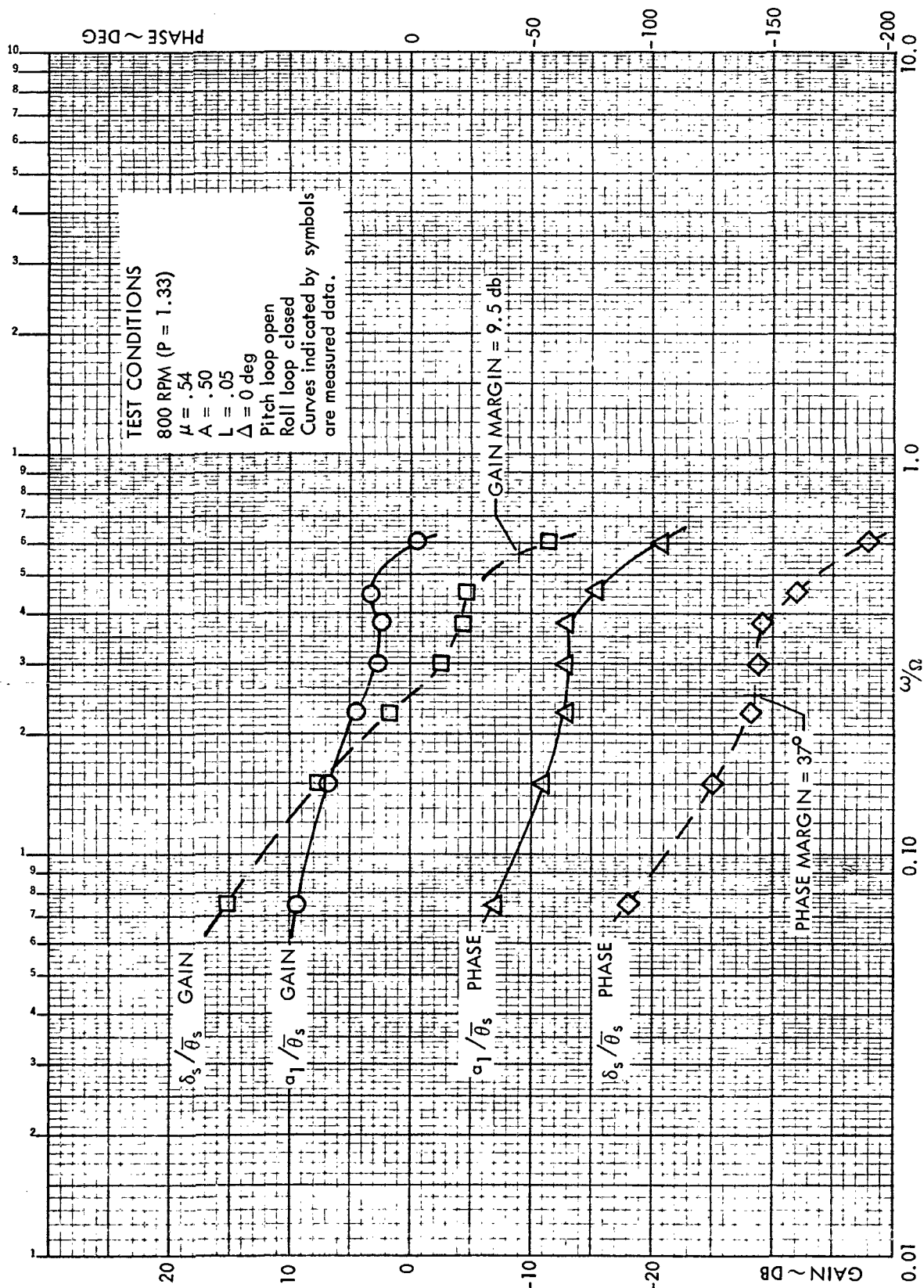


Figure D10. Longitudinal Transfer Functions ($a_1 / \bar{\theta}_s$, $\delta_s / \bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg

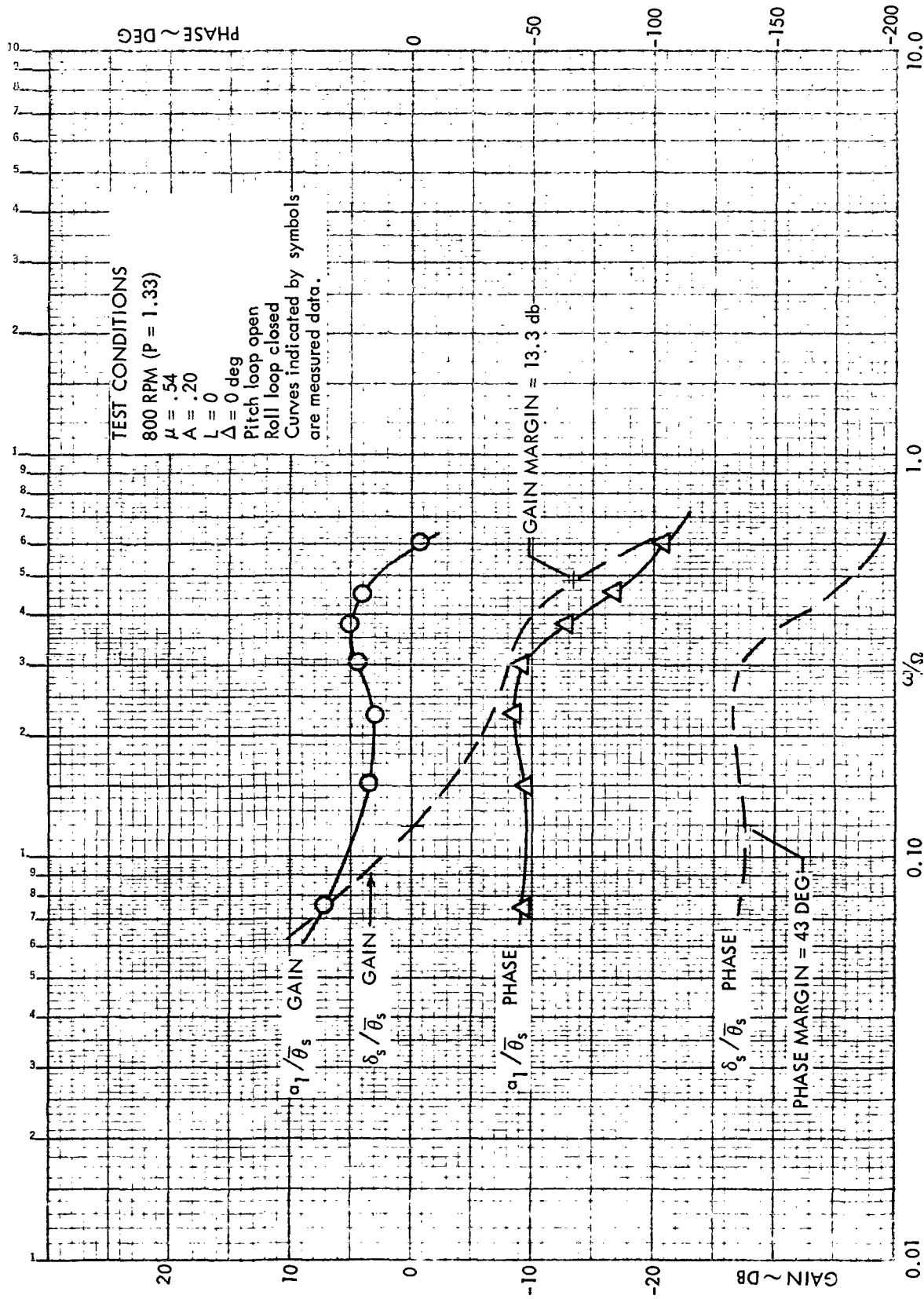


Figure D11. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg

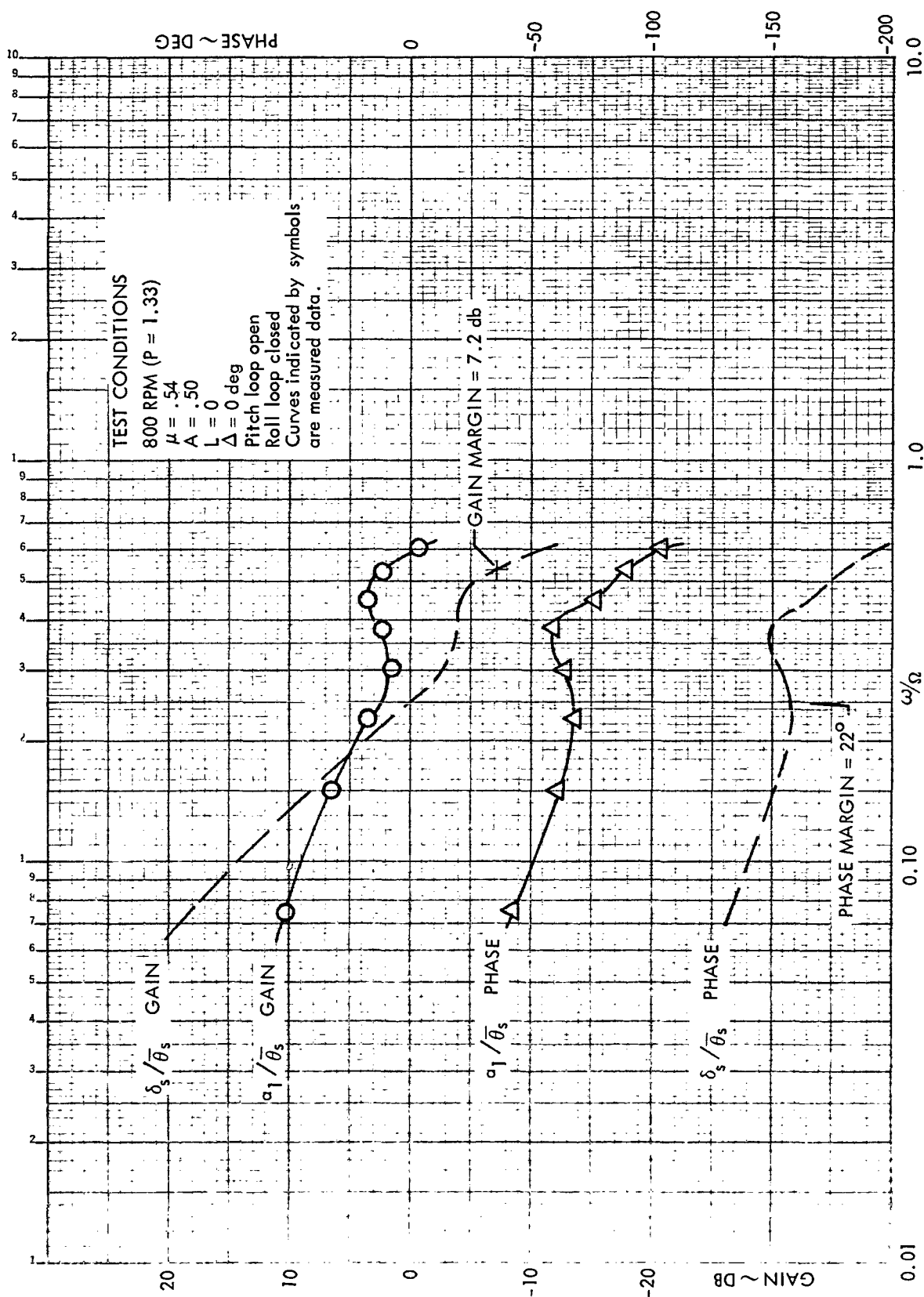


Figure D12. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg

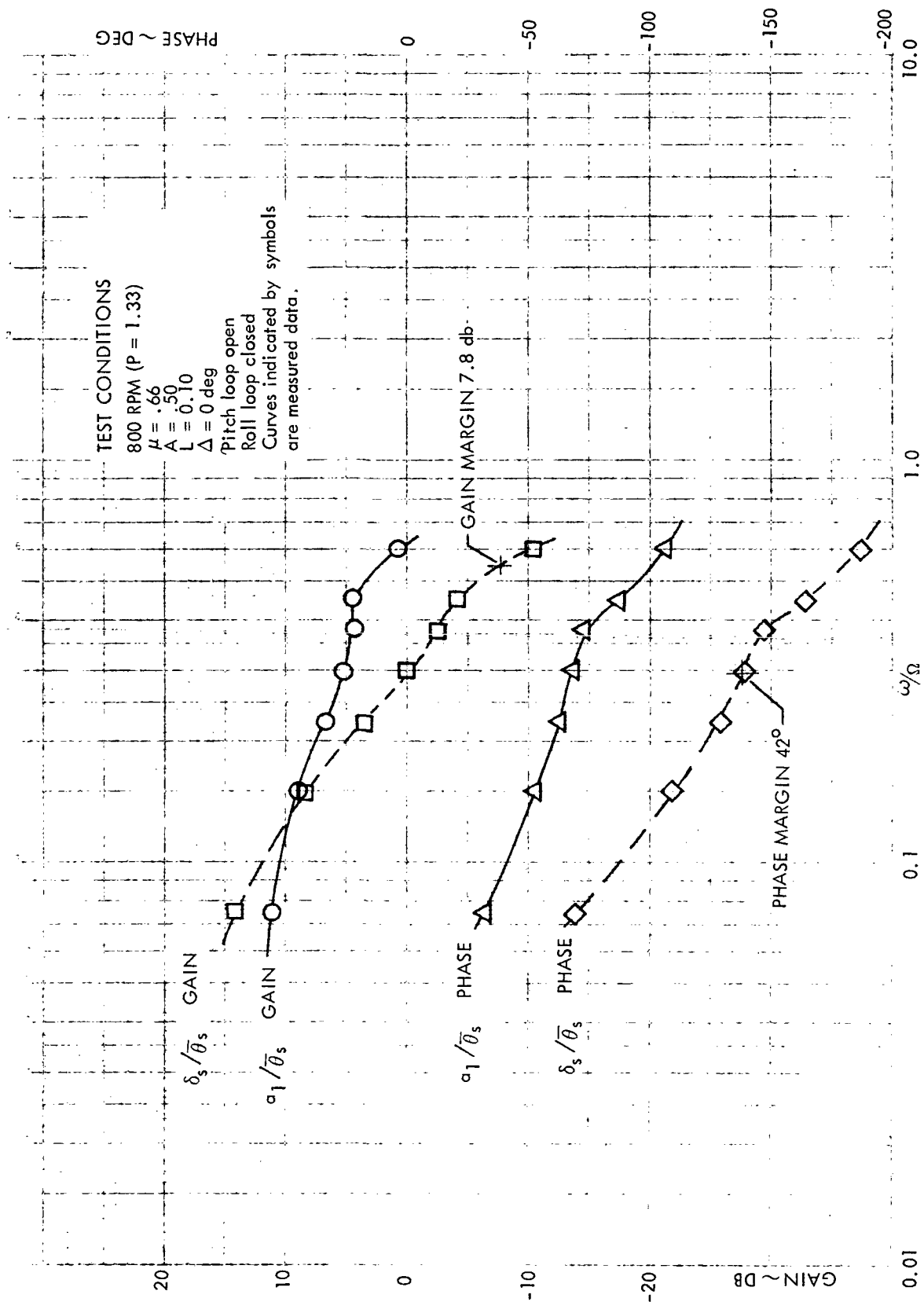


Figure D13. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = .10$, $\Delta = 0$ deg

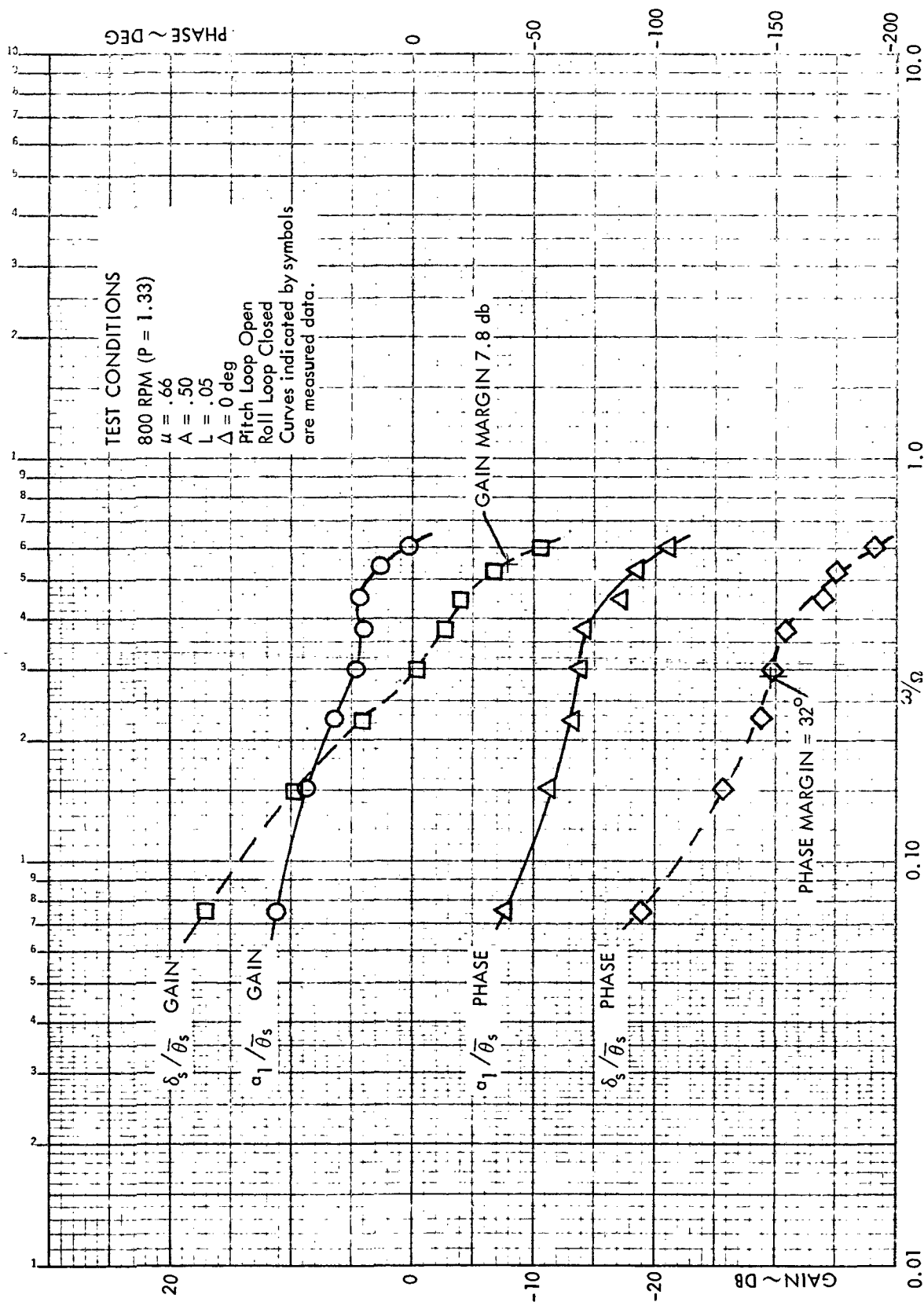


Figure D14. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = .05$, $\Delta = 0$ deg

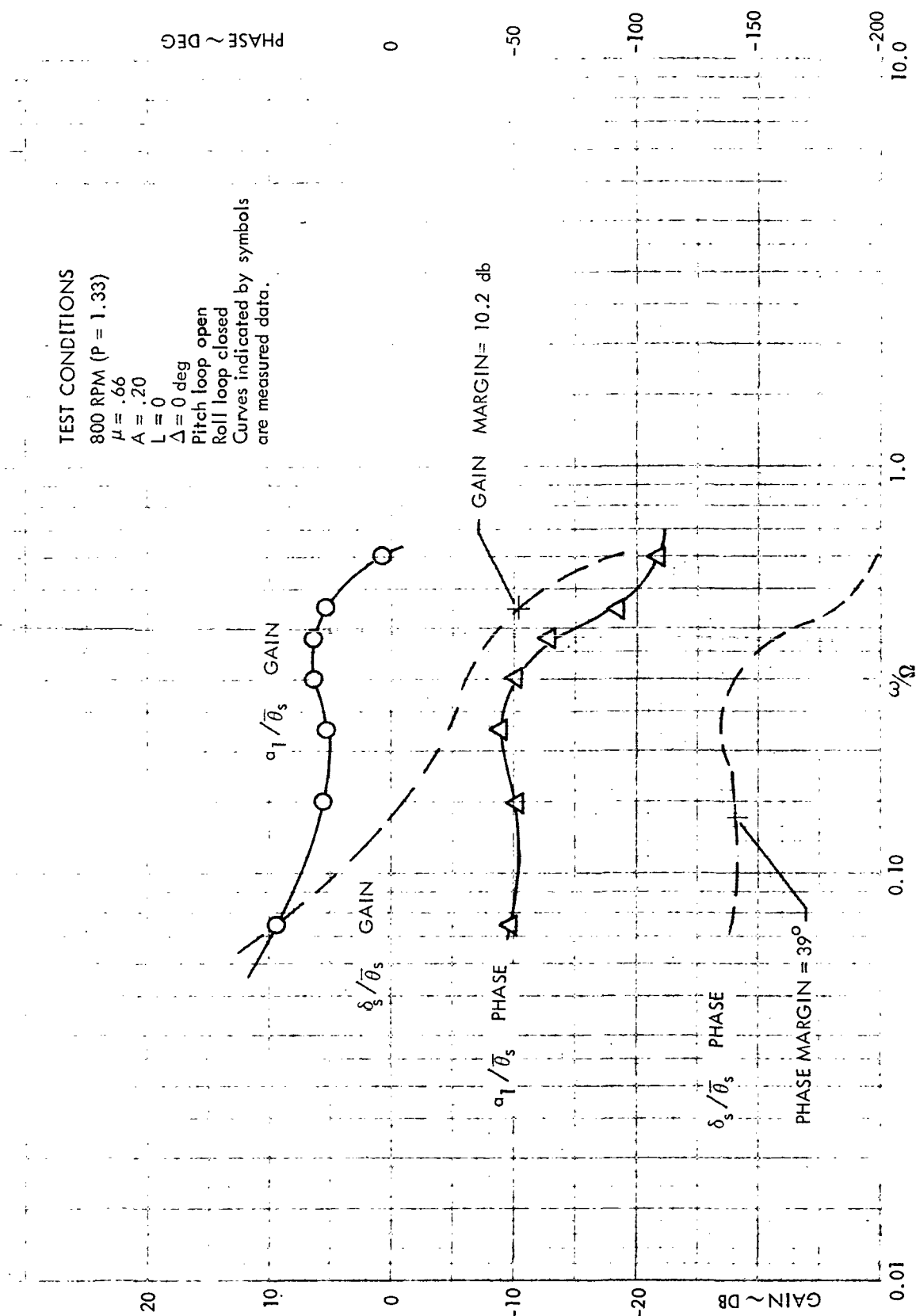


Figure D15. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed,
 $\mu = .66$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg

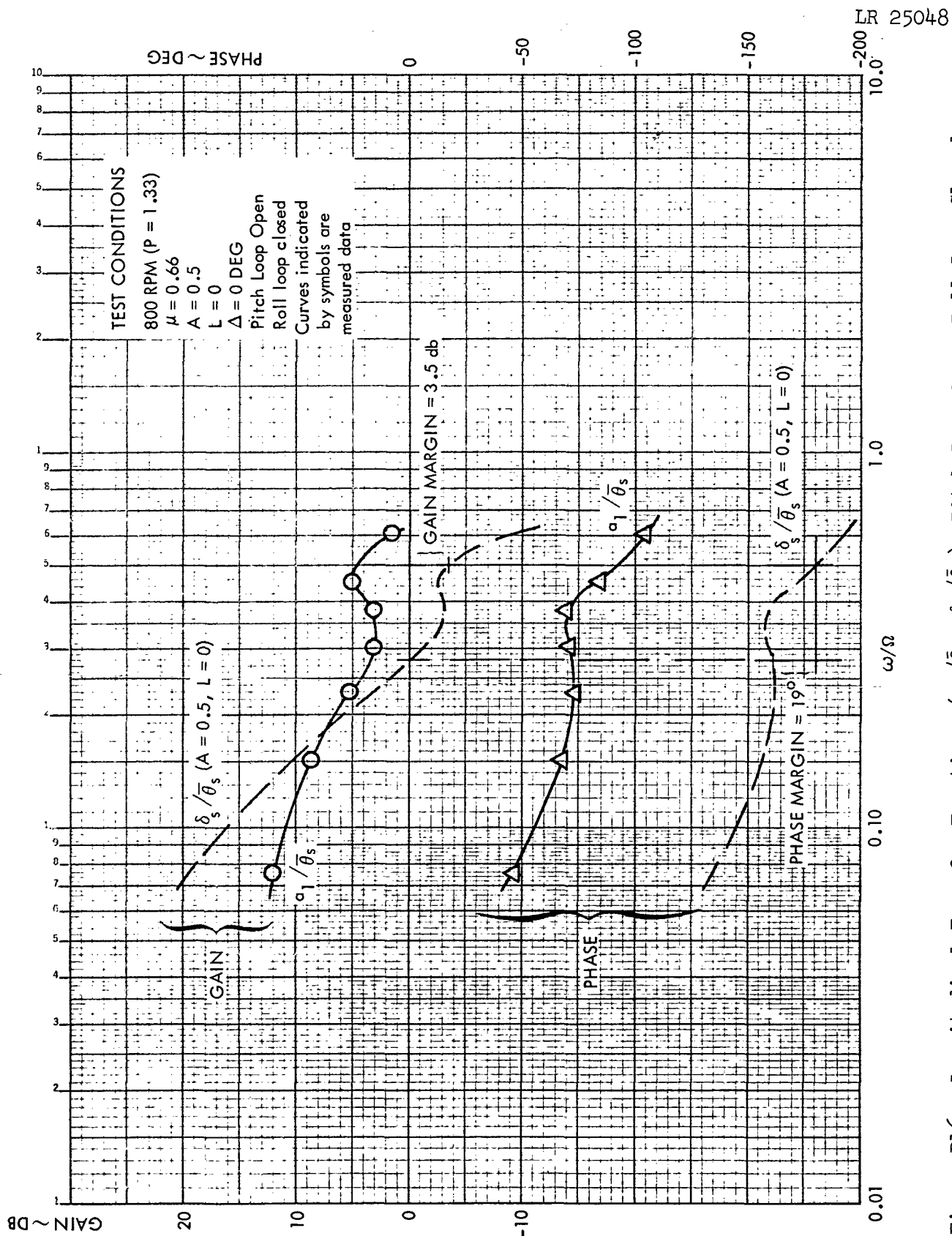


Figure DL6. Longitudinal Transfer Functions ($a_1/\bar{\theta}_s$, $\delta_s/\bar{\theta}_s$), Pitch Loop Open, Roll Loop Closed, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg

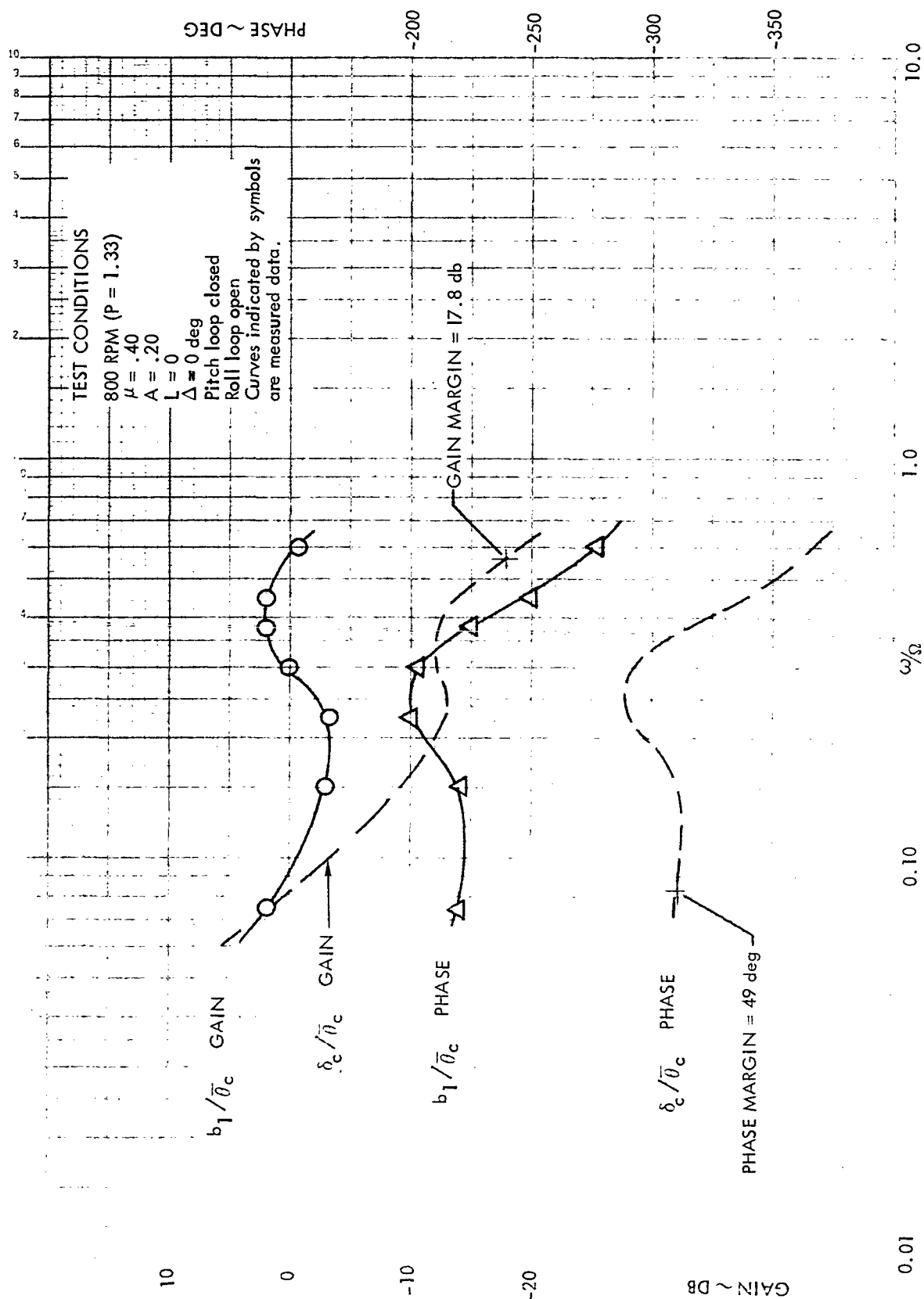


Figure D17. Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open,
 $\mu = .40$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg

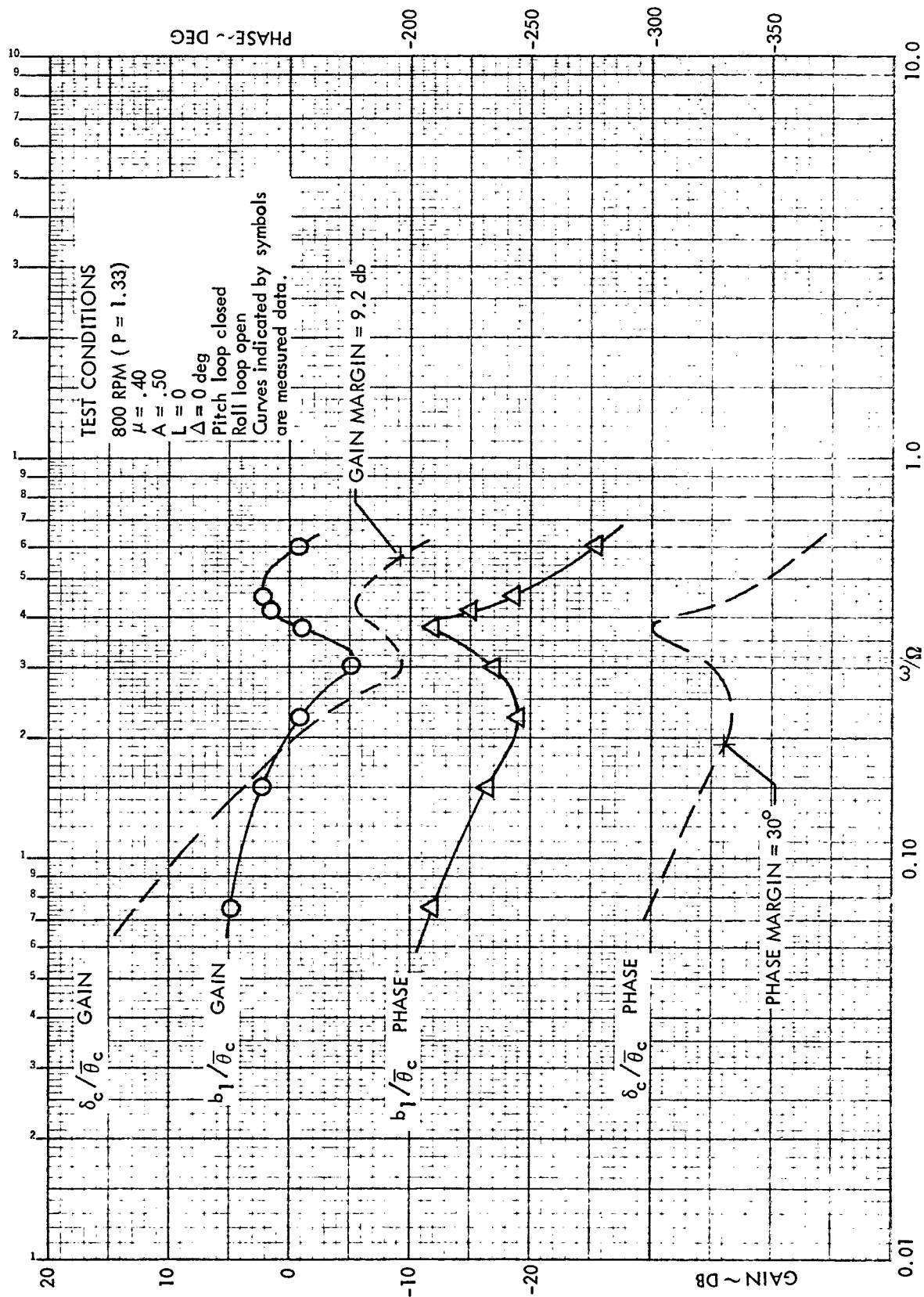


Figure D18. Lateral Transfer Functions ($b_1 / \bar{\theta}_c$, $\delta_c / \bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open,
 $\mu = .40$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg

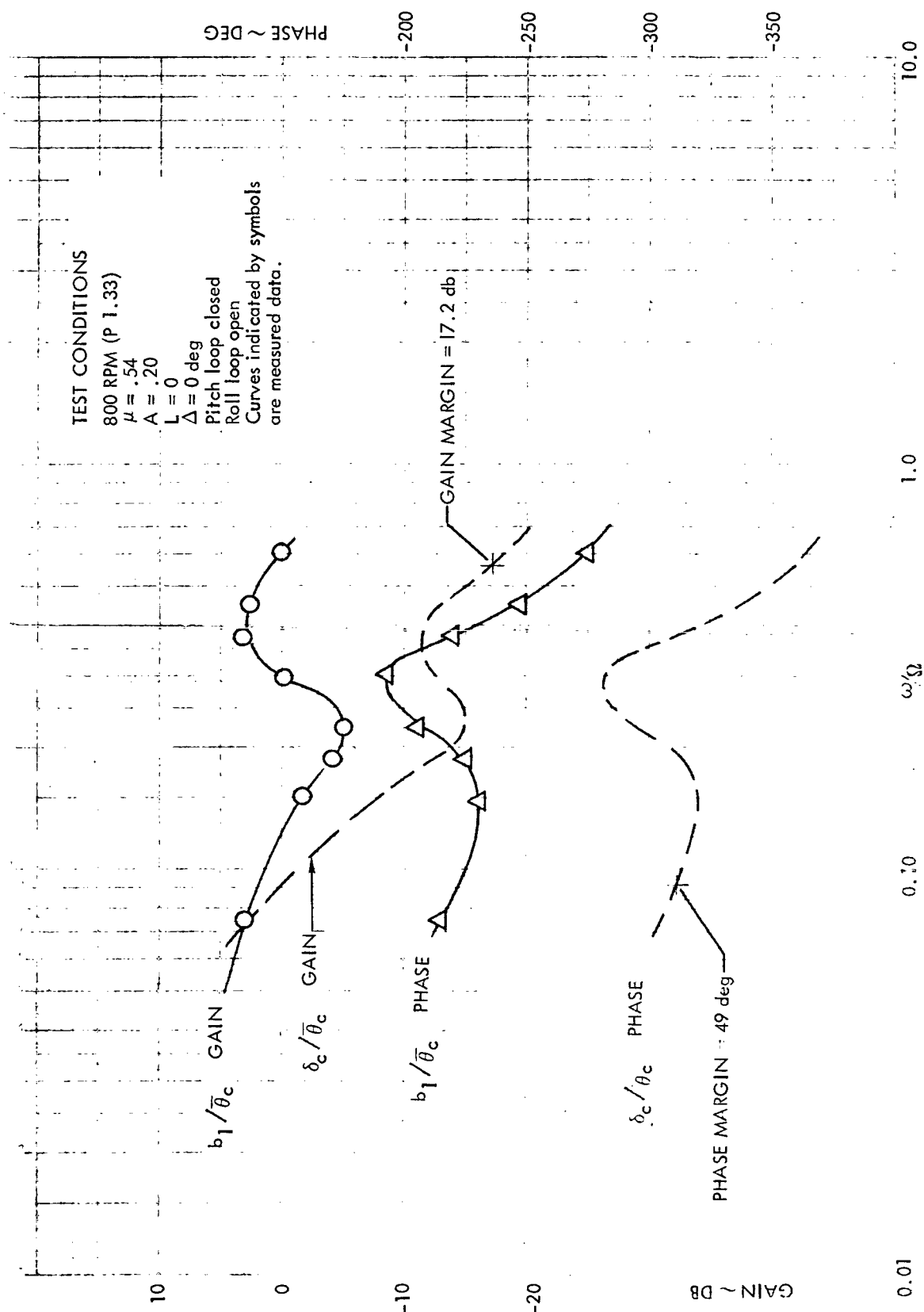


Figure D19. Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .54$, 800 rpm (P = 1.33), $A = .20$, $L = 0$, $\Delta = 0$ deg

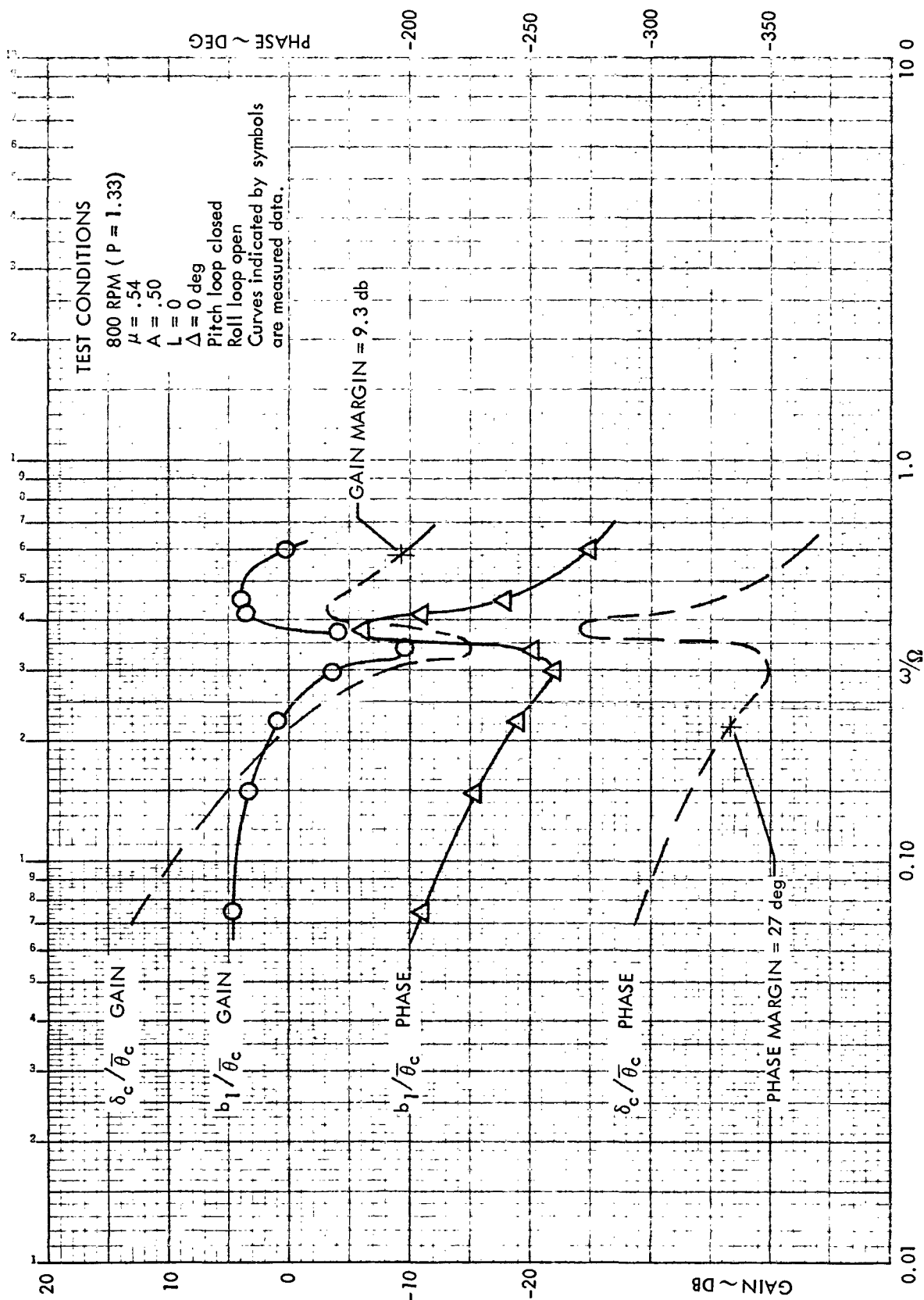


Figure D20. Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .54$, 800 rpm (P = 1.33), A = .50, L = 0, $\Delta = 0$ deg

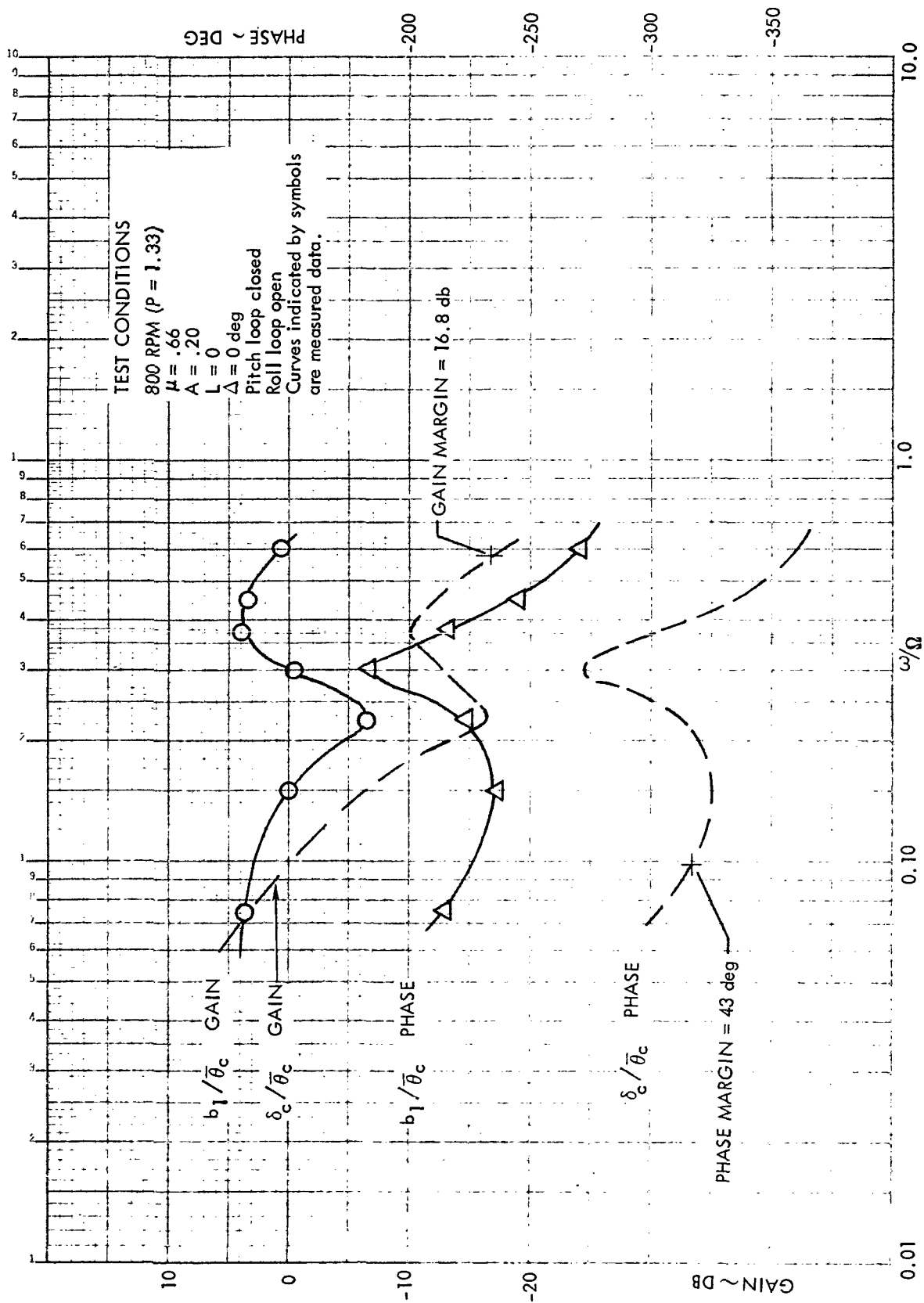


Figure D21. Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open,
 $\mu = .66$, 800 rpm ($P = 1.33$), $A = .20$, $L = 0$, $\Delta = 0$ deg

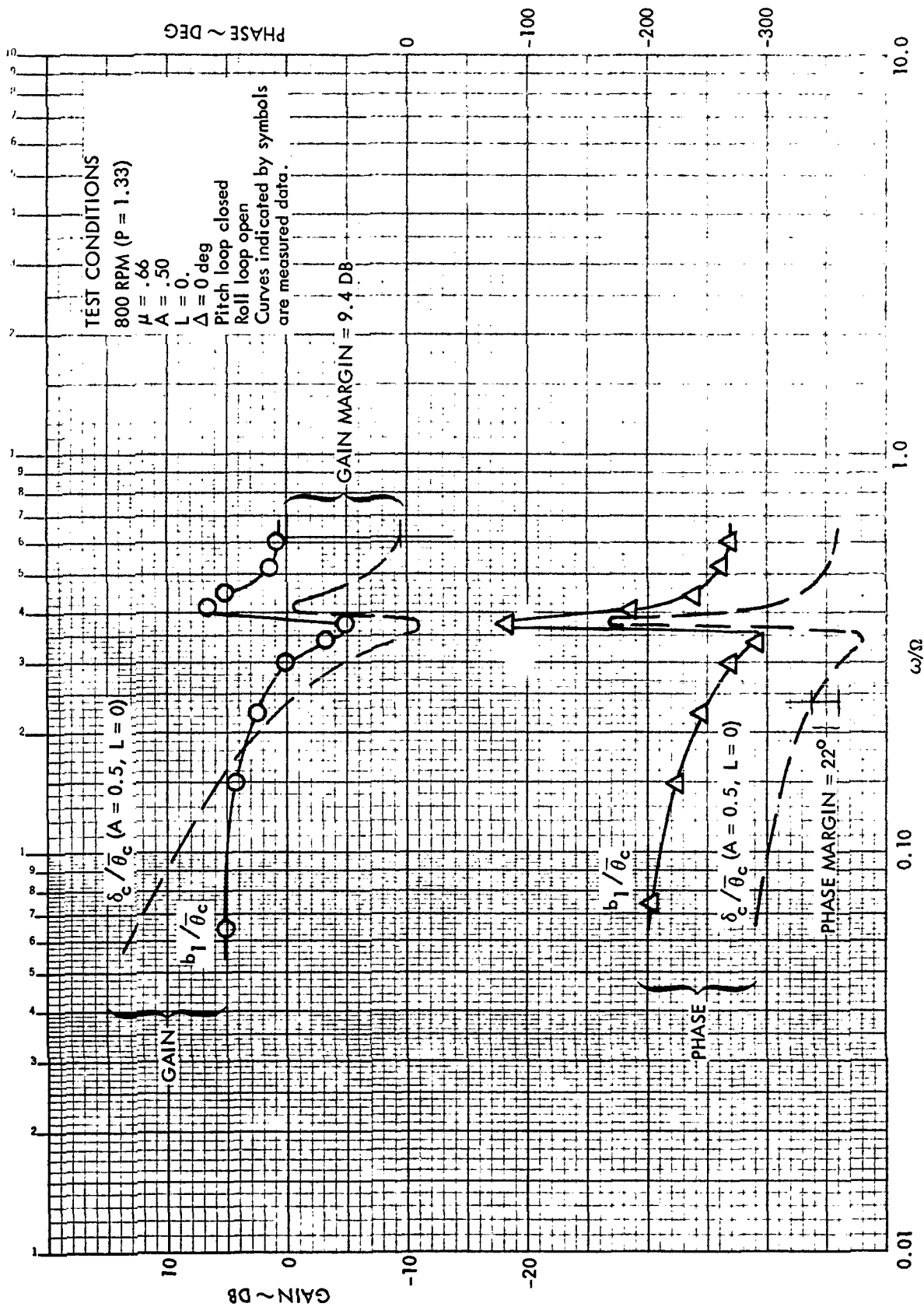


Figure D22. Lateral Transfer Functions ($b_1/\bar{\theta}_c$, $\delta_c/\bar{\theta}_c$), Pitch Loop Closed, Roll Loop Open, $\mu = .66$, 800 rpm ($P = 1.33$), $A = .50$, $L = 0$, $\Delta = 0$ deg

APPENDIX E

EXPERIMENTAL CLOSED LOOP STEADY STATE AND FREQUENCY RESPONSE DATA

Closed loop rotor frequency response data with respect to θ_o , $\bar{\theta}_s$, θ_{long} and θ_{lat} are plotted in Figures E1 to E14. The tests were conducted at advance ratios of 0.29 and 0.54 at a rotor speed of 800 RPM with the following control system parameter combination.

$$A = 0.5$$

$$L = 0$$

$$\Delta = 0 \text{ deg}$$

$$\Gamma = 0 \text{ deg}$$

Closed loop steady state test data are plotted in Figures E15 to E42. The data were recorded at advance ratios from 0.29 to 1.44, nondimensional flapping frequencies of 1.33 and 2.32 for several combinations of control system parameters.

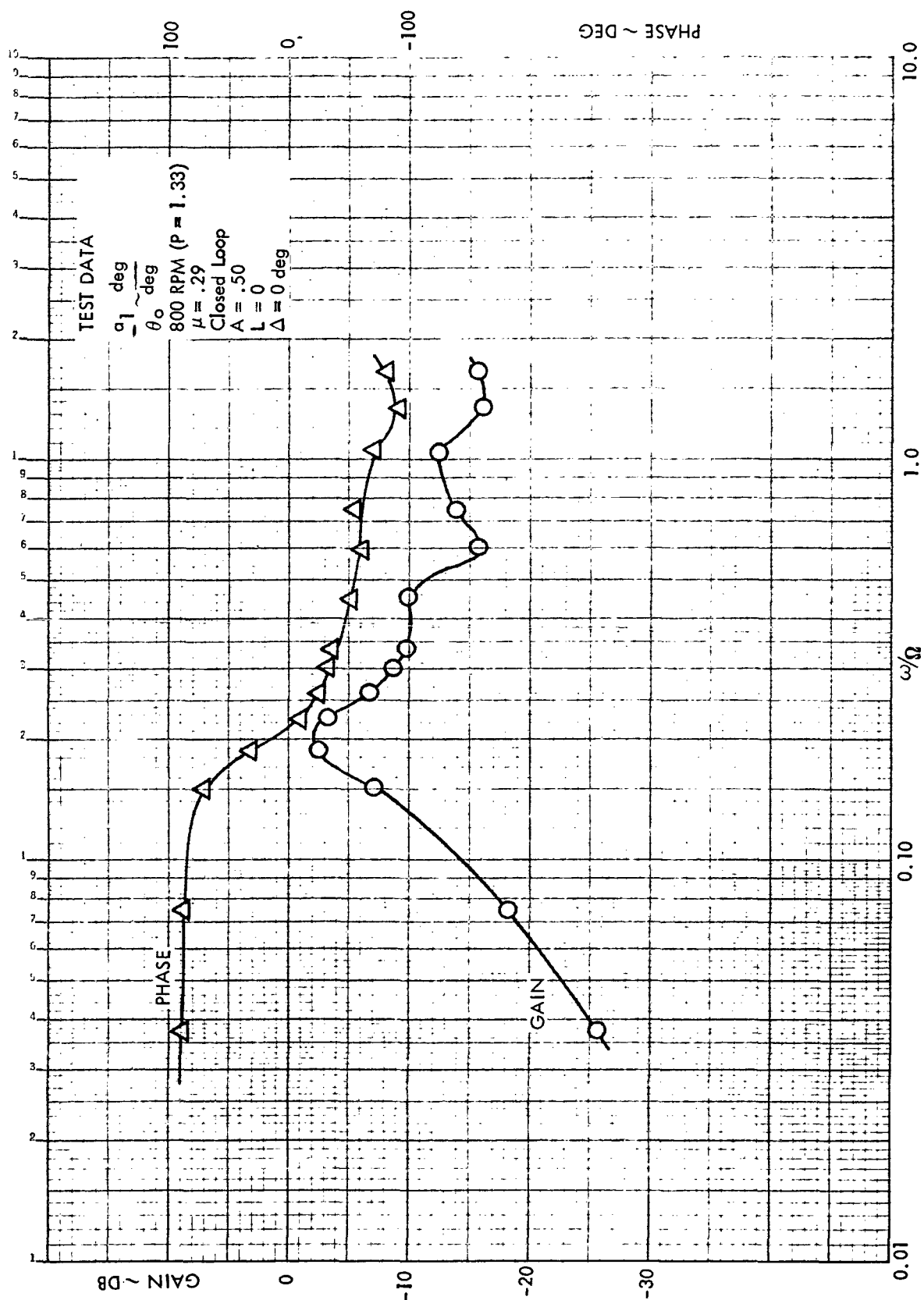


Figure E1. Closed Loop Rotor Longitudinal Frequency Response to θ_0 ,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg

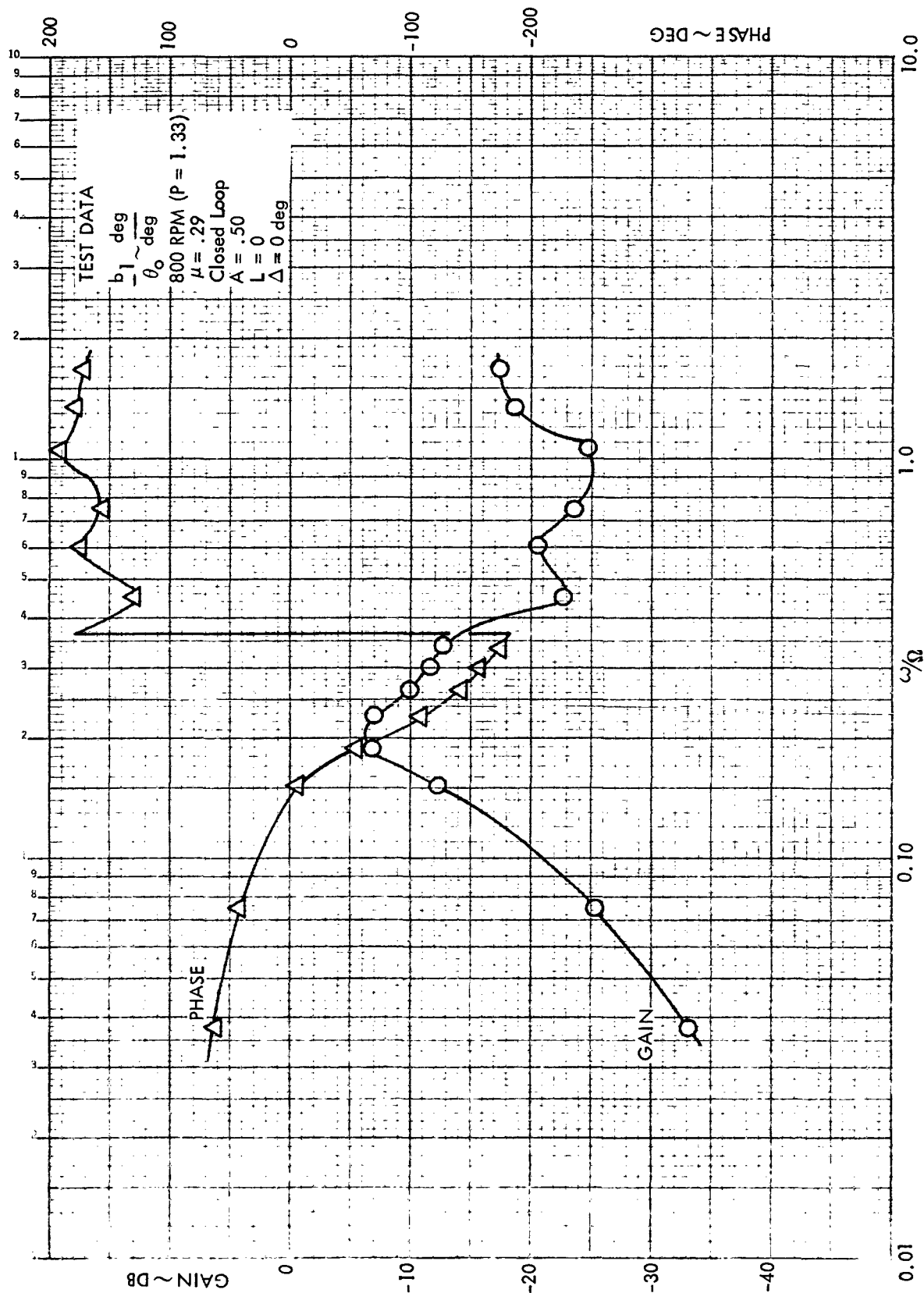


Figure E2. Closed Loop Rotor Lateral Frequency Response to θ_o ,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0 \text{ deg}$

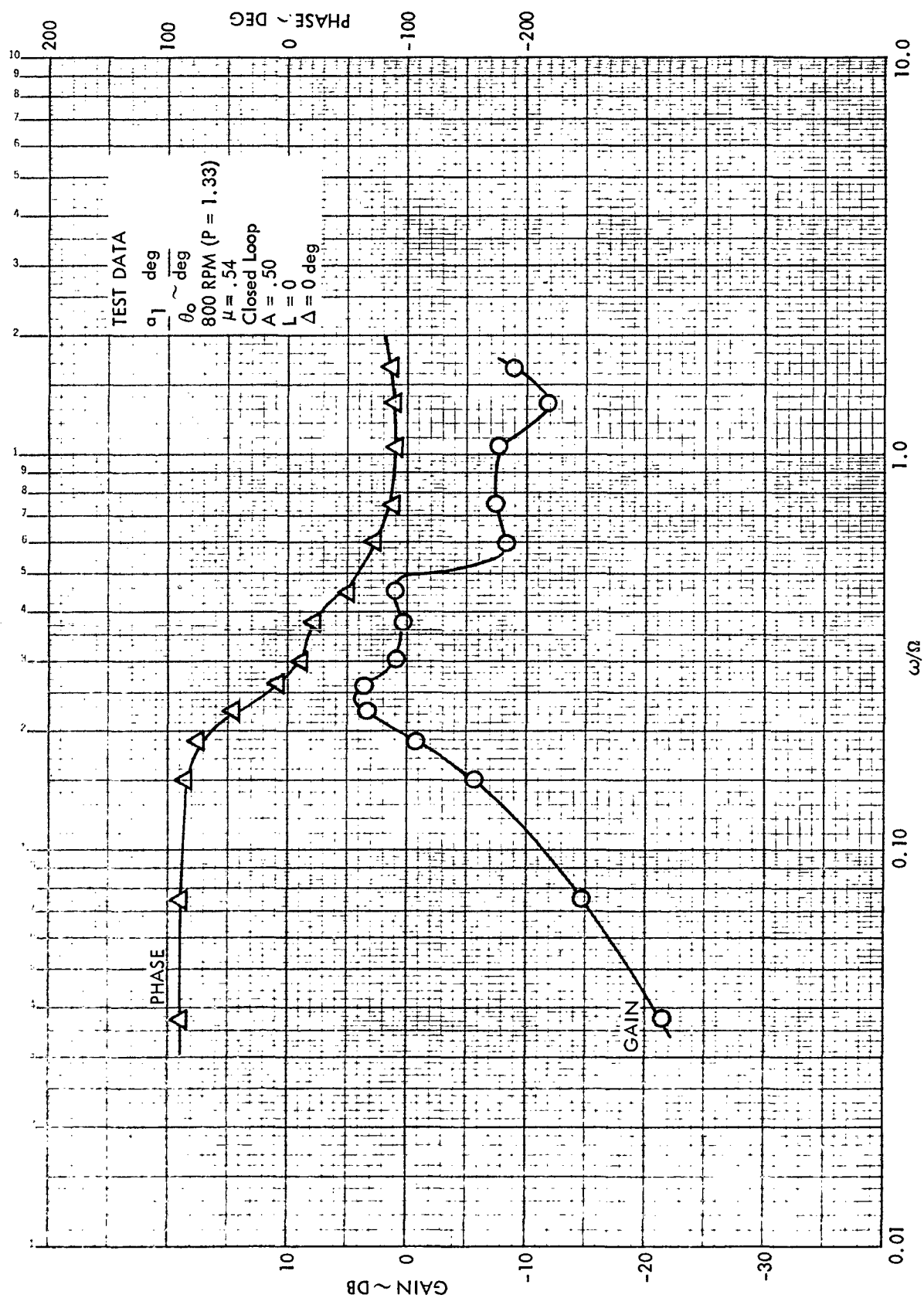


Figure E3. Closed Loop Rotor Longitudinal Frequency Response to θ_0 ,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg

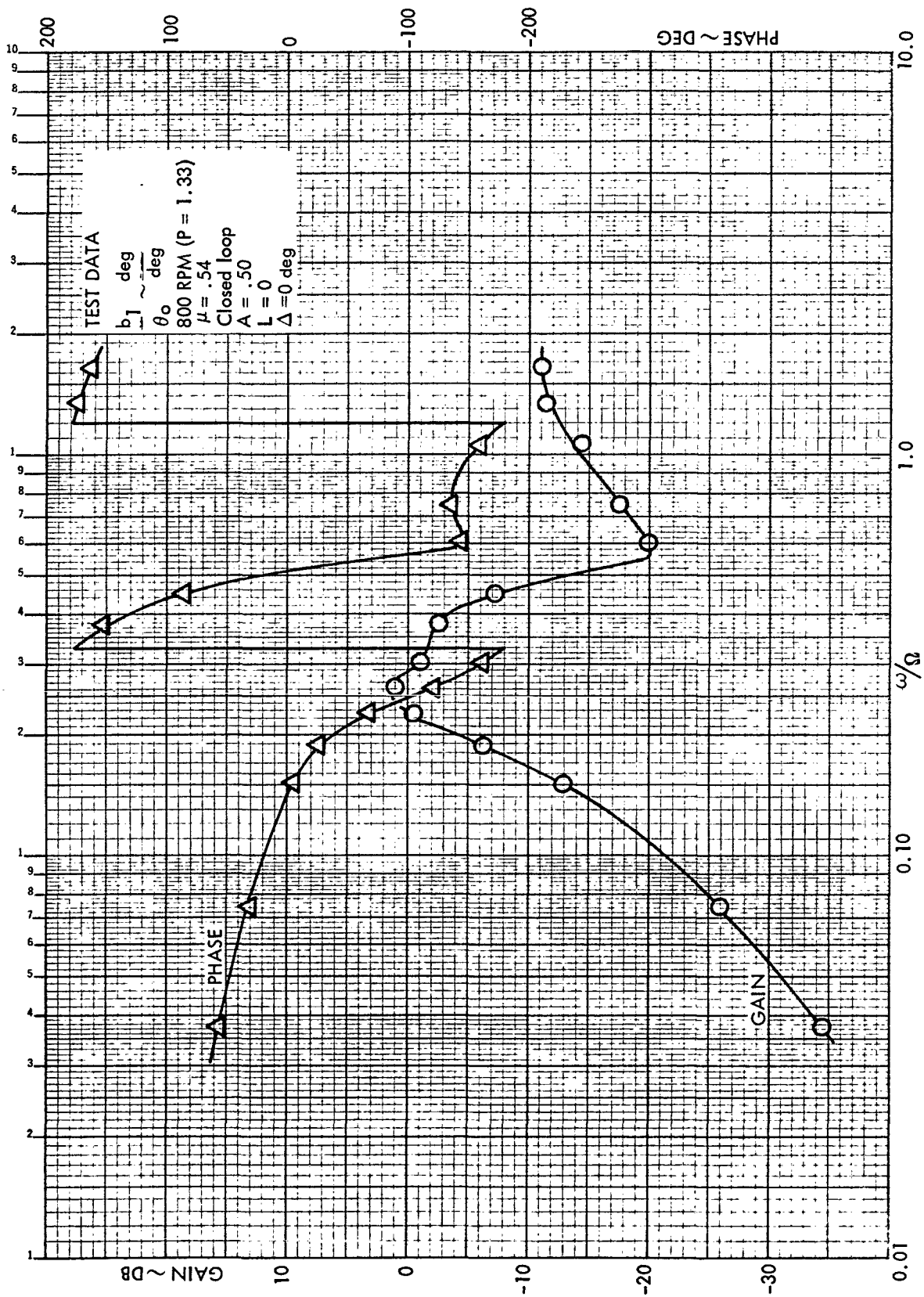


Figure E4. Closed Loop Rotor Lateral Frequency Response to θ_o ,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg

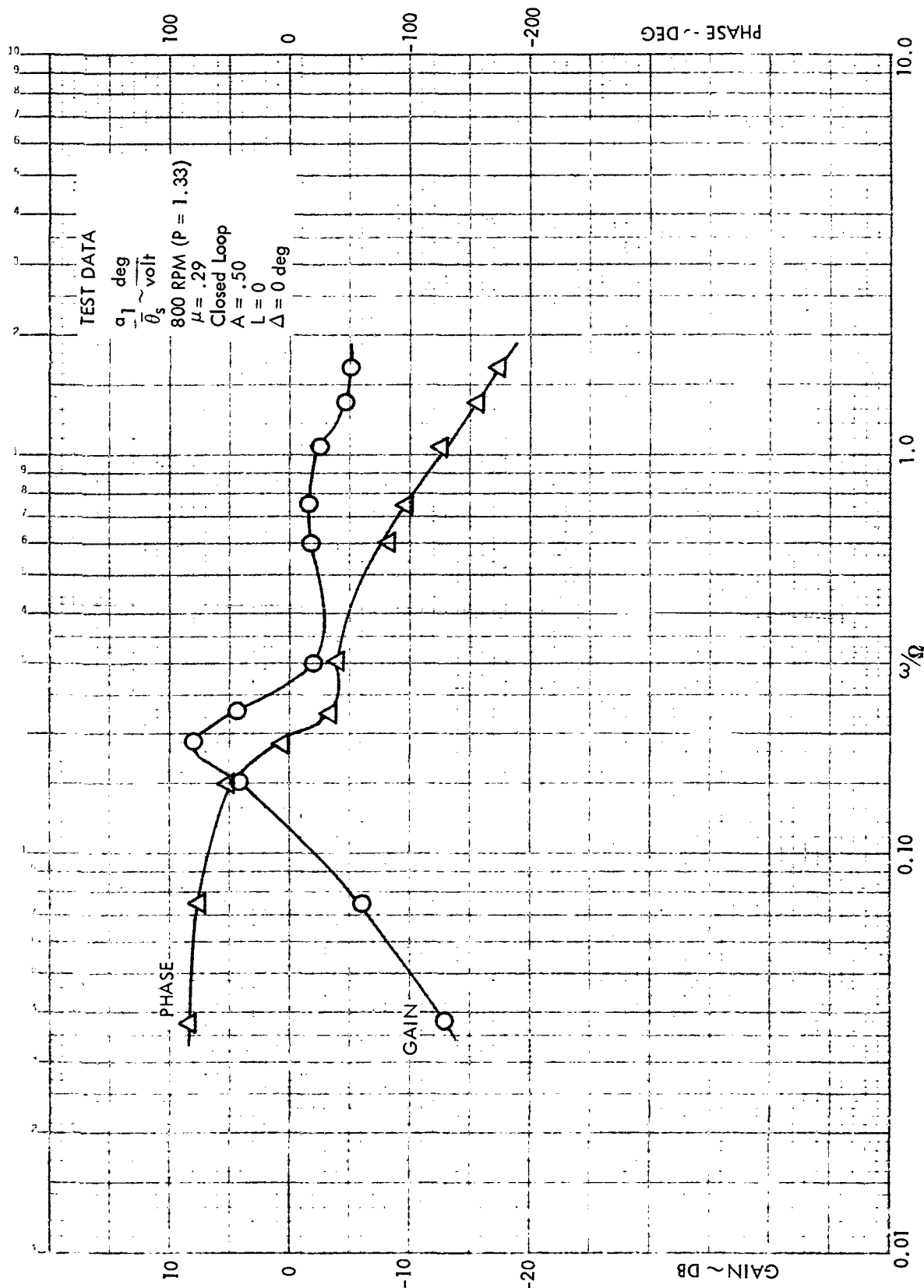


Figure E5. Closed Loop Rotor Longitudinal Frequency Response to $\bar{\theta}_s$, $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg

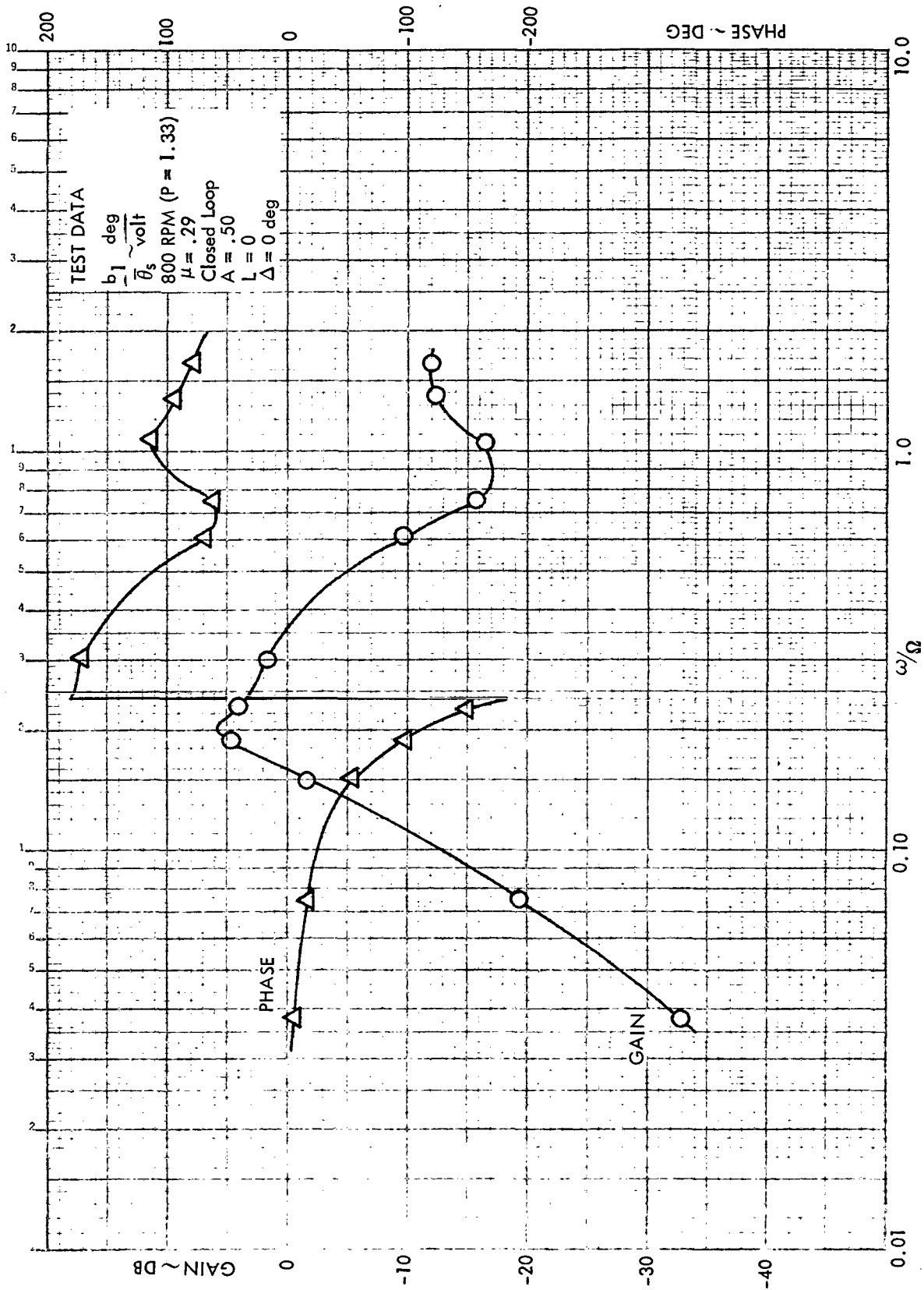


Figure E6. Closed Loop Rotor Lateral Frequency Response to $\bar{\theta}_s$,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0 \text{ deg}$

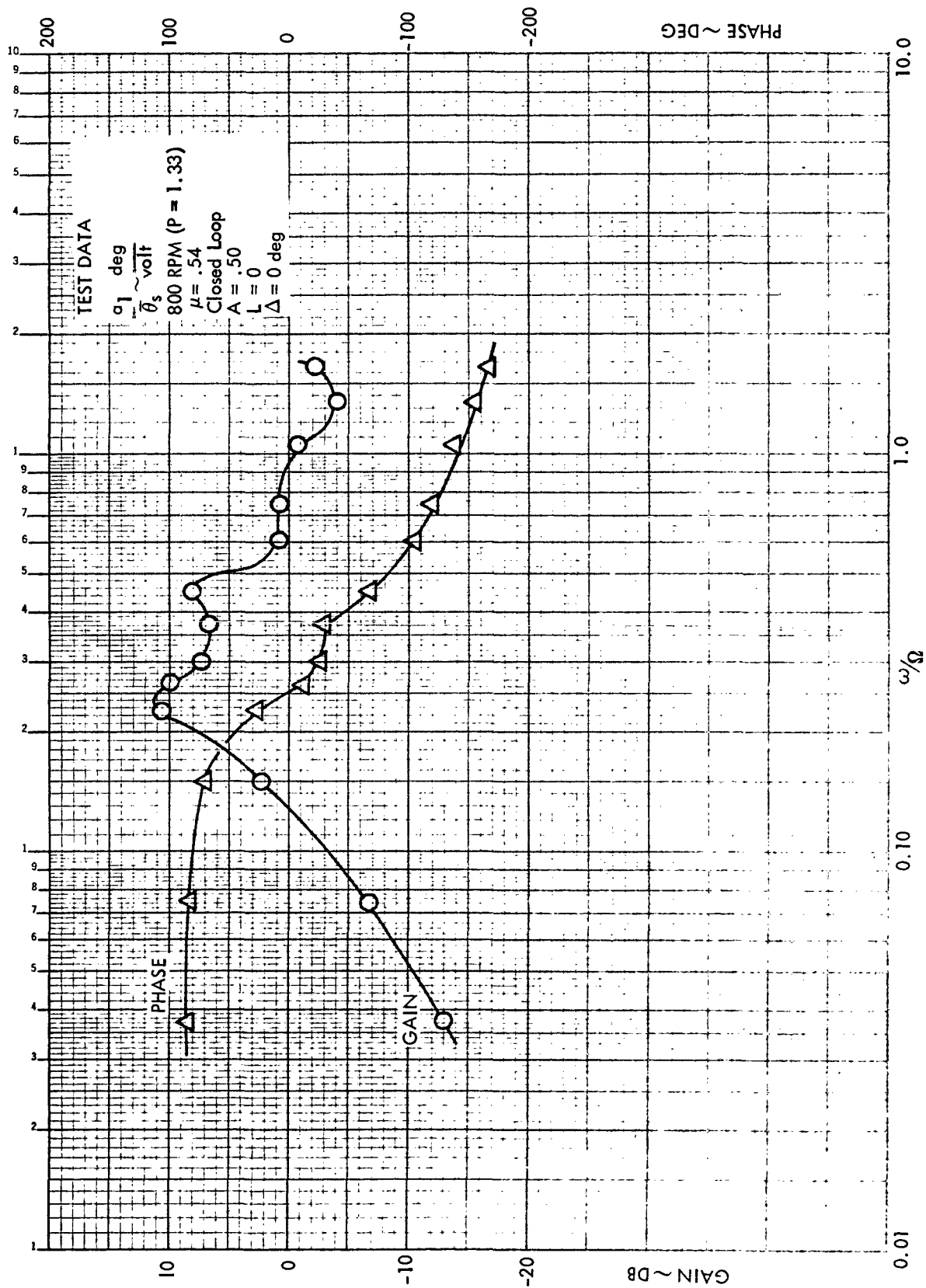


Figure E7. Closed Loop Rotor Longitudinal Frequency Response to $\bar{\theta}_s$,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg

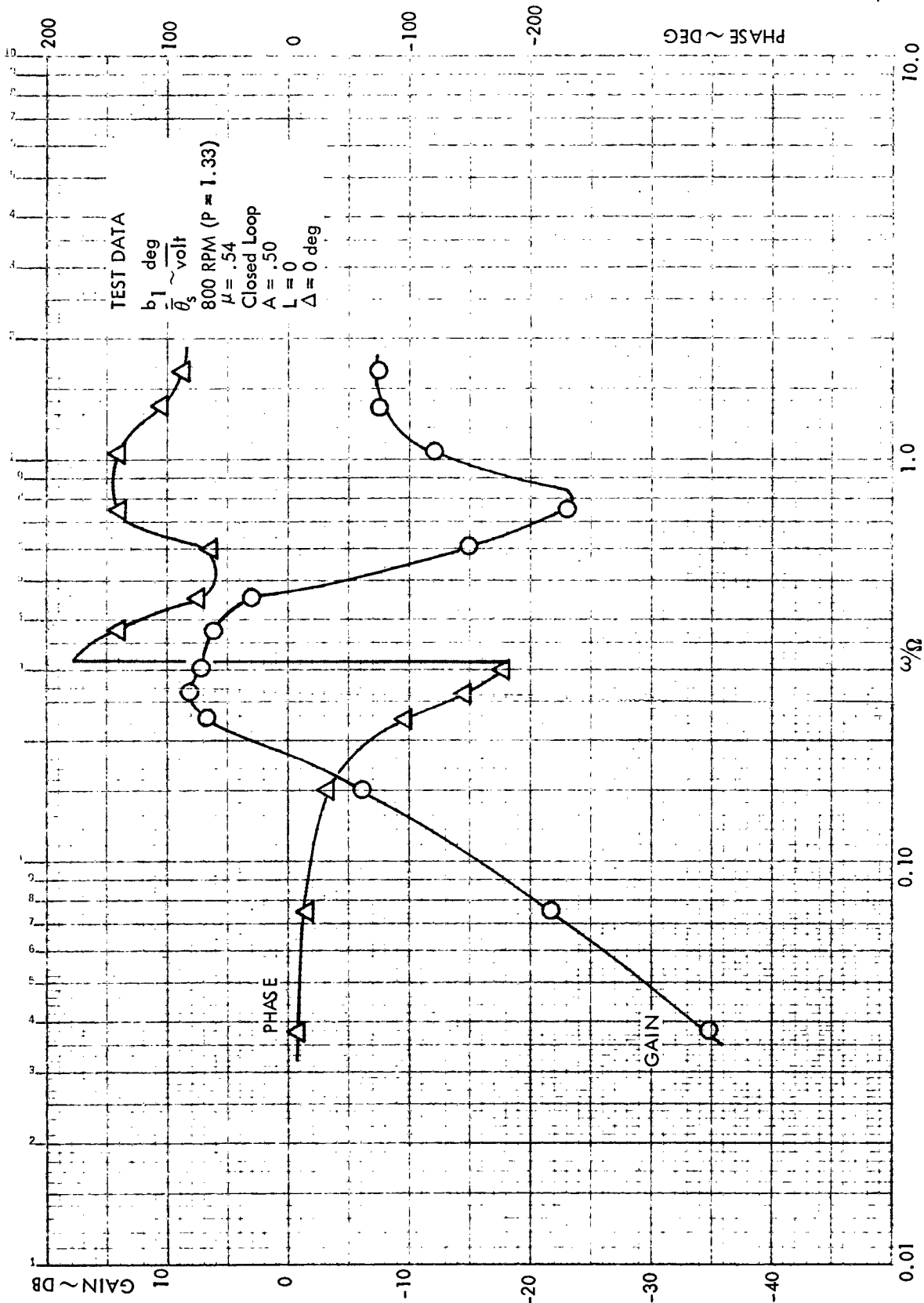


Figure E8. Closed Loop Rotor Lateral Frequency Response to $\bar{\theta}_s$,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0 \text{ deg}$

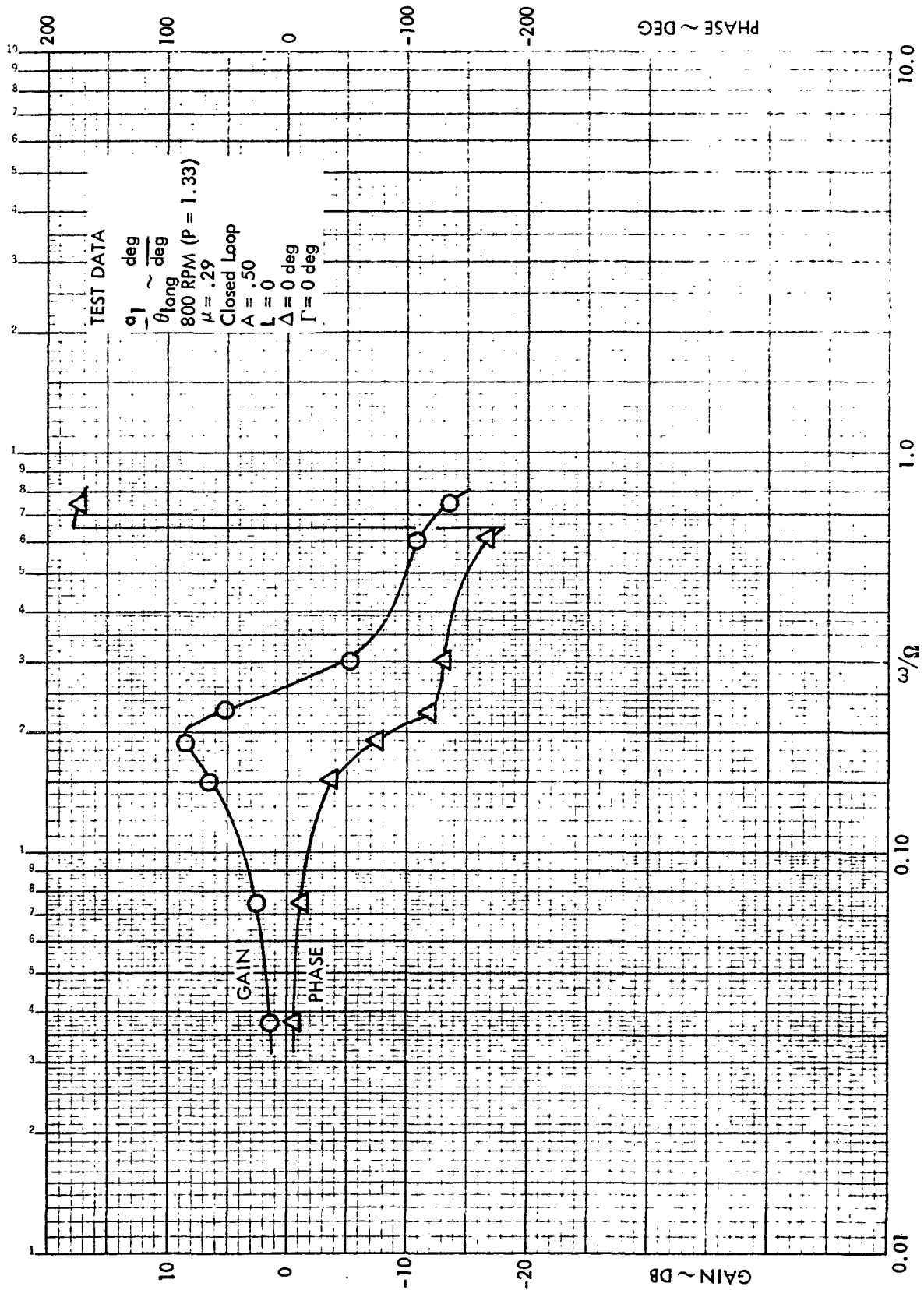


Figure E9. Closed Loop Rotor Longitudinal Frequency Response to θ_{long} ,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0 \text{ deg}$, $\Gamma = 0 \text{ deg}$

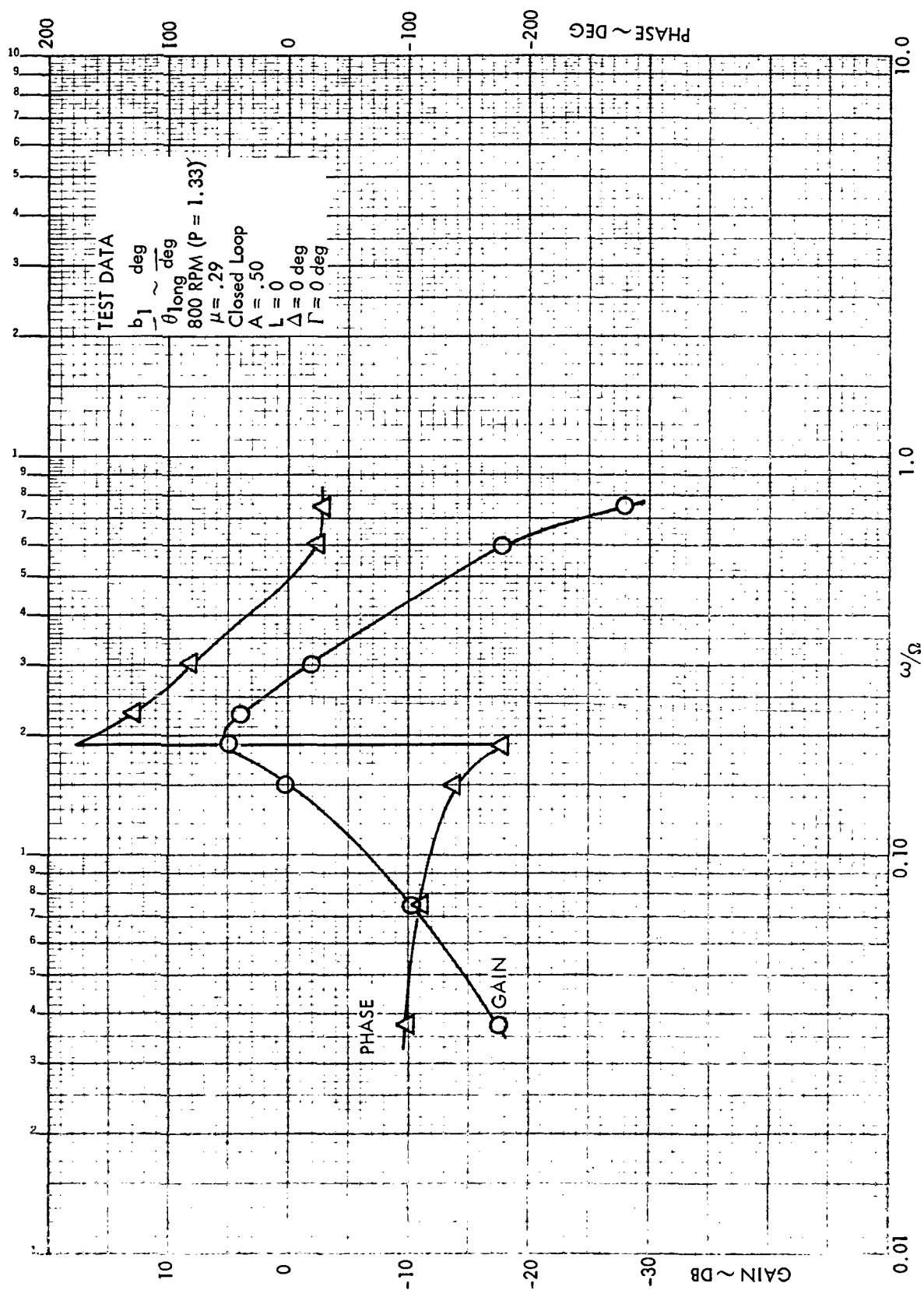


Figure E10. Closed Loop Rotor Lateral Frequency Response to θ_{long} ,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0 \text{ deg}$, $\Gamma = 0 \text{ deg}$

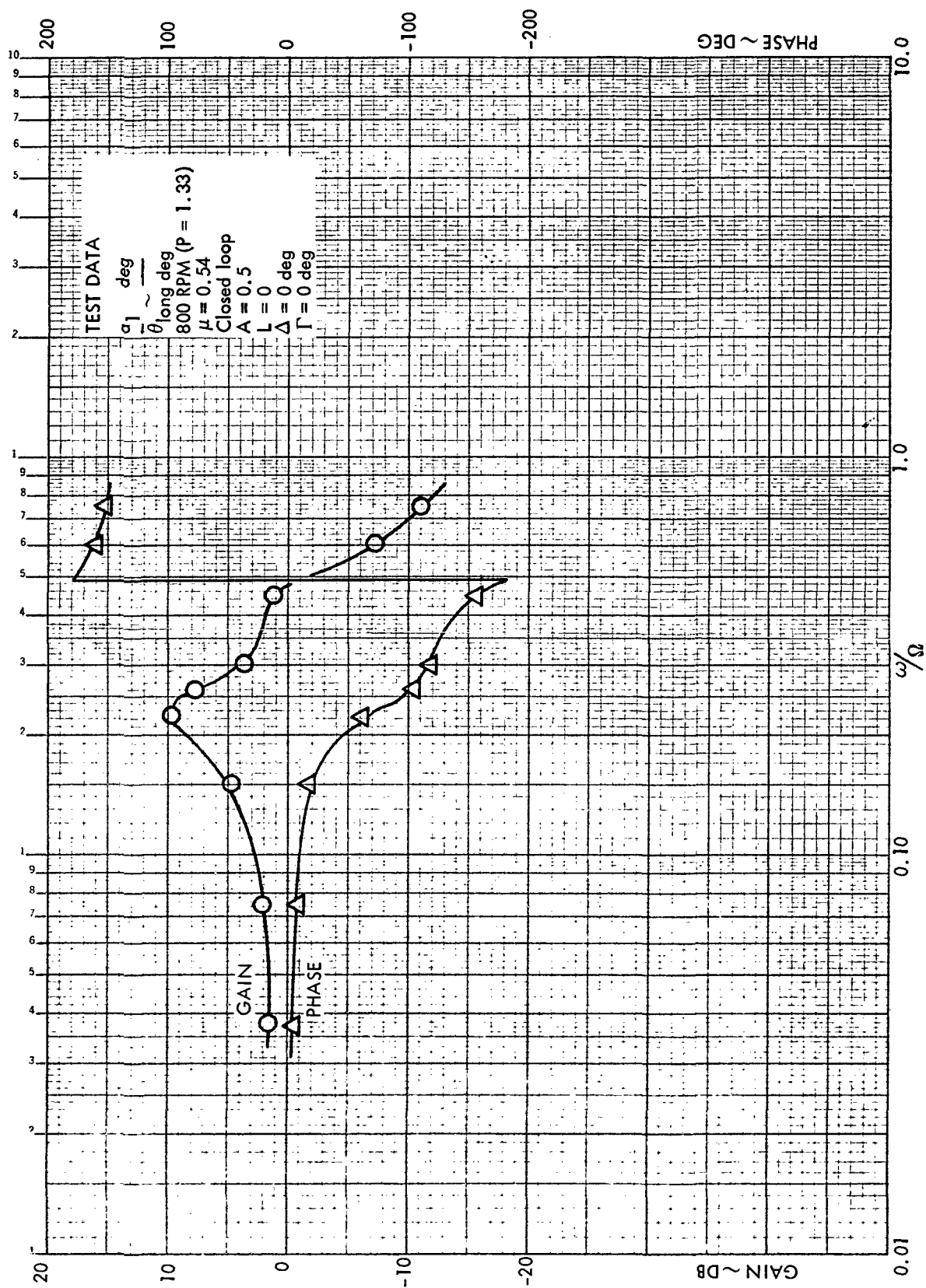


Figure E11. Closed Loop Rotor Longitudinal Frequency Response to θ_{long} ,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg

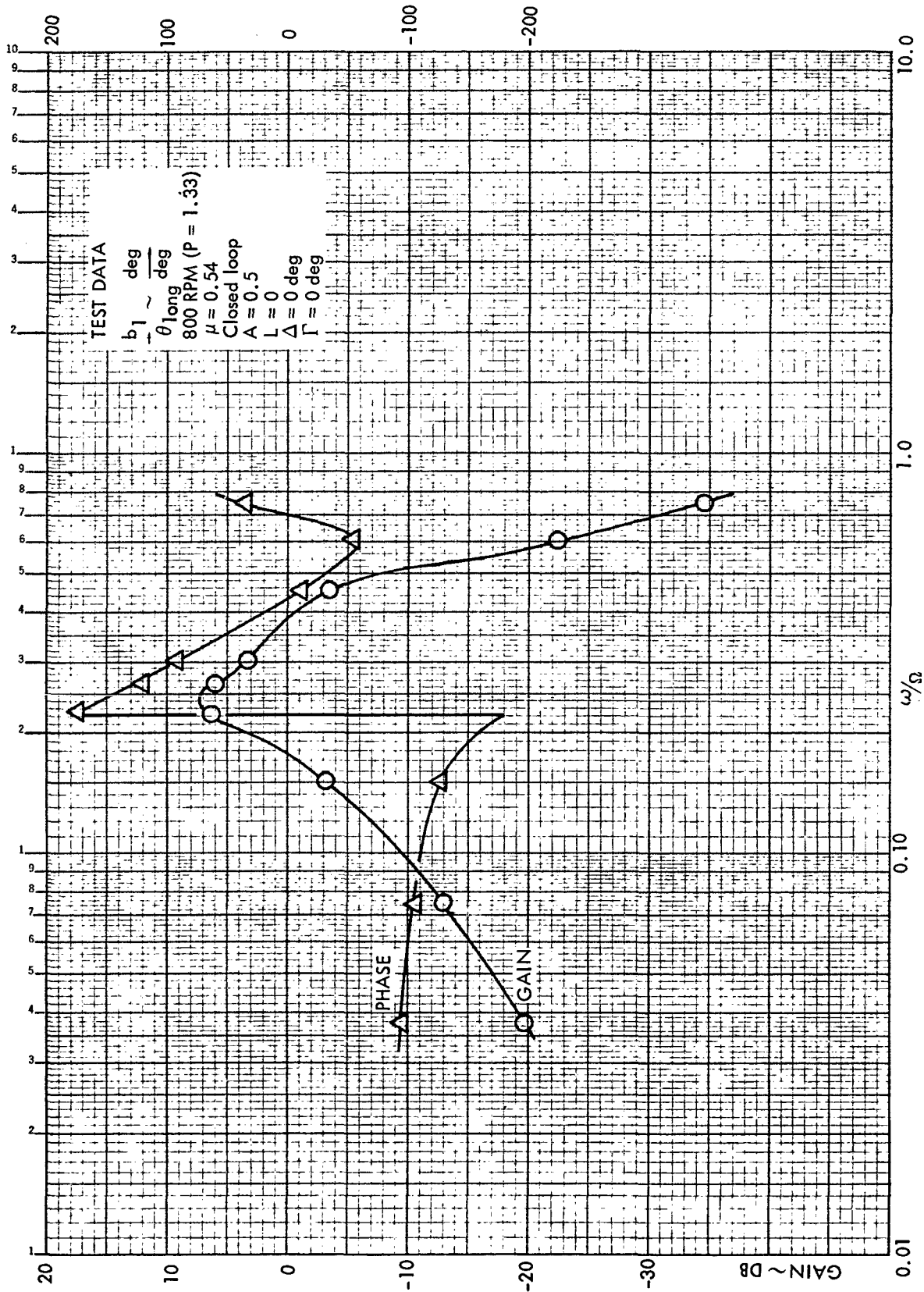


Figure E12. Closed Loop Rotor Lateral Frequency Response to θ_{long} , $\mu = .54$,
800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0 \text{ deg}$, $\Gamma = 0 \text{ deg}$

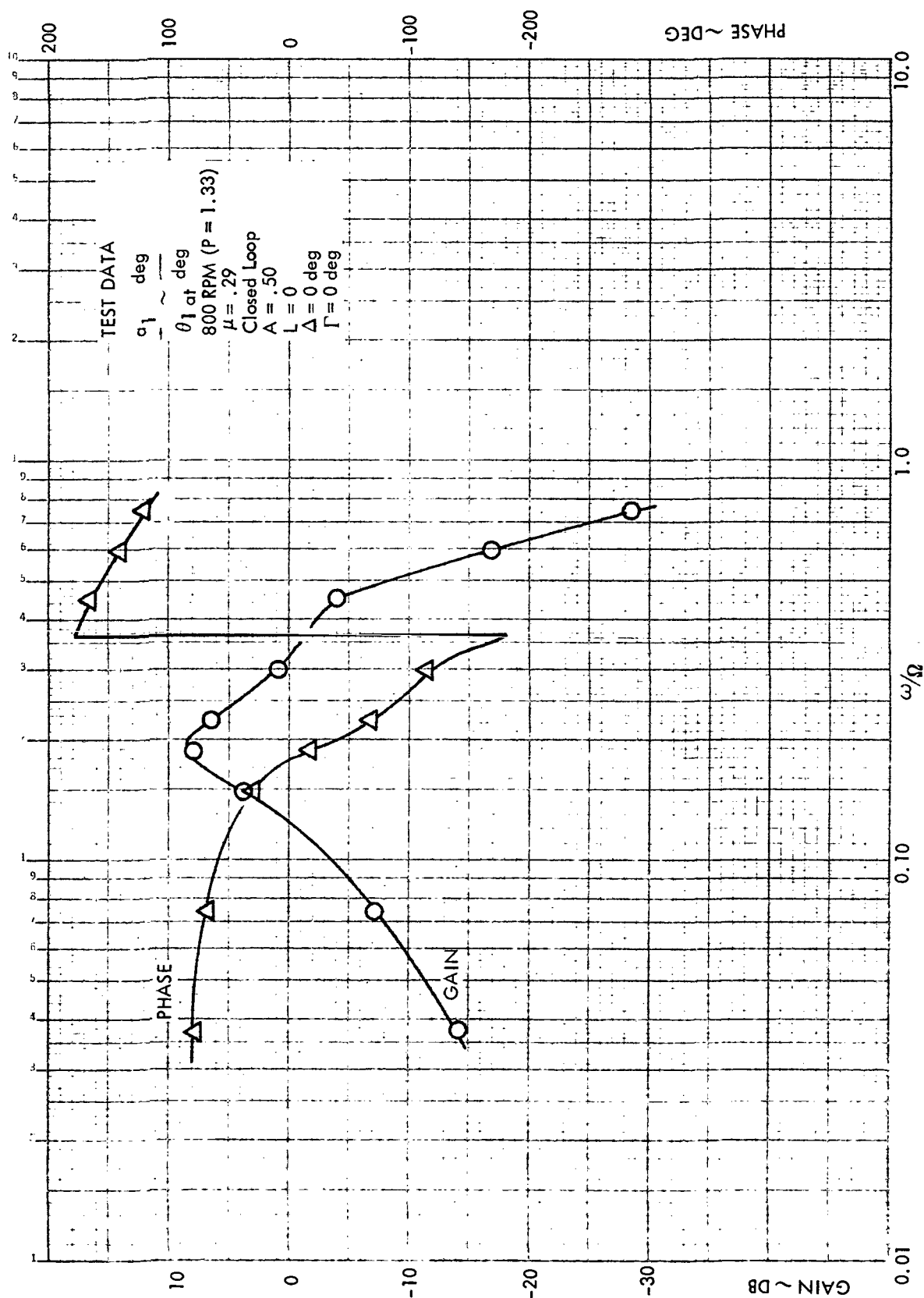


Figure E13. Closed Loop Rotor Longitudinal Frequency Response to θ_{lat} , $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg

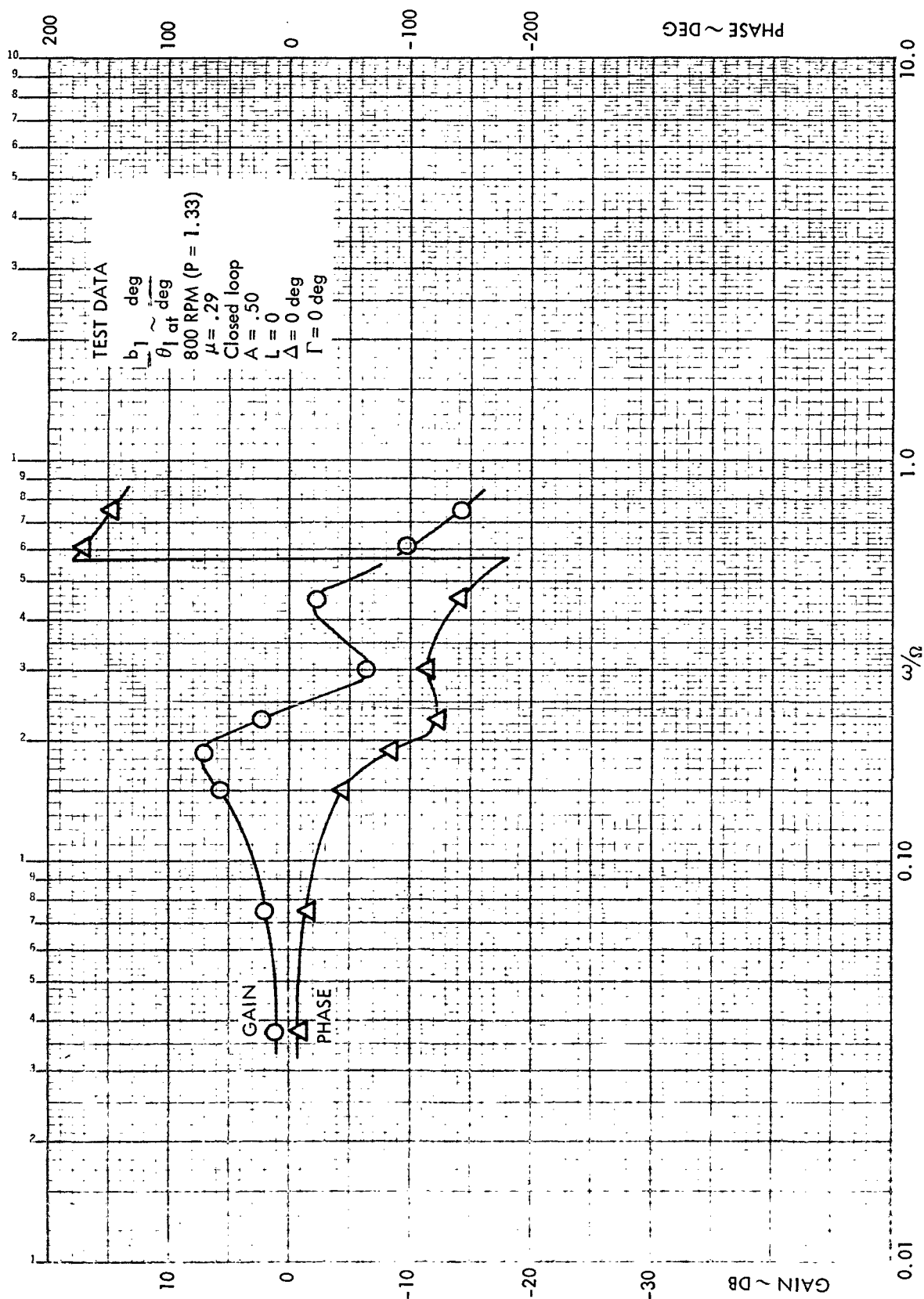


Figure E14. Closed Loop Rotor Lateral Frequency Response to θ_{lat}
 $\mu = .29$, 800 rpm ($P = 1.33$), $A = 0.50$, $L = 0$, $\Delta = 0$ deg, $\Gamma = 0$ deg

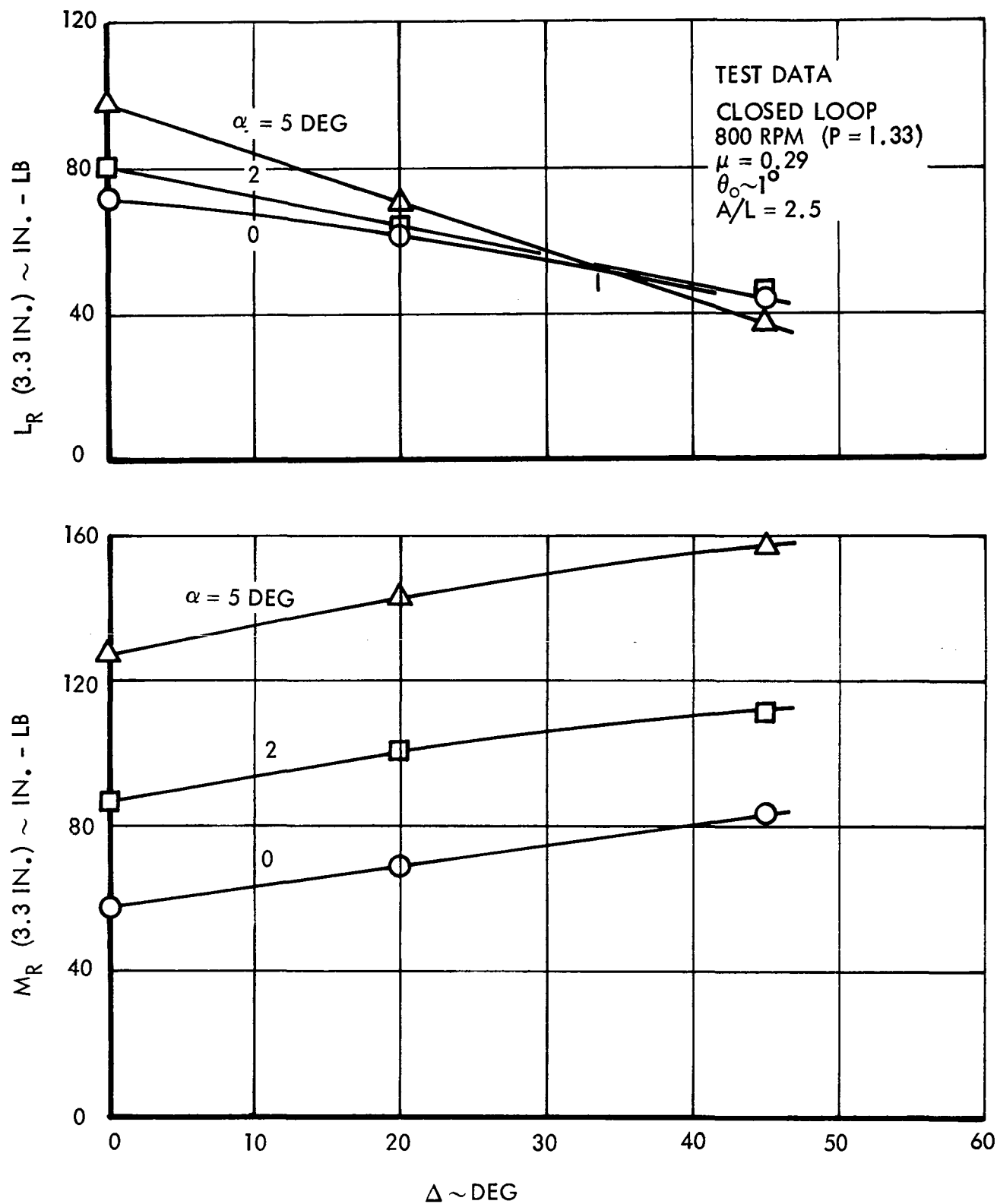


Figure E15. Closed Loop Steady State Rotor Response to an α - Disturbance,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 2.5$

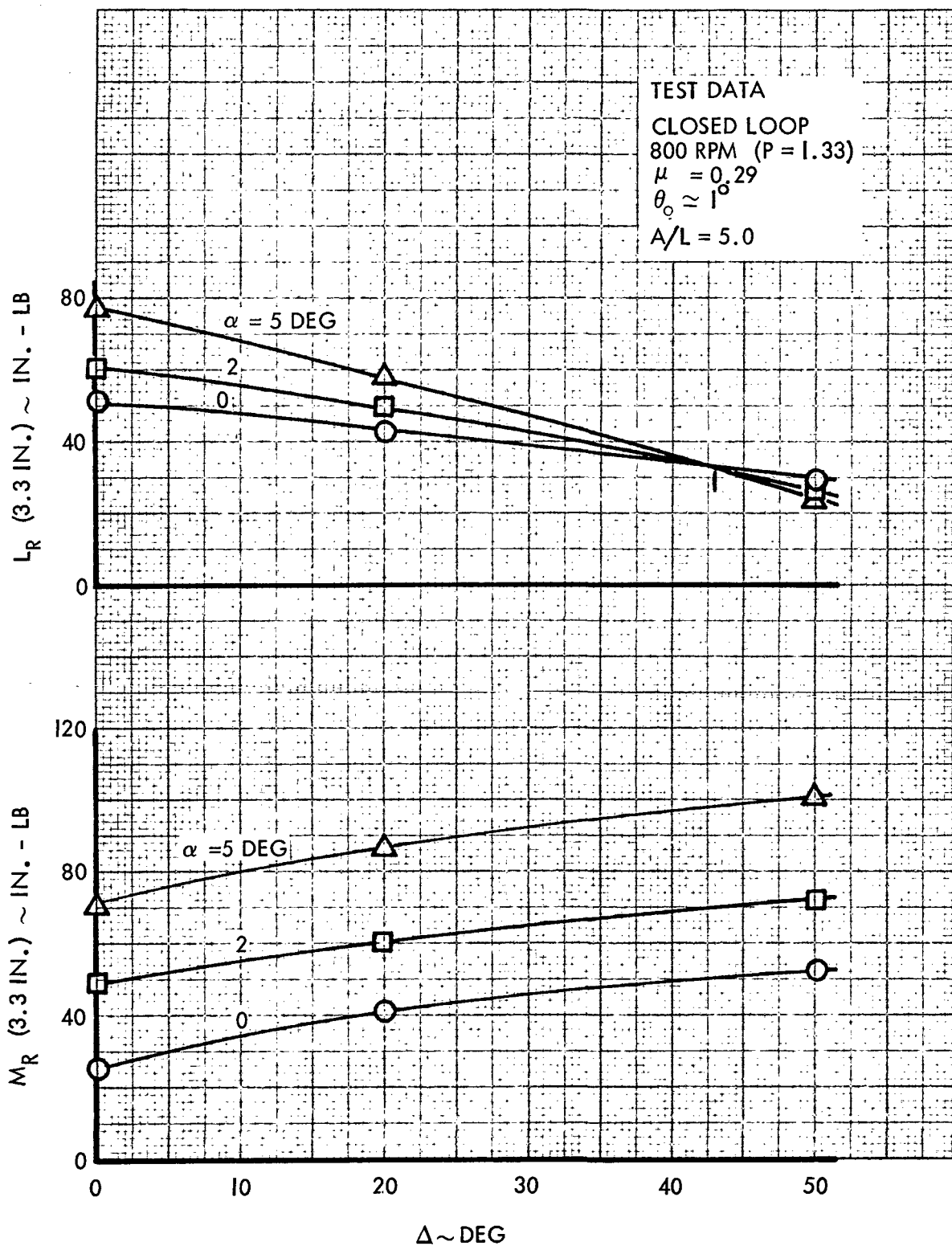


Figure E16. Closed Loop Steady State Rotor Response to an α - Disturbance,
 $\mu = .29$, 800 rpm (P = 1.33), A/L = 5.0

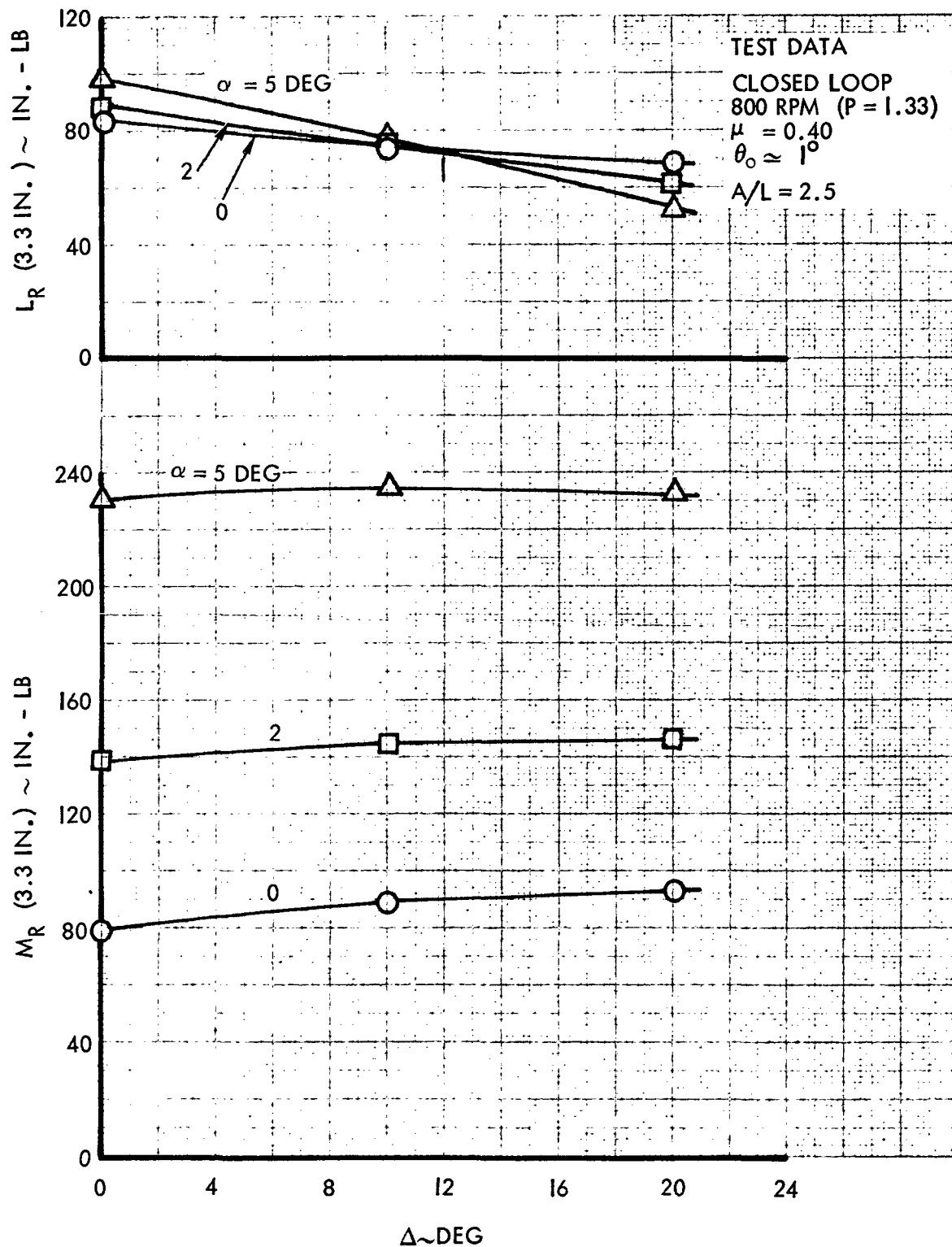


Figure E17. Closed Loop Steady State Rotor Response to an α - Disturbance,
 $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 2.5$

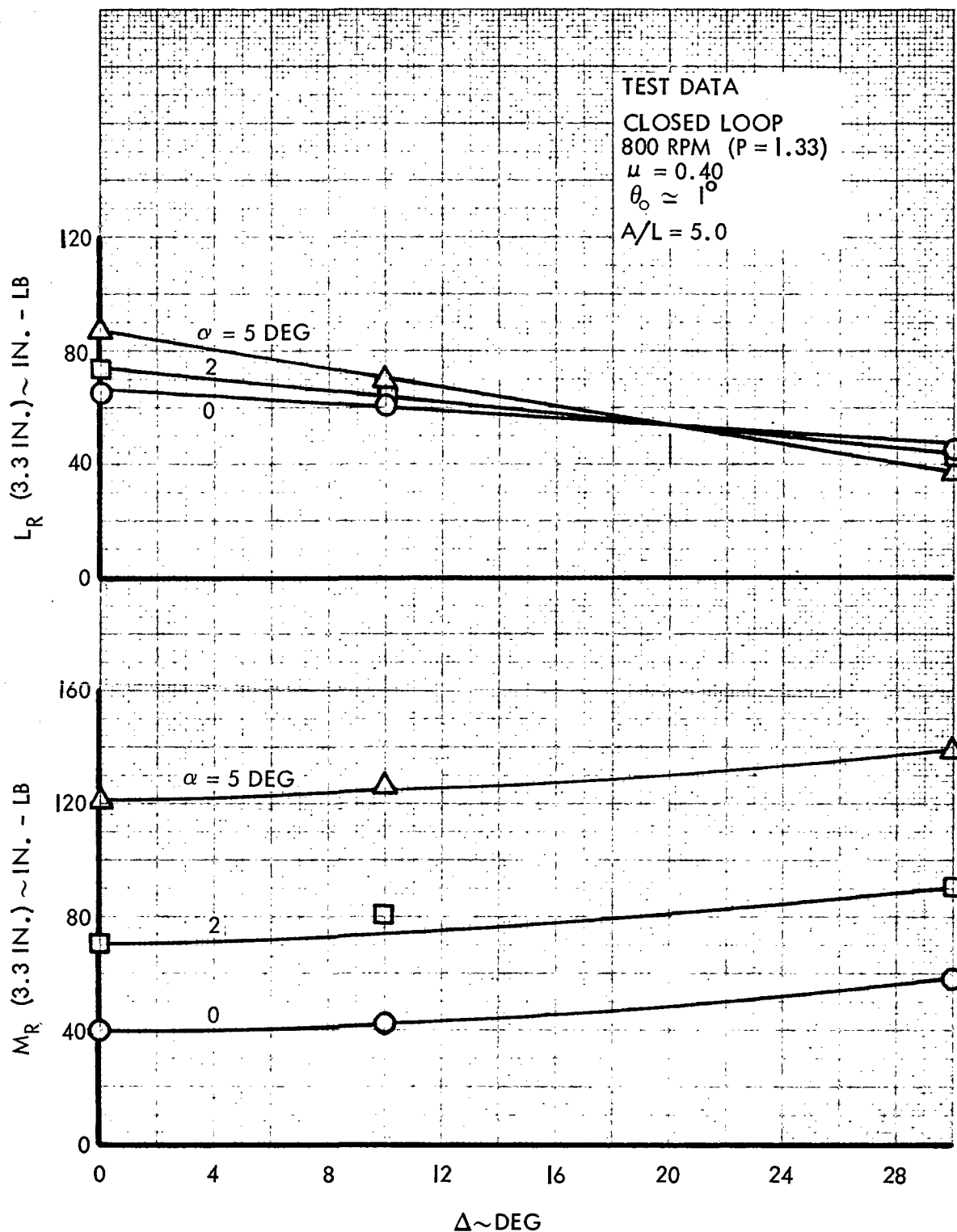


Figure E18. Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 5.0$

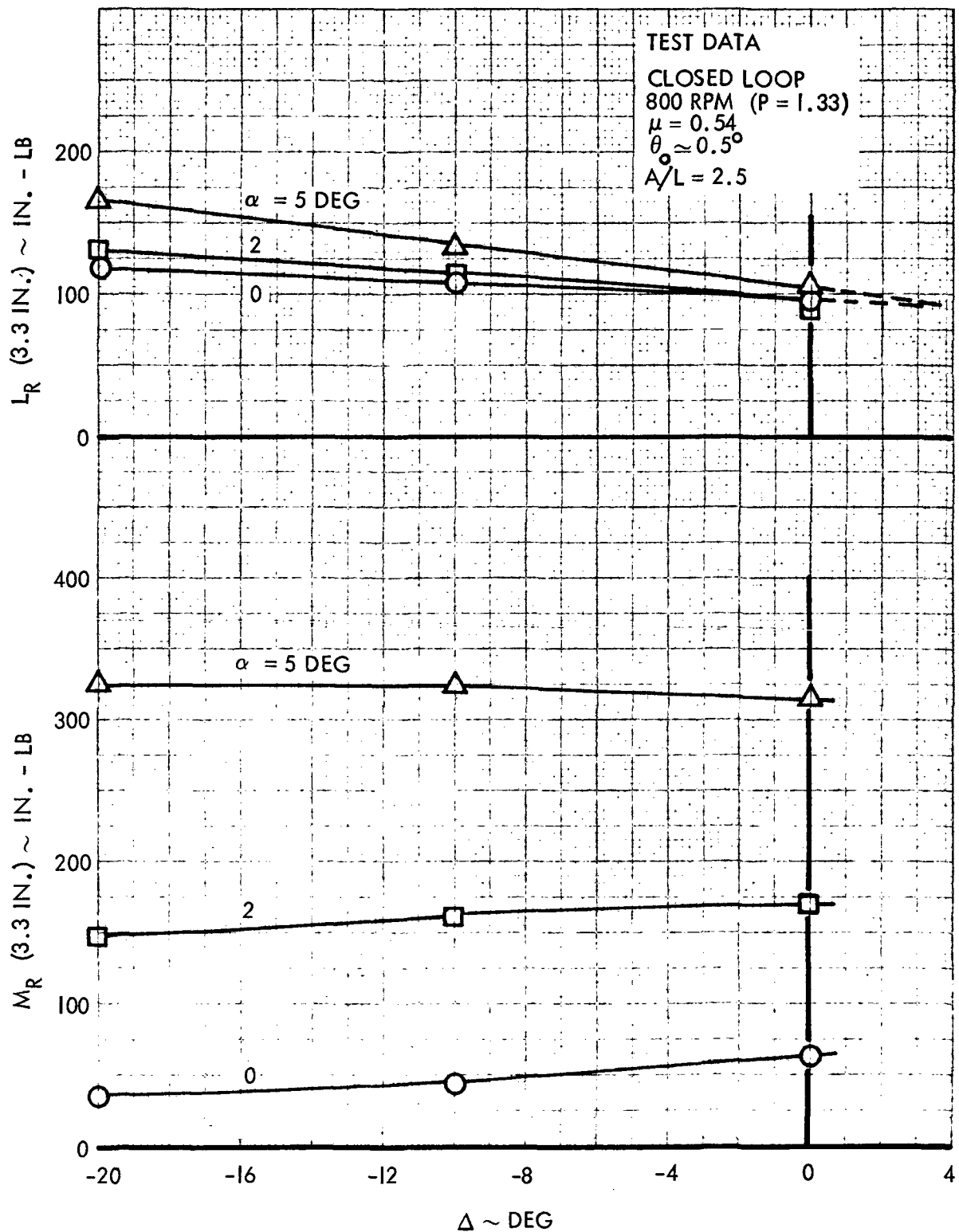


Figure E19. Closed Loop Steady State Rotor Response to an α - Disturbance,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 2.5$

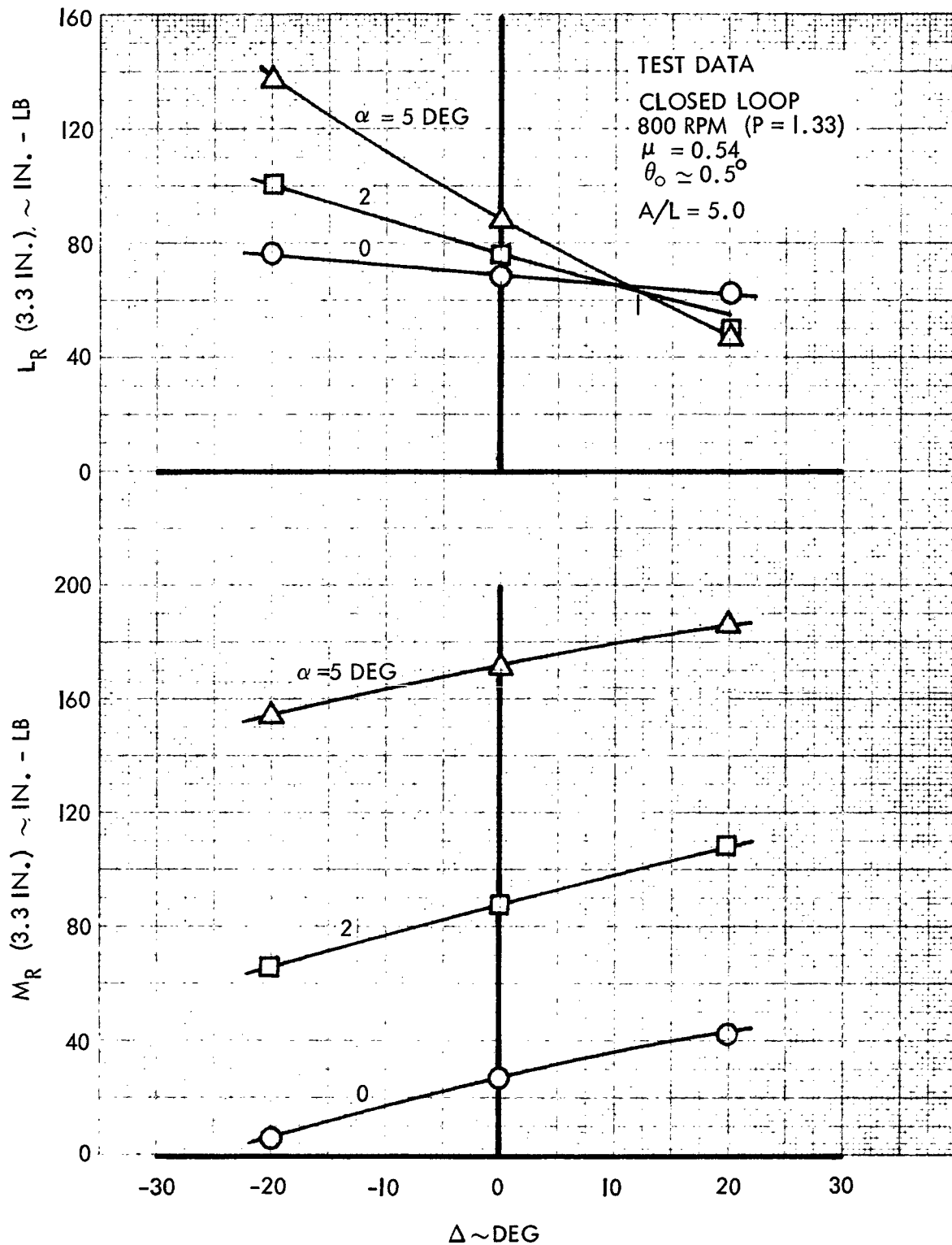


Figure E20. Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 5.0$

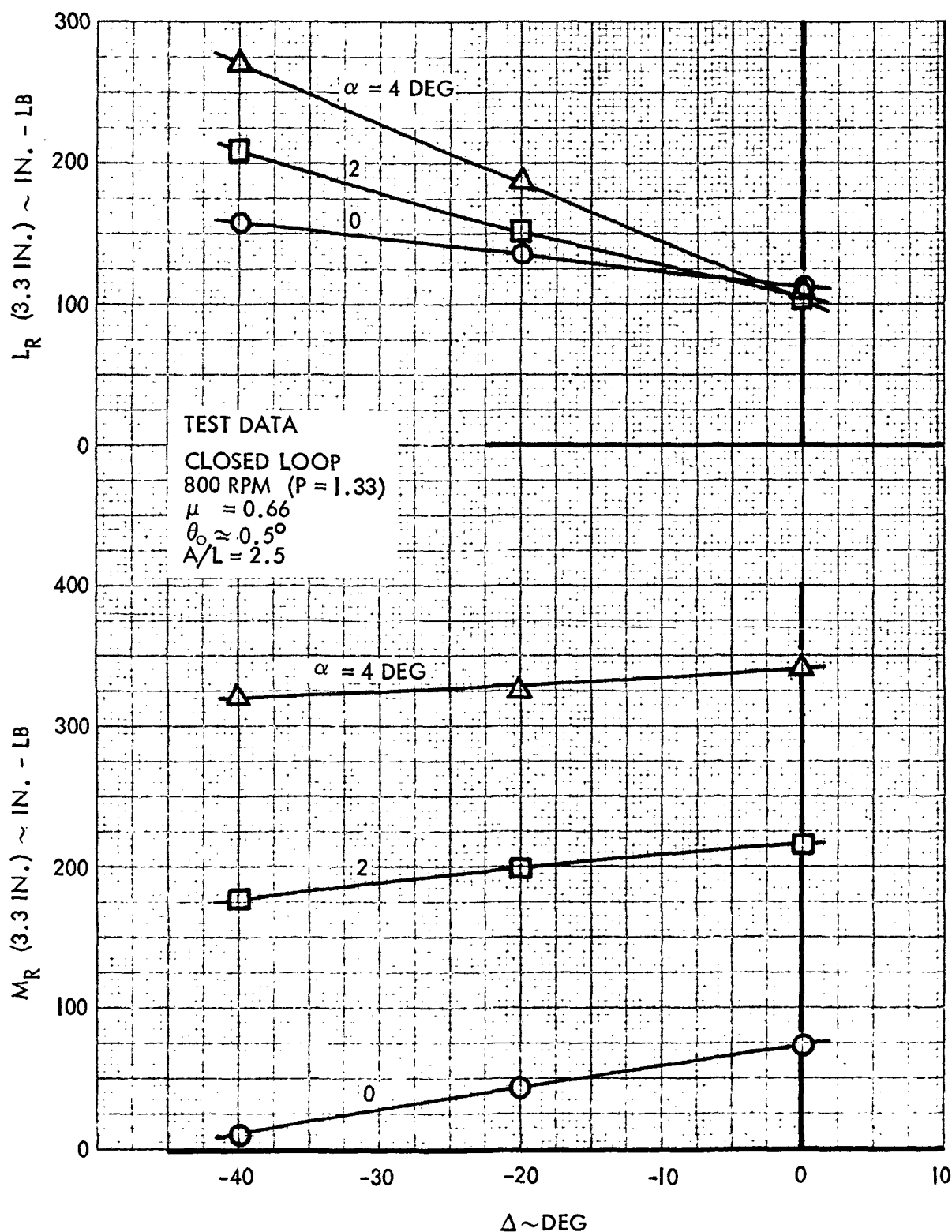


Figure E21. Closed Loop Steady State Rotor Response to an α - Disturbance,
 $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 2.5$

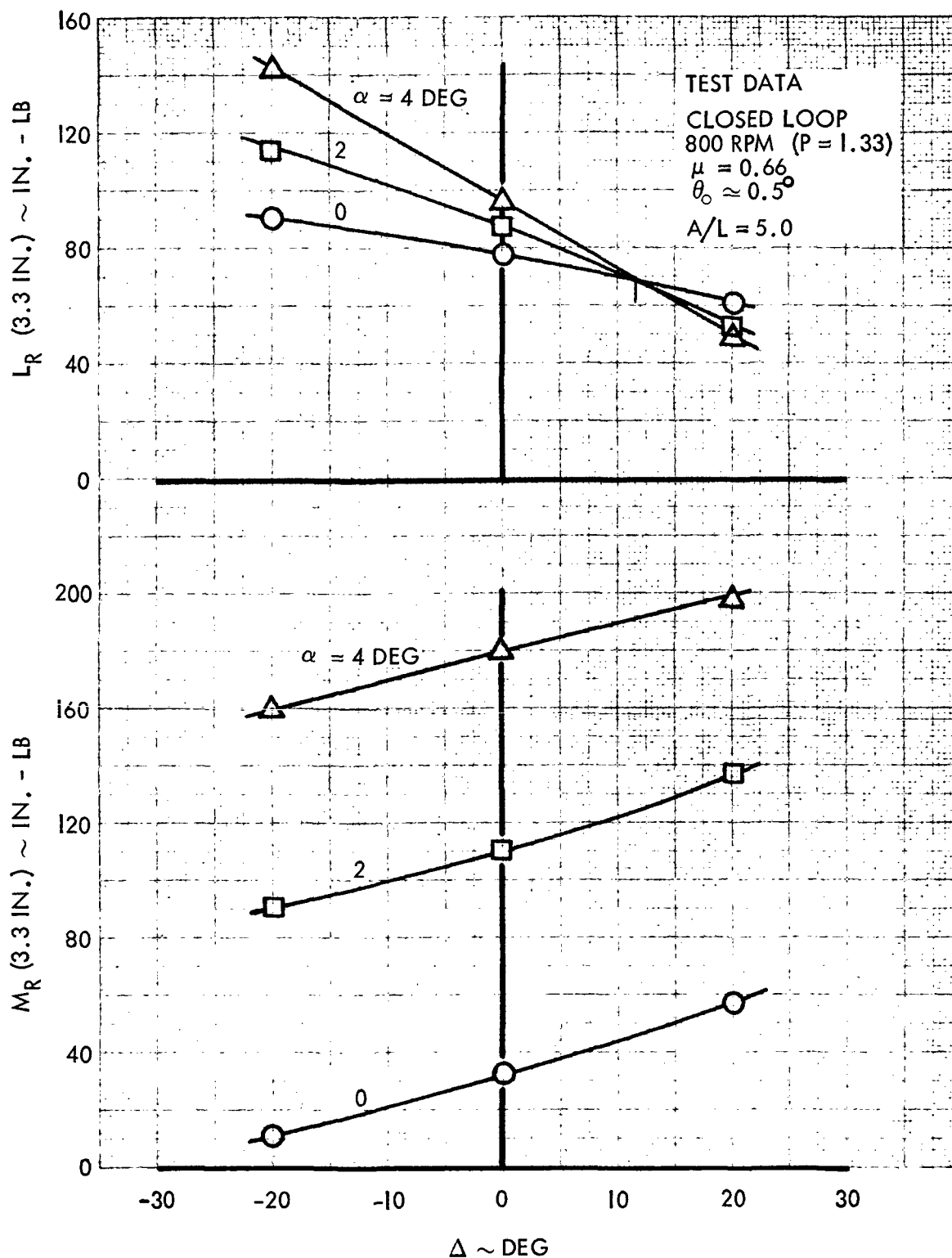


Figure E22. Closed Loop Steady State Rotor Response to an α - Disturbance, $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 5.0$

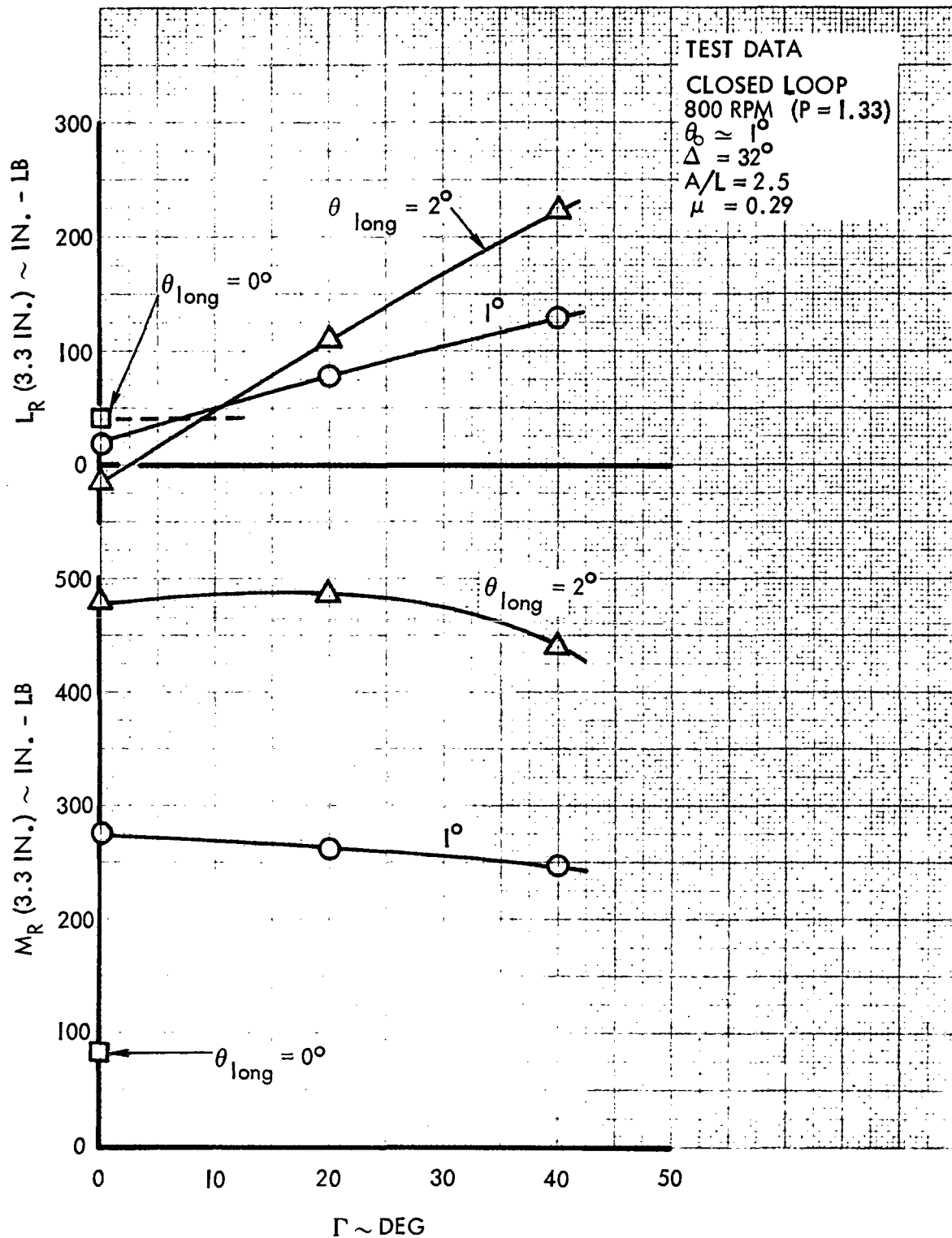


Figure E23. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = 32 \text{ deg}$

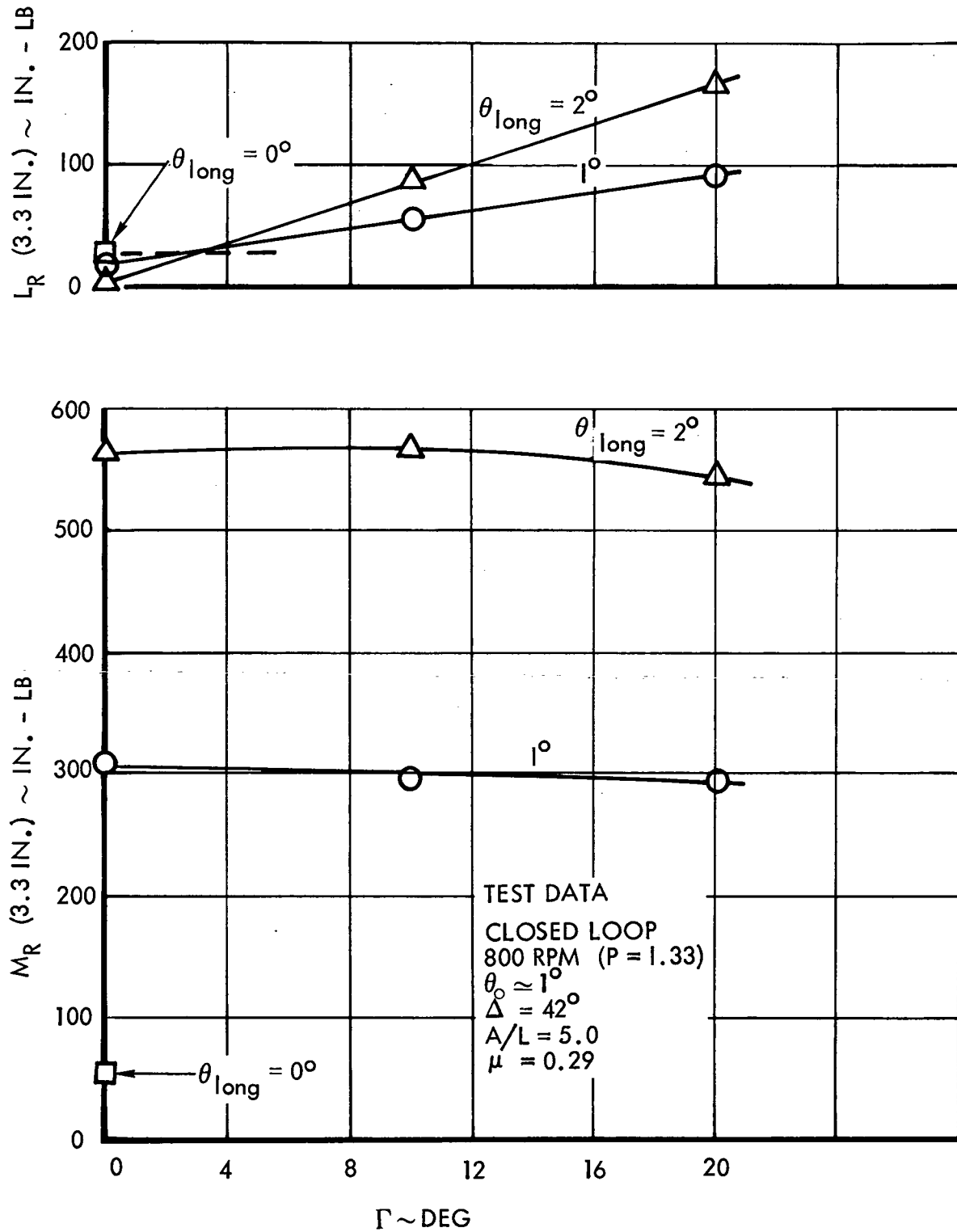


Figure E24. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .29$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 42 \text{ deg}$

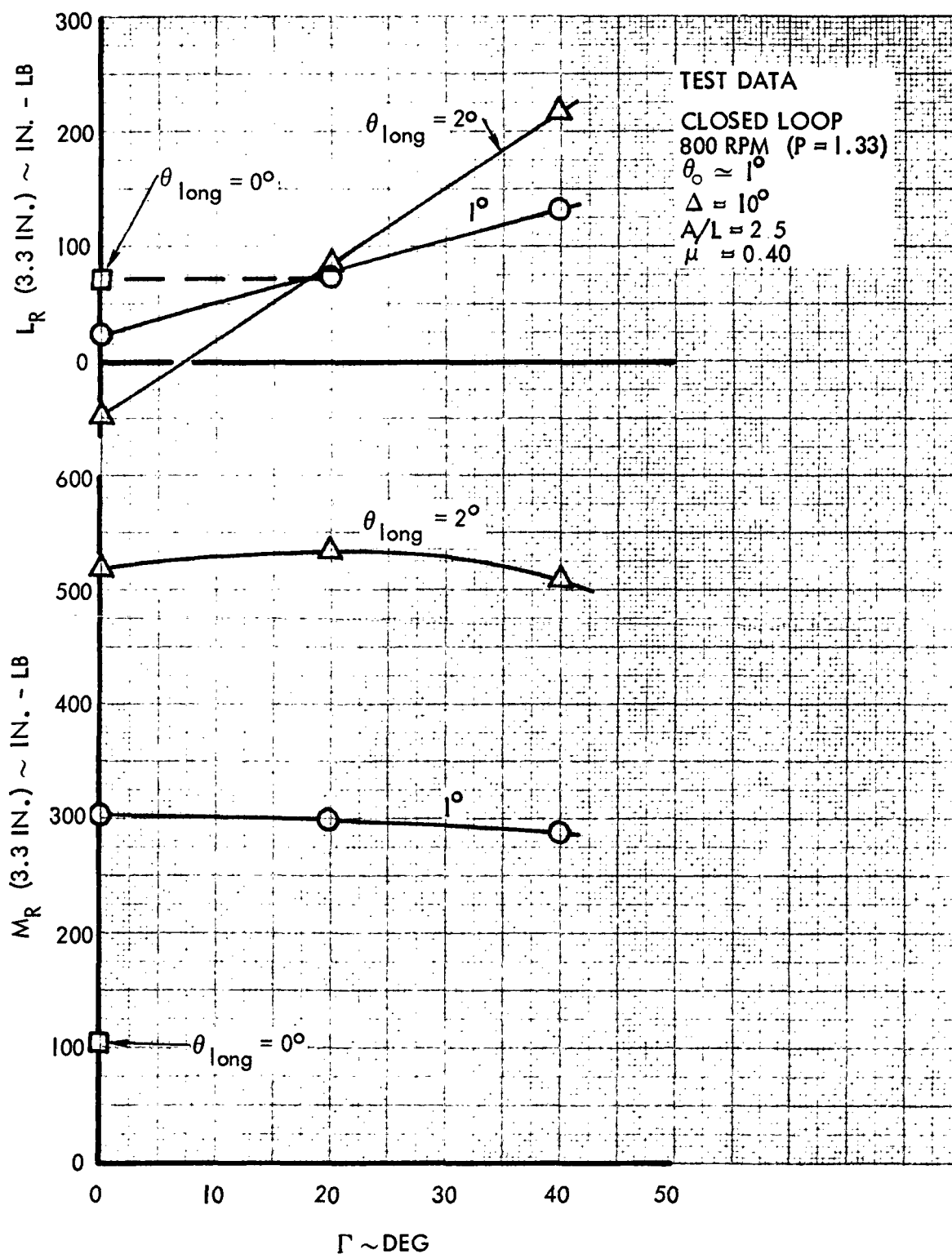


Figure E25. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = 10$ deg

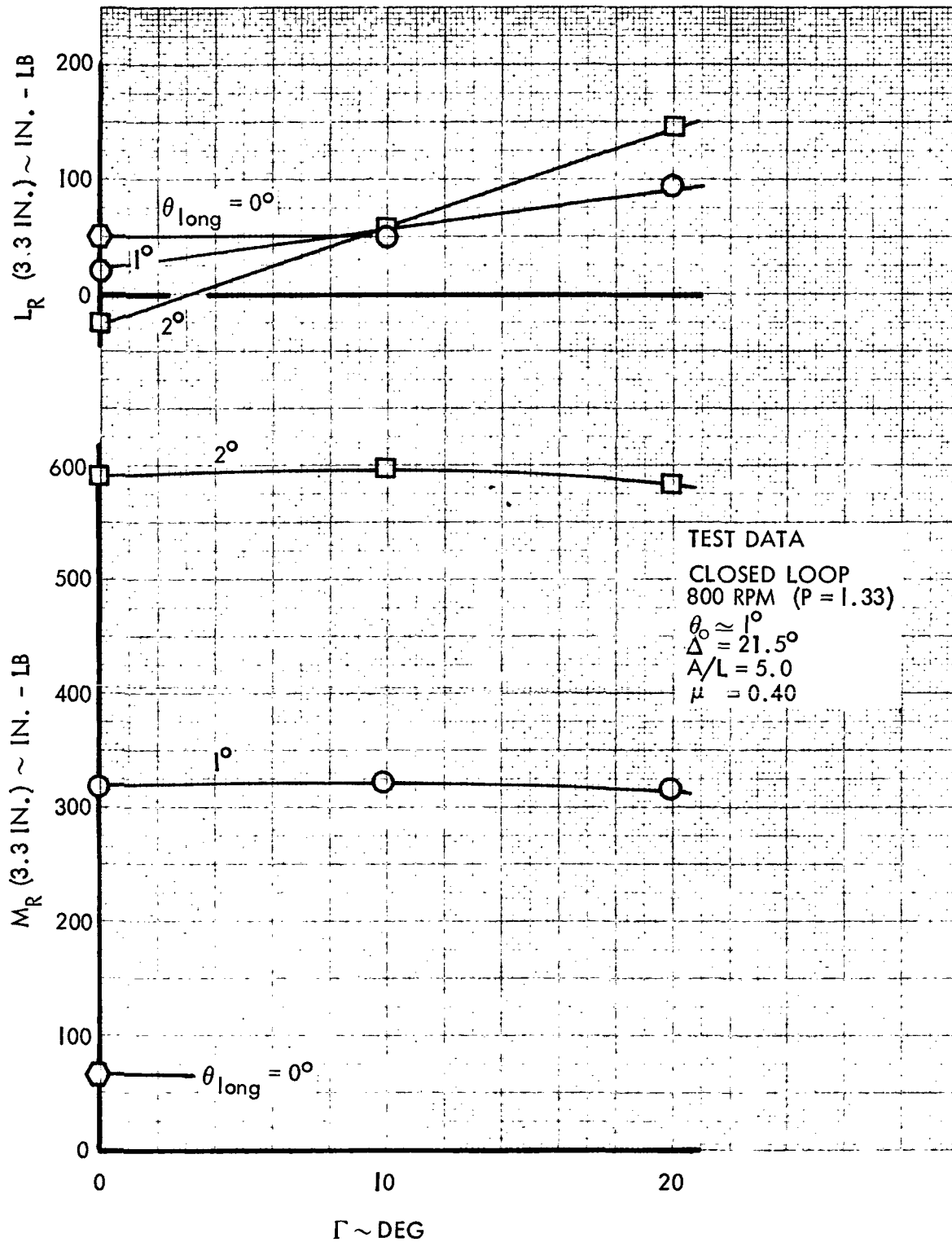


Figure E26. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .40$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 21.5$ deg

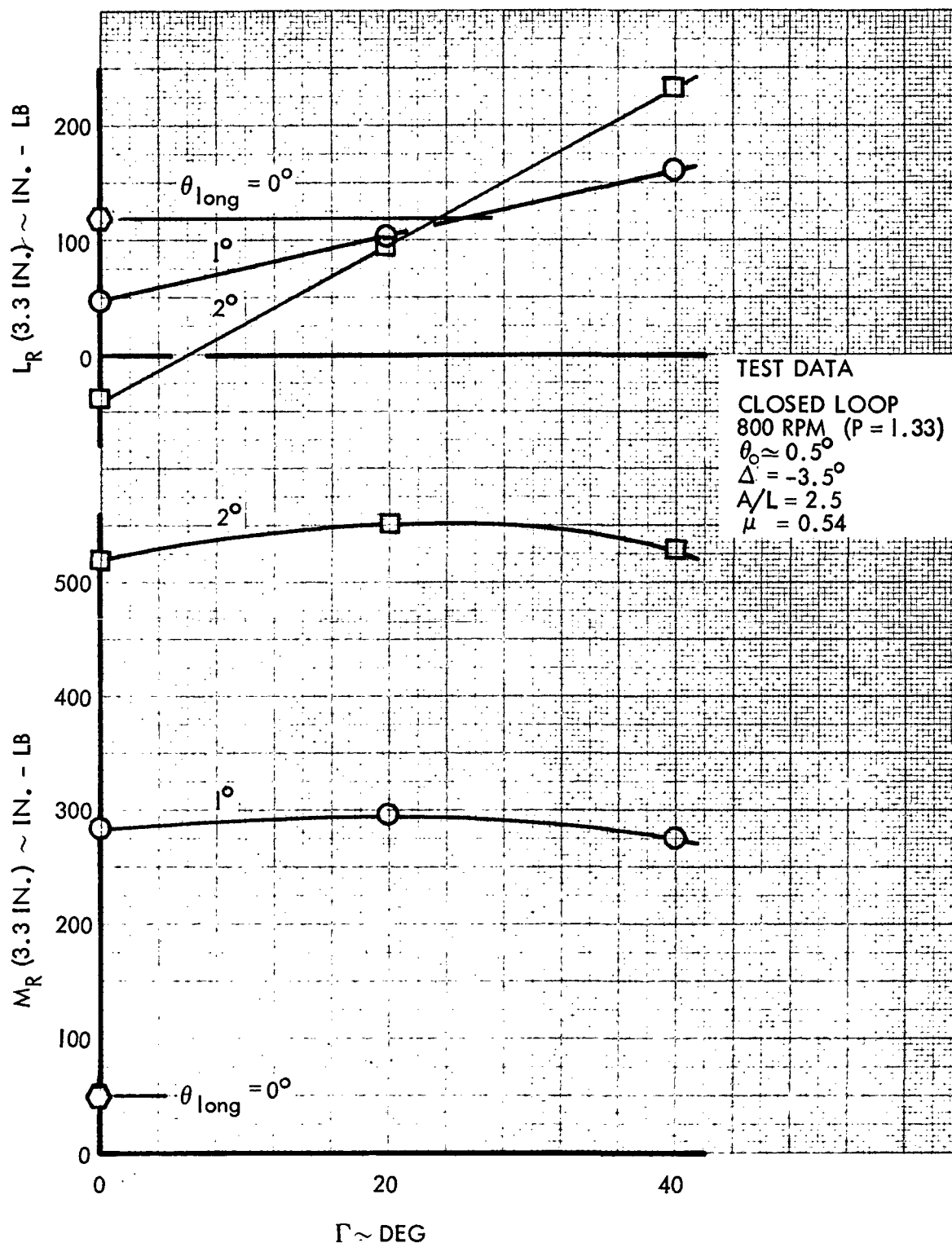


Figure E27. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = -3.5$ deg

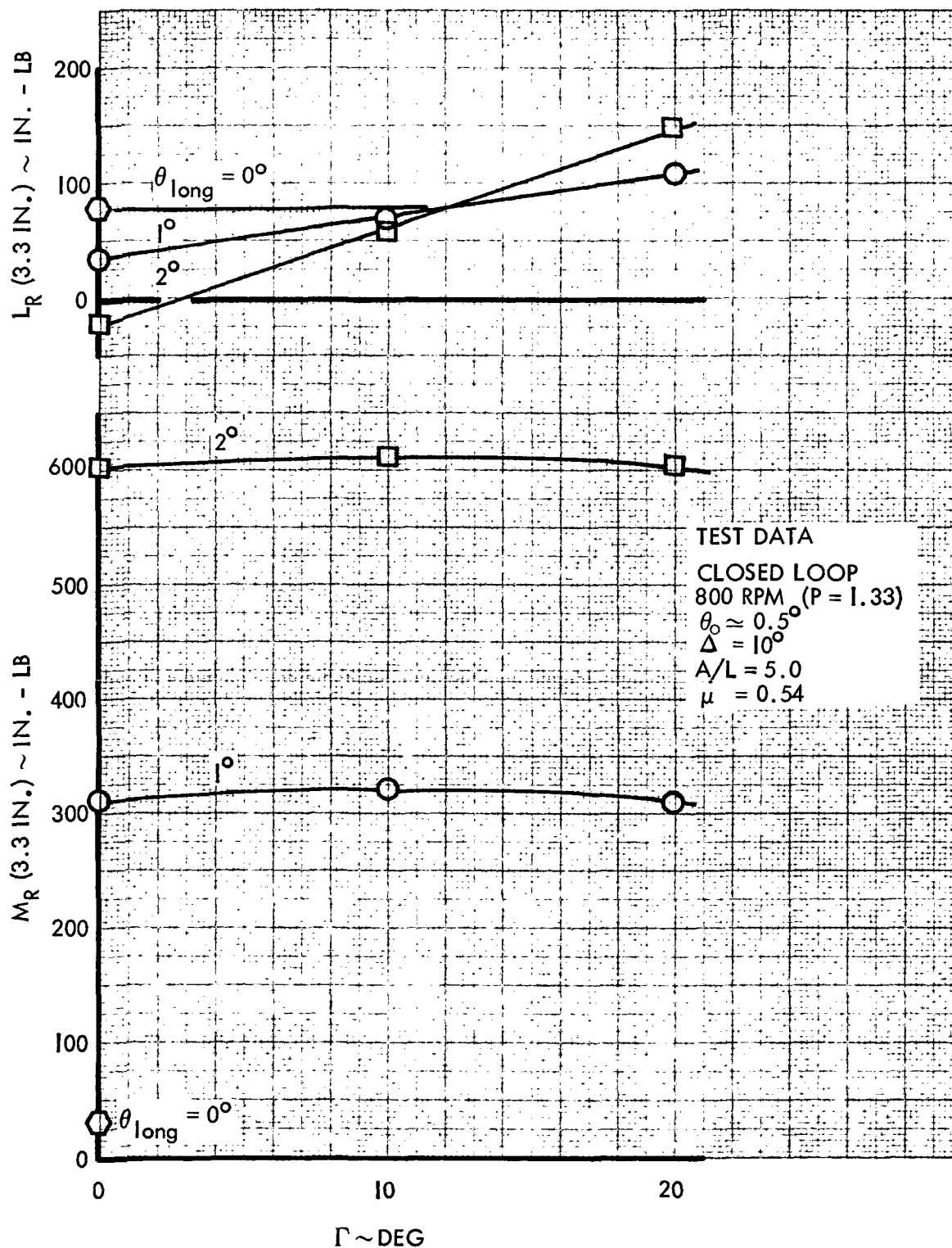


Figure E28. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .54$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg

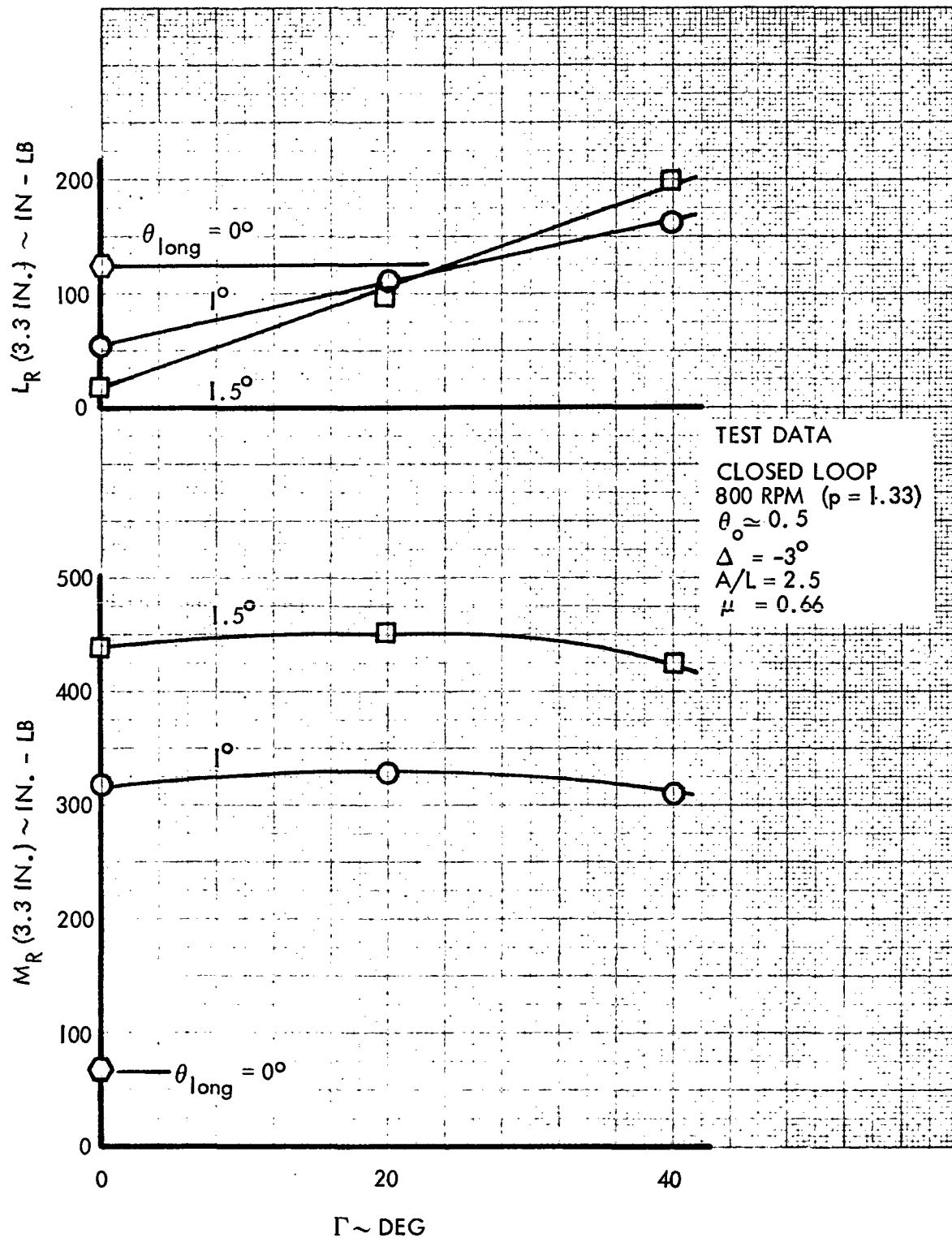


Figure E29. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 2.5$, $\Delta = -3$ deg

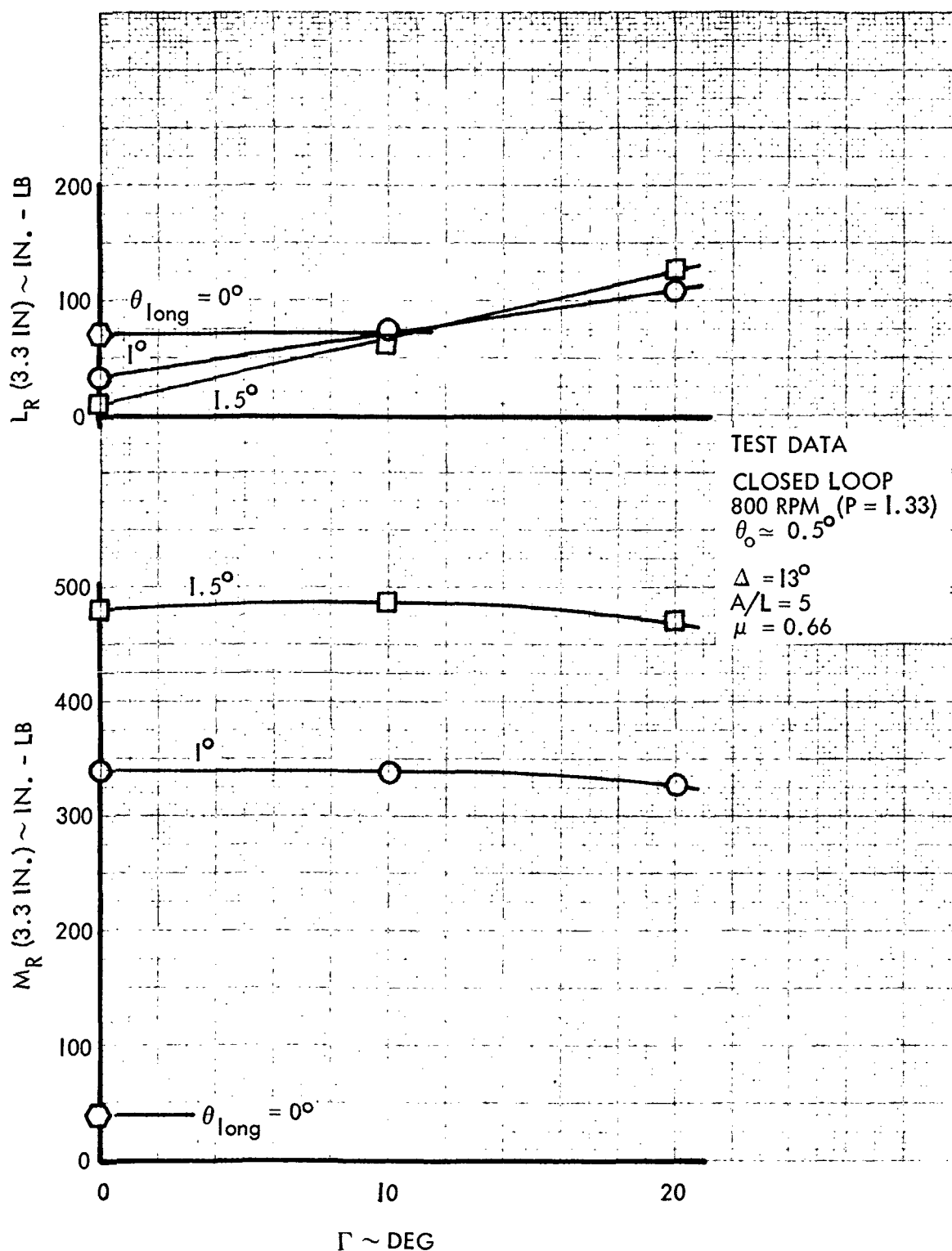


Figure E30. Closed Loop Steady State Rotor Response to θ_{long} ,
 $\mu = .66$, 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 13$ deg

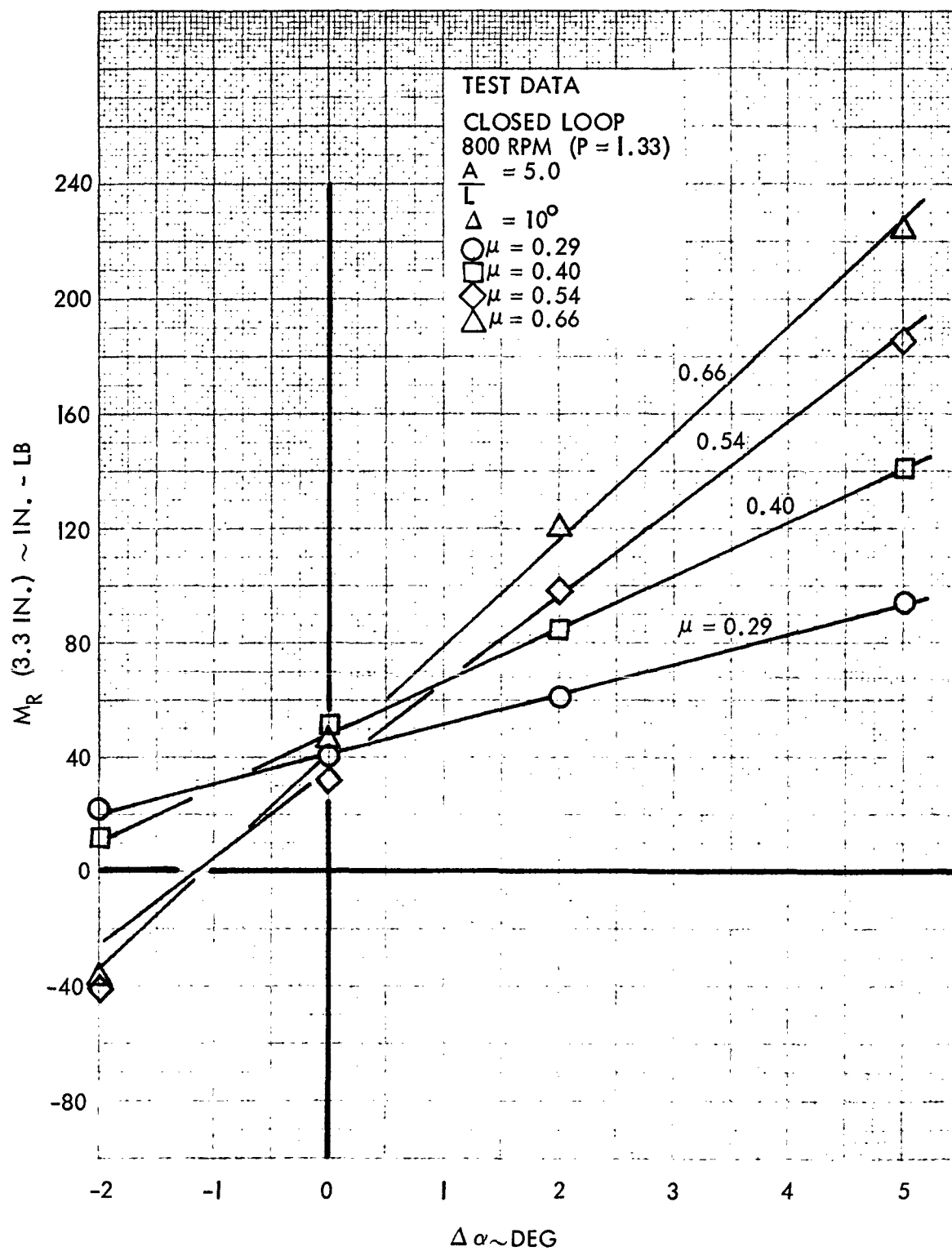


Figure E31. Closed Loop Rotor Pitching Moment Response to α ,
 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg

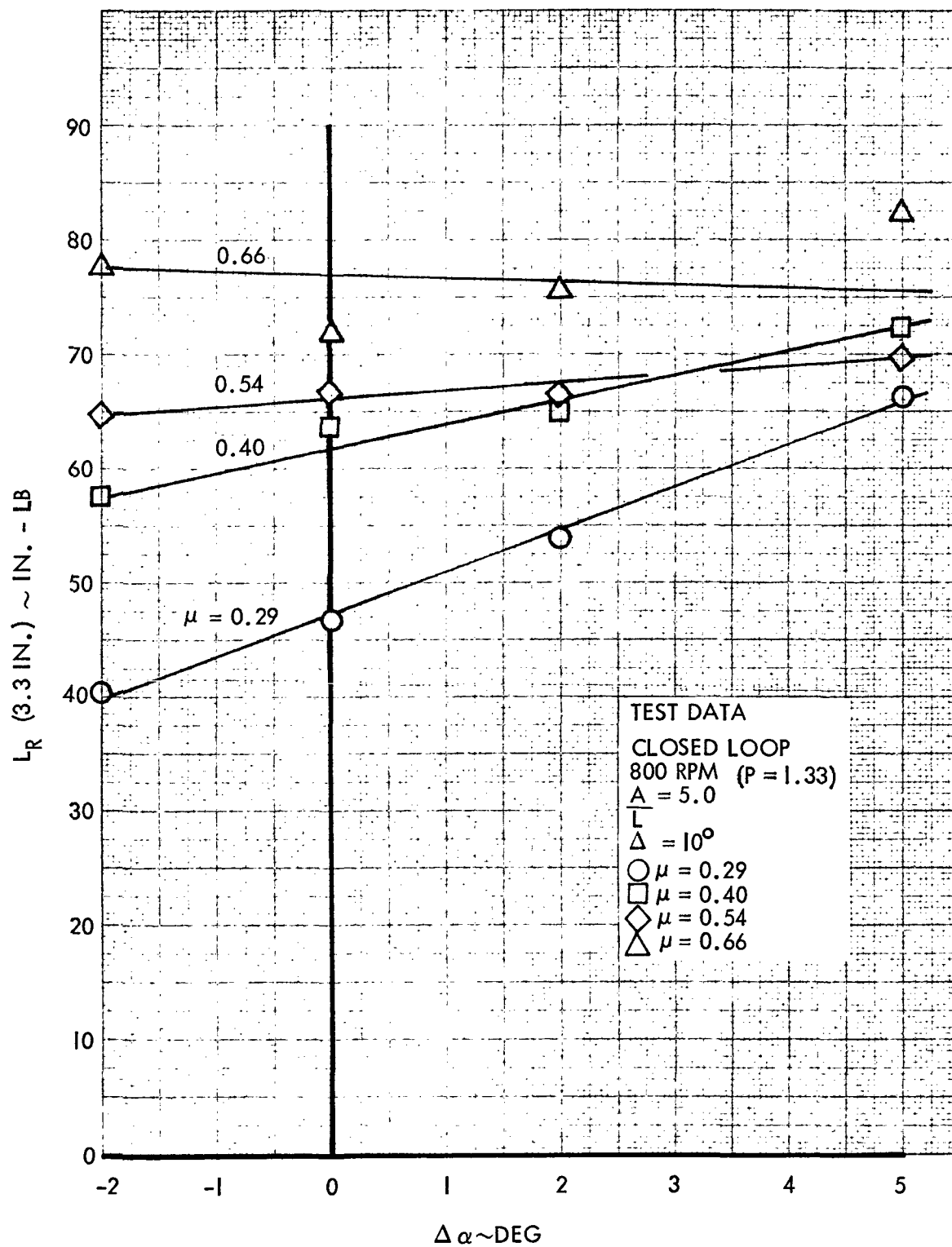


Figure E32. Closed Loop Rotor Rolling Moment Response to α , 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg

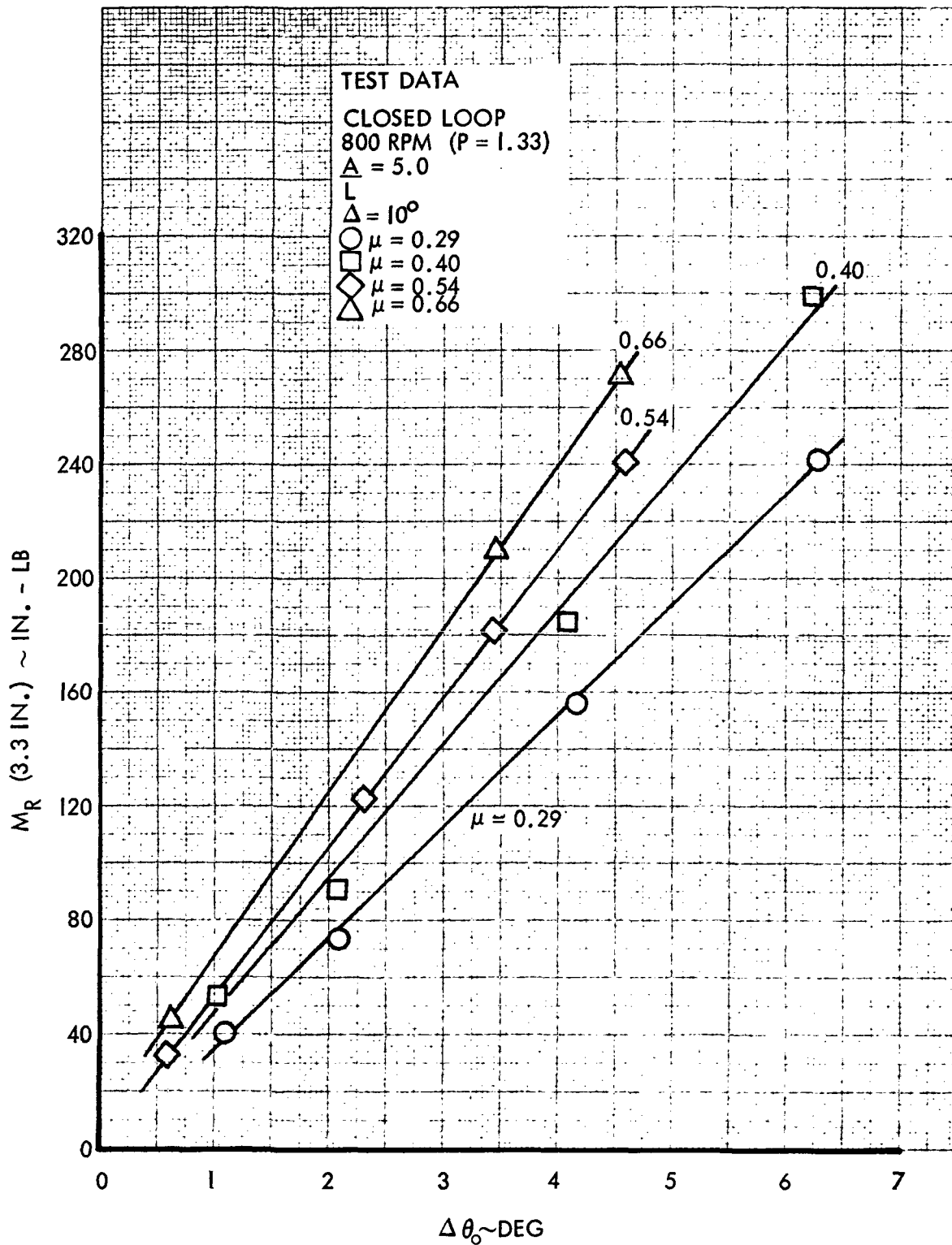


Figure E33. Closed Loop Rotor Pitching Moment Response to θ_o ,
800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg

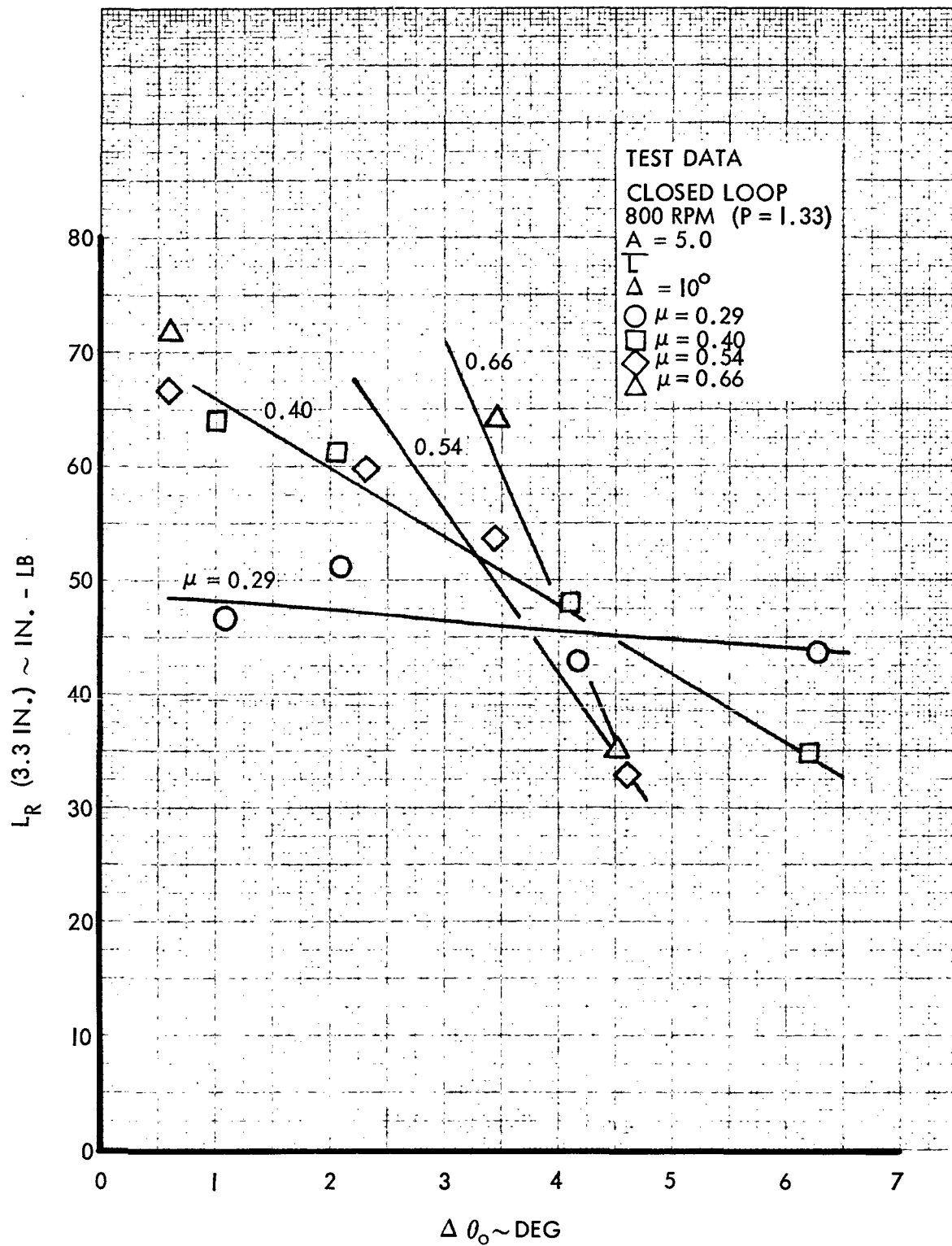


Figure E34. Closed Loop Rotor Rolling Moment Response to θ_o ,
800 rpm (P = 1.33), A/L = 5.0, Δ = 10 deg

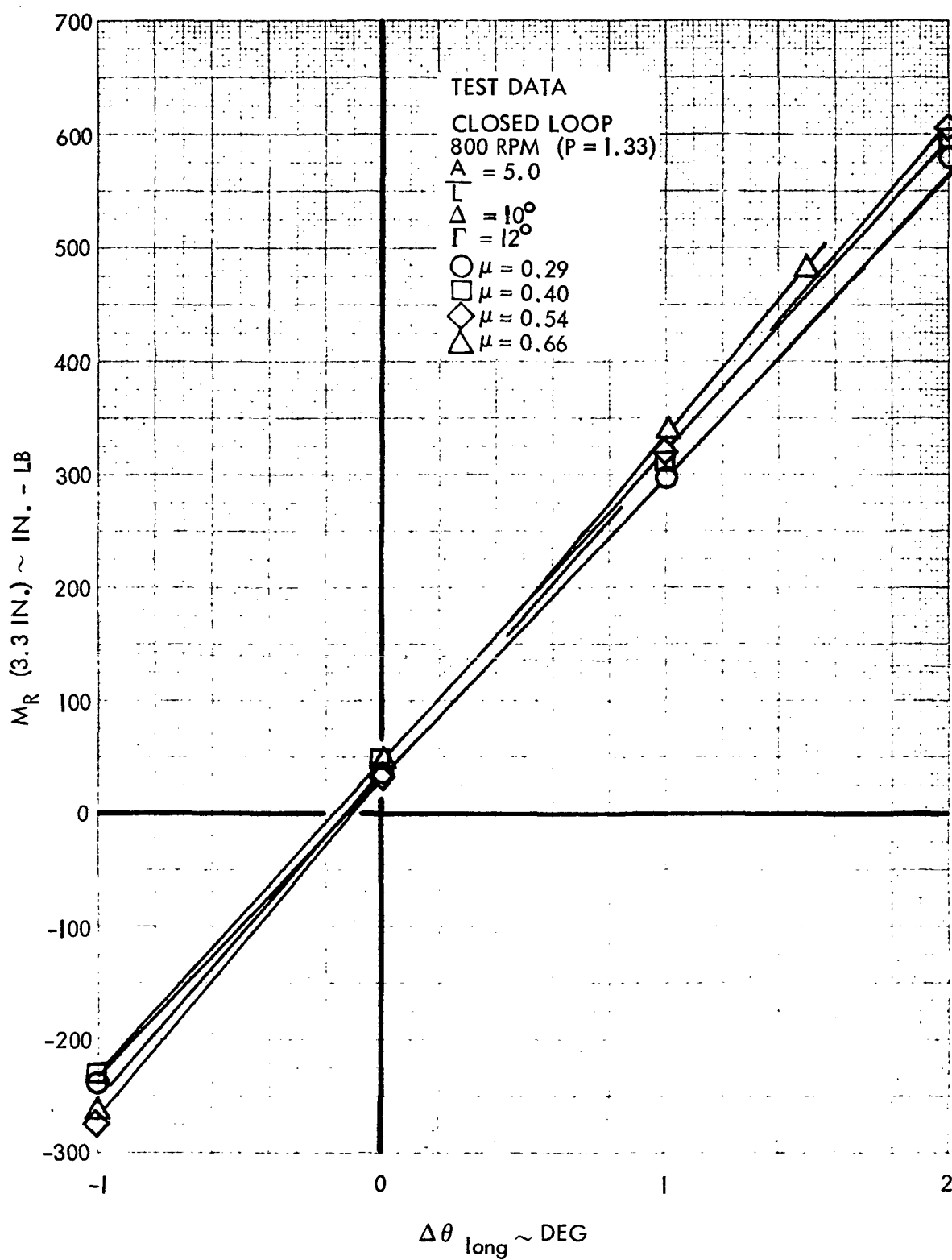


Figure E35. Closed Loop Rotor Pitching Moment Response to θ_{long} ,
800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg

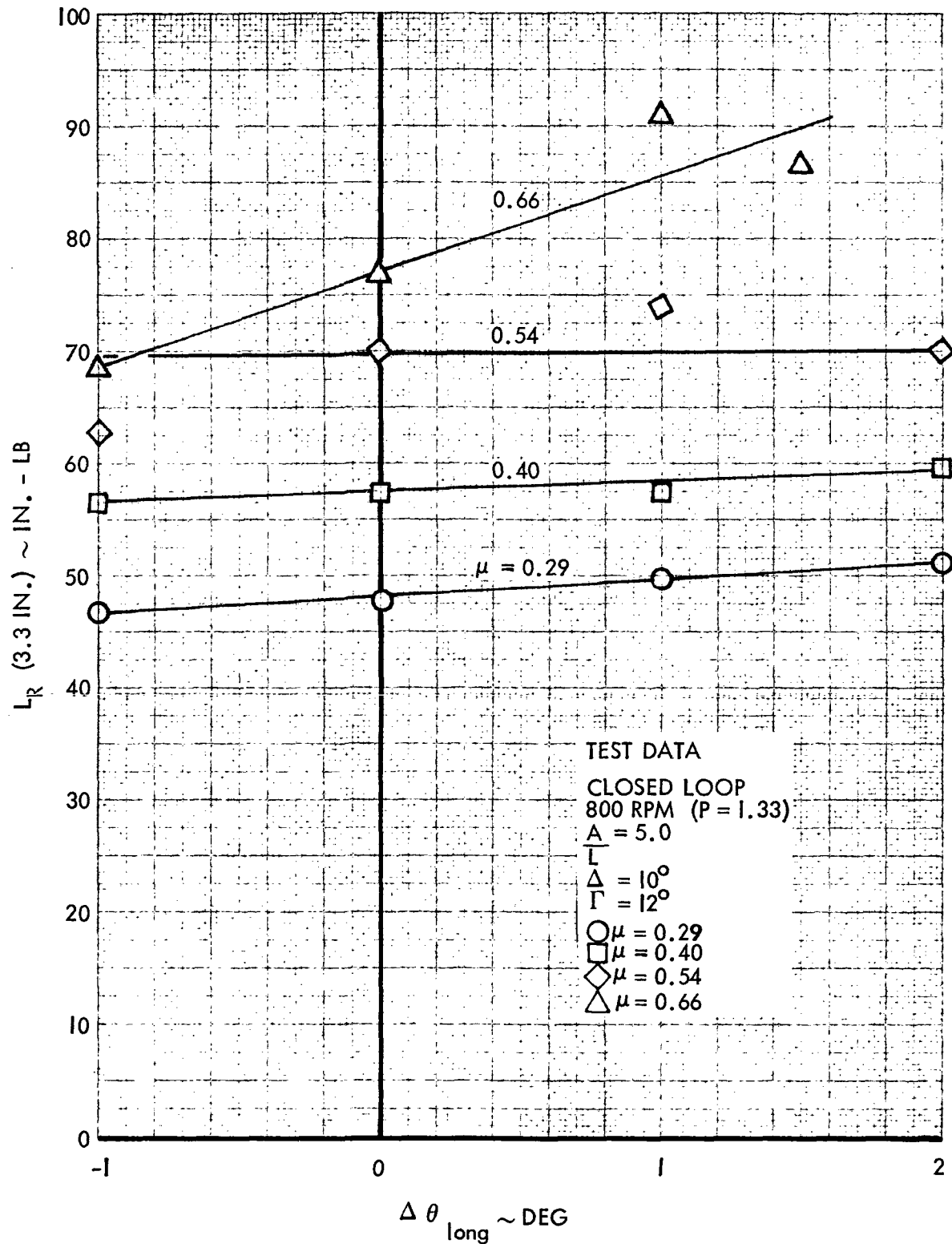


Figure E36. Closed Loop Rotor Rolling Moment Response to θ_{long} ,
 800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg

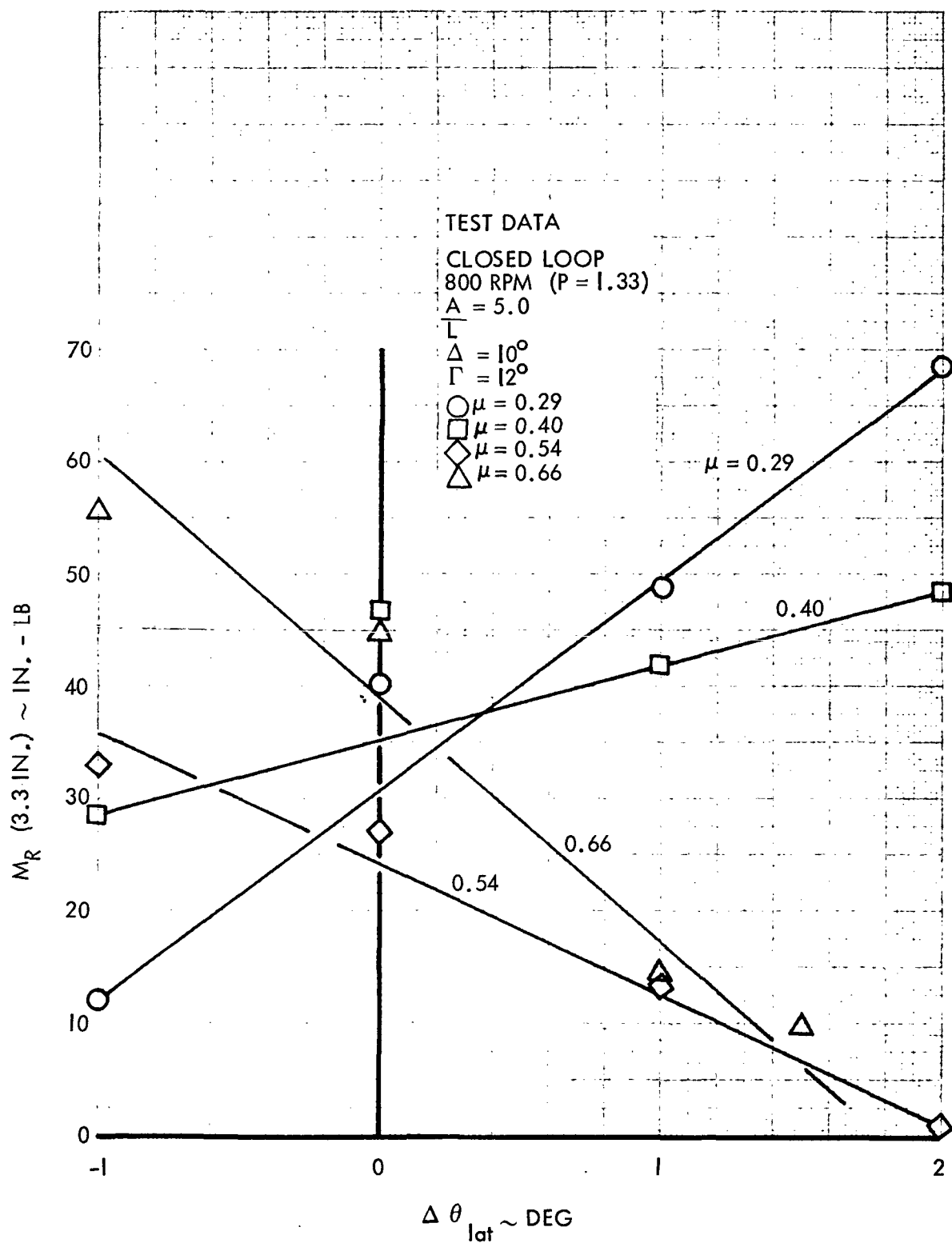


Figure E37. Closed Loop Rotor Pitching Moment Response to θ_{lat} ,
800 rpm (P = 1.33), A/L = 5.0, $\Delta = 10$ deg, $\Gamma = 12$ deg

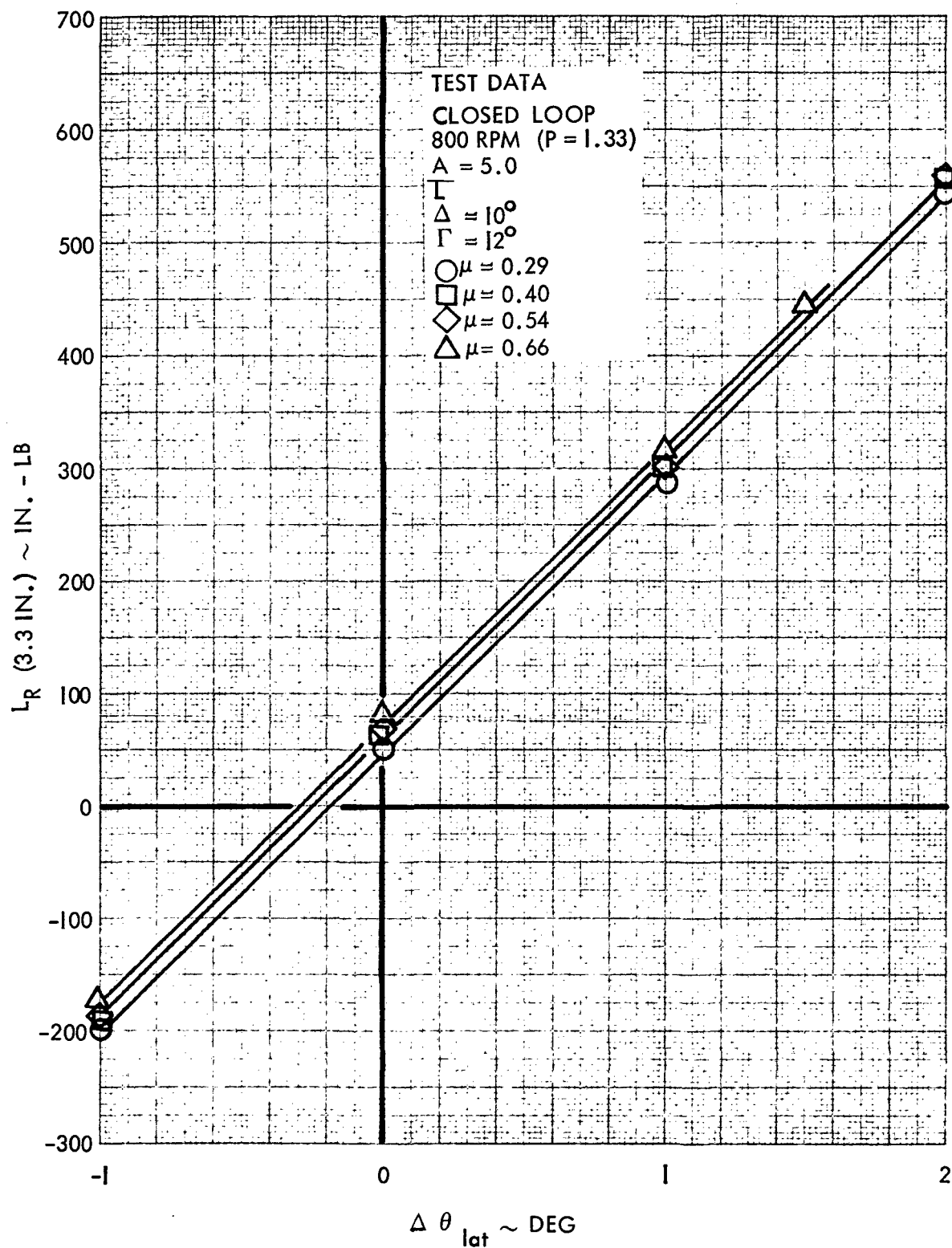


Figure E38. Closed Loop Rotor Rolling Moment Response to θ_{lat} ,
800 rpm ($P = 1.33$), $A/L = 5.0$, $\Delta = 10$ deg, $\Gamma = 12$ deg

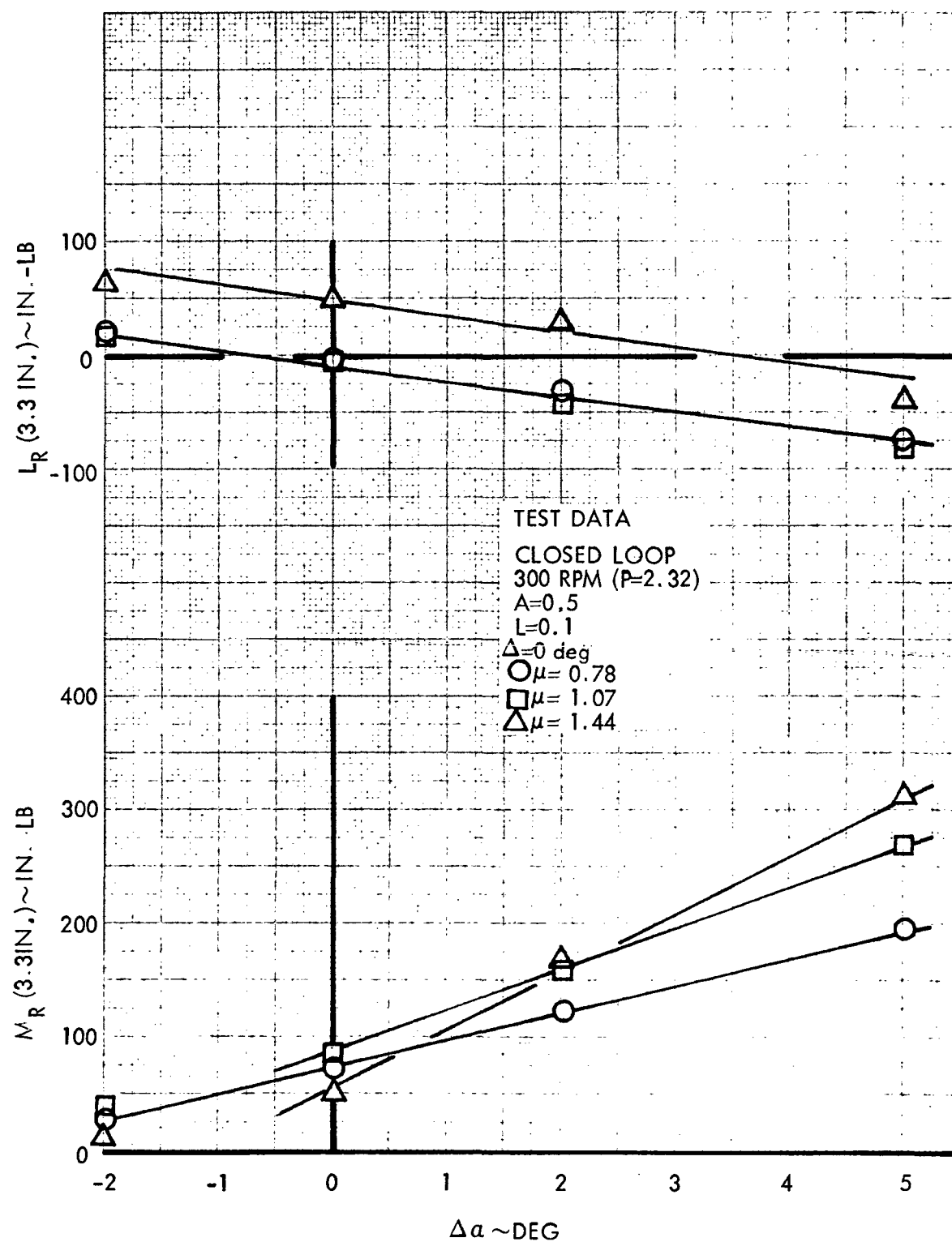


Figure E39. Closed Loop Rotor Moment Responses to α ,
 300 rpm ($P = 2.32$), $A/L = 5.0$, $\Delta = 0$ deg

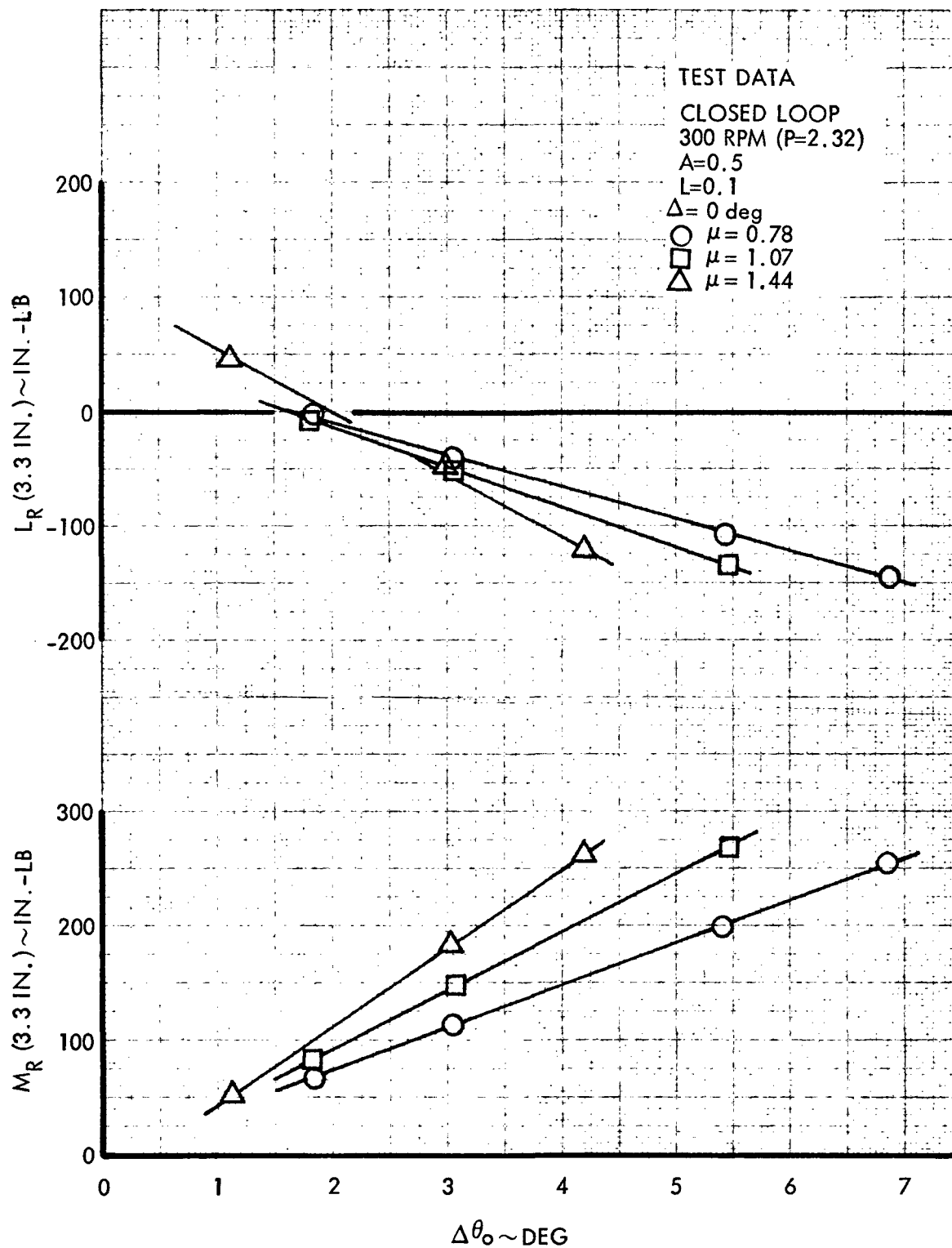


Figure E40. Closed Loop Rotor Moment Responses to θ_0 ,
300 rpm (P = 2.32), A/L = 5.0, $\Delta = 0$ deg

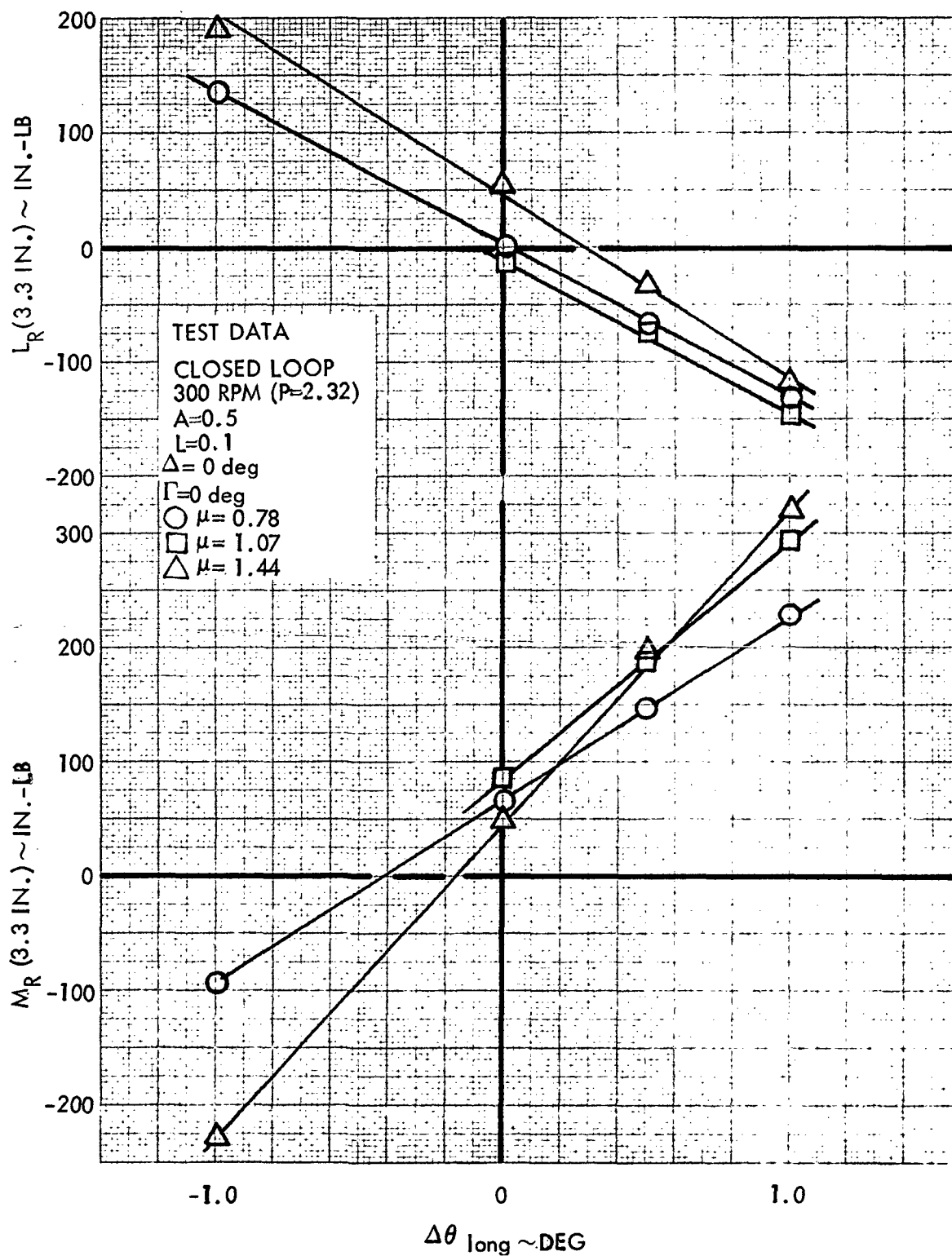


Figure E41. Closed Loop Rotor Moment Responses to θ_{long} ,
 300 rpm (P = 2.32), A/L = 5.0, Δ = 0 deg, Γ = 0 deg

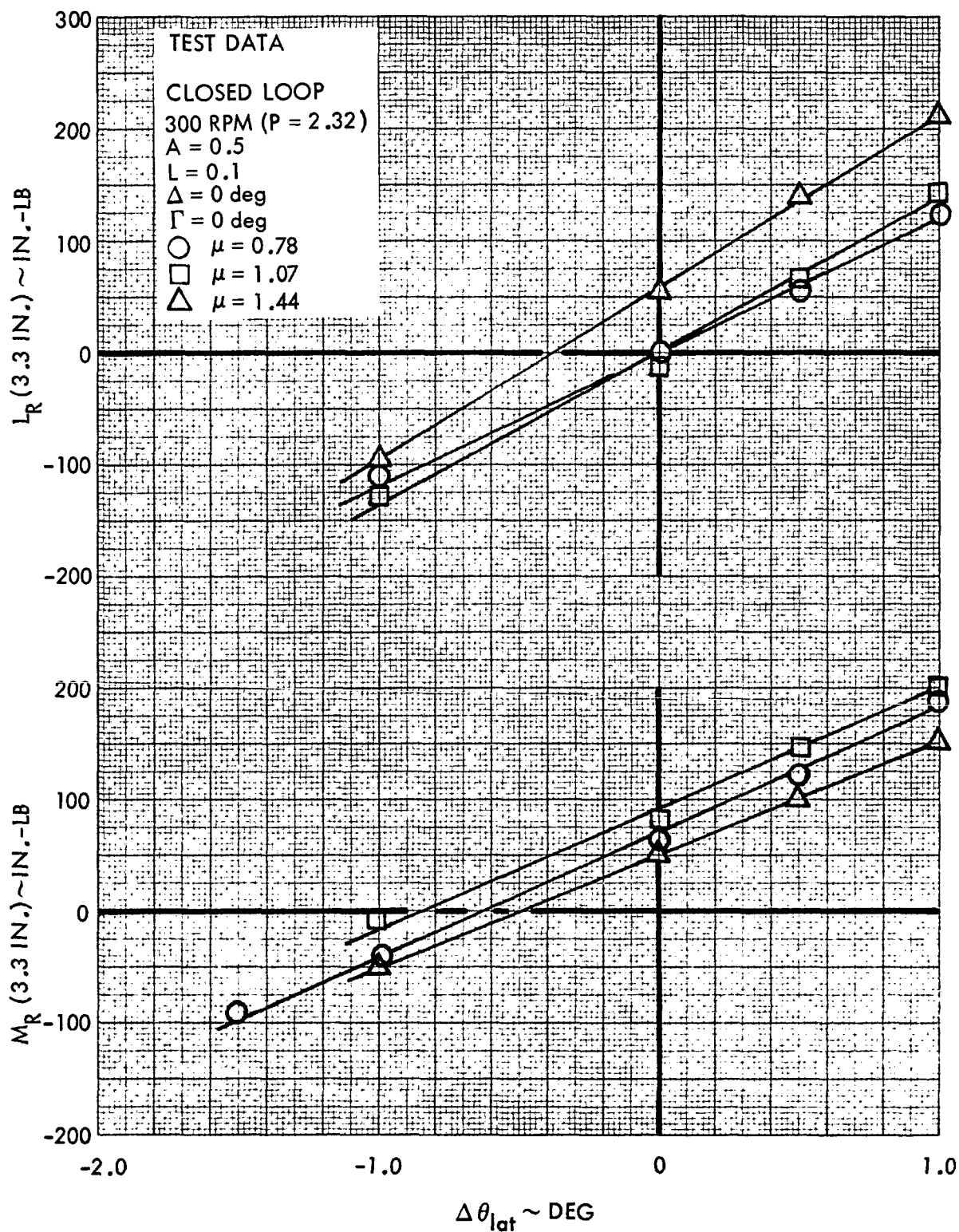


Figure E42. Closed Loop Rotor Moment Responses to θ_{lat} , 300 rpm
 ($P = 2.32$), $A/L = 5.0$, $\Delta = 0$ deg, $\Gamma = 0$ deg

APPENDIX F

OPEN LOOP STEADY STATE ROTOR RESPONSE DATA

The data used to determine the steady state rotor response derivatives at a rotor speed of 1200 RPM are plotted in Figures F1 to F10. Rotor pitch and rolling moments and lift generated by α , θ_o , θ_s and θ_c excitations are shown at advance ratios ranging from 0.07 to 0.44.

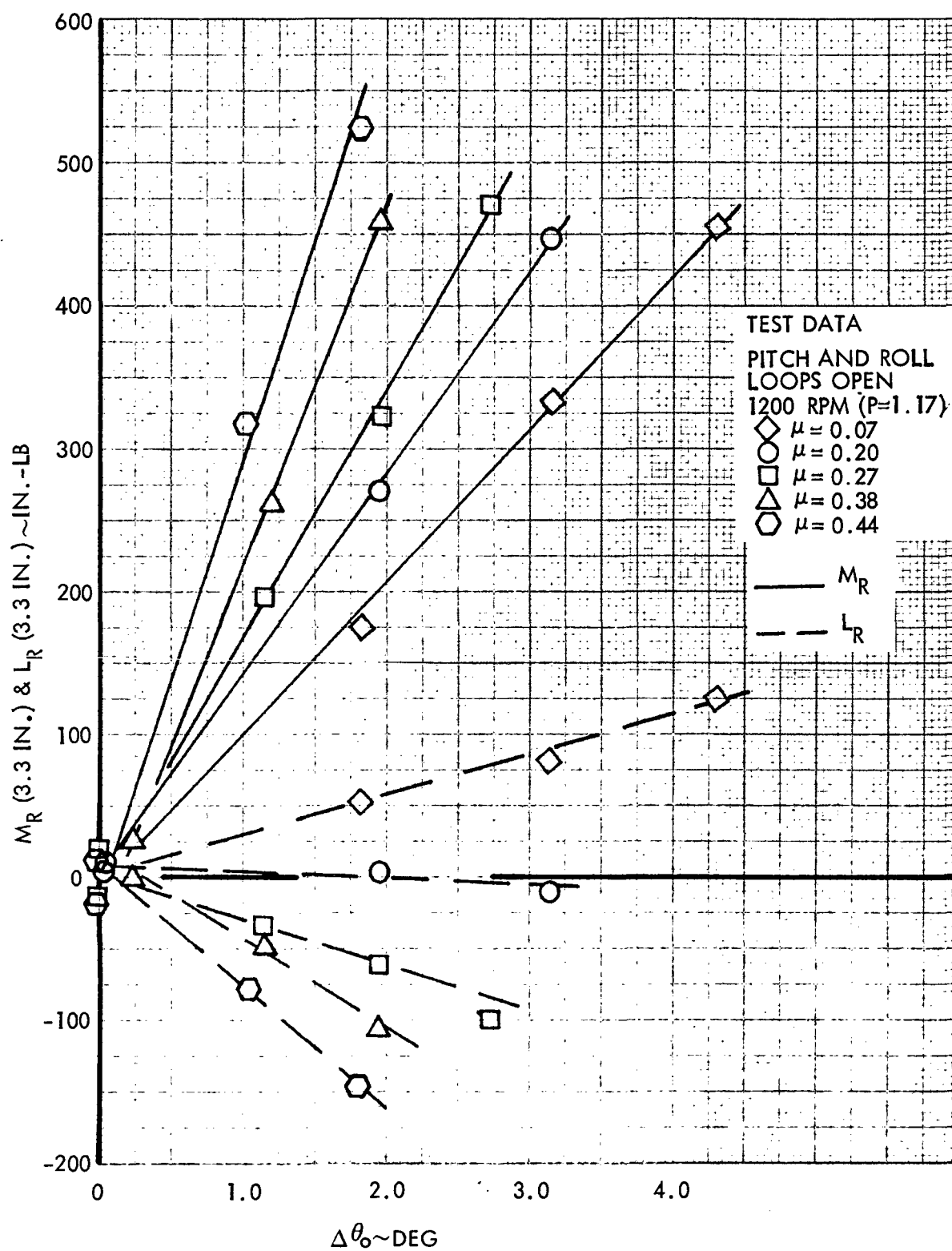


Figure F1. Open Loop Rotor Moment Responses to θ_o ,
1200 rpm ($P = 1.17$), $\gamma = 5.0$

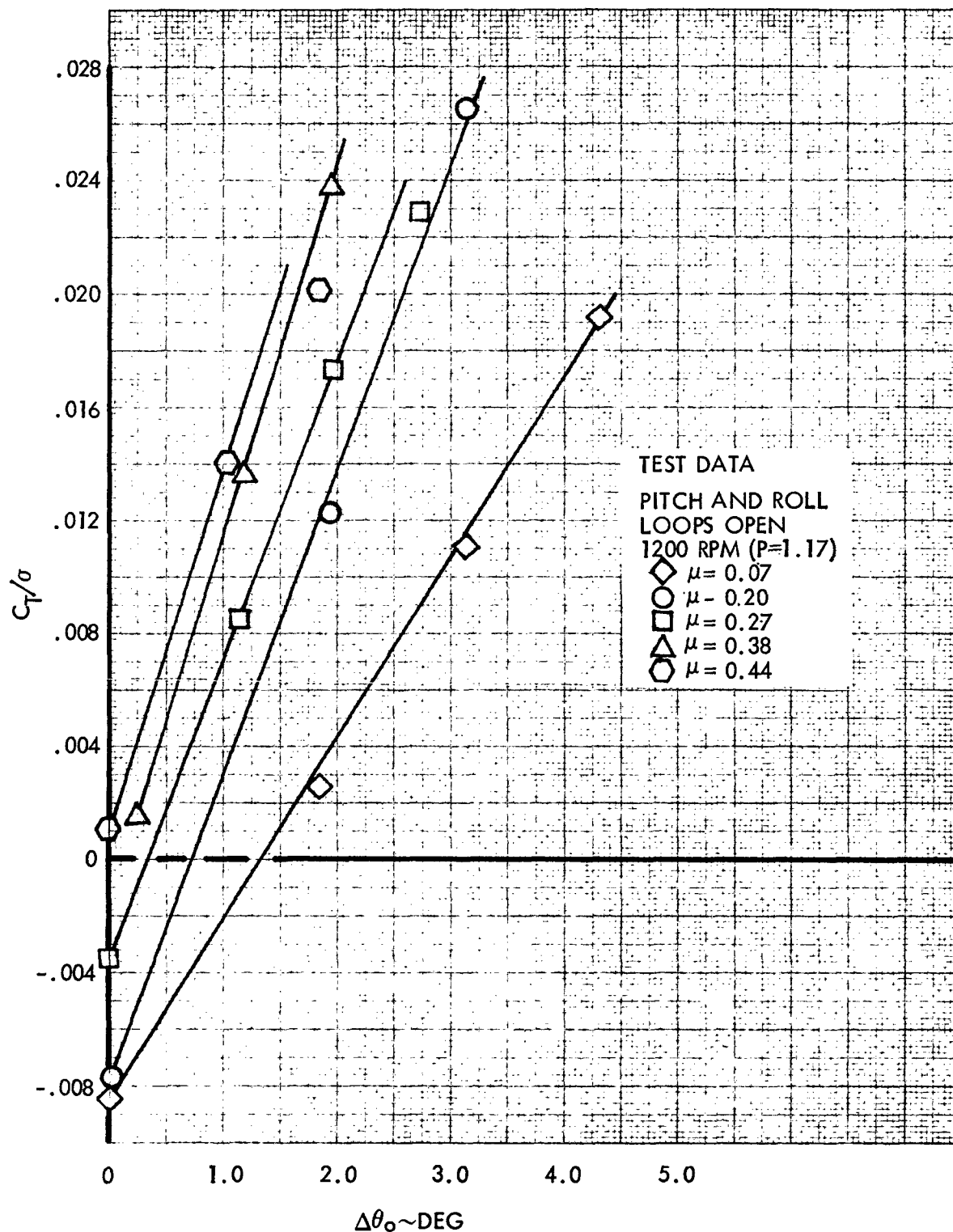


Figure F2. Open Loop Rotor Lift Response to θ_0 ,
1200 RPM (P = 1.17), $\gamma = 5.0$

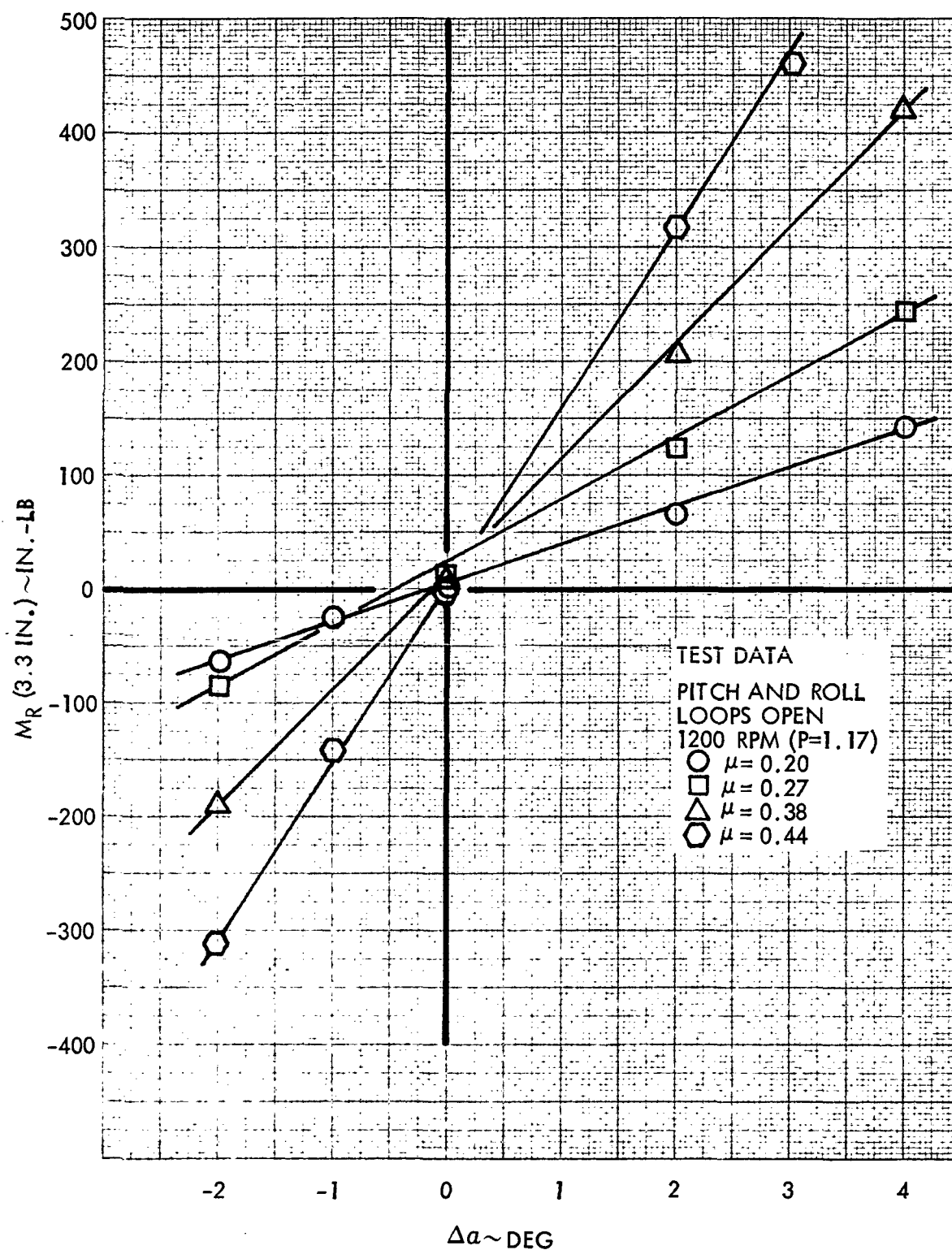


Figure F3. Open Loop Rotor Pitching Moment Response to α ,
1200 rpm (P = 1.17), $\gamma = 5.0$

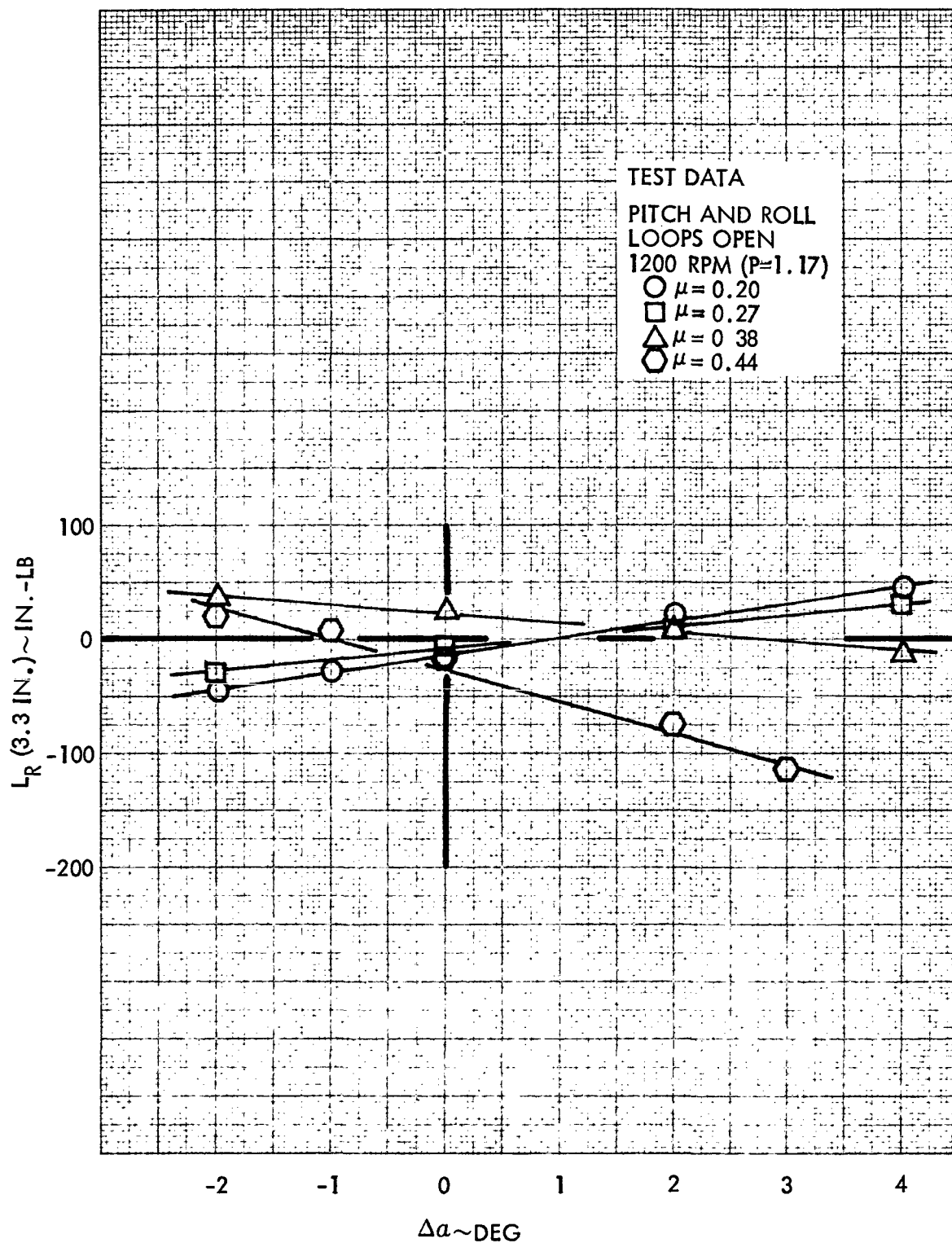


Figure F4. Open Loop Rotor Rolling Moment Response to α ,
1200 rpm (P = 1.17), $\gamma = 5.0$

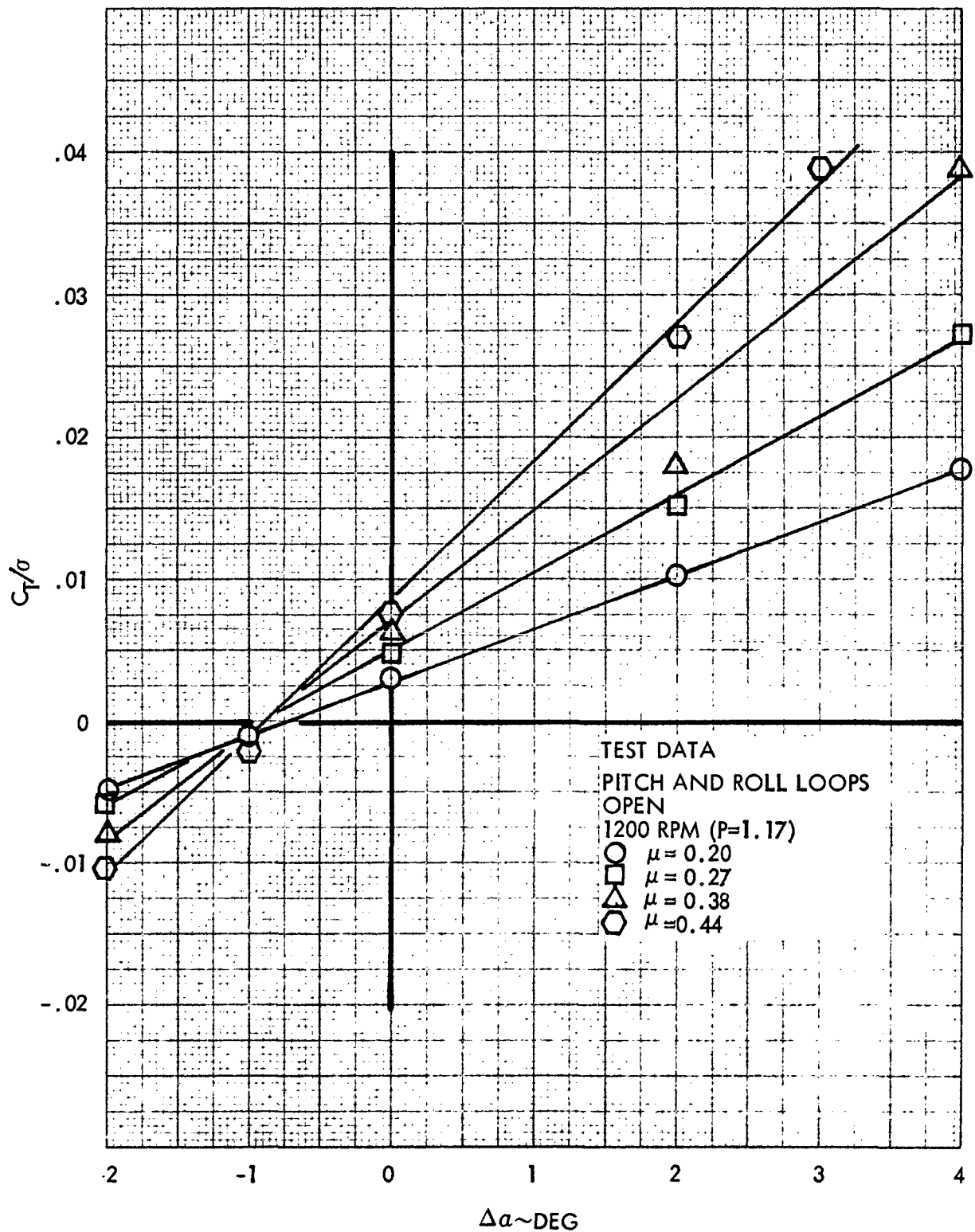


Figure F5. Open Loop Rotor Lift Response to α ,
1200 rpm ($P = 1.17$), $\gamma = 5.0$

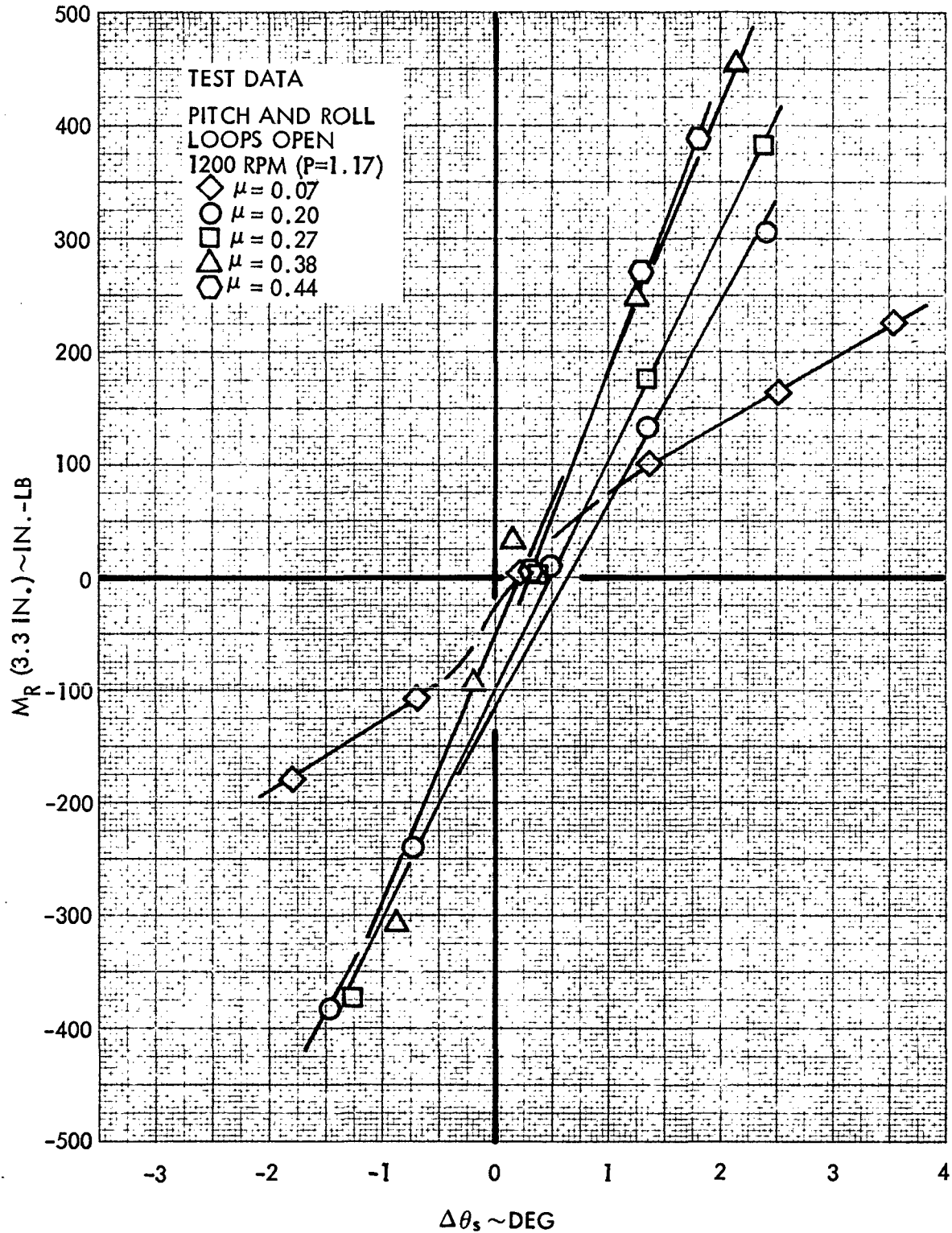


Figure F6. Open Loop Rotor Pitching Moment Response to θ_s ,
1200 rpm (P = 1.17), $\gamma = 5.0$

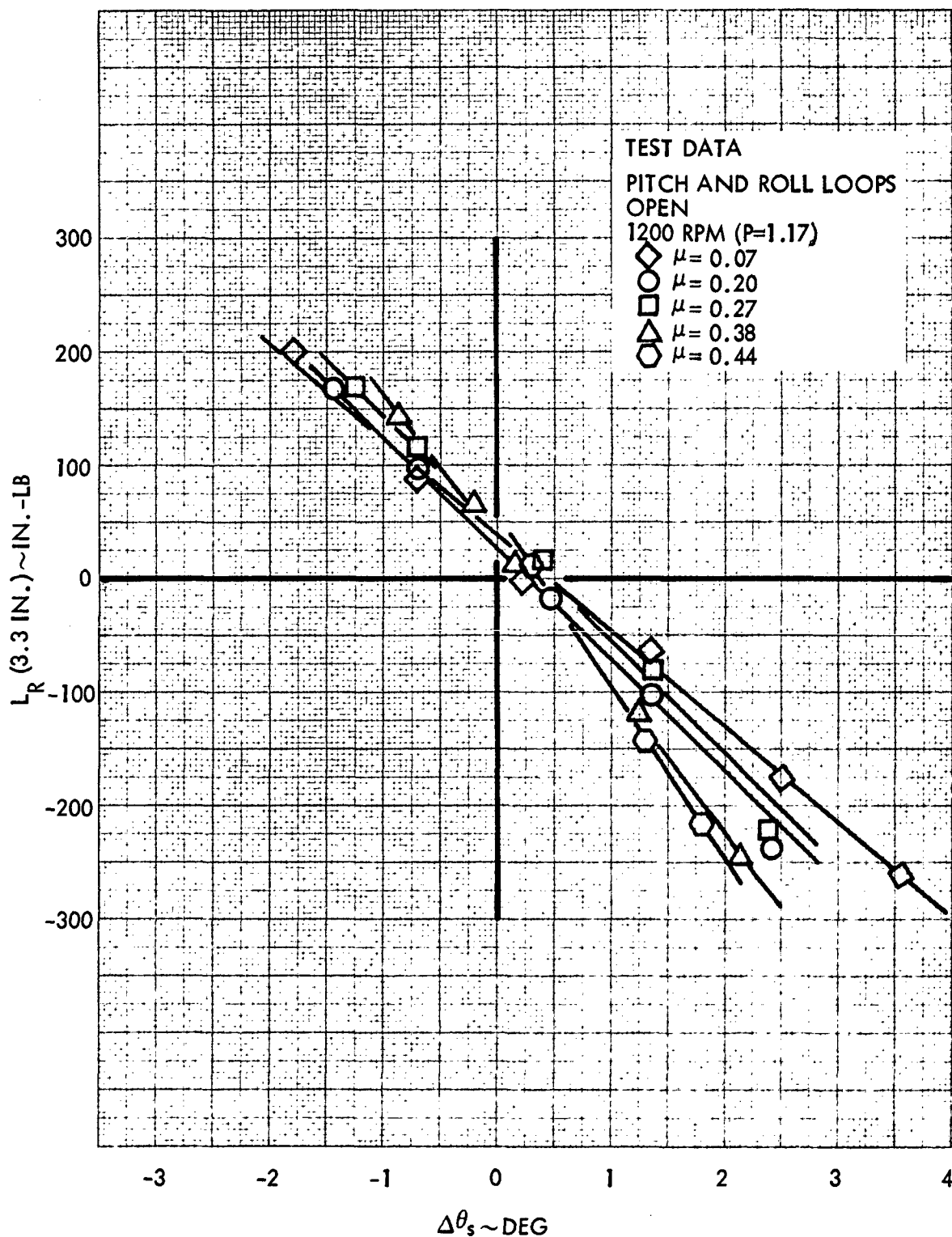


Figure F7. Open Loop Rotor Rolling Moment Response to θ_s ,
1200 rpm (P = 1.17), $\gamma = 5.0$

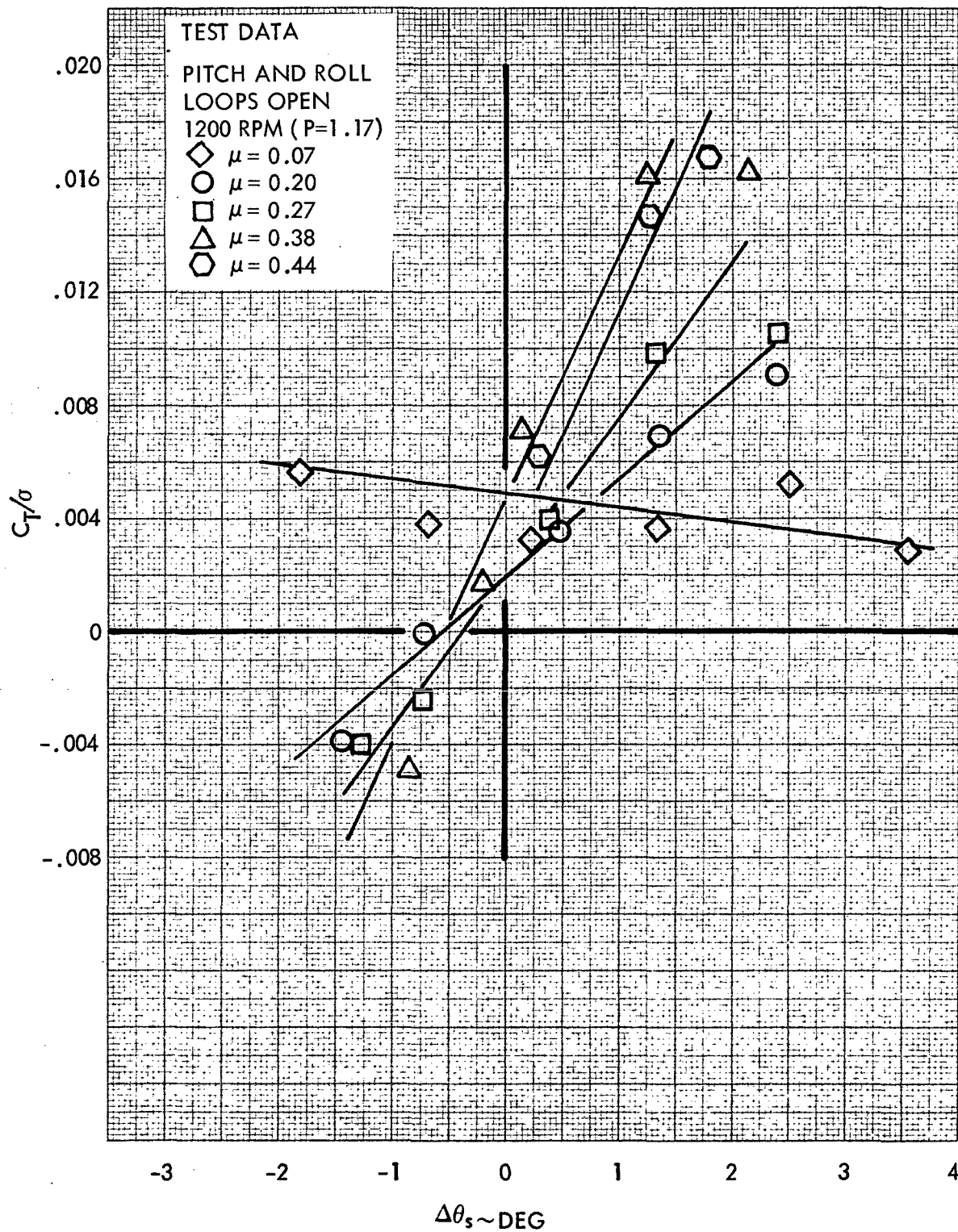


Figure F8. Open Loop Rotor Lift Response to θ_s ,
1200 rpm (P = 1.17), $\gamma = 5.0$

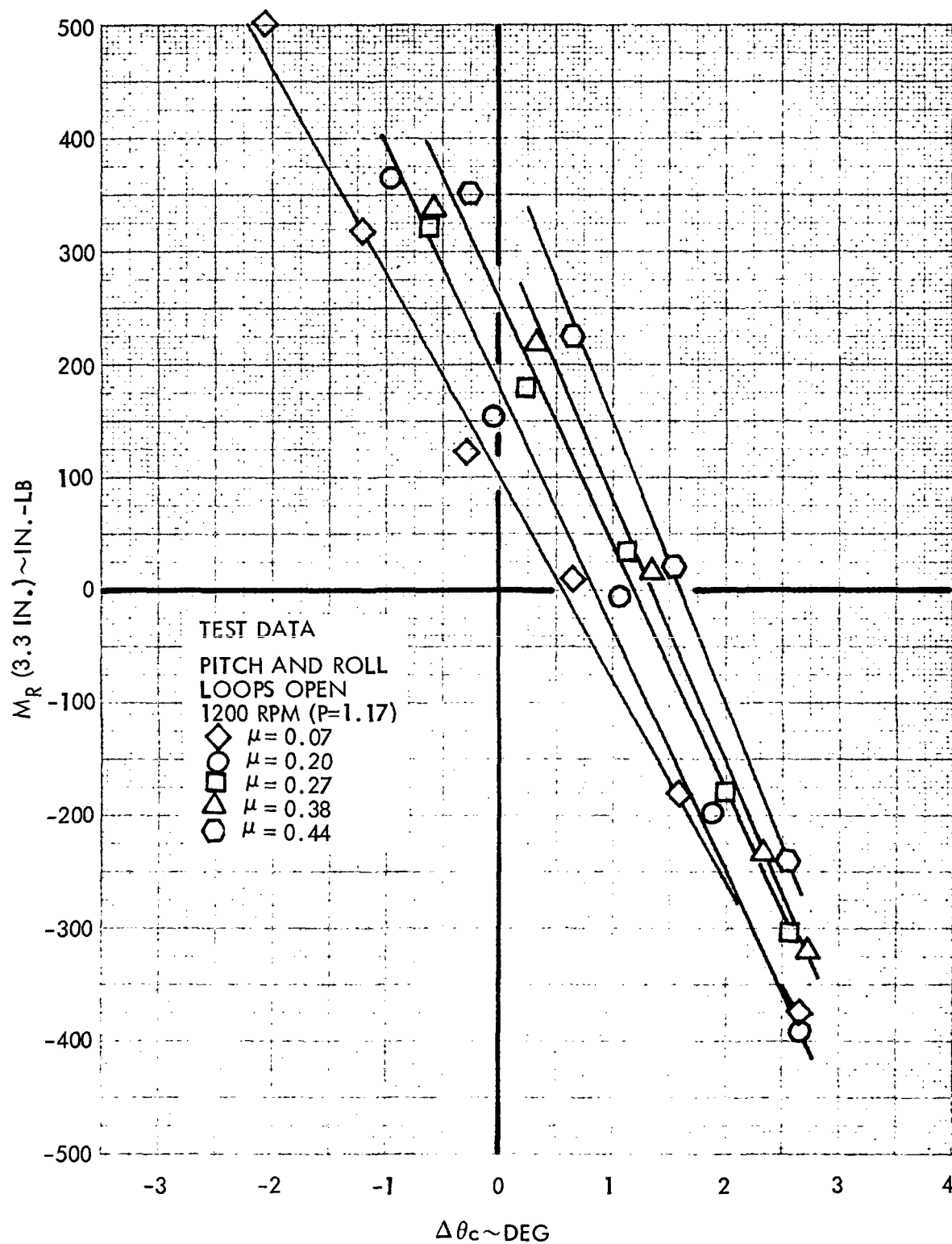


Figure F9. Open Loop Rotor Pitching Moment Response to θ_c ,
 1200 rpm (P = 1.17), $\gamma = 5.0$

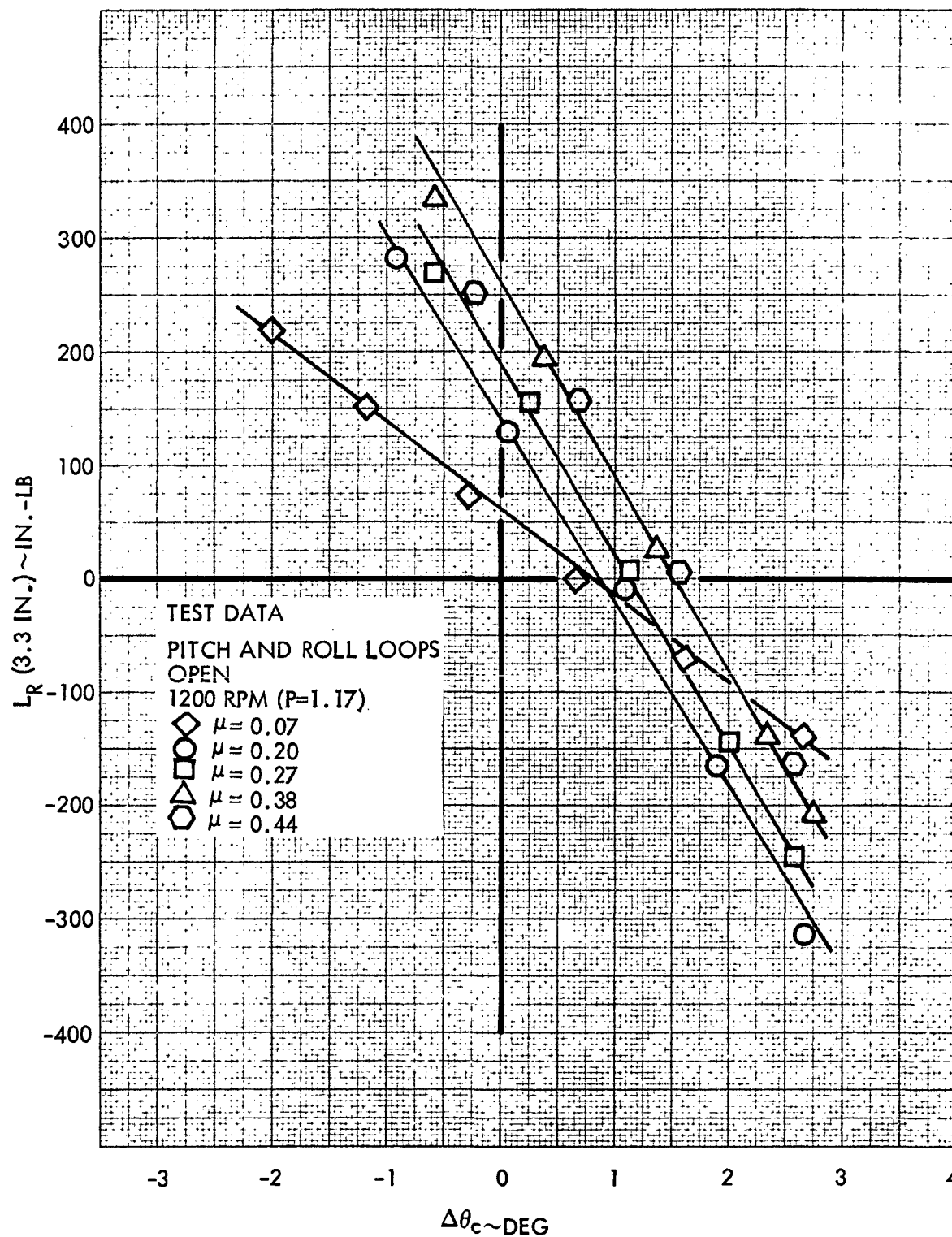


Figure F10. Open Loop Rotor Rolling Moment Response to θ_c ,
1200 rpm (P = 1.17), $\gamma = 5.0$