BIN: BIF-055-13834-69
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J Henry

TOPIC	PRESENTER	TIME

FRIDAY, MARCH 21, 1969

9.	VDP COMPONENT DESCRIPTION (LH AND RH)	SMITH	8:30 AM
10.	DRIVE K BRASSBOARD TEST STATUS	NAVON	9:00 AM
11.	DESCRIPTION OF PLANNED TESTS AND TEST METHODS AND PARAMETERS THAT ARE TO BE VERIFIED:		

	DC	DSS-1	LMQTV, 114, 115, EDCTU
SUB A VDP MDKE ADKE LHS GYRO LMMC	DISANTO (60 MIN.)	NAVON (45MIN.)	NICOLINI (30 MIN.)

(INCLUDE ANY SPECIFIC COMPONENT TEST PROBLEM AND THE CURRENTLY PLANNED SOLUTION OR PLAN TO OBTAIN A SOLUTION)

12.	CRITICAL OPEN INTERFACE ITEMS	NICOLINI	1:00 PM

---- LUNCH ----

13.	ALPHA ALIGNMENT DESCRIPTION AND STATUS	KOPANSKI	1:15 PM
14.	STATUS OF DYNAMIC MODEL		2:00 PM
15.	STATUS OF JANUARY TD ACTION ITEMS	SCHWARTZ	2:30 PM
16.	ALPHA SUBSYSTEM SPECIAL MODES		3:00 PM
17.	REPORT ON THERMAL MEETING	KARP	3:15 PM

JUN 12 1969

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ALPHA SUBSYSTEM TEM

THURSDAY, MARCH 20, 1969

	TOPIC	PRESENTER	TIME
1.	ALPHA S/S MILESTONE SCHEDULES (DC, DSS, 114)	DISANTO	8:30 AM
2.	ALPHA S/S FUNCTIONAL DESCRIPTION ELECTRICAL BLOCK DIAGRAM INCLUDING INTERFACE WITH CONSOLE CONTROLLER	MANLEY	9:00 AM
3.	DRIVE K FUNCTIONAL DESCRIPTION CIRCUIT AND PACKAGING BLOCK DIAGRAMS	HOOKER/ BILLINGS	9:30 AM
4.	PREDICTED S/S AND COMPONENT PERFORMANCE AS RELATED TO CEI REQUIREMENTS (INCLUDE ANY SPECIFIC COMPONENT DEVELOPMENT PROBLEM AND THE PLANNED SOLUTION OR PLAN TO OBTAIN A SOLUTION)	MONTGOMERY/ CHEESEMAN/ MANLEY	11:00 AM
	----LUNCH----		
5.	ALPHA INTERNAL MECHANISMS DESCRIPTION AND DESIGN STATUS	KOPANSKI	2:00 PM
6.	ALPHA EXTERNAL COMPONENT DESCRIPTION AND DESIGN STATUS	GOOSS/STEARNS	3:00 PM
7.	SUN SENSOR DESIGN STATUS	SCHWARTZ	4:15 PM
8.	COMPONENT WEIGHT AND POWER STATUS (INCLUDE SUB A UPDATE)	MANLEY/MAYER	4:30 PM

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AGENDA FOR THERMAL MTG.

THURSDAY, MARCH 20, 1969

1. ENVIRONMENTAL CONSTRAINTS 9:00 AM
    - A. VARIATION OF β ANGLE
    - B. RANGE OF OPERATING VARIABLES
        1. DOOR OPEN TIME
        2. USAGE DENSITY
        3. ENVIRONMENTAL FLUXES
    - C. ACTS THRUSTER FIRING - IMPACT ON THERMAL COATINGS
    - D. TIME AVAILABLE TO EQUALIZE SYSTEM AFTER LIFT-OFF

2. SYSTEM THERMAL REQUIREMENTS
    - A. TEMPERATURE LEVEL
    - B. TEMPERATURE GRADIENTS

3. CONCEPTS
    - A. HEATERS + PARTIALLY INSULATED DESIGN
        1. POWER PENALTY - EXTERNAL AND INTERNAL
    - B. BAS CONCEPT

4. STATUS OF MDAC THERMAL MODEL

5. QUAL. TESTING PROBLEM
    - A. SYSTEM DESIGN MARGIN
    - B. IMPLICATIONS OF MEETING ORIGINAL REQUIREMENTS OF DR1100

ALPHA SUBSYSTEM

COMPONENT STATUS

3-19-69

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MAIN DRIVE K ELECTRONICS (MDKE)

LAST 60 DAYS

- MODULE BREADBOARD TESTING COMPLETED
  - 70% MODULE DRAWINGS ISSUED: FABRICATION INITIATED
  - PRELIMINARY WEIGHT, THERMAL, AND WORST CASE ANALYSIS COMPLETED
  - PARTS FOR 3 UNITS ORDERED
  - INDEPENDENT PACKAGING/REQUIREMENTS REVIEW HELD
  - 60% OF MODULE TEST REQUIREMENTS ISSUED
  - ENVELOPE DRAWINGS ISSUED

NEXT 90 DAYS

MAJOR TASKS ARE RELATED TO DETAIL DESIGN AND RELEASE TO MANUFACTURING FOR DC-1, DSS-1, AND 114 UNITS

o COMPLETE RELEASE OF MODULE DRAWINGS	(MAR 21
o COMPLETE FABRICATION AND TESTING OF MODULES	(JUNE 6)
o RELEASE PC BOARDS	(MAR 15-APR 15)
o RELEASE TEST EQUIPMENT DESIGN	(APR 30)
o DESIGN REVIEW	(APR 15)
o ISSUE BLOCK DIAGRAMS	(APR. 4)

PROBLEMS

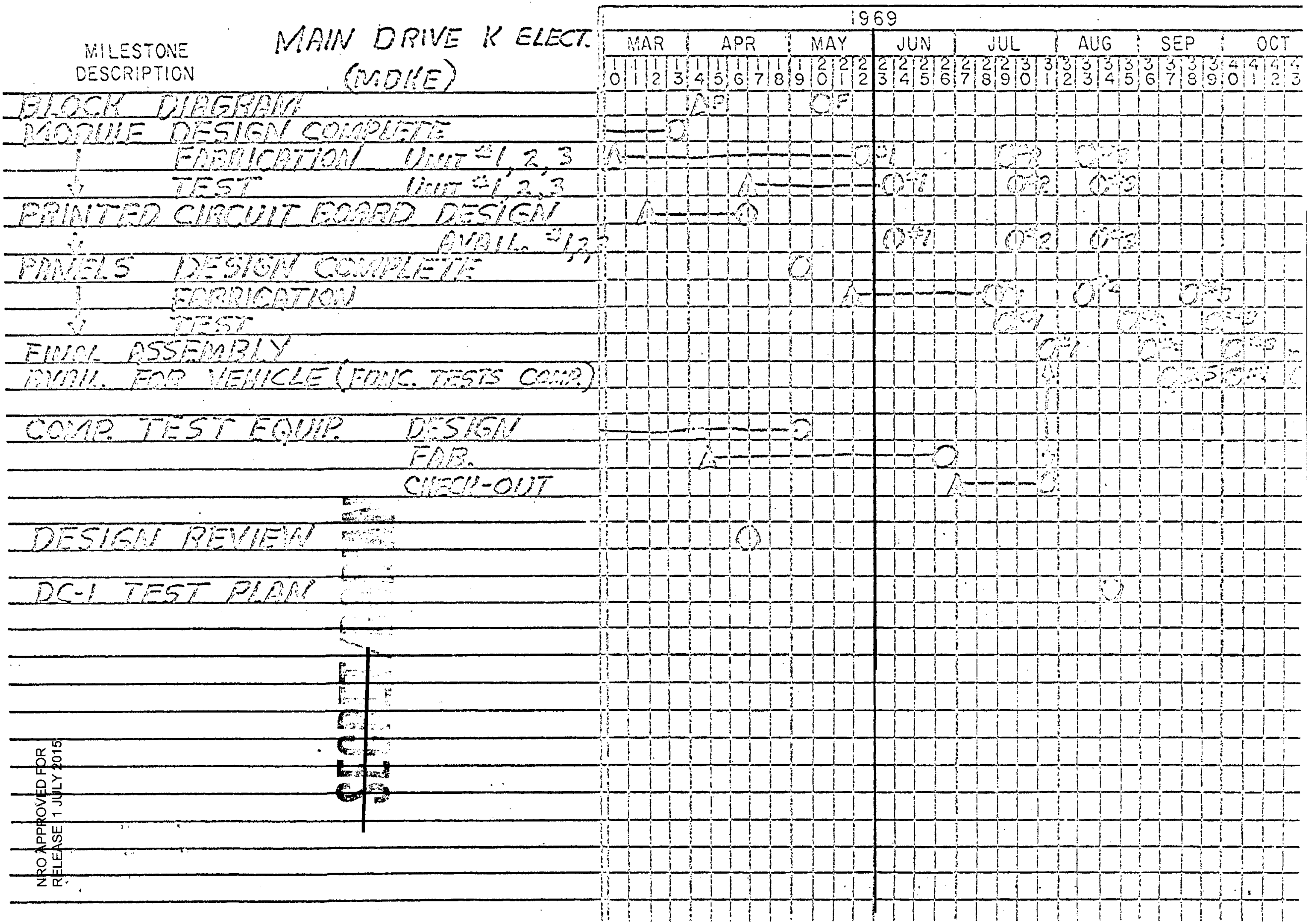
- TIGHT SCHEDULE (100% SUCCESS)

ALPHA SUBSYSTEM

MARCH 19, 1969

6

MOL PROGRAM MILESTONE SCHEDULE



AUXILIARY DRIVE K ELECTRONICS (ADKE)

LAST 60 DAYS

- ENGINEERING SPEC. ISSUED
- BREADBOARD TESTS COMPLETED
- PRELIMINARY PACKAGING, WEIGHT, AND THERMAL ANALYSIS COMPLETED
- 40% MODULE DRAWINGS COMPLETED (7 OF 18 CORDWOOD)
- 3 OF 18 MODULE TEST REQUIREMENTS ISSUED
- ADVANCE ORDER OF PARTS FOR ADKE AND TEST EQUIP. PLACED

NEXT 90 DAYS

- MAJOR TASKS ARE RELATED TO DETAIL DESIGN AND RELEASE TO MANUFACTURING FOR DC-1, DSS-1, AND 114 UNITS
- CONCEPTUAL/BREADBOARD DESIGN REVIEW (MAR 25)
- COMPLETE MODULE DESIGN, FAB., AND TEST (JUNE 6)
- COMPLETE P.C. BOARDS DESIGN AND FAB. (JUNE 13)
- COMPLETE DESIGN AND BEGIN FAB. OF TEST EQUIP. (MAY 27)

PROBLEMS

- TIGHT SCHEDULE (100% SUCCESS)

ALPHA SUBSYSTEM

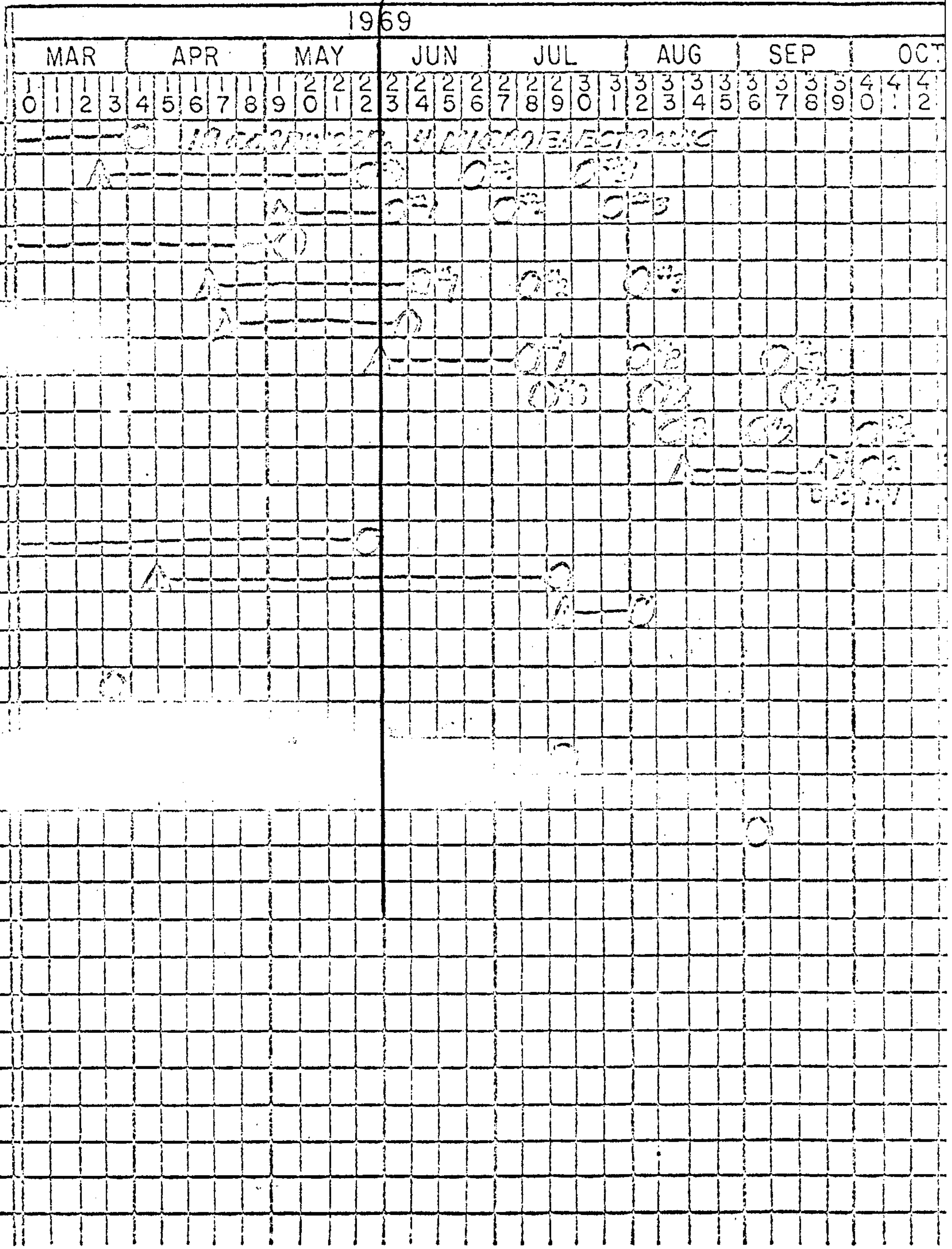
MARCH 19, 1969

MOL PROGRAM MILESTONE SCHEDULE

AUX. DRIVE K ELECTRONICS
(ADKE)

MILESTONE DESCRIPTION

MODULE DESIGN
FABRICATION
TEST
PRINTED CIRCUIT BOARDS DESIGN
AVAIL.
PANELS DESIGN
FABRICATION
TEST
FINAL ASSEMBLY
AVAIL. TO VEHICLE (FUNC. TESTS COMP.)
COMPONENT TEST EQUIP. DESIGN
FAB.
CHECK-OUT
DESIGN REVIEW
ACCEPT. TEST PLAN
DC-1 TEST PLAN



LEFT-HAND CONTROL STICK - (LHC)

LAST 60 DAYS

- O 42 DETAIL DRAWINGS ISSUED (GRIP DEFINITION, 2 TRANSITION ARMS, AND TOP ASSEMBLY ARE ONLY OUTSTANDING ITEMS FOR DC-1, DSS-1, AND 114 RELEASE)
- O LONG LEAD ITEMS ORDERED (SWITCHES ORDERED; OUT FOR QUOTES ON HERMETICALLY-SEALED POTS; OUT FOR QUOTES ON GRIP)
- O EMI ANALYSIS COMPLETE
- O INTERFACE AND SCHEMATIC COMPLETE

NEXT 90 DAYS

- O EVALUATE QUOTES FROM THREE GRIP VENDORS (MAR 20-MAR 27)
- O SELECT GRIP VENDOR (MAR 28)
- O COMPLETE DRAWING RELEASE (APR.10)
- O DESIGN REVIEW (APR 11)
- O DESIGN AND FAB. TEST EQUIPMENT (APR. 24-JULY 26)
- O DSS-1 AND 114 RELEASE (JUNE 6)
- O ADDITIONAL SUPPORTING ANALYSES (STRESS, WEIGHT, PACKAGING, RFMA, FMEA) (APR 11)

PROBLEMS

- O DSS-1 AND 114 RELEASE PRIOR TO ENVIRONMENTAL TESTS ON DC UNIT
- O INITIAL RESPONSES OF 26 WEEK LEAD-TIME ON GRIP JEOPARDIZES SCHEDULE FOR ENGINEERING UNITS.

MOL PROGRAM MILESTONE SCHEDULE

LEFT HAND CONTROL STICK (LHC)

	1969																																	
MILESTONE DESCRIPTION	MAR				APR					MAY				JUN				JUL					AUG.				SEP				OCT			
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
EVAL. GRIP VENDOR QUOTES			Δ	○																														
SELECT GRIP VENDOR				○																														
DC-1																																		
COMPLETE DC DRAWING RELEASE						○																												
COMP. ADDITIONAL SUPPORT ANALYSIS						○																												
DESIGN REVIEW						○																												
FAB. & ASSEMBLE DC-1 (WITHOUT GRIP			Δ	—	—	—	—	—	—	—	○																							
FUNCTIONAL TESTS (NO ENVIRONMENTS)												Δ	—	—	—	—	○																	
DC-1 REWORK- ADD GRIP & HERMETICALLY-SEALED POT.																	Δ	—	—	—	—	○												
DC-1 ENVIRONMENTAL TESTS																							Δ	—	—	—	—	—	—	—	—	—	—	○
DC-1 TEST PLAN																			○															
DSS : 114																																		
DSS-1 / 114 DESIGN RELEASE														○																				
FABRICATION														Δ	—	—	—	—	—	—	—	—	—	—	—	—	—	○					○	
FUNCTIONAL TESTS (AVAIL. TO VEHICLE)																												Δ						

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LAB MODULE MODE CONTROLLER (LMMC)

LAST 60 DAYS

- ○ SPEC. DRAFT WRITTEN
- ○ PRELIMINARY ANALYSIS ISSUED (PACKAGING, WEIGHT, POWER)
- ○ SCHEMATIC ISSUED
- ○ LONG LEAD ITEM ORDER PLACED (JAN 15)

NEXT 90 DAYS

- ○ COMPLETE PRELIMINARY ANALYSIS (APR 11)
- ○ DESIGN REVIEW (APR 15)
- ○ COMPLETE DESIGN/ISSUE TOP ASSEMBLY DRAWING (APR 30)
- ○ DESIGN TEST EQUIPMENT
- ○ ISSUE TEST PLANS (ACCEPTANCE, DC) (APR 22)
  - (FOR DSS-1, 114) (APR 29)
- ○ START FAB AND ASSEMBLY
  - DC/DSS-1 (MAY 29)
  - 114 (MAY 9)

ALPHA SUBSYSTEM

MARCH 19, 1969

12

MOL PROGRAM MILESTONE SCHEDULE

LAB MODULE MODE CONTROL.

(LMMC)

MILESTONE DESCRIPTION

COMPLETE ALL PRELIM. ANALYSIS

DESIGN REVIEW

TOP ASSEMBLY DRAWING & PARTS LIST

FAB. & ASSEMBLY 114 }

FUNCTIONAL TEST 114 }

FAB. & ASSEMBLY DC/DSS }

FUNCTIONAL + DC-1 TEST }

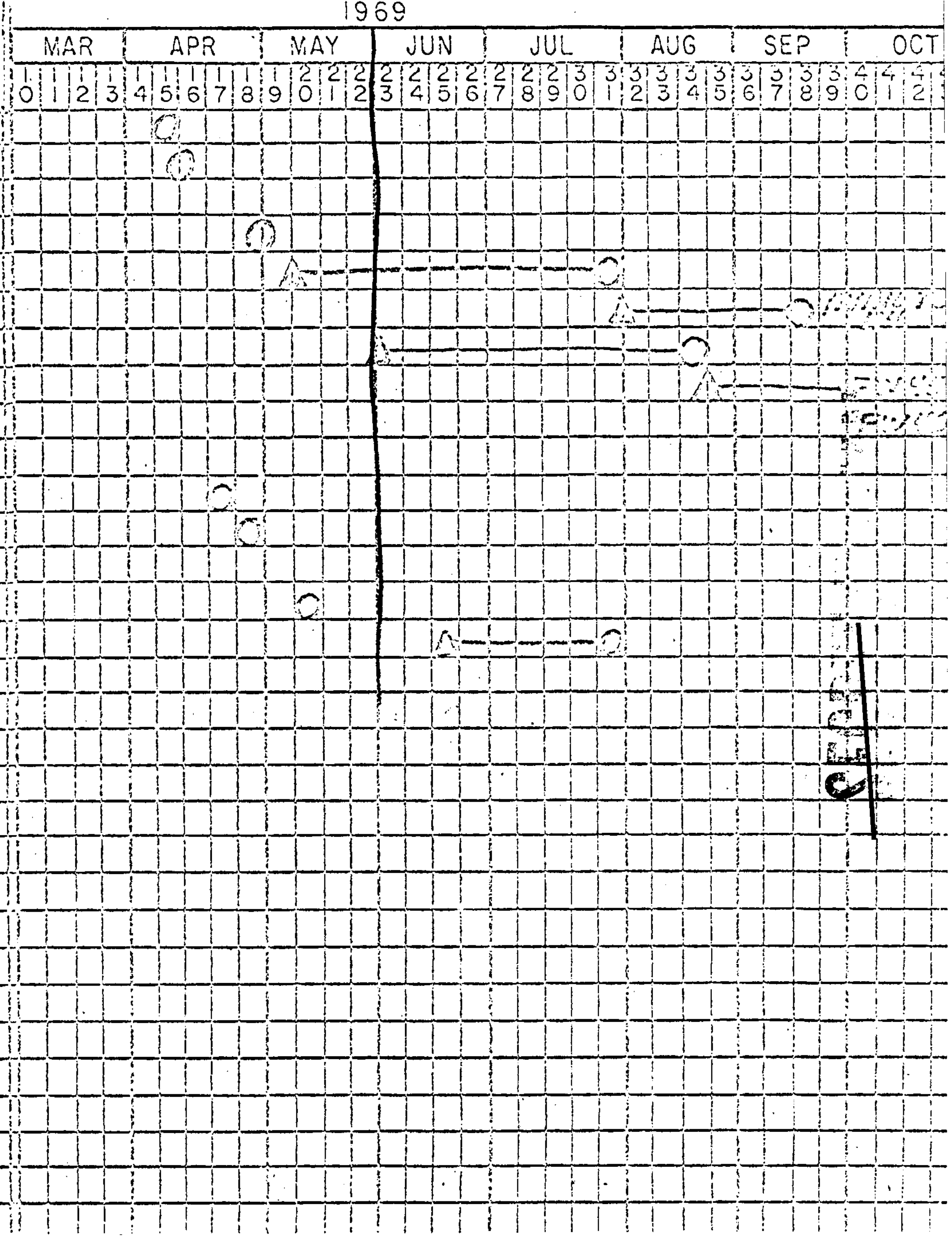
AVAIL TO DSS }

FUNCTIONAL TEST PLAN

DC-1 TEST PLAN

COMP. TEST EQUIPMENT DESIGN

FAB. & C/O



NRO APPROVED FOR RELEASE 1 JULY 2015

VISUAL DISPLAY PROJECTOR (VDP) :
VISUAL DISPLAY MODULE (VDM)

BUILT BY LEA SIEGLER INC., PER WS 1307

LAST 60 DAYS

- TOP ASSEMBLY DRAWINGS STARTED
- BLOCK DIAGRAM ISSUED
- NEW OPTICAL ASSEMBLY AND PRESCRIPTION ISSUED (PRELIMINARY)
- FILM FORMAT CHANGED TO AID IN FINE POSITIONING
- TEST FILM SUBCONTRACT AWARDED TO DATA CORP.
- NEW 3-FILAMENT PROJECTOR LAMP SURVIVED 150% OF SHOCK AND QUAL. VIB. LEVELS; SURVIVED 72 HOURS, 2 ATMS, HELIUM OPERATION WITHOUT NOTICEABLE DEGRADATION: AND IS PRESENTLY IN LIFE TEST
- NEW OPTICAL DESIGN TESTS INDICATE THAT BOTH RESOLUTION AND BRIGHTNESS REQUIREMENTS WILL BE MET.

G.E.

- THERMAL REQUIREMENTS ADDED TO SPEC.
- 30 MIN. THERMAL-VACUUM REQUIREMENT ADDED TO SPEC.
- TELEMETRY REQUIREMENTS ADDED TO SPEC.
- WORKED CONSOLE 2 INTERFERENCE PROBLEM
- UPDATE FILM FORMAT IN CEI SPEC.

NEXT 90 DAYS

LSI

- COMPLETE PART PROCUREMENT AND START ALL PHASES OF ASSEMBLY FOR TWO DEVELOPMENT UNITS (BOTH CONSOLE 8 VERSIONS)
- START CEI SPECS.
- COMPLETE EXERCISER DESIGN AND BEGIN PROCUREMENT
- ISSUE TOP ASSEMBLY DRAWINGS

G.E.

- ANALYZE NEW OPTICAL DESIGN (MAY 7)
- ESTABLISH MOUNTING INTERFACE DEFINITION (MAY 14)
- RESOLVE CONSOLE 2 INTERFERENCE (ISSUE DIRECTION BY MAR. 27)

PROBLEMS

- CONSOLE 2 INTERFERENCE
    - PROBLEM, TRADE-OFFS, RESOLUTION - PART OF CIE PITCH PREVIOUSLY GIVEN -- MOCKUP TOUR
    - IMPACT ON VDP AND VDM - LATER (FRI. MORN.)

DRIVE-K SCANNER

- PROGRESS WITHIN LAST 60 DAYS
  - DETAIL DESIGN REVIEW (EMK)
  - DETAIL DRAWING RELEASE (EMK)
  - INITIATE PROCUREMENT (EMK)
  - RELEASE DRAWINGS AND SPEC.
    - ENCODER (EMK)
    - TORQUERS (EMK)
  - INITIATE LONG-LEAD PROCUREMENT (EM-1)

- MILESTONE SCHEDULE

EM1 PEDESTAL DESIGN RELEASE	(6-1)
EMK TEST PLAN	(6-9)
EMK ASSEMBLY COMPLETE	(6-15)
EMK TEST START	(7-15)
DELIVER DSS-1	(11-1)
DELIVER 114	(12-1)

SCANNER PROCUREMENT STATUS

THE EMK SCANNER PROCUREMENT, AS OF 3/14/69, BREAKS DOWN AS FOLLOWS:

		EMI
1.0	MIRROR BEZEL PHASE	
1.1	BEZEL - AMERICAN BERYLLIUM CORPORATION - COMPLETE SARASOTA, FLORIDA	(5-23)
1.2	HONEYCOMB END PLATE - PARSONS CORPORATION - COMPLETE STOCKTON, CALIFORNIA	(5-16)
1.3	BEZEL/END PLATE INTEGRATION - AMERICAN BERYLLIUM - 4/9/69	(6-18)
2.0	PITCH GIMBAL PHASE	
2.1	YOKE ASSEMBLY - BARDEN LEEMATH - COMPLETE WOODBURY, NEW YORK	(5-23)
	THIS PROCUREMENT INCLUDES THE TORQUER AND ENCODER HOUSINGS	
2.2	TORQUE MOTORS - AEROFLEX CORPORATION - PLAINVIEW, NEW YORK	(4-20)
2.3	ENCODER - WAYNE-GEORGE - 5/1/69	(8-8)
3.0	ROLL AXIS PHASE	
3.1	ROLL HOUSING - BARDEN LEEMATH - 3/24/69	DESIGN CHG.
3.2	PEDESTAL - BARDEN LEEMATH (COMPLETE) WOODBURY, NEW YORK	DESIGN CHG.
3.3	ROLL HOUSING/PEDESTAL INTEGRATION - BARDEN LEEMATH - 3/28/69	--
3.4	TORQUE MOTOR - AEROFLEX CORPORATION - 4/20/69	(4-20)
3.5	ENCODER - WAYNE-GEORGE - 5/1/69	(5-1)

THE EMK ASSEMBLY AND TEST PHASE IS AS FOLLOWS:

1.0 ROLL AXIS ENCODER ASSEMBLY
ASSEMBLY COMPLETED. DATA REDUCTION IS IN PROCESS.

(JUNE 1)

DRIVE-K TELESCOPE

- PROGRESS WITHIN LAST 60 DAYS
  - BENCH TEST DESIGN COMPLETE
  - FAB BENCH TEST ELEMENTS:
    - OBJECTIVE END COMPLETE
    - EYEPIECE ELEMENTS IN WORK
  - DETAIL DESIGN (EMK) COMPLETE
  - RELEASE DESIGN (EMK)
  - LONG-LEAD ITEM (EMI) RELEASED
  - INITIAL THERMAL ANALYSIS COMPLETED

- MILESTONES SCHEDULE

INITIAL BENCH TEST	(3-11)
COMPLETE BENCH TEST	(4-27)
FINAL BENCH TEST REPORT	(5-10)
INITIATE EMK ASSEMBLY	(4-21)
EMK ASSEMBLY COMPLETE	(7-30)
EMK TEST PLAN	(8-1)
DELIVERY DSS-1 UNIT	(9-15)
DELIVERY 114 UNIT	(12-1)

PROCUREMENT STATUS

THE EMK TELESCOPE PROCUREMENT AS OF 3/14/69 BREAKS DOWN AS FOLLOWS:

		EM-1
1.0	OBJECTIVE TUBE - BUDD COMPANY 4/27/69 FORT WASHINGTON, PA.	(5-23)
2.0	INTERMEDIATE TUBE - LUDWIG HONOLD 5/30/69 FOLCROFT, PA.	(6-30)
3.0	ELBOW CASTING - ANADITE CORPORATION 7/15/69 SOUTH GATE, CALIFORNIA	(9-25)
4.0	ZOOM CASTING - UNI CAST, INCORPORATED 6/1/69 DERRY, NEW HAMPSHIRE	(6-23)
5.0	PERIPHERAL DISPLAY - LA POINTE INDUSTRIES 5/1/69 ROCKVILLE, CONNECTICUT	(5-1)

FFW/MOUNT

- PROGRESS WITHIN LAST 60 DAYS
  - CONCEPTUAL DESIGN COMPLETE
  - MECHANICAL LAYOUTS IN PROCESS

- MILESTONES

COMPLETE DESIGN LAYOUTS	(4-15)
COMPLETE THERMAL DESIGN	(5-15)
COMPLETE DETAIL DESIGN (EMK)	(5-25)
PDR	(6-24)
EMK TEST PLAN	(10-1-69)
CDR	(11-24-69)
DELIVER DSS-1	(12-1-69)
DELIVER 114	(12-10-69)
DELIVER ELECTRONIC SENSORS FOR DSS-1 TESTING	(10-15-69)

SHROUD

- PROGRESS WITHIN LAST 60 DAYS
  - CONCEPTUAL LAYOUTS INITIATED
  - THERMAL ANALYSIS INITIATED

- MILESTONE SCHEDULES

COMPLETE DETAIL LAYOUTS	(5-1)
COMPLETE THERMAL ANALYSIS	(5-15)
PDR	(6-10)
CDR	(12-16)
RELEASE DETAIL DRAWINGS FOR ENGINEERING MODELS	(7-23)
DSS-1 DELIVERY	(10-15)
114 DELIVERY	(11-22)
EMK TEST PLAN	(9-1)

~~SECRET/DORIAN~~

DRIVE-K GYRO & ELECTRONICS

BUILT BY HONEYWELL INC. PER WS1717

LAST 60 DAYS

HONEYWELL

- CDR — JAN 29-30
- CDR ACTION ITEMS
- DELIVERED 1 PROTOTYPE UNIT TO G.E. FOR S/C "A" DEV. UNIT — MAR 4

G.E.

- CDR
- CDR ACTION ITEMS
- TESTED PROTOTYPE UNIT & DELIVERED TO S/C A — MAR 7

NEXT 90 DAYS

HONEYWELL

- COMPLETE CDR ACTION ITEMS
- DELIVER SECOND PROTOTYPE UNIT TO GE FOR S/C A DEV. UNIT — APR 15
- RESOLVE MECHANICAL PROBLEMS

G.E.

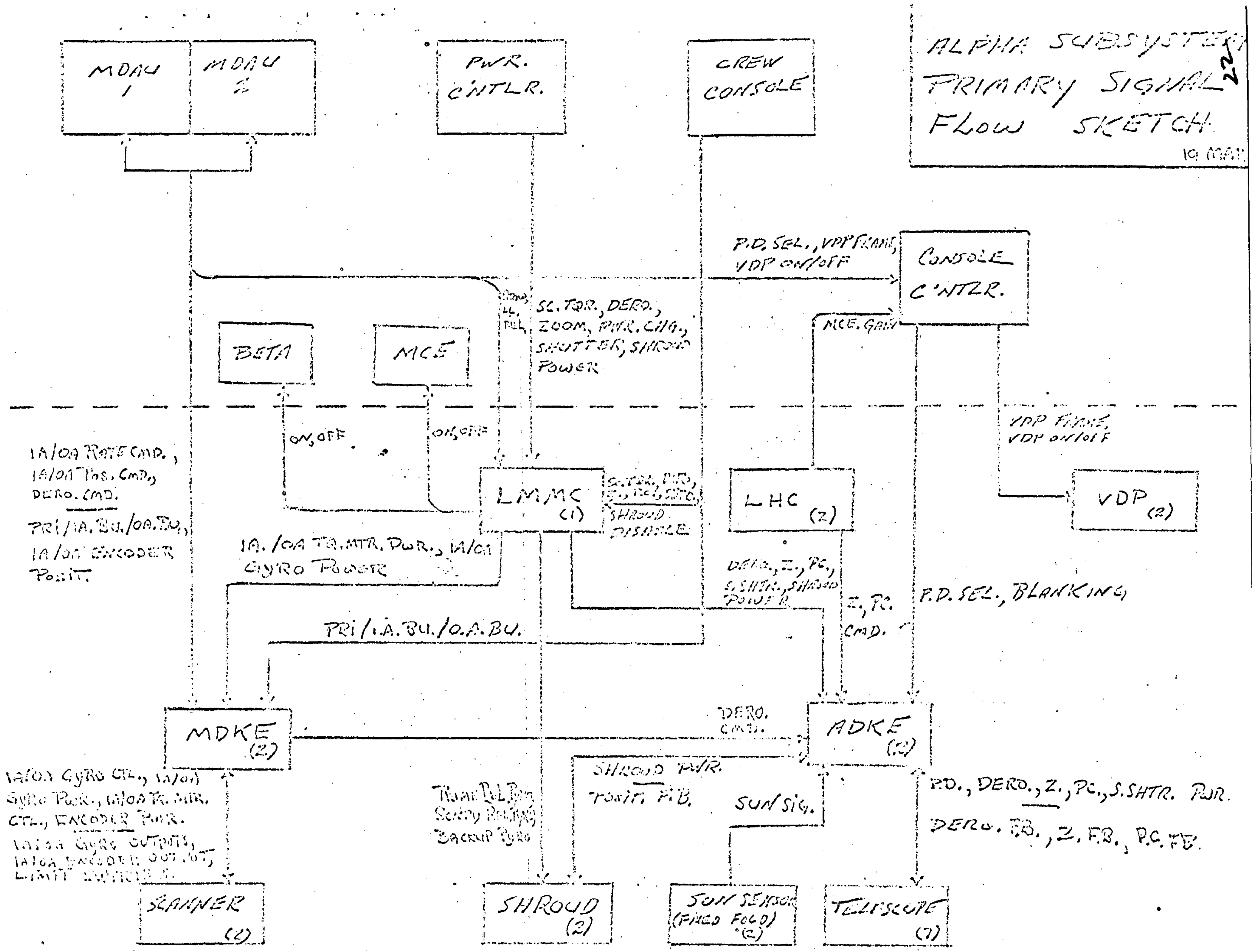
- TEST SECOND PROTOTYPE UNIT AND DELIVER TO S/C A — MAY 1
- ISSUE DC TEST REPORT — MAY 16

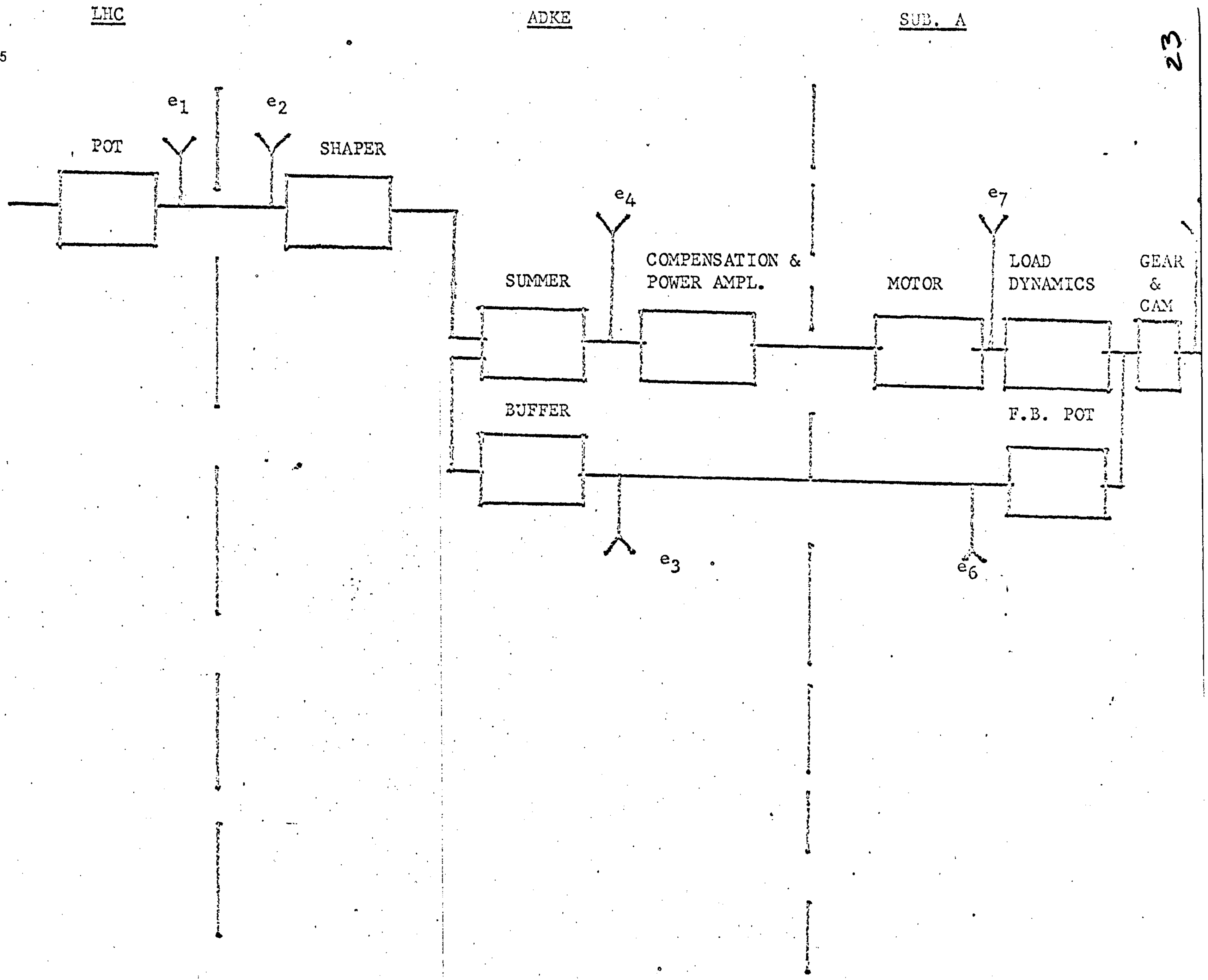
PROBLEMS

- GYRO FAILED LATEST VIBRATION REQUIREMENTS - FIX REQUIRES REDESIGN TO ELIMINATE SHAFT NOTCH

~~SECRET~~/DORIAN

ALPHA SUBSYSTEM ELECTRICAL INTERFAC




LHC
ADKE
SUB. A
e_1
e_2
POT
SHAPER
e_4
e_7
SUMMER
COMPENSATION & POWER AMPL.
MOTOR
LOAD DYNAMICS
GEAR & CAM
BUFFER
F.B. POT
e_3
e_6

Servo Requirements

Errors (Gimbal)

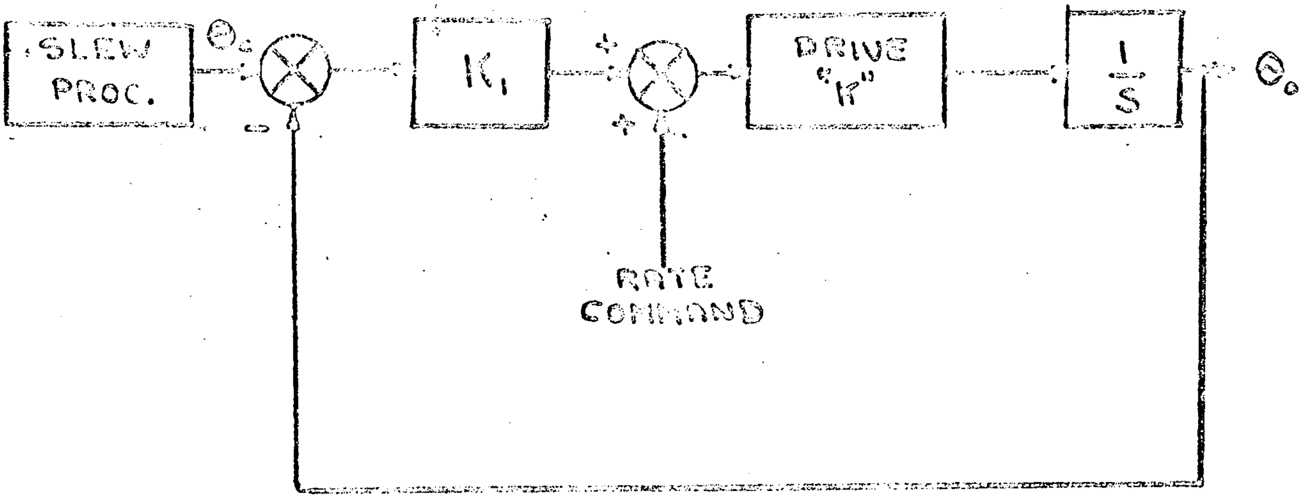
$< 0.84\ \widehat{\text{min}}$

< 0.01 deg/sec

Time

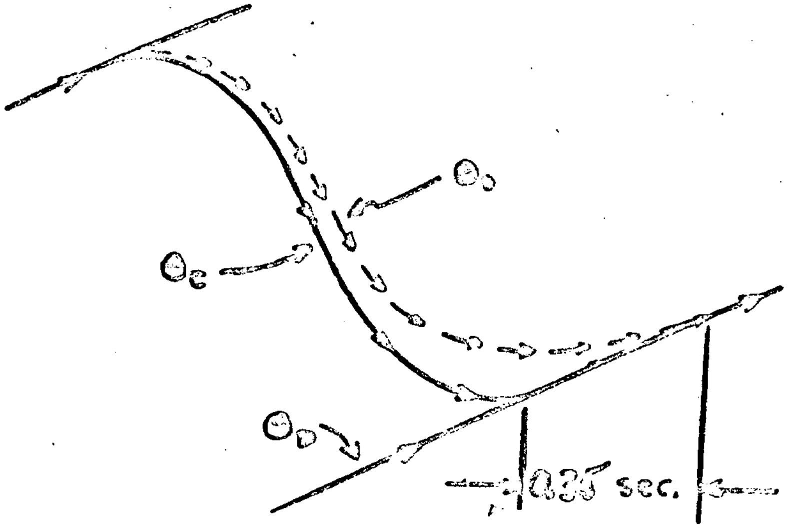
Pitch $\left(\frac{\Delta\theta}{15}+1\right)$ sec

Roll $\left(\frac{\Delta\theta}{30}+1\right)$ sec



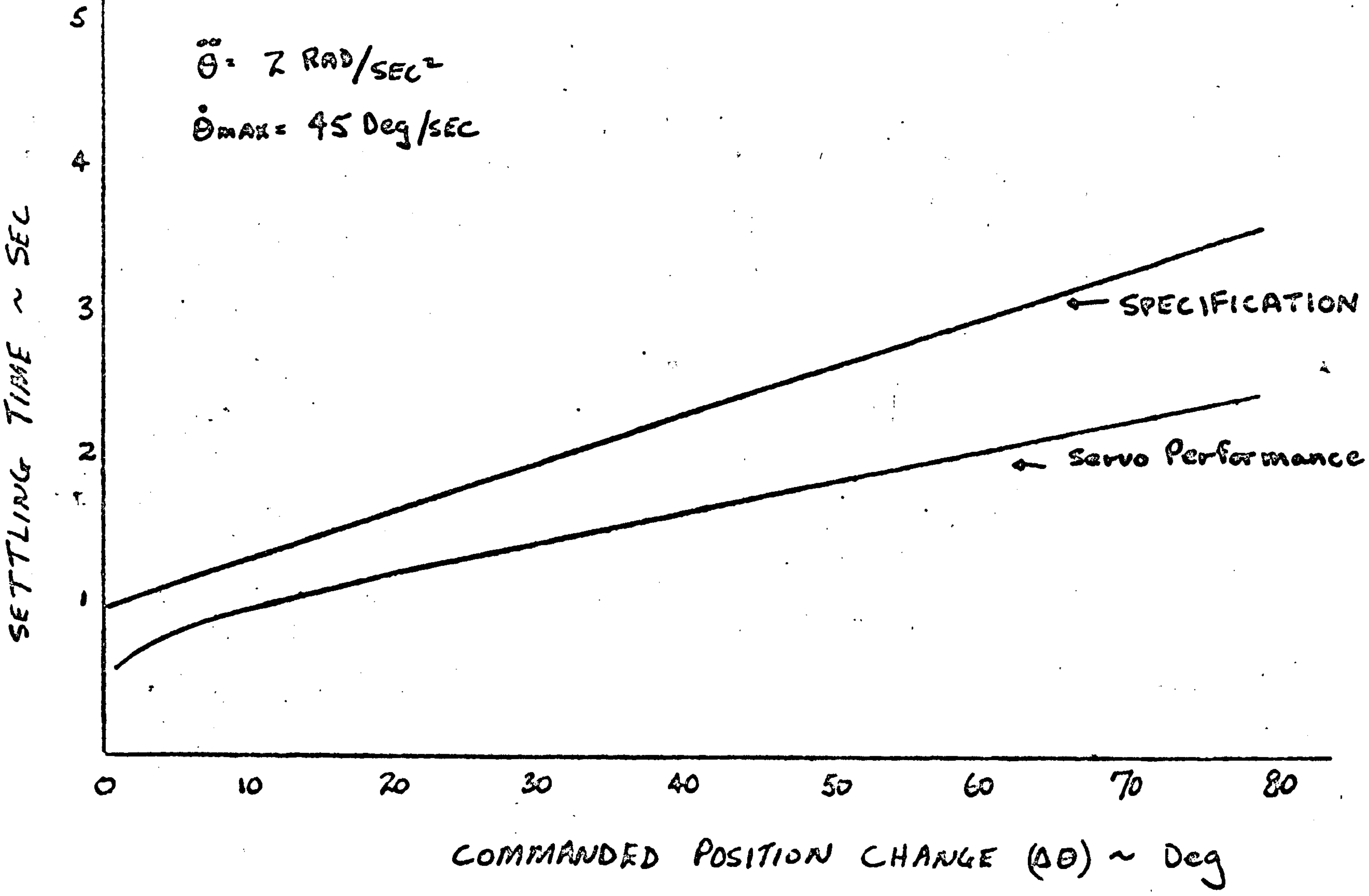
$K_1 = 12$

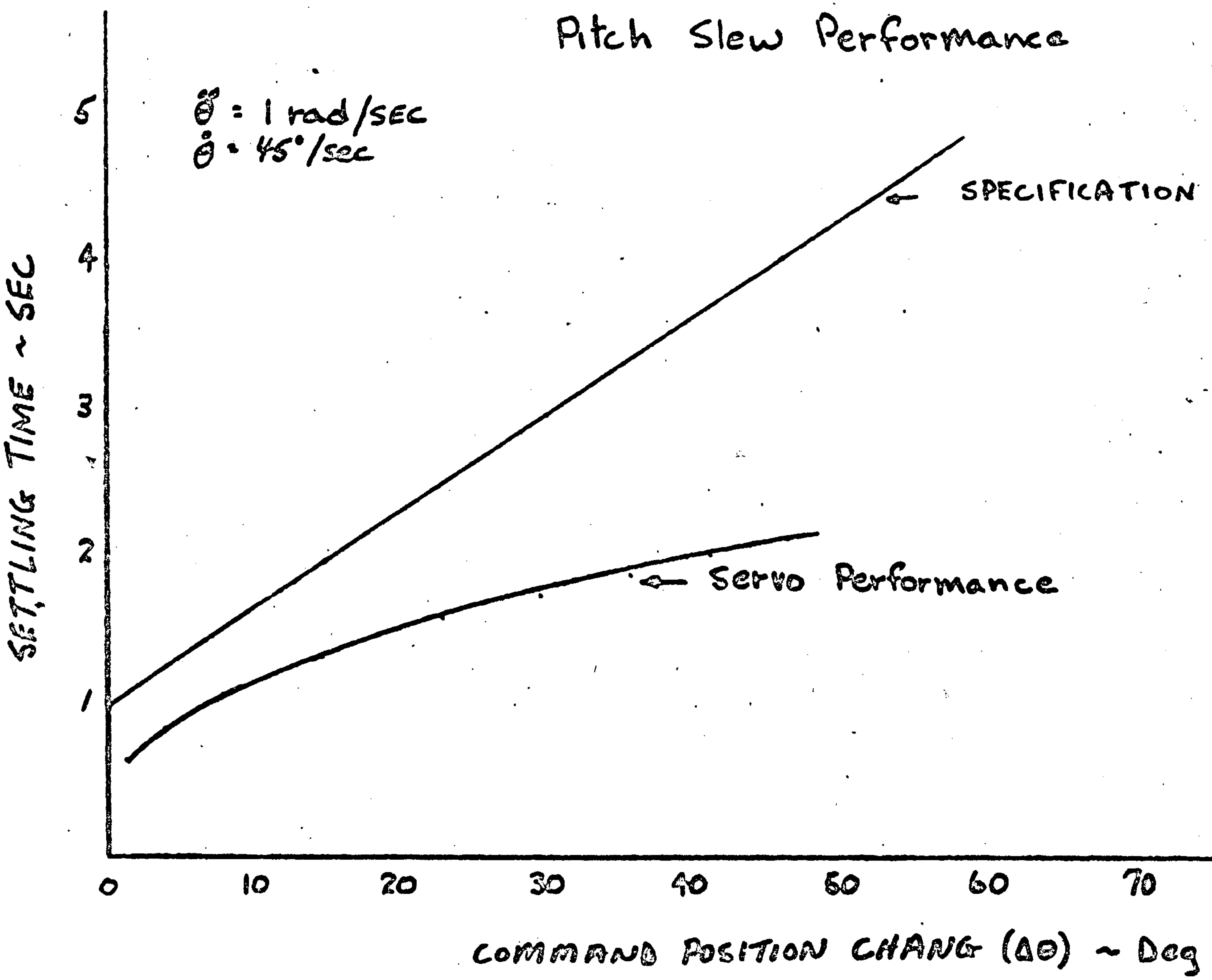
SLEW MODE BLOCK DIAGRAM



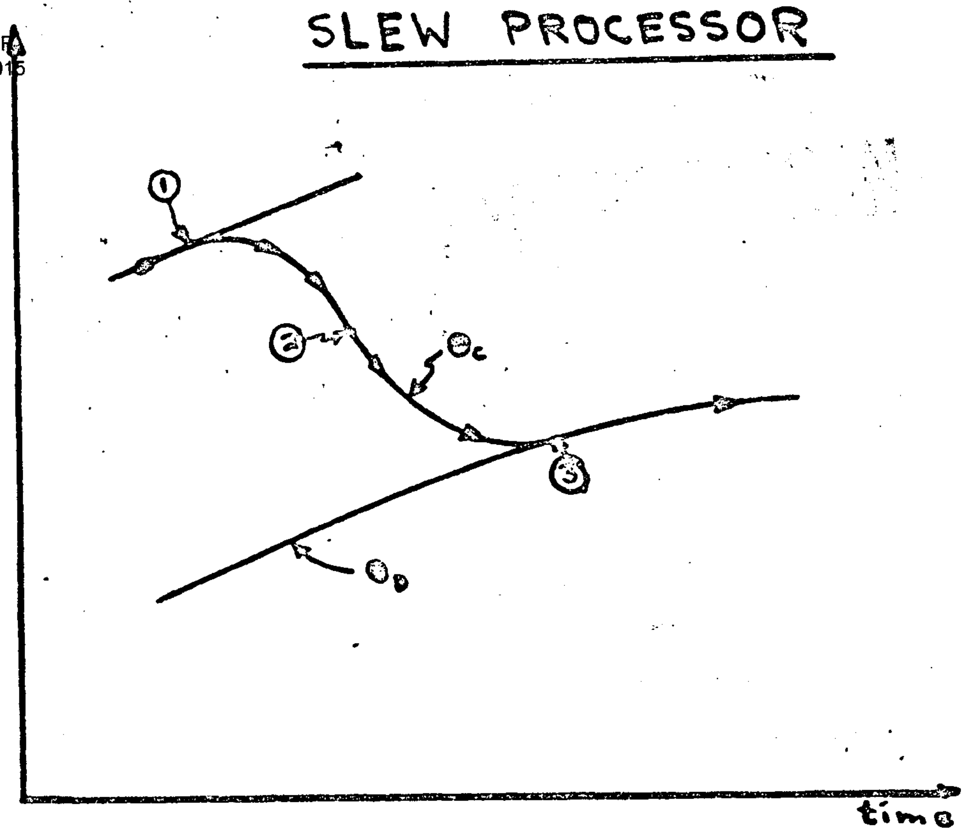
SERVO RESPONSE IN SLEW

Roll Slew Performance

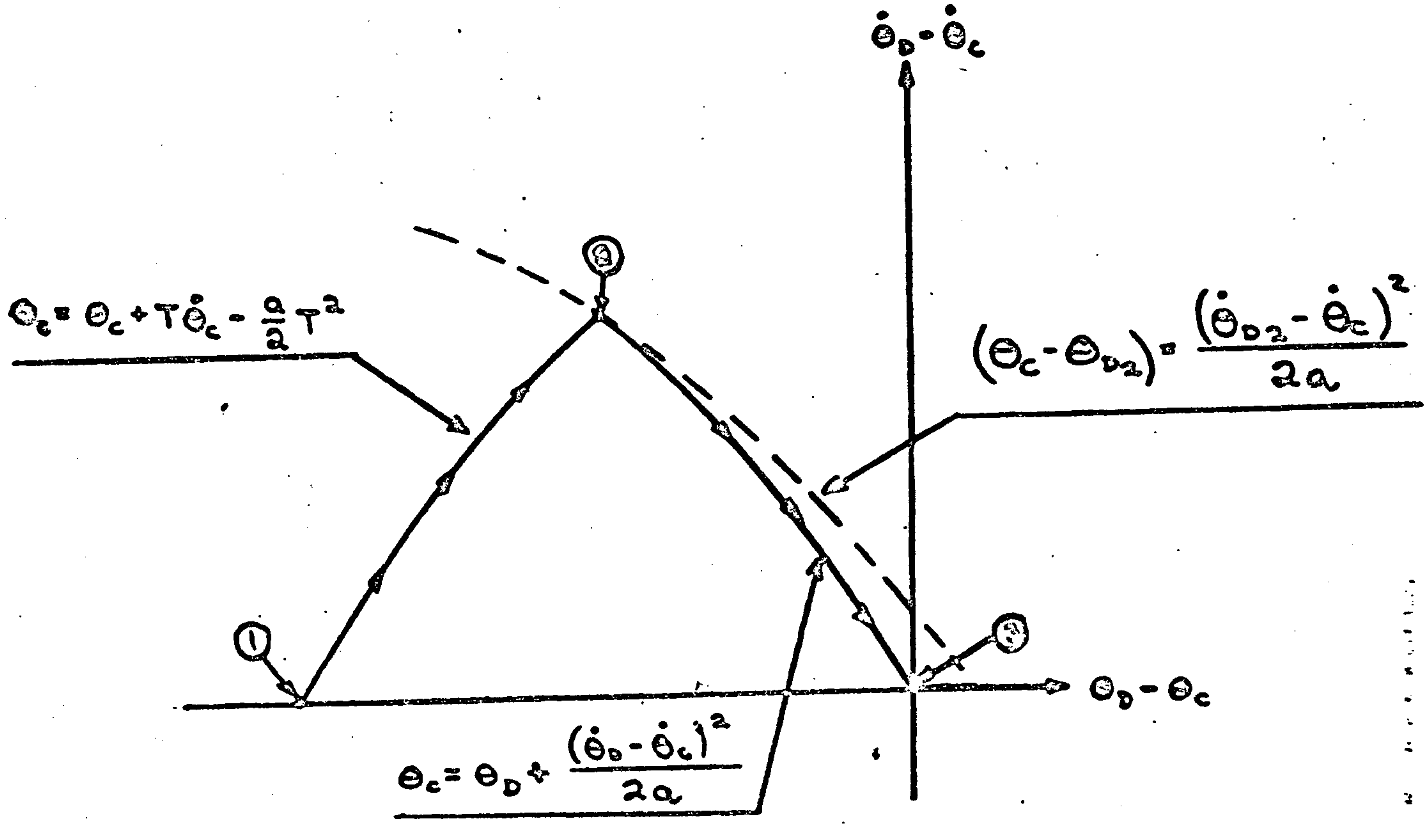



Pitch Slew Performance
$\ddot{\theta}$ = 1 rad/SEC
$\dot{\theta}$ = 45°/sec
SPECIFICATION
Servo Performance
SETTLING TIME ~ SEC
5
4
3
2
1
0
10
20
30
40
50
60
70
80
COMMAND POSITION CHANG ($\Delta\theta$) ~ Deg

SLEW PROCESSOR



POSITION VS. TIME



PHASE PLANE PLOT

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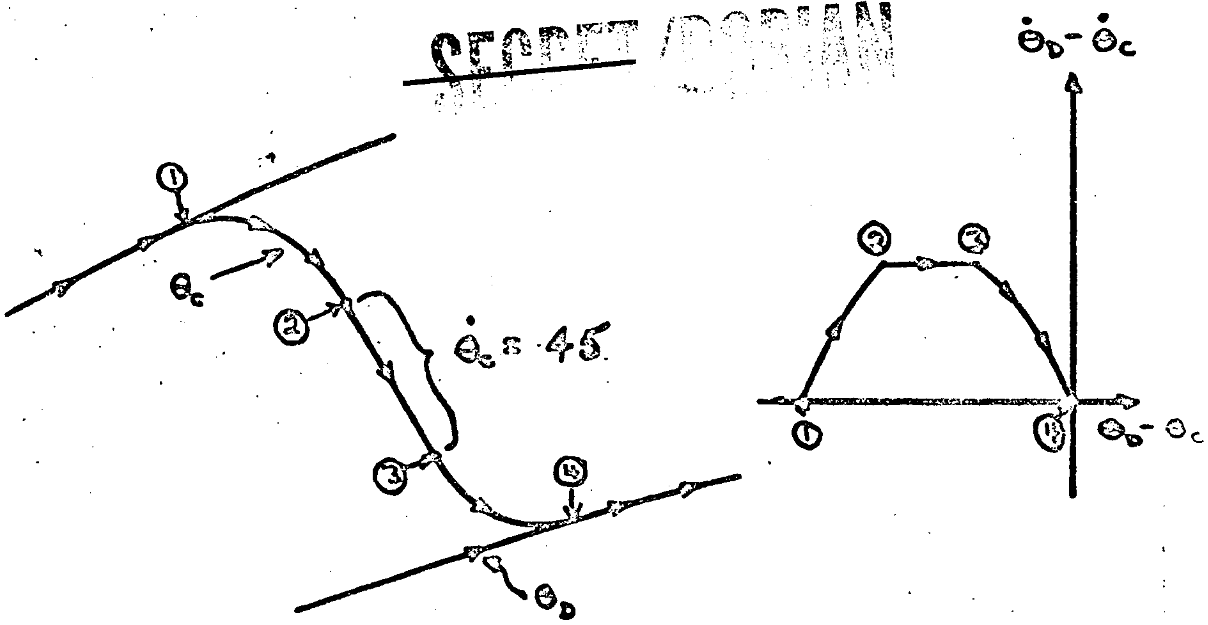
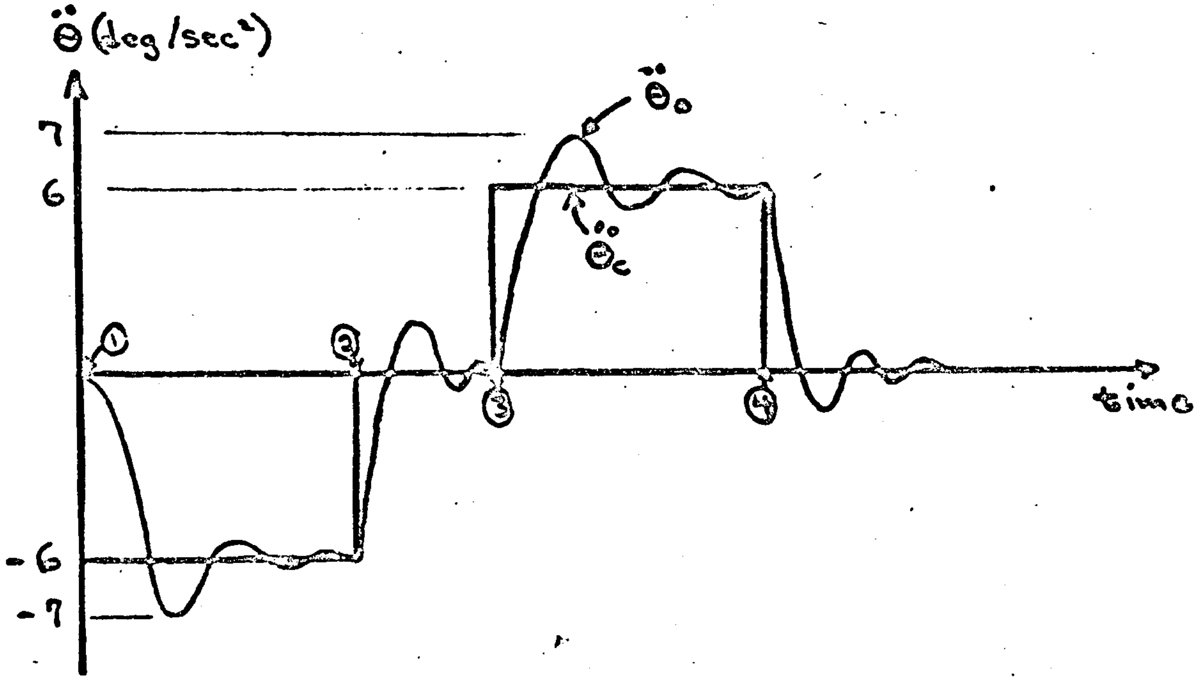
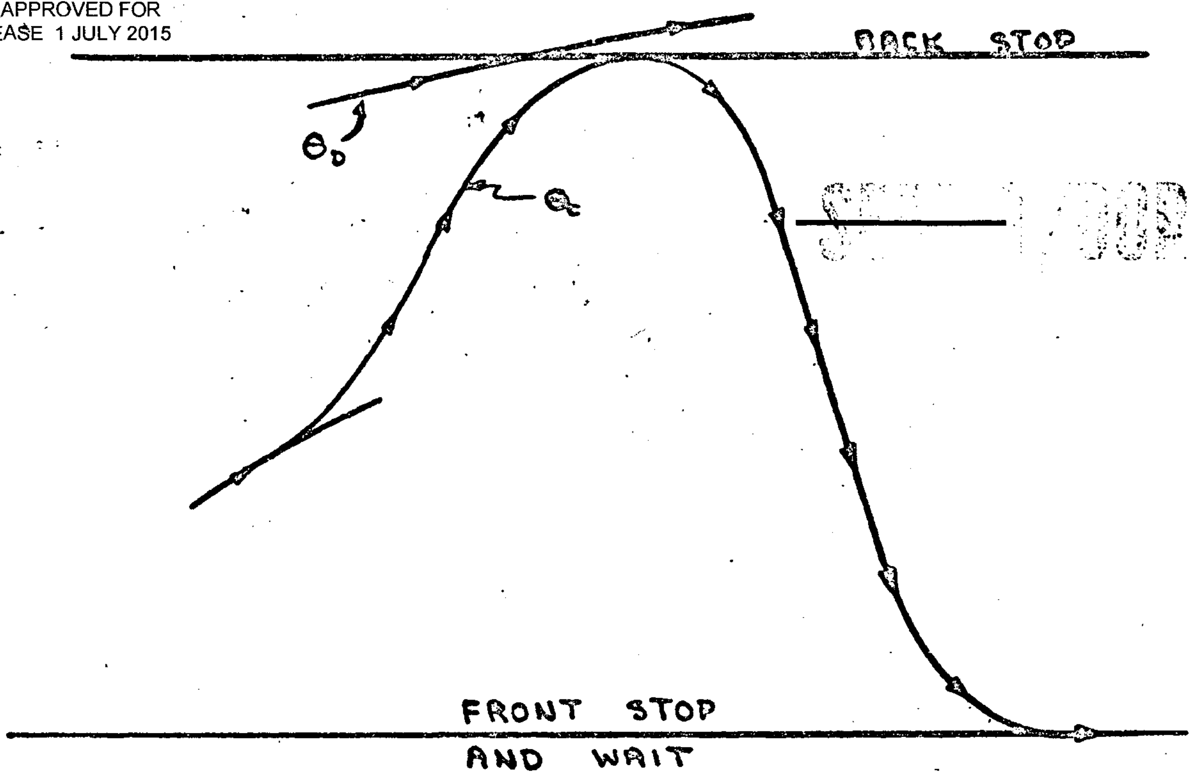


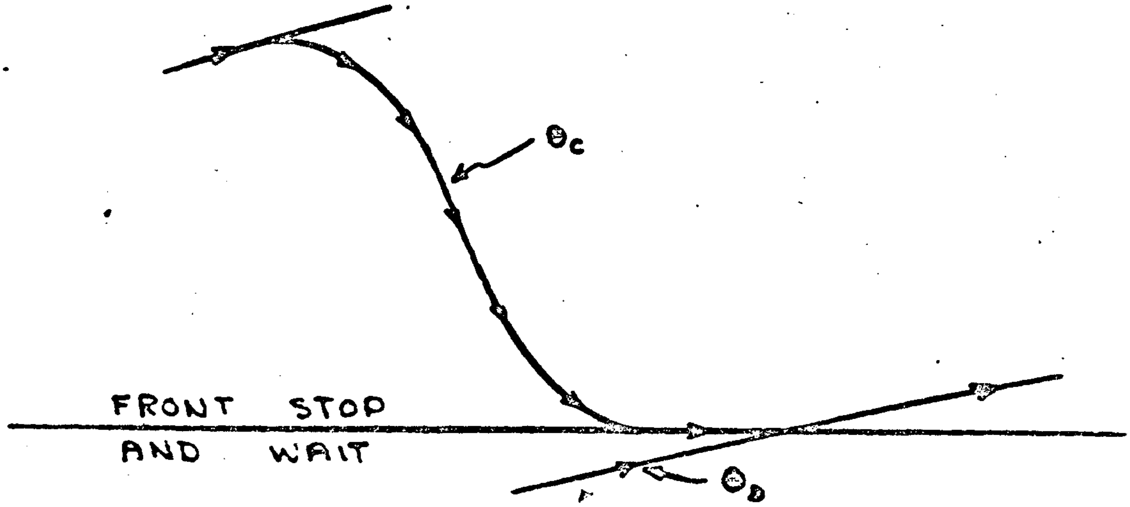
RATE LIMIT $|\dot{\theta}_c| \leq 45$ deg/sec.



ACCELERATION RESPONSE

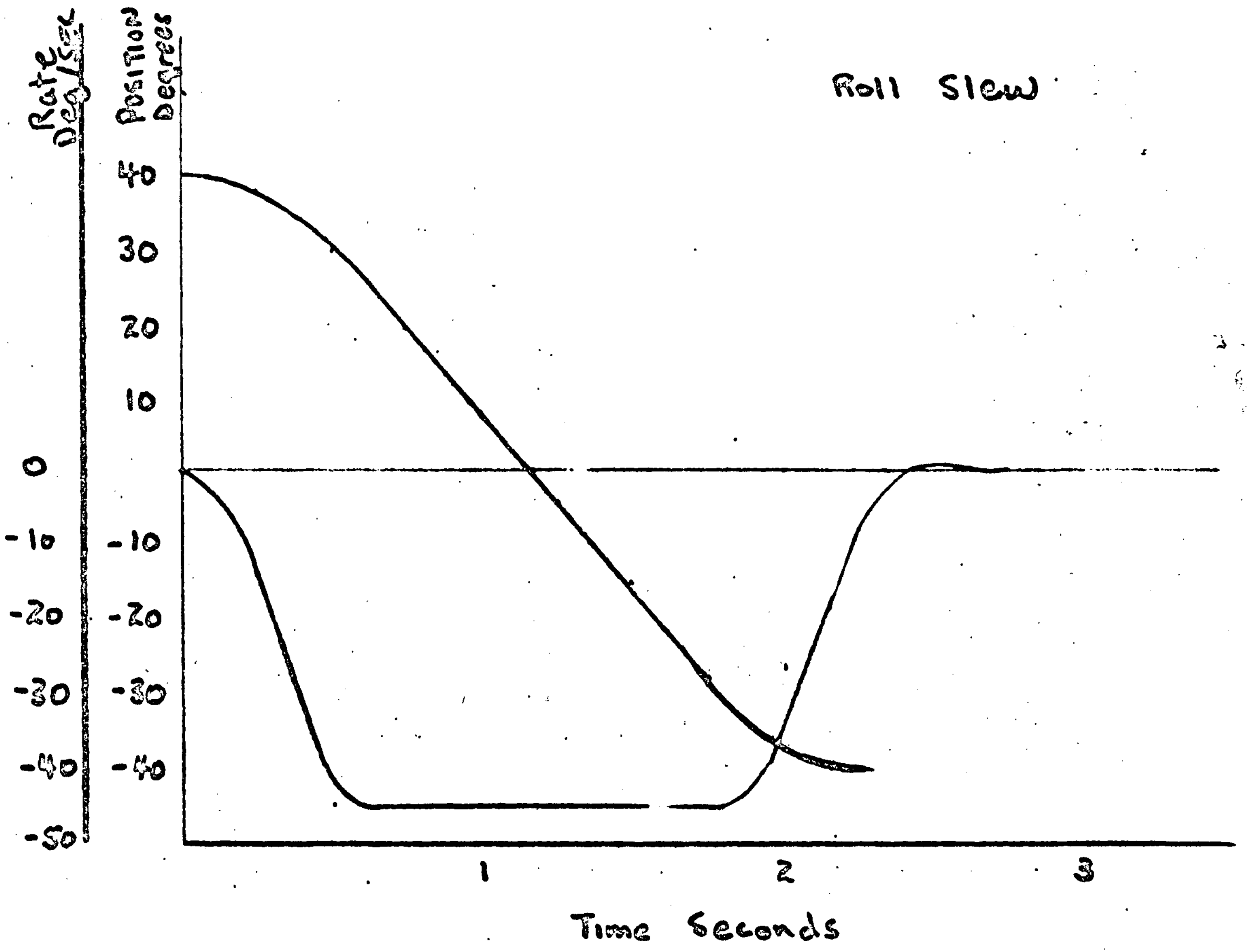


SLEW INTO BACK STOP - PITCH

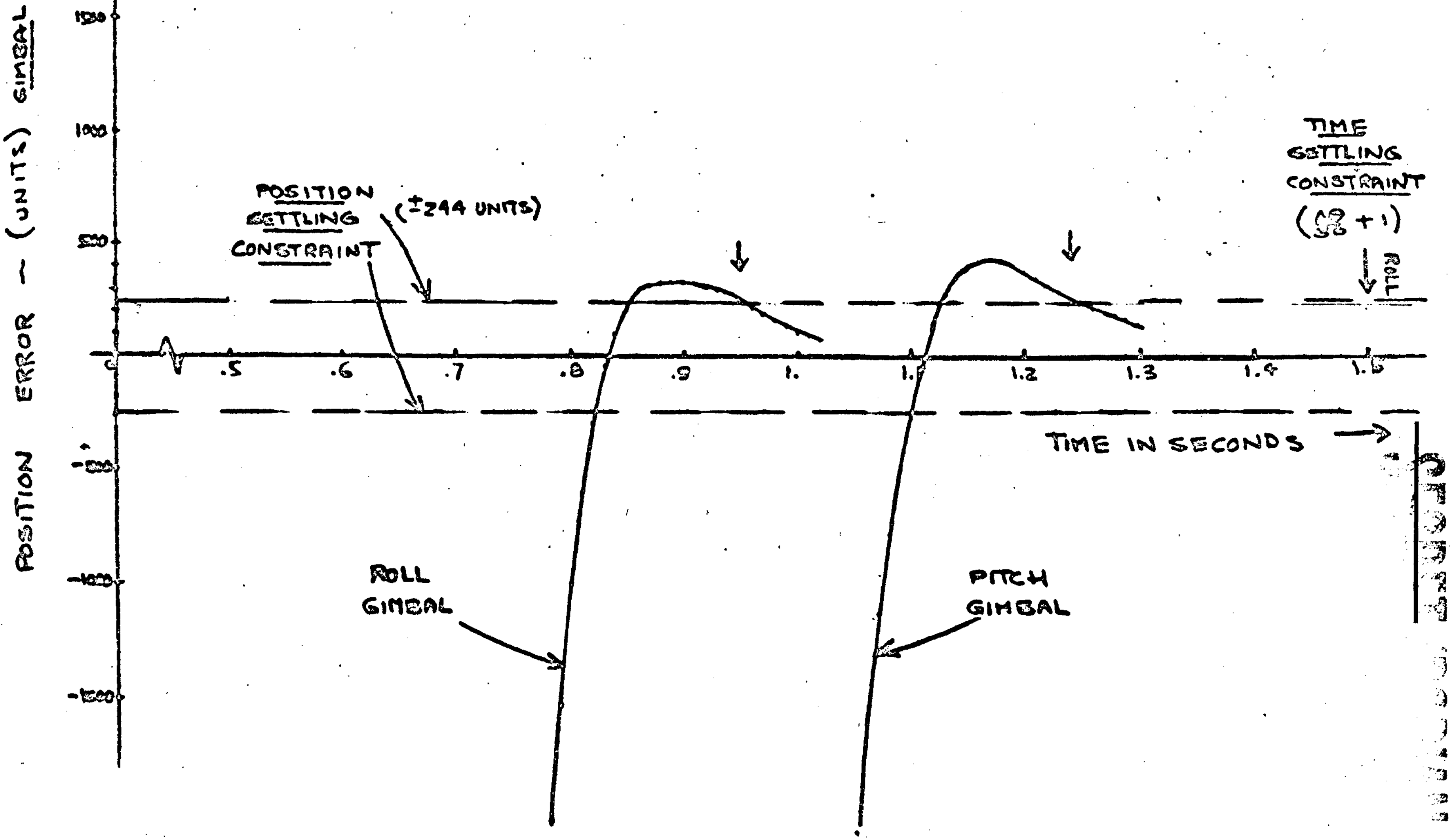


SLEW INTO FRONT STOP - PITCH

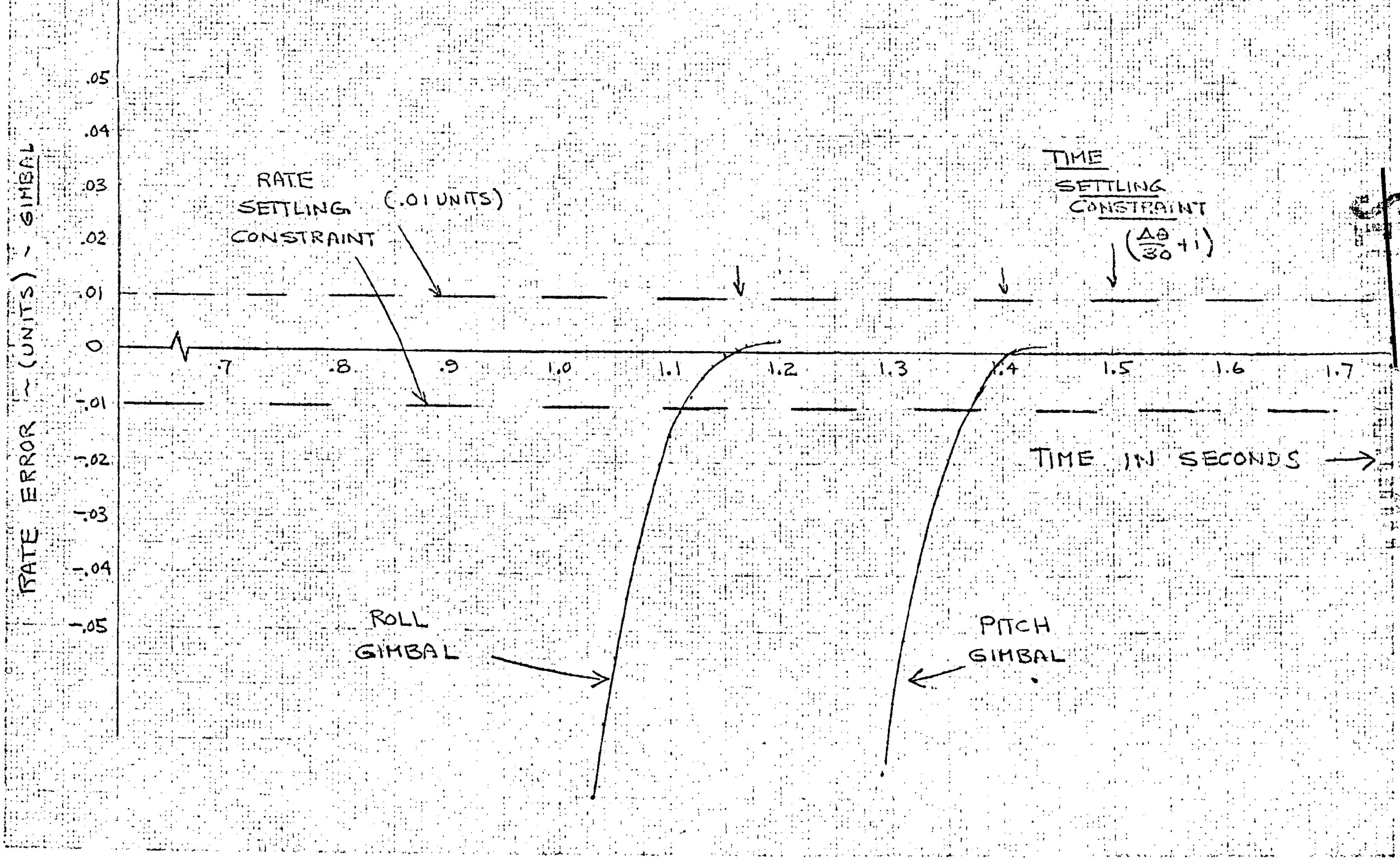
Roll Slew


Rate Deg/Sec
Position Degrees
40
30
20
10
0
-10
-20
-30
-40
-50
-10
-20
-30
-40
1
2
3
Time Seconds

POSITION SETTLING RESPONSE AT THE END OF SLEW



RATE SETTLING RESPONSE AT THE END OF SLEW



Servo Transfer Functions

Pitch

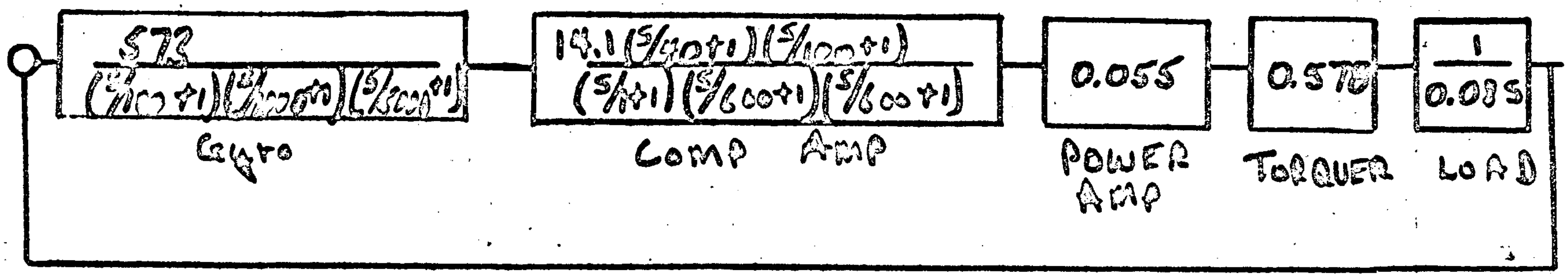
$$GH = \frac{3200\,(s/40+1)}{s\,(s/1+1)\,(s/600+1)^2\,(s/1000+1)\,(s/5000+1)}$$

Roll

$$GH = \frac{2800\,(s/25+1)}{s\,(s/0.62+1)\,(s/550+1)^2\,(s/1000+1)^3\,(s/5000+1)}$$

Servo DIAGRAM

Pitch



Roll

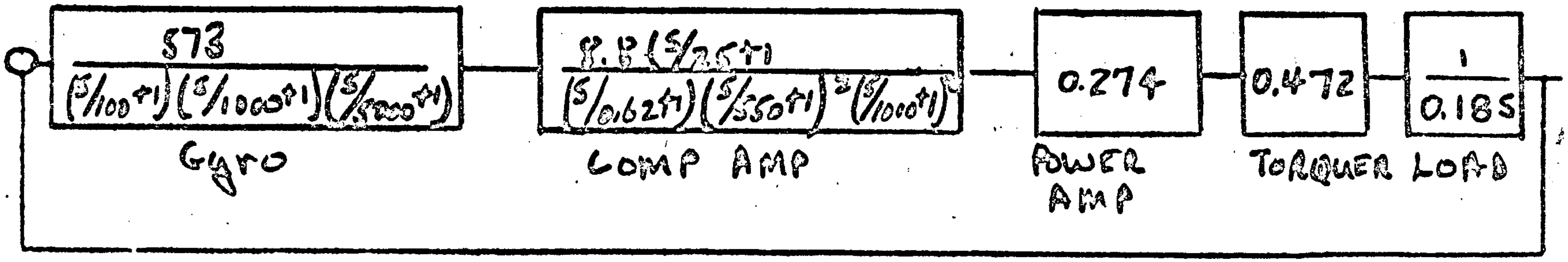


Table V
Recommended Servo Configurations

Error Allocation (High Freq)

Source	Pitch Axis	Roll Axis
Bearing Noise	0.0325	0.0265
Gyro Noise	0.0350	0.0345
Input Noise	0.0175	0.0155
Electronic Noise	0.0145	0.0125
	0.0529	0.0478
	0.1058	
	0.1160	
2 (σ)	0.232 sec	

Table VI
Recommended Servo Configurations
Present Estimated Performance *

Source		Pitch Axis	Roll Axis
Bearing Noise		0.0290	0.0207
Gyro Noise		0.0247	0.0244
Input Noise	P/A Buffer	0.001	0.001
	DAC Sources	0.014	0.014
Electronic Noise	Amplifiers	0.001	0.001
	EMI	0.010	0.010
		0.0418	0.0363
		0.0836	
	2(σ)	0.1822 sec	

* Assumes Bearing Noise Requirements will be met.

Special Lub

Error Allocation

	Pitch	Roll
Bearing Noise	0.041	0.030
Gyro Noise	0.035	0.0345
Input Noise	0.0175	0.0155
Electronic Noise	0.0145	0.0125
	0.0585	0.0498
LOS(1σ)	0.1262	
LOS (2σ)	0.2524 sec	

Estimated Error

	Pitch	Roll
Bearing Noise	0.0365	0.0286
Gyro Noise	0.0247	0.0244
Input Noise	0.0141	0.0141
Electronic Noise	0.011	0.011
	0.0475	0.0383
LOS(1σ)	0.1024	
LOS(2σ)	0.2048 sec	

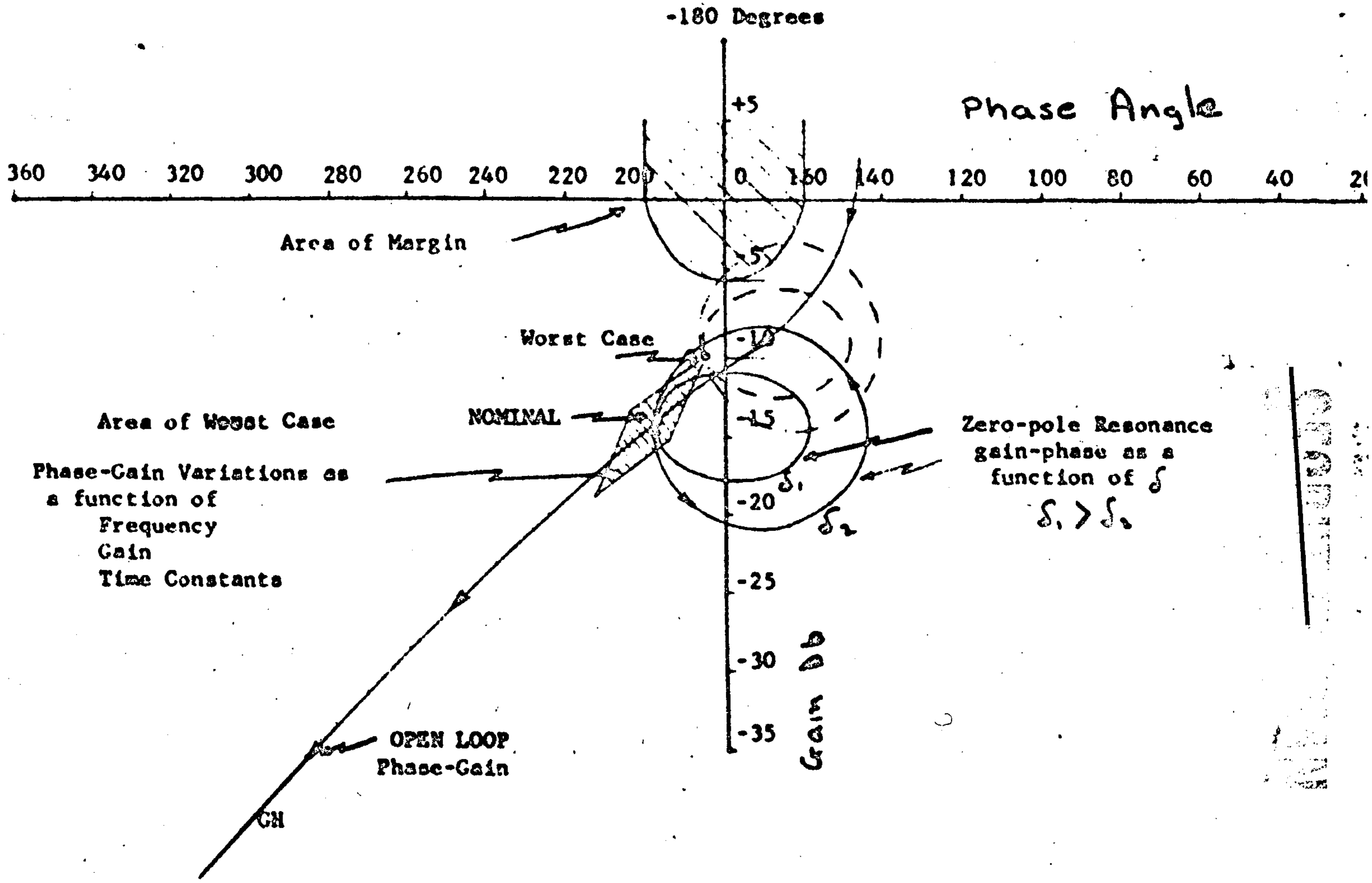

-180 Degrees
Phase Angle
360
340
320
300
280
260
240
220
200
0
160
140
120
100
80
60
40
+5
-5
-10
-15
-20
-25
-30
-35
Gain db
Area of Margin
Worst Case
NOMINAL
Area of Worst Case
Phase-Gain Variations as
a function of
Frequency
Gain
Time Constants
Zero-pole Resonance
gain-phase as a
function of δ
δ₁ > δ₂
δ₁
δ₂
OPEN LOOP
Phase-Gain
GH

Figure 1

~~SECRET~~/DORIAN

Figure (2)

Allocated Errors

Pitch Axis Noise Errors as a Function of Bandwidth.

$$GH = \frac{K\left(\frac{s}{70}+1\right)}{s\left(\frac{s}{1}+1\right)\left(\frac{s}{600}+1\right)^2\left(\frac{s}{6000}+1\right)}$$

Wc = Crossover frequency of recommended servo configuration

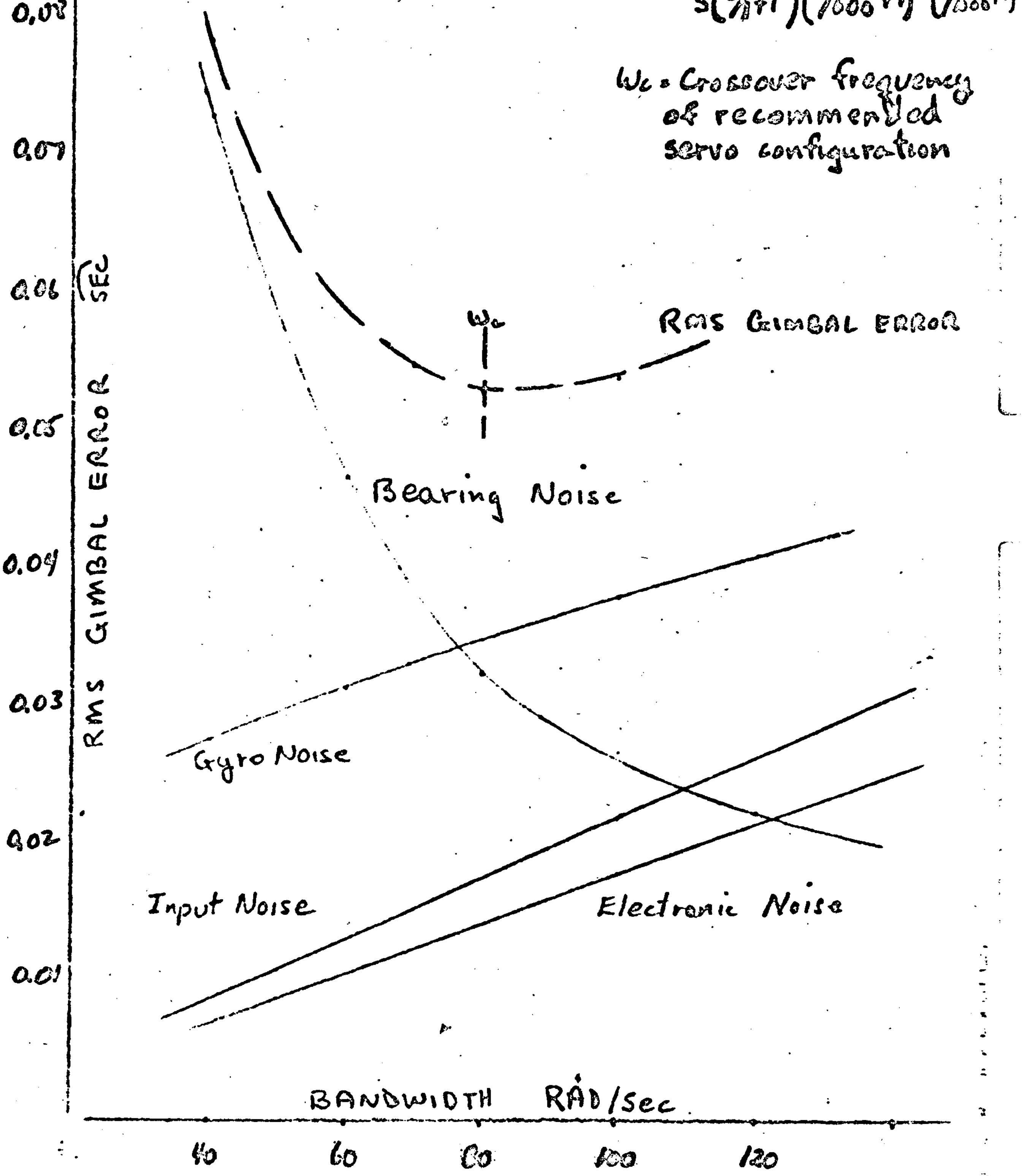


Figure (6)

Estimated Performance

Roll Axis Noise
Error As A Function
of BANDWIDTH

$$GH \frac{K(s/25+1)}{s(s/.625+1)(s/550+1)^2(s/1000+1)}$$

Wc = Crossover frequency
of recommended
servo configuration

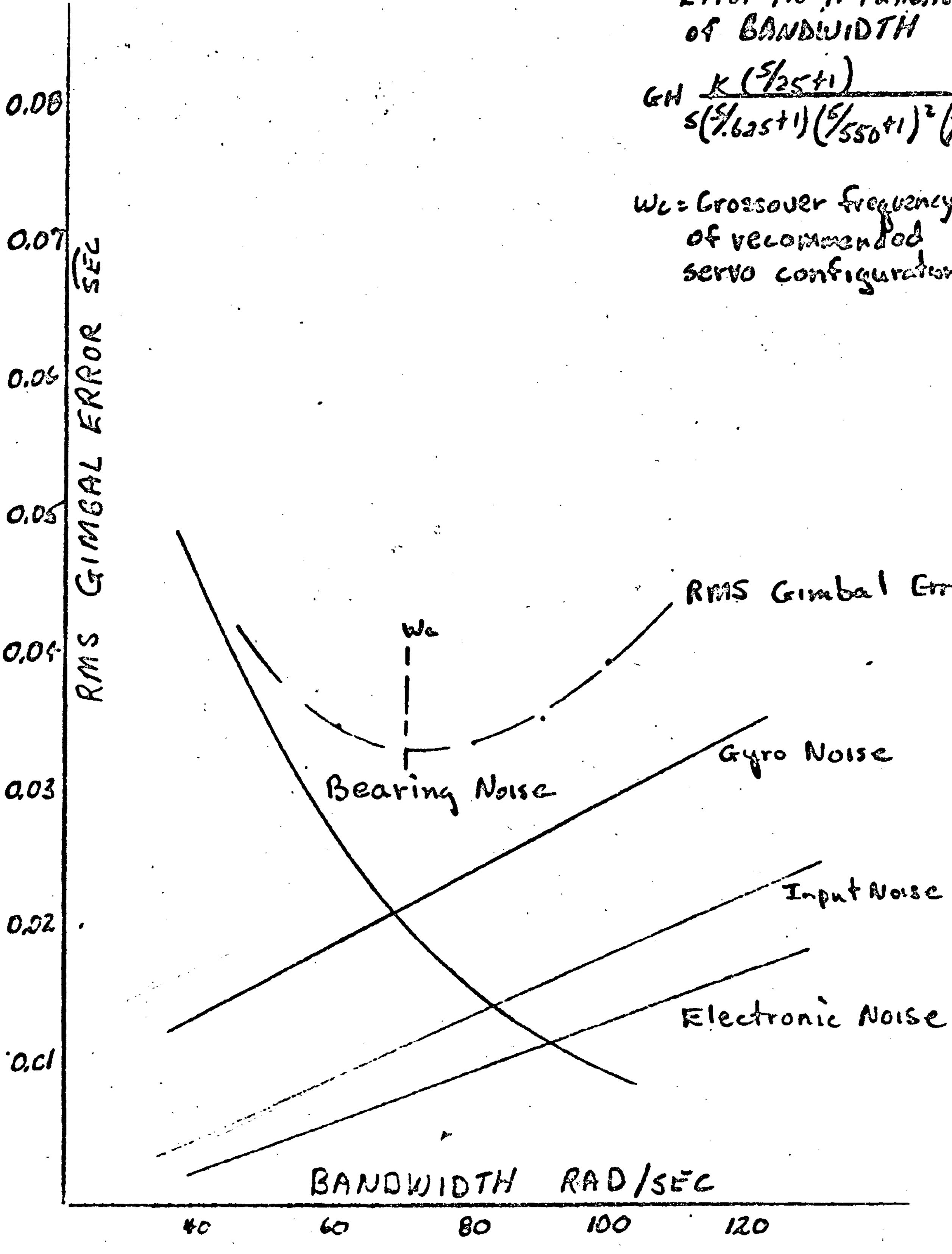


Figure (4)
Estimated Performance

Pitch Axis Noise
Errors As A Function
of BANDWIDTH

$$GH = \frac{K(s/40+1)}{s(s/1+1)(s/600+1)^2(s/1000+1)}$$

W_c = Crossover frequency
of recommended
servo configuration

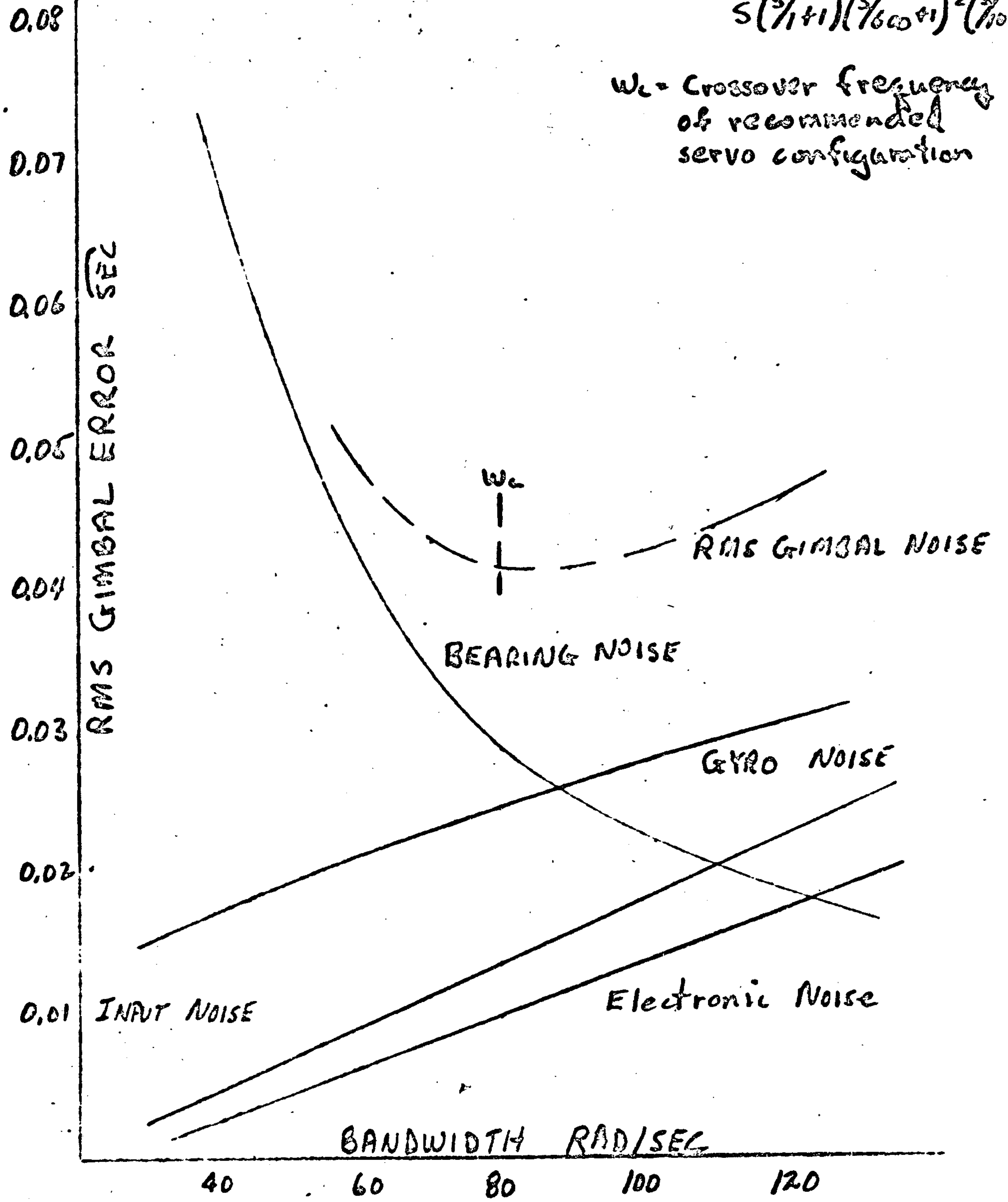


Figure (3)

Allocated Errors

Roll Axis Noise
Errors As A Function
of BANDWIDTH

$$GH = \frac{K(s/7+1)}{s(s/625+1)(s/550+1)^2(s/1000+1)^3}$$

Wc = Crossover frequency of recommended servo configuration

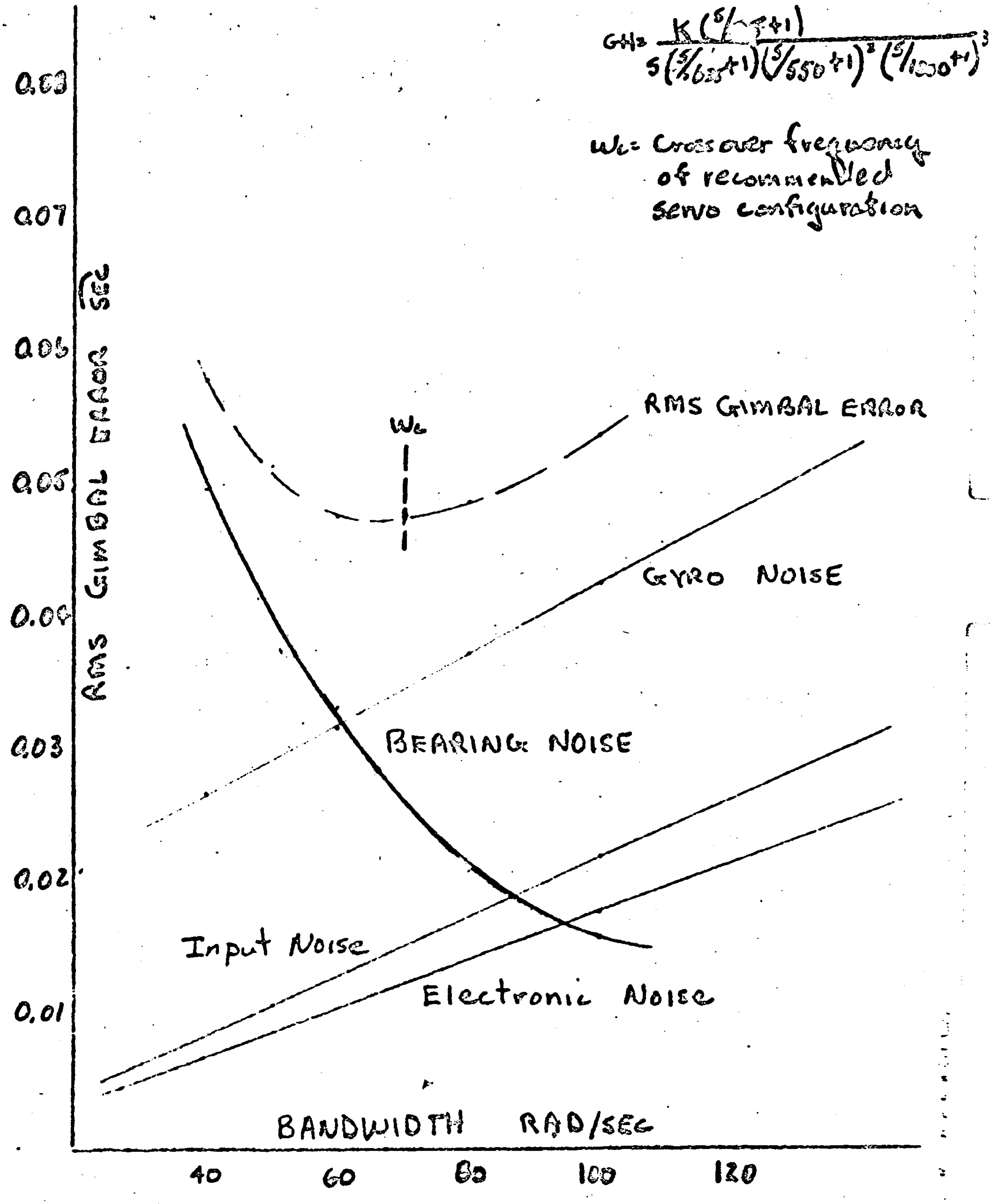


Figure (9)

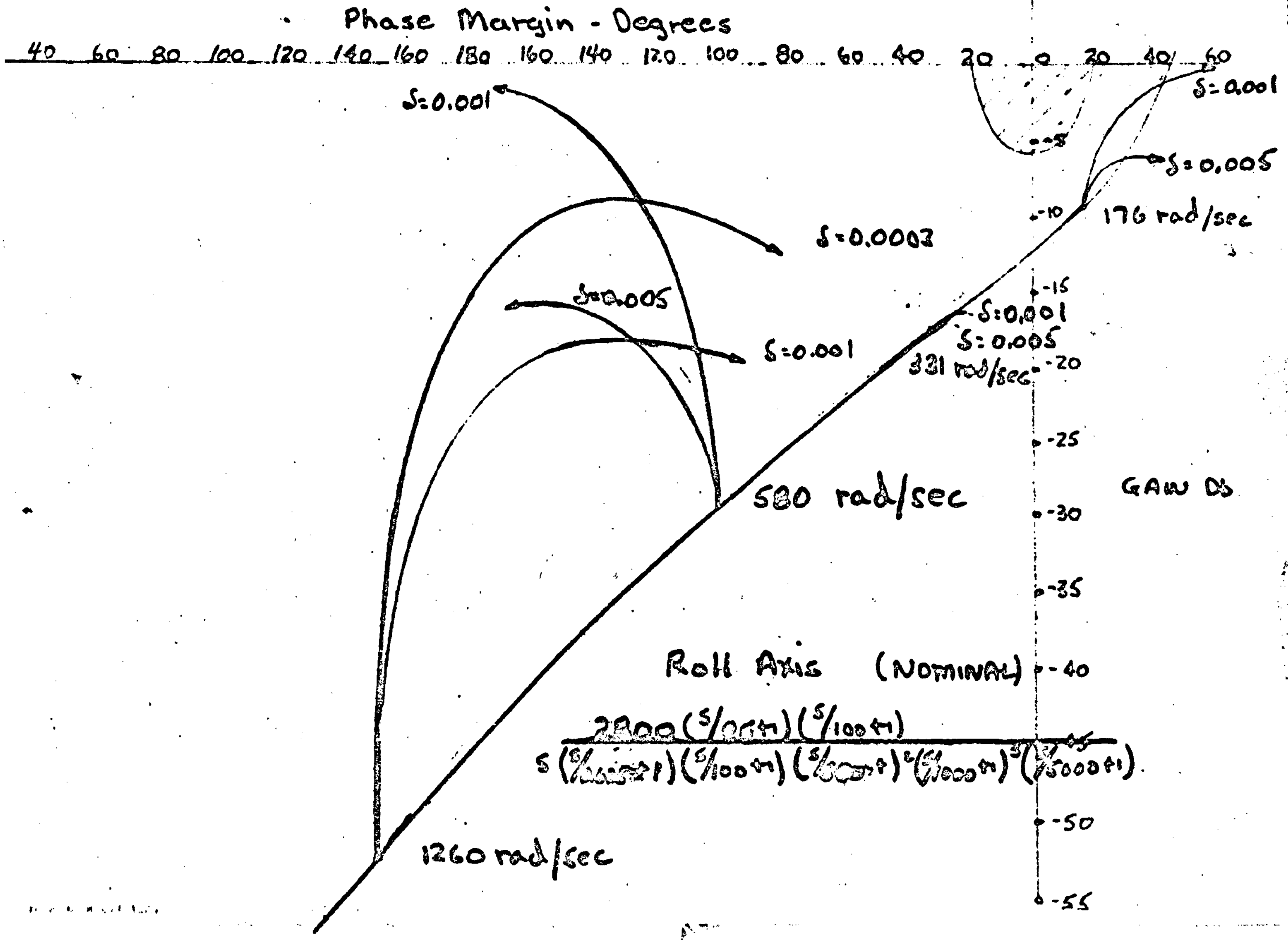

Phase Margin - Degrees
40
60
80
100
120
140
160
180
160
140
120
100
80
60
40
20
0
20
40
60
-5
-10
-15
-20
-25
-30
-35
-40
-50
-55
δ=0.001
δ=0.005
176 rad/sec
δ=0.0003
δ=0.005
δ=0.001
δ:0.001
δ:0.005
331 rad/sec
580 rad/sec
GAIN DB
1260 rad/sec
δ=0.001
Roll Axis (NOMINAL)
2800(s/[illegible]+1)(s/100+1)
s(s/[illegible]+1)(s/100+1)(s/[illegible]+1)²(s/1000+1)³(s/5000+1)

Figure (10)

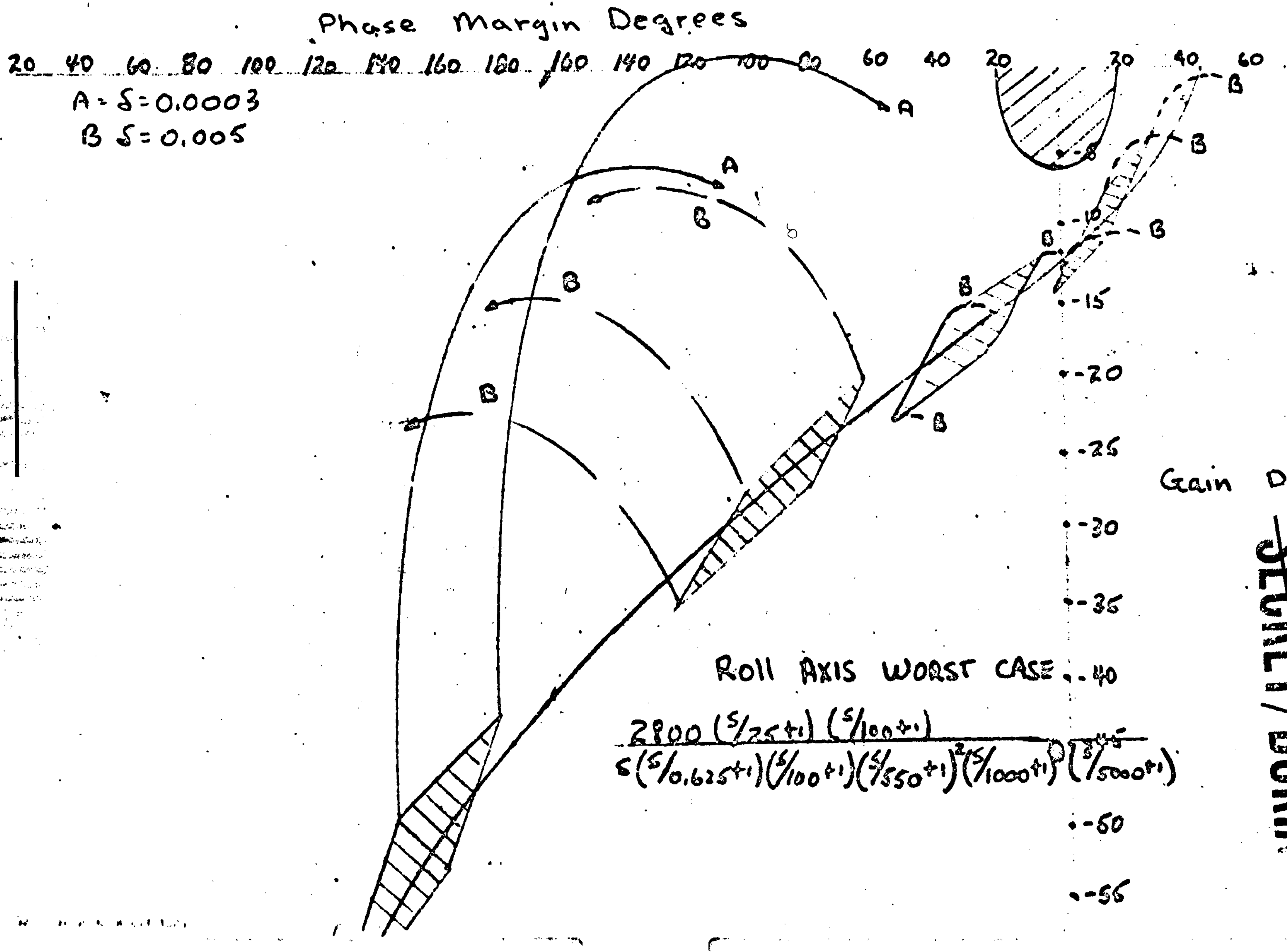
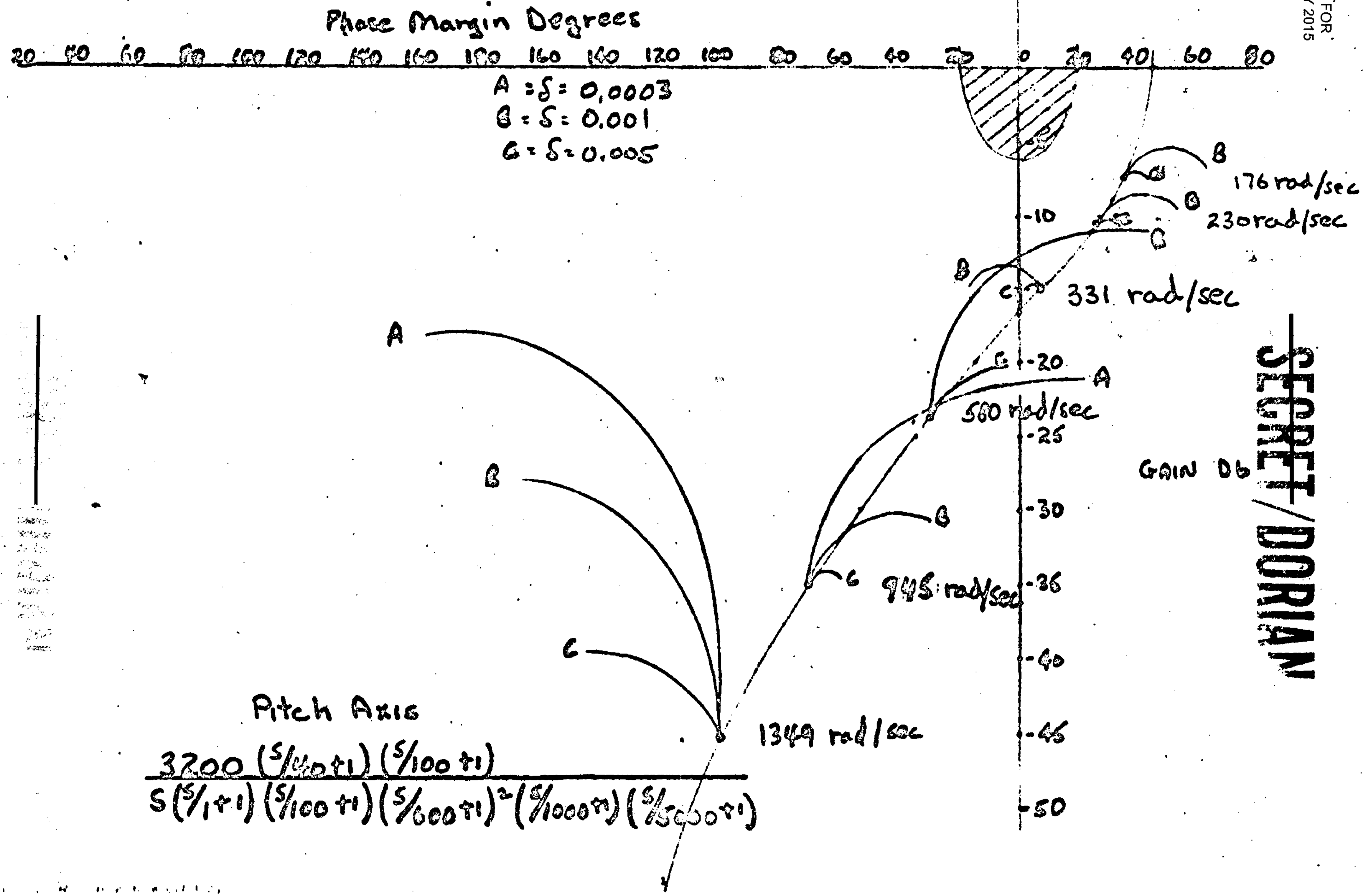

Phase Margin Degrees
20 40 60 80 100 120 140 160 180 160 140 120 100 80 60 40 20 20 40 60
A - $\delta = 0.0003$
B $\delta = 0.005$
A
B
A
B
B
B
B
B
B
B
B
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
Gain Db
Roll Axis Worst Case
$\frac{2800(s/25+1)(s/100+1)}{s(s/0.625+1)(s/100+1)(s/550+1)^2(s/1000+1)(s/5000+1)}$

Figure (11)

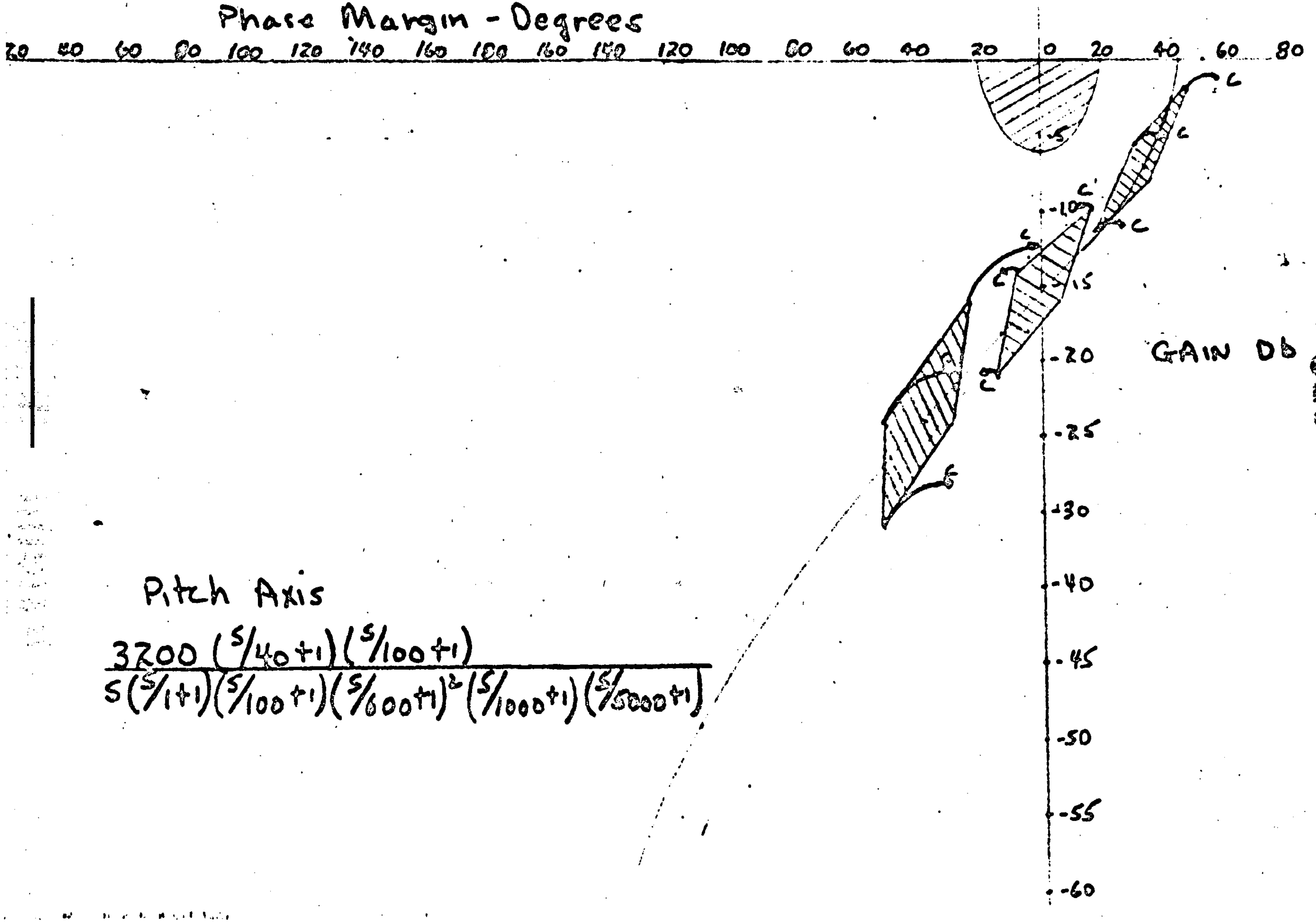


A = δ = 0.0003
B = δ = 0.001
C = δ = 0.005

Pitch Axis

$$\frac{3200\,(S/40+1)\,(S/100+1)}{S\,(S/1+1)\,(S/100+1)\,(S/600+1)^2\,(S/1000+1)\,(S/5000+1)}$$

Figure (12)



Pitch Axis

$$\frac{3200\,(s/40+1)(s/100+1)}{s(s/1+1)(s/100+1)(s/600+1)^2(s/1000+1)(s/5000+1)}$$

Table VII

Stability Margins for Recommended Roll Configuration

Mode Frequency	Mode Amplitude	Worst Case Stability Margins
176 rad/sec	$\delta = 0.005$ 2db Z-P	12.5 db
331 rad/sec	>1 db Z-P	13 db
580 rad/sec	12db P-Z	9db 100 Degrees
1260 rad/sec	$\delta = 0.0003$ 44 db Z-P	60 Degrees

Assumptions

15% Tolerance on Mode Frequency
10% Amplifier and Torquer Gains
10% Time Constants

3σ Worst Case

~~SECRET~~/DORIAN

Table VIII

Stability Margins for Recommended Pitch Configuratio

Mode Frequency	Mode Amplitude		Worst Case Stability Margins
176 rad/sec	$\delta = 0.005$	< 1 db Z-P	12 db 20 Degrees
230 rad/sec		< 1 db Z-P	8 db 20 degrees
331 rad/sec		< 1 db P-Z	9 db
580 rad/sec		4 db Z-P	12 db
945 rad/sec	$\delta = 0.0003$	12 db Z-P	10 db
1349 rad/sec		27 db P-Z	8 db > 100 degees

N = GEAR RATIO = 2

θ_I = IMAGE POSITION

θ_T = TRANSDUCER POSITION

θ_C = COMMAND SIGNAL (STEP INPUT)

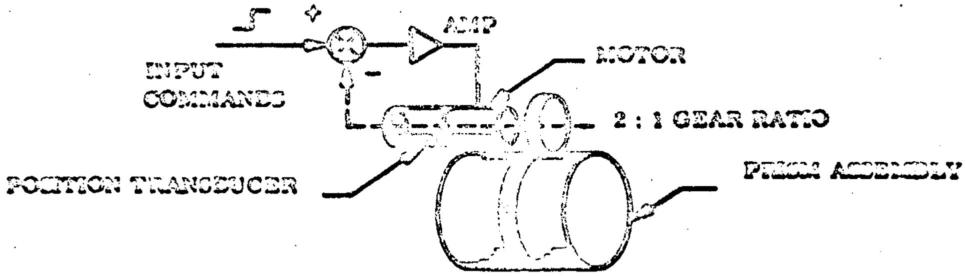


Figure 2.2-48. Image Orientation Control Loop

Requirements

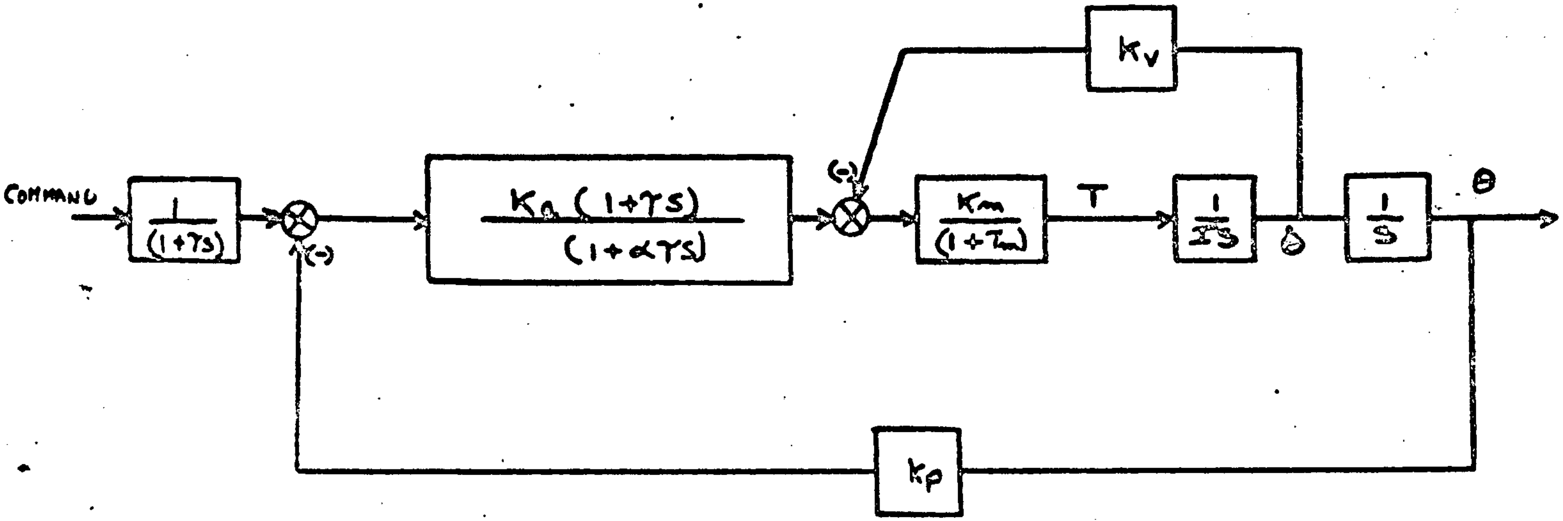
Reposition in

$\left(\frac{\Delta\theta}{30}+1\right)$ sec

Servo Accuracy

$\leq$ 0.5 Degrees

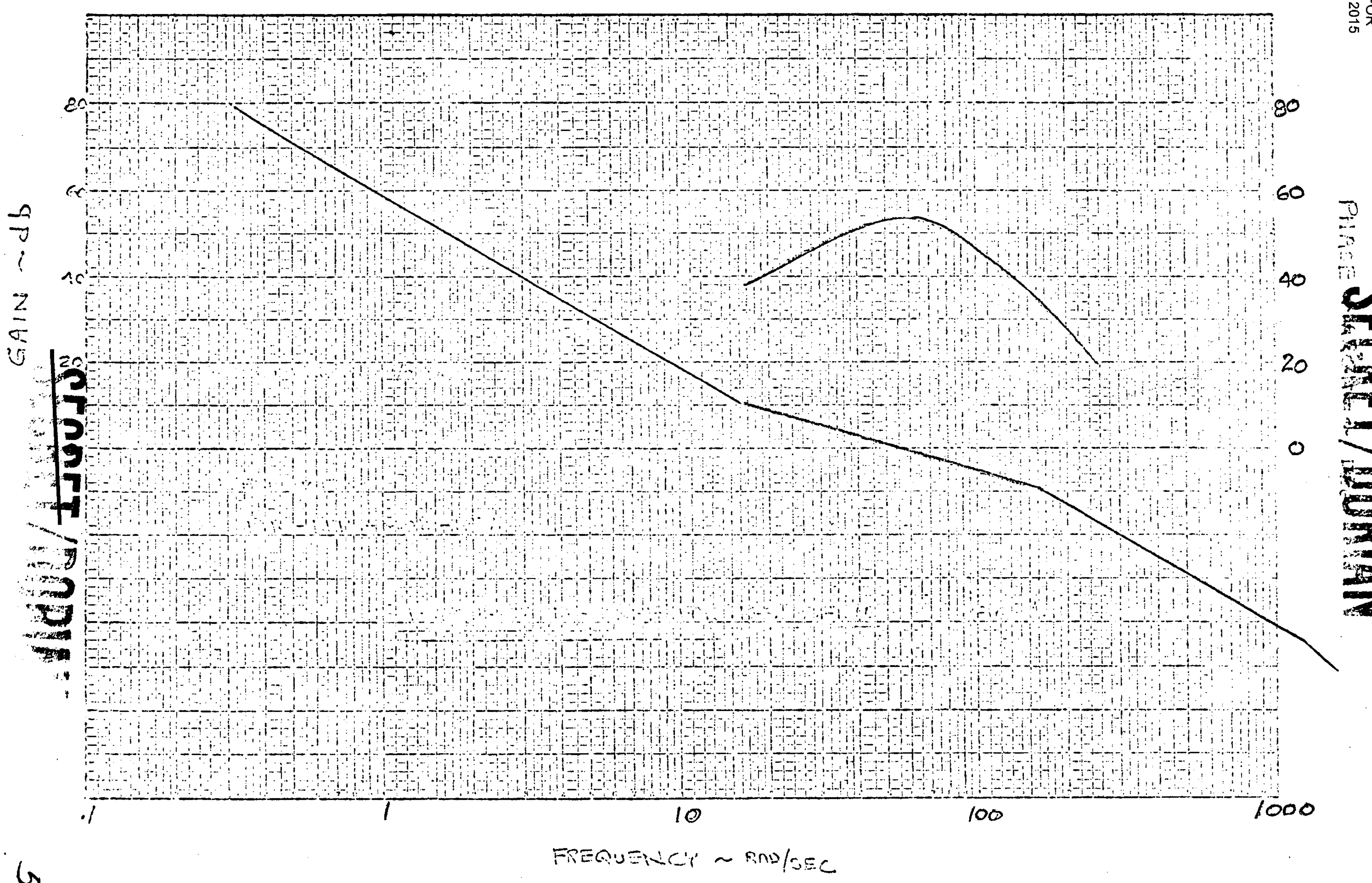
8



LINEAR MODEL OF K-3 SUBSYSTEM FIG 3

FN-522-B (8-50) GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., U. S. A. 4 Log Cycles X Divisions

~~SECRET~~/DORIAN



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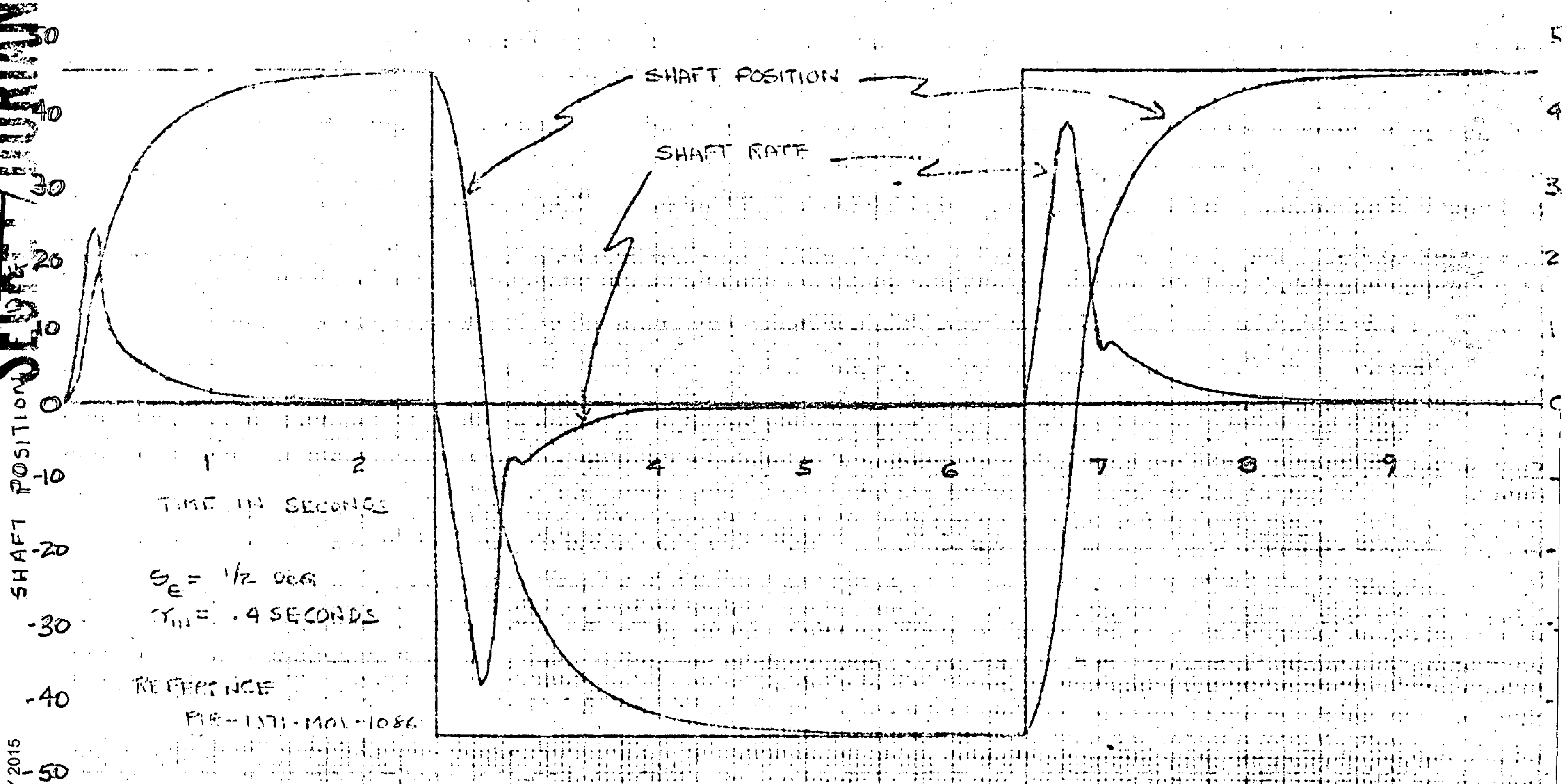
RESPONSE OF K-3 SUBSYSTEM TO A STEP COMMAND FIG-2



OPTICAL ERRORS

PRESENT SPEC.

HI $127\,X\,^{+5}_{-3}$

LO $16\,X \pm 1$

CHANGE TO *

HI $127\,X\,^{+0}_{-2}$

LO $16\,X \pm 1$

EXPECTED PERFORMANCE (0.1% E.P. DIAMETER MEASUREMENT ERROR)*

HI $127\,X\,^{+0}_{-.127X}$

LO $16\,X \pm .016X$

*PENDING VENDOR CONFIRMATION

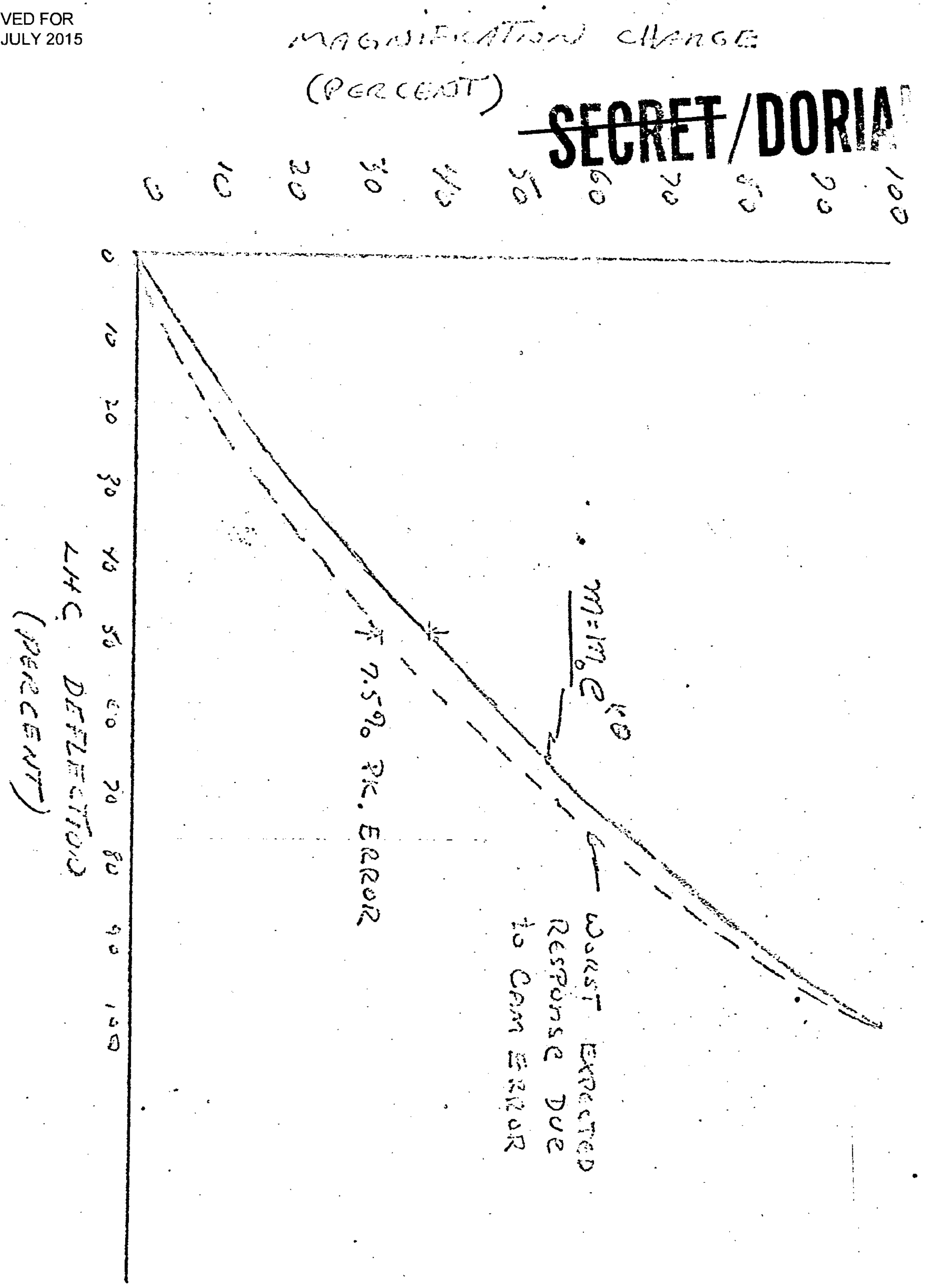
SERVO AND INSTRUMENTATION ERRORS

	POT REF.	CAM REF.
LHC POT ALIGNMENT & NOISE (e1)	6 $\widehat{\text{MIN}}$.	22 $\widehat{\text{MIN}}$.
ADKE SHAPER SCALE FACTOR (e2)	8.2	36.6
ADKE FEEDBACK BUFFER (e3)	8.2	36.6
F.B. POT ALIGNMENT (e6)	6	22
RSS	14.3 $\widehat{\text{MIN}}$.	52.6 $\widehat{\text{MIN}}$.
SERVO STANDOFF (e4)	60 $\widehat{\text{MIN}}$.	220. $\widehat{\text{MIN}}$.

MECHANISM ERRORS (e5)

	REFERENCE TO POT	REFERENCE TO CAM
POT WIND-UP	0.5 $\widehat{\text{MIN}}$.	1.83 $\widehat{\text{MIN}}$.
GEARTOOTH TOLERANCES	2.	7.34
SHAFT STRAIGHTNESS	2.	7.34
GEAR DECENTER	2.	7.34
GEAR TO SHAFT COUPLING	3.	11.01
BEARING TO BORE	3.	11.01
SHAFT TO BEARING	3.	11.01
POT REPEATABILITY	0.5	1.83
SHAFT WIND-UP	0.	0.
CAM TORSIONAL WIND-UP	0.	0.
CAM FOLLOWER BACKLASH	0.	0.
CAM FOLLOWER TO RAIL PIN DEFLECTION	0.	0.
GEAR DEFLECTIONS	0.	0.
PERFORMANCE (RSS)	5.72 $\widehat{\text{MIN}}$.	20.9 $\widehat{\text{MIN}}$.

~~SECRET~~/DORIAN



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ZOOM ERROR SUMMARY

ERROR DESCRIPTION	SOURCE MAGNITUDE	LOW RANGE MAGN ERROR	HI RANGE MAGN ERROR
OPTICS	$\pm 1/^{+0}_{-2}$	1.0	+0 -2
MECHANISMS	20.9 $\hat{\text{MIN}}$.	.00349	.087
SERVO RANDOM	52.6 $\hat{\text{MIN}}$.	.00876	.218
RSS		1.	+.235 -2.01
SERVO BIAS	220 $\widehat{\text{MIN}}$.	.0367	.916
COMPOSITE		± 1.0367	+1.151 -2.926
CEI		± 1	+5 -3

~~SECRET~~/DORIAN

LINE OF SIGHT DEFINITION

ALIGNMENT PURPOSES - LINE OF SIGHT IS THE LINE CONNECTING THE SPACECRAFT TO THE PROJECTION OF THE TELESCOPE RETICLE ON THE TARGET PLANE.

JITTER PURPOSES - LINE OF SIGHT IS THE LINE CONNECTING THE SPACECRAFT TO A GROUND OBJECT IN THE CENTER OF THE TELESCOPE FIELD OF VIEW.

UNRESOLVED SOFTWARE PROBLEM

STOW/UNSTOW APPROACHES

I.
- 5°/SEC. SLEW FROM STOW
- WORD SYNCHRONIZATION AT 0°ROLL, 56.25° PITCH
- SYSTEM READY FOLLOWING SLEW

II.
- WIRED SYNCHRONIZATION WORD AT STOW POSITION
- SLEW FROM STOW

DRIVE K BEARINGS

- REQUIREMENTS
- GE/SUBCONTRACTOR A AGREEMENT
- RESULTS OF DEVELOPMENT TESTS
- RESULTS OF ANALYSIS
- DESIGN SOLUTION
- FUTURE STEPS TO COMPLETION

REQUIREMENTS

- LOW TORQUE RIPPLE PERFORMANCE
- LAUNCH SURVIVABILITY
- SPACE ENVELOPE CONSTRAINTS
- STIFFNESS
- AVERAGE RUNNING TORQUE
- THERMAL ENVIRONMENT
- INSTALLATION-INDUCED DEGRADATION

GE/SUBCONTRACTOR A AGREEMENT

- DRIVE A BEARING TECHNOLOGY DIRECTLY TRANSFERABLE - CAPABILITY EXISTED AT GE FOR BEARING DEVELOPMENT.

- FINAL RESPONSIBILITY FOR DESIGN REMAINS AT SUB A BECAUSE OF OVERALL SUBSYSTEM REQUIREMENTS AND TRADES.

- GE PERFORMS DEVELOPMENT TESTS, ANALYSIS

- OUTPUTS FROM GE TO SUB A INCLUDE TEST DATA, DESIGN ANALYSIS, MECHANICAL PERFORMANCE DATA, SPECIFICATION DEFINITION, INSTALLATION REQUIREMENTS. ALSO SUPPLIED EM-K BEARINGS. FUTURE PROCUREMENTS TO BE DECIDED.

BACKGROUND

- THIN-SECTION PITCH AXIS BEARINGS ON DRIVE-K RETAINED AS HIGH-RISK, LOW-COST APPROACH. - JUNE '68
- ALLOCATION NOT MET BY DEVELOPMENT TEST DATA (AS PREDICTED), EVEN WITH NO INSTALLATION OR THERMAL MARGIN. - NOV. '68
- RATHER THAN IMMEDIATE REDESIGN TO FULL-SECTION BEARINGS, DRIVE-K HIGH-PERFORMANCE PROGRAM EXPANDED. - DEC. '68
- INITIAL RESULTS OF HIGH-PERFORMANCE PROGRAM INDICATE CERTAIN NECESSARY COURSES OF ACTION.

THERMAL ANALYSIS

- GRADIENT AND TOTAL TEMPERATURE EXCURSION EQUATIONS FORMULATED.
- CHANGES IN NORMAL APPROACH CALCULATED AS FUNCTIONS OF GRADIENT OR TOTAL TEMPERATURE.
- NORMAL APPROACH CHANGES CONVERTED TO PRELOAD.
- RMS AND DCT AS FUNCTIONS OF PRELOAD COMBINED WITH ABOVE TO PRODUCE CONSTRAINT ENVELOPES

FIGURE 11: DRIVE K BEARING THERMAL ENVELOPES FOR POTTED AND UNPOTTED CONDITIONS

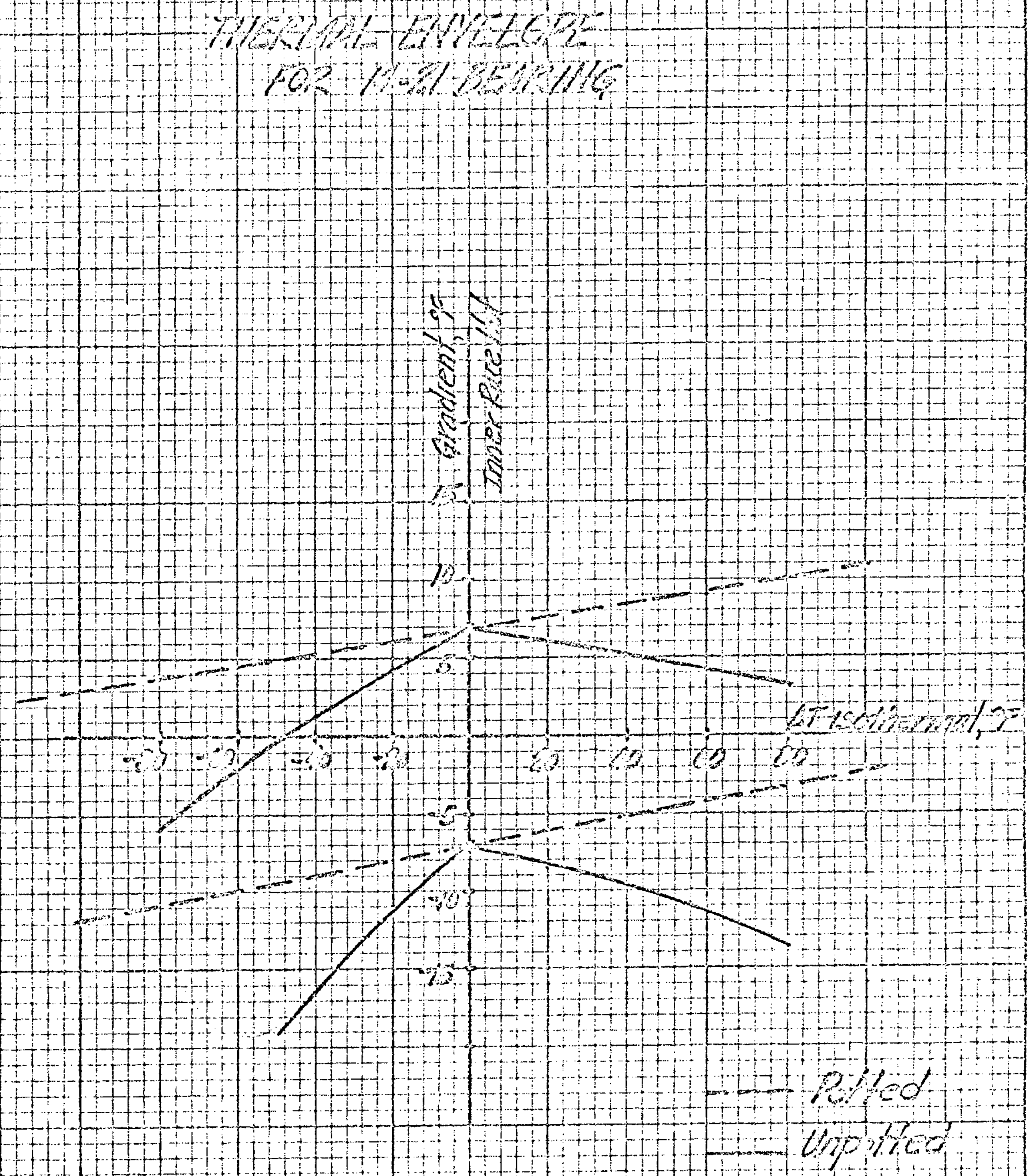


FIGURE 12: DRIVE & BEARING THERMAL ENVELOPES FOR POTTED AND UNPOTTED CONDITIONS

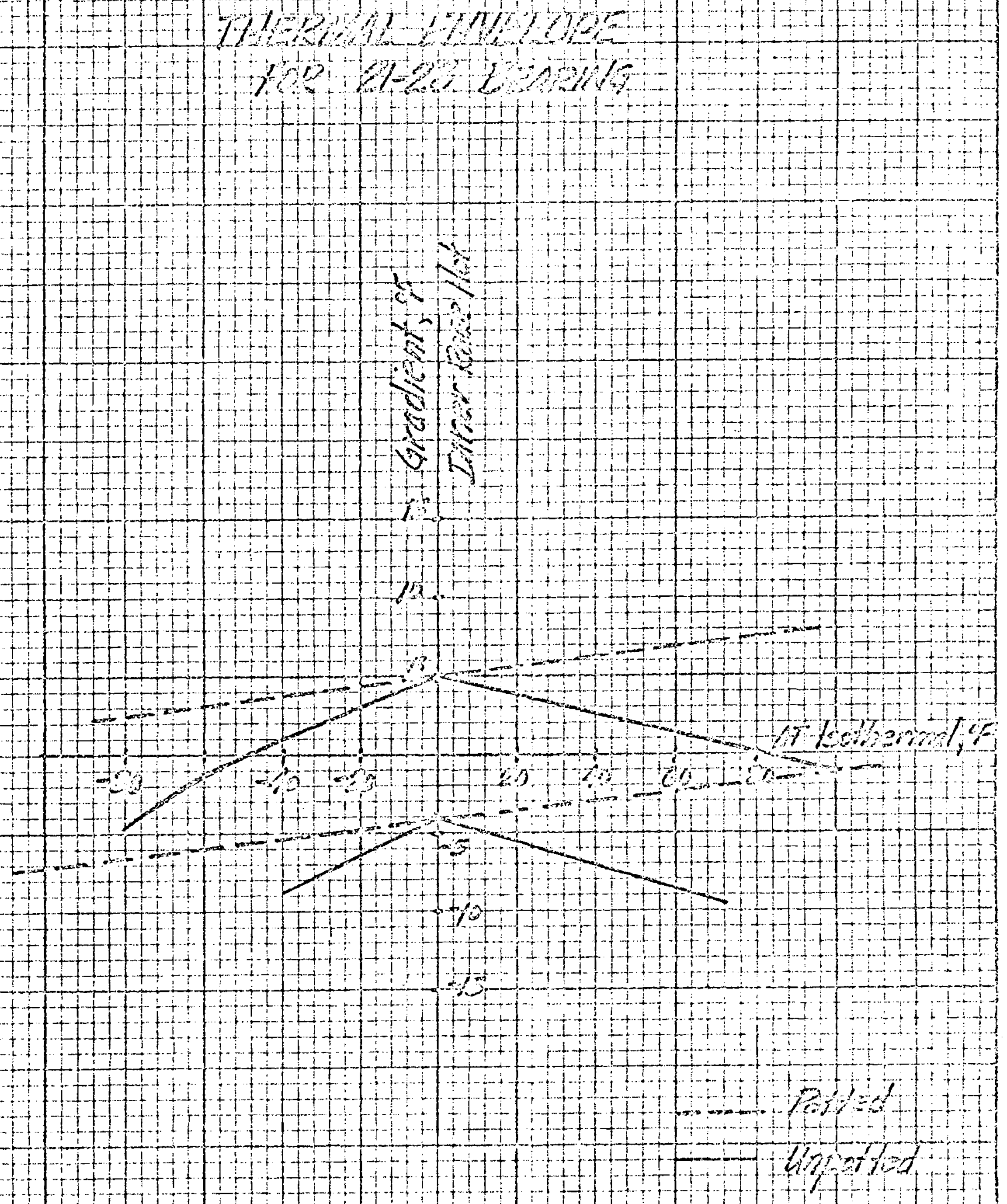


FIGURE 10: DRIVE K BEARING THERMAL ENVELOPES FOR POTTED AND UNPOTTED CONDITIONS

THERMAL ENVELOPE
FOR 9105 BEARING

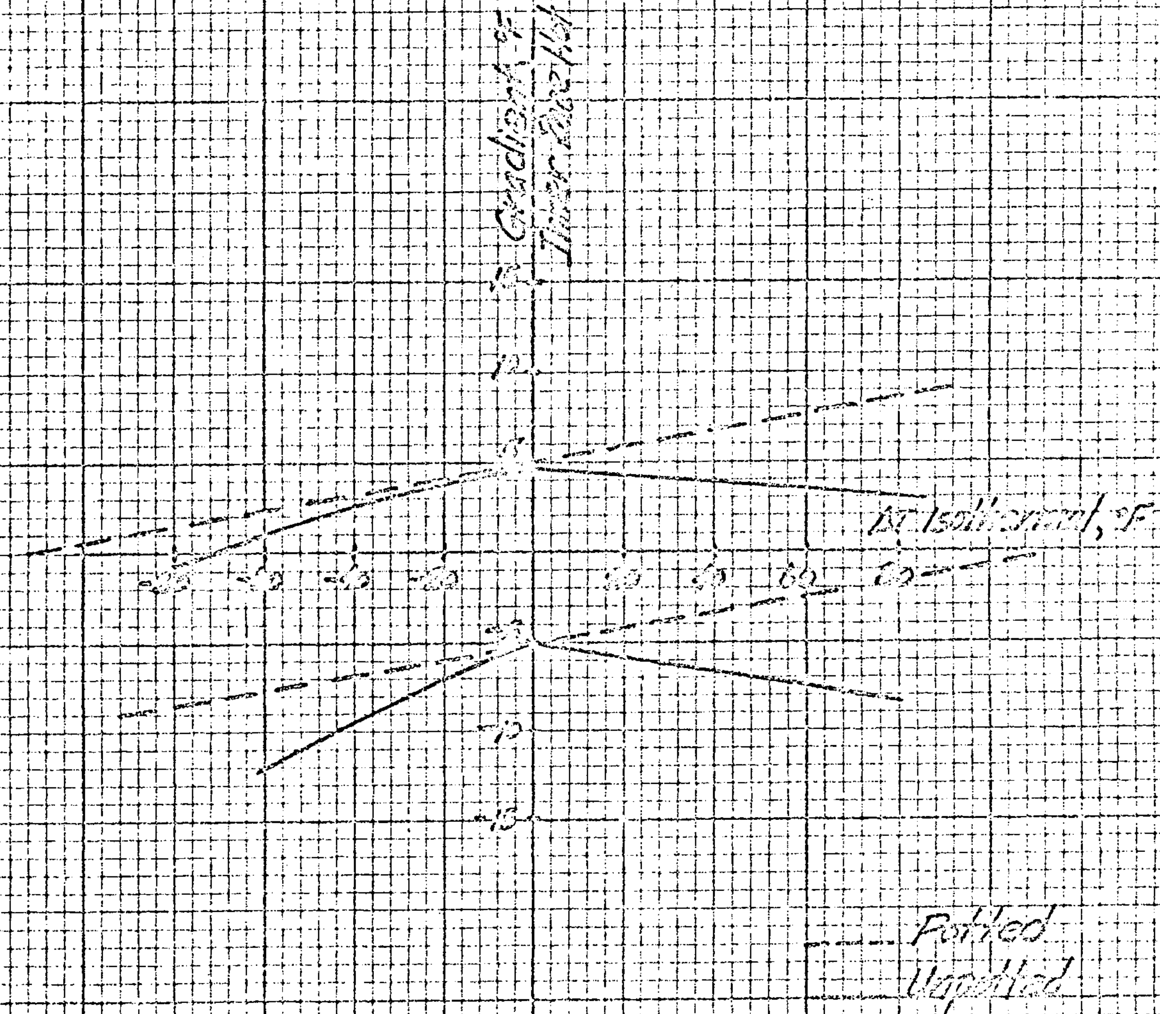
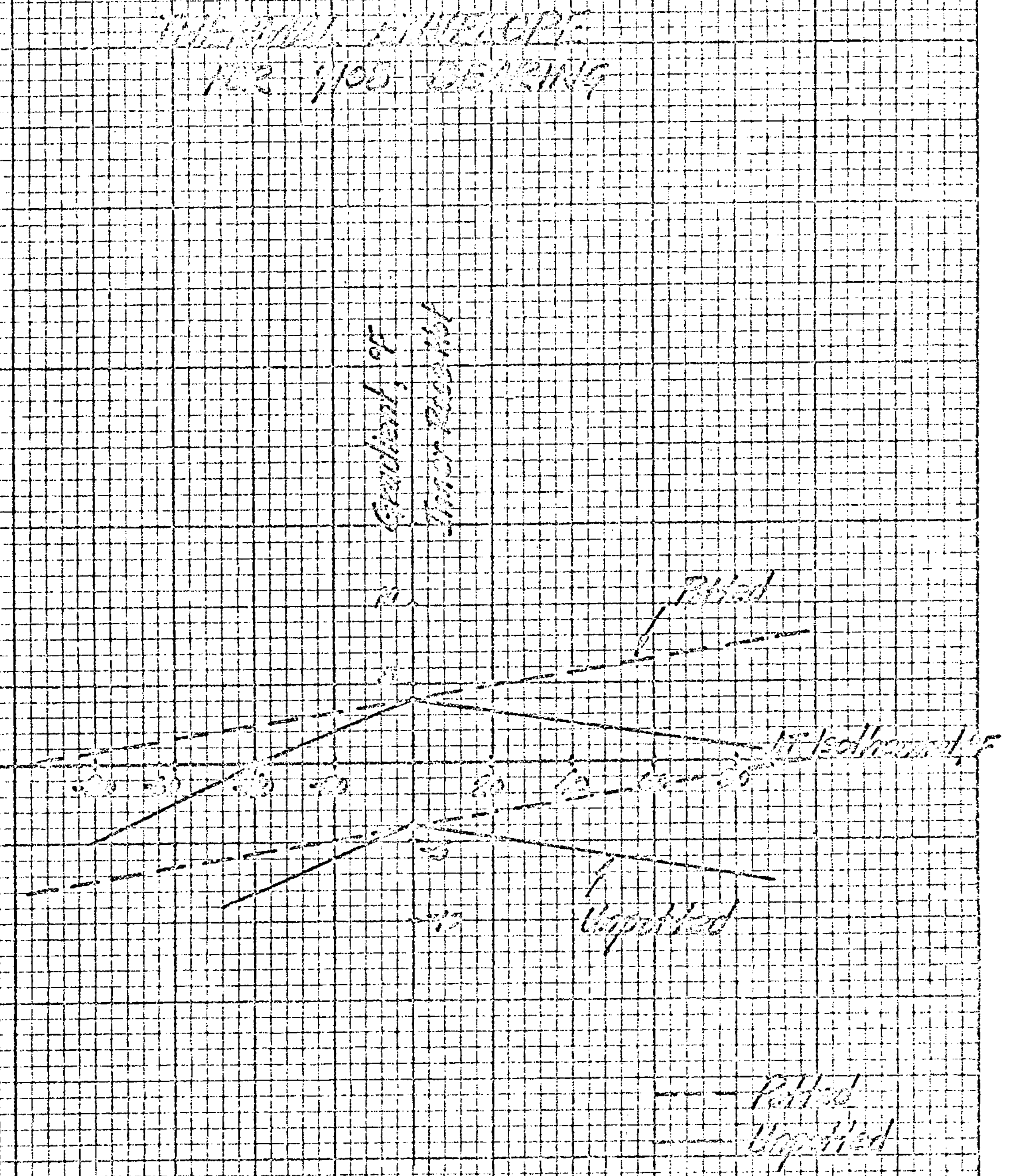


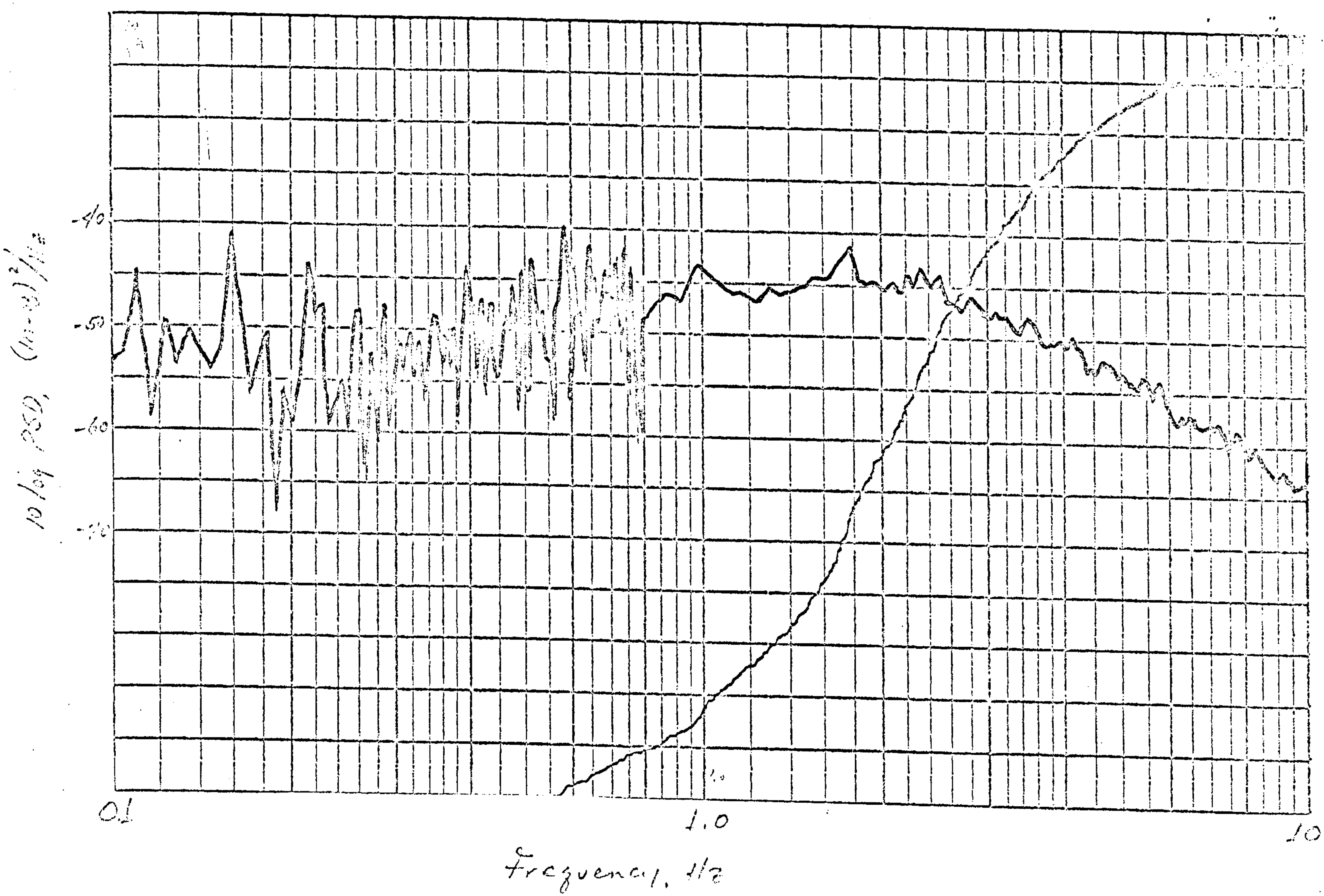
FIGURE 9: DRIVE K BEARING THERMAL ENVELOPES FOR POTTED AND UNPOTTED CONDITIONS



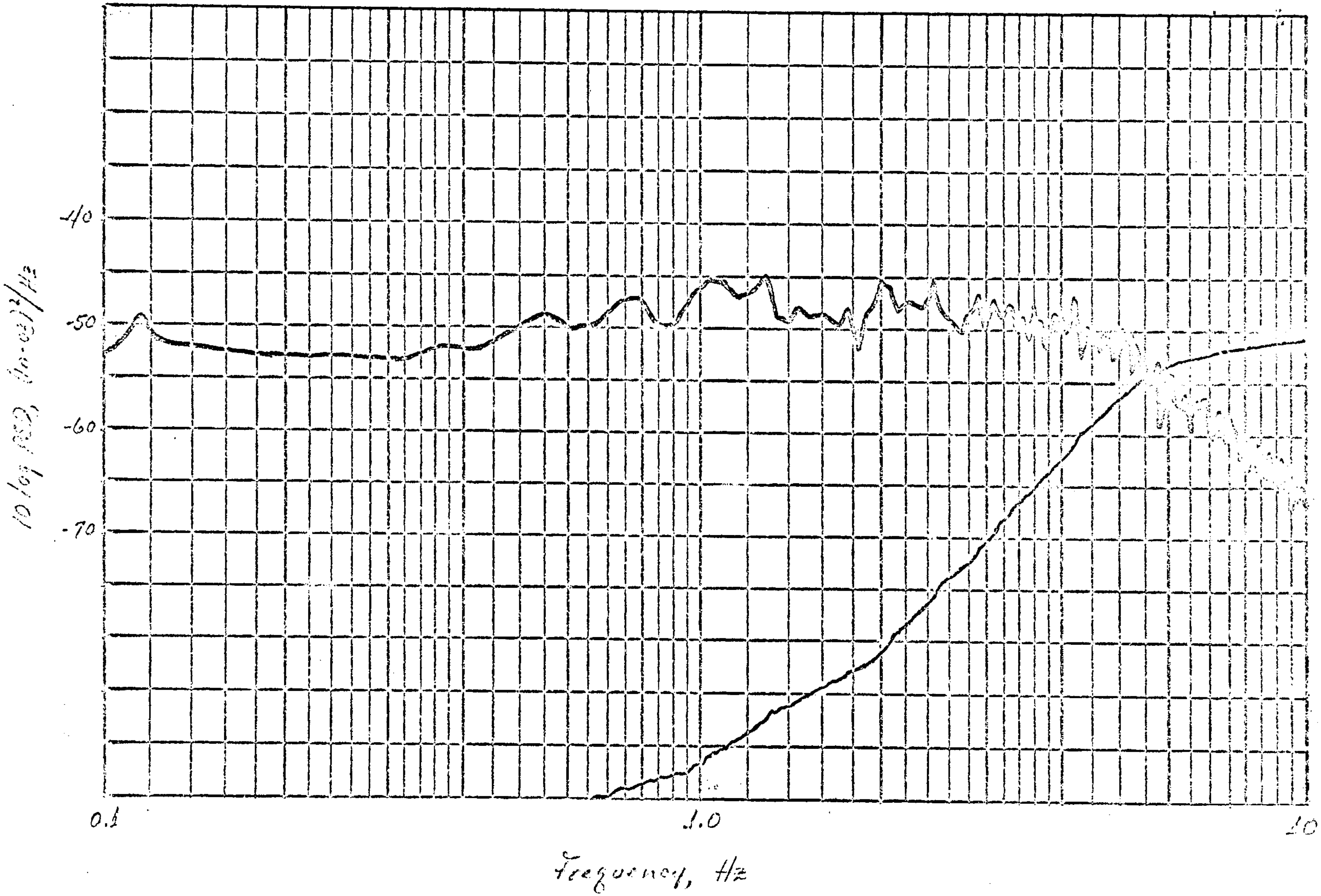
HIGH-PERFORMANCE PROGRAM

- SUPERFINISHES PRODUCED BY SBB EFFECT UP TO 30% DECREASE IN RMS WITH NO CHANGE IN FREQUENCY CONTENT. BARDEN SUPERFINISH SHOULD DO EQUALLY OR BETTER. THE PRACTICAL LIMIT FOR THIN RACE BEARINGS HAS BEEN REACHED.

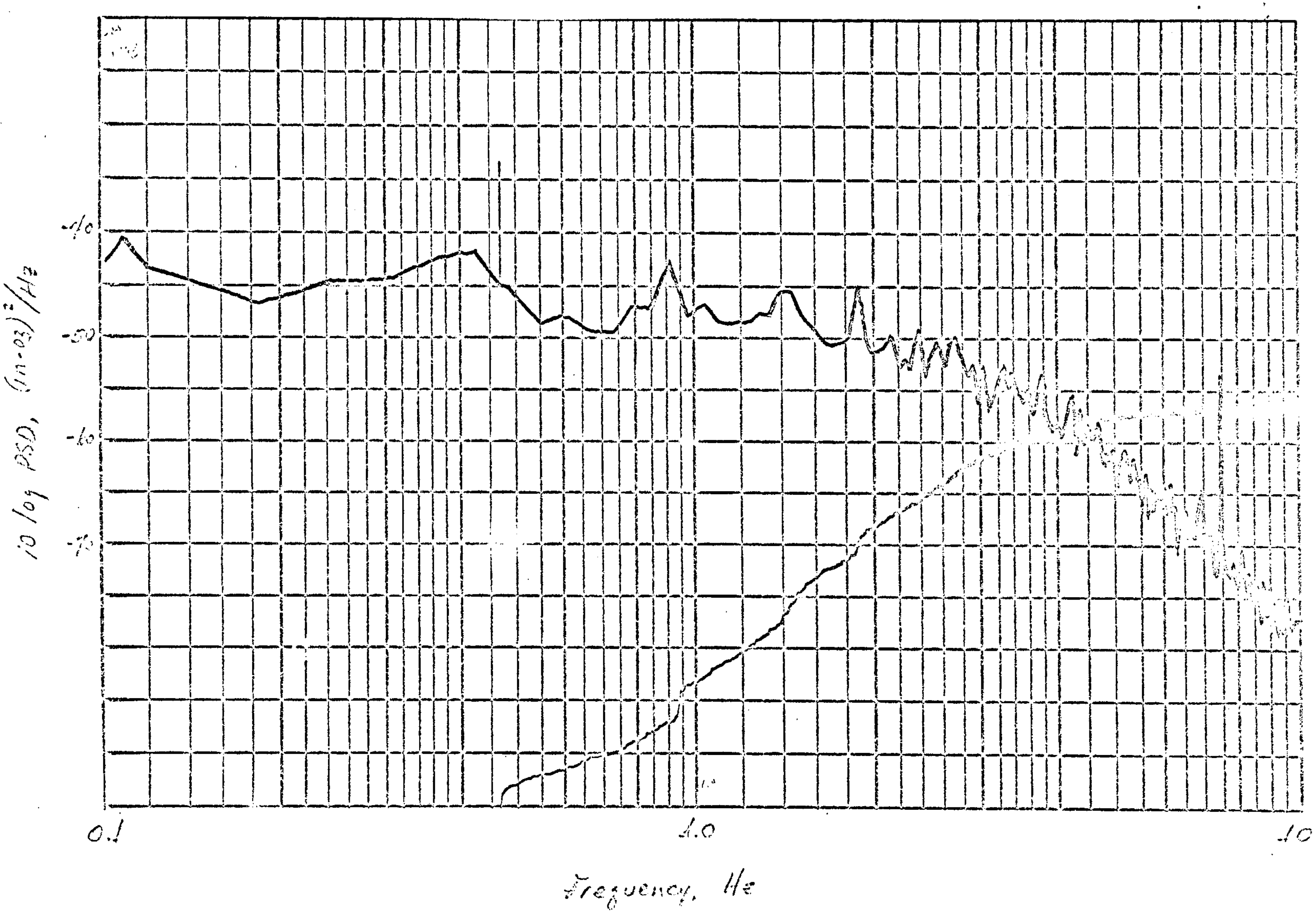
- MOLOIL. HIGH-VISCOSITY SILICON FLUID LUBRICANT CAN, WITH PROPER APPLICATION, PRODUCE DRAMATIC PERFORMANCE INCREASES WHICH WILL LIKELY PERMIT THE USE OF THE EXISTING THIN-SECTION BEARINGS. DEVELOPMENT IS WARRANTED.



Bearing 55A, Pre-honing, F-50, 10lb.



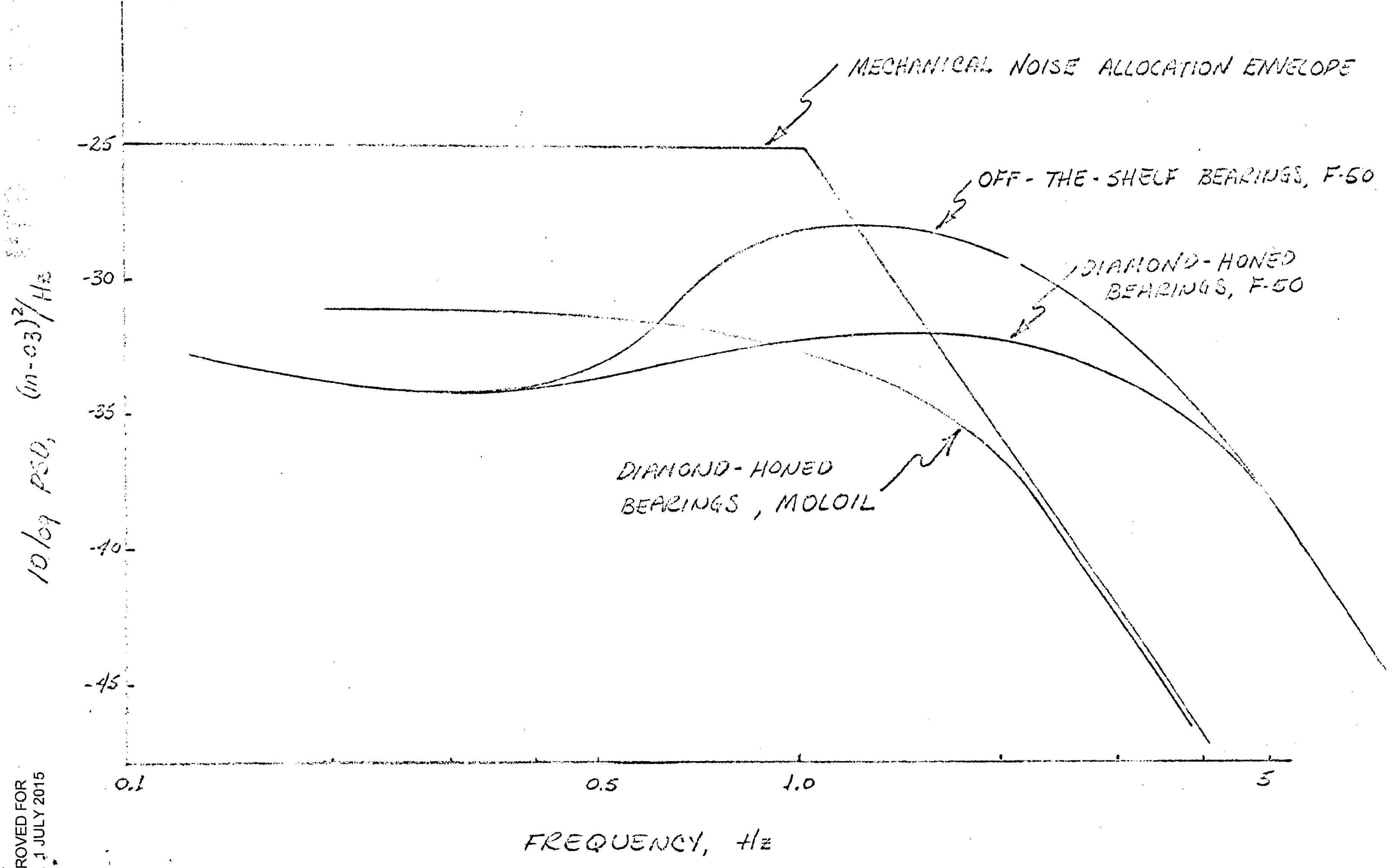
Bearing 55H, Diamond-Honed, F-50, 10 lb.



Bearing S5A, Diamond-Honed, HOLOIL, 10lb.

DRIVE K PITCH AXIS BEARING NOISE SUMMARY

(Δ FOR INSTALLATION, THERMAL = 5 db)



[redacted]

SUMMARY

- DEVELOPMENT TEST BEARINGS WERE OUTSIDE ALLOCATION
- HIGH PERFORMANCE PROGRAM HAS PRODUCED A DESIGN SOLUTION WHICH IS IN EXECUTION

SCANNER ASSEMBLY DESCRIPTION

TWO AXIS GIMBAL SYSTEM

- PEDESTAL
- ROLL HOUSING
- YOKE ASSEMBLY
- BEZEL ASSEMBLY
- MIRROR

BEARINGS

GYROS AND ELECTRONICS

INCREMENTAL ENCODERS

TORQUE MOTORS

OTHER FEATURES

- CABLES AND HARNESS
- STOW LOCK AND STOPS
- ALIGNMENT MIRRORS
- BALANCED GIMBALS

SCANNER COMPONENTS

ENCODERS

- SPECIFICATIONS SUBMITTED FOR APPROVAL
- EMK ASSEMBLY STARTED
- WAYNE-GEORGE BEING MONITORED CLOSELY
- STATIC ACCURACY TEST LATE APRIL
- PSEUDO-RATE TESTS THIS SUMMER

TORQUERS

- AEROFLEX DELIVERED LOW TORQUE UNITS
- REDESIGN MAY RESULT IN INCREASED WEIGHT
- POWER TRADE-OFF POSSIBLE

BEARINGS

- COVERED SEPARATELY
- GENERAL ELECTRIC TESTING THROUGH JUNE, 1969
- STATIC TORQUE AND RIPPLE TESTS TO BE DONE ON SINGLE AXIS TESTER THIS SPRING

GYROS

- HONEYWELL HANGAR QUEENS FURNISHED BY GENERAL ELECTRIC
- PRIME UNITS INSTALLED AT GENERAL ELECTRIC
- HONEYWELL AND GENERAL ELECTRIC RUNNING TESTS
- VALIDATION TESTS TO BE PERFORMED BY ITEK ON SATS CONSOLE
- HANGAR QUEENS WILL BE USED TO MEASURE TORQUE TRANSMISSIBILITY AND POSSIBLY MECHANICAL NOISE

CABLES/HARNESS

- WIRE SPECIFICATIONS SUBMITTED FOR APPROVAL
- DESIGN LIMITED BY TORQUE REQUIREMENT
- THROUGH-BORE DESIGN IS SPACE LIMITED
- REQUIRE GROUND STRAP WAIVER
- TORQUE AND RIPPLE TESTS ON ACROSS-THE-GIMBAL CABLES BEING RUN THIS SPRING

SCANNER DEVELOPMENT TESTING

EMK SCANNER ASSEMBLY

- DRAWINGS AND ASSEMBLY PROCEDURES COMPLETE
- ALL COMPONENTS ON ORDER
- PROCUREMENT TO BE COMPLETE EARLY MAY
- DEVELOPMENT TEST PROCEDURES DUE EARLY JULY
- FULL DEVELOPMENT TESTS TO START AUGUST
- ENVIRONMENTAL TESTING FOLLOWS PERFORMANCE BASELINE TEST

THERMAL TEST (TDT-1A)

- SCANNER REPRESENTED BY MIRROR POTTED INTO BEZEL
- TESTING TO BE PERFORMED IN MAY

SINGLE AXIS TESTER (GAS BEARING)

- BROAD BANDWIDTH DESIRED POSES SERVO/NOISE PROBLEM
- DESIGNED TO MEASURE CABLE SPRING RATE AND TORQUE RIPPLE
- USE EXTENDED TO TEST BEARINGS
- CURRENTLY OPERATING SUCCESSFULLY WITH PSD PROGRAM

SCANNER TEST STAND (STS)

- TO BE USED WITH DEVELOPMENT AND PRIME UNITS
- PERMITS BALANCING AND "ZERO-G" TESTING
- DUE FROM PALO ALTO IN AUGUST

SCANNER TEST CONSOLE (SATS)

- GYRO RATE LOOP ONLY OUTSTANDING PROBLEM
- FULL CAPABILITY TO EXERCISE SCANNER
- DUE FROM PALO ALTO IN JUNE

SCANNER PROBLEM AREAS

BEARING NOISE PERFORMANCE

BERYLLIUM ENCODER FLEXURE

PITCH GIMBAL MAINTAINABILITY

CDR DATE VS. TEST SCHEDULE

GYRO INSTALLATION AND BALANCE

SCANNER INSTALLATION AND ALIGNMENT

SCANNER REPLACEABILITY ON LAUNCH PAD

POWER GROUND

- WAIVER IN PROCESS FOR MAIN TORQUERS
- PLAN WAIVER REQUEST FOR DEROTATION AND ZOOM MOTORS

OPTICAL FILTERS

A filter wheel is required that employs four different filters any one of which can be used at a given time. Generally, the filters will include a clear glass filter, neutral density, and haze filters. The clear glass filter, of which only one is needed, serves as a dummy optical element to maintain system oberration balance and focus when no functional filters are being used. To determine the requirements of the other filters, the content of the viewed scene must be analyzed.

Carman and Caruthers[1] made a study of the distribution of scene luminance and luminance differences for a variety of terrain types as viewed from an aircraft flying at 4000 ft. altitude. The recording photometer scanned the terrain with a spot diameter of 3 feet. In every case, the luminance distribution was very nearly normal. The following table describes the scene content in terms of an assumed normal distribution.

Sun Altitude - 64^{o}
Weather - Clear or Light Haze
Illumination - 10965 lumens/ft.^{2}

TERRAIN TYPE	MEAN LUMINANCE (FT.-LAMBERTS)	3σ LUMINANCE DIFF. (FT.-LAMBERTS)
City	1000	2.5
Small Town	1000	2.5
Orchard & Cultivated Land	1585	2.5
Heavily Wooded	891	1.8

The table indicates the luminance levels to be expected without the addition of the atmospheric haze associated with an orbital mission. On a clear day the maximum addition due to haze is about 750 foot-lamberts. Sunlit clouds[2], however, reach levels of 10,000 ft.-lamberts, snow 5000 ft.-lamberts and sea glint much higher than either. Neglecting the latter phenomenon (because it is analyzed and found to be of minor effect in another study), let us assume that the mean scene luminance level that is to be attenuated is 3000 ft.-lamberts.

Introducing the ℒ system transmission of 35% this quantity becomes very nearly 1000 ft.-lamberts. The previous reference[2] lists minimum illumination levels for various activities verying from 2500 lumens/ft.^{2} for a hospital operating table to 3 lumens/ft.^{2} for candle light dining. Perhaps the activity nearest to that of the ℒ system function is that of engineering drafting. The recommended level for drafting room work is 100-200 lumens/ft.^{2}. A white piece of drawing paper on a drafting table would have a luminance of roughly the same numerical value, 100-200 ft.-lamberts. Let us assume that the ℒ system image should have a mean luminance of 100-ft.-lamberts. The required neutral density filter must attenuate by a factor of 10:1. Its density is 1.0. Because of the constancy of mean scene luminance, as evidenced by the above table, it is recommended that only one neutral density filter be used. Haze, on the other hand, is quite variable. It is therefore recommended that the other two filters be used for cutting two relatively different levels of haze.

The spectral content of the scattered light making up the haze varies with the amount of haze. When haze is very low, on a relatively clear day, scattering is predominantly at the shorter visible wavelength, the blue end of the spectrum. Scattering is then proportional to λ^{-4}. For heavier haze, such as that of an overcast day, the scattered light is primarily white indicating that the scattering is then ideally proportional to λ^{0}.

Any haze spectral filter, in order to be of any use, according to the above analysis must be one that filters out the shorter wavelengths. Typical minus blue filters, such as these, transmit very little blue light, cutting on (50% level) at about 470 m/u. With heavier haze, light begins scattering at even longer wavelengths requiring that the cut-on wavelength must also be longer. In order to preserve some transmission, and for want of any other sources of definition, let us recommend a filter that cust on at 510 m/u. Both of the above can be represented by Kodak Wratten Filters #6 and #9.

CDR ACTION ITEMS
STATUS

ACTION ITEM	COMPLETE	INCOMPLETE	PLANNED COMPLETION DATE
1. SMRD - New Time	GE-ACTION		GE-ACTION AN in process
2. 1703 Noise			
a. EMI Noise	YES } CEL #31		accepted } H. to resubmit
b. Pressure Start-Stop	YES		
c. Pressure Slew Rate	YES		
3. K Gyro Vibration Study	YES - CEL #30		H. to resubmit
4. Power Supply-Start Res.	YES - CEL #28		accepted
5. Power Darlington	YES - CEL #32		accepted
6. Heater Inhibit			
a. Large CAPS	YES } CEL #29		accepted
b. Inhibit Bridge	YES		
7. 1717 Ripple	YES - CEL #33		just received
8. Design Proof Tests	YES - Honeywell Letter Dated 3-13-69		just received
9. Thermal Analysis	YES - CEL #36		just received
10. Thermal Resistance - Mounting Ring	YES - CEL #30		H. to resubmit
11. 1703 Freq. Response	YES - CEL #28		{ accepted GE-ACTION - April 1
12. Humidity	YES - CEL #35		just received
13. EMI GG2000 GG2001	YES - Data Submittal by 3-21-69 (mailed) NO	X	} not received yet April 1, 1969
14. Reliability			
a. Gyro Failure Rates	YES - CEL #27		accepted
b. Parts Failure } c. Error Removal }	NO	In Duplicating Now	{ not received? April 1, 1969
d. Crystal Stability	YES - CEL #37		just received
15. Circuit Analysis	NO	X	April 1, 1969
16. External Effects Scale Factor	YES - CEL #30		accepted
17. Welded Module Potting	NO	X	April 1, 1969

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~~ROUGH DRAFT~~

~~SECRET~~/DORIAN

STATUS OF GYRO CDR ACTION ITEMS

5	FULLY ACCEPTED
1	GE ACTION - IN PROCESS
3	HONEYWELL TO RESUBMIT
4	SUBMITTED BY HONEYWELL NOT YET REVIEWED BY GE
4	INCOMPLETE (HONEYWELL)
17	

~~ROUGH DRAFT~~
~~DESTROY OR LOG BY April 21, 1967~~

NRO APPROVED FOR
RELEASE 1 JULY 2015

INTERFACE DOCUMENT SCHEDULING REPORT

SECRET/DORIAN

~~SECRET~~ D ~~ROUGH DRAFT~~

IFS/ICD	TBD/R	ICN	TITLE	ASSOC RESP	SIGNED BY D	G	A	S	SCHEDULED SIGN-OFF DATE
S003	D119-1		AO Component Areas and Heat Capacities Tolerances	G					TSOM 10
	D119-2		Radiator, Temperatures, Prelaunch	D					2 June 69
	D119-3		Film Coefficients, Boundary Temperatures, Prelaunch	G/D					TSOM 10
	D119-4		Film Coefficients, Ascent and Early Orbit	D					2 June 69
	D119-5		Film Coefficients and Boundary Temperatures, On-Orbit, Pressurized	D					TSOM 10
	D119-6		Boundary Temperatures, On-Orbit, Depressurized	D					TSOM 10
	D119-7		Film Coefficients and Boundary Temperatures, ACTS Translation	D					2 June 69
	D119-9		Heat Rates, Telescope	G					TSOM 10
	D119-11		Area Tolerance, Penetration Fitting	D					TSOM 10
	D119-12		Pedestal Conductance	D					TSOM 10
	D119-15		Boundary Temperatures, Launch, Ascent & Early Orbit	D/G					2 June 69
	R119-1		Penetration Fitting Temperature, Prelaunch Thru Ascent	D					2 June 69
	R119-2		Emissivity Tolerances, AO Components	G					TSOM 10
	R119-12		Air Temperature Inside Aerodynamic Fairing, Prelaunch	D					TSOM 10
	R119-13		Electrical Cable, Thermal Properties	G					TSOM 10
	R119-15		Net Interchange Factor, Window/Cell Tolerances	G					TSOM 10
S003	R119-16		Radiator Temperature excursions	D/G					TSOM 10

~~ROUGH DRAFT~~
~~DESTROY OR LOG BY~~ ~~April 21, 1969~~

~~SECRET~~ / D ~~ROUGH DRAFT~~

CRITICAL OPEN INTERFACE ITEMS

- o LM SHELL STIFFNESS
    - . ICN 144 ANTICIPATED SIGN-OFF BY TSOM 9.5
- o THERMAL
    - . ICN 119 SIGNED OFF AT TSOM #9 WITH 19 TBD/TBR
    - . ACTION PLAN TO RESOLVE TBD/TBR BY JUNE 1969
- o SHROUD FOOT PRINT
    - . NEED TO RESOLVE:
        - SHROUD SUPPORT -- 2 PIECE -- 1 PIECE
        - BOOT TIE DOWN

~~SECRET~~ D

~~ROUGH DRAFT~~

114 DEVELOPMENT TEST ARTICLE

EQUIPMENT

- MISSION MODULE AFT AND FORWARD SECTIONS AND TRANSPORTATION FIXTURE TO WHICH ARE MOUNTED CONSOLES 2 AND 8
- TRANSPORTATION FIXTURE TO PROVIDE MOUNTING POINTS FOR TELESCOPE, SCANNER, FIXED FOLD AND SHROUD
- CONSOLE 2 SIDE FOLLOWING COMPLETION DSS-1 TESTS
- CONSOLE 8 SIDE WITH PRIME GLASS

OBJECTIVES

- ESTABLISH MECHANICAL COMPATIBILITY
- ESTABLISH ELECTRICAL COMPATIBILITY BETWEEN AVE SUBSYSTEMS
- DETERMINE SYSTEM FUNCTIONAL PERFORMANCE CHARACTERISTICS
- VERIFY THE SYSTEM EMC CHARACTERISTICS
- DEVELOP AND VERIFY GROUND TEST PROCEDURES TO BE USED FOR ACCEPTANCE TESTING

~~SECRET~~/DORIAN

~~ROUGH DRAFT~~
~~DESTROY ON LOG BY~~
~~April 21, 1969~~

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~~ROUGH DRAFT~~

114 PLANNED TESTING FOR ATS

o SLEW MODE

o TRACKING MODE

o ZOOM CONTROL

o MAGNIFICATION STEP CONTROL

o IMAGE DEROTATION

o SOLAR BLANKING

o PERIPHERAL DISPLAY

o CUE RETRIEVAL (AUTO)

o LAMP INHIBIT

o MANUAL CUE RETRIEVAL

o SINGLE FRAME STEP

~~SECRET~~/DORIAN

~~ROUGH DRAFT~~
~~DESTROY OR LOG BY~~
~~April 21, 1969~~

~~SECRET~~ D
~~ROUGH DRAFT~~

115 SYSTEMS QUALIFICATION TEST ARTICLE

EQUIPMENT

- HOLDING FIXTURE SAME AS 114
- PRIME UNITS FOR CONSOLE 2 AND 8

OBJECTIVE

- DEMONSTRATION OF PERFORMANCE TO AVE CEI REQUIREMENTS

TESTING FOR ATS

o	SLEW MODE	TA
o	TRACKING MODE	TA
o	ZOOM CONTROL	T
o	MAG STEP CHANGE	T
o	IMAGE DEROTATION	TA
o	SOLAR BLANKING	T
o	SHROUD	T
o	PERIPHERAL DISPLAY	T
o	CUE RETRIEVAL (AUTO)	T
o	CUE AVAILABILITY	T
o	LAMP INHIBIT	T
o	MANUAL CUE RETRIEVAL	T
o	SINGLE FRAME STEP	T
o	FILM MODULE REPLACEMENT TIME	T
o	MAGNIFICATION CONTROL STICK FUNCTIONS	T
o	FILTERS	T

~~SECRET~~/DORIAN

~~ROUGH DRAFT
DESTROY OR LOG BY April 21, 1969~~

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~~ROUGH DRAFT~~

EDCTU (GD-5)

- o EQUIPMENT FROM DSS-1 TO BE USED ON 114 - WILL NOT BE SHIPPED AS GD-5
- o K BRASSBOARDS WILL BE SHIPPED AS GD-5

LMQTV (GD-6)

EQUIPMENT

- o PRIME UNITS FOR CONSOLES 2 AND 8

OBJECTIVE

- o DEMONSTRATION OF PERFORMANCE TO AVE CEI REQUIREMENTS
- o THERMAL VACUUM TESTING SIMILAR TO 115

~~SECRET~~/DORIAN

~~ROUGH DRAFT~~
~~DESTROY [illegible] LOG BY April 21, 19 [illegible]~~

THERMAL DESIGN - SUMMARY

- THERMAL DESIGN REQUIREMENTS
  - TELESCOPE -

VARIATION IN TEMP. FROM ASS'Y TEMP.	±12°F.
AXIAL GRADIENT (OBJECTIVE WINDOW - ELBOW)	±3°F
TUBE CIRCUMFERENTIAL GRADIENT	±7°F
OBJECTIVE WINDOW RADIAL GRADIENT	±1°F
OBJECTIVE ELEMENT #1 RADIAL GRADIENT	±1°F
OBJECTIVE ELEMENT #2 RADIAL GRADIENT	±1°F

- SCANNER ASSEMBLY

TEMP. VARIATION	50 - 90°F
BEARING GRADIENTS	<5°F

- PROPOSED DESIGN CONCEPT

TOTALLY INSULATED SHROUD
UMBRA COOLING
HEATED LENS CELL + FIXED FOLD HOUSING
<u>ANALYTICAL CONCLUSIONS</u>

SCANNER ASS'Y TEMP. VARIES
BETWEEN 47° - 90°F

BEARING GRADIENTS LESS THAN 5°F

HEATER POWER REQ. ~ 13 WATTS.

AXIAL GRADIENT 11.2°F (1.3 diopters reticle/scene defocus).
~ 8 watts to [illegible]

AMBIENT VAR. OF TELESCOPE $^{+9}_{-8}$ °F

CIRCUMFERENTIAL GRAD. 1.5°F

OPTICAL ERROR BUDGET FOR SCAN
MIRROR MET.
[illegible]

- ALTERNATE DESIGN CONCEPT

PARTIALLY INSULATED SHROUD
NO UMBRA COOLING REQ.
HEATED SCANNER ASS'Y OR SHROUD
HEATED LENS CELL + FIXED FOLD HOUSING

SCANNER ASS'Y TEMP. VARIES
BETWEEN 50°F – 130°F.

BEARING GRADIENTS - 10° (ROLL TORQ), 18° (PITCH MOTOR)
W/O HEATER.

AXIAL GRADIENT 11.2°F

AMBIENT VAR. OF TELESCOPE +9°F
−8

CIRCUMFERENTIAL GRAD. 1.5°F

HEATER POWER 33WATTS +
(ASSUMES HEATERS MTD. ON SCANNER)

OPTICAL ERROR BUDGET FOR
SCAN MIRROR NOT MET.

[illegible]

QUAL. TESTING PROBLEM

REQUEST WAIVER TO SAFSL 10003.

- SAFSL10003 REQ.

  INTERNAL COMPONENTS -
  TEMPERATURE CYCLE BETWEEN
  10°F TO 140°F
  PERFORMANCE TEST AT HIGH AND
  LOW TEMP. EXTREMES.

  EXTERNAL COMPONENTS -
  ADJUST ENVIRONMENT SIMULATOR
  TO YIELD COMPONENT TEMPERATURES
  30°F ABOVE THE MAX. AND 30° BELOW
  MINIMUM.

RATIONALE FOR WAIVER REQUEST -

OPTICAL PERFORMANCE CAN NOT

BE MET UNDER ABOVE <u>ARBITRARY</u>

ENVIRONMENTAL EXTEMES

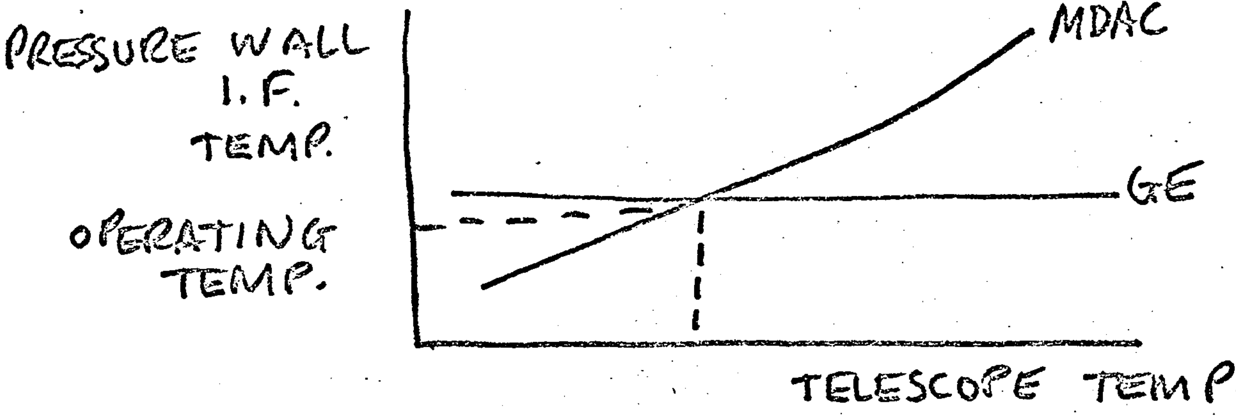
1. EXCEEDS PERMISSABLE TEMP. VAR. FOR TELESCOPE.
2. MAKE GRADIENT PROBLEMS IN BEARINGS MORE SEVERE AND CONSEQUENTLY TORQUE AND JITTER REQ CANNOT BE MET.
3. CREATES ADD'L GRADIENTS IN SCAN MIRROR - OPTICAL ERROR BUDGET WOULD NOT BE MET.

GE/MDAC INTERFACE SPEC. STATUS.

RESULTS FROM EARLIER MODEL
±6°F VAR. IN PRESSURE WALL TEMP.

11°F MAX. AXIAL GRADIENT.

UPDATED MODEL.



ORBITAL DATA - DUE TSOM #10.

ASCENT, & ACTS DATA - JUNE 2.

PROBLEM AREAS (MAJOR)

1. DEFINITION OF PRESSURE WALL TEMP. - NEED VARIATION HELD TO ±2°F TO ELIMINATE LENS CELL HTR.

2. MORE REALISTIC DEFINITION OF CONSOLE AREA BOUNDARY TEMPERATURES.

a

OPERATIONAL & ENVIRONMENTAL CONSTRAINTS

- BETA ANGLE $-60° \le \beta \le 60°$
- ENVIRONMENTAL FLUXES (BTUS/HR, FT.^{2})

	SOLAR	ALBEDO	EARTH	MOLECULAR HTG.
MAX.	460	202	75	71.4 BTUS/HR FT
NOM.	440	167	67	28.6
MIN.	425	136	61	0

- DOOR OPEN TIME – 0-40 MIN./REV.
  CUMULATIVE TIME 250 MIN./DAY.

- TARGET DENSITY

NON-OPERATING	0
MINIMUM OPERATING	.5 TARGETS/MIN.
MAXIMUM OPERATING	4.0 TARGETS/MIN.
NOMINAL	1.6 TARGETS/MIN.

IMPACTS TORQUER HEAT DISSIPATION – HEAT DISSIPATION DURING SLEWING MANEUVER ~100× THAT DURING TRACKING MANEUVER.

- TRANSLATION THRUSTER FIRING
  ON-ORBIT - MAX. DURATION 900 SEC.
  NOM. DURATION 205 SEC.
  HIGH TEMPERATURE PROB.
  FORCES COATING SELECTION
  CREATES CONTAMINATION PROBLEM.

- GYRO MOUNTING SURFACE - MAINTAIN BETWEEN 0 - 100 °F

- READY TIME - AFTER LIFTOFF

  10 HRS. PER CEI SPEC.

c,

- SYSTEM THERMAL REQUIREMENTS
  - BEARINGS -

    INCREASING OR DECREASING THE TEMPERATURE FROM THE ASS'Y TEMP. INCREASES THE BEARING PRELOAD

    TEMPERATURE GRADIENTS ON BEARINGS WILL RESULT IN AN INCREASE IN PRELOAD OR A DECREASE DEPENDING ON THE DIRECTION OF THE GRADIENT.

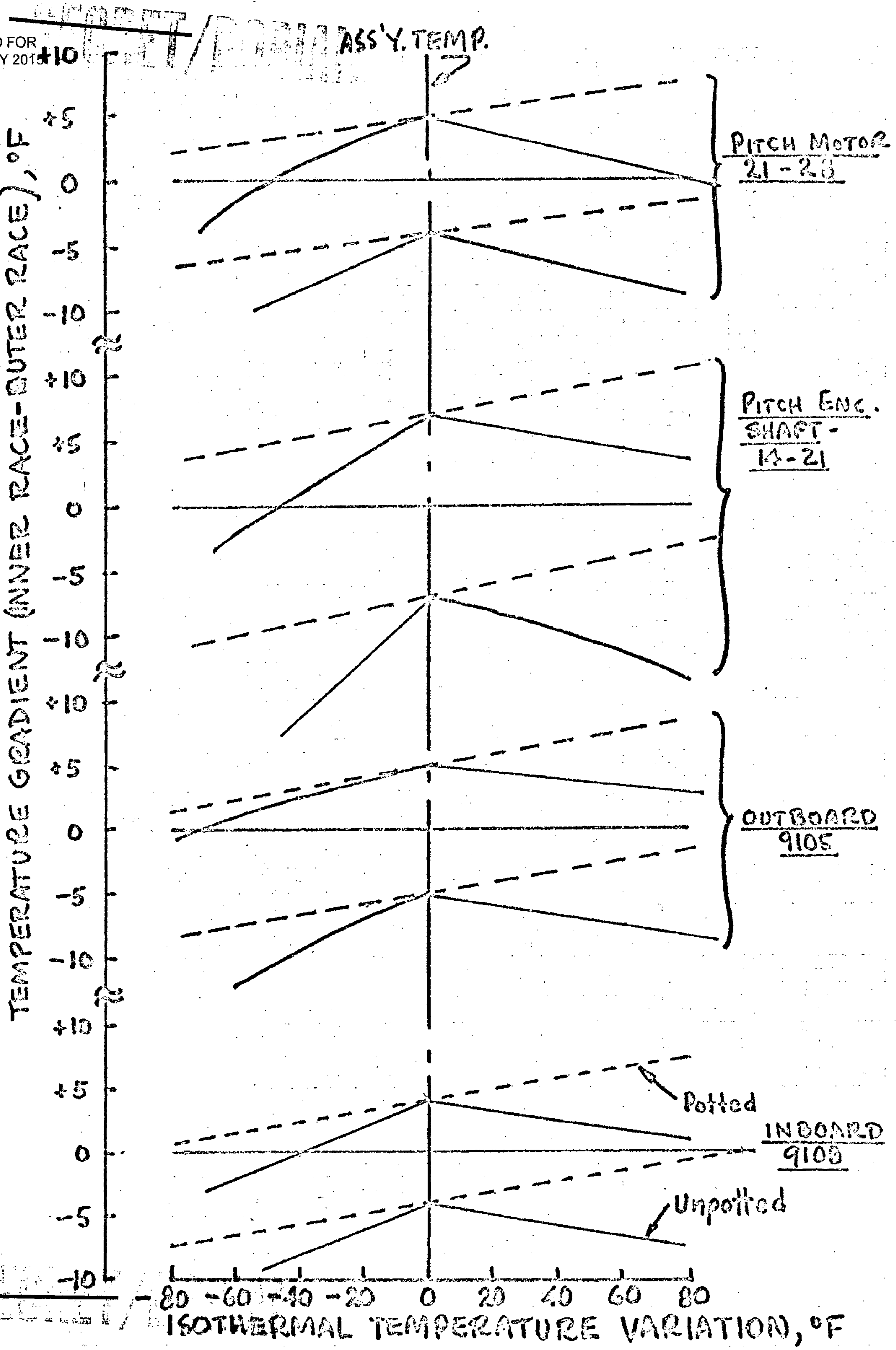
    CURVES SHOWN GIVE PERMISSABLE RANGE OF TEMPERATURE GRADIENT WITH CHANGES IN THE AVERAGE BEARING ASS'Y TEMP.

  - THERMAL/OPTICAL CONSTRAINTS.

    SCANNER - ERROR BUDGET
      SURFACE DISTORTION - PEAK TO VALLEY -
        [redacted] .56 μ in.

    SENSITIVITY COEFF. (THEOR.)
      AMBIENT VAR. - .0007 μ in./°F
      RADIAL GRADIENTS - .009 μ in./°F
      AXIAL GRADIENTS - .316 μ in/°F.
      POTTING GAP GRAD. - .01125 μ in./°F.

BEARING THERMAL OPERATING ENVELOPE.



- FIXED FOLD ERROR BUDGET

SURFACE DISTORTION - .24µ IN. PK. TO VALLEY

SENSITIVITY COEFF. (THEOR.).
AMB. VAR. .0007µ IN./°F.
RAD. GRAD. .009µ IN./°F.
AXIAL GRAD. .316µ IN/°F.
POTTING GAP GRAD. .01125µ IN./°F.

- OBJECTIVE WINDOW ERROR BUDGET.
SURF. DIST. - 1.04µ IN. PEAK TO VALLEY.

SENSITIVITY COEFFICIENTS

RADIAL GRAD. — 1.348µ IN./°F
AXIAL GRAD. — .00012µ IN./°F.
PRESSURE DIFFERENCE — .0004µ IN./PSI.

- TELESCOPE THERMAL REQUIREMENTS.

OBJECTIVE AMBIENT VAR.	± 12°F
AXIAL GRADIENT.	± 3°F
CIRCUMFENTIAL GRAD.	±7°F
RADIAL GRADIENTS -	
OBJECTIVE WINDOW -	1°F
ELEMENT #1	1°F
ELEMENT #2	1°F.

- THERMAL DESIGN CONCEPTS

EXTERNAL ASS'Y - SCANNER

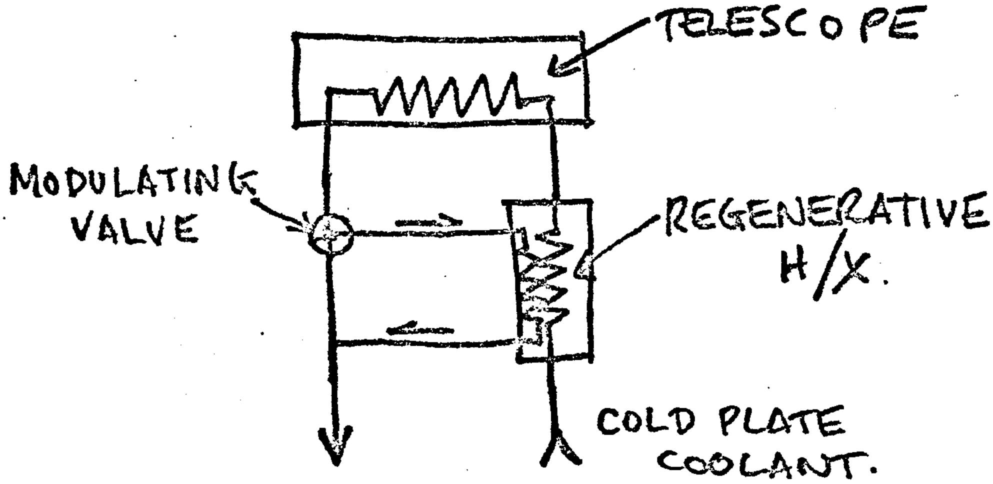
- PASSIVE - PARTIALLY INSULATED SHROUD.
  HEATERS TO MAINTAIN SCANNER ASS'Y
  ABOVE MINIMUM TEMP.
  COATINGS - WHITE COATING ON SHROUD
  POSSIBLE PATCHWORK ON
  YOKE AND OTHER SELECT AREAS
  OF SCANNER ASS'Y.

- ACTIVE - (BAS) - BIG APERTURE SHUTTER.
  TOTALLY INSULATED SHROUD.
  WHITE COATING ON SHROUD.
  POSSIBLE PATCHWORK ON YOKE
  AND OTHER AREAS.
  UMBRA COOLING.
- PARTIALLY INSULATED SHROUD USING
  BAS CONCEPT.

INTERNAL ASS'Y - TELESCOPE.

- PASSIVE - LOW EMITTANCE SHELL.
  - INSULATED SHIMS.
  - HEATERS ON OBJECTIVE LENS CELL
    & FIXED FOLD MOUNT.

OTHER CONCEPTS EXAMINED.
- COOLANT LOOP BUILT INTO TELESCOPE

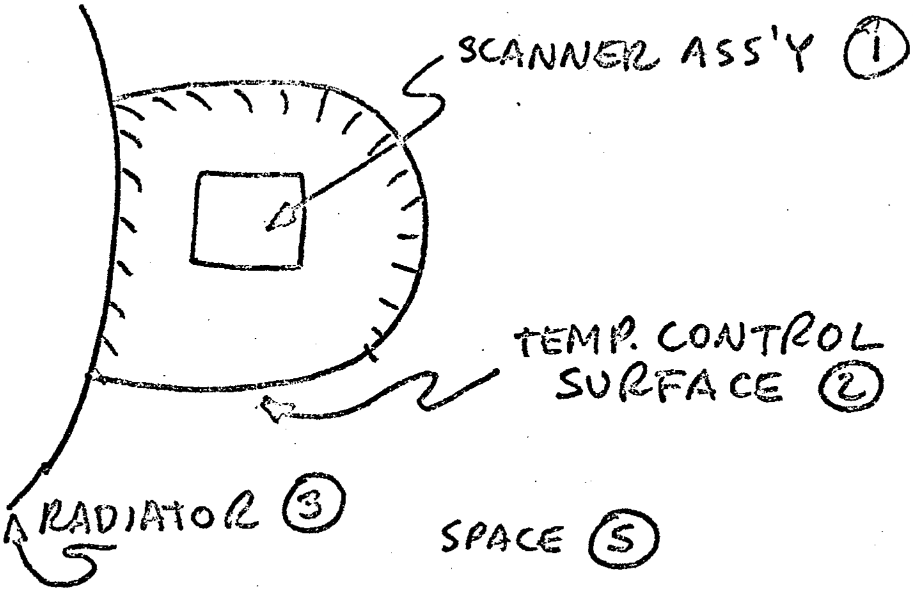


- LOW EMITTANCE COATING ON OBJECTIVE WINDOW.
- INCREASE WALL THICKNESS OF TELESCOPE
- PROVIDE FORCED AIR CIRCULATION AROUND TELESCOPE.
- HEAT TELESCOPE TO UNIFORM TEMPERATURE.

● ANALYTICAL CONCLUSIONS

SCANNER ASS'Y -

- PASSIVE DESIGN - SCANNER ASS'Y TEMP. VARIES BETWEEN. −30°F to +125−130°F. ($\alpha/\epsilon = .125/.125$).
- USE OF HEATERS TO INCREASE MINIMUM TEMP. POTENTIALLY COULD CREATE LARGER GRADIENTS IN SCAN MIRROR AND IN BEARINGS.
- OPTICAL ERROR BUDGET EXCEEDED. .725μ IN - .56 ALLOWABLE.
- IN ORDER TO ACHIEVE REQ. PITCH AND 8 ROLL TORQUE VALUES, 6 IN OZ. SCANNER MUST BE MAINTAINED BETWEEN 50°F-90°F
- ≈20 WATTS MAX. REQ. TO MAINTAIN SCANNER ASS'Y ABOVE 50°F. AT COLD COND. (ASSUMES HEATERS MOUNTED ON SCANNER).



$$Q_{HTR} = \epsilon_1 \epsilon_2 A_1 \Big[\sigma T_1^4 (\epsilon_2 \epsilon_3 A_2 F_{23} + \epsilon_2 A_2 F_{25}) - \epsilon_2 \epsilon_3 A_2 F_{23} \sigma T_3^4 - \epsilon_2 A_2 E - \alpha_s A_2 \bar{A} \Big] \div \epsilon_1 \epsilon_2 A_1 + \epsilon_2 \epsilon_3 A_2 F_{23} + \epsilon_2 A_2 F_{25}$$

NOTE: ASSUMES INSULATED PORTION OF SHROUD ACTS AS AN ADIABATIC WALL.

· BEARING GRADIENTS - WORST CASE -

ROLL TORQUER -
INBOARD - 10°F
OUTBOARD - 10°F

PITCH MOTOR - 18°F.

ADDITIONAL WORK REQ. TO OPTIMIZE BOTH TEMP. LEVEL & TEMP. GRAD.

BAS -

SCANNER ASS'Y TEMP. VARIES BETWEEN. 47°F TO 62-90

OPTICAL ERROR BUDGET MET -
.530 VS. .56 ALLOWABLE.

BEARING GRADIENTS - WORST CASE

ROLL TORQUER
INBOARD - 5.0 °F
OUTBOARD - 2.5°F

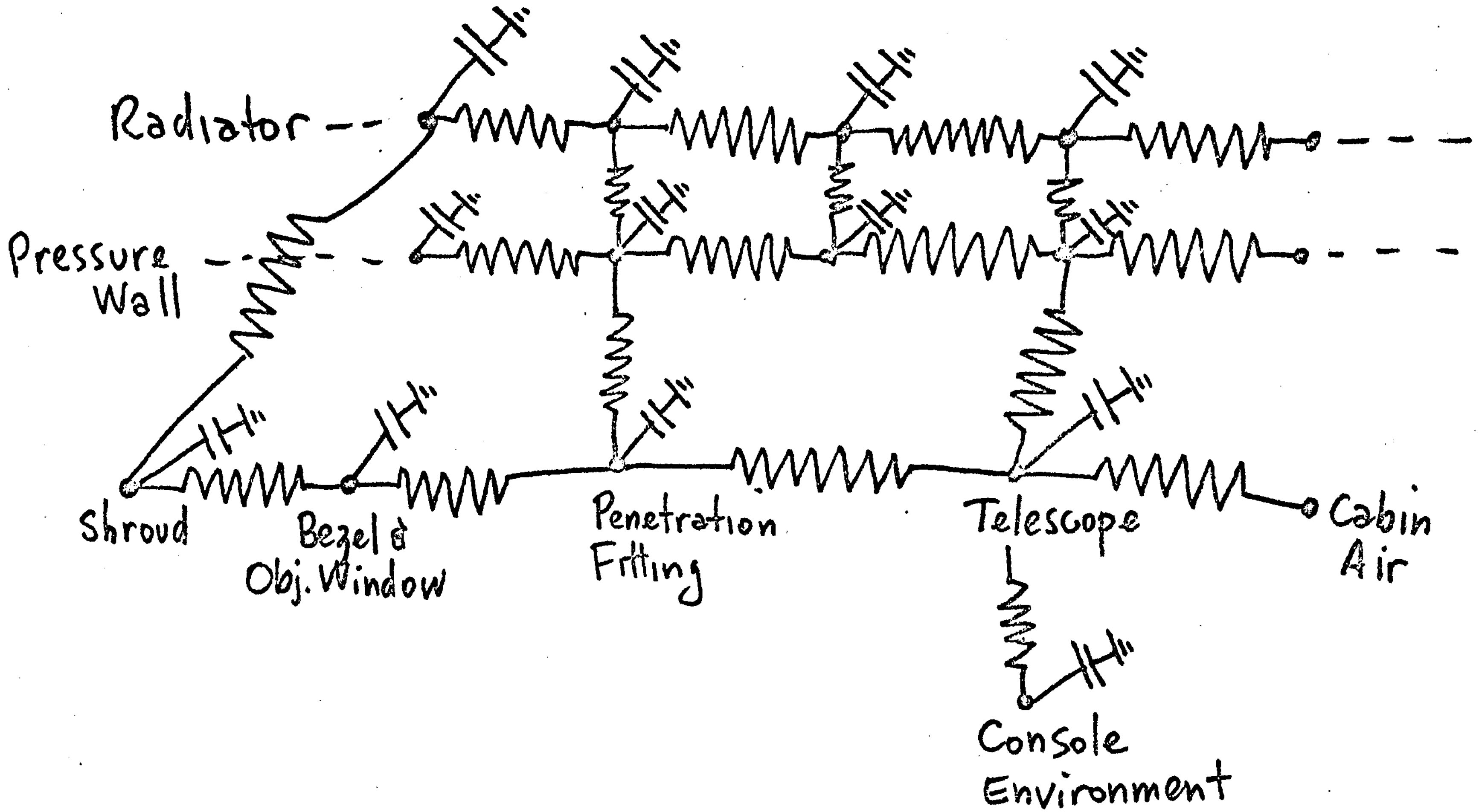
PITCH MOTOR - 5.0 °F.

- OBJECTIVE LENS CELL.
  - USE OF THIN FILM GOLD COATING ($\epsilon \approx 0.1$) YIELDS RADIAL GRADIENTS < 1°F.
  - TRANMITTANCE IS MARGINAL. 25% REQ.
  - PROPOSED SOL'N CONSISTS OF HTG LENS CELL TO EVEN OUT TEMP. CYCLING. (EST. PK. POWER ≈ 3WATTS). ALSO HEAT FIXED FOLD MOUNT TO MATCH LENS CELL TEMP. (EST. PK POWER ≈ 10W).
  - HEATING TELESCOPE TO ELIMINATE AXIAL GRADIENTS AGGRAVATES THE RADIAL GRADIENT PROBLEM IN THE OBJ. WINDOW & LENS CELL.

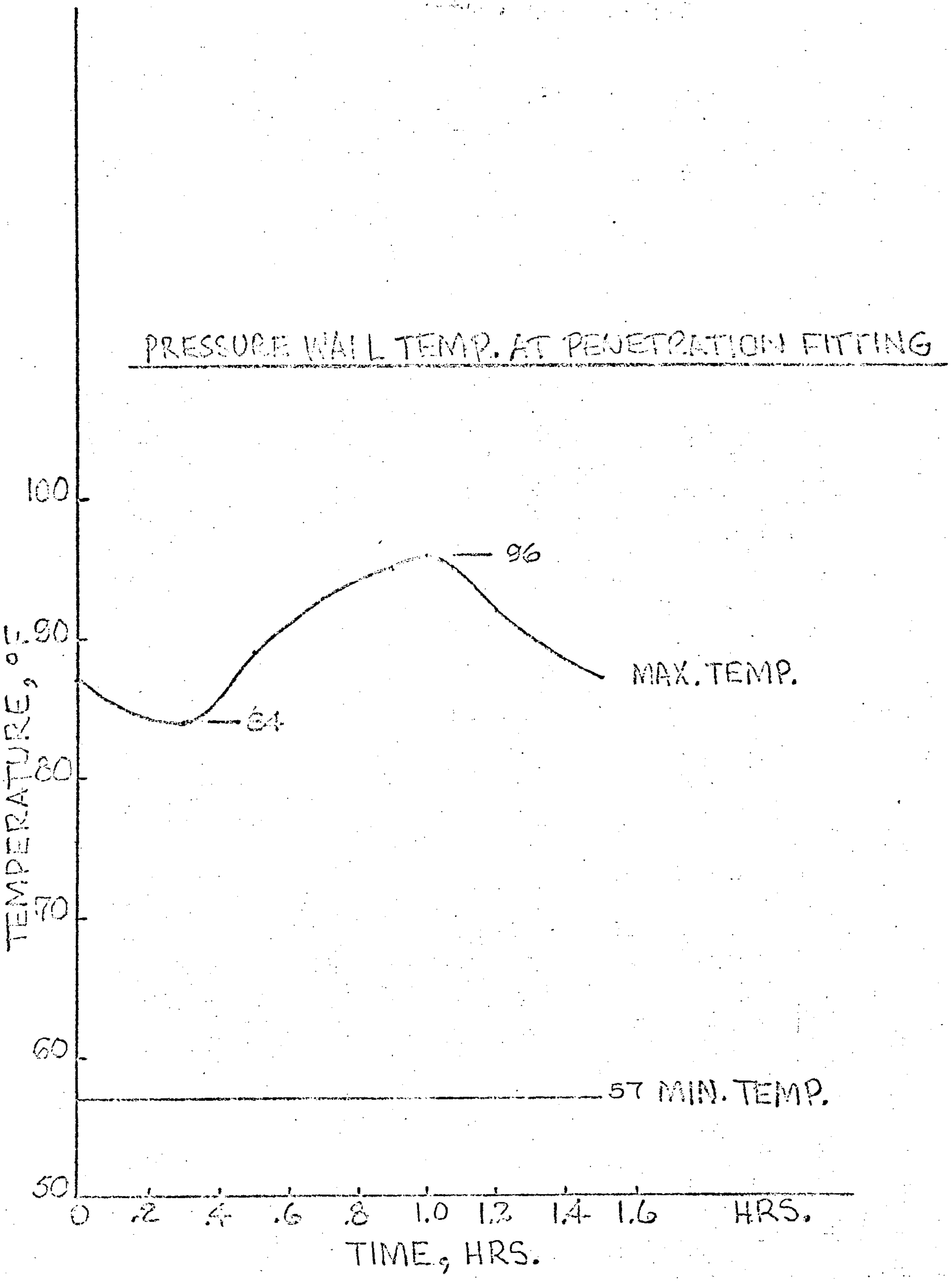
	GRAD. W. HTRS.	W/O HTRS.
OBJ. WINDOW	3.5	2.75
ELE. # 1.	3.5	2.85
ELE #2	1.2	2.12

- TELESCOPE

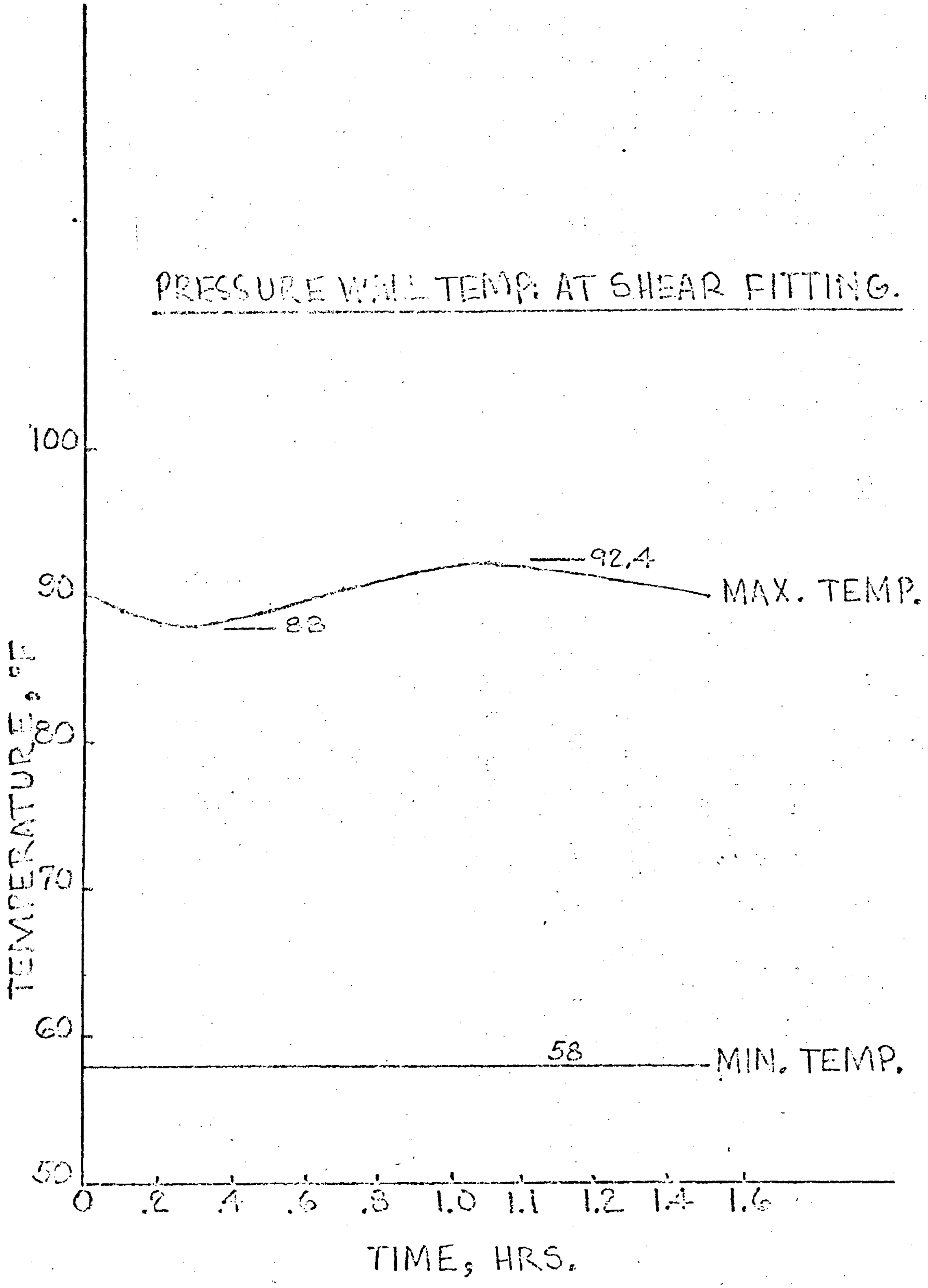
AMB. VAR.	+18 °F −10 °F.	+9 −8
AXIAL GRAD	3°F	11.2
CIRC. GRAD	1.5 °F	1.5
RETICLE/SCENE DEFOCUS	.	1.3 diopters.



G.E./MDAC Thermal Interface Model.



PRESSURE WALL TEMP. AT PENETRATION FITTING



PRESSURE WALL TEMP. AT SHEAR FITTING.