 Whelan

Document No. 50301-122-1

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MINUTES

OF

INCREMENTAL PRELIMINARY DESIGN REVIEW

OF

ACQUISITION SUBSYSTEM

OF

GE-AVE CEI-010AI

APR 3 - 1968

50348-62-4

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c/4

SUBJECT: Minutes - Incremental Preliminary Design Review of the Acquisition Subsystem of CEI MOL 010AI.

REFERENCES: a) Statement of Work Contract AF 18(600)-2955

CONTENTS

1.0 Purpose

To conduct an Incremental Preliminary Design Review (PDR) of the Acquisition Subsystem of CEI MOL 010AI of Specification CP 1000AI.

2.0 Results

2.1 This incremental PDR was satisfactorily completed. General Electric agreed to provide completion dates for the action items with the formal minutes, which are provided below:

2.2 Pre-PDR Action Items

None

2.3 Post-PDR Action Items

2.3.1 GE will analyze and optimize the backup mode using the inverse of the curve shown in Figure (1) and the additional constraint that the optimum performance is desired for angles from nadir to +50 degrees. Action to be completed by 4/19/68.

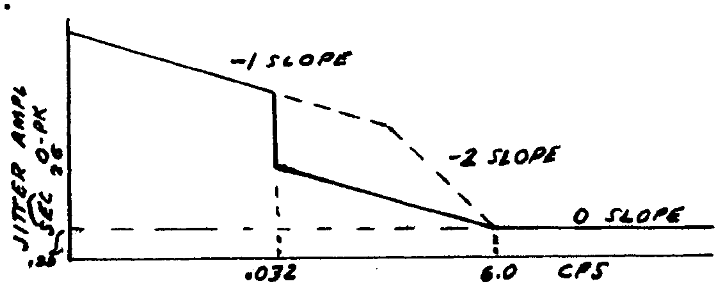


FIG. 1

2.3.2 GE to provide impact on system reliability program costs, weight and power by deleting the back-up capability, etc. Action to be completed by 4/19/68.

2.3.3 Propose changes to para. 3.1.2.1 (d&e) to CP 1000AI to consider effectiveness relative to target selection. GE will determine the reliability/effectiveness, determine what changes can be made (without redesign) to increase the number by considering:

A. Better estimates of component performance
B. On-orbit maintenance
C. Considering only mission critical items
D. Degraded modes of operation

Action to be completed by 5/6/68

2.3.4 AF/AS to consider revision of Para. 3.1.2.1 of CP 1000AI to reflect use of ATS operation.

2.3.5 Determine impact of extended door-open times on:

A. Scanner temperature gradient
B. Operational temperatures on roll & pitch gyros.

Action to be completed by 5/6/68

2.3.6 GE shall submit a recommended program to AF/AS over and above the AEDC plume test to define the contamination problem for the Alpha Subsystem. Action to be completed by 4-26-68

2.3.7 AF/AS to provide presently available definition of a pressurized gloved hand.

2.3.8 AF/AS to provide photographic procedure for processing 3404 type emulsion on base film to obtain spatial frequencies provided on a standard Air Force resolving target per MIL-STD 150A with 6:1 contrast ratio.

2.3.9 GE will review and refine the data proposed as to spectral reflection eye hazard potential to the crewman when using the ATS system. In particular 2% reflectance from water should be used in computing answers. Spectral cut-offs provided by the lens-coatings combination of the proposed systems should be included in the analyses. Action to be completed 4-26-68.

2.3.10 GE will review the cue pre-pass briefing procedure with the objective of:

A. Eliminating or simplifying the four-step procedure

B. Minimize power requirements

C. Minimize hardware impact and submit recommendation to AF/AS. Action to be completed 4-19-68.

2.3.11 GE will submit to AF/AS an interim report on the jitter test planned at Subcontractor A. Action to be completed 5-3-68.

2.3.12 GE to transmit to AF/AS the Advanced boresighting analysis, including definition of simultaneity required on VO & ATS buttons. Action to be completed by 5-13-68.

2.3.13 GE to submit updated set of Subcontractor A drawings to AS. Action to be completed by 4-19-68.

2.3.14 GE to prepare an analysis which will show the amount of focus adjustment required after insertion of a new film module. Action to be completed, 5-31-68 (Preliminary), 6-17-68 (Demonstration), 7-12-68 (Final).

2.3.15 GE to send TWX to AF/AS giving results of trade study incorporating Be in the film module and VDP. Action to be completed by 6-17-68.

2.3.16 GE will report to the Air Force the size (angular) of the peripheral display lights in the present Itek design. Action to be completed by 4-19-68.

3.0 <u>Discussion</u>

3.1 <u>Time and Place</u> - The meeting was held at Radnor, Pa., on March 6, 7 and 8, 1968.

3.2 <u>Attendees</u>

<u>General Electric</u>

J. McGuckin
W. T. Jones
W. Nicholini
R. J. Barchet
C. J. Galen
G. P. O'Brien
D. M. Smith
R. A. Englund
W. J. Manley
C. T. Boman
P. Feig
W. R. Guard
R. B. Phillips
L. D. Taylor
P. J. Ferrara
F. B. Woestemeyer
E. H. Ernst
G. Stocking
V. Reis
E. Siegrist
E. H. Reese
G. R. Christopher
F. Nistico
B. L. Bailey
L. Petkofsky
R. J. Boram
D. C. Marr
M. L. Peterson
D. Ungvarsky
W. Montgomery
M. A. Payonk
J. H. Frey
B. Bresnick
J. M. Denshaw
M. H. Peters
R. E. Roney
R. T. Kern

Aerospace	Air Force
D. E. Whelan	Maj. F. Neubeck
L. L. Thomas	Lt. Col. N. J. Farrell
H. L. Ferger	Lt. B. A. Knight
D. Nicholson	Maj. H. W. Hartsfield, Jr.
F. W. Belina	Maj. F. F. Doppelt
B. Siegel	
L. C. Lidstrom	
R. H. Leatherman	
J. E. Bennett	
W. C. Crooker	
W. P. Denson	
H. Apoian	
P. Dahl	
T. A. Hussman, Jr.	
D. Griep	
R. F. Gehrke	

3.3 Comments

3.3.1 GE states that the modulation at the film plane theoretically will not exceed 15% due to Newton's rings. LSI has assured GE that the solenoid can be adjusted such that the film gate pressure will not cause Newton Rings.

3.3.2 The thermal effects of firing the hi-thrustor for 1500 sec, for orbit adjust, was discussed. There is a minimal effect on peak shroud and insulation temperatures, however, the effect of degradation of the thermal control coatings due to thrustor exhaust products must be evaluated by tests.

3.3.3 GE will work with the Air Force to define a limited search mode which is consistant with the capability of the baseline design and mission objectives.

3.3.4 GE will continue to study need for relaxing decoupling requirement.

3.3.5 GE will submit a report on telemetry capability associated with the Acquisition Subsystem.

3.3.6 GE to review film qualification at 15 PSI with 100% oxygen for possible test relief.

3.3.7 TBD items in specification, i.e., off-axis performance, etc. must be completed prior to completion of PDR.

3.3.8 Prior to completion of PDR updated subcontractor specifications and film module specification shall be submitted to AF/AS.

/s/ J. McGuckin	/s/ N.J. Farrell L/Col.	/s/ D. E. Whelan
General Electric Co.	Air Force	Aerospace

The actions and comments contained in these minutes are certified to be a true copy of those recorded and signed in rough draft form at the PDR meeting.

W. T. Jones
W. T. Jones, Manager Design Review

ACQUISITION SUBSYSTEM

AGENDA

NO.	PDR AGENDA ITEM
1.0	REQUIREMENTS (Q#2,15,61,62)* SPDR CEI
2.0	INTERFACES
3.0	DESIGN CONCEPTS
3.1	Introduction - S/S Description
3.1.1	Functional Description (first level breakdown)
3.1.2	Power Tabulation (Q#57)*
3.1.3	Weight Tabulation
3.1.4	Critical Subsystem Analysis
3.1.4.1	Jitter Performance (Q#8)*
3.1.4.2	Slew Performance
3.1.4.3	Unbalance Effects (Q#59)*
3.2	Acquisition Optics Assembly
3.2.1	S/C A Action Items (Status/Resolution)
3.2.2	ATS Optics Analysis (Q52, 53, 20, 17, 4, 5, 18, 19, 21, 22)**
3.2.3	ATS Optics/Vibration Analysis (Q#12)*
3.2.4	ATS Controls Analysis (Q#26,27,28, 29,30,31)*
3.2.5	Bearings (Aft, Fwd, Cross-Roll)

3.2.6	ATS Thermal Analysis (Q#38, 39, 40)*
3.2.7	ATS Structure Analysis
	Weight (Q#43,55)*
3.2.8	Boresighting
3.2.9	ATS Error Analysis (Side Meeting) (Q#60)*
3.2.10	Image Derotation
3.2.11	Eye Hazards/Blanking (Q#33,34,35)*
3.3	VDP Action Items (Status/Resolution) (Q#6,14,63,64,65)*
3.3.1	Optical Analysis (Q#7,36,37)*
3.3.2	Film Module
3.4	Drive K Electronics
3.4.1	Requirements
3.4.2	Functional Description (2nd level)
3.4.2.1	Schematics/Block Diagrams
3.4.3	Weight and Power by Function (@#41,42)*
3.4.4	AF/AS Questions (#23,24,25,32,58)*
3.4.5	EMI Design (Q#10)*
3.4.6	Thermal Design
3.4.7	Interfaces
3.4.7.1	Command
3.4.7.2	Acquisition Optics
3.4.7.3	Mounting

3.5	Human Factors
3.5.1	General Approach (Restraints) (Q#51,66,49)*
3.5.2	Headrest
3.5.3	Consoles
3.5.3.1	D. Panel Layout
3.5.3.2	C Panel Layout
3.5.3.3	Film Module Storage
3.6	L. H. Control Stick (Questions Only)
3.7	Gyros (Q#9,11)*
3.8	Subsystem Consideration
3.8.1	Reliability/Safety
3.8.2	Maintainability
4.0	UNSOLVED AREAS
4.1	Inconsistency in Requirements
4.1.1	Proposed Changes (Q#54)*
4.2	Areas of High Risk
4.3	Problems and Recommended Solutions
4.4	Shroud Design (Q#44,45,46)*
5.0	DEVELOPMENT PLAN
5.1	Development Schedule

5.2 Mockups/Breadboards/Brassboards

5.3 Development Test Plan

*Refers to questions answered during the course of the presentation.

** Written answers to questions included in minutes.

AF/AS Questions Based Upon Pre-PDR Documentation Submittal

NOTE: All questions were answered satisfactorily during the course of the PDR presentations. AF/AS reviewed the questions during a caucus on the second day of the PDR and asked for additional information on several questions, which was provided. The point in the PDR where the submitted questions were answered is indicated on the agenda.

1. How does computer accept updating information?
2. Two minute accuracy with MCS corrections - is it independent of magnification?
3. What is the impact of incorporating the Alpha Numerics into the Acquisition Optics?
4. Page 2-76: They are questioning the correctness of the mathematics (706.5 - 708)
5. What the the effects on the adjustments on the r ticle of the Acquisition Optics?
6. GE to conduct a trade study to find the advantages and disadvantages of projecting the light through the film base.
7. Will placing the film against the prism cause Newtonian rings - How do we plan to avoid this problem?
8. Subcontractor A controls - explain. Customer desires a general discussion to determine if characteristics of encoders, torque motors, etc. are meeting GE error allocation.
9. In the Honeywell PDR package a statement is made: "Lab experiments show that this is the lowest noise configuration" - please explain. Aerospace considers this a very grandiose statement. Noise performance exceeds GE spec - please explain.
10. Drive A Electronics treated effects of EMI on performance - why was a similar discussion not included in Drive K Electronics, particularly with reference to jitter and smear.

11. In the Honeywell documentation the statement was made that the hold down clamp was torqued to 100 inch ounces. Is this an error? If correct, please discuss.

12. ATS Optics/Vibration Analyses - Aerospace considers there is a lot of work remaining to be accomplished -- discuss the future activities planned for this area (jitter test)

13. EAR report page 2-69/2-70: Please update our vignetting study and including obscuration.

14. Paragraph 1.2.5 - VDP - Frame retrieval time--GE states that we meet the frame retrieval time because we have numbered the frames consecutively. Can GE really meet the Spec? - Please discuss.

    GE Comment: Please make the point that we have gone to the octal system which permits us to number the frames consecutively. If the film supplier numbers the frames consecutively, GE will meet the Spec.

15. Is the first stick to go into the visual optics range the controlling stick? Is the right hand stick still controlled by the magnification stick when you are in the main optics?

16. Summarize human engineering studies, either simulations or analysis on peripheral display. For example, with FOVEA at center of eye-piece field of view, what must characteristics of peripheral display be in order to be "seen" by the peripheral visual sensors as functions of various variables (soon as scene brightness, brightness of peripheral display lights, size of peripheral display lights in angular subtense at the eye, color of peripheral display lights, etc.) How does preliminary design stack-up against such criteria?

17. What the focus characteristics of the peripheral display lights relative to the scene?

18. Are CE/SUB following up on these recommendations? (Para. 2.1.2.3, Re: Optical Design). When will results be known? (Tolerances on curvature Radii; triplet instead of doublet objective).

19. The results contained in table 21-3 indicate definite need for corrective action. Resolution provided is in some cases worse than using a window.

20. Comment: GE analysis makes some approximations which may not

be valid for this design. Conclusions and recommendations might be different if better model was used.

21. What about the field curvature-off-axes resolution trade-off?

    No consideration was given in EAR on tilting the decentering tolerances. What is effect on performance?

22. Discuss tests which will be used to verify optical performance of the flight hardware.

DIGITAL PROCESSOR:

23. What is the magnitude of the drift caused by integrating the least significant bit of the rate command at 19.5 KHz?

24. Does the least significant bit of the rate command in the digital processor correspond to the least significant bit of the rate c mmand that is generated by the software?

25. The number of bits that is required in view of the above does not seem compatible with the 16-bit(?) word that is transmitted from the computer to the digital processor.

JITTER DUE TO ENCODER BIT-TO-BIT ERROR:

26. What is the PSD from the bit-to-bit error on the 18-bit encoder as you now see it? How does this compare to the requirement given in the EAR?

27. Does the 19-bit encoder which has the same package size as the 18-bit encoder have one more natural bit, or does it extrapolate one more bit?

PSD Analysis:

28. Justify the "2" or lack of it for:

    (a) Your bearing PSD program
    (b) Honeywell's gyro PSD data
    (c) Your encoder noise analysis

29. Page 2-96 - How was low frequency of 0.9 RAD/SE cut-off for bearing noise obtained? The Bearing Model does not seem to be derived from the main drive model, what is the basis for the bearing model?

30. Pages 2-138 and 2-144 - Figure 2.2.25 does not appear to be the correct figure for data described on references pages. Please clarify.

31. Verify selection of brushless torquer.

32. Provide and discuss the mechanization of the D/A conversion in the digital processor.

SOLAR BLANKING SHUTTER

33. Can it be made to operate against specular reflections discussed in eye-hazards study?

34. Can it be made to operate when laser beam impinges? What will color characteristics of sensor be?

35. Where is shutter reset mechanism located? How long required to manually reset it?

VDP

36. No off-axis optical analysis provided.

37. Analysis does not include optical data length through film base. In previous discussions in which justification for projecting image through base, it was stated that this different optical path was accounted for in the analysis. The off-axis rays could be affected by this omission.

THERMAL ANALYSIS

38. Trade-offs provided in EAR are satisfactory. Would like to have preliminary thermal design for selected hardware, design, particularly for the equipment mounted externally from the LM.

39. What are results in terms of optical performance of the selected thermal design?

40. What thermal problem areas are still under study?

WEIGHT

41. Paragraph 1.2.7 and 4.4.1 - What is weight status of Drive K Electronics? How does it compare with weights negotiated in October?

42. In 4.4.1 there must be a TYPO. Drive K have always weighed more than 3.5 lbs.

43. Table 4.4.1 should be updated. Believe weight is closer to 330 lbs than to 375 lbs.

SHROUD DESIGN:

44. Would like discussion in detail of the new shroud design.

45. Is its design compatible with the vignetting analysis provided in the EAR? What are the vignetting characteristics?

46. What are out-gassing characteristics of fiber-glass shroud and what is impact on optical performance?

LAUNCH LOCKS:

47. Discuss launch-lock characteristics. Where used? Reliability, etc.?

ALIGNMENT

48. Discuss features permitting optical alignment of various elements and also alignment of the optical elements relative to the vehicle.

49. Can alignment to vehicle be accomplished without major disassembly such as separating LM & MM?

HUMAN FACTORS

50. Discuss use of ATS controls back-up as well as primary ones. Can controls be operated in pressurized suit?

51. Discuss means used to protect recon console optical components from damage that might be inflicted due to crew motions (e.g., ingress, egress, DPC loading ops, etc.)

SPECS:

52. What is status of your specs to subcontractors? is "A" Spec different than one included in Vol. I of the "A" PDR?

53. Discuss any changes which are currently under negotiation.

54. What are your recommended changes to Spec. data of ECP 17, particularly regarding elimination of the TBD's (TBR's etc.)?

WEIGHT

55. GE delete the weight allocation from Subcontractor A for cue insertion.

56. GE to provide drawing to AF/AS which identifies the location of the electrical penetration for the GE/sub A/DAC interface.

57. GE to present its position on Subcontractor A weight and power at PDR.

58. GE shall delete the requirement for the cue insertion function in Drive K. Space for the cue insertion function will be retained in Drive K.

CONTROLS

59. GE to present the results of its roll unbalance study at PDR.

60. GE to perform a study to define the maximum allowable Alpha Subsystem pointing error consistent with the operational requirements resulting from the normal target acquisitions, boresighting, and slaved-mode functions. Further, GE will determine the detail alignment error allocations (GE/sub A/DAC) required to satisfy the maximum allowable Alpha pointing error defined earlier in the study. Based on the results of the study, GE will submit an ECP to modify the AVE-CEI Specification.

61. GE to prepare an ECP to the AVE-CEI Specification clarifying the jitter pitch performance requirement. (Tracking rate of .01 in pitch).

62. GE to prepare an ECP to the AVE-CEI Specification relaxing the decoupling requirement from F 2^{o} to F 5^{o}.

VISUAL DISPLAY PROJECTOR

63. GE to prepare an analysis which will show the amount of focus adjustment required after insertion of a new film module.

64. GE to examine the desirability of placing indexing marks on the focus adjustment knob to permit pre-pass focus adjustments.

65. GE to conduct a trade study of impact of using Be in film module instead of Al.

66. GE to define method for handling film modules during pre-pass briefings and target passes.

REPORT OF OPTICAL SIDE MEETING - ALPHA SUBSYSTEM - 3/7/68

A meeting was held between D. Nicholson of Aerospace and A. C. Eckert and J. Denshaw of General Electric. The meeting centered on the degree of confidence that could be placed upon results obtained using computer programs in light of the limitations imposed by the mathematical techniques employed. It was agreed that the degree of confidence would be increased by further exchange of information.

Prior to this side meeting, during the regular PDR meeting, it was agreed that GE would deliver the results of ITEK's off-axis analysis as soon as this analysis is received from ITEK. GE also expressed a strong desire to receive the results of Aerospace's computer analysis (CDC 6600), based upon ITEK's prescription, as soon as it is available.

No action items resulted from the side meeting.

REPORT OF THERMAL SIDE MEETING

Attendees:

Harry Apoian
G. Karp

I. DOOR OPEN TIME LINE - Design Limits (Uses Target Profile)

a. Gyro shell 0° to 100°F Allowable Range Gyro fluid controlled to 160° ±5°F.

b. Scanning mirror temp. gradient is limit on optical performance. Folding mirror not so critical. Need definition of optical perf. degradation vs temperature gradient.

c. Temperature control with door position (penumbra cooling) will give only marginal benefits. Temperature control surface very closely follows sink temperature.

1. Low α/ϵ coating (.2/.9)

2. Low mass

3. Sun "Blip" limits D/O time to less than 45 mins.

4. Instrumentation & controls required to position door for cooling.

II. GYRO RELIABILITY - Not Known (Gene Ryan) (See Reliability Presentation)

Gyro heat pulse on backside of scanner will tend to reduce its temp. gradient, due to almost equal heat flux on both sides.

ITEK contractual spec is:

1. 25 mins/orbit, max.

2. 50/720 hrs (7% duty cycle 100 mins/D max)

3. Off-time max, 12 hrs (encoder may go to -20°F)

III. SHROUD POWER - 2.85 W ±.15 Wheel
12.5 ±1.3W, 26 V Fine heater
50 ±5W, 26 V Coarse Heater, Warm-up
? Torquers
? Encoders

IV. HI-THRUSTOR, 1500 Sec operation for orbit adjust.

1. Peak shroud and insulation temps. reach equilibrium in less than 5 mins.

800°F Shroud	Max at
175°F Insulation	Stag pt.

2. Thermal control coatings will withstand mix temps (being thermatrol investigated)

3. 600 sec firing temp gradient is less severe than on-orbit operation (8 consecutive orbits). Will investigate 1500 sec firing.

4. Degradation of coating due to contamination of ACTS firing not known. A comprehensive test and more suitable test time is necessary to resolve uncertainties.

V. OPTICAL PERF. DEGRADATION AS A FUNCTION OF TEMP. GRADIENT

1. ITEK currently evaluating optical system performance as effected by thermal and mechanical perturbances (due 1 May). Performance degradation caused by hot case under study, 25 mins door open. Effect on perf. due to temp. gradient only (D/O) not known and unknown if capability exists. (Elg. method unknown to ITEK)

VI. FAILURE MODE - OPEN DOOR CONDITIONS FAILURE ANALYSIS

ITEK currently studying effect of D/O failure, on optical system performance degradation. Due approx. 1 May.

SUBJECT: SIDE MEETING WITH AEROSPACE AT ALPHA PDR

ATTENDEES: M. PAVLICK - GE
J. BENNETT - Aerospace
W. CROOKER - Aerospace

PURPOSE OF MEETING

Review Itek drawings and discuss design evolution design criteria and discuss the effects of shell pressure distortions on the telescope and shear web.

DISCUSSION AND RESULTS

The Itek drawings of the telescope, scanner and fixed-fold mirror and the shroud were reviewed in detail. The design concepts were discussed along with their evolution. The design concepts behind the telescope restraints were discussed. It was shown by GE that, if the shear tie was not used in the present configuration, serious deflection and structural frequency problems would exists. It was also shown using very preliminary calculations, that when the shell is pressurized, the stresses induced into the telescope tube and the shear web would be minimal. It was also shown that the angular rotation of the telescope with respect to the penetration fitting would be approximately 1.34 arc sec. Copies of these calculations were transmitted to J. Bennett for his information. A discussion was also held on the shroud design and its evolution.

M. J. PAVLICK - GENERAL ELECTRIC

J. BENNETT - AEROSPACE

W. CROOKER - AEROSPACE

/wm

ACQUISITION SUBSYSTEM REQUIREMENTS

THIS PRESENTATION WILL,

(1) SUMMARIZE OBJECTIVES OF THE ACQUISITION SUBSYSTEM

(2) SUMMARIZE MAJOR REQUIREMENTS (SPDR & CEI)

(3) DISCUSS STATUS OF GE COMPLIANCE WITH THOSE REQUIREMENTS WHERE PARTICULAR PROBLEMS OR RISK EXIST

ACQUISITION SUBSYSTEM OBJECTIVES

INCREASE DORIAN SYSTEM EFFECTIVENESS BY MARRIAGE OF MAN AND SENSORS TO PERFORM THE FOLLOWING:

1. SELECTION OF OPTIMUM TARGETS FOR PHOTOGRAPHY BY,
   - WEATHER EVALUATION
   - TARGET ACTIVITY EVALUATION
2. OPTIMIZE PHOTOGRAPHIC RESOLUTION BY CENTERING TARGETS IN THE FORMAT VIA "POSITION UPDATE".
3. PERFORM RATE NULLING AND TARGET CENTERING FOR THE MAIN OPTICS IN THE EVENT OF IVS OR VISUAL OPTICS FAILURE.

ATS OBJECTIVES

- SUFFICIENT RESOLUTION TO ALLOW DETECTION OF ACTIVITY INDICATORS (<5 FT.)
- SUFFICIENT FOV TO MINIMIZE PROBABILITY OF MISSING TARGET BECAUSE OF EPHEMERIS, TARGET LOCATION & SYSTEM ERRORS. ($>0.5^0$)
- SCAN FIELD GREATER THAN THAT OF THE MAIN OPTICS ($\pm 40^0$ OBLIQUITY, $\pm 30^0$ STERO)
- ABILITY TO BACK-UP MAIN VISUAL OPTICS
- ABILITY TO VARY OBSERVED SCENE BRIGHTNESS

S.P.D.R. REQUIREMENTS

1) PROVIDE TWO ACQUISITION TELESCOPES WITH,

   - 3.6 FEET/L.P. RESOLUTION
   - 127 X $\pm$5X MAGNIFICATION MAX.
   - 16 X $\pm$1X MAGNIFICATION MIN.
   - 2 : 1 ZOOM CAPABILITY - HIGH AND LOW RANGE
   - 4^{o} MINIMUM F.O.V.

2) EACH CREW STATION WILL DISPLAY 1 ATS AND BE CAPABLE OF DISPLAYING THE VISUAL OPTICS IMAGE

3) MANUAL CONTROLLER INPUTS SHALL BE ACCEPTED FOR THE ATS AND M.O. FROM EACH CREW STATION

4) IT SHALL BE POSSIBLE TO SLAVE THE M.O. TO THE ATS L.O.S.

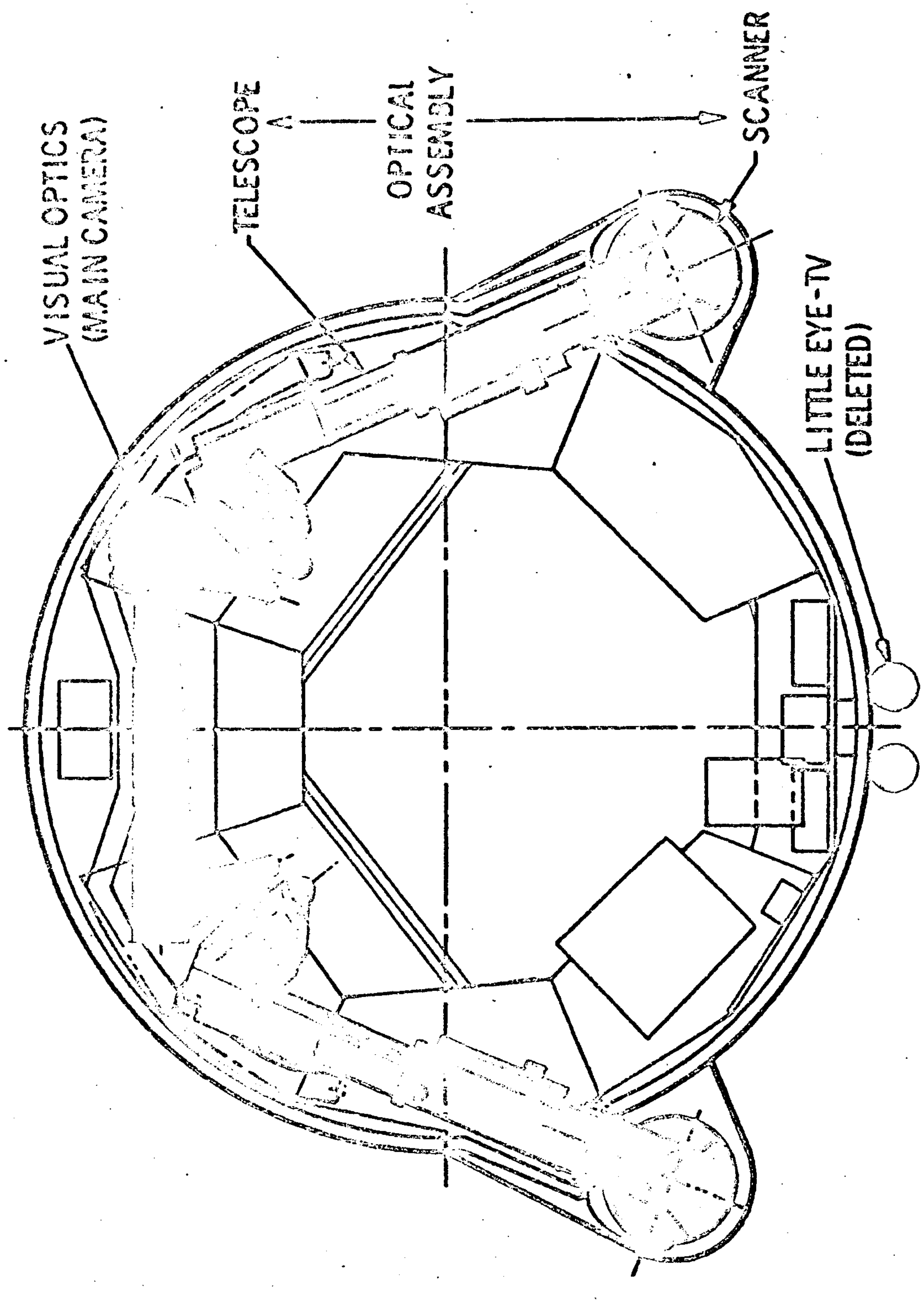
5) IT SHALL BE POSSIBLE TO AUTOMATICALLY CALL UP AND DISPLAY CUEING AIDS TO THE CREW

MAJOR ELEMENTS OF ACQUISITION SUBSYSTEM

ITEM	SOURCE
o ACQUISITION AND TRACKING SCOPES (2)	ITEK
. SCANNERS (2)	
. TELESCOPES (2)	
. WINDOWS (2)	
o GYROS	HONEYWELL
o SCANNER AND TELESCOPE CONTROL UNITS (2)	GE
o MAGNIFICATION CONTROL STICKS (2)	GE
o VISUAL (CUE) DISPLAY PROJECTORS (2)	LEAR-SIEGLER

ATS OPTICAL REQUIREMENTS

RESOLUTION:	3.3 FEET "STATIC" AT 80 NM AND 2 : 1 CONTRAST RATIO (HIGH POWER)
MAGNIFICATION:	16 ±1X TO 32 X, 63.5 X TO 127 X +5, - 3 X
FIELD OF VIEW:	4 DEGREES AT 16 X 1 DEGREE AT 63.5 X
SCAN FIELD:	+70° TO -40° IN PITCH +45° TO -45° IN ROLL
VIGNETTING:	NONE FROM +10° TO +40° PITCH +35° TO -35° ROLL LESS THAN 60% EVERYWHERE IN THE SCAN FIELD
PERIPHERAL DISPLAY:	TIME COUNTDOWN AND REFERENCE, TARGET INFORMATION, ETC.
RETICLE:	CIRCLE INDICATING HIGH ZOOM F.O.V. - CROSS HAIRS
EYE RELIEF:	0.40" MIN, (0.7")
FILTERS:	FOUR - UNDEFINED


VISUAL OPTICS
(MAIN CAMERA)
TELESCOPE
OPTICAL
ASSEMBLY
SCANNER
LITTLE EYE-TV
(DELETED)

ATS CONTROLS REQUIREMENTS

1. POINTING ACCURACY (AUTO) - 8 MINUTES AFTER BORESIGHTING

2. POINTING ACCURACY (CREW/MCS) - 2 MINUTES

3. TRACKING RATE ACCURACY 540 RAD/SEC.

4. L.O.S. FILTER - 1/4 ARC SECOND 2σ

5. IMAGE ORIENTATION - $\pm 5^{\circ}$ AT END OF SLEW

6. RECOUPLING - $\pm 2^{\circ}$

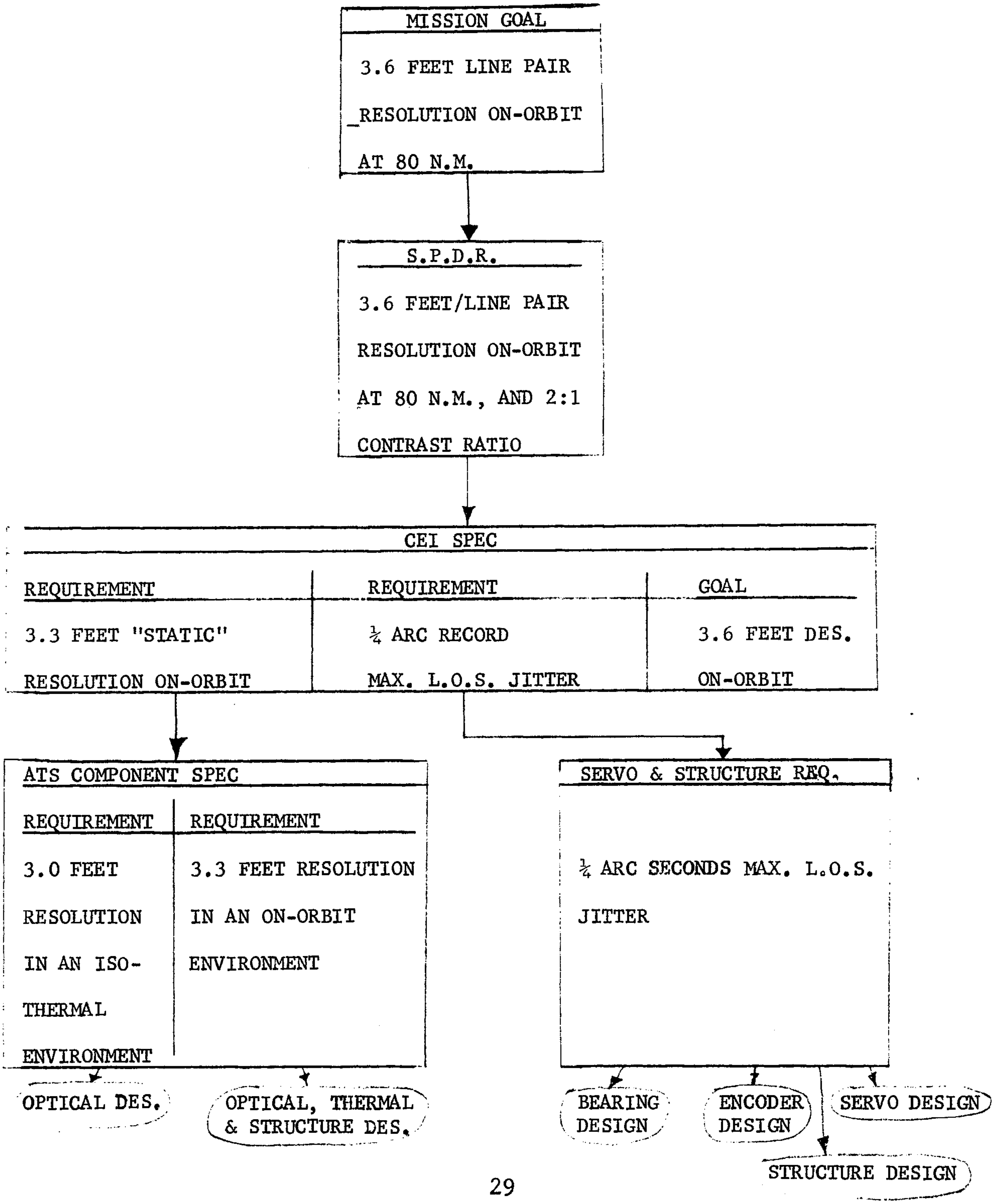
7. SLAVE RATE ACCURACY - $100\,\mu$ RAD/SEC.

8. BLANKING - PREVENT SOLAR VIEWING

9. BORESIGHTING - PROVIDE ON ORBIT ALIGNMENT CORRECTIONS

10. ZOOM RESPONSE - 0.5 SECONDS END TO END

RESOLUTION & JITTER



ATS RESOLUTION

REQUIREMENT: THE STATIC HIGH POWER RESOLUTION OF THE ATS AT 80 NM ALTITUDE SHALL BE 3.3 FEET/LINE PAIR OR LESS, ON AXIS, WHEN THE CONTRAST RATIO IS 2.1.

PROPOSED CEI CHANGES: EXCLUDE EFFECTS OF CONTAMINATION FROM SOURCES OTHER THAN GE EQUIPMENT.

RESULTS OF ANALYSIS TO RATE:

1) ALL GE ANALYSIS, WHICH TREATED LESS THAN WORST CASE ERROR BUILDUPS, YIELDED RESOLUTION OF 3.3 FEET OR LESS.
2) ALL ITEK ANALYSIS SUBMITTED TO DATE INDICATES THAT 3.3 FEET RESOLUTION IS ACHIEVABLE, BUT THAT A TIGHT TOLERENCE BUDGET IS NECESSARY.
3) GE ANALYSIS WITH A WORST CASE TOLERENCE BUILDUP YIELDED A RESOLUTION OF 3.4 FEET.

COMMENTS:

1) ANALYSIS IS BASED ON THE "SCHADE" VISUAL THRESHOLD CURVE. THIS CURVE HAS NOT BEEN VERIFIED EXPERIMENTALLY. THE USE OF THE "LOWRY-DE PALMA" CURVE WOULD YIELD BETTER RESULTS.
2) ANALYTICAL RESULTS ARE APPROXIMATE! THE RESULTS ARE A FUNCTION OF THE NUMBER OF RAYS TRACED, NUMBER OF COLORS CONSIDERED, AND OTHER FACTORS RELATING TO THE ANALYTICAL TECHNIQUES EMPLOYED.
3) ANALYSIS DOES NOT PROVIDE FOR RESOLUTION DEGRADATION DUE TO CONTAMINATION OF THE OPTICAL SURFACES. INHIBITS FOR WASTE MANAGEMENT, MOLECULAR SIEVE, AND FUEL CELL WATER ARE NOT

PRESENTLY PROVIDED.

4) THERMALLY INDUCED RESOLUTION DEGRADATION IS DIFFICULT TO ANALYZE. THE MAINTAINANCE THERMAL EFFECTS OR THE EXTERNAL MIRRORS ARE EXPECTED TO BE PARTICULARLY CRITICAL.

5) THE FOLLOWING DUTY CYCLY IS ASSUMED IN THE DESIGN

   a) MAX. OPEN TIME PER ORBIT IS 25 MINUTES

   b) MAX. OPEN TIME PER DAY IS 120 MINUTES

   c) SHROUD DOOR OPEN 50 HOURS PER MISSION

OFF AXIS RESOLUTION

REQUIREMENTS:

A. WITHIN 10 DEGREES OF THE CENTER OF THE APPARENT F.O.V. THE RESOLUTION SHALL BE TBD.

B. AT THE EDGE OF THE F.O.V. THE RESOLUTION SHALL BE TBD.

POSSIBLE CEI CHANGES:

INCLUDE THIS INFORMATION IN SECTION 6.

PROBLEM:

ANALYTIC PREDICTION OF OFF-AXIS PERFORMANCE IS DIFFICULT DUE TO ASTIGMATIC EFFECTS.

POSSIBLE SOLUTIONS:

A. PUT PREDICTED PERFORMANCE IN SECTION 6 AS INFORMATION.

B. USE SUBCONTRACTOR DATA TO FILL IN THE TBD'S IN SECTION 3, WITH SUFFICIENT MARGINS.

TIME REQUIRED TO ACHIEVE 3.3 FEET RESOLUTION ON-ORBIT

REQUIREMENT:

A. NO REQUIREMENT EXISTS CONCERNING THE TIME ON ORBIT WHEN THE SYSTEM MUST BE OPERATING IN SPEC.

B. D.A.C. LIMITS SEAL LEAKAGE TO 100 cc/LINEAR INCH FOR BOTH WINDOW AND OBJECTIVE LENS.

PROBLEM:

THE SPACE BETWEEN THE ATS OBJECTIVE LENS AND THE TELESCOPE MUST BE VENTED TO ANALYZE PRESSURE ACROSS THE LENS BEFORE FULL RESOLUTION CAN BE ACHIEVED.

POSSIBLE SOLUTIONS:

A. OBTAIN CUSTOMER OR D.A.C. O.K. TO PROVIDE CONTINUOUS 600 cc/LINEAR INCH LEAK.

B. PROVIDE VALVE WHICH WOULD BE CLOSED IN THE EVENT OF WINDOW FAILURE.

DYNAMIC RESOLUTION

CEI DESIGN GOAL - THE ATS WILL RESOLVE 3.6 FEET BAR PAIRS FROM 80 N.M. ALTITUDE WHEN THE CONTRAST RATIO IS 2:1.

COMMENTS:

1. INDEPENDENT GE AND ITEK ANALYSIS HAS SHOWN THAT THE GOAL WILL BE MET WHEN MONOTONIC L.O.S JITTER DOES NOT EXCEED ¼ ARC RECORD HALF-AMPLITUDE.

2. A "JITTER TEST" IS BEING SET UP AT ITEK TO EXPERIMENTALLY VERIFY THE ANALYTIC PREDICTIONS OF RESOLUTION IN THE PRESENCE OF MONOTONIC JITTER, AND TO DETERMINE THE VISUAL THRESHOLD.

3. ACTUAL SYSTEM L.O.S. JITTER WILL BE RANDOM, NOT MONOTONIC!
   EFFECT OF RANDOM JITTER NOT DETERMINED BY ANALYSIS OR EXPERIMENT

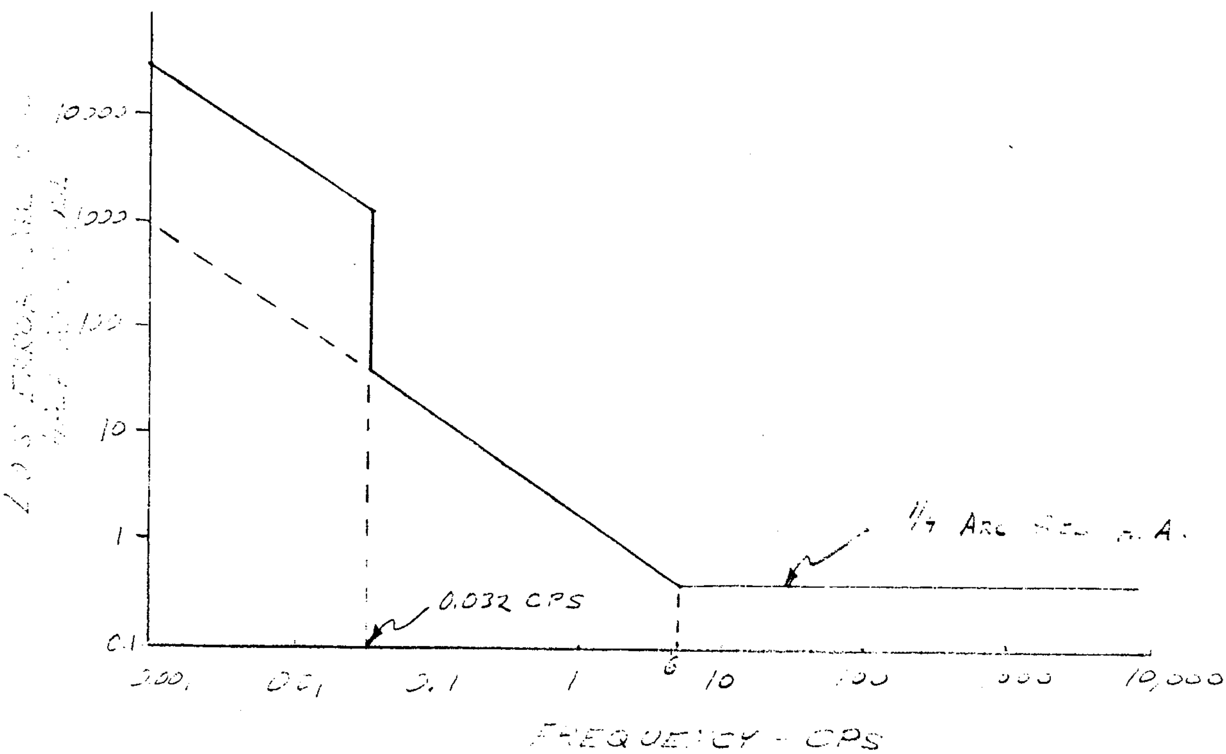
L.O.S JITTER

REQUIREMENT: IN AUTOMATIC OPERATION, COMBINED DRIFT AND JITTER ERROR SHALL BE LESS THAN SHOWN IN FIG. 1, EXCLUSIVE OF;

A) EFFECTS OF OV RATES DUE TO NON-GE EQUIPMENT

B) EFFECTS OF ATS GIMBAL RATES BELOW 0.01 DEG./SEC.

PROPOSED CEI CHANGE: NONE AT PRESENT



JITTER PERFORMANCE (CONT)

PROBLEM: AVAILABLE ENCODER NOISE DATA INDICATES THAT A 19 OR 20 BIT ENCODER IS REQUIRED WITH PRESENT "RATE PLUS POSITION DESIGN". PRESENT DESIGN INCLUDES 18 BIT ENCODER. SPACE NOT AVAILABLE FOR 20 BIT ENCODER.

POSSIBLE SOLUTIONS

A) DESIGN PITCH LOOP AS A PURE RATE LOOP.

B) PROVIDE 19 OR 20 BIT ENCODER

C) CHANGE CEI SPEC TO APPLY THE JITTER REQUIREMENT ONLY TO A LIMITED PORTION OF THE SCAN FIELD

PROBLEM: THE "POSITION PLUS RATE" PITCH LOOP WILL NOT PERMIT TRACKING WITHIN SPEC TO 0.01°/SEC EVEN WITH THE 20 BIT ENCODER.

POSSIBLE SOLUTION:

A) CHANGE CEI SPEC.

B) CHANGE DESIGN TO A PURE RATE LOOP.

JITTER REQUIREMENT (CONT)

PROBLEM: A DYNAMIC MODEL IS NOT YET AVAILABLE TO PERMIT THE CONTRIBUTION OF THE STRUCTURE TO JITTER TO BE EVALUATED.

SOLUTION: A DYNAMIC MODEL IS BEING DEVELOPED TO PERMIT EVALUATION OF STRUCTURALLY INDUCED L.O.S. JITTER.

VIGNETTING

REQUIREMENT: THERE SHALL BE NO VIGNETTING BETWEEN $+10^{0}$ AND $+40^{o}$ IN PITCH AND BETWEEN $\pm 35^{o}$ IN ROLL (REF. TO VEHICLE CO-ORDINATES). VIGNETTING SHALL NOT EXCEED 60% ANYWHERE IN THE SCAN FIELD.

PROPOSED CEI CHANGE: T.B.D.

PROBLEM: PRESENT DESIGN YIELDS AS HIGH AS 80% VIGNETTING (AT 70^{o} FORWARD AND 45^{o} OUTBOARD). VIGNETTING DOES NOT EXCEED 60% AT PITCH ANGLES BELOW +60 DEGREES.

PROPOSED SOLUTION: REVISE CEI SPECIFICATION

POINTING ACCURACY

REQUIREMENTS: AFTER ON-ORBIT BORESIGHTING THE ATS SHALL BE POINTED TO THE TARGET TO WITHIN ± 8 ARC MINUTES, TWO SIGMA, NEGLECTING ERRORS DUE TO EPHEMERIS AND TARGET LOCATION INFORMATION, AND ASSUMING O.V. STRUCTURAL DEFORMATION DOES NOT CONTRIBUTE MORE THAN 0.5 MIN. L.O.S. ERROR.

PROPOSED CEI CHANGES:

1. EXCLUDE EFFECTS OF VISUAL OPTICS MISALIGNMENTS WHICH EXCEED TBD MINUTES OF ARC.
2. CHANGE PERMISSABLE POINTING ERROR FROM 8 TO 10 MINUTES.

STATUS: THE E.A.R. CONTAINS AN ERROR ANALYSIS WHICH DEMONSTRATES COMPLIANCE WITH THIS REQUIREMENT IF:

a) DEFLECTIONS OF THE D.A.C. STRUCTURE AFTER BORESIGHTING DO NOT CAUSE MORE THAN 0.5 ARC MINUTES OF L.O.S. POINTING ERROR AS STATED IN THE GE, CEI SPEC.

b) THE RELATIVE ALIGNMENT ERRORS, ON-ORBIT BEFORE BORESIGHTING, BETWEEN THE SEVERAL ATS COMPONENTS, AND BETWEEN CERTAIN MAIN OPTICS COMPONENTS, DO NOT EXCEED THE VALUES ASSUMED IN THE ANALYSIS.

PROBLEMS:

1) POST BORESIGHTING POINTING ACCURACY IS A FUNCTION PRE-BORESIGHTING ERRORS DUE TO GROUND ALIGNMENT TOLERANCES, L.M. PRESSURIZATION, "L-G" RELIEF, ETC. LM PRESSURIZATION IS EXPECTED TO INTRODUCE SIGNIFICANT ERROR.

2) D.A.C. HAS NOT AND IS NOT EXPECTED TO ACCEPT INTERFACE SPEC. LIMITATIONS FOR ON-ORBIT ALIGNMENT ERRORS WHICH ARE CONSISTANT WITH THOSE ASSUMED IN THE ANALYSIS.

3) IT IS BELIEVED THAT THE D.A.C. STRUCTURE MAY CAUSE MORE THAN 0.5 ARC MINUTES OF L.O.S. ERROR DUE TO DEFLECTIONS AFTER BORESIGHTING. (GE IS PROTECTED IN THE CEI AGAINST THIS EVENTUALITY.)

4) GE DOES NOT HAVE AN INTERFACE SPEC. GUARANTEE OF THE ALIGNMENT OF THE VISUAL OPTICS.

<u>POSSIBLE SOLUTION</u>:

A. INCREASE THE COMPLEXITY OF THE BORESIGHT ROUTINE TO PERMIT REMOVAL OF ALIGNMENT ERRORS BETWEEN THE FOLDING MIRROR AND THE SCANNER.

B. USE D.A.C. ANALYTICAL PREDICTIONS OF STRUCTURAL DEFECTIONS TO DETERMINE ON-ORBIT COMPONENT ALIGNMENT.

C. MOUNT THE SCANNER AND THE HOLDING MIRROR TO A CONNECTING STRUCTURAL ELEMENT RATHER THAN DIRECTLY TO THE PRESSURE SHELL.

<u>STATUS:</u>

A. EXPANDED BORESIGHT ROUTINE EQUATIONS WRITTEN AND EVALUATED. MATHEMATICAL FEASABILITY HAS BEEN DEMONSTRATED. COMPATABILITY WITH SOFTWARE CAPACITY IS BEING EVALUATED.

B. D.A.C. HAS BEEN REQUESTED TO RE-EVALUATE THE POSSIBILITY OF ALIGNING THE ATS HARDWARE ON A PRESSURIZED L.M.

TRACKING RATE

REQUIREMENT: AT THE END OF SLEW THE L.O.S. RATE ERROR SHALL BE LESS THAN 540 μ RAD/SEC.

POSSIBLE PROBLEM AREA: POSITION ERRORS BEFORE BORESIGHTING WILL INTRODUCE RATE ERRORS WHICH ARE NOT PRESENTLY CONTAINED IN THE ERROR ANALYSIS RELATIVE TO 540 μ RAD/SEC.

SOLAR BLANKING

REQUIREMENT: AUTOMATIC BLANKING PROVISION SHALL BE INCORPORATED TO PREVENT CREW INJURY RESULTING FROM INADVERTANT SUN VIEWING THROUGH THE ATS.

PROPOSED CEI CHANGE: "THE CONTRACTOR SHALL NOT BE RESPONSIBLE FOR EYE DAMAGE RESULTING FROM CAUSES OTHER THAN DIRECT VIEWING OF THE SUN."

THERMAL

PROPOSED NEW CEI PROVISION: INCORPORATE D.A.C. SUPPLIED THRUSTER PLUME CHARACTERISTICS WITH CEI SPEC. VS DESIGN BASELINE.

REASON: SHROUD THERMAL DESIGN DEPENDANT ON THIS INFORMATION.

POSSIBLE PROBLEM AREA: THE EFFECTS OF CONTAMINATION FROM WASTE MANAGEMENT, THRUSTERS, ETC., ON THERMAL COATINGS HAS NOT BEEN DETERMINED.

MANUAL CONTROL STICK CONTROL

OF THE MAIN OPTICS

QUESTION: IS THE FIRST STICK TO GO INTO THE VISUAL OPTICS RANGE THE CONTROLLING STICK? IS THE RIGHT HAND STICK STILL CONTROLLED BY THE MAGNIFICATION STICK WHEN IN THE MAIN OPTICS RANGE?

1. THE DECISION AS TO WHICH, IF EITHER OF THE TWO MC'S CAN CONTROL THE MAIN OPTICS IS A FUNCTION OF;

   A) THE STATUS OF THE LEFT-RIGHT-AUTO SWITCH.

   B) THE STATUS OF THE IVS, MANUAL-IVS SWITCH.

   C) THE RANGE OF EACH MAGNIFICATION CONTROL STICK.

   D) WHICH OF THE TWO ATS'S WAS ASSIGNED THE TARGET FOR OBSERVATION?

2. WHEN OPERATING IN THE AUTO MODE, ONLY THE CREW STATION WHICH WAS ASSIGNED THE TARGET FOR OBSERVATION CAN CONTROL THE MAIN OPTICS WITH THE MCS, AND THEN ONLY WHEN

   A) THE IVS IS IN THE MANUAL POSITION

   B) THE MAGNIFICATION STICK IS IN THE MAIN OPTICS RANGE.

3. WHEN THE SWITCH IS IN THE LEFT (OR RIGHT) POSITION THE CREW MEMBER AT THE LEFT (OR RIGHT) CONSOLE CAN GET CONTROL OF THE M.O. IF:

   A) THE IVS IS OFF

   B) THE MAGNIFICATION STICK IS IN THE M.O. RANGE

VISUAL OPTICS AVAILABILITY AT A CREW STATION

THE VISUAL OPTICS WILL BE AVAILABLE AT A CREW STATION WHENEVER

A) THE LEFT - RIGHT -AUTO SWITCH IS IN THE AUTO POSITION AND THE M.O. TARGET WAS ASSIGNED TO THAT CREW STATION OR,

B) THE LEFT - RIGHT - AUTO SWITCH IS IN POSITION REPRESENTATIVE OF THAT CREW STATION.

CUE SYSTEM OBJECTIVES AND OPERATIONAL FEATURES

GENERAL: AID CREW IN LOCATING TARGETS AND RECOGNIZING ACTIVITY

PRE - PASS:

- PROVIDE HIGH RESOLUTION SCENES FOR STUDY
- CUES CALLED UP BY COMPUTER COMMANDS, IN ORDER, WHEN REQUESTED VIA THE KEYBOARD
- STUDY TIME IS REGULATED BY CREW
- ALPHA-NUMERIC DISPLAYED WITH EACH CUE

ON-TARGET

- PROVIDE MEDIUM RESOLUTION CUES WITH SUFFICIENT F.O.V. TO INCLUDE "LANDMARK" AIDS FOR TARGET LOCATION
- CUES CALLED UP AUTOMATICALLY WITHOUT CREW COMMANDS
- CUE DWELL TIME CONTROLLED BY COMPUTER (2 SEC.) CREW CAN OVERRIDE
- ALPHA-NUMERIC DISPLAYED WITH EACH CUE
- TWO MODULE INTERCHANGES CAN BE MADE DURING PASS, EACH WITHIN 10 SECONDS

CUE PROJECTOR REQUIREMENTS

RESOLUTION:	-	228 LINE PAIRS/MM ON FILM FOR 6 : 1 CONTRAST RATIO
SCREEN SIZE:	-	6.5 INCHES
SCREEN BRIGHTNESS:	-	0 - 15 FOOT LAMBERTS
CUE RETRIEVAL:	-	0.45 SECONDS + /100 SEC.
MANUAL FRAME SELECT:	-	OCTAL FORMAT
MODULE STORAGE:	-	16 MODULES (8 EACH)
ALPHA NUMERIC RETRIEVAL:	-	0.3 SEC.

MISSION OBJECTIVE

AID IN IDENTIFYING AND
LOCATING TARGETS AND
ACTIVITY INDICATORS

SPDR

CUE SYSTEM
OPEN LOOP COMMANDS TO CUE SYSTEM
FOR AUTO. PRESENTATION OF CUES.

CEI

CUE SYSTEM
PROVIDE FOR:(@ EACH RECON CONSOLE)
AO DISPLAY
CUE DISPLAY
CONTROLS
PROVIDE 6 CHARACTER α-N
CUE PROJECTOR SHALL:
DISPLAY 0.5" FILM ON 6.5" DIA. SCREEN.
MTF @ 1 LP/MM ≥ 0.83

FILM MODULES
STORAGE FOR 16 FILM MODULES.
VDP PRESENT UP TO 4094 SEPERATE
CUE FRAMES/MODULE
FILM MODULE EXCH ≤ 10 SECS DURING TGT PASS

RESOLUTION
CUE RESOLUTION W/6:1 CONT. RATIO TARGET.
NEAR CENTER OF SCREEN 228 LP/MM
NEAR EDGE OF SCREEN 204.5 LP/MM
CUE SCREEN BRIGHTNESS (VARIABLE)
NEAR CENTER OF SCREEN 0 TO 15 FT LAMBERT
NEAR EDGE OF SCREEN ≥ 1/2 @ CENTER

CUES
DISPLAY WITHIN $[0.45+\frac{N}{100}]$ SEC AFTER
RELEASE OF PREVIOUS CUE.
VDP SATISFY REQM'TS WITH 6:1 CONTRAST
RATIO IDENT. CODE ON GFE FILM
DISPLAY CUE FOR K_2 SECS.
RELEASE CUES WHEN TGT BUTTON IS ACTUATED
HOLD CUES WHILE "HOLD" BUTTON IS DEPRESSED
PROVIDE CONTROL FOR DISPLAY AUTO. DURING PREPASS
PROVIDE CONTROL FOR CUE CALLUP W/O COMPUTER
PROCESSING

α-N
DISPLAY WITHIN 0.3 SEC. AFTER START OF SLEW.
DISPLAY AT SAME TIME SCREEN CUES
ARE PROJECTED.
RELEASE WHEN TGT BUTTON IS ACTUATED

FILM MODULE INTERCHANGE DURING TARGET PASS

REQUIREMENT: THE CREW STATION SHALL BE DESIGNED SUCH THAT A VDP FILM MODULE CAN BE INTERCHANGED DURING A TARGET PASS WITHIN 10 SECONDS.

COMMENT: PRESENT DESIGN WILL PERMIT TWO MODULES TO BE STORED AT EACH CREW STATION TO PERMIT THIS REQUIREMENT TO BE MET. WILL MORE THAN TWO MODULE CHANGES BE REQUIRED DURING A PASS?

VDP USER FILM

PROPOSED NEW CEI PROVISION: TEST FILM FOR MEASURING VDP RESOLUTION SHALL BE SUPPLIED BY THE GOVERNMENT.

REASON:

1. TO PREVENT THE SUBCONTRACTOR FROM DUPLICATING FILM DEVELOPMENT PROGRAMS UNDERTAKEN BY THE AIRFORCE. HAS NOT FOUND A VENDOR TO SUPPLY 228 LINE PAIR/MM ON 1304 FILM.
2. TO INSURE COMMONALITY BETWEEN THE USER AND TEST FILMS.

INTERFACE STATUS
ACQUISITION OPTICS/LAB MODULE

1. DOCUMENTATION
2. AGREEMENTS ON INTERFACE REQUIREMENTS
3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025
4. INTERFACE PROBLEM NOT DOCUMENTED.

1. DOCUMENTATION

- ICN-025 TO IFS-MOL-707003, LAB MODULE TO GE-AVE
- ICD-MOL-707001, SHEET 11, MECHANICAL INTERFACE DRAWING
- ICD-MOL-707022, EQUIPMENT SPACE ALLOCATION
- ICD-MOL-707031, ACCESS SPACE ALLOCATION.

2. INTERFACES ON WHICH AGREEMENT EXISTS
IFS-MOL-707003, ICN-025

REQUIREMENT	PARAGRAPH	COMMENTS
NOMENCLATURE IDENTIFICATION	1.1.2.C	
ELECTRICAL CON. PENETRATION	3.1.1.4.4	SENTENCE DEFINING NUMBER AND GENERAL LOCATION OF CONNECTORS WILL BE ADDED TO IFS. DETAILS OF SIZE, CLOCKING, INDEXING WILL BE SHOWN ON MECHANICAL AND ELECTRICAL ICD.
TELESCOPE INSTALLATION	3.1.1.4.6	BASIC REQUIREMENTS ONLY. DETAILS WILL BE ON ICD-MOL-707001, SHEET 11
FIXED FOLD ASS'Y INSTALLATION	3.1.1.4.5	
PROTECTIVE SHROUD INSTALLATION	3.1.1.4.10	

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
DESIGN LOADS INDUCED AT STRUCTURAL INTERFACE	3.1.1.1.2	1. DAC WILL PROVIDE DATA BASED ON FOURTH-CYCLE LOAD ON 15 OCT. 1968. 2. GE WILL RESPOND WITH COMPONENT DATA ON 21 NOV. 1968.
MOUNTING POINT STIFFNESS COEFFICIENTS	3.1.1.1.3	1. GE GENERATED STIFFNESS MATRIX BASED ON AVAILABLE STRUCTURE DATA INCLUDED IN ICN-025 AND IS BEING USED AS DESIGN BASELINE. 2. DAC WILL PROVIDE STIFFNESS MATRIX ON 31 JULY 1968 (PER A/I # 5-311) FOR ZERO PSI ONLY. GE REQUIRES DATA AT 0 AND 5 PSI.

3. INTERFACES COVERED IN IFS -MOL -707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
PRESSURE SHELL DEFLECTION ON ORBIT	3.1.1.1.4	1. ONE OF THREE CONDITIONS OF AO POINTING ERROR IS THAT LM SHELL DEFLECTION DOES NOT CAUSE LOS DEFLECTION OF MORE THAN 0.5 ARC MIN. 2. DAC TO ANALYZE RELATIVE MOTION OF AO MOUNTING POINTS DUE TO PRESSURE/TEMPERATURE CHANGES PER A/I # 5-315; DUE: AUGUST 1968

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENTS	PARAGRAPH	STATUS/COMMENT
RELATIVE MOTION OF LM PRESSURE SHELL AND RADIATOR	3.1.1.1.5	1. PROTECTIVE SHROUD IS MOUNTED TO RADIATOR; SCANNER AND FFA ARE MOUNTED TO PRESSURE SHELL REQUIRE ADEQUATE CLEARANCE 2. DAC IS RE-EVALUATING LONGITUDINAL MOTION; MAY INCREASE FROM .375 TO .625 IN. ANSWER DUE 27 FEB. 1968

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ALIGNMENT	3.1.1.2.2	1. GE WILL REDEFINE COORDINATE SYSTEM AND MEASUREMENT REQUIREMENTS FOR COORDINATE SYSTEM DUE 15 MARCH '68 2. DAC TO DETERMINE WHETHER CALIF. BOILER LAWS PERTAINING TO PRESSURIZED VESSELS CAN BE WAIVERED TO ALLOW ALIGNMENT WITH LM PRESSURIZED TO 5.0 PSIG 3. ADJUSTMENT FEATURE REQUIRED FOR SCANNER MOUNTING BASE (ON EITHER GE OR DAC SIDE OF INTERFACE). GE AND DAC NOW STUDYING; TO BE WORKED

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ALIGNMENT (CONT.)	3.1.1.2.2 (CONT.)	3. (CONT.) AT MARCH 1968 TEM. 4. DAC TO ANALYZE RELATIVE MOTION OF AO MOUNTING POINTS FOR PRESSURE BIAS, ZERO G RELIEF AS PART OF A/I #5-315; DUE: AUGUST 1968.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ACCESS TO TELESCOPE	3.1.1.3.9	1. INSTALLATION ACCESS TO BE DEFINED ON ICD-MOL-707031 2. GE REQUIRES MAINTENANCE ACCESS AND ON-ORBIT ACCESS. DEFINITION.
WINDOW MOUNTING	3.1.1.4.7	1. WINDOW MOUNTING IS CRITICAL DUE TO POSSIBILITY OF DISTORTION CAUSED BY UNEQUAL STRESSES OR THERMAL GRADIENTS. 2. GE WILL DETERMINE "CLAMPING FORCES" SPECIFICATION BASED ON A MECHANICAL REQUIREMENT: DUE 15 MAY '68 PER A/I # 4-467.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
WINDOW MOUNTING (CONT.)	3.1.1.4.7 (CONT.)	3. (CONT.) MAY REQUIRE PENETRATION FITTING EXCHANGE HARDWARE OR DEVELOPMENT FIXTURE TO MAKE OPTICAL TESTS AT 5.0 PSI TO EVALUATE DISTORTION ON WINDOW IN DAC DESIGNED MOUNT.

SECRET SPECIAL HANDLING

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENTS	PARAGRAPH	STATUS/COMMENT
SCANNER MOUNTING	3.1.1.4.9	1. SCANNER MOUNTING APPROACH IS BEING RE-EVALUATED FOR ALIGNMENT REQUIREMENTS. 2. TEM SCHEDULED FOR MID-MARCH; GE AND DAC TO INVESTIGATE POSSIBLE ALTERNATIVES BETWEEN NOW AND TEM.
PENETRATION FITTING THERMAL CONTROL	3.1.3.1.1.3	1. PERIPHERAL GRADIENT OF WINDOW MOUNTED IN PENETRATION FITTING MUST BE HELD WITHIN $\pm$ 1^{o}F OF A NOMINAL TEMPERATURE. 2. PENETRATION FITTING TO BE THERMALLY INSULATED FROM RADIATOR TO MINIMIZE THERMAL EFFECTS ON TELESCOPE.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
PENETRATION FITTING THERMAL CONTROL (CONT.)	3.1.3.1.1.3 (CONT.)	3.PENETRATION FITTING EXTENSION SURFACE TO BE TREATED TO MINIMIZE GRADIENTS ON WINDOW AND FIXED FOLD ASSY. 4.RESOLUTION DEPENDENT ON DAC/GE INTEGRATED THERMAL MODEL. DUE DATE FOR DAC ANALYSIS: 6 MAY 1968.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
BAYS 3 AND 7 THERMAL CONTROL	3.1.3.1.1.4	1. HEAT SOURCES OR SINKS IN VICINITY OF TELESCOPE HOUSING TO BE TREATED AS REQUIRED (INSULATION, BARRIERS, SURFACE TREATMENT) TO LIMIT TEMPERATURE GRADIENTS ON TELESCOPE. 2. RESOLUTION DEPENDENT ON DAC/GE INTEGRATED THERMAL MODEL. DUE DATE FOR DAC ANALYSIS: 6 MAY 1968

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
SCANNER ASSY THERMAL CONTROL	3.1.3.1.1.5	1. THERMAL CONDUCTIVITY BETWEEN SCANNER AND LM PRESSURE SHELL TO BE LIMITED TO PRECLUDE COLD SPOTS ON LM SHELL INTERIOR (AND RESULTANT CONDENSATION). 2. DAC TO SPECIFY THERMAL CONDUCTIVITY OF MOUNT. DATE FOR DAC TO PROVIDE DATA DELAYED UNTIL RESOLUTION OF SCANNER MOUNT ADJUSTABILITY REQUIREMENT

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
PROTECTIVE SHROUD THERMAL CONTROL	3.1.3.1.1.6	1. RADIATOR BENEATH PROTECTIVE SHROUD TO BE INSULATED BY DAC. DAC IS NOW EVALUATING INSULATION CHARACTERISTICS (THERMAL CONDUCTIVITY AND SURFACE EMMITANCE) (DAC RESPONSE 27 FEB. 1968 ACCEPTABLE FOR CONDUCTIVITY; SURFACE EMITTANCE VALUE TO BE WORKED WITH DAC AT MARCH TEM).

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
PROTECTIVE SHROUD THERMAL CONTROL (CONT.)	3.1.3.1.1.6 (CONT.)	2. REQUIREMENT NOW IN ICN-025 TO THERMALLY INSULATE PROTECTIVE SHROUD FROM RADIATOR MAY BE DELETED IF SHROUD IS CONSTRUCTED OF NON METALLIC MATERIAL. 3. NEW RADIATOR TEMPERATURE PROFILES SUPERCEDING THOSE IN ICN-025 ARE BEING GENERATED BY DAC TO COVER PRELAUNCH, ASCENT, ON ORBIT AND DURING ACTS ORBIT ADJUST FIRING. DATE FOR SUBMITTAL: 1 APRIL 1968

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
OUTGASSING OF MATERIALS	3.1.3.3	1. MATERIALS IN VICINITY OF OPTICAL SURFACES SHALL BE PROCESSED TO REDUCE RESIDUAL CONDENSABLES TO TOLERABLE LEVELS. 2. DAC/GE ACTION TO DETERMINE MAXIMUM TEMPERATURES AT LOCATION OF THESE MATERIALS TO ESTABLISH PROCESSING REQUIREMENTS. USE INTEGRATED THERMAL MODEL FOR ACQUISITION OPTICS.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ENVIRONMENT (INTERNAL TO LAB MODULE)	3.2.1.4 3.2.1.5 3.2.1.6	1. COVERED IN BASIC VERSION OF IFS-MOL-707003 WITH EXCEPTION OF BOUNDARY CONDITIONS AROUND TELESCOPE IN ANNULUS BETWEEN LM PRESSURE SHELL AND BIRDCAGE AND INTERIOR OF BAYS 3 & 7. 2. GE/DAC INTEGRATED THERMAL MODEL WILL DEFINE ANNULUS AND BAYS 3 & 7 BOUNDARY CONDITIONS; INTERFACE DEFINITION WILL BE ADDED DURING NEGOTIATION OF ICN-025.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ENVIRONMENT (INTERNAL TO LAB MODULE) (CONT.)	3.2.1.4 3.2.1.5 3.2.1.6 (CONT.)	3. (CONT.) DEFINITION REQUIRED OF SHOCK SPECTRA DUE TO SEPARATION EVENTS (AERO FAIRING, HORIZON SENSOR FAIRING) AND ACTUATED EVENTS (E.G. ECLS AND ACTS VALVES, ACTS THRUSTOR FIRING); DATA TO BE PROVIDED BY DAC APRIL 1968 PER ACTION ITEM NO. 5-313

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ENVIRONMENT FOR EXTERIOR MOUNTED EQUIPMENT: PRE-LAUNCH	3.2.2.1	1. GE REQUIRES THAT AERO/FAIRING (OR A SUITABLE SUBSTITUTE COVER) PROVIDE PROTECTION AGAINST MOISTURE AND CONTAMINATION WHEN MES IS NOT IN POSITION. BASELINE DESIGN OF AERO FAIRING DOES NOT AFFORD DEGREE OF PROTECTION REQUIRED. TO BE WORKED AT MARCH TEM. 2. PENETRATION FITTING TEMPPERATURE TO BE LIMITED TO MAXIMUM VALUE DURING PERIOD IMMEDIATELY PRIOR TO LAUNCH RESOLUTION DEPENDENT ON INTEGRATED THERMAL MODEL ANALYSIS.

SECRET SPECIAL HANDLING

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
LAUNCH AND ASCENT	3.2.2.2	1. AERO FAIRING DESIGN CONSIDERATIONS AS IN ITEM 1 ABOVE 2. ACOUSTIC FIELD UNDER AERO FAIRING NOT DEFINED BY DAC. NO DATE FOR DEFINITION PRESENTLY AGREED TO. 3. SHOCK DUE TO SEPARATIO[N] EVENTS REQUIRED. DAC TO ANSWER IN APRIL 196[illegible] PER ACTION ITEM NO. 5-313 4. AERO FAIRING EJECTION DURING ASCENT.

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ON-ORBIT	3.2.2.3	1. ACTS ORBIT ADJUST PLUME DEFINITION PROVIDED BY DAC FOR INFORMATION FOR DESIGN ONLY - NOT AN INTERFACE AGREEMENT. 2. GE REQUIRES METALLIC FRAGMENT CONTENT OF ORBIT ADJUST PLUME. 3. GE REQUIRES DEFINITION OF CONTAMINATION FROM FUEL CELL, WASTE MANAGEMENT AND MOLECULAR SIEVE VENTS - QUANTITY, CONSTITUENTS, EJECTION TRAJECTORY, PARTICLE/GLOBULE SIZE.

~~SECRET~~ SPECIAL HANDLING

3. INTERFACES COVERED IN IFS-MOL-707003, ICN-025 (CONT.)

REQUIREMENT	PARAGRAPH	STATUS/COMMENT
ON-ORBIT (CONT.)	3.2.2.3 (CONT.)	4. (CONT.) INHIBIT VENT EJECTIONS DURING MISSION OPERATIONS. 5. SHOCK SPECTRA DEFINITION.

4. INTERFACE PROBLEM (NOT COVERED IN IFS-MOL-707003, ICN-025)

REQUIREMENT	COMMENT/STATUS
1. VENTING OF SPACE BETWEEN OBJECTIVE LENS AND WINDOW	1. DAC REQUIRES OBJECTIVE LENS BE A PRESSURE SEAL BACKUP FOR WINDOW IN CASE OF WINDOW/SEAL FAILURE. 2. SPECIFIED SEAL LEAKAGE ACROSS OBJECTIVE LENS RESULTS IN ACQUISITION OPTICS PERFORMANCE DEGRATION FOR 33 HRS. AFTER ORBIT INJECTION. 3. ALTERNATIVES: A. INCREASE OBJECTIVE LENS LEAKAGE SPECIFICATION B. INSTALL VALVE (MANUALLY OPERATED OR AUTOMATIC) 4. TO BE WORKED WITH DAC AT MARCH TEM.

SUBSYSTEM DESCRIPTION

~~SECRET~~ SPECIAL HANDLING

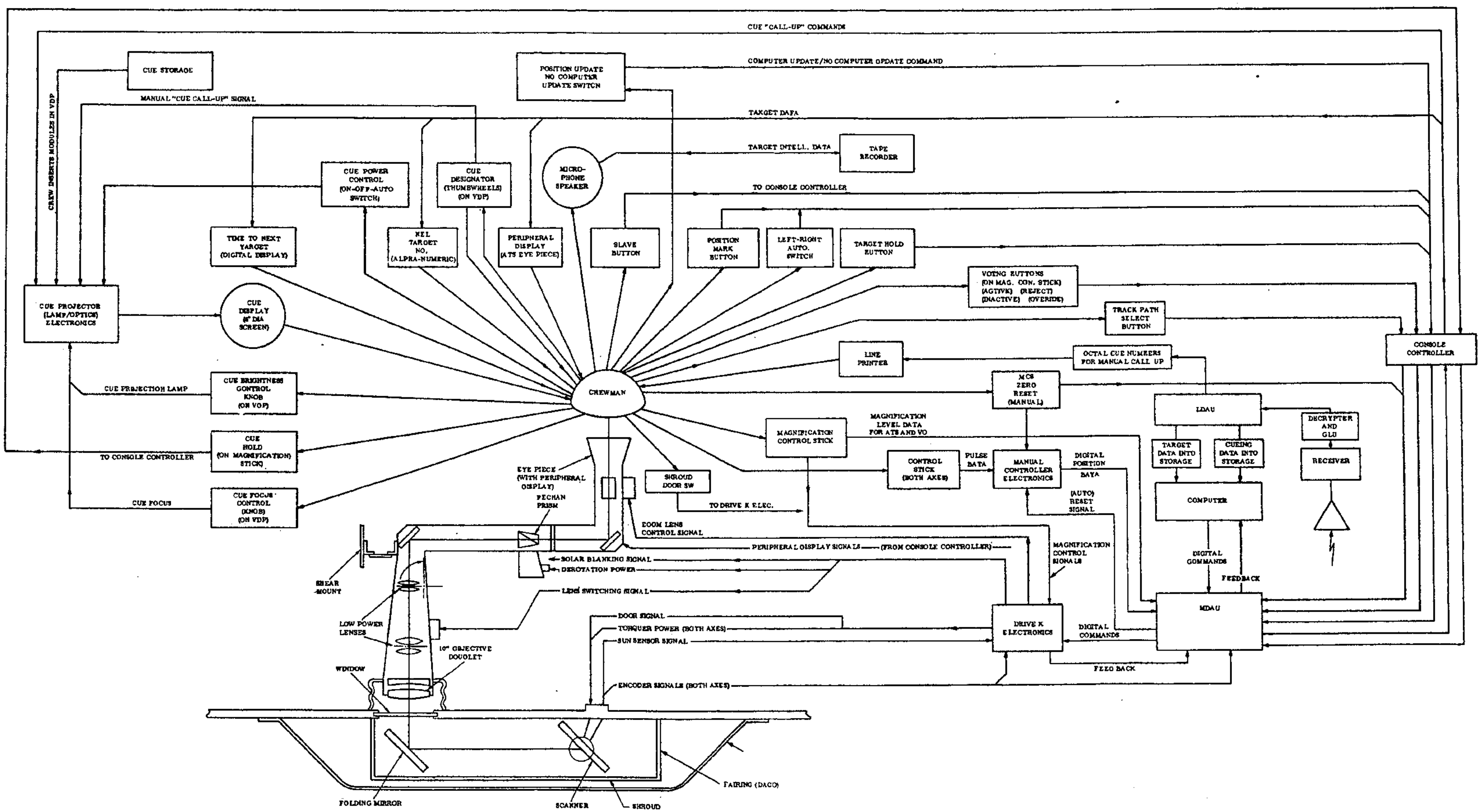


Figure 1.3-1. Acquisition Subsystem and Related Hardware

~~SECRET~~ SPECIAL HANDLING

ALPHA SUBSYSTEM PEAK AND AVERAGE POWER SUMMARY (WATTS)

	SHROUD OPEN	SLEW	TRACK	SHROUD CLOSE	MISSION AVERAGE
Torque Motor IA		3.9	0.1		0.42
Torque Motor OA		36.	0.1		1.3
Prism Actuator		9.5			0.02
Zoom Actuator			3.5		0.01
Power Changer Actuator			16.		0.04
Sun Shield Motor		2.5	2.5		2.5
Shroud Actuators	20.			20.	
Encoders (2)		9.4	9.4		0.62
Prism Feedback		0.5	0.5		
Zoom Feedback		0.5	0.5		
Power Changer Feedback					
Sun Shield Feedback					
Peripheral Display			3.		0.17
Sun Sensor		0.5	0.5		0.1
Gyro Warmup Heater IA	61.5				3.12
Gyro Control Heater IA			8.5		0.83
Gyro Electronics IA	5.5	5.5	5.5		1.08
Gyro Spin Motor IA	2.5	2.5	2.5		
Gyro Torquer IA		4.0	4.0		
Gyro Electronics, Htr., Etc., OA	69.5	12.	20.5		5.03
Drive K Electronics K0,K3 thru K10		36.9	36.9		
DKE K2 Modules, IA and OA		3.4	3.4		
DKE Torquer Power Amplifier, IA		1.7	1.7		
DKE Torquer Power Amplifier, OA		17.3	5.4		3.69
DKE Power Amplifier, Prism		2.19			
DKE Power Amplifier, Zoom			2.19		
DKE Power Amplifier, Power Changer			2.1		
DKE Power Amplifier, Sun Shield			1.0		
DKE Power Amplifier, Shroud	1.6			1.6	
DKE Power Amplifier, IA and OA Gyro Torquers		7.2	7.2		
Visual Display Projector		44.	44.		8.42
Total Peak, per Crew Station	155.61	199.53	181.01	21.6	
Total Average, per Crew Station					27.37
Total Peak, per Subsystem	311.21	399.06	362.02	43.2	
Total Worst Case Peak Allocation		420.			
Subsystem Average					54.74
Allocated Average					50.

ACQUISITION SUBSYSTEM

WEIGHT STATUS SUMMARY

	OCTOBER 1967 STATUS (LBS.)	CURRENT BEST ESTIMATE (LBS.)	DELTA (LBS.)
GE COMPONENTS	165	165	0
DRIVE K ELECTRONICS	40	74	+ 34
SUBTOTAL	205	239	+ 34
ITEK	329	344	+ 15
TOTAL	534	583	+ 49

	EST.	CALC.	ACT.	EST.	CALC.	ACT.
PERCENTAGE BREAKDOWN	100			66	31	3

ACQUISITION SUBSYSTEM WEIGHT STATUS

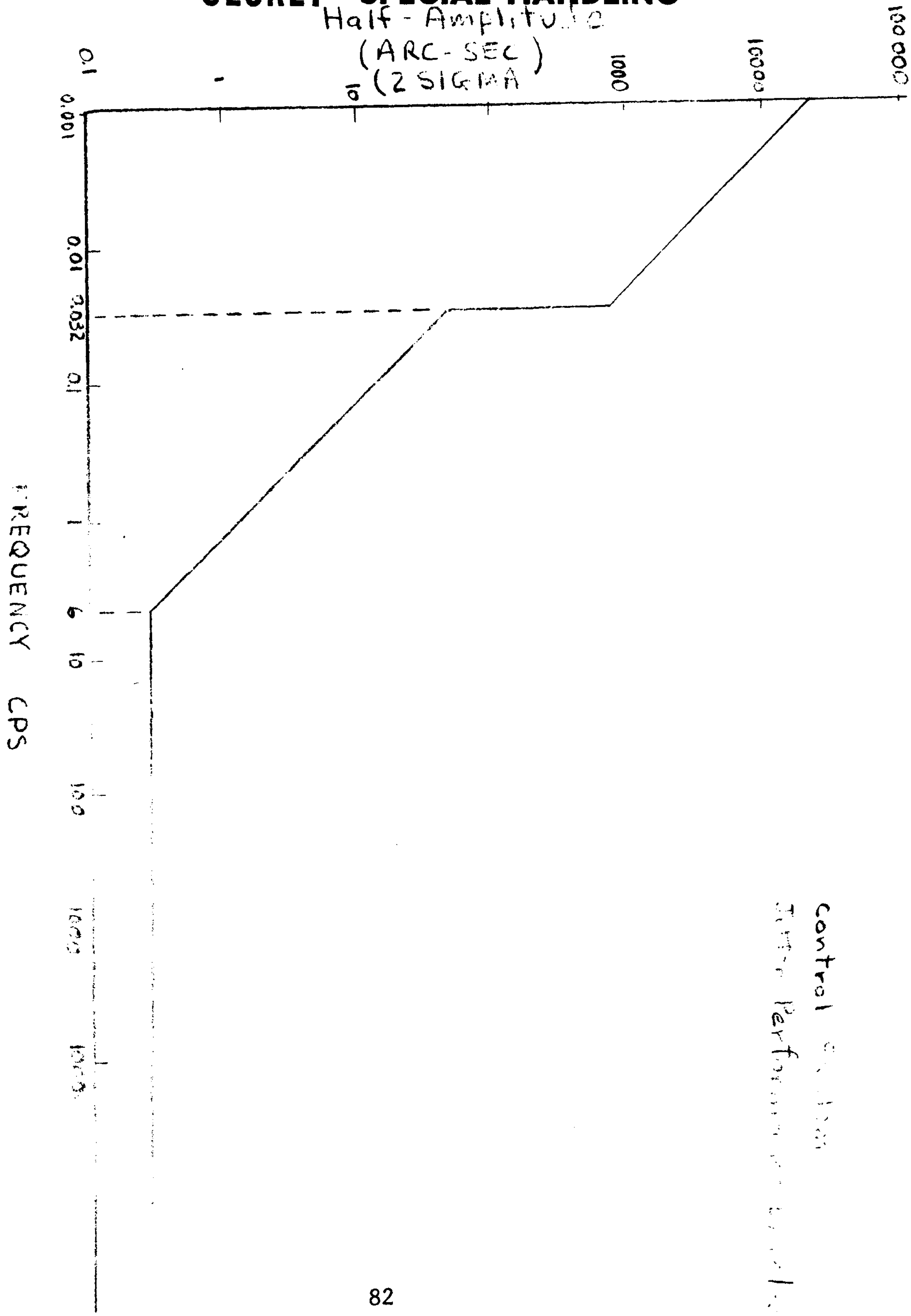
COMPONENTS		OCT.1967 STATUS (LBS.)	CURRENT REPORTED WEIGHTS (lbs.)	CURRENT BEST EST/ SPEC.WTS. (LBS.)	BASIS (%) E	BASIS (%) C	BASIS (%) A	ONE TIME WORST WEIGHT TOTAL	ONE TIME WORST WEIGHT DELTA
GYROS & ELECTRONICS	(4)	22	20.2	22	13	41	46		
VDP (EXCLUDES FILM MODULES - GFE)	(2)	50	45.4	50	100			65	- 15
DRIVE K ELECTRONICS	(2)	40	74.0	74	40	60		110	- 36
CONTROL STICKS	(2)	5	5.0	5	100			6	- 1
HEADRESTS	(2)	5	5.0	5			100		
THERMAL INSULATION	(2)	3	3.0	3	100			10	- 7
CONSOLE & DISPLAY CONTROLLER △	(2)	12	12.0	12	100				
POWER CONTROLLER △	(1)	5	5.0	5	100				
HARNESS		50	51.9	50	25	75		83	- 33
MDAU (DELTA)	(2)	TBD	TBD	TBD					
CONSOLE STRUCTURE △	(2)	13	10.0	13	90	10		15	- 2
SUBTOTAL		205	231.5	239	53	41	6		
ITEK		329	344.0	344	75	25		404	- 60
TOTAL		534	575.5	583	66	31	3		

CRITICAL SUBSYSTEM ANALYSIS

&

CONTROLS ANALYSIS

NRO APPROVED FOR
RELEASE 1 JULY 2015



CALCULATION OF LOS JITTER

WEIGHTING FUNCTION $F(\omega) = \frac{0.0275}{(S/37 + 1)}$

PSD $\Phi(\omega) = \int_{-\infty}^{\infty} R(\tau) e^{-j\omega\tau} d\tau$

TRANSFER FUNCTION $G(\omega) = \frac{\theta(\omega)}{N(\omega)}$

Honeywell PSD Definition

$$R(\tau) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} X(t) \cdot X(t+\tau)\, dt$$

$X(t)$ = signal of interest

$$\Phi_{xx}(\omega) = \int_{-\infty}^{\infty} R(\tau)\, e^{-j\omega\tau}\, d\tau$$

$\Phi(\omega)$ = PSD

$$R_x(\tau) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \Phi_{xx}(\omega)\, e^{j\omega\tau}\, d\omega$$

Letting $\tau \to 0$

$$\overline{X^2} = E\left[(X - \overline{X})^2\right] = R(0) = \frac{1}{2\pi} \int_{-\infty}^{\infty} \Phi_{xx}(\omega)\, d\omega$$

$$= \frac{2}{2\pi} \int_{0}^{\infty} \Phi_{xx}(\omega)\, d\omega$$

CALCULATION OF RMS ERROR

$$\theta_{RMS} = \sqrt{2\int_{0.2}^{\infty} \left(\Phi(\omega)\right) \cdot \left(F(\omega)\right)^2 \cdot \left(G(\omega)\right)^2 \, d\omega}$$

θ = RADIANS OF DISPLACEMENT

$\Phi(\omega) = \dfrac{(\text{ft-lb})^2}{\text{RADIAN per SECOND}}$

$G(\omega) = \dfrac{\text{RADIANS}}{\text{ft-lb}}$

$F(\omega)$ IS DIMENSIONLESS

CONFIGURATIONS EVALUATED

1. RATE

2. POSITION

3. RATE + POSITION

RATE CONFIGURATION

ADVANTAGES

LOW RATE TRACKING CAPABILITY

MINIMUM ERROR RESULTING FROM VEHICLE TRANSIENTS

COMMONALITY WITH MAIN TRACKING MIRROR

DISADVANTAGES

LOW BEARING NOISE REJECTION

RATE SERVO CONFIGURATION

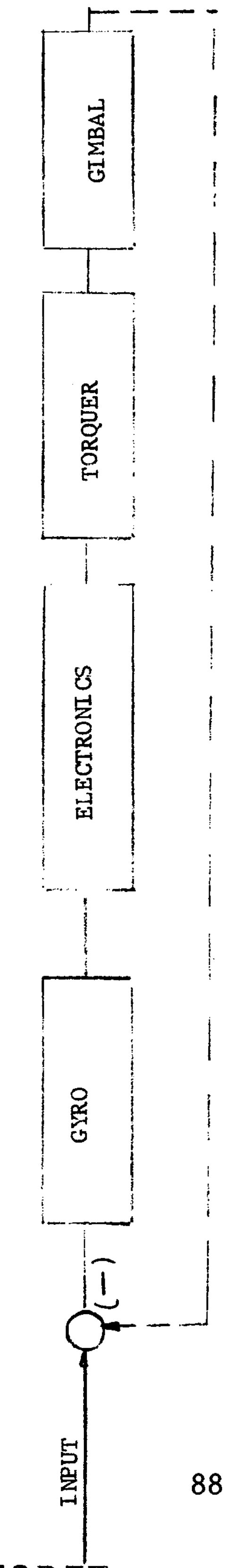


TABLE 2.2-1. RATE SERVO CONFIGURATION ERROR SUMMARY
(JITTER PERFORMANCE)

ERROR SOURCE	PITCH AXIS	ROLL AXIS
Bearing Noise	0.043 sec	0.0143 sec
Gyro noise	0.023 sec	0.023 sec
Loop Electronic Noise	0.016 sec	0.016 sec
Input Noise (D/A)	0.022 sec	0.022 sec
RMS Gimbal Error	0.054 sec	0.0375 sec
RMS LOS	0.1105 sec	
	0.221 sec	

POSITION CONFIGURATION

ADVANTAGES

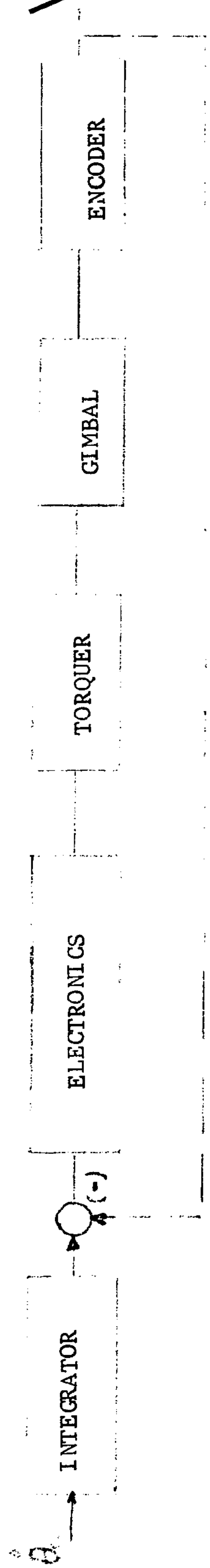
MINIMUM WEIGHT AND POWER

DISADVANTAGES

LIMITED LOW RATE TRACKING CAPABILITY

LOW BEARING NOISE REJECTION

MAX ERROR RESULTING FROM VEHICLE TRANSIENTS



POSITION SERVO CONFIGURATION

TABLE 2.2-2. POSITION SERVO CONFIGURATION ERROR SUMMARY

ERROR SOURCE	PITCH	ROLL
Bearing Noise	0.18 sec	0.165 sec
Electronic Noise	0.016 sec	0.016 sec
Quantizing Error	0.025 sec	0.062 sec
	RMS Gimbal = 0.182 sec	0.172 sec
	RMS LOS = 0.403 sec	
	2σ LOS = 0.806 sec	

POSITION + RATE CONFIGURATION

ADVANTAGES

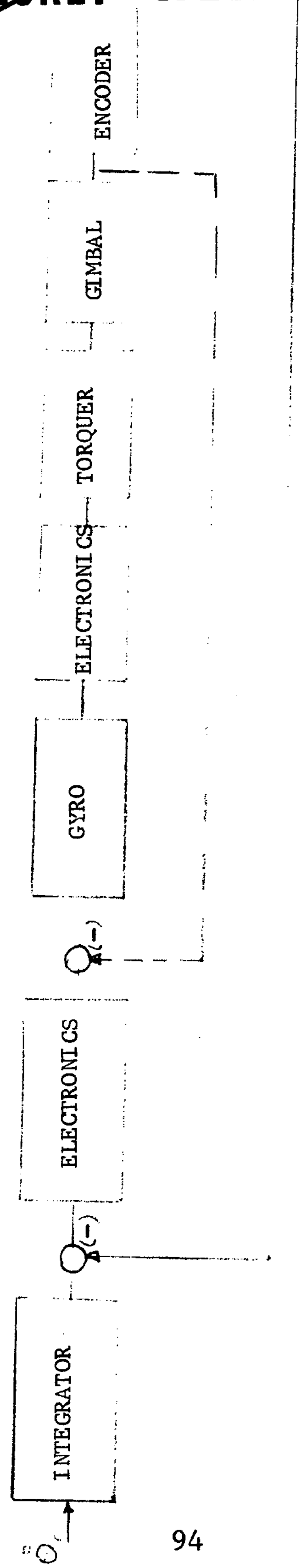
MAXIMUM BEARING NOISE REJECTION

DISADVANTAGES

LIMITED LOW RATE TRACKING CAPABILITY

INCREASED COMPLEXITY

POSITION + RATE SERVO



POSITION + RATE PERFORMANCE

	PITCH		ROLL
Bearing Noise	.02		.007
Gyro Noise	.022		.023
Electronic Noise	.016		.016
Quantizing Noise	.0125		.068
RMS Gimbal	.037		.074
RMS LOS		0.105 sec	
2σ LOS		0.21 sec	

PERFORMANCE COMPARISION

	RATE		POSITION		POSITION + RATE	
	Pitch	Roll	Pitch	Roll	Pitch	Roll
Bearing Noise	0.043	0.014	0.018	0.165	.02	.007
Gyro Noise	0.023	0.023	---	---	.023	.023
Electronic Noise	0.016	0.016	.016	.016	.016	.016
Input Noise (D/A)	0.022	0.022	---	---	---	---
Quantizing Error	---	---	.025	0.62	.0125	.068
RMS Gimbal	0.054	0.038	0.182	0.172	.037	.074
RMS LOS	0.1105		0.430		0.105	
2 LOS	0.221 sec		0.806 sec		0.21 sec	

Baseline Servo Configuration

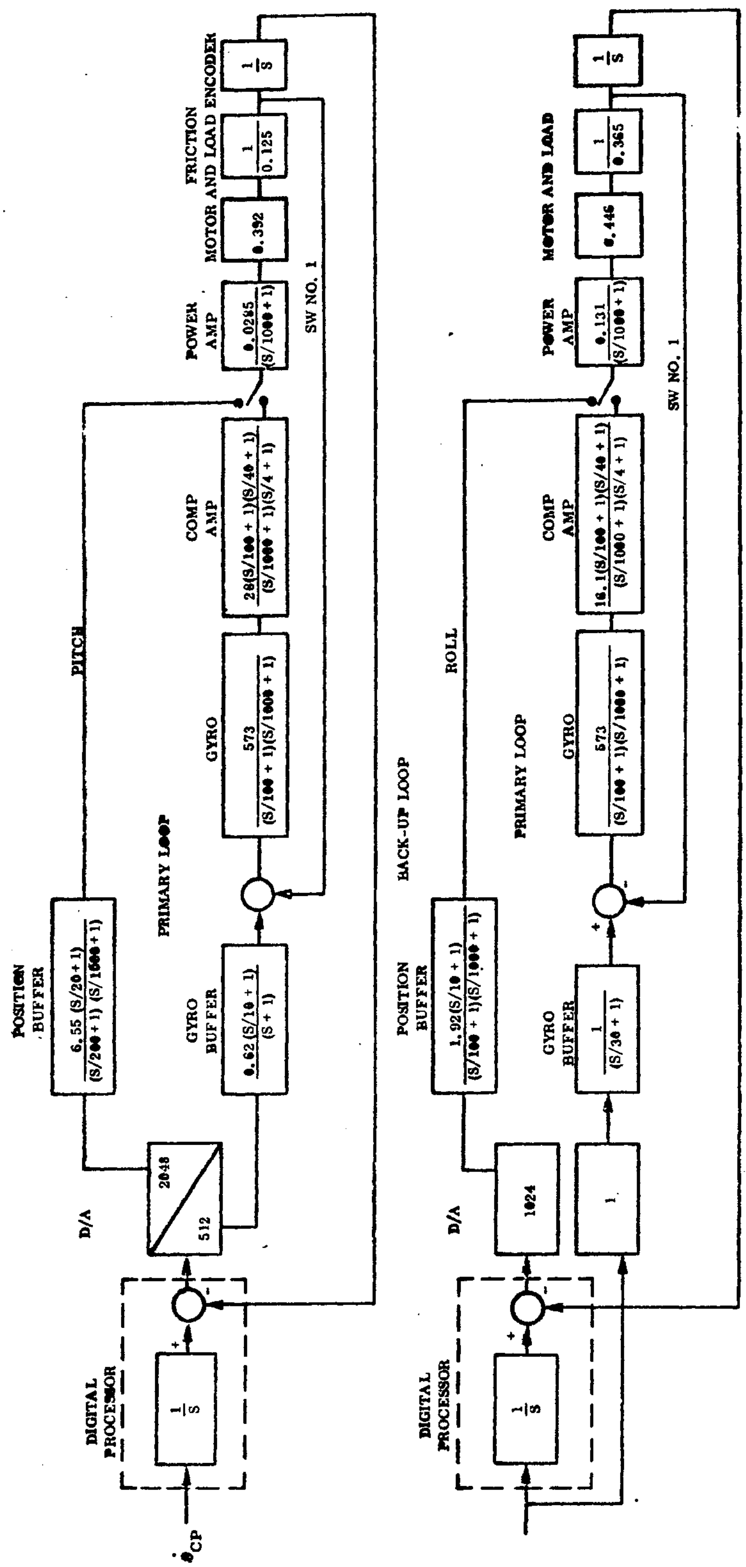


Figure 2.2-24. Pitch and Roll Servo Configurations – ~~Backup Mode Loop~~

BASELINE PERFORMANCE

TABLE 2.2-4. PRIMARY MODE ERROR SUMMARY

		PITCH	ROLL
Bearing Noise		0.02 sec	0.026 sec
Electronic Noise		0.016 sec	0.022 sec
Gyro Noise		0.022 sec	0.023 sec
Input Noise			0.016 sec
Quantizing Noise		0.0125 sec	
	RMS Gimbal error -	0.037 sec	0.0434 sec
	RMS LOS -	0.086 sec	
	2 LOS -	0.172 sec	

BACKUP MODE ERROR SUMMARY

		PITCH	ROLL
Bearing Noise		0.180 sec	0.165 sec
Electronic Noise		0.016 sec	0.016 sec
Quantizing Noise		0.0125 sec	0.062 sec
	RMS Gimbal -	0.182 sec	0.172 sec
	RMS LOS -	0.403 sec	
	2 LOS -	0.806 sec	

CONSTRAINTS

STRUCTURE

COMMAND RATE (100cps)

INCORPORATION IN SLEW SERVO

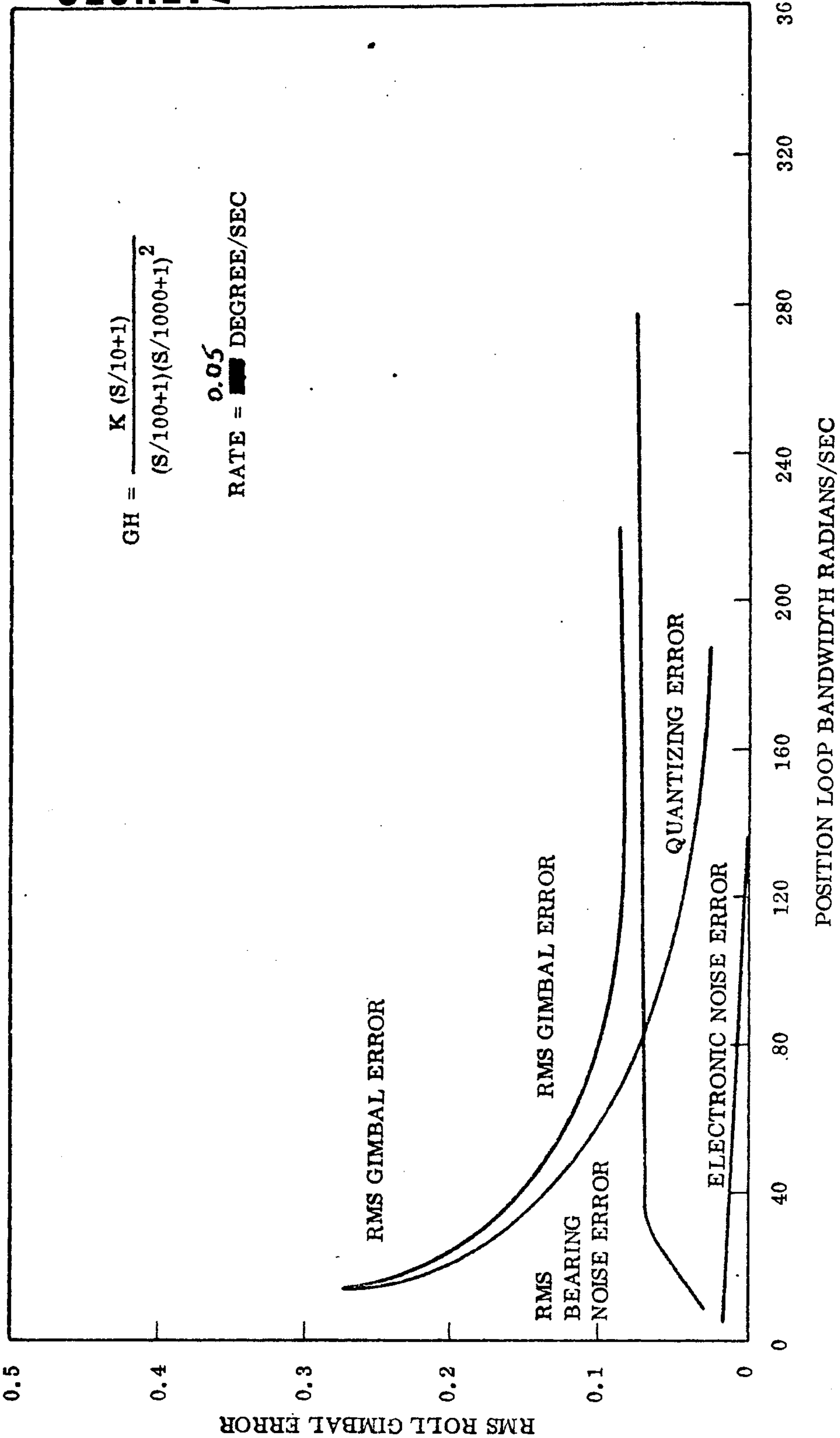
LOW TRACKING RATE

TRADEOFFS

BANDWIDTH vs ERROR

INERTIA vs ERROR

LAG-LEAD RATIO vs ERROR



$GH = \frac{K(S/10+1)}{(S/100+1)(S/1000+1)^2}$
0.05
RATE = [redacted] DEGREE/SEC
RMS GIMBAL ERROR
RMS GIMBAL ERROR
RMS BEARING NOISE ERROR
QUANTIZING ERROR
ELECTRONIC NOISE ERROR
RMS ROLL GIMBAL ERROR
0.5
0.4
0.3
0.2
0.1
0
0
40
80
120
160
200
240
280
320
360
POSITION LOOP BANDWIDTH RADIANS/SEC

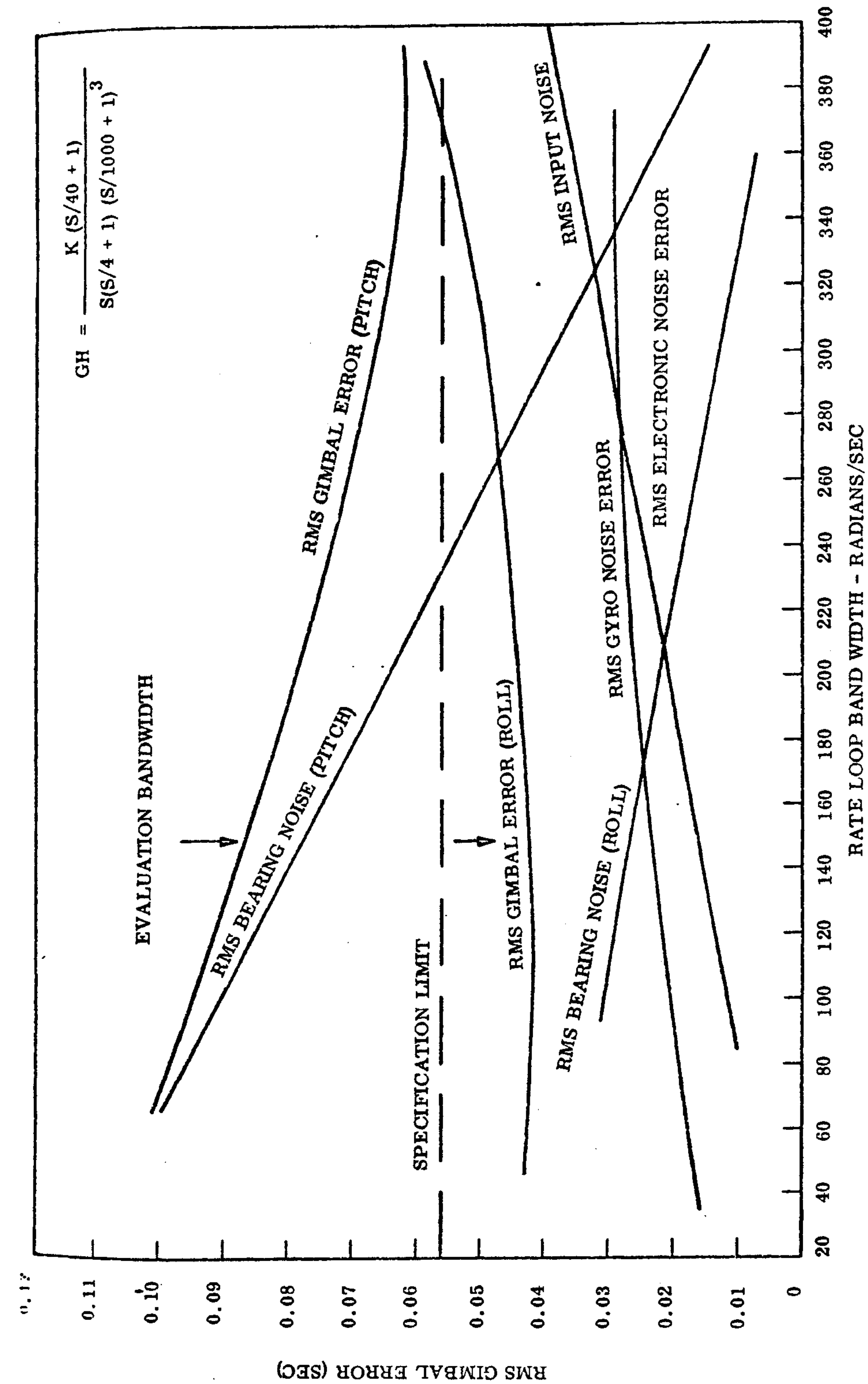
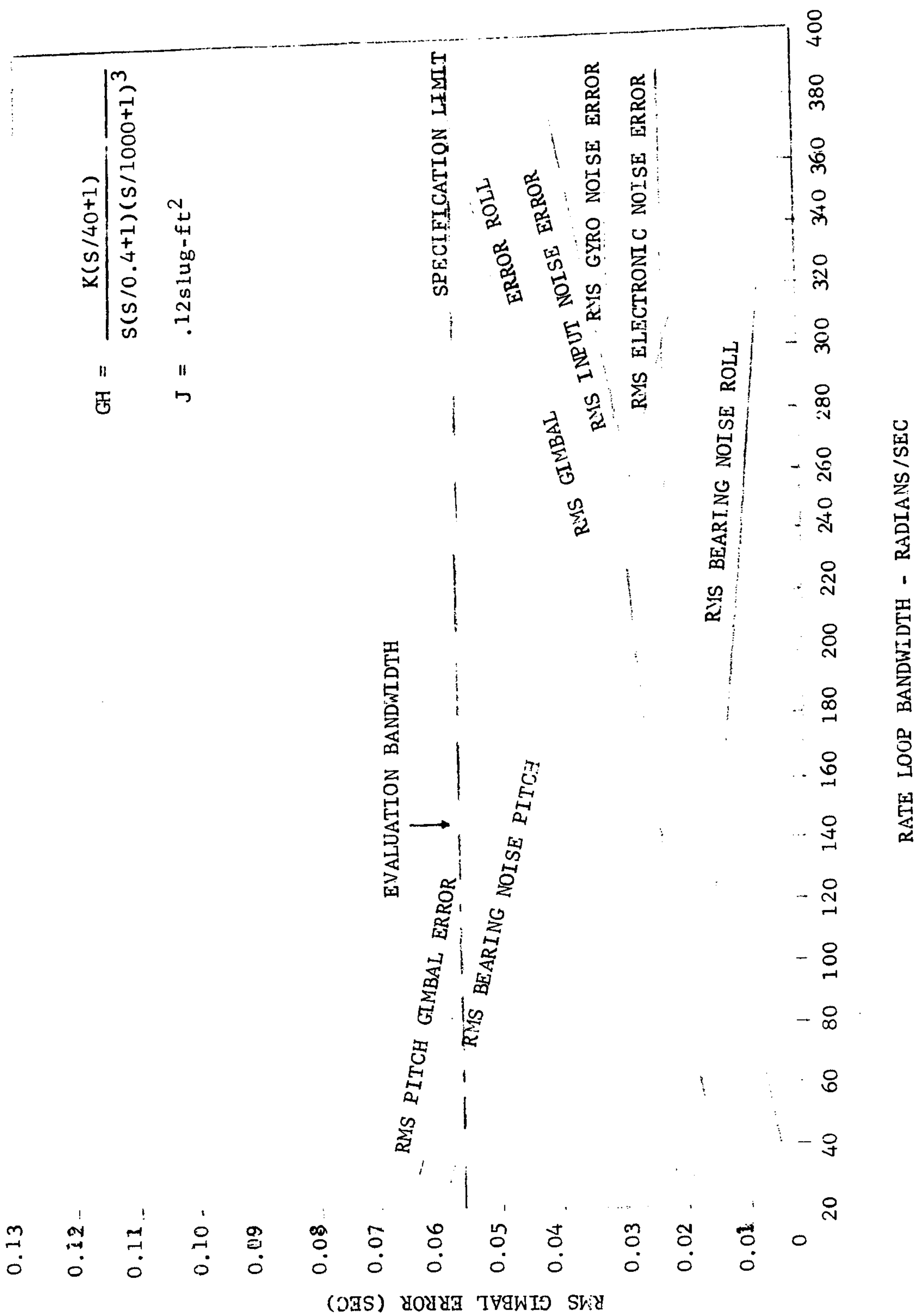


Figure 2.2-5. Rate Configuration (Jitter Performance)


GH = K(S/40+1) / S(S/0.4+1)(S/1000+1)^3
J = .12slug-ft^2
SPECIFICATION LIMIT
ERROR ROLL
RMS INPUT NOISE ERROR
RMS GIMBAL
RMS GYRO NOISE ERROR
RMS ELECTRONIC NOISE ERROR
RMS BEARING NOISE ROLL
EVALUATION BANDWIDTH
RMS PITCH GIMBAL ERROR
RMS BEARING NOISE PITCH
RMS GIMBAL ERROR (SEC)
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
RATE LOOP BANDWIDTH - RADIANS/SEC

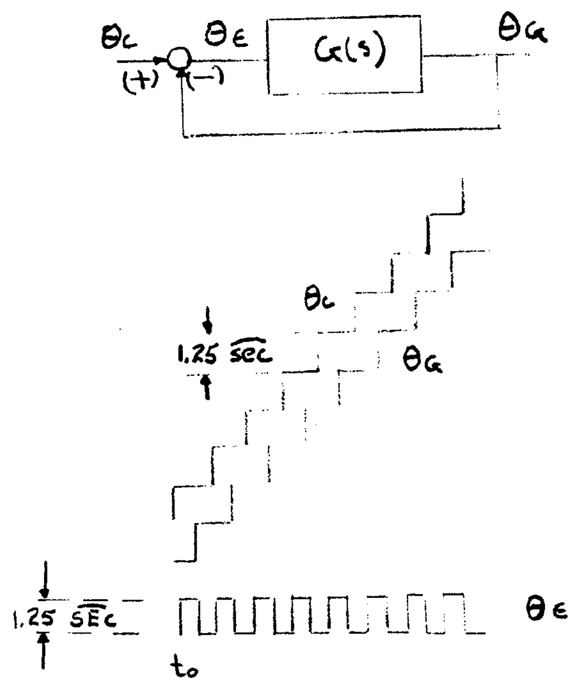
NEW NOISE SOURCES

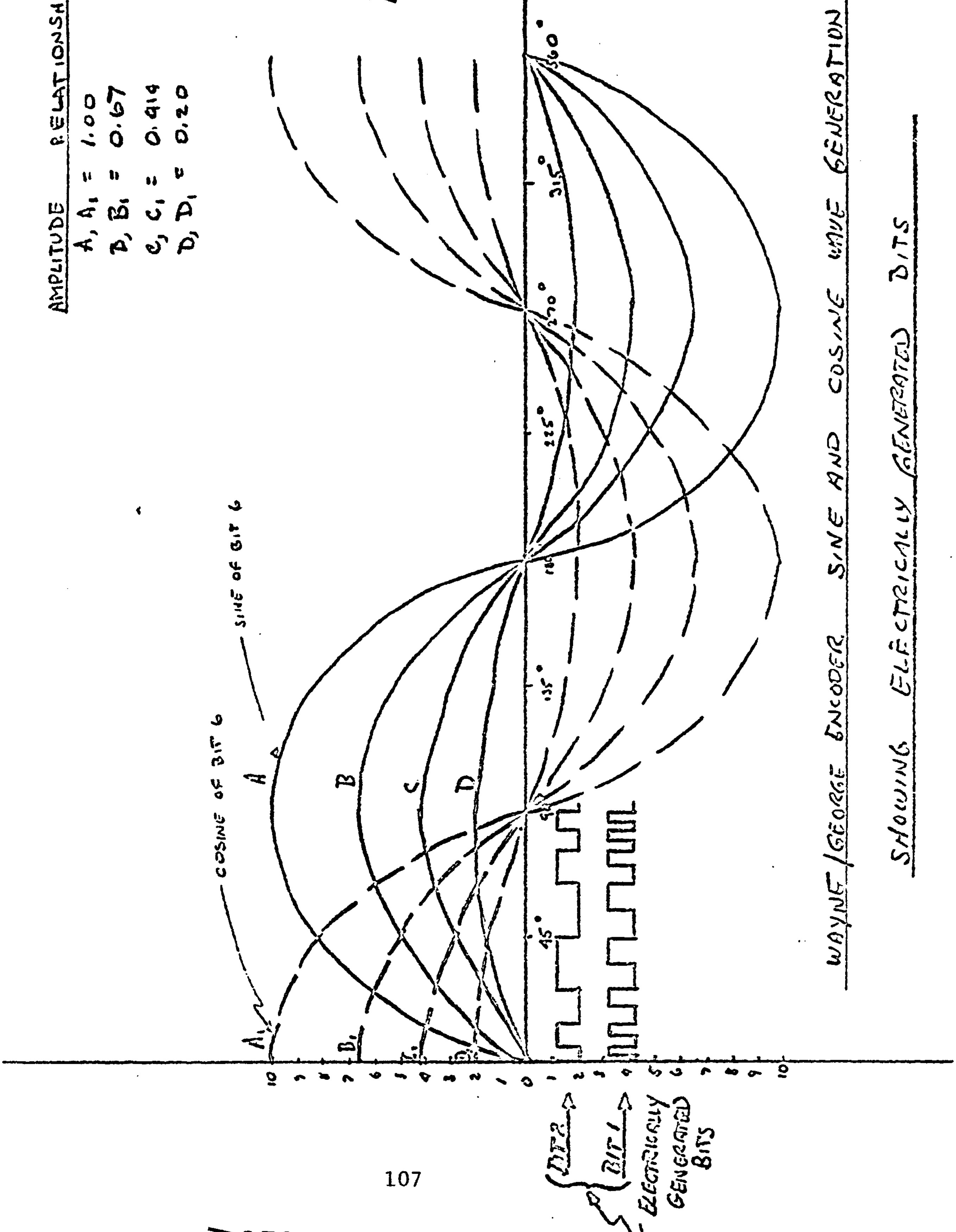
QUANTIZING ERRORS

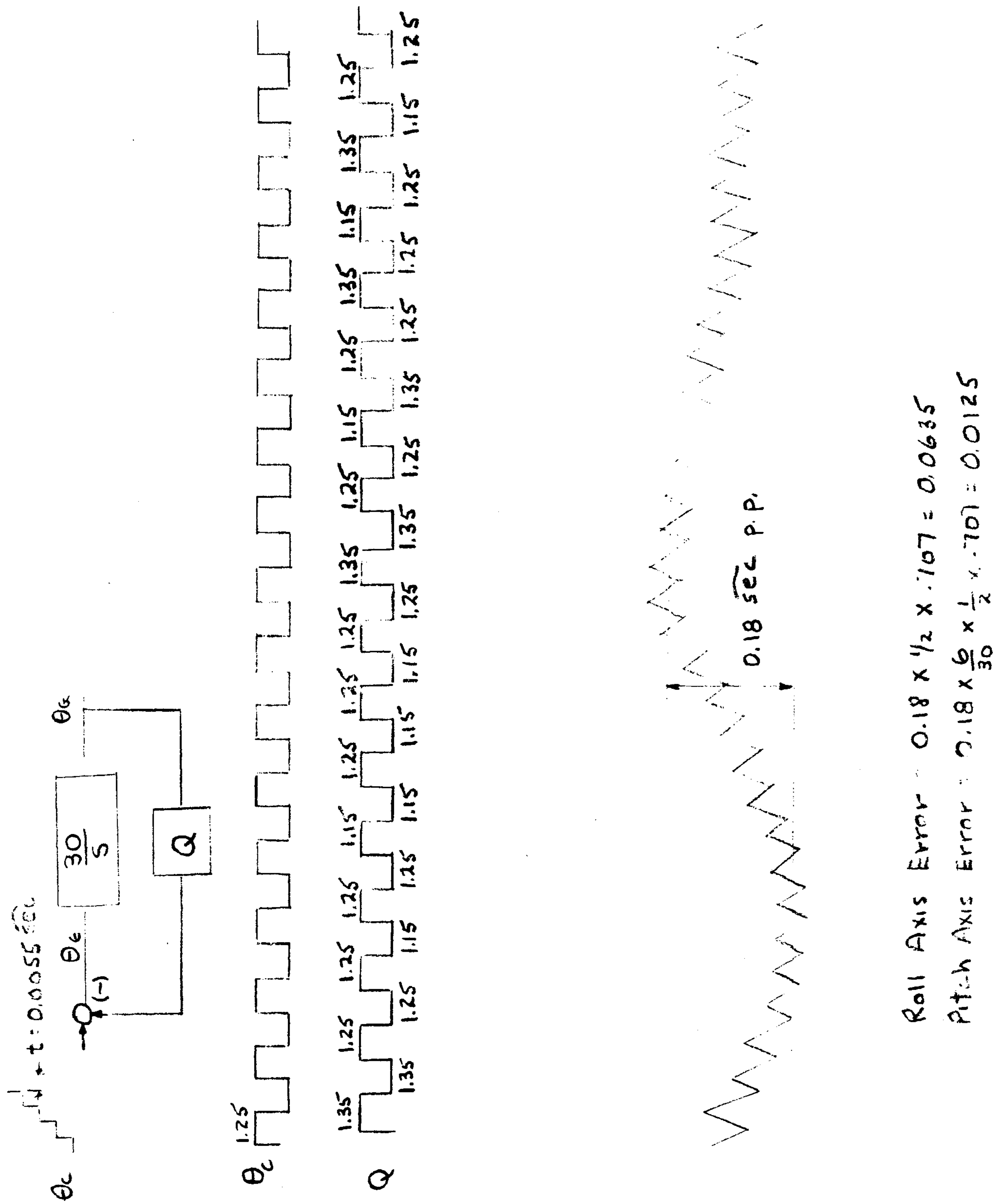
SUMMATION ERROR GENERATION

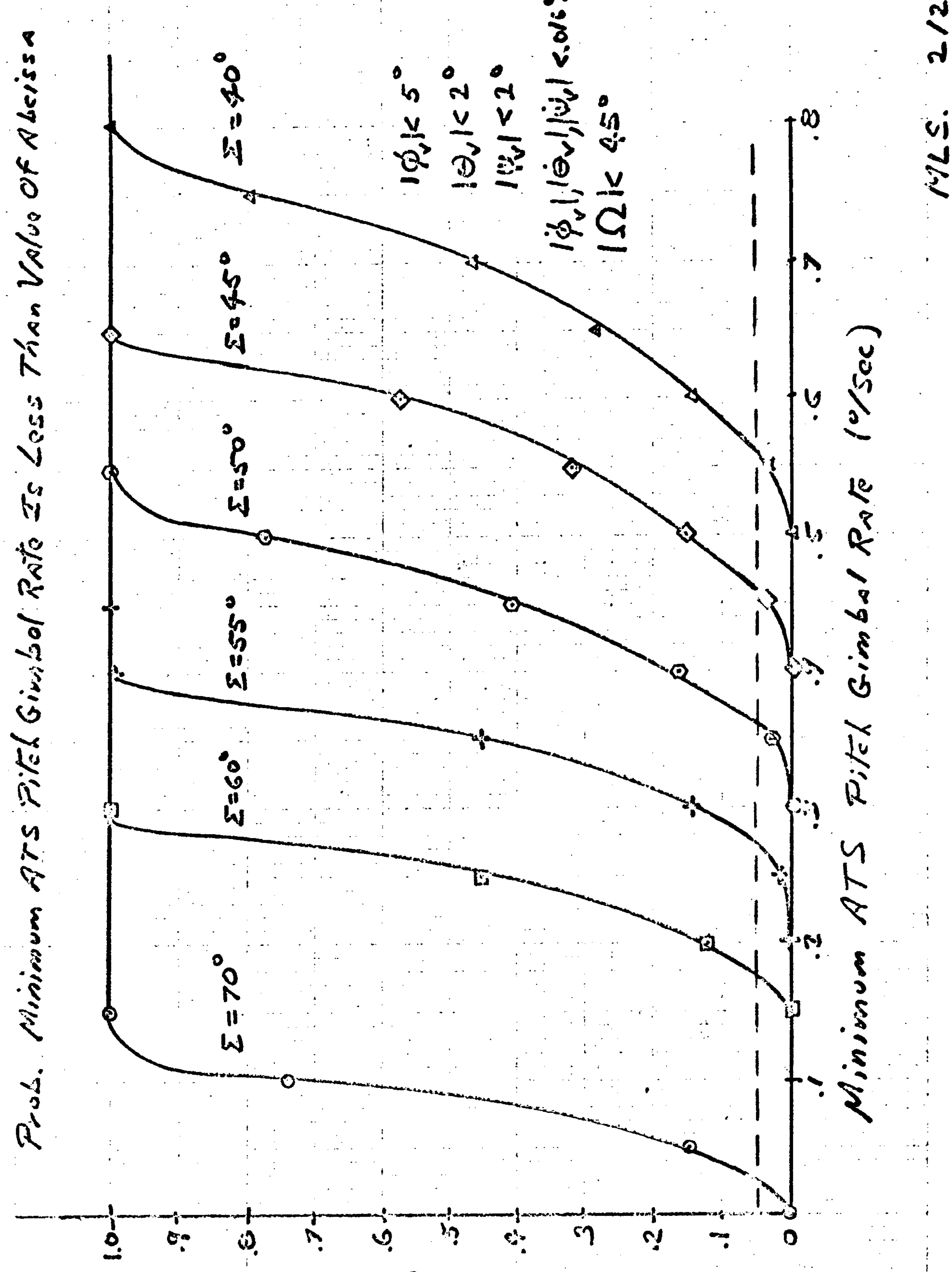
BIT JITTER ERROR

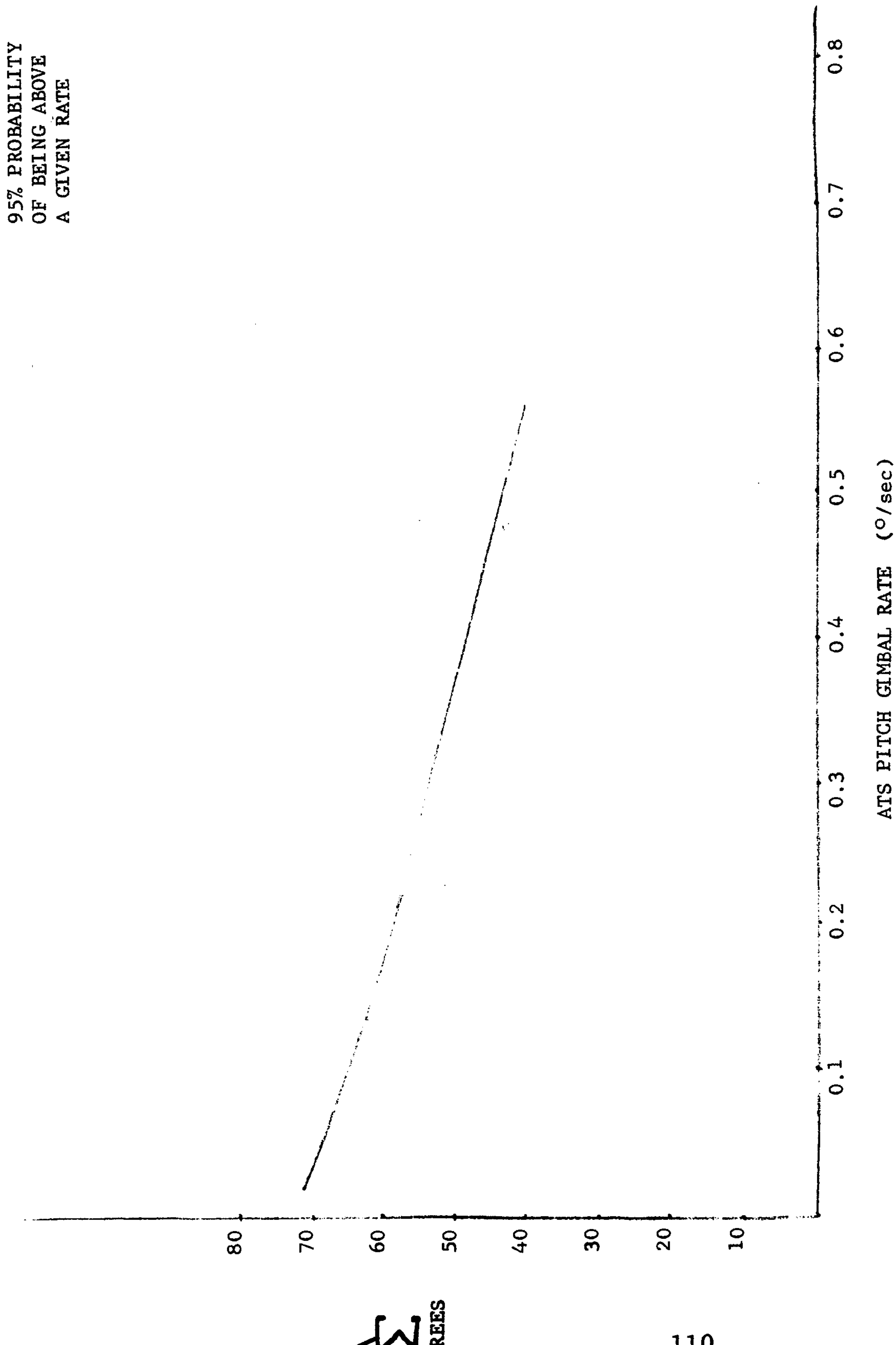
Summation Error Generation

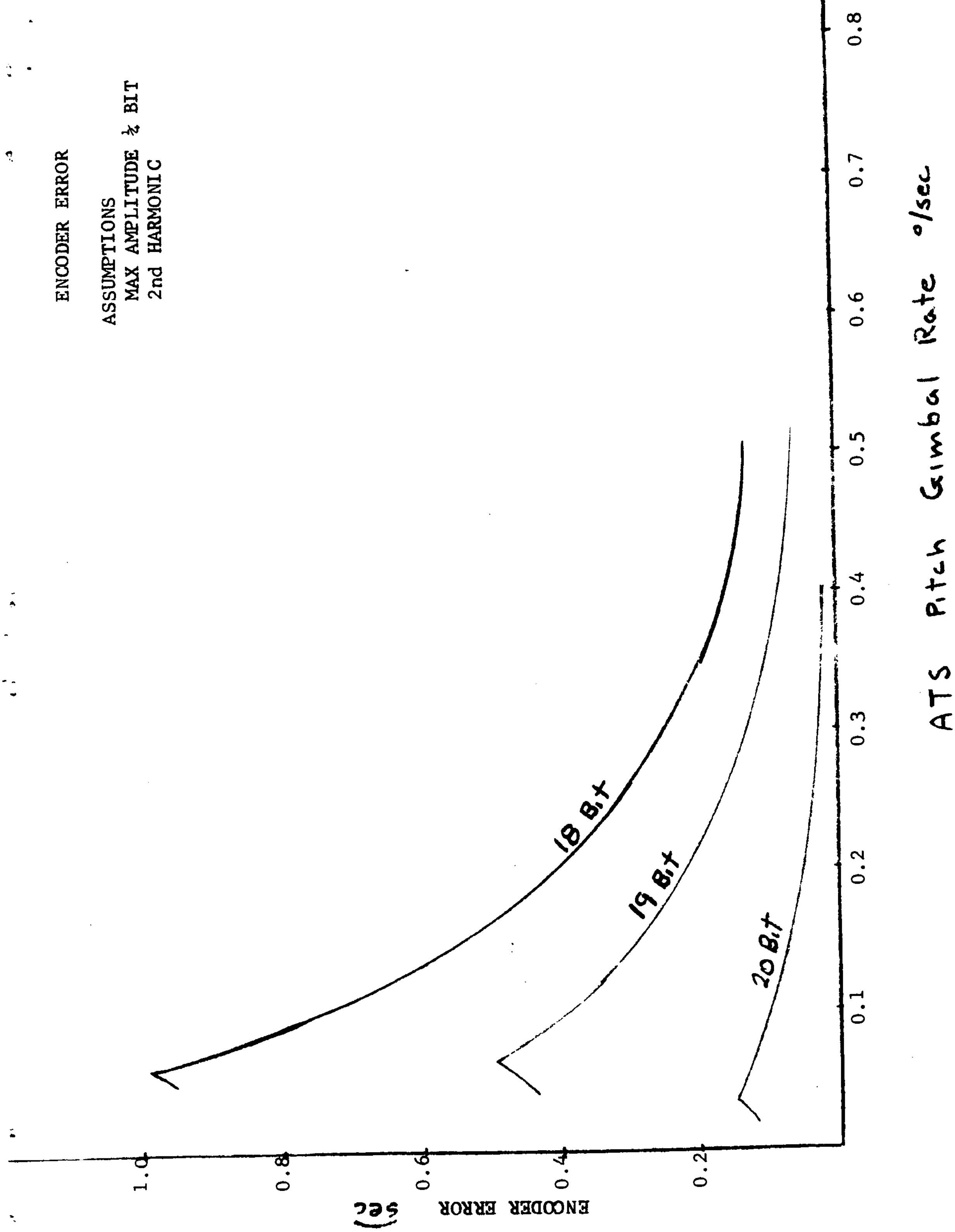


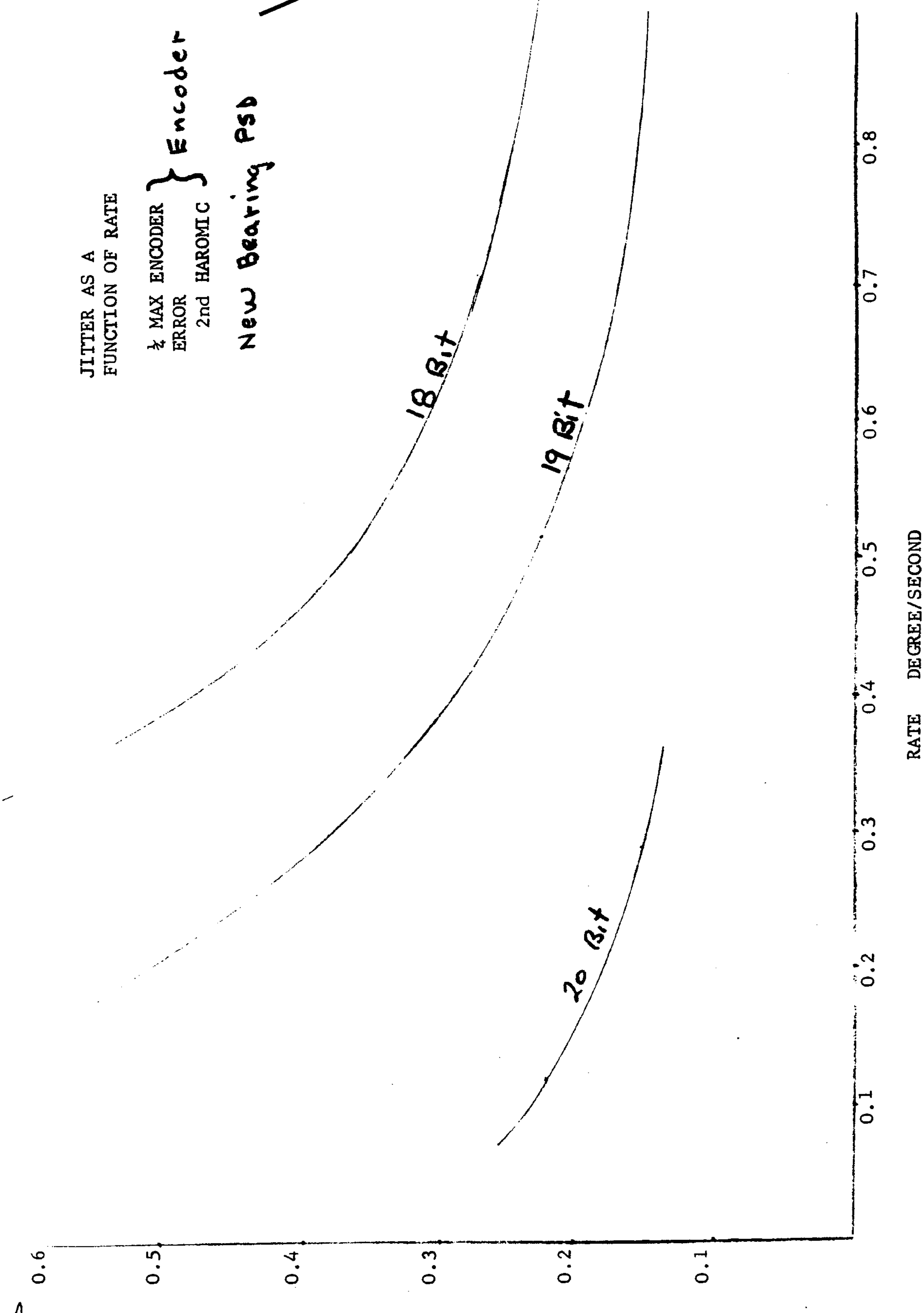

AMPLITUDE RELATIONSHIPS
A, A1 = 1.00
B, B1 = 0.67
C, C1 = 0.414
D, D1 = 0.20
WAYNE/GEORGE ENCODER SINE AND COSINE WAVE GENERATION
SHOWING ELECTRICALLY GENERATED BITS
COSINE OF BIT 6
SINE OF BIT 6
A
B
C
D
A1
B1
C1
D1
45°
90°
135°
180°
225°
270°
315°
360°
10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10
BIT 2
BIT 1
ELECTRICALLY GENERATED BITS

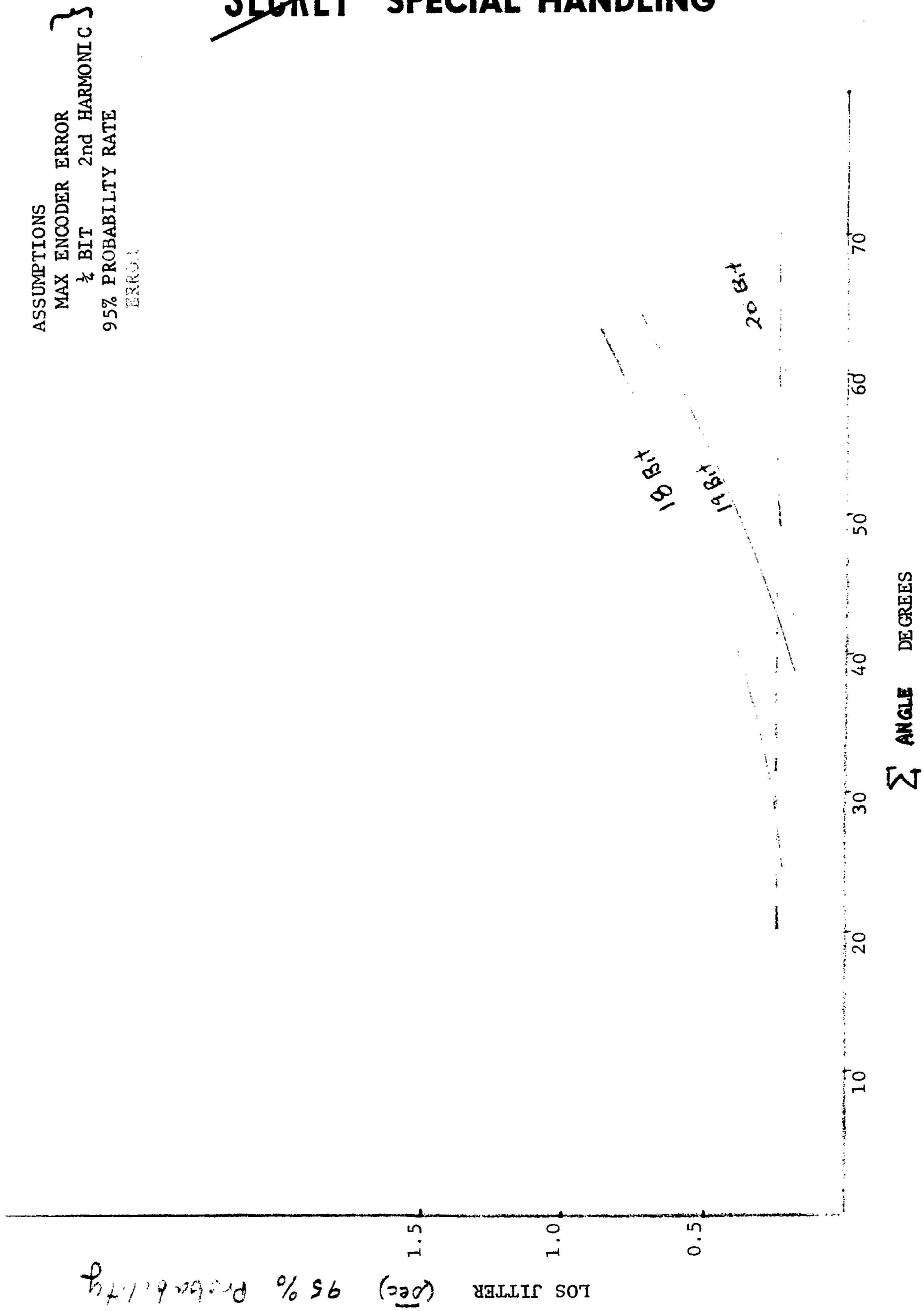

θc
t = 0.0055 sec
θe
(-)
30/S
Q
θG
0.18 sec P.P.
Roll Axis Error = 0.18 x 1/2 x .707 = 0.0635
Pitch Axis Error = 0.18 x 6/30 x 1/2 x .707 = 0.0125

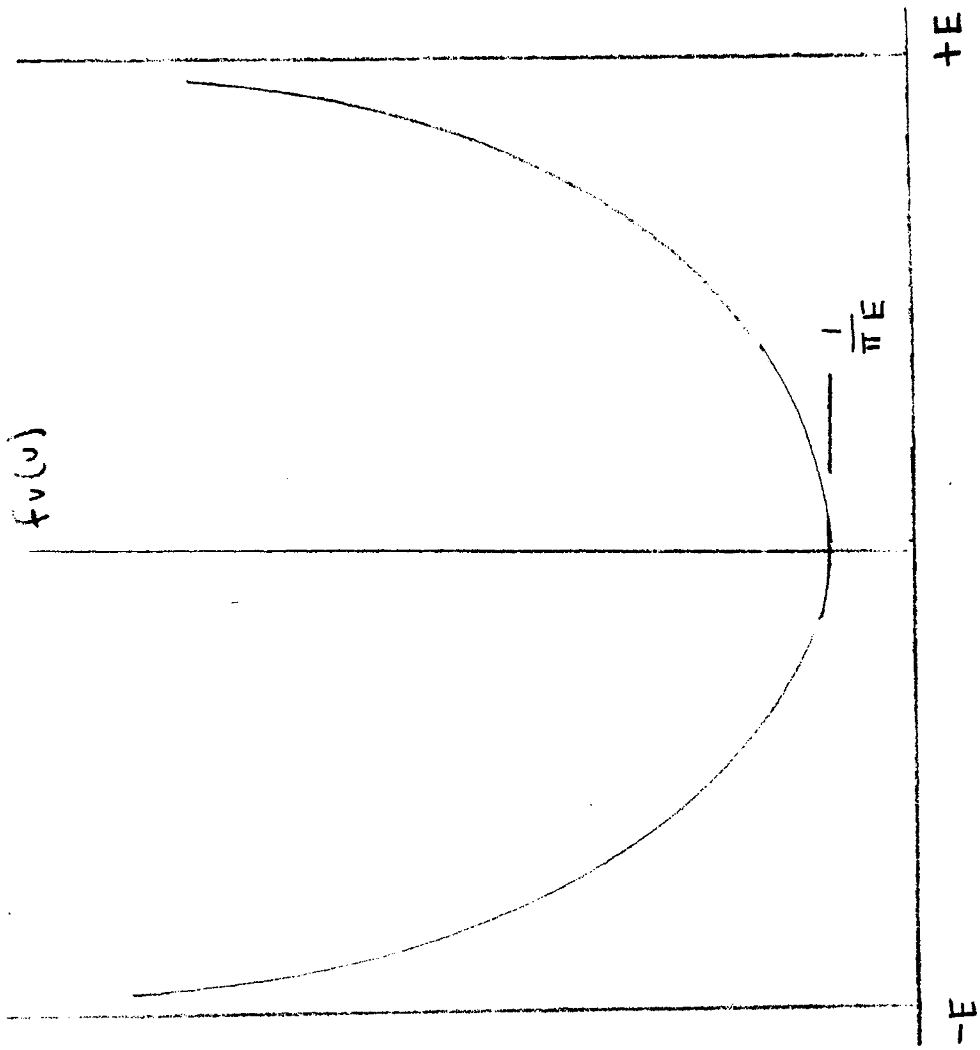

Prob. Minimum ATS Pitch Gimbal Rate Is Less Than Value Of Abscissa
Minimum ATS Pitch Gimbal Rate (°/Sec)
Σ = 40°
Σ = 45°
Σ = 50°
Σ = 55°
Σ = 60°
Σ = 70°
|φ_v| < 5°
|θ_v| < 2°
|ψ_v| < 2°
|φ̇_v|, |θ̇_v|, |ψ̇_v| < .06°/s
|Ω| < 45°
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
.1
.2
.3
.4
.5
.6
.7
.8
MLS. 2/28/66


95% PROBABILITY
OF BEING ABOVE
A GIVEN RATE
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ATS PITCH GIMBAL RATE (^{o}/sec)
80
70
60
50
40
30
20
10
DEGREES


ENCODER ERROR
ASSUMPTIONS
MAX AMPLITUDE ½ BIT
2nd HARMONIC
18 Bit
19 Bit
20 Bit
ENCODER ERROR sec
1.0
0.8
0.6
0.4
0.2
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ATS Pitch Gimbal Rate °/sec


JITTER AS A FUNCTION OF RATE
¼ MAX ENCODER ERROR
2nd HAROMIC
Encoder
New Bearing PSD
18 Bit
19 Bit
20 Bit
RATE DEGREE/SECOND
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.1
0.2
0.3
0.4
0.5
0.6
LOS JITTER sec
Probability


ASSUMPTIONS
MAX ENCODER ERROR
¼ BIT 2nd HARMONIC
95% PROBABILTY RATE
18 Bit
19 Bit
20 Bit
10
20
30
40
50
60
70
Σ ANGLE DEGREES
0.5
1.0
1.5
LOS JITTER (sec) 95 % Probability



E: Max Value

Probability Density Distribution of A Sinusoidally Varying Random Variable

ERROR ANALYSIS

BASELINE	NEW DATA
J = .12 ROLL	J = .08 ROLL
J = .36 PITCH	J = .25 PITCH
20 BIT ENCODER	19 BIT ENCODER
	$\sum$ = 43 DEGREES

	PITCH	ROLL	PITCH	ROLL
BEARING NOISE	0.02	0.026	.009	.01
GYRO NOISE	0.022	0.023	.022	.023
ELECTRONIC NOISE	0.016	0.016	.016	.016
QUANTIZING ERROR	0.0125	--	.12	--
INPUT NOISE	--	0.022	--	.022
RMS GIMBAL	0.037	0.0434		
RMS LOS	0.086		95% Gimbal	0.125
2 LOS	0.172 sec.		95% LOS	0.25 sec

PROPOSED BASELINE

RATE - RATE CONFIGURATION

ADVANTAGES

MINIMUM VEHICLE TRANSIENT ERRORS

NO ENCODER RISK

COMMONALITY WITH DRIVE "A"

GREATER FLEXIBILITY IN MAN-LOOP SERVO CONFIGURATION

GREATER SERVO FLEXIBILITY FOR STABILIZING WITH THE STRUCTURE

LOW RATE CAPABILITY (0.01°/sec)

INCREASED RELIABILITY

DISADVANTAGES

HIGHER BEARING RISK

POSITION - RATE CONFIGURATION

ADVANTAGES

- LOWER BEARING RISK
- CAN HAVE LARGER NOISE IN D/A BUFFER

DISADVANTAGES

- HIGHER VEHICLE TRANSIENT ERRORS
- LESS SERVO FLEXIBILITY
- ENCODER RISK
- LIMITED LOW RATE CAPABILITY
- LOWER RELIABILITY

PROPOSED BASELINE

ERROR ANALYSIS

	PITCH	ROLL
BEARING NOISE	0.045	0.0144
GYRO NOISE	0.018	0.018
D/A INPUT NOISE	0.022	0.022
LOOP ELECT. NOISE	0.016	0.016
RMS GIMBAL	0.0555	.0355
RMS LOS	0.116	
2 LOS	0.232 sec.	

PROPOSED BACKUP

	PITCH	ROLL
BEARING NOISE	0.103	0.033
ELECTRONIC NOISE	0.032	0.032
QUANTIZING	0.53 max.	0.38 max.

95% PROBABILITY GIMBAL = 0.57 0.385

95% PROBABILITY LOS = 1.18 $\widehat{\text{sec}}$.

19 BIT ENCODER PITCH

20 BIT ENCODER ROLL

$\sum$ max = 62 DEGREES

60 RADIAN BANDWIDTH BOTH LOOPS

ENCODER ERROR

1/4 BIT MAX. AMP

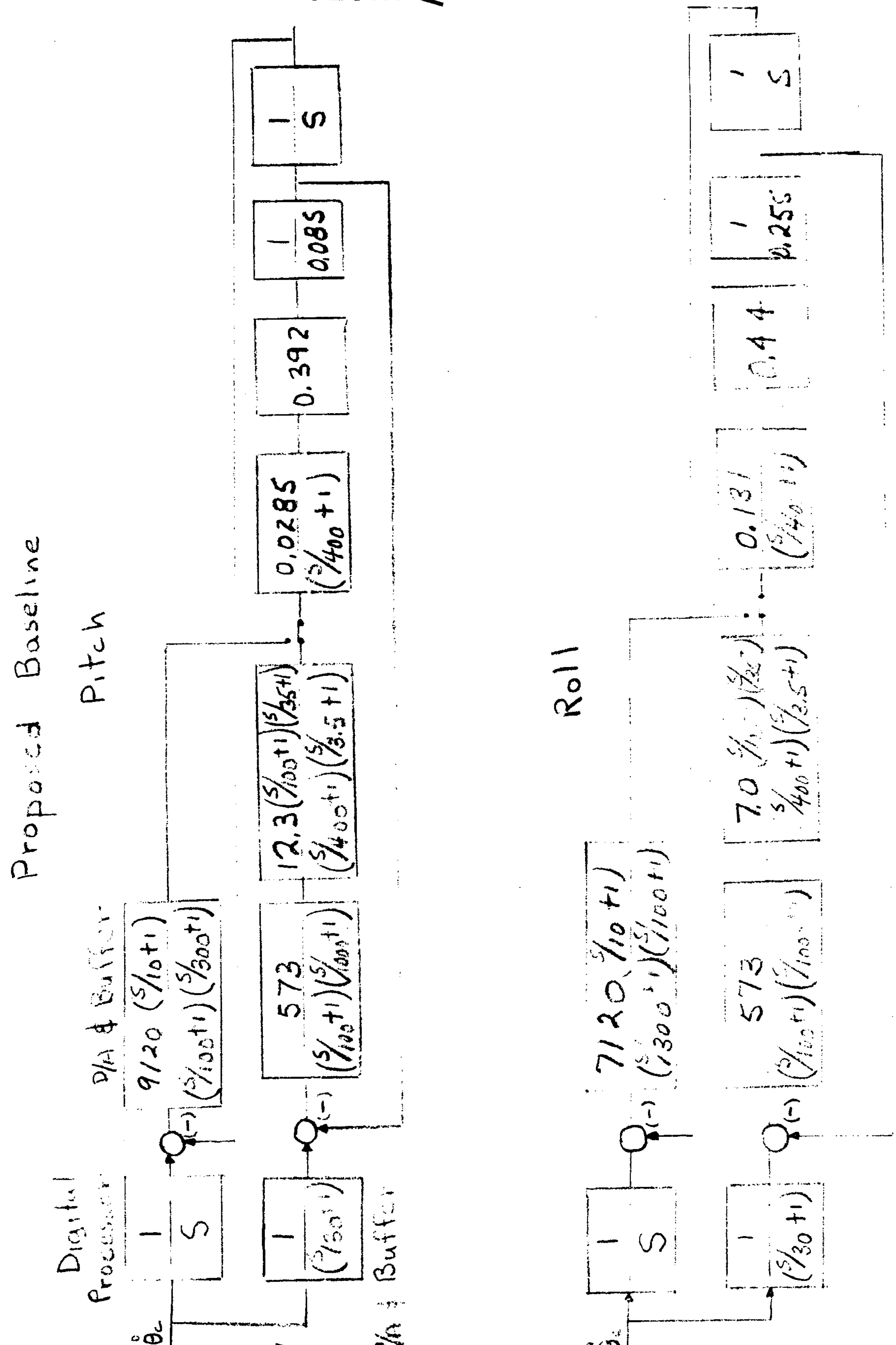
2nd. HARMONIC ERROR CONTENT

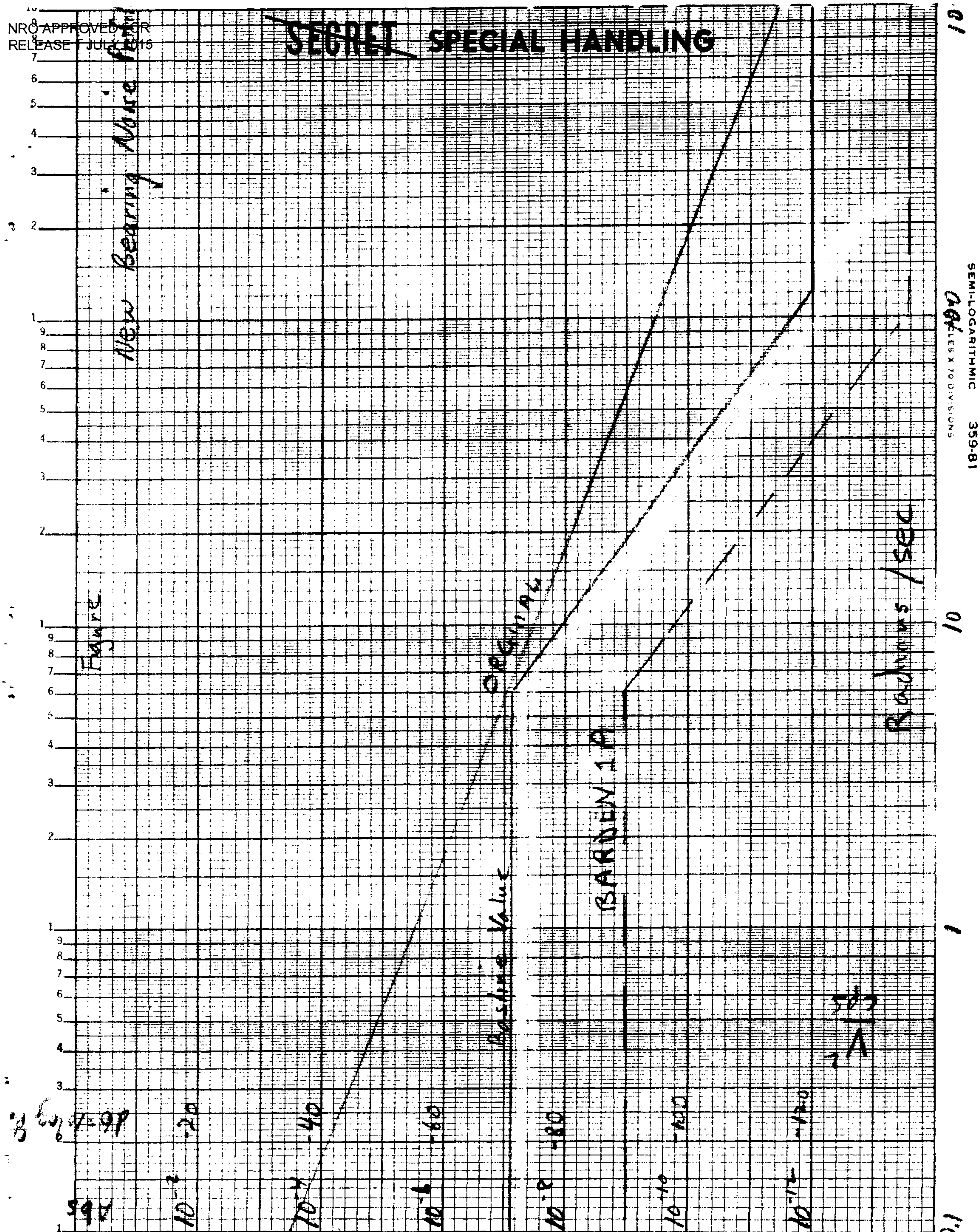
ERROR	18 BIT (RATE)	19 BIT (RATE)	20 BIT (RATE)
0.625	0.13 o/sec	0.065 o/sec	
0.3125	0.26	0.13	
0.156	0.52	0.26	0.065 o/sec
0.078	1.04	0.52	0.13
0.039		1.04	0.26

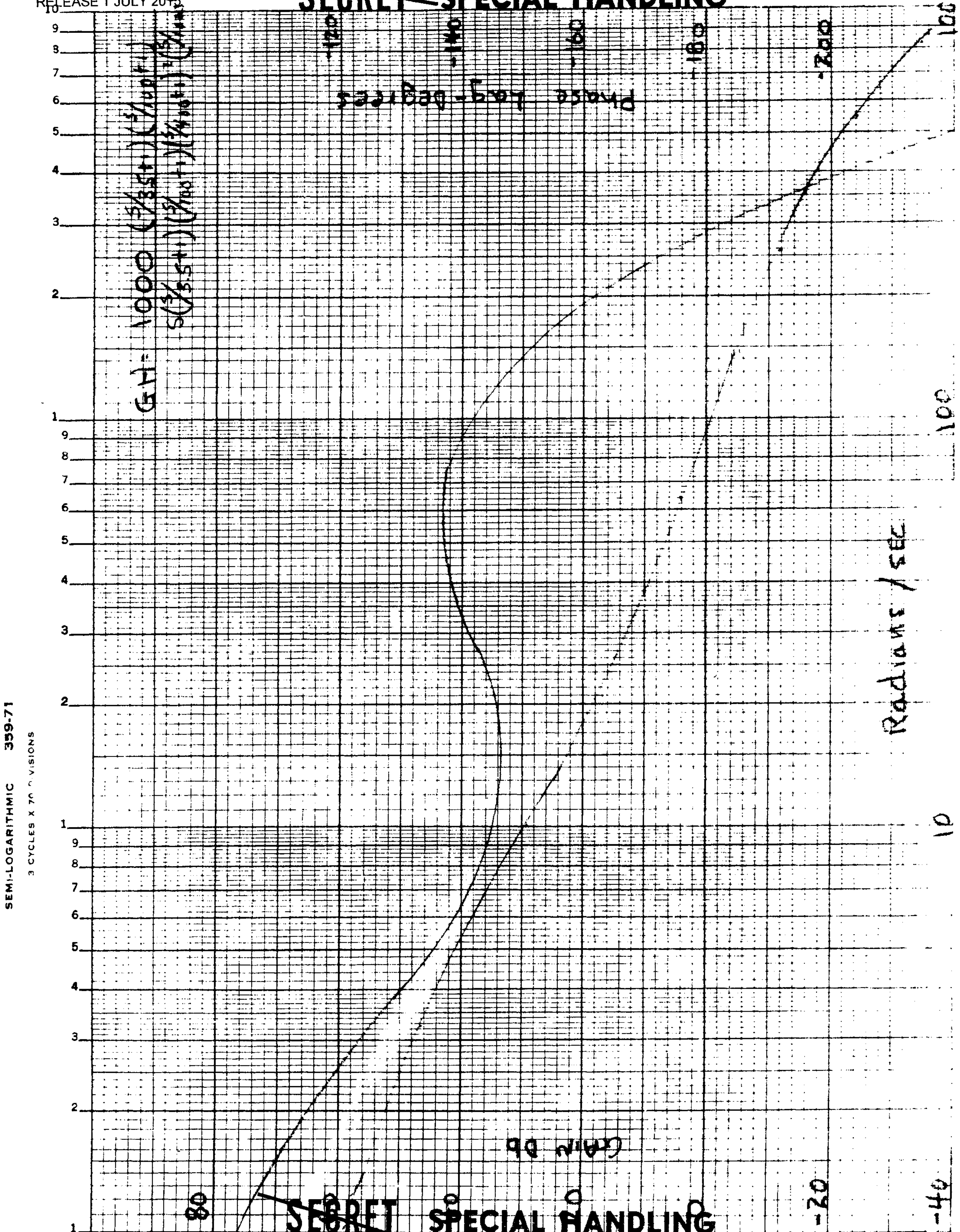
$$\frac{3600\ \theta^{o}}{Q \times 2^{n}} = \text{BW (cps)}$$

18 BIT ENCODER

$$\theta^{o} = \frac{6 \times 5 \times 16}{3600} = 0.13\ \text{o/sec}$$


Proposed Baseline
Pitch
Roll
Digital Processor
D/A & Buffer
Buffer


New Bearing
Figure
Original
Baseline Value
BARDEN 1A
Radians / sec
0.1
1
10
-20
-40
-60
-80
-100
-120
SEMI-LOGARITHMIC 359-81



Phase Lag-Degrees
Radians / SEC
Gain Db
-120
-140
-160
-180
-200
100
10
80
-20
-40
SEMI-LOGARITHMIC 359-71

SLEW

SLEW REQUIREMENTS

RATE ERROR $<$ 0.01 degrees/sec

POSITION ERROR $<$ 0.014 degrees

at $\frac{\Delta\theta}{30} + 1$ seconds after

START OF SLEW

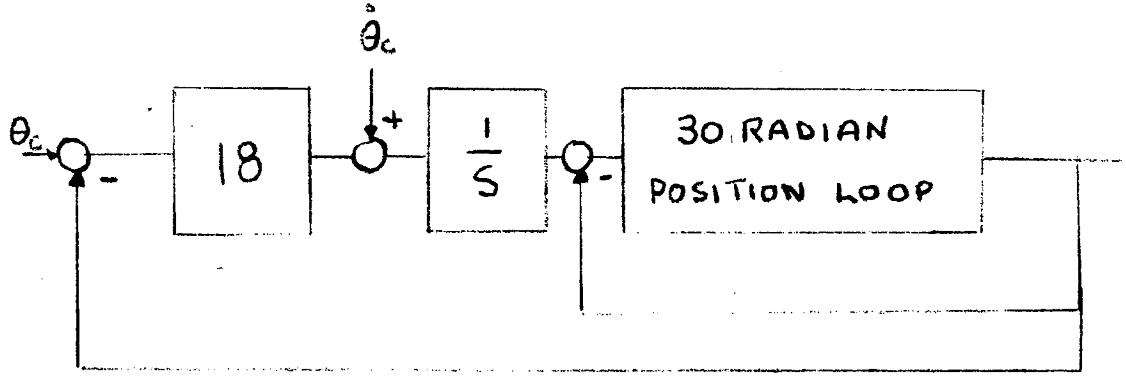
SLEW

SAME TECHNIQUE AS MAIN TRACKING MIRROR

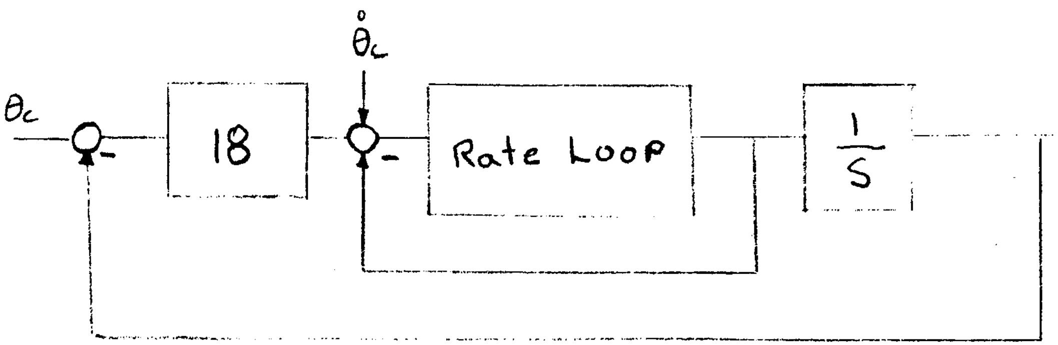
ADVANTAGES

- DEADBEAT OPERATION
- NO SATURATIONS
- MINIMUM STRUCTURAL EXICATION
- SOFTWARE COMMON WITH MAIN TRACKING MIRROR

SLEW SERVO CONFIGURATIONS



Pitch



Roll

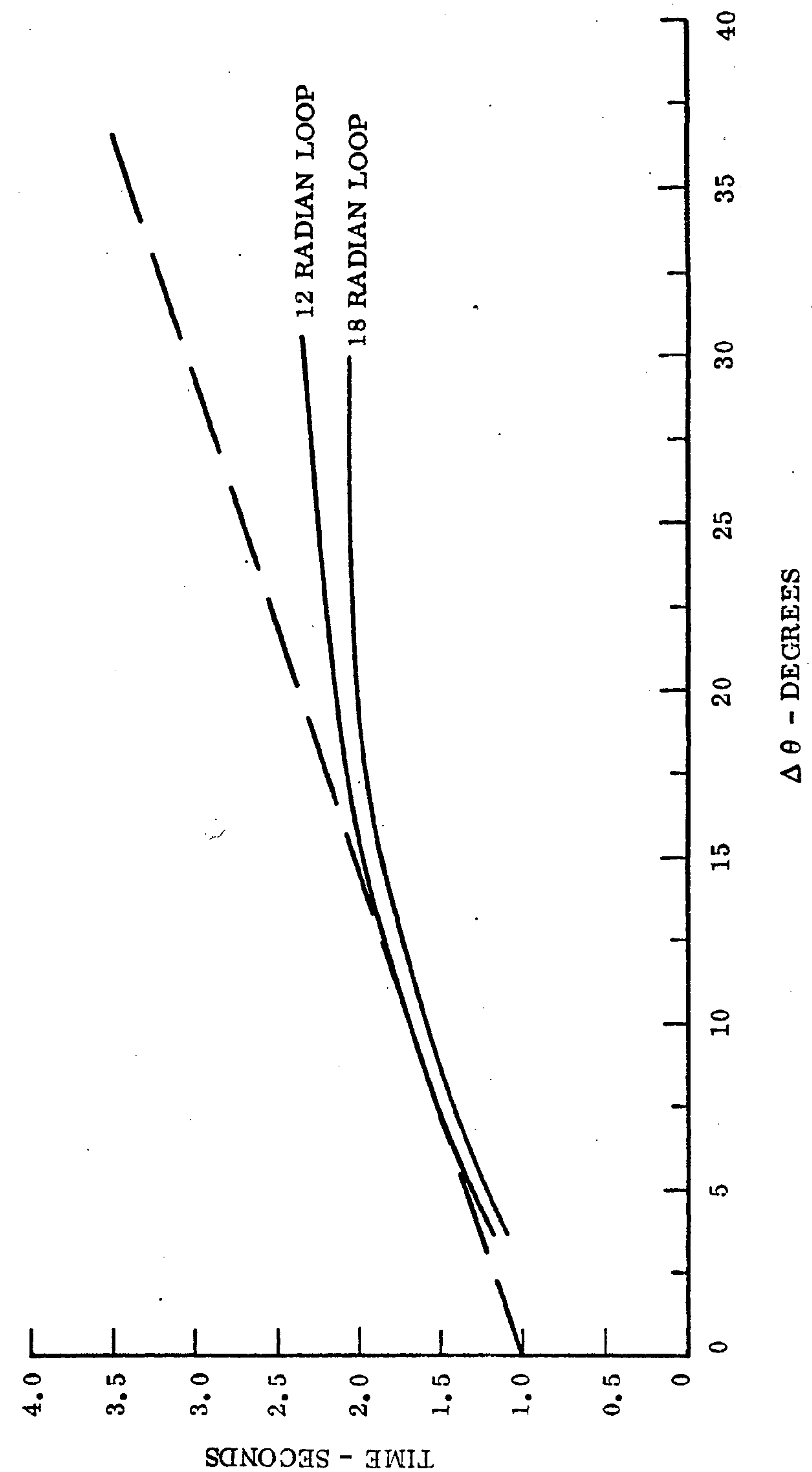
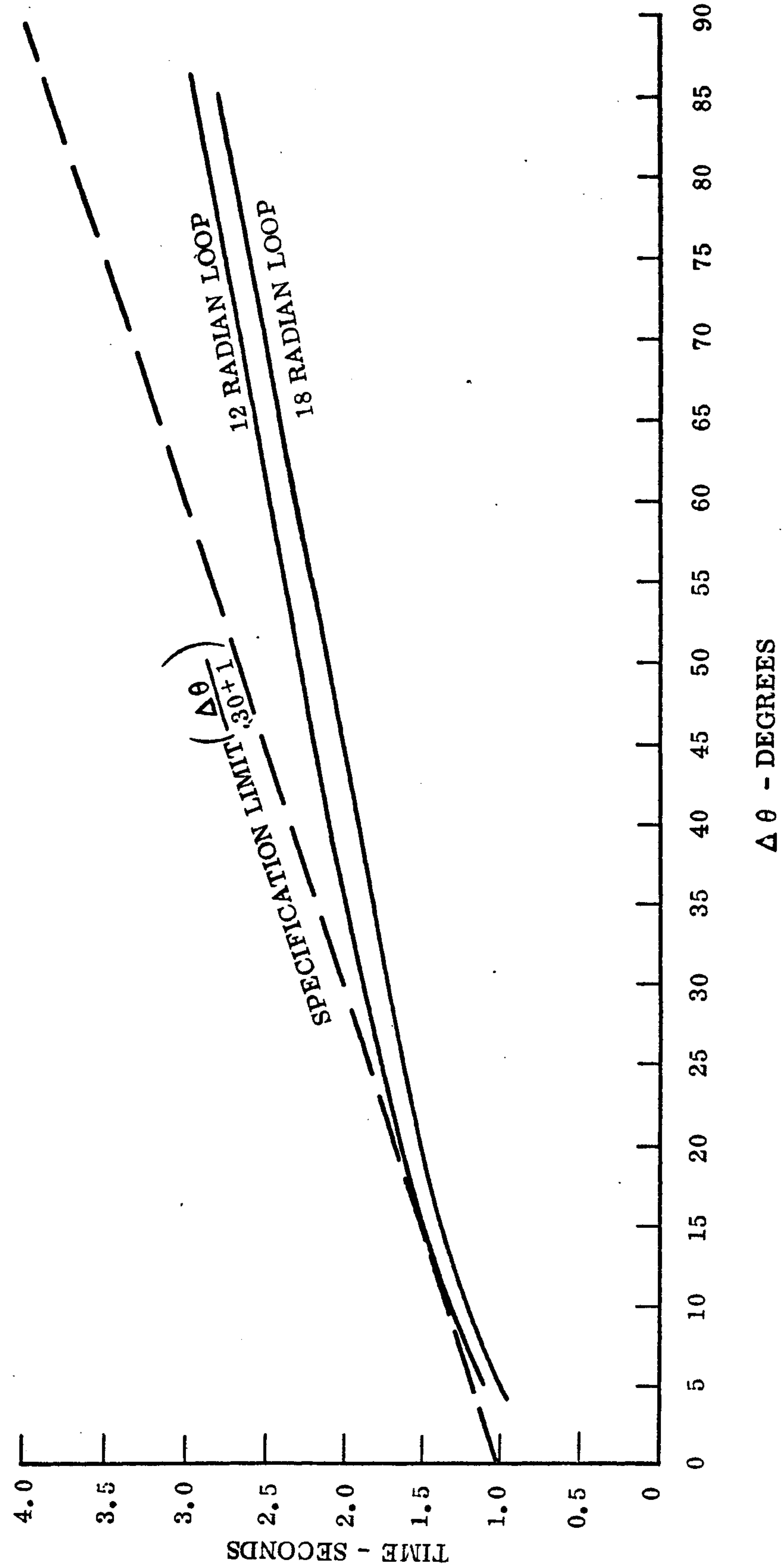


Figure 2.2-30. Pitch Slew Performance



12 RADIAN LOOP
18 RADIAN LOOP
SPECIFICATION LIMIT $\left(\frac{\Delta\theta}{30} + 1\right)$
$\Delta\theta$ - DEGREES
TIME - SECONDS
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

Figure 2.2-31.

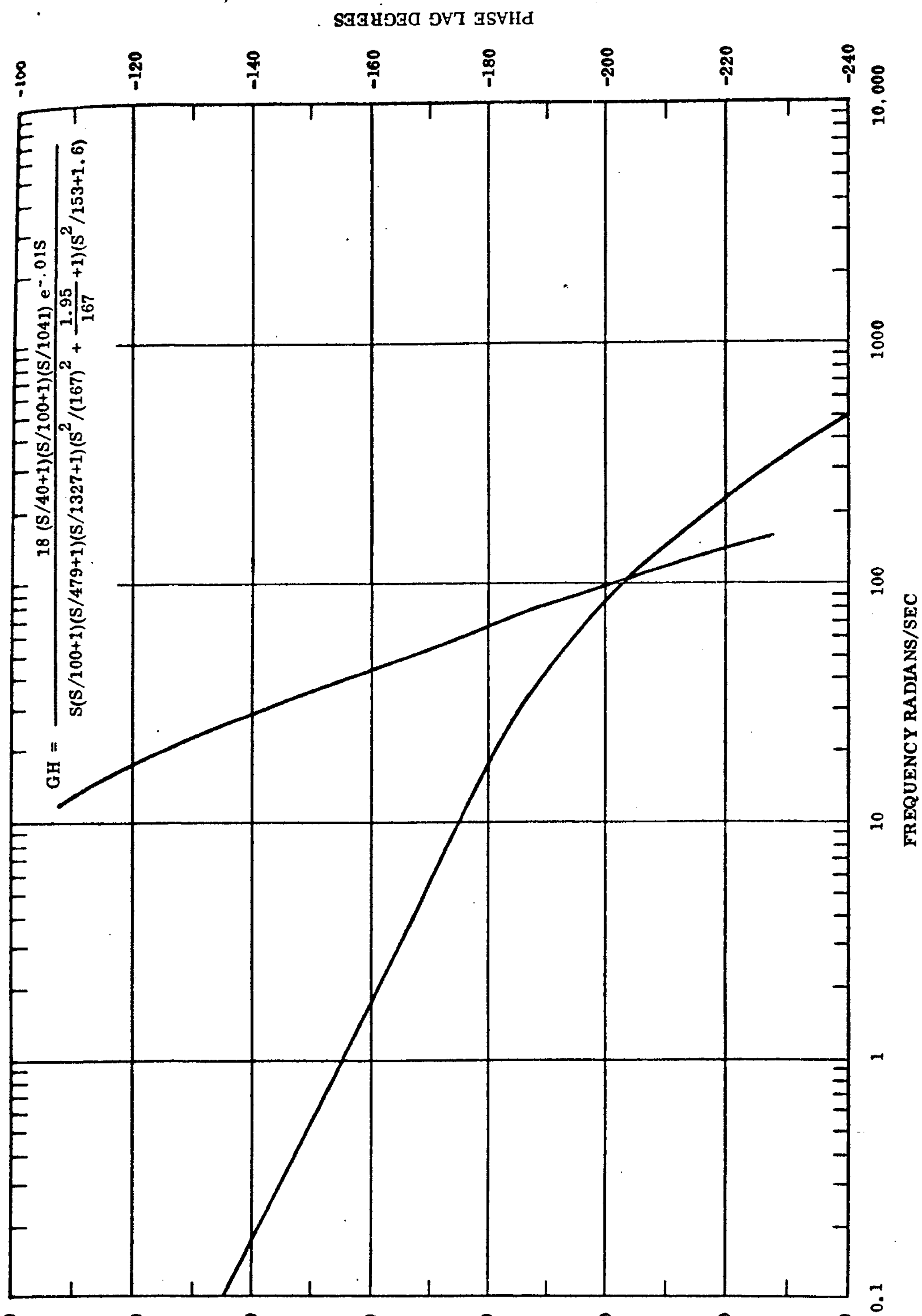


Figure 2.2-29. Open Loop Frequency Response of Pitch Slew Servo

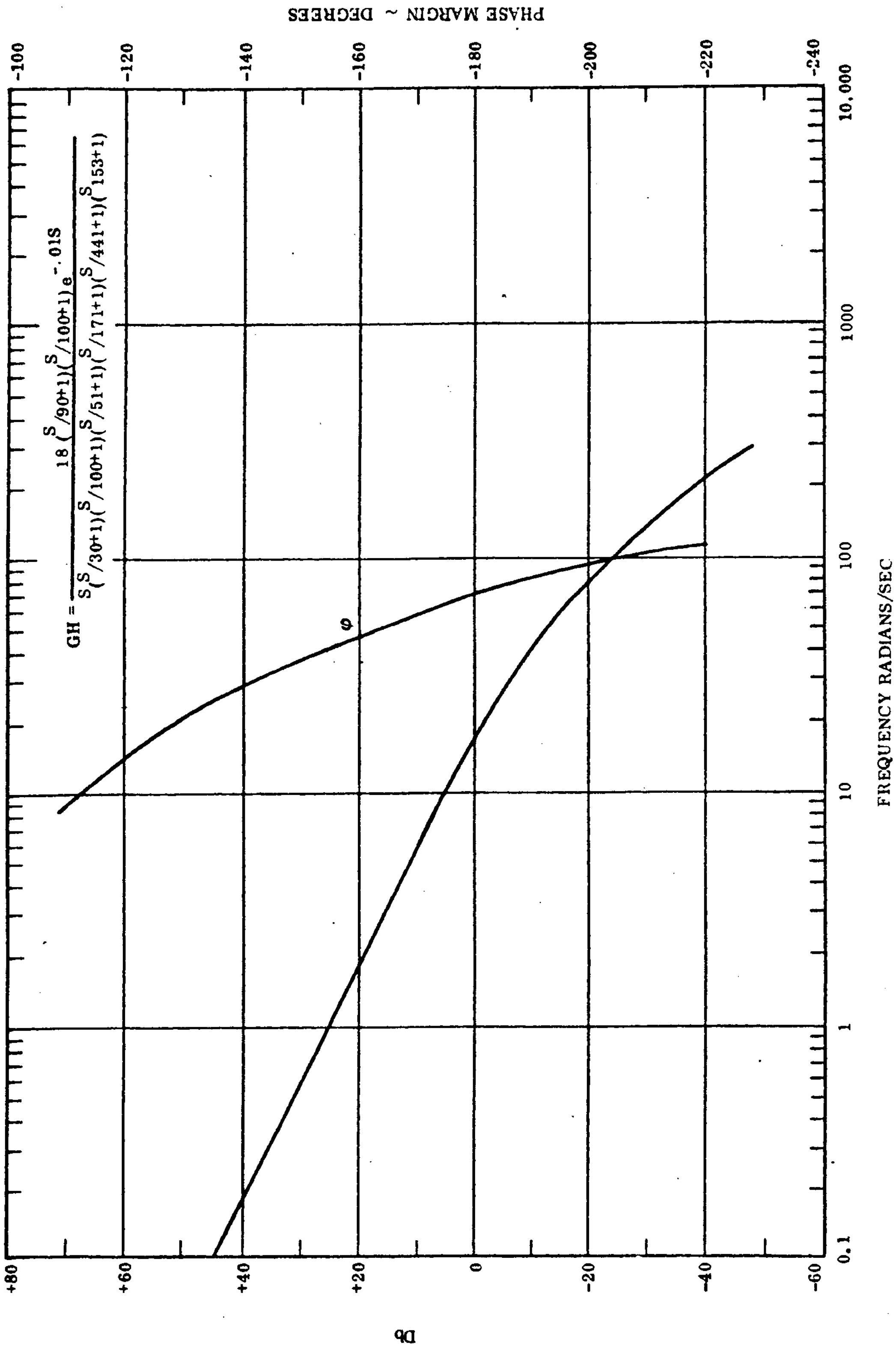
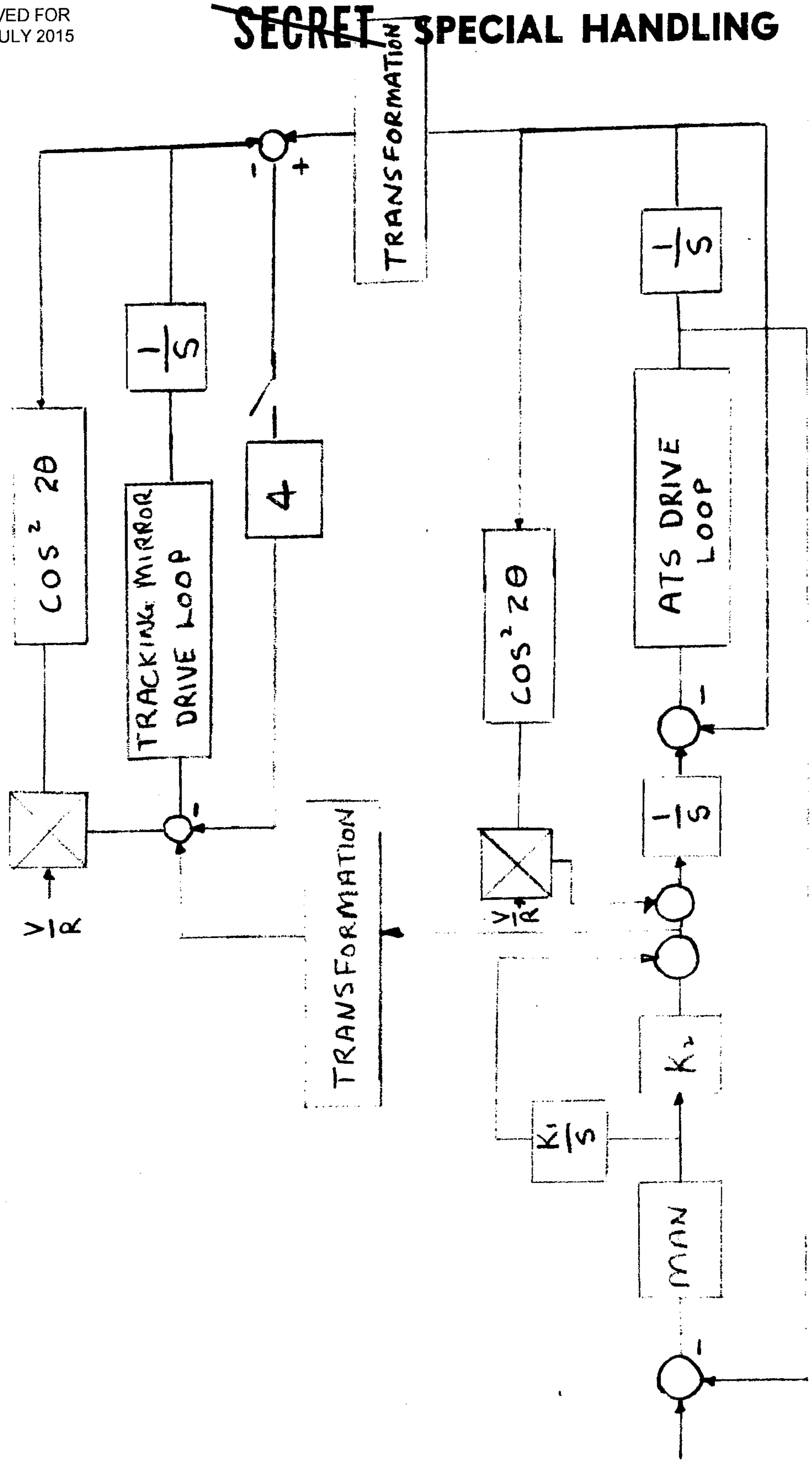


Figure 2.2-28. Open Loop Frequency Response Roll

SLAVING

SLAVING PERFORMANCE

STRUCTURAL VIBRATION	26 u rad/sec
TM SERVO NOISE	26 u rad/sec
ATS SERVO NOISE	45 u rad/sec
CREW ERROR	17 u rad/sec
SLAVING ERROR	20 u rad/sec
MISALIGNMENT ERROR	50 u rad/sec
RSS TOTAL	81 u rad/sec

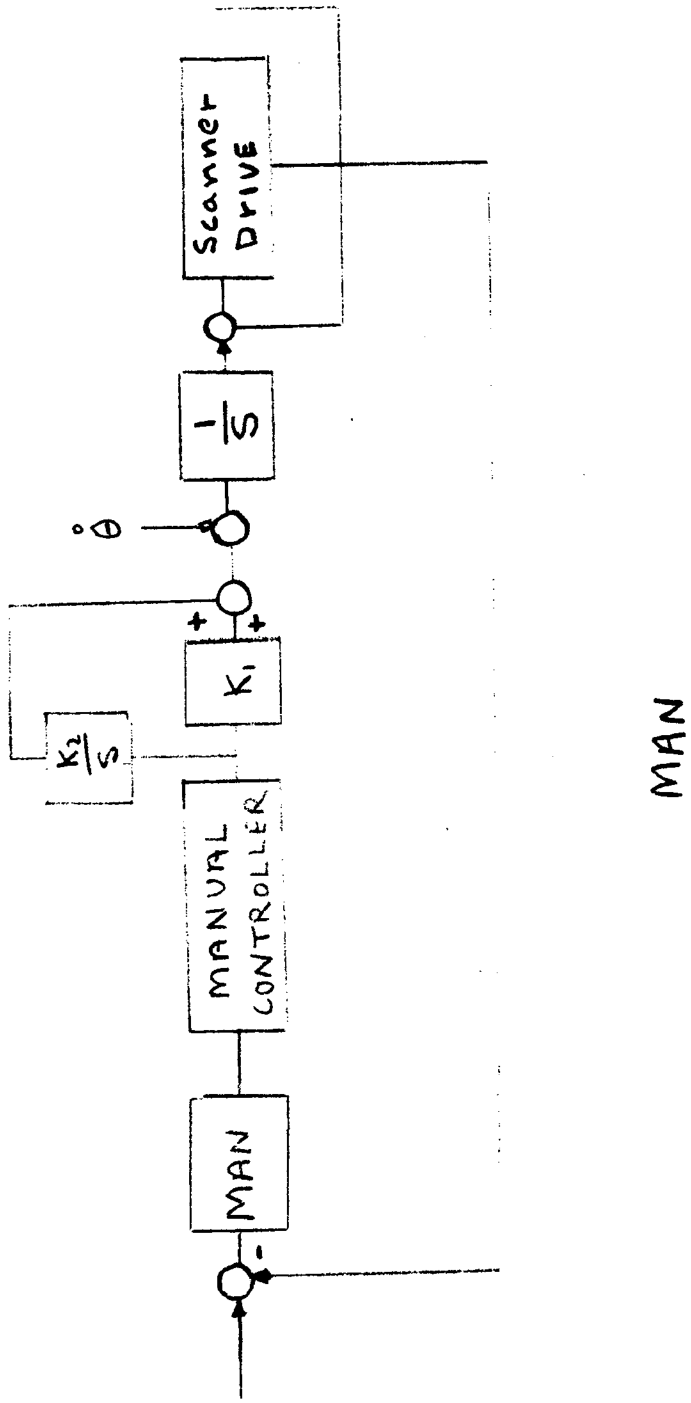

TRANSFORMATION
1/S
COS² 2θ
TRACKING MIRROR DRIVE LOOP
4
V/R
TRANSFORMATION
COS² 2θ
V/R
1/S
ATS DRIVE LOOP
1/S
K₂
K₁/S
MAN

METHOD #1

MAN-LOOP

Assumed Man Model

$$G_m = \frac{10\, e^{0.1S}}{\left(S/10 + 1\right)^2}$$


Scanner Drive
1/S
K1
K2/S
MANUAL CONTROLLER
MAN
MAN

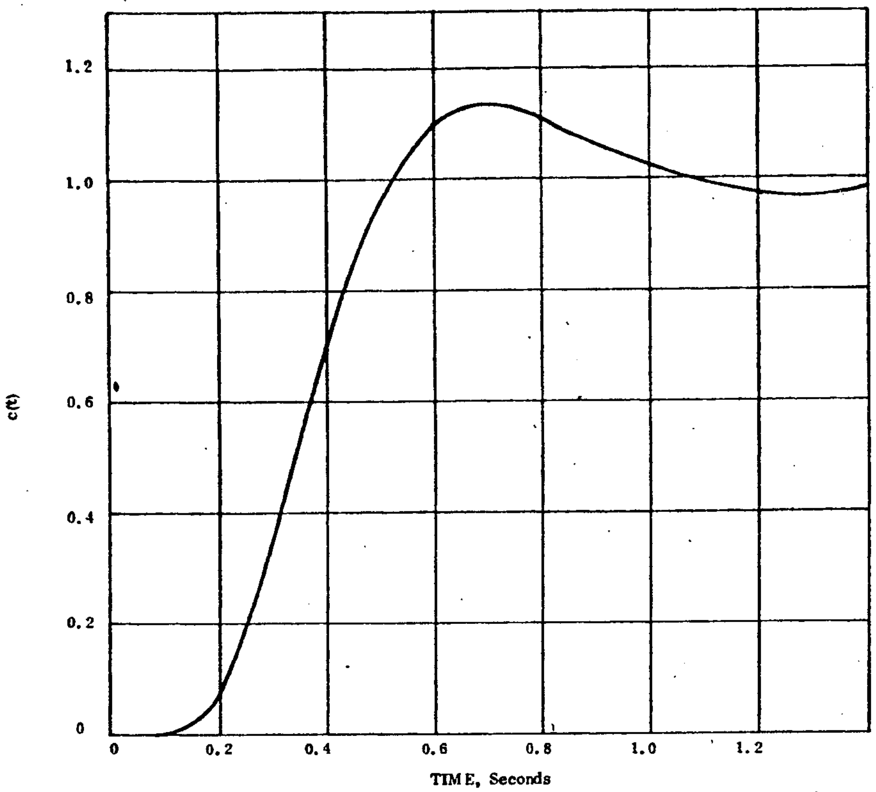
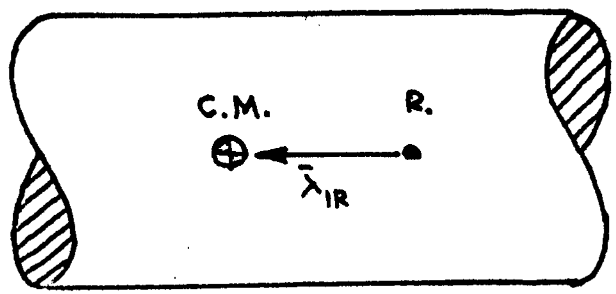


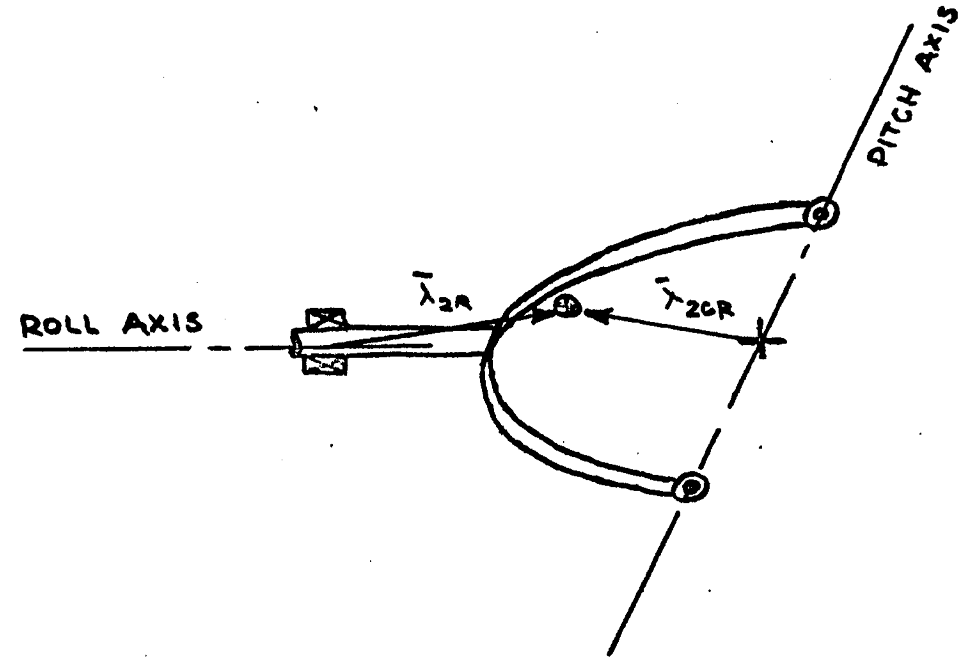
Figure 5-79. Response with Man in the Loop to a Unit Step Input

UNBALANCE AND PRODUCTS OF INERTIA



$$\bar{T}_1 = \bar{T}_{12} - \bar{\lambda}_{1R} \times \bar{f}_{12} - \bar{\lambda}_{1\ell} \dot{\times} \bar{f}_{1\ell} = \bar{\bar{I}}_1 \dot{\bar{\omega}}_1 + \bar{\omega}_1 \times (\bar{\bar{I}}_1 \bar{\omega}_1)$$

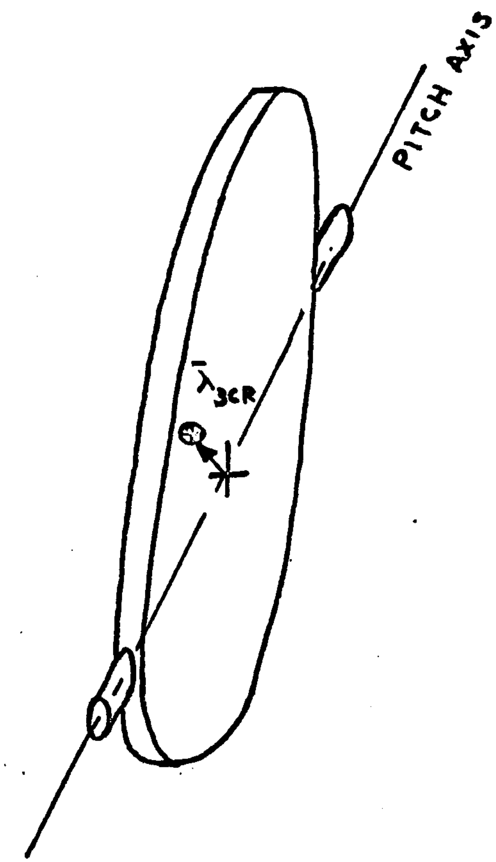
$$\bar{f}_1 = \bar{f}_{12} + \bar{f}_{1\ell} = m_1 \left[\bar{a}_R + \dot{\bar{\omega}}_1 \times \bar{\lambda}_{1R} + \bar{\omega}_1 \times (\bar{\omega}_1 \times \bar{\lambda}_{1R}) \right]$$



$$\bar{T}_2 = \bar{T}_{21} + \bar{T}_{23} + \bar{\omega}_2 \times \bar{H}_{GR} - \bar{\lambda}_{2R} \times \bar{f}_{21} - \bar{\lambda}_{2CR} \times \bar{f}_{23} = \bar{\bar{I}}_2 \dot{\bar{\omega}}_2 + \bar{\omega}_2 \times (\bar{\bar{I}}_2 \bar{\omega}_2)$$

$$\bar{f}_2 = \bar{f}_{21} + \bar{f}_{23} = m_2 \left[\bar{a}_R + \dot{\bar{\omega}}_2 \times \bar{\lambda}_{2R} + \bar{\omega}_2 \times (\bar{\omega}_2 \times \bar{\lambda}_{2R}) \right]$$

$$= m_2 \left[\bar{a}_{CR} + \dot{\bar{\omega}}_2 \times \bar{\lambda}_{2CR} + \bar{\omega}_2 \times (\bar{\omega}_2 \times \bar{\lambda}_{2CR}) \right]$$



$$\bar{T}_3 = \bar{T}_{32} + \bar{\omega}_3 \times \bar{H}_{OCR} - \bar{\lambda}_{3CR} \times \bar{f}_{32} = \bar{\bar{I}}_3 \dot{\bar{\omega}}_3 + \bar{\omega}_3 \times (\bar{\bar{I}}_3 \bar{\omega}_3)$$

$$\bar{f}_3 = \bar{f}_{32} = m_3 \left[\bar{a}_{CR} + \dot{\bar{\omega}}_3 \times \bar{\lambda}_{3CR} + \bar{\omega}_3 \times (\bar{\omega}_3 \times \bar{\lambda}_{3CR}) \right]$$

$$\bar{f}_{32} = -f_{23} = m_3 \Big[-\dot{\bar{\omega}}_1 \times \bar{\lambda}_{1R} - \bar{\omega}_1 \times (\bar{\omega}_1 \times \bar{\lambda}_{1R}) + \dot{\bar{\omega}}_2 \times \bar{\lambda}_{2R} + \bar{\omega}_2 \times (\bar{\omega}_2 \times \lambda_{2R})$$
$$- \dot{\bar{\omega}}_2 \times \bar{\lambda}_{2CR} - \bar{\omega}_2 \times (\bar{\omega}_2 \times \bar{\lambda}_{2CR}) + \dot{\bar{\omega}}_3 \times \bar{\lambda}_{3CR} + \bar{\omega}_3 \times (\bar{\omega}_3 \times \lambda_{3CR}) \Big]$$
$$+ \frac{m_3}{m_1} \bar{f}_{1e}$$

$$\bar{f}_{21} = -\bar{f}_{12} = (m_2 + m_3) \Big[-\dot{\bar{\omega}}_1 \times \bar{\lambda}_{1R} - \bar{\omega}_1 \times (\bar{\omega}_1 \times \bar{\lambda}_{1R}) + \dot{\bar{\omega}}_2 \times \bar{\lambda}_{2R} + \bar{\omega}_2 \times (\bar{\omega}_2 \times \bar{\lambda}_{2R}) \Big]$$
$$+ m_3 \Big[-\dot{\bar{\omega}}_2 \times \bar{\lambda}_{2CR} - \bar{\omega}_2 \times (\bar{\omega}_2 \times \bar{\lambda}_{2CR}) + \dot{\bar{\omega}}_3 \times \bar{\lambda}_{3CR} + \bar{\omega}_3 \times (\bar{\omega}_3 \times \lambda_{3CR}) \Big]$$
$$+ \frac{(m_2 + m_3)}{m_1} \bar{f}_{1e}$$

$$T_\theta = [0 \;\; 1 \;\; 0] \{T_{32}\}$$

$$= I_{Y3Y3}\dot{\omega}_{Y3} + I_{X3Y3}(\dot{\omega}_{3X3} + \omega_{3Y3}\omega_{3Z3}) + I_{Y3Z3}(\dot{\omega}_{3Z3} - \omega_{3X3}\omega_{3Y3})$$

$$+ I_{X3Z3}(\omega_{3Z3}^2 - \omega_{3X3}^2) + (I_{X3X3} - I_{Z3Z3})\omega_{3X3}\omega_{3Z3} - \omega_{3Z3}H_{GCRX3}$$

$$\bar{T}_{23} = -\bar{T}_{32}$$

$$T_{\phi} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \left\{ T_{21} \right\}$$

$$\begin{aligned}
= {} & I_{x2x2}\,\dot{\omega}_{2x2} + I_{x2y2}\left(\dot{\omega}_{2y2} - \omega_{2x2}\,\omega_{2z2}\right) + I_{x2z2}\left(\dot{\omega}_{2z2} + \omega_{2x2}\,\omega_{2y2}\right) \\
& + I_{y2z2}\left(\omega_{2y2}^{2} - \omega_{2z2}^{2}\right) + \left(I_{z2z2} - I_{y2y2}\right)\omega_{2y2}\,\omega_{2z2} \\
& + \cos\theta\left[I_{x3x3}\,\dot{\omega}_{3x3} + I_{x3y3}\left(\dot{\omega}_{3y3} - \omega_{3x3}\,\omega_{3z3}\right) + I_{x3z3}\left(\dot{\omega}_{3z3} + \omega_{3x3}\,\omega_{3y3}\right)\right. \\
& \qquad \left. + I_{y3z3}\left(\omega_{3y3}^{2} - \omega_{3z3}^{2}\right) + \left(I_{z3z3} - I_{y3y3}\right)\omega_{3y3}\,\omega_{3z3}\right] \\
& + \sin\theta\left[I_{x3z3}\left(\dot{\omega}_{3x3} - \omega_{3y3}\,\omega_{3z3}\right) + I_{y3y3}\left(\dot{\omega}_{3y3} + \omega_{3x3}\,\omega_{3z3}\right)\right. \\
& \qquad \left. + I_{z3z3}\,\dot{\omega}_{3z3} + I_{x3y3}\left(\omega_{3x3}^{2} - \omega_{3y3}^{2}\right) + \left(I_{y3y3} - I_{x3x3}\right)\omega_{3x3}\,\omega_{3y3}\right]
\end{aligned}$$

continued

$$
\begin{aligned}
T_\phi = & -m_2 \lambda_{2RY2} \lambda_{1RX1} \left[(-\dot{\omega}_{1Y1} + \omega_{1X1} \omega_{1Z1}) \cos\phi - (\dot{\omega}_{1Z1} + \omega_{1X1} \omega_{1Y1}) \sin\phi \right] \\
& - m_2 \lambda_{2RY2} \lambda_{1RY1} \left[(\dot{\omega}_{1X1} + \omega_{1Y1} \omega_{1Z1}) \cos\phi + (\omega_{1X1}^2 + \omega_{1Z1}^2) \sin\phi \right] \\
& + m_2 \lambda_{2RY2} \lambda_{1RZ1} \left[(\omega_{1X1}^2 + \omega_{1Y1}^2) \cos\phi + (-\dot{\omega}_{1X1} + \omega_{1Y1} \omega_{1Z1}) \sin\phi \right] \\
& + m_2 \lambda_{2RZ2} \lambda_{1RX1} \left[(\dot{\omega}_{1Z1} + \omega_{1X1} \omega_{1Y1}) \cos\phi + (-\dot{\omega}_{1Y1} + \omega_{1X1} \omega_{1Z1}) \sin\phi \right] \\
& - m_2 \lambda_{2RZ2} \lambda_{1RY1} \left[(\omega_{1X1}^2 + \omega_{1Z1}^2) \cos\phi - (\dot{\omega}_{1X1} + \omega_{1Y1} \omega_{1Z1}) \sin\phi \right] \\
& + m_2 \lambda_{2RZ2} \lambda_{1RZ1} \left[(-\dot{\omega}_{1X1} + \omega_{1Y1} \omega_{1Z1}) \cos\phi - (\omega_{1X1}^2 + \omega_{1Y1}^2) \sin\phi \right] \\
& + m_3 (\lambda_{2RZ2} - \lambda_{2CRZ2}) \lambda_{2CRZ2} (-\dot{\omega}_{2X2} + \omega_{2Y2} \omega_{2Z2}) \\
& + m_2 \lambda_{2RY2} (f_{1RZ1} \cos\phi - f_{1RY1} \sin\phi) / m_1 \\
& - m_2 \lambda_{2RZ2} (f_{1RY1} \cos\phi + f_{1RZ1} \sin\phi) / m_1 \\
& + \omega_{2Z2} H_{GRY2} + \omega_{3Y3} H_{GCRX3} \sin\theta
\end{aligned}
$$

$$\{x_2\} = [\Phi]\{x_1\}$$

$$\{x_3\} = [\Theta]\{x_2\}$$

$$\{\omega_2\} = [\Phi]\{\omega_1\} + \{\dot{\Phi}\}$$

$$\{\omega_3\} = [\Theta]\{\omega_2\} + \{\dot{\Theta}\}$$

$$\{\dot{\omega}_2\} = [\Phi]\{\dot{\omega}_1\} + \frac{d}{dt}[\Phi]\{\omega_1\} + \{\ddot{\Phi}\}$$

$$\{\dot{\omega}_3\} = [\Theta]\{\dot{\omega}_2\} + \frac{d}{dt}[\Theta]\{\omega_2\} + \{\ddot{\Theta}\}$$

$$T_\theta = A\ddot{\theta} + B\ddot{\phi} + C$$

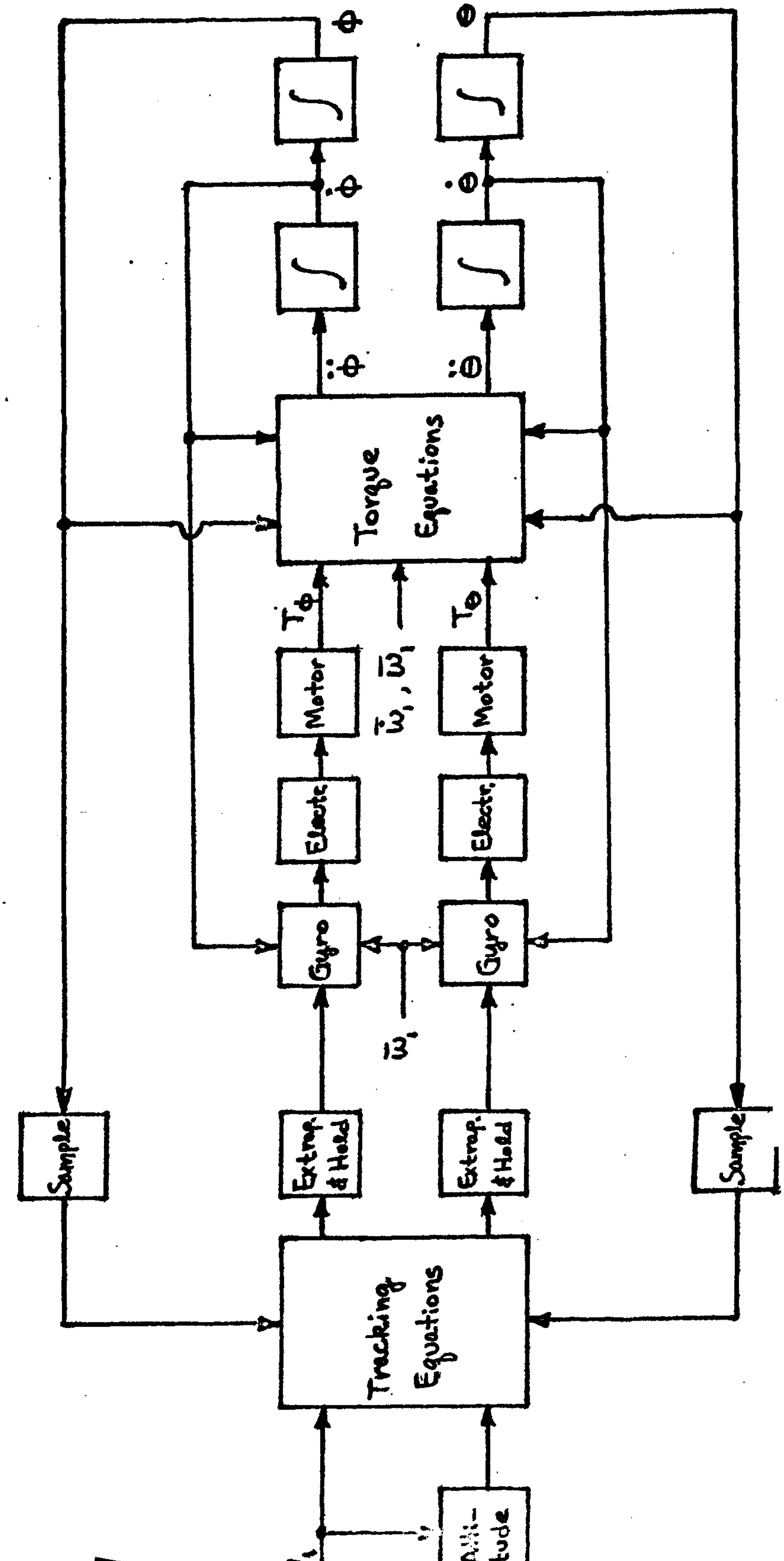
$$T_\phi = D\ddot{\phi} + B\ddot{\theta} + E$$

$$\ddot{\theta} = \left[D(T_\theta - C) - B(T_\phi - E) \right] / (AD + B^2)$$

$$\ddot{\phi} = \left[A(T_\phi - E) - B(T_\theta - C) \right] / (AD + B^2)$$

	PITCH	ROLL	
I_{xx}	.0778	.0906	(.208)
I_{yy}	.0903	.1307	
I_{zz}	.1564	.1778	
I_{xy}	-.0054	.0128	
I_{xz}	.0059	.0170	
I_{yz}	.0027	.0133	

	PITCH	ROLL
m	.811	.670
λ_{CRX}	0	-.506
λ_{CRY}	0	.030
λ_{CRZ}	0	-.006
λ_{RX}	-	.184
λ_{RY}	-	.030
λ_{RZ}	-	-.081


Torque Equations
Motor
Motor
Electr.
Electr.
Gyro
Gyro
Extrap. & Hold
Extrap. & Hold
Sample
Sample
Tracking Equations
Alti-tude

ACTION ITEMS ON S/C A

64 TOTAL

I	COMPLETED AND CLOSED	37
II	HELD OPEN PENDING DESIGN CONCEPT CHANGE ACCEPTANCE BY GE	8
III	CONSIDERED UNSATISFACTORY WITH WRITTEN COMMENTS TO S/C A	11
IV	STILL BEING WORKED AT S/C A AND/OR GE	8
		64

ACTION ITEMS ON GE

11 TOTAL

I	COMPLETED AND DOCUMENTED	9
II	PARTIALLY ANSWERED BUT STILL NOT COMPLETE	2
		11

ACTION ITEMS ON GE

ACTION ITEM #	SUBJECT	ANSWERED	DOCUMENTED FORM
13	ULTIMATE LOAD FACTOR IS 1.4 OR 1.25?	YES	PIR 7223-1098 AN #4 TO EC331B ALSO TO BE CHANGED IN DR 1100B
15	CONTROLS SPACING AND CRITERIA FOR SUITED OPERATION -- DUE FROM AF/AS	YES; GLOVED HAND INFO SENT	
17	WILL AN SHOCK LOAD DEFINITION	YES	AN #6 TO EC331B DR 1100B
19	DEFINE TELESCOPE ELECTRICAL CONNECTOR LOCATIONS	YES	MECH. ICD
24	SHOCK SPECTRA CURVE BELOW 10G'S	YES	PIR 7223-1057 DR 1100B
27	PLUME THERMAL CHARACTERISTICS	YES	7170-2920 7173-2889
28	THRUSTER OPERATING MODES	YES	7173-2840
30	HEAT FLUX PROFILE OF SHROUD AFTER FAIRING EJECT	YES	7173-3138
31	FLATNESS OF GYRO MOUNT	YES	MECH. ICD
53	BRIGHTNESS, COLOR AND SPACING FOR PERIPHERAL LIGHTS	NO; NEED COLOR YET	--
55	CONTAMINATION DEFINITION OF THRUSTOR PLUME, WASTE MANAGEMENT	NO; NEED WASTE MANAGEMENT DEF.	--

~~SECRET~~ SPECIAL HANDLING

S/C A PDR ACTION ITEM STATUS

I CONSIDERED COMPLETE AND CLOSED -- 37 TOTAL

2, 3, 4, 8, 9, 11, 12, 14, 16, 18, 21, 22, 23, 32, 33, 35, 39
42, 43, 46, 47, 48, 50, 51, 56, 57, 58, 59, 60, 61, 62, 63, 65
68, 69, 71, 73

II HELD OPEN PENDING DESIGN CHANGE ACCEPTANCE -- 8

#29 (SHROUD)

#41 (18 BIT ENCODER)

#44 (GIMBAL BALANCE WEIGHTS)

#49 (SHROUD DRIVE)

#52 (BRUSHLESS MOTOR)

#54 (BRUSHLESS MOTOR)

#72 (MANUAL REOPEN BLANKING SHUTTER)

#75 (FMEA'S OF DESIGN)

S/C A PDR ACTION ITEM STATUS (CONT'D)

III CONSIDERED UNSATISFACTORY WITH THE ENCLOSED WRITTEN COMMENTS TO S/C A -- 11

#5 THE ACTION ITEM RESPONSE IS NOT COMPREHENSIVE. THERE IS LITTLE DETAIL AS TO HOW THE SUBCONTRACTOR WILL MINIMIZE DOWNTIME. APPARENTLY, THE DESIGN HAS NOT PROGRESSED TO THE POINT THAT SPECIFIC MAINTENANCE CONSIDERATIONS HAVE BEEN DEVELOPED.

#6 THE RELIABILITY BLOCK DIAGRAM PROVIDED IS NOT ACTUALLY A RELIABILITY BLOCK DIAGRAM, PARTICULARLY CONSIDERING THE PRIME SAFETY FUNCTION OF THE MECHANISM. THE BLOCK DIAGRAM DOES POINT OUT SOME UNDESIRABLE FEATURES. FUNCTIONAL OR BLOCK REDUNDANCY SHOULD BE PROVIDED TO ASSURE PERFORMANCE OF THE BLANKING FUNCTION. THERE ARE SINGLE FAILURE ELEMENTS FOLLOWING THE LOGIC.

SOME ADDITIONAL COMPLEXITY WOULD RESULT IN PROVIDING REDUNDANCY FOR THE PRIME FUNCTION; HOWEVER, CONSIDERING THAT THIS IS AN EQUIPMENT USED ONLY IN THE MANNED MODE, THE UNBLANKING FUNCTION COULD BE MADE MANUAL WITH WARNING PROVISIONS AND APPROPRIATE PROCEDURES, AND THEREBY ELIMINATE THE MOTOR. THE BLANKING FUNCTION IS FAR MORE IMPORTANT THAN THE UNBLANKING FUNCTION.

IT IS RECOMMENDED THAT THE SUBCONTRACTOR PROVIDE REDUNDANCY FOR THE BLANKING FUNCTION TO THE EXTENT PRACTICAL AND THE RE-SET FUNCTION SHOULD BE MANUALLY PERFORMED.

#10 THIS ACTION ITEM HAS NOT BEEN ANSWERED SATISFACTORILY. ITEK HAS LEFT THIS ITEM OPEN UNTIL THEY ESTABLISH A TOLERANCE BUDGET WHICH CAN YIELD AN MTF WHICH MEETS THE SYSTEM REQUIREMENT. THIS TOLERANCE BUDGET WILL THEN BE USED TO MAKE A WORSE CASE ANALYSIS. THUS, THIS ITEM CANNOT BE CLOSED UNTIL THE BUDGET IS ESTABLISHED AND THE ANALYSIS PERFORMED.

#20 ACTION ITEM 20 DISCUSSED ALIGNMENT TECHNIQUES AND ACCURACY OBTAINABLE. IN A SUPERFICIAL WAY THE ACTION ITEM IS SATISFIED; HOWEVER, CONSIDERABLE JOINT EFFORT WILL BE REQUIRED TO GENERATE THE PROCEDURES NECESSARY TO RESOLVE THIS PROBLEM COMPLETELY. RECOMMENDATION IS FOR AN ICWG MEETING AFTER WE FIRST DEVELOP A FIRST CUT AT AN ALIGNMENT PROCEDURE.

S/C A PDR ACTION ITEM STATUS (CONT'D)

#25 ITEM #25 RESPONSE IS UNACCEPTABLE AS RECEIVED BECAUSE IT BEGGED THE SPECIFIC QUESTIONS TO WHICH IT WAS ADDRESSED.

THE ALTERNATE DESIGNS MENTIONED WERE INFEASIBLE DESIGNS. THE INTENTION OF THE ACTION ITEM IS TO IDENTIFY FEASIBLE DESIGNS AGAINST WHICH THE MERITS AND PENALTIES OF THE PYROTECHNIC APPROACH CAN BE TRADED. INFEASIBLE CONCEPTS SEEM TO BE NO CONTENT AND DON'T PROVIDE MUCH OF A TRADE.

THE TRADE STUDIES PRESENTED SEEM TO BE THE RESULTS OF STUDIES RATHER THAN THE STUDIES THEMSELVES, AS REQUESTED. THE ASSUMPTIONS, BASES, AND ANALYSES THAT YIELDED THE 0.5 INCH RELATIVE MOTION OF THE SCANNER WITH RESPECT TO THE SHROUD AND/OR LABORATORY MODULE AND THE 200 TO 300 LB. PIN FORCE ARE WHAT ARE REQUIRED BY THE ACTION ITEM.

#38 AN ARBITRARY ALLOTMENT OF MECHANICAL NOISE BETWEEN FLEX CABLE NOISE AND BEARING NOISE WAS MADE. NO ANALYSES OR BACKUP DATA WAS PRESENTED TO JUSTIFY THE ALLOTMENTS.

INTENT OF ACTION ITEM NOT SATISFIED.

#40 SEE ATTACHED COPY

#45 THIS ITEM WAS THE STRUCTURAL ANALYSIS OF THE TOTAL ACQUISITION SYSTEM STRUCTURE. THIS ACTION ITEM INCLUDED 14 ENCLOSURES. EACH ONE WILL BE DISCUSSED SEPARATELY.

ENCLOSURE 1 ANALYSIS OF YOKE -- THIS ANALYSIS IS CONSIDERED TO BE ADEQUATE AND SATISFIES THE REQUIREMENTS.

ENCLOSURE 2 ANALYSIS OF PEDESTAL -- THIS ANALYSIS IS CONSIDERED TO BE ADEQUATE AND SATISFIES THE REQUIREMENTS.

ENCLOSURE 3 ANALYSIS OF PROTECTIVE SHROUD -- THIS ANALYSIS IS NOT ADEQUATE. THE ANALYSIS DWELLS ON A NUMBER OF FITTINGS AND FAILS TO SHOW THE ADEQUACY OF THE SHROUD ITSELF. NO ANALYSIS HAS BEEN PERFORMED TO DETERMINE IF THE SHROUD MEETS THE DESIGN REQUIREMENTS. IT IS REQUESTED THAT AN ANALYSIS OF THE SHROUD BE PERFORMED. THIS ANALYSIS SHOULD REFLECT THE SHROUD DESIGN AS OF THE FEBRUARY 1, 1968 TD MEETING.

ENCLOSURE 4 ANALYSIS OF PRESSURE WINDOW -- THIS ANALYSIS IS CONSIDERED TO BE ADEQUATE AND SATISFIES THE REQUIREMENTS.

S/C A PDR ACTION ITEM STATUS (CONT'D)

#45 (CONT'D)

ENCLOSURE 5 ANALYSIS OF OBJECTIVE LENS ASSEMBLY

ENCLOSURE 6 ANALYSIS OF FIRST LOW POWER ASSEMBLY

ENCLOSURE 7 ANALYSIS OF SECOND LOW POWER ASSEMBLY

IN THE ABOVE ACTION ITEMS (5, 6 AND 7) MUCH ANALYSIS IS PERFORMED ON THE LENS ELEMENTS. THE LENS RETAINERS, RINGS, SPACERS, ETC., ARE ADEQUATELY ANALYZED, BUT THE STRUCTURE WHICH TIES THE LENS SYSTEM TOGETHER (THE TELESCOPE TUBE) IS NOT ANALYZED TO ANY EXTENT. IT IS FELT THAT THIS ANALYSIS IS OF THE UTMOST IMPORTANCE AND SHOULD BE PERFORMED AS SOON AS POSSIBLE.

ENCLOSURE 8 ANALYSIS OF INTERNAL FOLD MIRROR -- THE TITLE OF THIS ENCLOSURE IS DECEIVING. THE ENTIRE ANALYSIS DOES NOTHING BUT ANALYZE THE DUST COVER OVER THE INTERNAL FOLD MIRROR ACCESS HOLE. IN NO WAY IS THE MIRROR AND THE MOUNTING STRUCTURE ANALYZED. THIS SHOULD BE DONE BEFORE THIS ENCLOSURE IS CONSIDERED COMPLETE.

ENCLOSURE 9 ANALYSIS OF PECHAN PRISM ASSEMBLY -- THIS ANALYSIS IS CONSIDERED TO BE ADEQUATE AND SATISFIES THE REQUIREMENTS.

ENCLOSURE 10 ANALYSIS OF RETICLE ASSEMBLY

ENCLOSURE 11 ANALYSIS OF ZOOM ASSEMBLY

ENCLOSURE 12 ANALYSIS OF ZOOM CYLINDER

ENCLOSURE 13 ANALYSIS OF EYE PIECE

ENCLOSURE 14 ANALYSIS OF FILTER ASSEMBLY

OF THE FIVE ABOVE ACTION ITEMS, FOUR OF THEM CONSIST ONLY OF A DETERMINATION OF THE ASSEMBLY WEIGHT. THE ANALYSIS OF THE ZOOM CYLINDER IS MORE COMPLETE AND MEETS THE REQUIREMENTS, THE REMAINDER BEING INADEQUATE, SINCE, IN ESSENCE, NO ANALYSIS WAS PERFORMED.

ON THE WHOLE, THIS ACTION ITEM IS INADEQUATE. IN MOST INSTANCES, THE ANALYSIS COMPRISES VERY DETAILED ANALYSIS OF FITTINGS, ETC., BUT THE IMPACT OF THESE

S/C A PDR ACTION ITEM STATUS (CONT'D)

#45 (CONT'D)

ITEMS ON THE TOTAL STRUCTURE IS NOT IN ANY WAY DETERMINED. THIS IS ESPECIALLY TRUE IN THE TELESCOPE WHERE NO ANALYSIS WAS SHOWN ON THE TELESCOPE STRUCTURE ITSELF. THERE WAS NO ANALYSIS SHOWN ON THE TELESCOPE ELBOW WHICH IS FELT TO BE A CRITICAL ITEM. ALSO, NO ANALYSIS IS PRESENT ON THE TRACKING MIRROR BEZEL. THE ANALYSIS OF THE GYRO MOUNTING WOULD BE OF MUCH INTEREST. THERE WAS ALSO NO ANALYSIS SHOWN ON THE EXTERNAL FIXED FOLD MIRROR. IT SHOULD BE NOTED THOUGH THAT THE ANALYSIS OF THE YOKE AND PEDESTAL WAS VERY GOOD AND SHOULD BE USED AS A BASIS FOR FURTHER ANALYSIS.

#67 THE ACTION ITEM RESPONSE APPEARS TO BE A REASONABLE PRELIMINARY FMEA ON THE LOW POWER CHANGER. THIS RESPONSE IS RELATED TO THAT ON ACTION ITEM #70.

#70 THERE IS LITTLE DIFFERENCE IN RELIABILITY AS INDICATED BY THE PREDICTIONS FOR THE 4 POWER CHANGER CONFIGURATIONS. THE SELECTED CONFIGURATION APPEARS TO BE REASONABLE WITH THE POSSIBLE EXCEPTION OF THE SPIROID GEAR ARRANGEMENT. IT IS POSSIBLE THAT THIS COULD INTRODUCE UNDESIRED FORCES WHICH WOULD BE A PROBLEM. DETAILED MECHANICAL EVALUATION IS NECESSARY TO FURTHER EVALUATE THE SELECTION.

#74 SEE ATTACHED COPY.

IV STILL BEING WORKED AT S/C A AND/OR GE -- 8

ITEMS TO BE RECEIVED FROM S/C A

26 (WEIGHT REDUCTION TRADE STUDIES)

34 (DYNAMIC ANALYSIS)

64 (VIGNETTING)

66 (DYNAMIC ANALYSIS)

ITEMS BEING REVIEWED BY GE

1 CRITICAL PARTS LIST

7 COMPLIANCE TO MIL-S-38130A AND MIL-STD-470

36 BEARINGS -- TEST PLAN

37 BEARINGS -- HOUSING

GENERAL ELECTRIC
MISSILE AND SPACE DIVISION
PHILADELPHIA

~~SECRET~~ SPECIAL HANDLING

PROGRAM INFORMATION REQUEST/RELEASE

*CLASS. LTR.	OPERATION	PROGRAM	SEQUENCE NO.	REV. LTR.
U		7L73	007	

PIR NO.

*USE "C" FOR CLASSIFIED AND "U" FOR UNCLASSIFIED

FROM Leon Brown, Manager
Parts and Applications Engineering
Room 133, Radnor, Ext. 460

TO D. Smith, Development Engineer
Alpha Subsystem
Room 126, Radnor

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
2/21/68			

SUBJECT

ACTION ITEM NO. 74

INFORMATION REQUESTED/RELEASED

The list of materials contained in the subject action item has been reviewed. This list indicates that the subcontractor has not conformed to the Selected Materials List for the Lab Module - DR1115. Materials have been included which will require testing to assure meeting the program requirements. Specific comments are:

Manufacturer	Material	Designation	Remarks
Sanders	Mylar and Kapton	Flexprint	Kapton-Satisfactory Mylar-Unacceptable
Shell Oil	Apiezon	Lubricant	Requires Testing
Dow Corning	White Thermatrol Paint	92-0007	Requires Testing
Mystic Tape	Pressure Sensitive Al Tape	7042	Acceptable
Bendix	Glass Reinforced Epoxy	MIL-C-26411	Note 1
Cannon	Glass Filled Thermosetting	MDB1-37SH	Note 1
Gudebrod	Nylon Lacing Tape	MIL-T-713A	Acceptable
Aeroflex	Potting Compound	--	Requires Testing
Beckman	Lubricant	--	Note 2
Integrated Dynamics	Energy Absorbent Sponge	--	Requires Testing
Bacon Industries	Epoxy	LCA-4	Requires Testing
Dupont	Mylar Shim	--	Note 2
3M	Paint	3M-3101	Requires Testing

PMPE Staff
P. Martin
V. Ries
D. Smith (4)
P. Momberger

PAGE NO. 1 OF 3

RETENTION REQUIREMENTS

COPIES FOR	MASTERS FOR
1 MO.	3 MOS.
3 MOS.	6 MOS.
6 MOS.	12 MOS.
MOS.	MOS.
	DO NOT DESTROY

~~SECRET~~ SPECIAL HANDLING

FORM 1020 H REV. (9-65)

Manufacturer	Material	Designation	Remarks
PK Neuses	Marking Ink	--	Note 2
H. B. Fuller	Epoxy Resin	--	Note 2
GE	RTV Silastic	--	Cannot Identify. GE makes RTV but not Silastic
Microseal Corp.	Lubricating Compound	--	Requires Testing
Armstrong	Adhesive	A-6	Requires Testing
Dow Corning	Grease	FS1291	Note 2
Kaydon Eng.	Phenolic Retainer	KA42AH	Requires Testing
Dupont	Nylon	MIL-P-17091, Type 1	Requires Testing
GE	RTV 103	--	Requires Testing
3M	Cement	EC1022	Requires Testing
GE	Silicone Sponge Rubber	SE547 or AMS3195	Requires Testing
Chemical Develop. Corp.	CEPOX 402	--	Requires Testing
3M	Paint Primer	3101-C10	Requires Testing
AMP	Nylon	FM10001	Requires Testing
GE	RTV30	--	Requires Testing

NOTE 1: These materials are parts of connectors. Connectors will require prior approval as parts in accordance with DR1110. Because of the complexity of the connectors, when testing is required, it should be done on completed units.

NOTE 2: Requirements for these items are waived due to the small quantity of material present. Waiver applies to the application specified only.

It is strongly recommended that the subcontractor review the latest issue of DR1115, as a potential source for materials presently approved. This could result in appreciable reduction in the amount of testing required. Future contacts on the approval of materials should be made to G. R. Bretts, Manager, Materials Engineering at Building A, Room 20A35.

TO: D. Smith

FROM: L. W. Gooss

SUBJ: PDR Action Item No. 40

The action item response received may be considered compliant. It is not satisfactory, however. This sounds somewhat inconsistent, but what it means is that they apparently supplied all the information they had and that this information leads one to assume they are lacking in technical depth and experience in this particular area.

They have obviously spent some time investigating the flexible cable harnesses and have indicated several "novel" ideas. They do not indicate if these "novel" ideas have been used before in served applications requiring low torques disturbances. They do mention some past experience with the "roll-along" cable, but do not elaborate.

A great deal of analysis could have (and perhaps should have) been done to analyse the torque levels versus position, and the perturbation which might occur. Mathematical models could have been constructed with assumed conditions such as friction and contact conditions where the cable might touch the containing walls. Calculations of the effect of "g" loadings should have been made.

The test description is too vague. What speeds will they run, and what frequency response and resolution will test equipment have? How will they factor this into their system to arrive at performance degradation? Their definition of torque disturbance and noise was not given.

Insufficient information is given as the pitch configuration. It would appear that the arrangement they selected is not optimum. Simpler configurations might suffice and could offer advantages.

It is not known whether they intend to cable the entire device with one continuous run of flex cable. This could limit their design possibilities. In any event, they do not indicate the effect on torque of end restraints, e.g., clamps, connections, etc. While the torque disturbances (as opposed to static restraint) would be difficult to calculate, they could be estimated and empirically verified--if specifically looked for.

As an example of a somewhat better reply to a similar action item, I refer you to the response given by Kollsman to their Star Tracker PDR action item on this same subject. While not fully satisfactory, it does indicate some areas where further investigation could be performed.

[signature]

cc:
W. J. Manley
L. Petkofsky
G. R. Quasius
S. B. Hobbs

ATS & VDP OPTICAL ANALYSIS (QUESTIONS ONLY)

4. QUESTION: Page 2-76 - The correction of the mathematics is questioned (706.5 - 708).

ANSWER: The equations on page 2-76 are correct; however, an error occurred in the numerical evaluation. As a simplification the slant range may be expressed as

$$d = \frac{h}{\cos\beta}\left[1 + \frac{h}{2R}(\tan\beta)^2\right]$$

where

$$\frac{h}{\cos\beta} = d_{flat} = \text{flat earth range}$$

and

$$\frac{h}{2R}(\tan\beta)^2 = \text{correction}$$

The following values may be determined

H n mi.	B deg.	Correction	d flat n mi	d n mi
80	70	.087	234	254
230	70	.25	673	875

Page 2-76 then should read:

The slant range at 70° and 80 n mi goes from 234 n mi to 254 n mi on a curved earth, on 8.7 per cent increase. At 230 n mi altitude at 70° the slant range is 673 n mi for a flat earth and 875 n mi on a curved earth which is a 25 per cent increase. At 80 n mi altitude the 8.7 per cent increase will increase the defocus error by approximately 8.7 per cent and will then amount to 0.0033 in. At 230 n mi. altitude, even with the 25 per cent increase, the defocus amounts to only 0.0031 well within eye accommodation as is the worst case at 80 n mi.

5. QUESTION: What are the effects on the adjustments on the reticle of the Acquisition Optics?

ANSWER: This is covered in detail on page 2.74, Section 2.1.4.5 - "Focus" of the Engineering Analysis Report. Briefly, the defocus due to this cause will be 0.14 diopters. The depth of focus of the eye is 0.5 diopters. The depth of focus of the eye is sufficient to compensate for this defocus.

17. QUESTION: What are the focus characteristics of the peripheral display lights relative to the scene?

ANSWER: The peripheral display will be placed in such a position in relation to the aerial image so as to require minimum eye accommodation.

18. QUESTION: Are GE/Sub following on these recommendations? (Tolerances on curvature radii; triplet instead of doublet).

ANSWER: GE and Subcontractor "A" are following up recommendations.

(1) Doublet radii should be selected such that all tolerances are plus or all tolerances are minus on a given assembly.

(2) The triplet will not be used. Latest estimates on weight indicate an increase of 10 lb. each for incorporation of the triplet. System performance can be met with the doublet.

19. QUESTION: The results contained in Table 2.1 - 3 indicate a definite need for corrective action. Resolution provided in some cases worse than using a window.

ANSWER: We have no specification for off-axis performance. The need for improvement is not apparent. We will provide Itek analysis of this problem as soon as it is available. We would be interested in seeing Aerospace analysis using CDC6600 computer program when results are available.

20. QUESTION: What about field curvature off axis resolution trade off?

ANSWER: Fully discussed in Section 3.6 P 201 of EAR.

21. QUESTION: No consideration was given in EAR on tilting and decentering tolerances.

ANSWER: That is correct. This problem was covered extensively in Itek's PDR report, Section 3.6.5, Page 3.6 - 84. Fabrication and alignment Tolerances. No attempt was made to duplicate work in EAR that was adequately covered in Subcontractor's PDR Report.

22. QUESTION: Discuss tests which will be used to verify optical performance of the flight hardware.

(22) ANSWER: Test used to verify performance have not been described to date. The philosophy used in preparing these test plans will be to provide detail tests during manufacture and assembly to insure that the performance curve provided in the Itek PDR Report is in fact the "worse case" that will be accepted for flight use.

52a. QUESTION: What is status of your spec to subcontractor.

ANSWER: The specification EC331B has been negotiated with Itek through Section 3. In Section 4, there are two items that have not been resolved. Both involve environmental test on the scanner, fixed fold, and window relative to salt fog, rain, propellant compatability, explosive atmosphere, and wind. These items are currently being negotiated.

ANSWER (52b continued)

(10)	3.1.1.1.21	Mechanical stops on zoom
(11)	3.1.1.1.22	Changed 5° obscuration to 3° Changed 70 lights to 35 lights added TBD brightness
(12)	3.1.1.1.23	Blanking fail safe
(13)	3.1.1.1.23	Manual Unblanks of FOV
(14)	3.1.1.1.25	Leakage Requirement - 100 cc/day/inch of Seal. Operational 5 hours after launch operational 3 hours after pressurization.
(15)	3.1.1.2.1	References defining scanner axis tolerance Change from ± 0.5 arc minutes to ± 0.25 arc minutes.
(16)	3.1.1.2.3	Field of View 60 degrees
(17)	3.1.1.2.4.1	Blanking Override
(18)		Reliability for Peripheral Display added.
(19)	3.1.2.3	Useful Life Prism Positionings 12,000 Shroud Door 500
(20)	3.2.1.1.4	Operating voltage and ripple, and power interrupt
(21)	3.3.1.1	Weight 166
(22)	3.3.1.2	Power 105 Pulse 110 (60MS)
(23)	3.3.1.3	Safety Factors added per DR1100

52b. QUESTION: Is "A" Spec different than one included in Volume 1 of the "A" PDR?

ANSWER: Yes. Spec in Vol. 1 of "A" PDR was based on EC331B. Changes from EC331B are outlined as follows:

(1) 3.1.1.1.1 Change tolerance on max. mag. 127X

(2) 3.1.1.1.2 Resolution

Old 3.3 ft. per line pair ground resolution on orbit.

New 3.3 ft. per line pair ground resolution (analysis)

3.0 ft. per line pair ground resolution simulated in laboratory (demonstration)

(3) 3.1.1.1.3 Maximum vignetting 60% over entire scan field

(4) 3.1.1.1.7 Change scanner gimbal inertia from .12 to .08 and .20 to .23.

(5) 3.1.1.1.9 Changed lower rate from .14 deg/sec to .10 deg/sec (max. 40 deg/sec).

(6) 3.1.1.1.11 Add stops to pechan prisms

(7) 3.1.1.1.12 Space allocation for cue mechanisms only

(8) 3.1.1.1.19 Range of focus + 3.5 to - 2.5 diopters added

(9) 3.1.1.1.20 Add resolution at four magnification points.

Resolution	3.3	6.6	13.2	26.4
Magnification	127.0	63,5	31.75	15.88

ANSWER (52b continued)

(24) 3.3.1.4 Steady state design load factors added

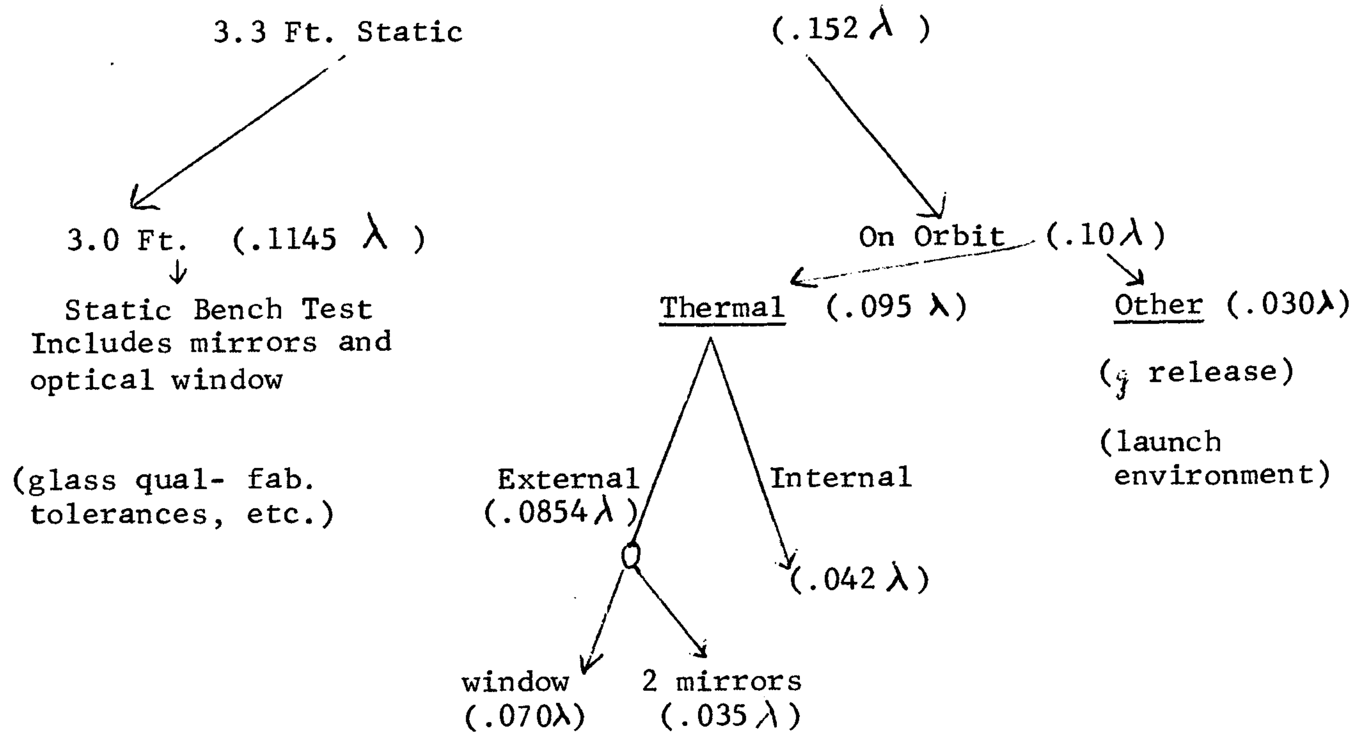
(25) 3.3.1.5 Wiring (Kapton) added

(26) 3.3.1.2 Cleanliness added

Surface: Per ST9802 Level 500

Packaging: Maintain ST9802 line 500

Expansion of Itek Error Allocation Per 3.1.1.1.2



53. QUESTION: Discuss any changes which are currently under negotiations?

This information is covered in the answers to 52a and 52b.

SUMMARY OF ACQUISITION SUBSYSTEM PERFORMANCE PREDICTION ANALYSIS

- STATIC PERFORMANCE

  SUMMARY OF ANALYSIS IN SECTION 2.1.3 OF EAR REPORT

  RESOLUTION AS A FUNCTION OF INPUT CONTRAST RATIO

  STATISTICAL PREDICTION OF SYSTEM RESOLUTION

- DYNAMIC PERFORMANCE

  SUBSYSTEM PERFORMANCE AS A FUNCTION OF HALF-AMPLITUDE L.O.S. JITTER (MONOTONIC)

- DISCUSSION OF JITTER EXPERIMENT AT SUBCONTRACTOR ALPHA

- FUTURE WORK

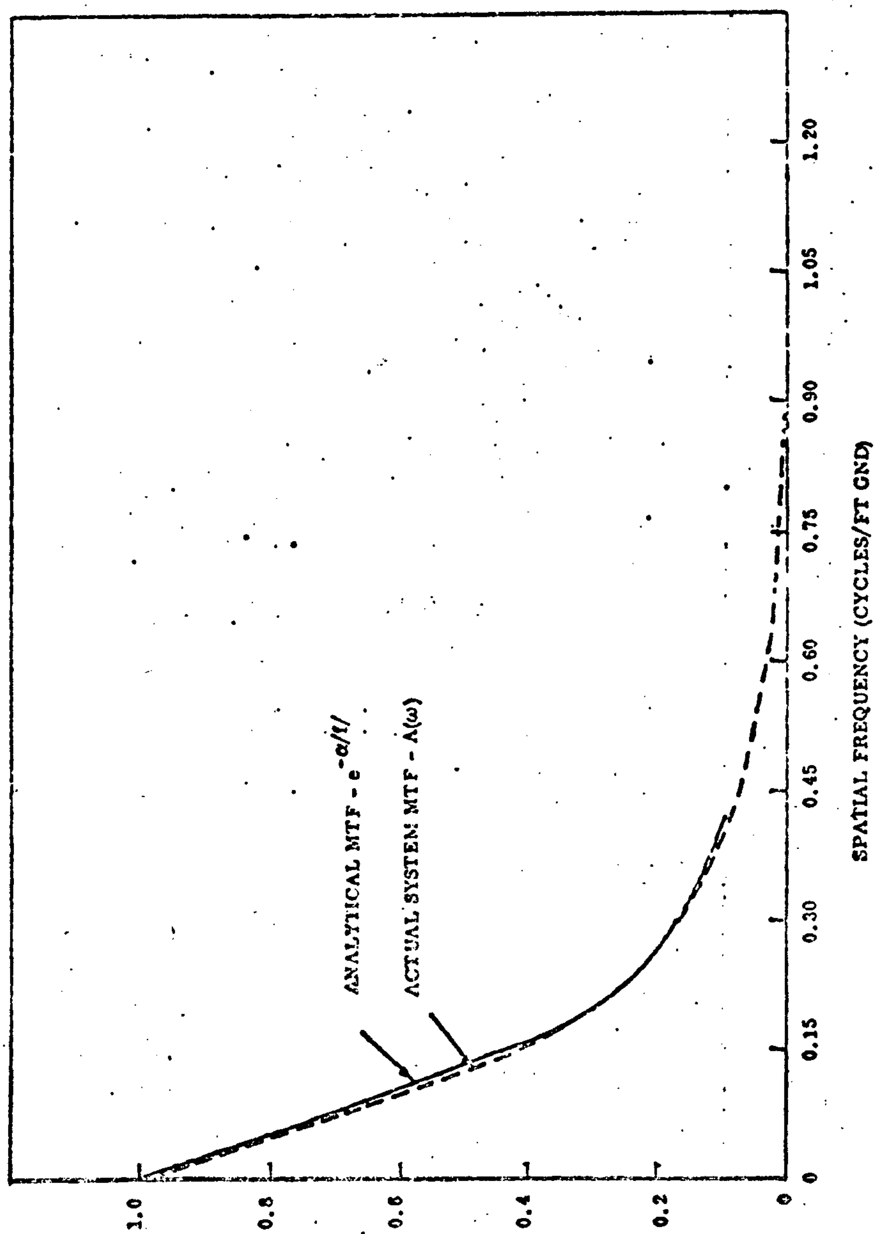
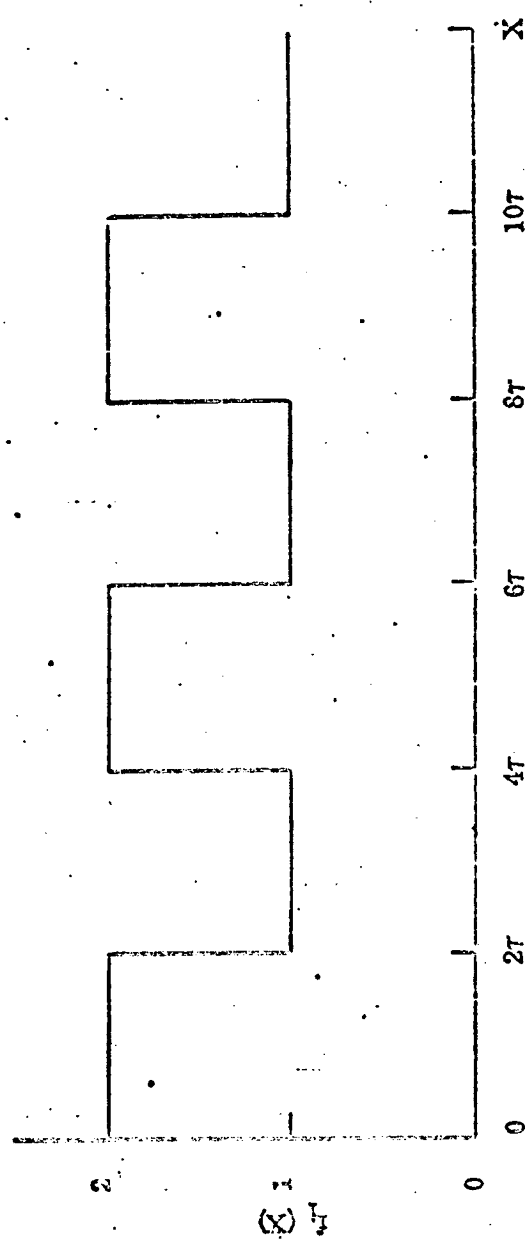


Figure 2.1-20. Acquisition Telescope Transfer Function

2-45



τ = 0.9 FT

Figure 2.1-22. Graphic Representation

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The ordinate of the output waveform $f_o(X)$ at $X = X_1$ is the product of the two functions with $\lambda = X$. For an input square wave with a period of 3.6 feet per line pair ($\tau = 0.9$ feet) the resultant output waveform is:

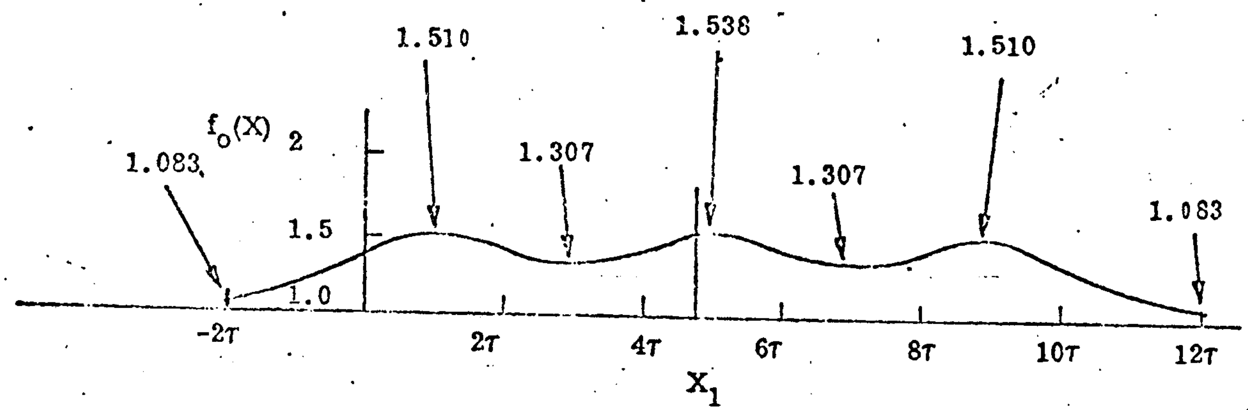
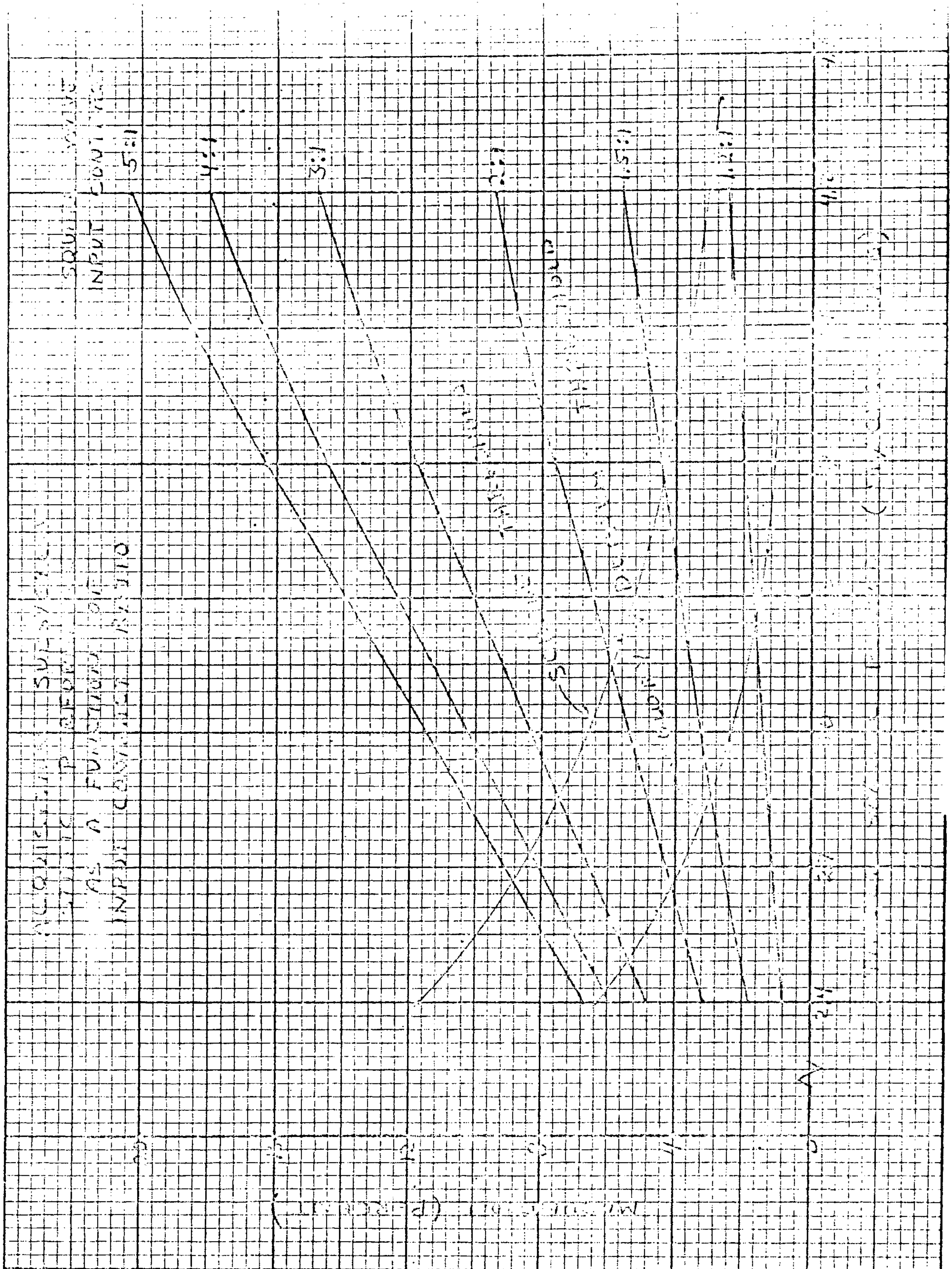
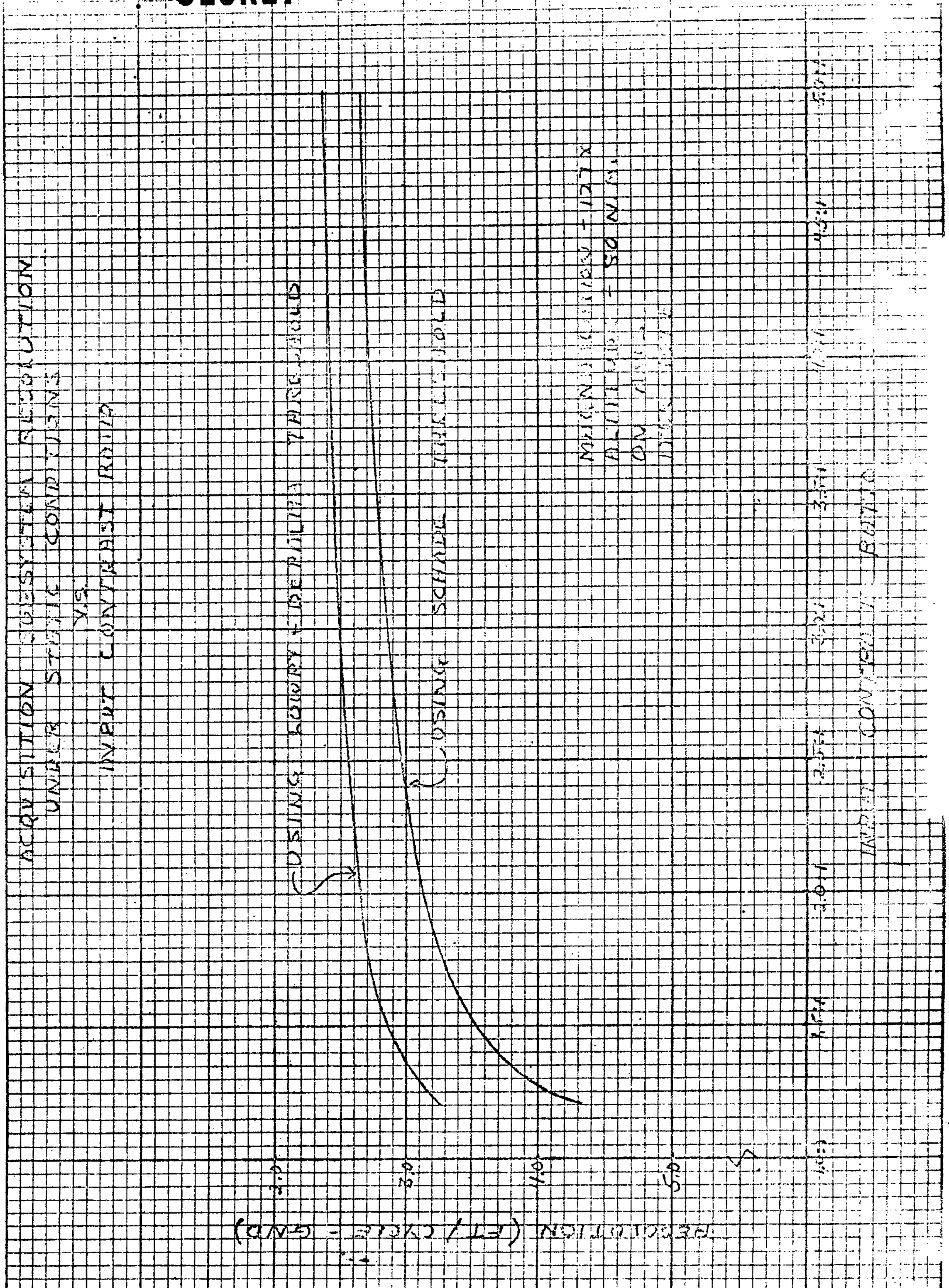
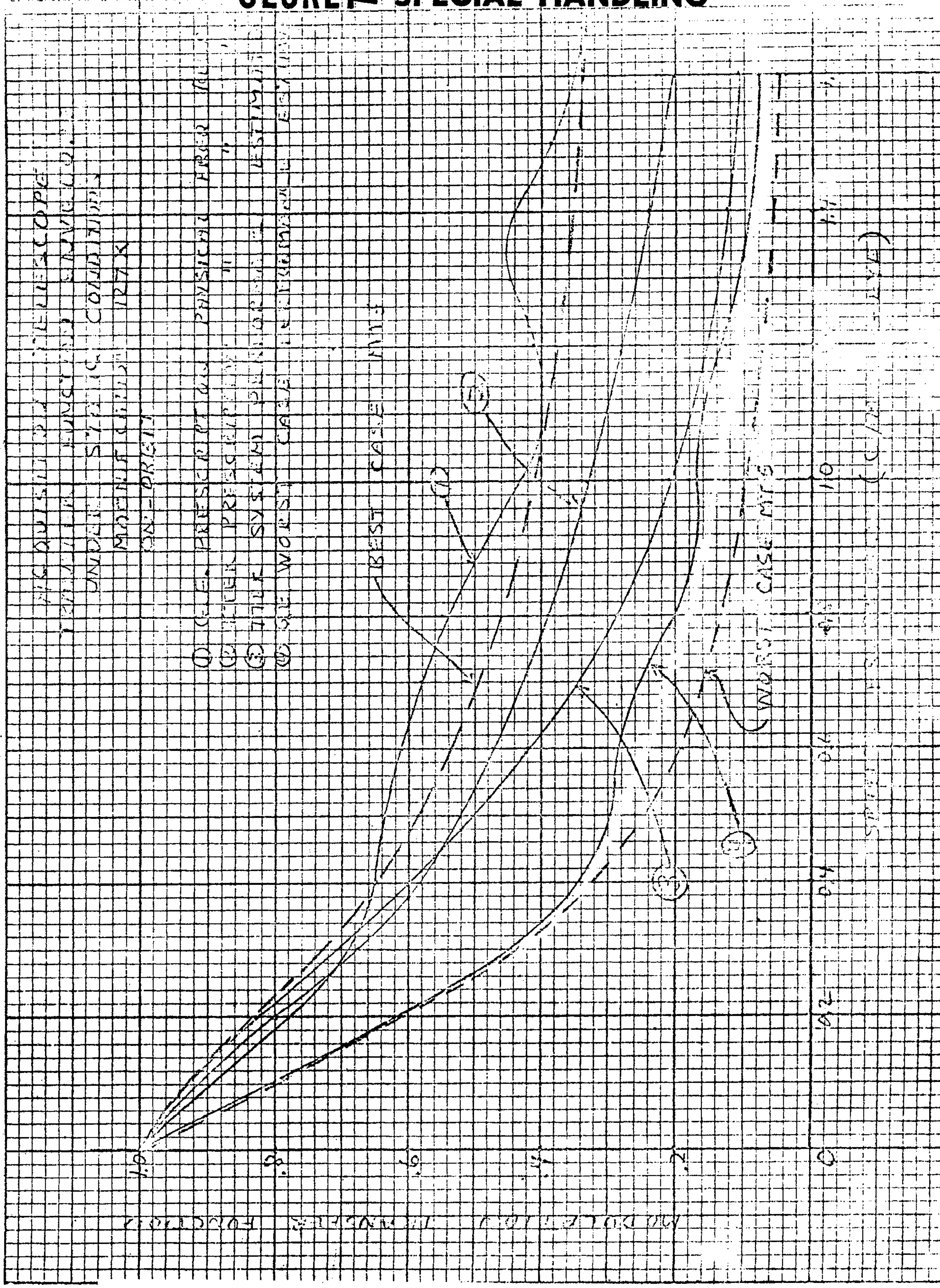
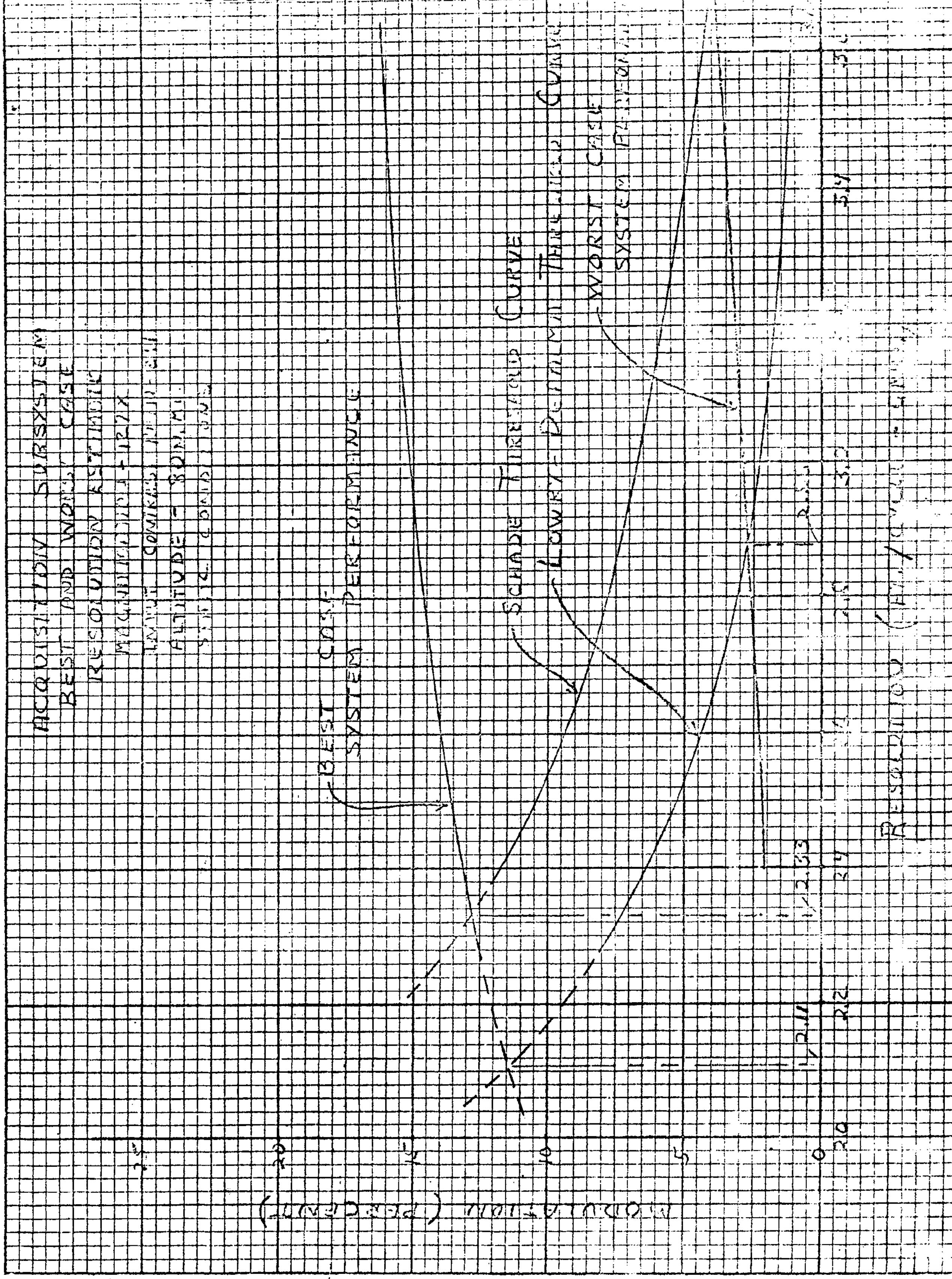


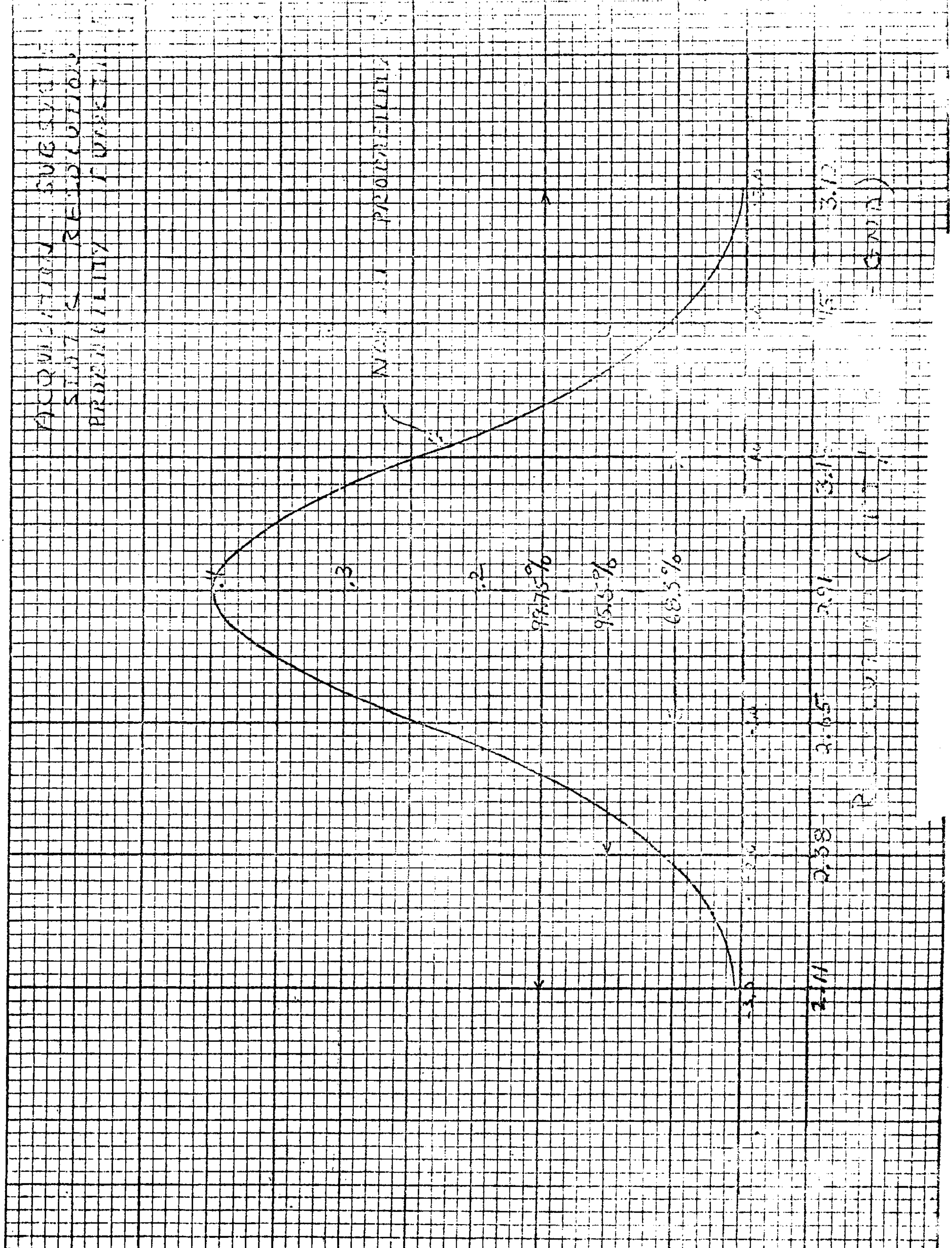
Figure 2.1-26c. Graphic Interpretations


5:1
4:1
3:1
2:1
1.5:1


ACQUISITION SUBSYSTEM RESOLUTION
UNDER STATIC CONDITIONS
VS
INPUT CONTRAST RATIO
USING LOWRY + DEPALMA THRESHOLD
USING SCHADE THRESHOLD
2.0
3.0
4.0
5.0
RESOLUTION (FT / CYCLE - GND)
INPUT CONTRAST RATIO


BEST CASE MTF
WORST CASE MTF
1.0
.8
.6
.4
.2
0
1.0


ACQUISITION SUBSYSTEM
BEST AND WORST CASE
BEST CASE
SYSTEM PERFORMANCE
SCHADE THRESHOLD CURVE
LOWRY-DEPALMA THRESHOLD CURVE
WORST CASE
SYSTEM PERFORMANCE
MODULATION (PERCENT)


99.75%
95.5%
68.5%
2.11
2.38
2.65
2.91
3.1

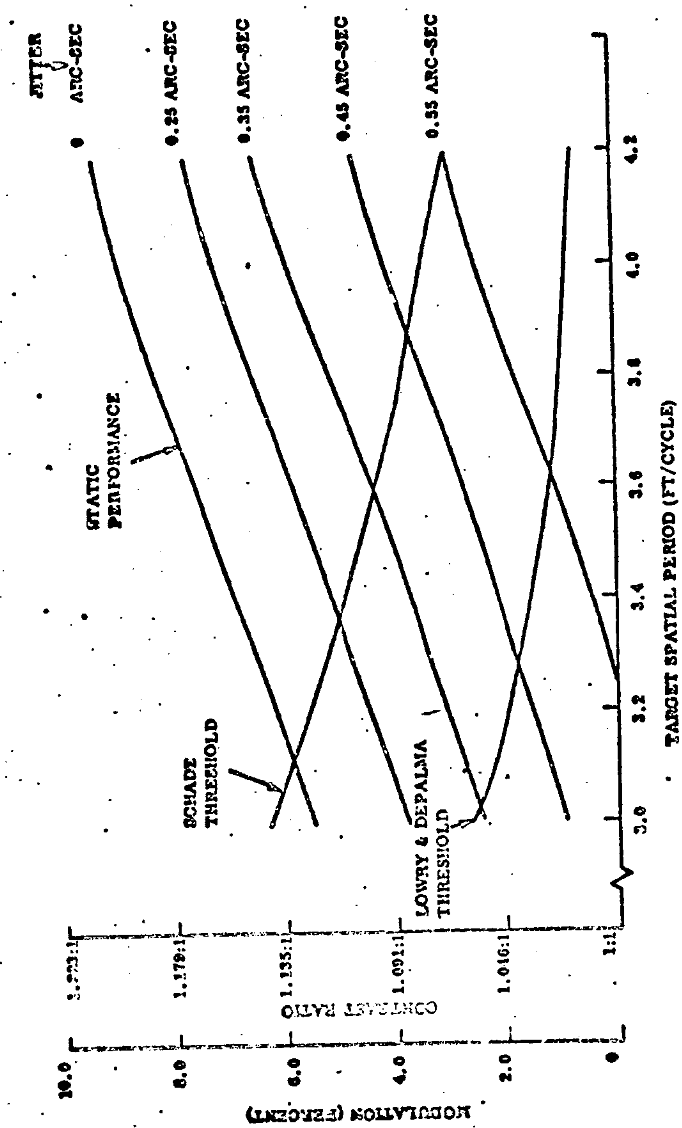


Figure 2.1-33. Acquisition Telescope Dynamic Performance Curves for Sinusoidal Jitter

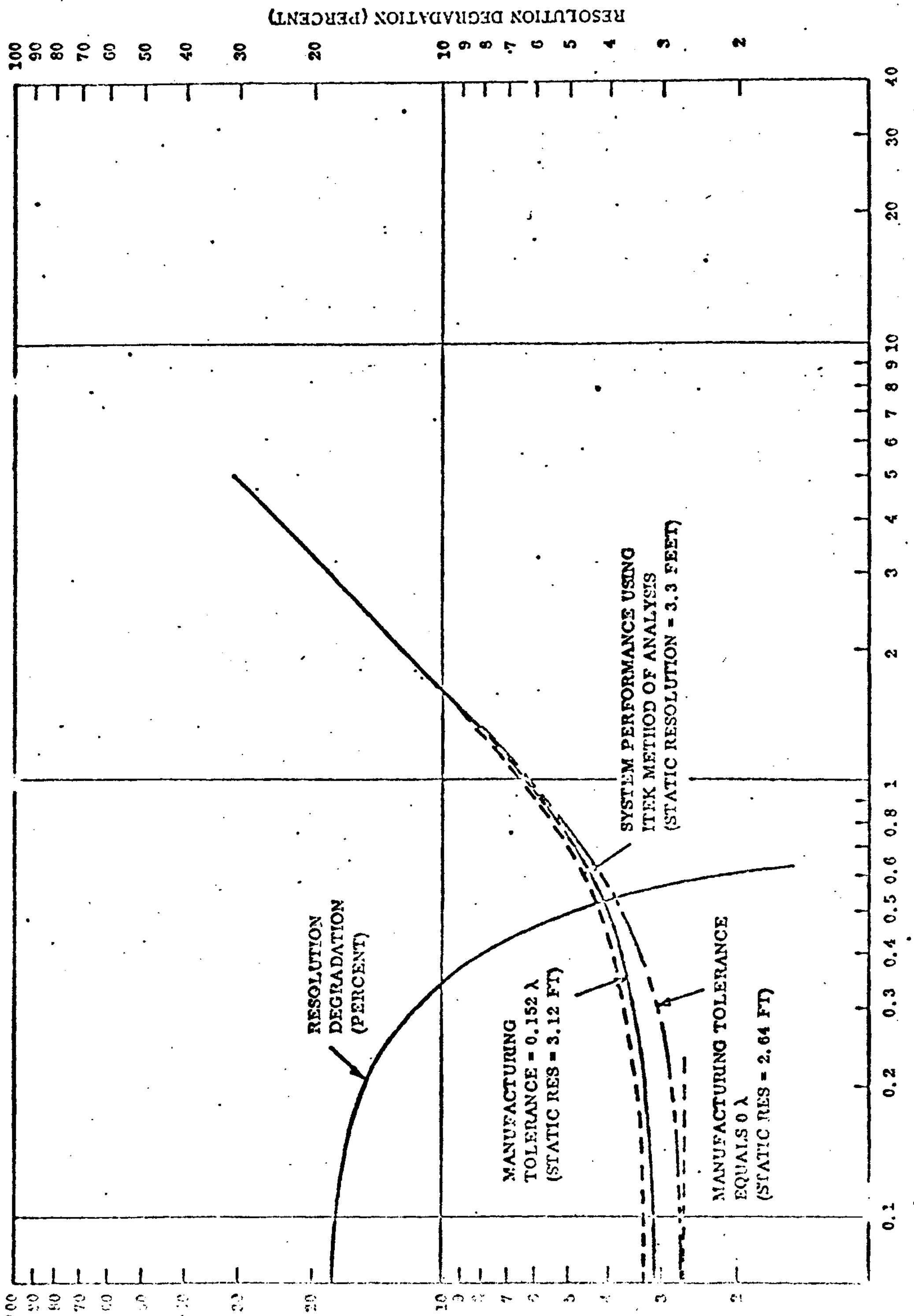
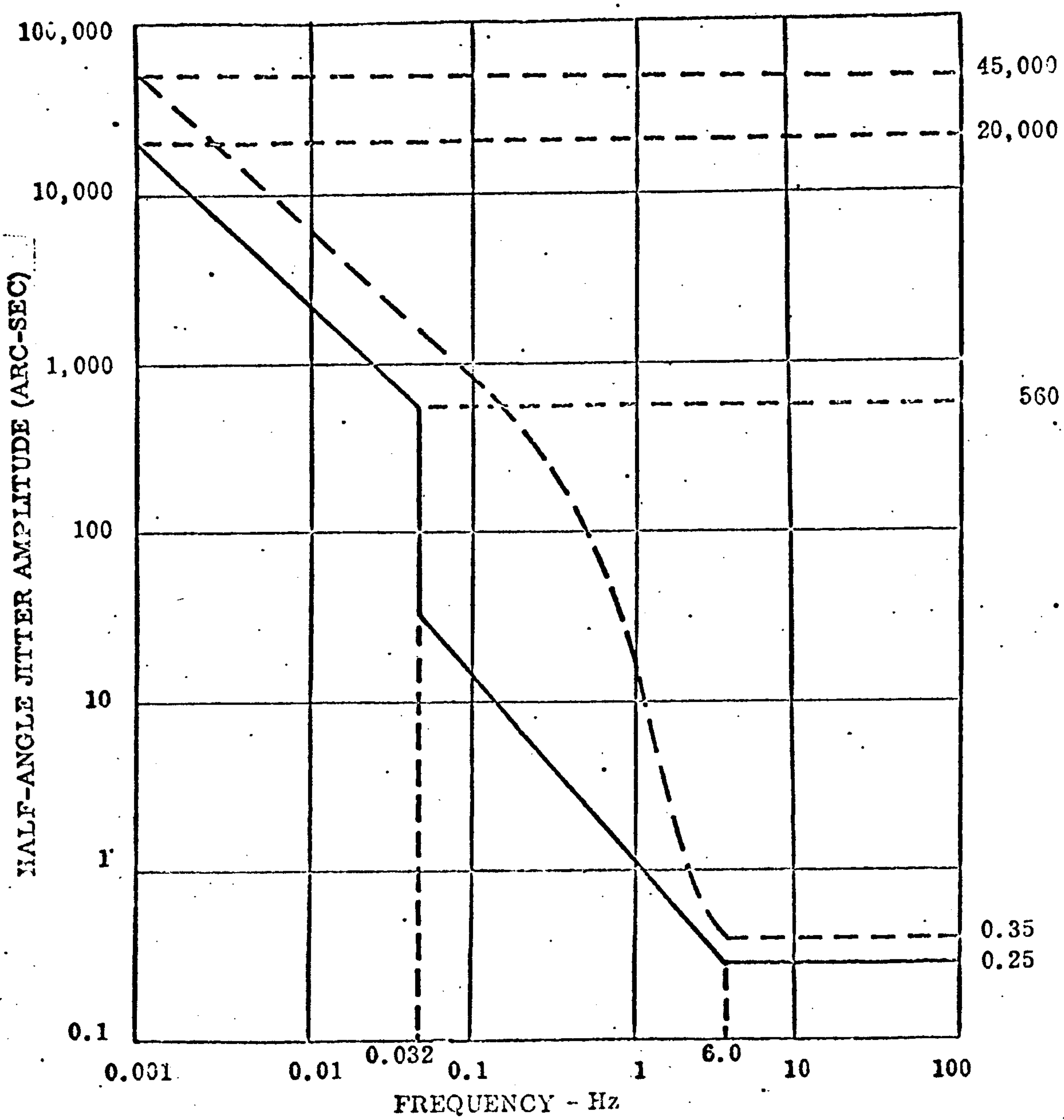


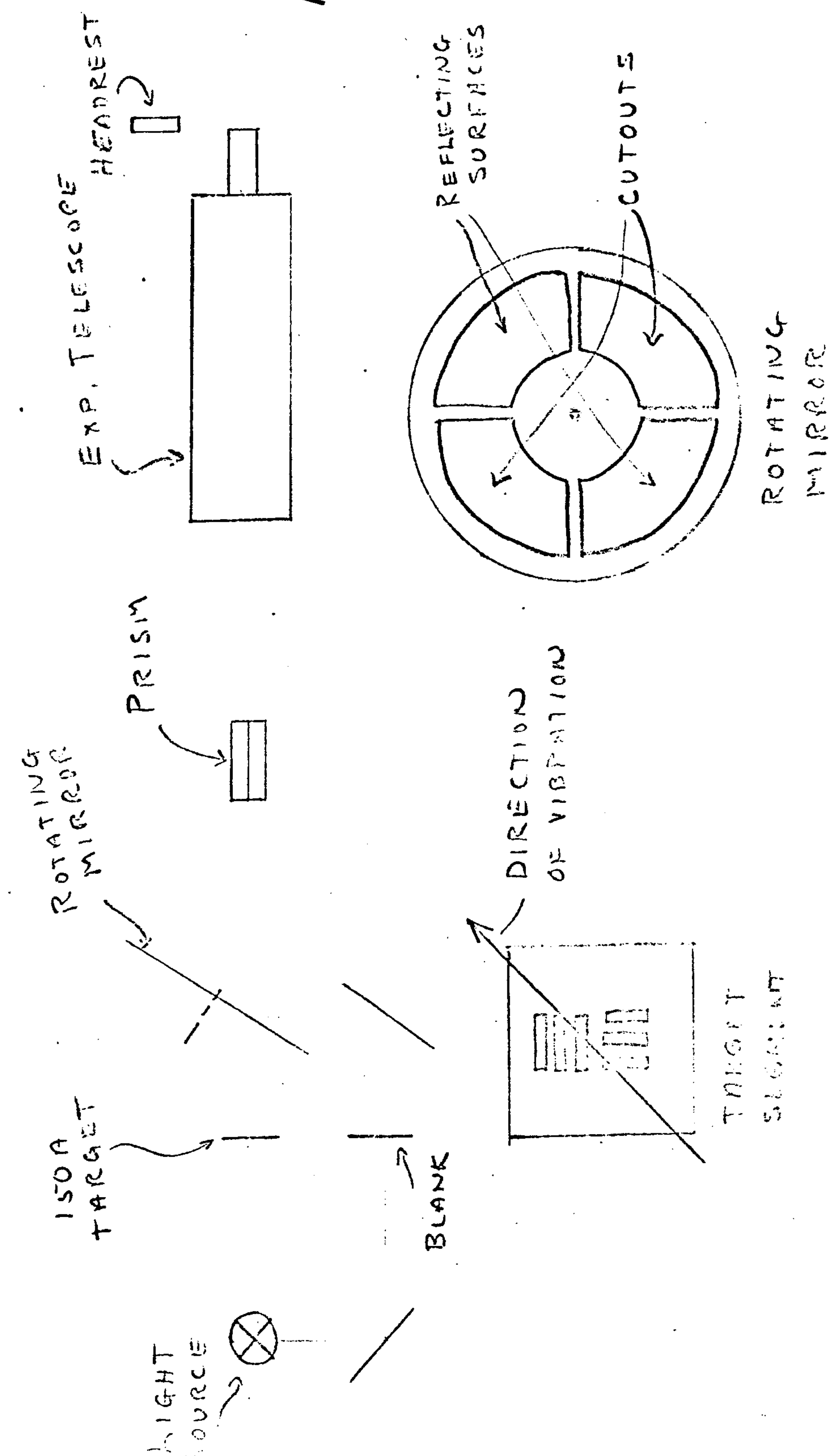
Figure 2.1-25. Acquisition Telescope Dynamic Performance Curve for Final System Design



——— ALLOWABLE JITTER FROM ECP 17 TO GE-AVE CEI SPEC.

– – – – ALLOWABLE JITTER FOR 3.6 FT/CYCLE RESOLUTION

JITTER EXPERIMENT
SCHEMATIC REPRESENTATION



FUTURE WORK

- REFINE PRESENT ESTIMATES OF NOMINAL ON-ORBIT PERFORMANCE
- COMPLETE WORK ON JITTER EXPERIMENT APPARATUS
- ESTABLISH AN AVERAGE RESOLUTION THRESHOLD CURVE FOR THE CREW
- EXPERIMENTALLY EVALUATE THE EFFECT OF MONOTONIC JITTER ON RESOLUTION AND COMPARE WITH ANALYTICAL STUDIES
- DETERMINE ACTUAL SUBSYSTEM LOS JITTER CHARACTERISTIC
- EXPERIMENTALLY AND/OR ANALYTICALLY EVALUATE THE EFFECT OF ACTUAL LOS JITTER ON SYSTEM PERFORMANCE

DRIVE K BEARINGS

PRELIMINARY DESIGN REVIEW

MARCH 6, 1968

SCOPE

- REQUIREMENTS DEFINITION
- STATUS ACTIVITY
- RESULTS TO DATA
  - BEARING DATA - BARDEN TASK IA
  - LUBRICATION TESTS
- ACTIVITIES IN PLANNING
- SUMMARY

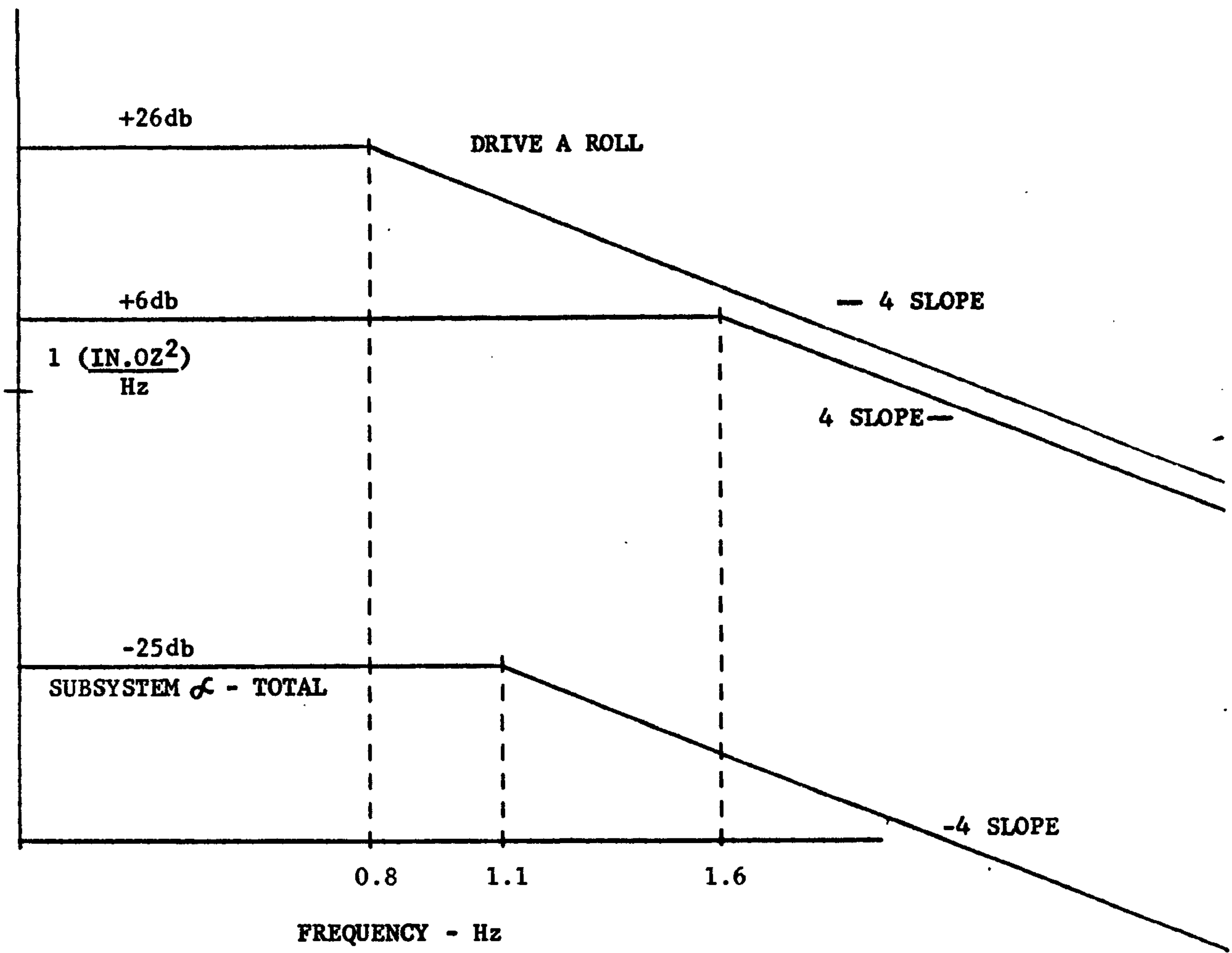
STATUS OF ACTIVITY

- PRELIMINARY DESIGN - COMPLETED BY SUBCONTRACTOR.
  - CONTINUING REVIEW BY G.E.
- BEARING TESTING - INITIAL TESTS COMPLETE - BARDEN IA.
  - SECOND SERIES OF TESTS UNDERWAY BY SUB.
  - G.E. LUBE TEST DATA IS APPLICABLE.
  - EVALUATE NECESSARY BEFORE ADDITIONAL TEST PLANNING.
- BRASS BOARD TESTS - FIXTURE UNDER DESIGN AT G.E.
  - COCKING AND CLEANLINESS ARE CONSIDERATIONS.
- "CUSTOM STRIPPED" F-50 SEEMS BEST CHOICE AGAIN.
- TEMPERATURE ENVIRONMENT IS "GREAT UNKNOWN."

BEARING DESCRIPTION

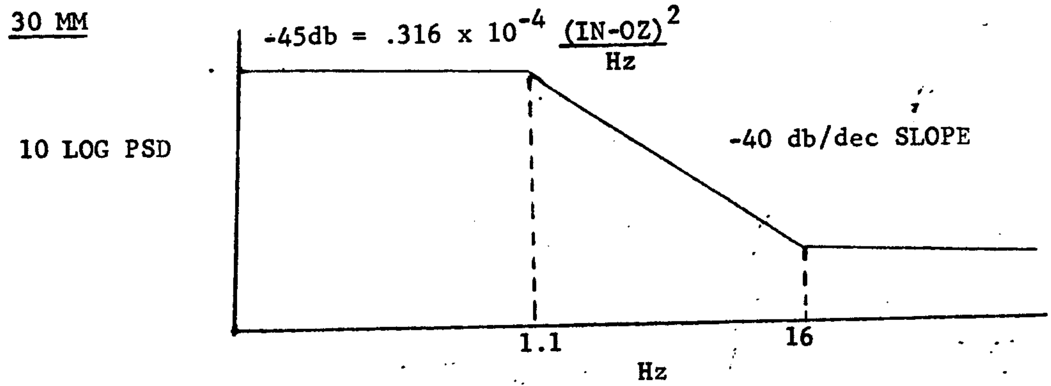
POSITION	MANUFACTURING NO.	ID	OD	NO BALL	DIA	CONT. ANGLE	CONFORM.	THRUST LOAD
o SUB A BEARINGS (DUPLEX)								
"R.A. IN"	FAFNIR 2MM9107 WO CR FS-130 35MM	1.378	2.44	15	5/16	18°	.54	20
"R.A. OUT"	FAFNIR 2MM9101 WO CR FS-130 12MM	.4724	1.102	9	3/16	18°	.54	10
"PA EN"	SBB 3TA 025-32-A93	1.5262	2.0	34	1/8	23°	.53	15
"PA TOR"	SBB 3TA 017-24-98	1.0625	1.5	24	1/8	23°	.53	15
	52100 STEEL							
o LUBRICATION BEARINGS (DUPLEX)								
	BARDEN A54011	0.875	1.3125	15	1/8	18°	.50	46
	440C STEEL							
o 30 MM BEARINGS (SINGLE)								
	BARDEN 20[illegible]H	1.81	2.44	12	1/8	16&26	.50	22
	52100 STEEL							

PSD ALLOCATION

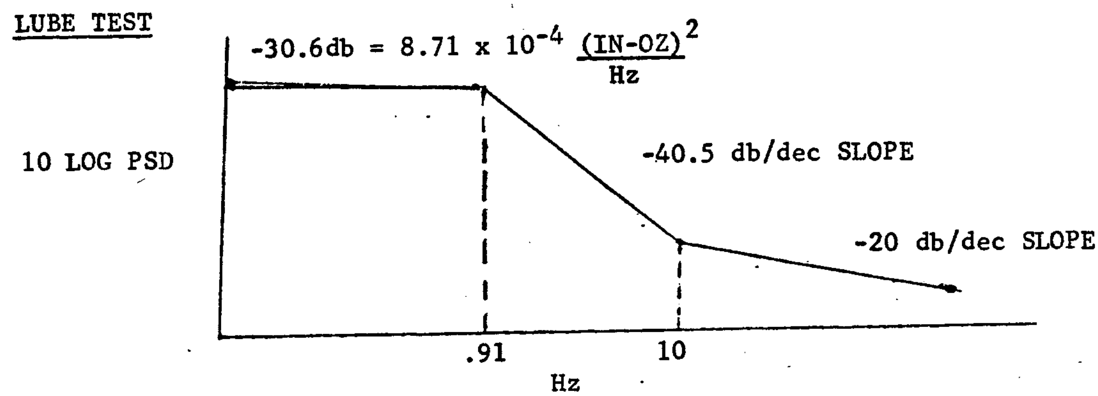


PSD DATA

o 30 MM



o LUBE TEST



GENERAL EQUATION:

$F_B = 1.17$ (RATE)

$= 1.17 \times 1^{o}$/SEC $= 1.17$ Hz (1.1) 30MM

$= 1.17 \times 8^{o}$/SEC $= 0.94$ Hz (0.91) LUBE

PERFORMANCE

o ESTIMATE OF HARDWARE

BARDEN IA DATA (.316 X 10^{-4} IN.OZ^2/Hz)	-45db
FOUR BEARINGS ON SHAFT = 4 X RMS	+12db
MISALIGNMENT ALLOWANCE (2X)	+ 3db
ALLOWANCE FOR F-50 OIL (25%)	+ 1db
ALLOWANCE FOR TEMPERATURE PROBLEM (GUESS)	+ 4db
	-25db

o CURRENT ALLOCATION -25db

ACTIVITIES IN PLANNING

- CORRELATION OF BARDEN DATA WITH G.E. DATA TO:
  - RESOLVE SAMPLING UNCERTAINTIES.
  - PROVE VALIDITY OF RESULTS.
  - ESTABLISH AVAILABILITY OF BEARING.
  - EVALUATE EFFECTS OF COCKING.
  - EVALUATE SUBSTITUTION OF SPACE LUBRICANT.
  - EVALUATE EFFECTS OF TORQUER SIDE FORCE.
- INVESTIGATE THE PERFORMANCE EFFECTS OF:
  - INSTALLATION (MISALIGNMENT, SIDE FORCE).
  - LOADS (FRETTING, BRINNELLING).
- DIRECT SUBCONTRACTOR EFFORTS IN AREA OF:
  - INSTALLATION.
  - CLEANLINESS.
- INVESTIGATE TEMPERATURE EFFECTS ON:
  - CLEARANCES AND LOADS.
  - LUBRICANT.
  - CREEP BARRIER.
  - SEALS.
  - TORQUE RIPPLE.
  - TORQUE.

SUMMARY

- "K" BEARINGS ARE IN THE EARLY DESIGN STAGES.
- PRELIMINARY TEST DATA INDICATES ACCEPTABLE PERFORMANCE AVAILABLE FROM HIGH QUALITY PRECISION INSTRUMENT BEARINGS.
- G.E. WILL EMPLOY "A" EXPERIENCE TO DIRECT SUBCONTRACTOR INSTALLATION PARAMETER.
- LUBRICATION TEST DATA IS DIRECTLY APPLICABLE.
- THE ERROR ALLOCATION SEEMS REASONABLE IN TERMS OF PRELIMINARY TEST DATA - SUBSTANTIATION MUST BE ACCOMPLISHED.
- BEARING S.O.A. - FROM PRELIMINARY DATA - SEEMS BETTER ON THIS SIZE BEARING THAN ON THE "A" BEARINGS.
- MAJOR PROBLEM - EFFECT OF TEMPERATURE RANGE ON PERFORMANCE.

DRIVE K TEST PLAN

- SUB A

  TESTING TO ESTABLISH TECHNICAL STATUS
  DONE IN ONE MONTH

  ANALYTICAL WORK ON TEMPERATURE PROBLEM

- G.E.

  TESTING TO ESTABLISH DESIGN POINT FEASIBILITY - DONE
  (BARDEN IA AND LUBRICATION TESTS)

- NEXT STEPS (IN PLANNING)

  - DEVELOPMENT TESTS
    (PRELOAD, MISALIGNMENT, TEMPERATURE, SURFACE MEASUREMENTS)

  - VERIFICATION TESTS
    (FULL AXIS TESTS)

- TEST SPECIMEN AVAILABILITY

  - 440C INSTRUMENT GRADE BEARINGS - JUNE - JULY

  - FIXTURE AVAILABILITY - SIMILAR

ASSESSMENT OF CURRENT SUB A

TEST PROGRAM

- o COMPETENT SUBCONTRACTOR WITH COPY OF MIT GYRO BEARING TEST EQUIPMENT DOING TESTS.

- o TEMPERATURE ANALYSIS WORK STARTED

  $100^\circ F \cong$ 10 LBS OF PRELOAD [UNCHECKED

  $\Delta 6^\circ F \cong$ 5 LBS OF PRELOAD SUB A NUMBERS]

- o PRELIMINARY DATA ON ABEC-7 SEEMS TO CORRELATE WITH G.E. DATA.

- o ERROR ALLOCATION STILL SEEMS REASONABLE.

- o SUB A WANTS TO DEVELOP CAPABILITY TO TEST BEARINGS FOR ACCEPTANCE - NEEDS ABILITY TO TEST AND UNDERSTAND RESULTS.

- o CLEANLINESS CRITERIA HAS BEEN TRANSMITTED TO SUB A.

THERMAL DESIGN

- o DESIGN BASELINE

A. ENVIRONMENT - EXTERNAL

1. ON-ORBIT

a. SOLAR, EARTH & ALBEDO HEATING
b. FREE MOLECULAR HEATING
c. ACTS THRUSTER FIRING
d. VACUUM
e. MISSION MODULE & RADIATOR TEMP. VAR. ($-100^{o}F$ to $+210^{o}F$) ($-60^{o}F$ to $+80^{o}F$)

2. ASCENT

a. AERODYNAMIC SHROUD REACHES A PEAK TEMPERATURE $\approx 1000^{o}F$ IN $\approx$ 120 SEC.
b. ON-ORBIT SHROUD REACHES PEAK TEMPERATURE $\approx 140^{o}F$
c. AFTER EJECTION OF AERO-FAIRING ON-ORBIT SHROUD SUBJECT TO SIGNIFICANT MOLECULAR HEATING
   - STAG. HTG. RATE $\approx$ .7 Btu/sec.-ft^2
   MAX. EST. TEMP. = $320^{o}F$ (FLAT PLATE)

B. INTERNAL ENVRIONMENT

1. PRESSURIZED COMPARTMENT

2. THREE DIFFERENT REGIONS

ON-ORBIT
a. LIVING CREW AREA - $66^{o}F$-$80^{o}F$
b. CONSOLES - $50^{o}F$-$150^{o}F$
c. ANNULAR SPACE BETWEEN BIRDCAGE & PRESSURE SHELL - $65^{o}F$-$80^{o}F$

- o PRELAUNCH & ASCENT - NOT COMPLETELY DEFINED

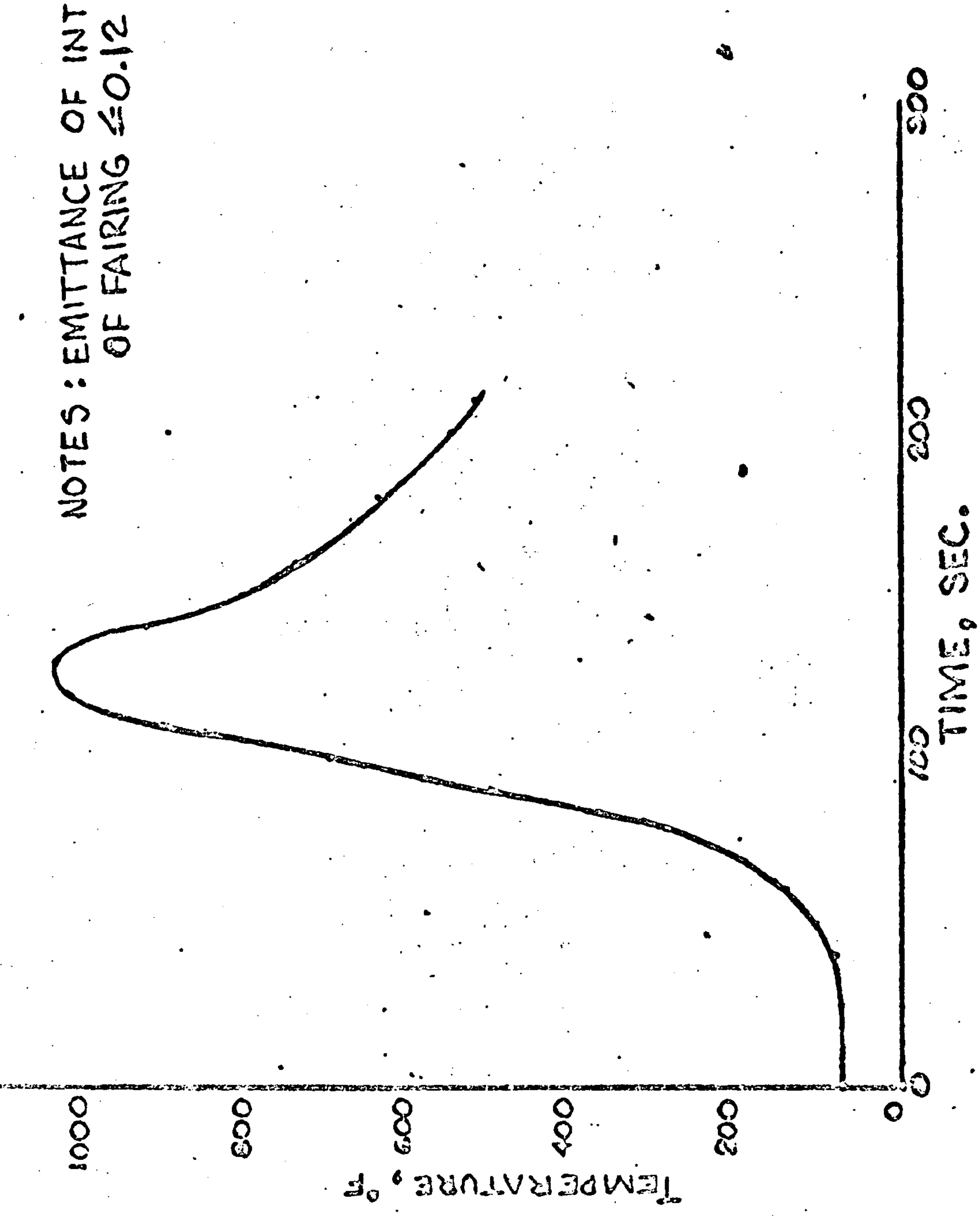


FIGURE : AERODYNAMIC FAIRING TEMPERATURE HISTORY DURING ASCENT.

C. DESIGN CONSTRAINTS

1. MINIMIZE SPURIOUS LIGHT REFLECTIONS

2. PERMIT VIEWING TIMES UP TO 25 MIN. MAX.

   10 MIN. NOMINAL

   120 MIN/DAY

   12 HOURS OFF TIME-MAX

3. MAXIMUM COMPONENT TEMPERATURE VARIATION LIMITS

   a. GYROS $0^{o}F$ to $+100^{o}F$

   b. MOTORS $-65^{o}F$ to $+160^{o}F$

   c. ENCODERS $-5^{o}F$ to $+160^{o}F$

   d. AMPLIFIERS $-65^{o}F$ to $+160^{o}F$

   e. MIRRORS $-10^{o}F$ to $+140^{o}F$

- THERMAL DESIGN OBJECTIVES

A. MAINTAIN COMPONENTS BETWEEN $0^{o}F$ to $+100^{o}F$

B. PASSIVE DESIGN

C. MINIMIZE TEMPERATURE GRADIENTS

D. MINIMIZE WEIGHT

- DESIGN CONCEPT

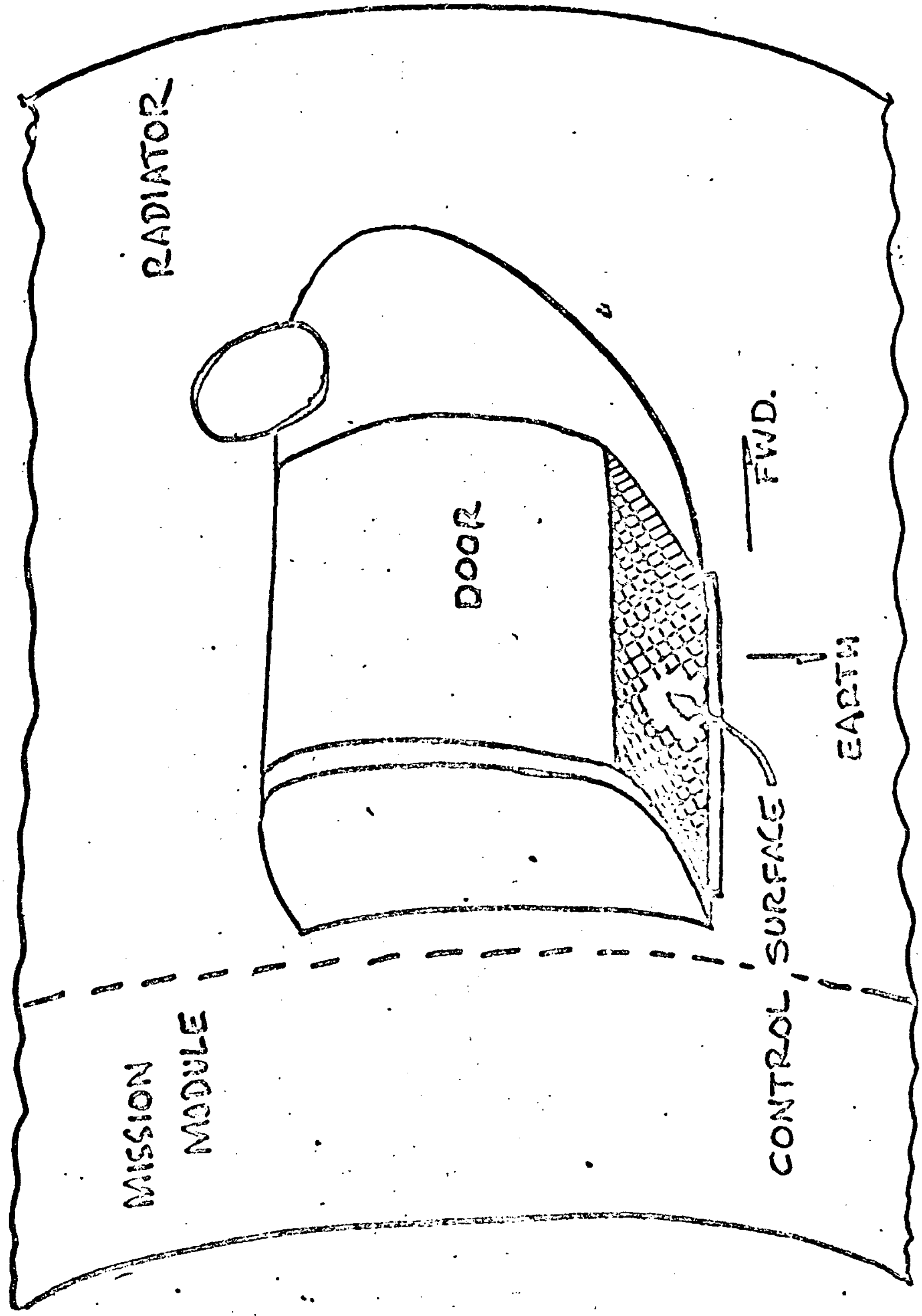
  A. EXTERNAL

  1. DUAL SHROUD
  2. INSULATED ON-ORBIT SHROUD
  3. CONTROL SURFACE
     a. EARTH FACING SIDE
     b. ISOLATED FROM IMPACT OF ACTS THRUSTERS
  4. FIBERGLAS LAMINATE SHROUD - IMIDITE - GOOD UP TO $1200^{o}F$

  B. INTERNAL

  1. TELESCOPE TUBE - HIGH THERMAL CONDUCTIVITY
  2. HIGHLY REFLECTIVE EXTERIOR
  3. ISOLATION MTG. OF ELEMENTS

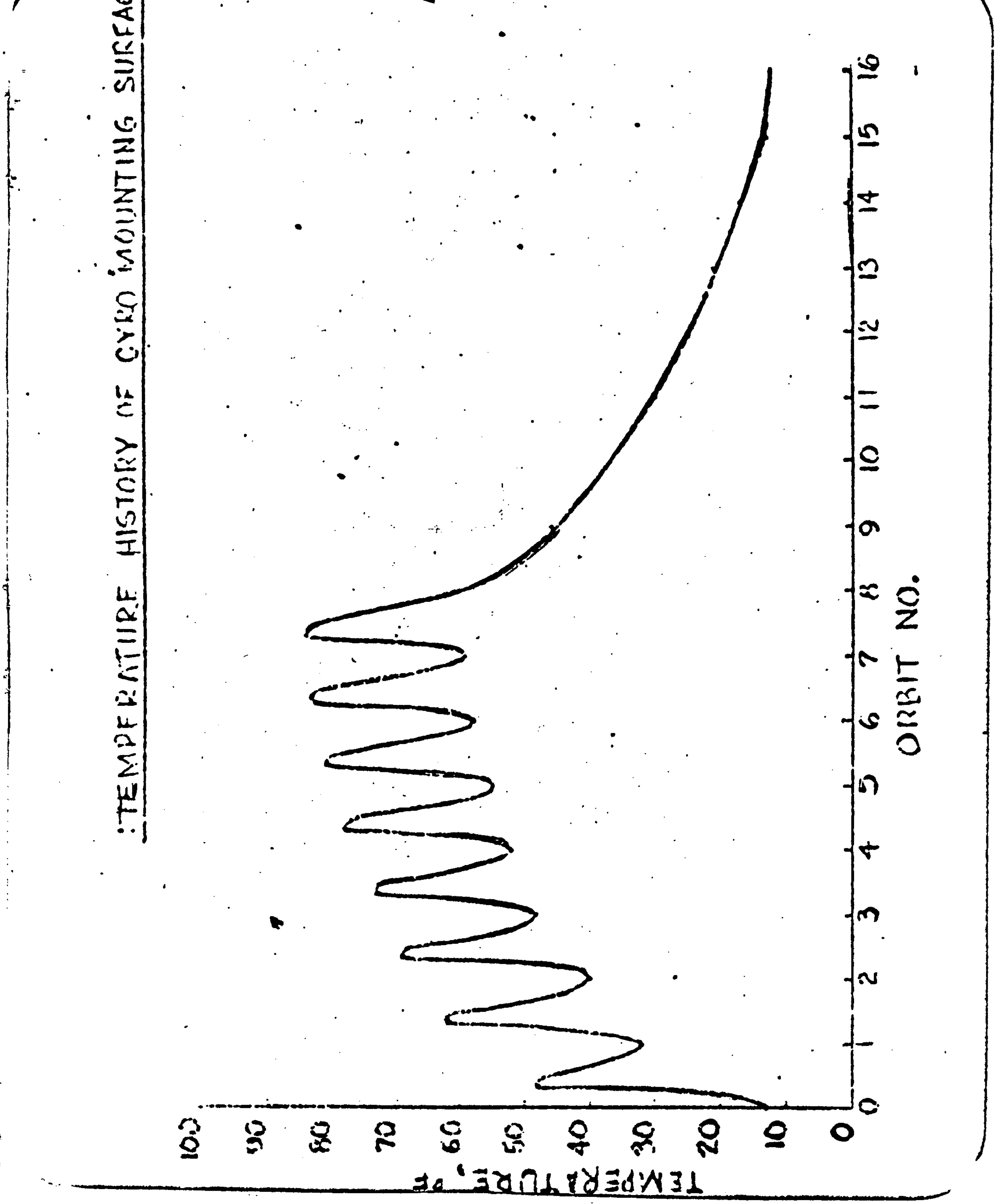
ON-ORBIT SHROUD CONFIGURATION

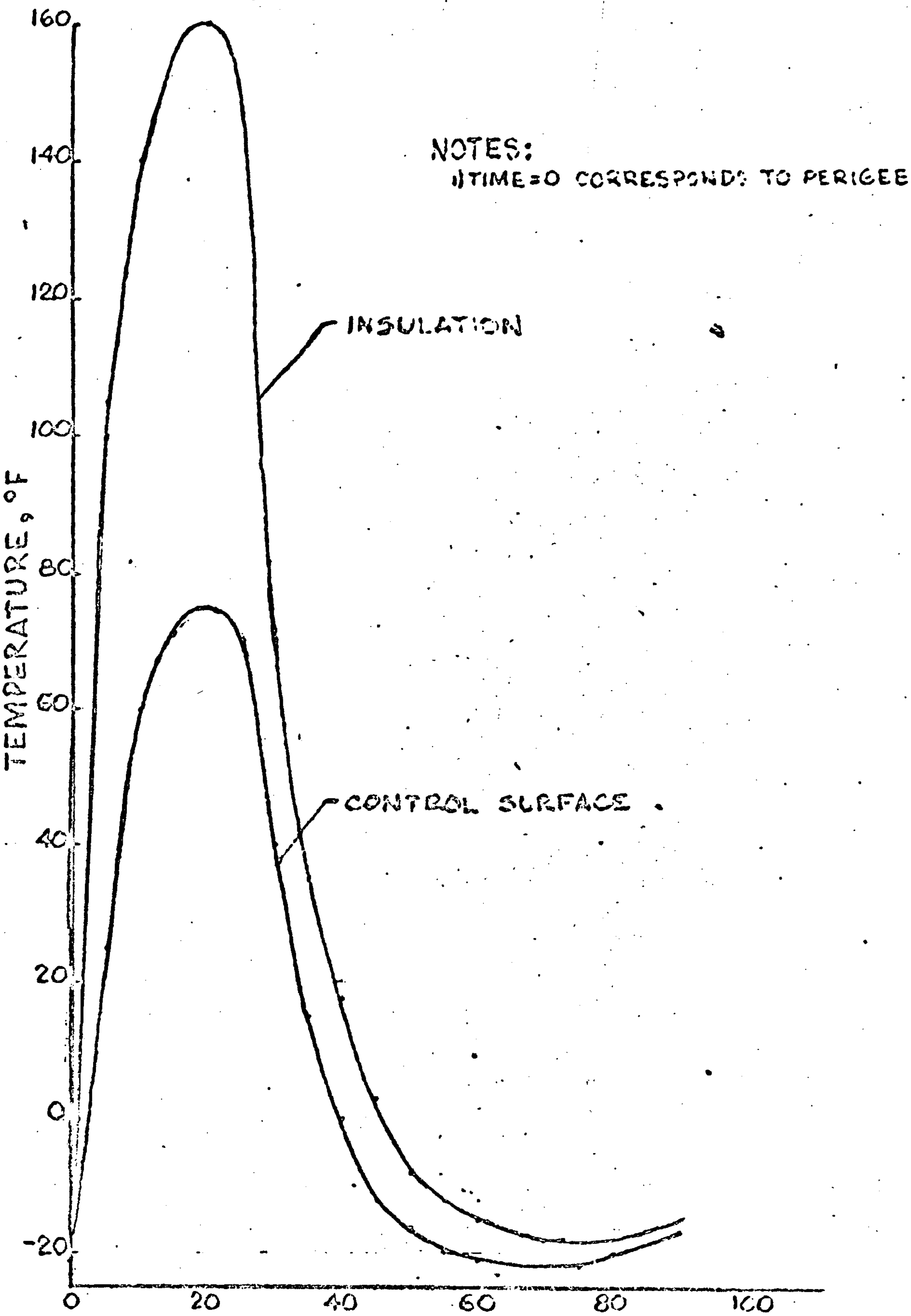


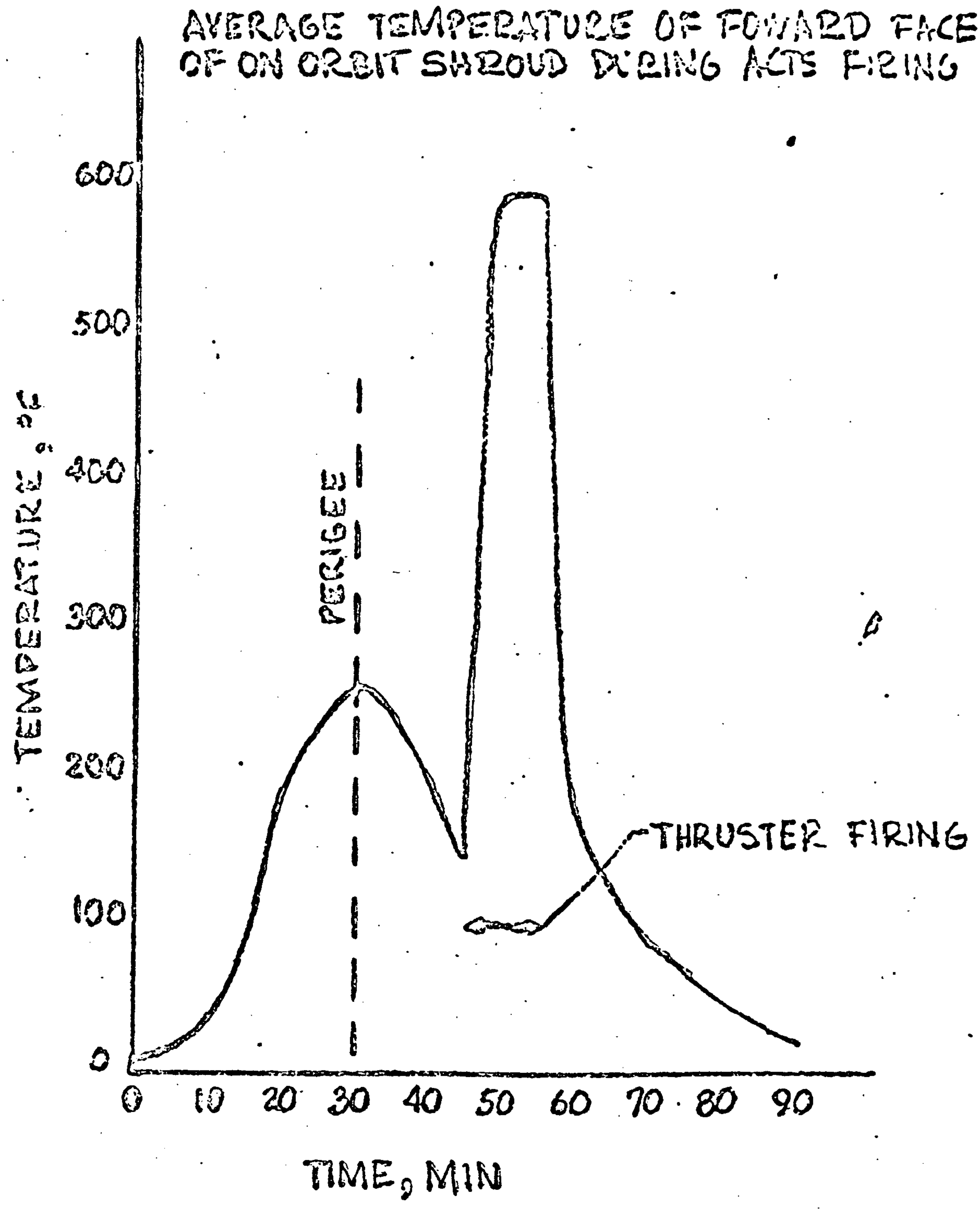
- ALTERNATE DESIGN CONCEPTS
  - A. SINGLE SHROUD
  - B. DOUBLE WALL ON-ORBIT SHROUD
  - C. HEAT OF FUSION CONTAINER

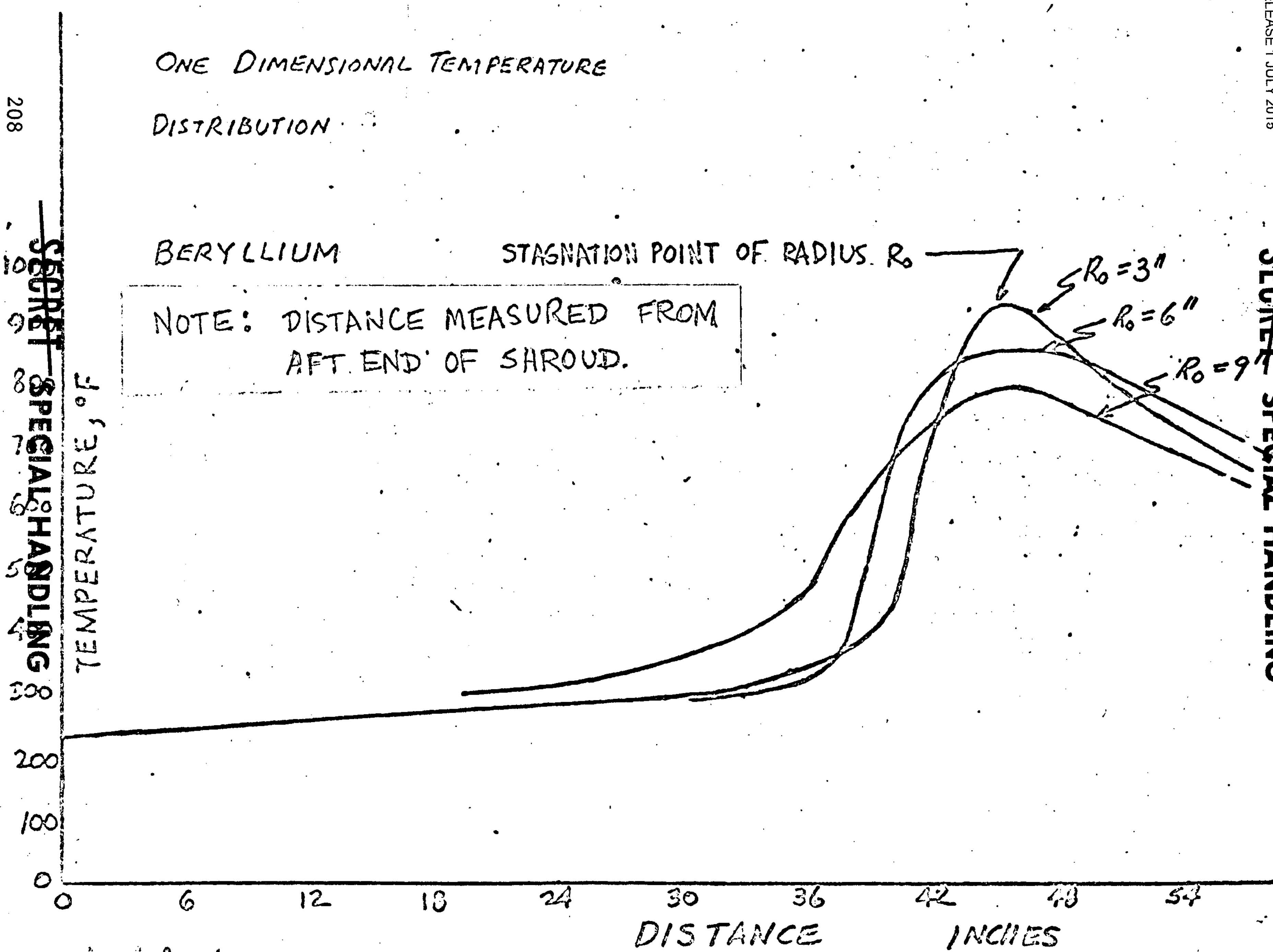
    EST. 30# WGT PENALTY PER SYSTEM

- DESIGN STATUS
  - A. EXTERNAL COMPONENTS
    1. ON-ORBIT (HOT CASE)
       - a. TRACKING MIRROR TEMPERATURE VARIATION -75°F (10°F to 85°F)
       - b. INSULATION −20°F to +160°F
       - c. CONTROL SURFACE -15°F to +75°F
    2. ACTS THRUSTER FIRING -10 MIN.MAX.
       - a. PEAK SHROUD TEMPERATURE < 800°F
       - b. CONTROL SURFACE TEMPERATURE < 120°F
       - c. MIRRORS < 2° TEMPERATURE RISE
       - d. SYSTEM RECOVERS FROM TRANSIENT WITHIN 2 ORBITS


TEMPERATURE HISTORY OF GYRO MOUNTING SURFACE
ORBIT NO.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
TEMPERATURE, °F
0 10 20 30 40 50 60 70 80 90 100

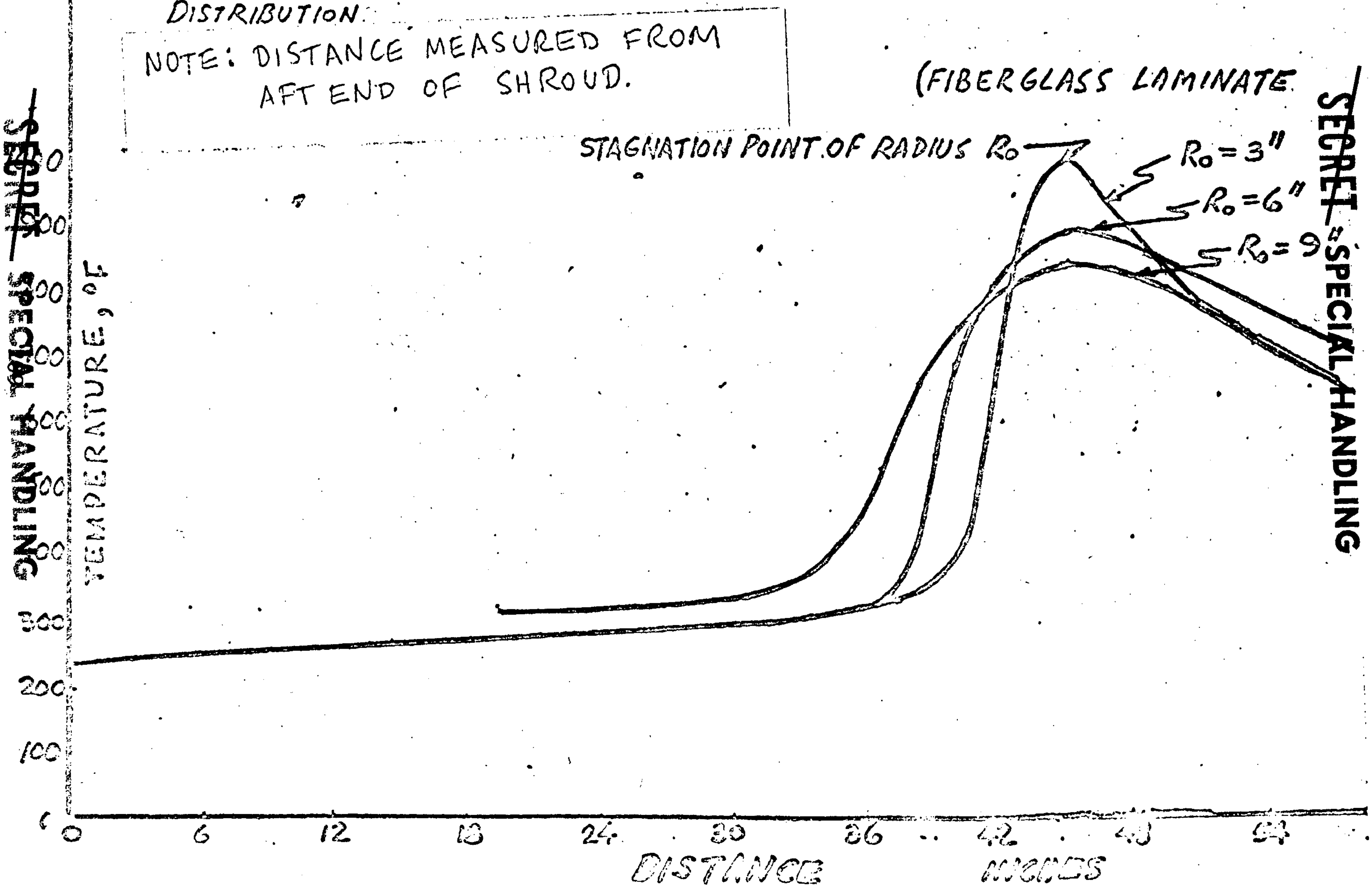

NOTES:
1) TIME=0 CORRESPONDS TO PERIGEE
INSULATION
CONTROL SURFACE
TEMPERATURE, °F
160
140
120
100
80
60
40
20
0
-20
0
20
40
60
80
100


AVERAGE TEMPERATURE OF FOWARD FACE
OF ON ORBIT SHROUD DURING ACTS FIRING
TEMPERATURE, °C
600
500
400
300
200
100
0
PERIGEE
THRUSTER FIRING
0 10 20 30 40 50 60 70 80 90
TIME, MIN


ONE DIMENSIONAL TEMPERATURE
DISTRIBUTION
BERYLLIUM
STAGNATION POINT OF RADIUS R_o
NOTE: DISTANCE MEASURED FROM AFT END OF SHROUD.
$R_o = 3''$
$R_o = 6''$
$R_o = 9''$
TEMPERATURE, °F
0
100
200
300
0
6
12
18
24
30
36
42
48
54
DISTANCE INCHES

~~SECRET~~ SPECIAL HANDLING

ONE DIMENSIONAL TEMPERATURE DISTRIBUTION.



~~SECRET~~ SPECIAL HANDLING

- DESIGN STATUS (CONT'D)

  B. INTERNAL COMPONENTS

  1. SUMMARY OF GRADIENTS

     a. WINDOW $-4^{\circ}F$ TOLERABLE

     b. OBJECTIVE ELEMENTS $-2.3^{\circ}F$

     c. ZOOM $-1.6^{\circ}F$

     d. PECHAN $-.01^{\circ}F$

     e. FIELD FLATTENER $-.15^{\circ}F$

o <u>INSULATION CONFIGURATIONS</u>

A. MULTILAYER INSULATION

1. ALUMINUM FOIL & TISSUGLAS - 900°F

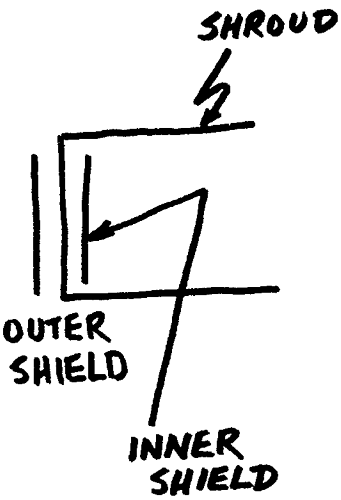
2. ALUMINIZED MYLAR - 300°F

3. ALUMINIZED KAPTON - 600°F

$\epsilon_{eff} \leq .03$

MAX. INTERNAL TEMP.	< 150°F, 175°F, 250°F	PEAK SHROUD TEMP.	< 600°F, 800°F, 1000°F

B. DOUBLE SHIELD



$\epsilon < .07$

a. INNER SHIELD = .02" THICK

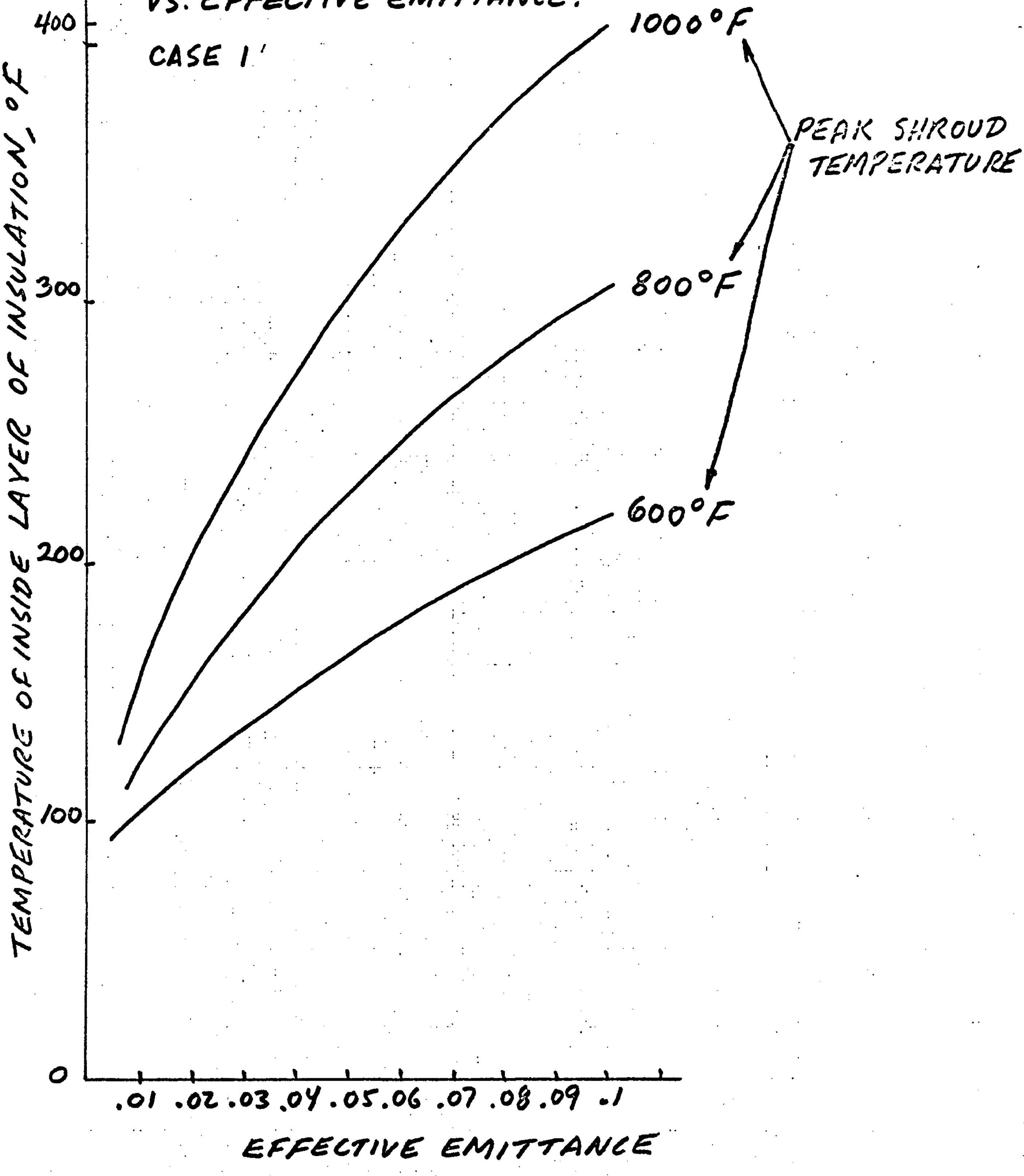
MAX. INTERNAL TEMP.	< 120°F, 145°F, 175°F	PEAK SHROUD TEMP.	< 600°F, 800°F, 1000°F

b. INNER SHIELD = .01" THICK

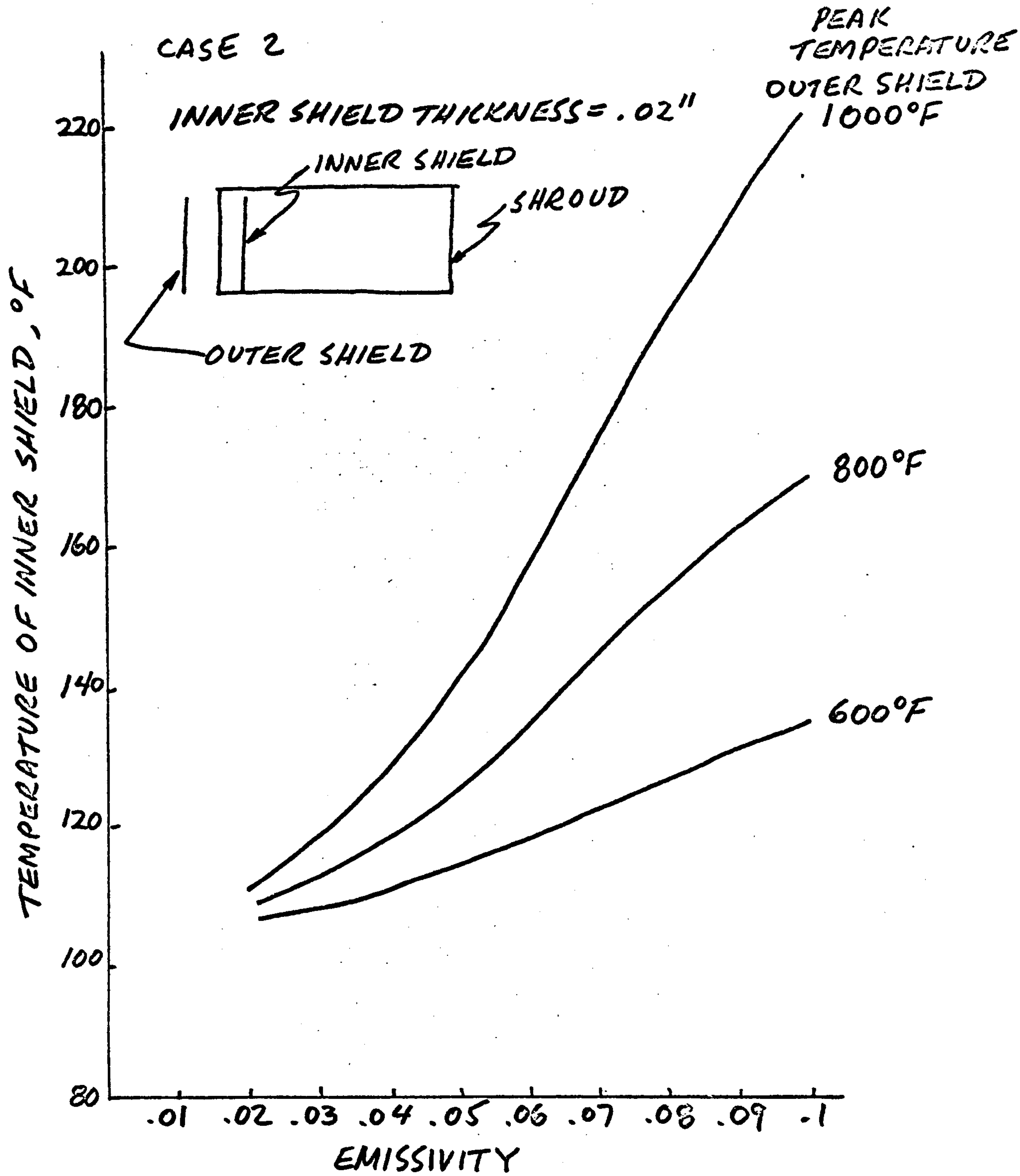
MAX. INTERNAL TEMP.	< 115°F, 137°F, 164°F	PEAK SHROUD TEMP.	< 600°F, 800°F, 1000°F

PEAK TEMPERATURE OF INNER SURFACE OF MULTILAYER INSULATION BLANKET VS. EFFECTIVE EMITTANCE.

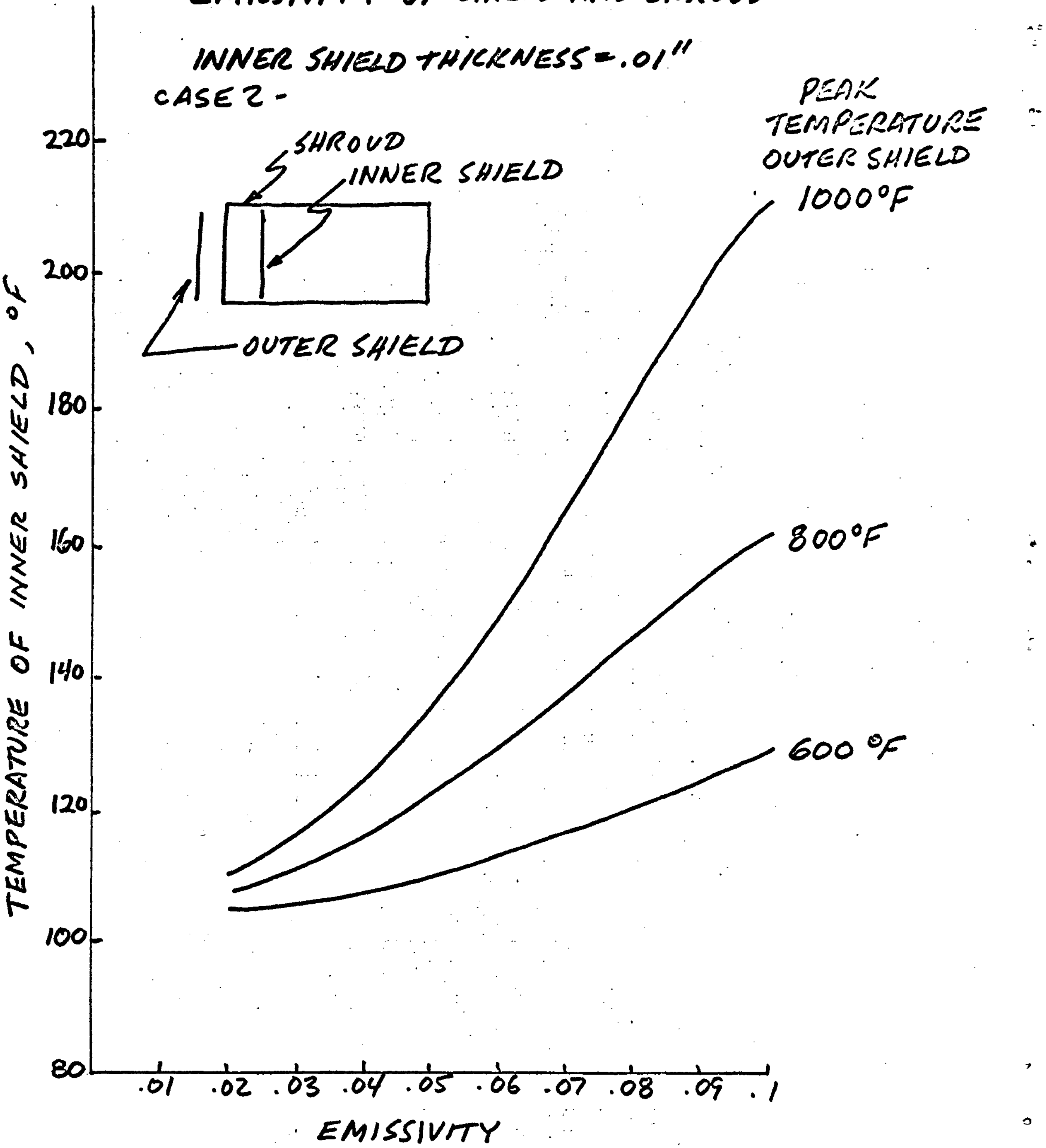
CASE I'

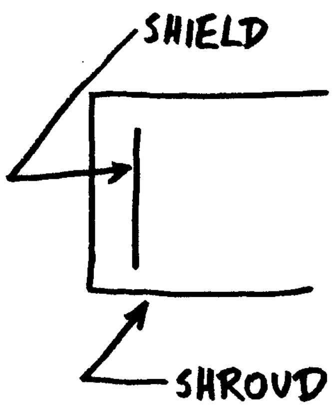


PEAK TEMPERATURE OF INNER SHIELD
VS
EMISSIVITY OF SHIELD AND SHROUD



PEAK TEMPERATURE OF INNER SHIELD
VS.
EMISSIVITY OF SHIELD AND SHROUD





C. SINGLE SHIELD

$\epsilon < .07$

a. SHIELD = .02"

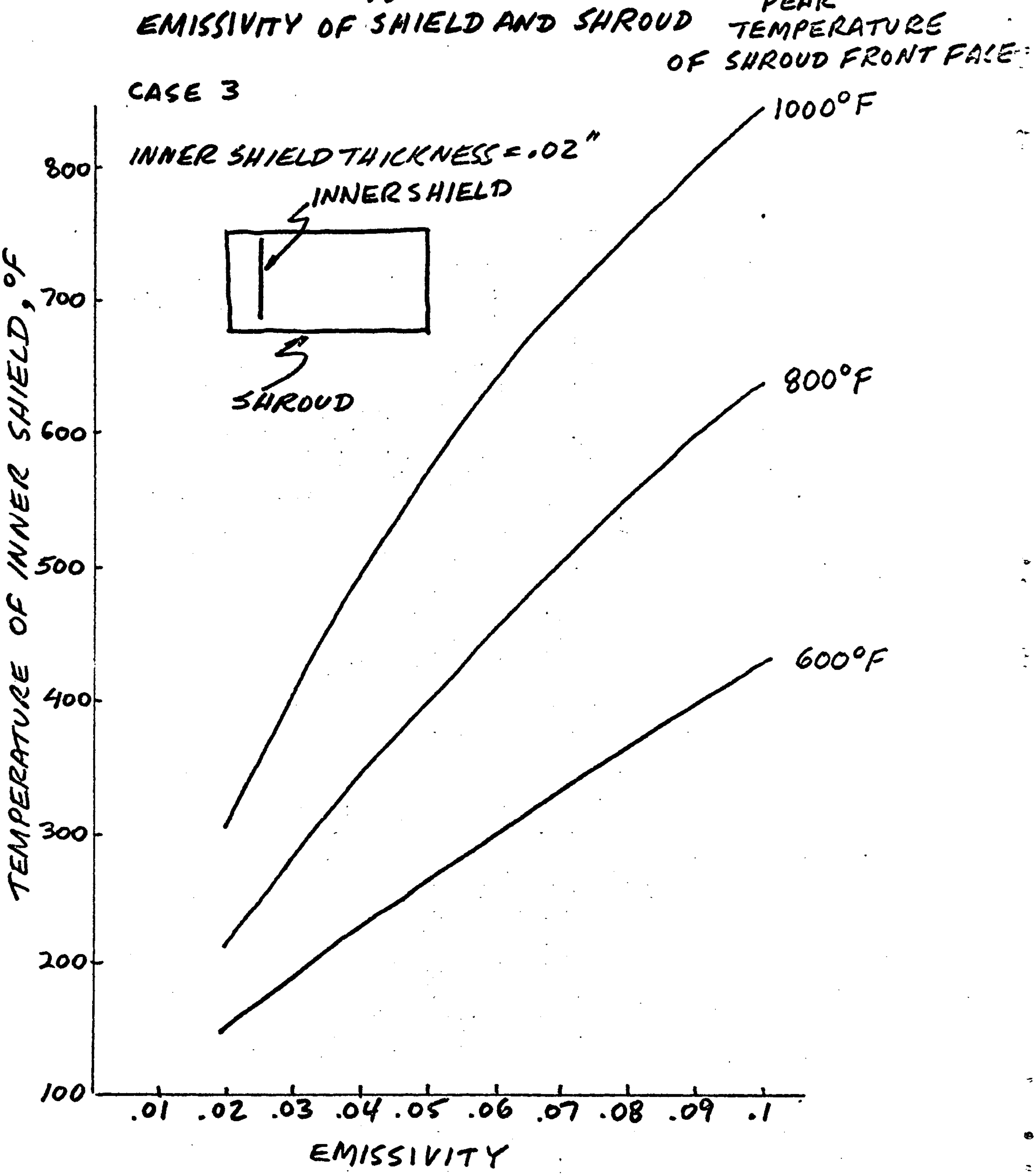
MAX. INTERNAL TEMP.	335°F < 500°F < 700°F	PEAK SHROUD TEMP.	600°F < 800°F < 1000°F

$\epsilon < .07$

b. SHIELD = .01"

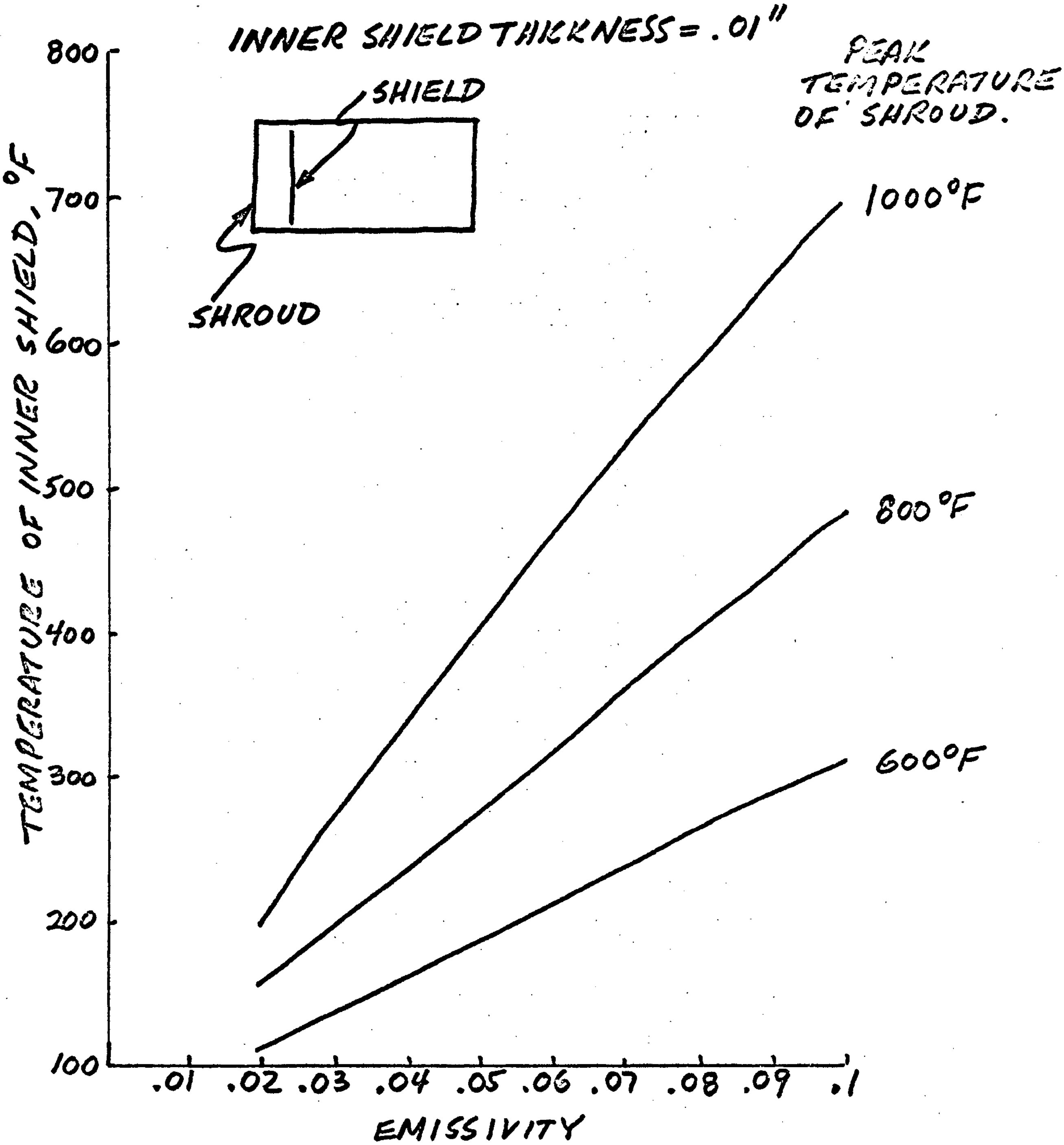
MAX. INTERNAL TEMP.	240°F < 355°F < 525°F	PEAK SHROUD TEMP.	600°F < 800°F < 1000°F

PEAK TEMPERATURE OF INNER SHIELD
VS
EMISSIVITY OF SHIELD AND SHROUD



PEAK TEMPERATURE OF INNER SHIELD VS EMISSIVITY OF SHIELD AND SHROUD

CASE 3



- DEVELOPMENT TESTING

A. TEST PHILOSOPHY

1. SYSTEM TESTED IN TWO PARTS
2. MATHEMATICALLY COMBINED BY SUPERPOSITION

B. EXTERNAL COMPONENT TEST SET-UP

1. TRACKING MIRROR, FOLDING MIRROR AND WINDOW MOUNTED IN SIMULATED SHROUD IN VACUUM CHAMBER
2. QUARTZ-LINE LAMPS AND I/R HEATERS USED TO SIMULATE SOLAR, ALBEDO AND EARTH FLUXES

C. INTERNAL COMPONENT TEST SET-UP

1. PARTIAL VACUUM TO SIMULATE "O" GRAVITY FIELD
2. TEMPERATURE ZONED SHROUD

D. ENVIRONMENTAL SIMULATION

1. EARTH, ALBEDO AND SOLAR HTG.
    a. HIGH PRESSURE XENON ARC LAMPS
    b. IODINE QUARTZ-LINE LAMPS
    c. I/R HEATER PANELS

ENVIRONMENTAL SIMULATION

SOURCE	ADVANTAGES	DISADVANTAGES
XENON ARC LAMPS	CLOSEST SOLAR SIMULATION	1. HIGHEST COST 2. NOT SUITABLE FOR VACUUM 3. POOR SPECTRAL MATCH OF EARTH AND ALBEDO 4. DIFFICULT TO OBTAIN UNIFORM BEAM INTENSITY
IODINE QUARTZ-LINE LAMPS	1. CLOSEST EARTH & ALBEDO SIMULATION 2. FAST RESPONSE CHAR. 3. SUITABLE FOR VACUUM	1. COST 2. DIFFICULT TO OBTAIN UNIFORM BEAM INTENSITY
I/R HEATERS	1. COST 2. SOURCE UNIFORMITY	1. POOR SPECTRAL MATCH

~~SECRET~~ SPECIAL HANDLING

2. COMPARATIVE DATA

SOURCE	α (ALUMINIZED SURFACE)	α (BLACK SURFACE)
ALBEDO AND EARTH	.106	.95
SOLAR	.153	↓
EARTH	.131	↓
IODINE QUARTZLINE	.093	↓
I/R SOURCE	.049	↓
XENON	.183	↓

3. PRESSURE AND TEMPERATURE SIMULATION

a. CHAMBER PRESSURE 1×10^{-5} MM HG.

b. SHROUD WALL TEMPERATURE $-310^{o}F$

c. "O" GRAVITY - REDUCED PRESSURE 2.5 CM HG

MAX. ΔT ("O" GRAVITY) = 1.5 MAX. ΔT(1-G FIELD @ 14.7 psia)

E. EXTERNAL COMPONENT TESTS

1. TRANSIENT

a. STATIC THERMAL TEST

b. OPTICAL TEST

c. OPERATIONAL TEST

2. STEADY STATE

SOAK TESTS $-0\text{-}100^{o}F$

F. INTERNAL COMPONENT TEST

1. INDIVIDUAL ELEMENT TESTING

2. TELESCOPE ASS'Y

o AEDC PLUME TEST

TEST SPECIMEN	ORBIT ADJ. SIM.	ATT. CONT. SIM.
THERMAL CONTROL COUPONS	⊥ TO FLOW - SEE NOTE 1 FLUSH MT'D. SAMPLE - INCORRECT POSITION	⊥ TO FLOW - INCORRECT POSITION ∥ TO FLOW - 8 SAMPLES 5 QUARTZ DISKS WITH NON-REFLECTING MgF COATING 3 - Al +SiO
FRONT FACE CALORIMETER	SEE NOTE 1	
HEAT FLUX PROBE	SEE NOTE 2	

NOTE 1 - CANNOT BE TESTED UNLESS ADD'TL. TESTS ARE MADE AFTER JUNE 30th, OR UNLESS DACo HORIZON SENSOR HEAD IS DELETED FROM TESTS 4 & 5 OR DACo MONOPOLE GROUND PLANE ANTENNA DELETED FROM TEST 6.

NOTE 2 - CANNOT BE TESTED UNLESS ADD'TL. TESTS ARE MADE AFTER JUNE 30th, OR UNLESS ONE OF THE GE OR DACo T/C COUPONS ARE DELETED OR ANTENNA TEST DELETED.

- MAJOR DESIGN PROBLEMS

A. COATING SELECTION AND OPTIMIZATION

1. DEGRADATION
2. TEMPERATURE COMPATIBILITY

B. FAILURE MODES

1. OPEN DOOR
2. WINDOW HTR'S

C. SHROUD SHAPE OPTIMIZATION

D. INSULATION CONFIGURATION OPTIMIZATION

1. MULTILAYER INSULATION
2. REFLECTING SHIELDS
3. MOUNTING METHOD

E. PLUME HEATING

1. PEAK TEMPERATURE FOR FINAL CONFIGURATION
2. RECOVERY TIME

F. SHROUD MATERIAL SELECTION

ATS STRUCTURAL ANALYSIS

STRUCTURAL ANALYSIS WAS PERFORMED ON THE FOLLOWING COMPONENTS:

1. TELESCOPE

2. SCANNER

3. SHROUD

PURPOSE OF ANALYSIS

1. DETERMINE IF ITEK'S STRUCTURE IS CAPABLE OF WITHSTANDING POWERED FLIGHT AND ON-ORBIT LOADS.

2. USE THE RESULTS OF THE ANALYSIS TO MAKE RECOMMENDATION ON DESIGN CHANGES TO ITEK.

3. DETERMINE THE DEGREE OF OPTIMIZATION OF ITEK'S STRUCTURE AND USE THE RESULTS TO RECOMMEND WEIGHT SAVINGS TO ITEK.

4. PERFORM ALIGNMENT STUDIES USING INFORMATION OBTAINED FROM THE ANALYSIS.

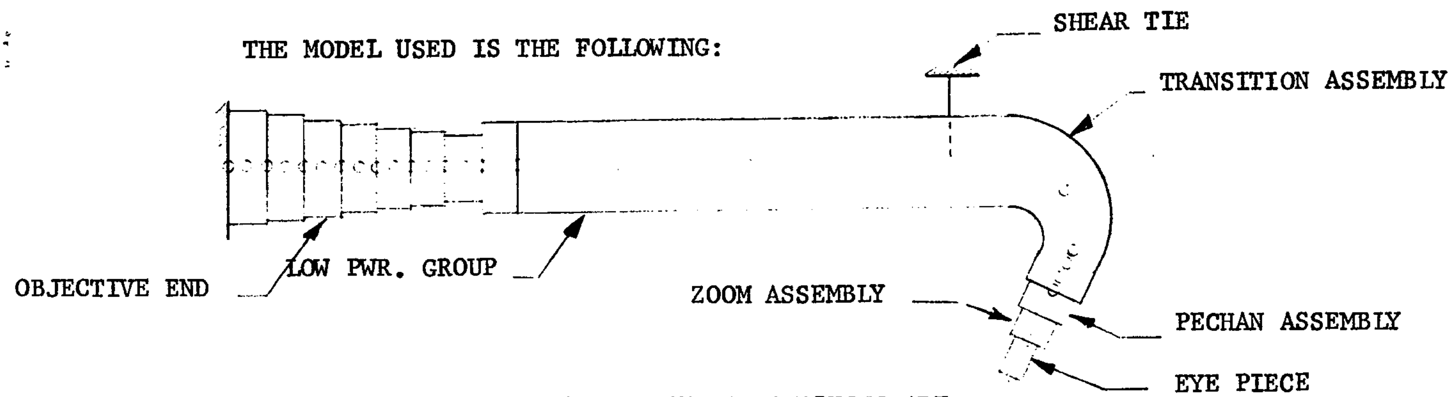
ATS STRUCTURAL ANALYSIS

STRUCTURAL ANALYSIS OF THE ATS TELESCOPE

ANALYSIS WAS PERFORMED USING GE STRUCTURAL COMPUTER PROGRAMS. A STRUCTURAL MODEL WAS MADE USING ITEK DRAWINGS. THE FOLLOWING ASSUMPTIONS WERE MADE IN CONSTRUCTION OF THE MODEL:

1. THE CONNECTION BETWEEN THE OBJECTIVE END AND THE PENETRATION FITTING WILL NOT TRANSMIT TORSIONAL LOADS.
2. THE TELESCOPE IS MADE OF BERYLLIUM AND ALUMINUM.
   (NOTE: IN DEFLECTION STUDIES, THE TELESCOPE WAS CONSIDERED TO BE ALUMINUM ONLY).
3. THE WEIGHT OF THE TELESCOPE IS 81.10 LBS.
4. THE LOADING USED WAS OBTAINED FROM DAC BIRDCAGE LOADS MODIFIED TO TRENDS SHOWN BY THE 3A LOAD CYCLE.

   THE MODEL USED IS THE FOLLOWING:



THE RESULTS OF THE TELESCOPE STRUCTURAL ANALYSIS ARE:

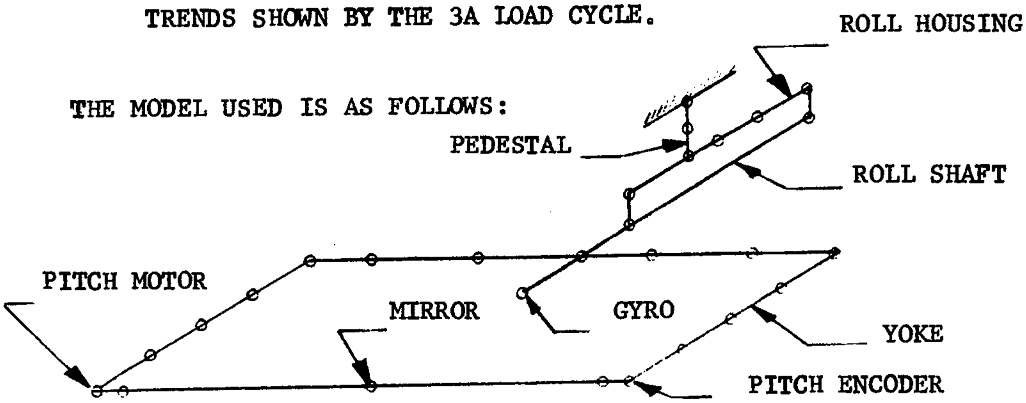
1. THE TELESCOPE WILL WITHSTAND THE LOADINGS IT IS SUBJECTED TO.
2. THE WEIGHT OF THE TELESCOPE STRUCTURE CAN BE REDUCED.
3. THE MINIMUM MARGIN OF SAFETY IS +0.46 (LIMIT) WHICH IS FOR CRIPPLING OF THE SHEAR TIE. ALL OTHER MARGINS ARE HIGH.

STRUCTURAL ANALYSIS OF THE ATS SCANNER

THE ANALYSIS WAS PERFORMED USING GE STRUCTURAL COMPUTER PROGRAMS. THE STRUCTURAL MODEL WAS MADE USING ITEK DRAWINGS. THE FOLLOWING ASSUMPTIONS WERE MADE IN THE CONSTRUCTION OF THE MODEL AND SUBSEQUENT ANALYSIS:

1. THE SCANNER IS MADE ENTIRELY OF BERYLLIUM
2. THE WEIGHT OF THE SCANNER IS 70.75 LBS.
3. WORST CASE INERTIA MAKE-UP WEIGHT WAS USED
4. THE MIRROR-BEZEL COMBINATION IS A RIGID BODY
5. THE LOADING USED WAS OBTAINED FROM DACO BIRDCAGE LOADS MODIFIED TO TRENDS SHOWN BY THE 3A LOAD CYCLE.

THE MODEL USED IS AS FOLLOWS:



THE RESULTS OF THE SCANNER STRUCTURAL ANALYSIS ARE AS FOLLOW:

1. THE SCANNER IS CAPABLE OF WITHSTANDING THE LOADS IT WILL BE SUBJECTED TO.
2. THE MARGINS OF SAFETY ARE HIGH.
3. A DEFINITE WEIGHT REDUCTION POTENTIAL EXISTS.

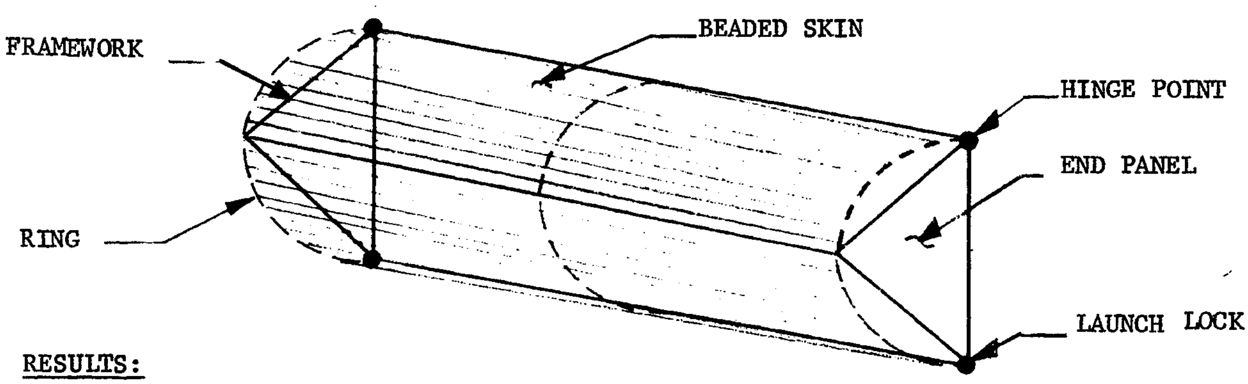
ATS STRUCTURAL ANALYSIS

STRUCTURAL ANALYSIS OF THE PROTECTIVE SHROUD

THE ANALYSIS PERFORMED WAS A HAND ANALYSIS WITH THE SPECIFIC PURPOSE OF DEMONSTRATING THAT A SHROUD WHICH WEIGHS APPROXIMATELY 14 LBS. IS FEASIBLE. THE ASSUMPTIONS MADE ARE AS FOLLOWS:

1. THE SHROUD WILL CONFORM TO THE SAME ENVELOPE AS THE ITEK PDR DESIGN SHROUD.
2. THE SHROUD WOULD UTILIZE BERYLLIUM, MAGNESIUM OR FIBERGLASS AS STRUCTURAL MATERIALS.
3. THE SHROUD WOULD SEE TEMPERATURES OF 400°F FOR ½ HOUR PERIODS.
4. SHELL ACCELERATIONS FROM MARTIN'S SECOND LOAD CYCLE WOULD BE USED TO DETERMINE LOAD FACTORS.
5. THE Δ P ACROSS THE SHROUD WALL WOULD BE 0.1 PSI OR LESS.
6. THE DRIVE MECHANISM WOULD BE A REDUNDANT DRIVE WITH A MOTOR AND GEAR BOX DIRECTLY CONNECTED TO EACH SIDE OF THE SHROUD.
7. THE WORST CASE ON-ORBIT LOADS ARE FOR THE CONDITION OF A MOTOR FAILURE WITH THE SHROUD THEN BEING DRIVEN FROM ONE SIDE ONLY.

THE CONCEPT STUDIED IS AS FOLLOWS:



RESULTS:

FOR THE ENVIRONMENT CONSIDERED, A SHROUD WEIGHT OF 14 LBS. IS FEASIBLE.

ATS ALIGNMENT STUDIES

AREAS STUDIED:

1. MECHANICAL JOINT SLIPPAGE
2. SHELL PRESSURIZATION
3. 1G LOAD RELIEF
4. VEHICLE THERMAL DISTORTIONS

DISCUSSION:

1. MECHANICAL JOINT SLIPPAGE

   - WORST CASE CONSIDERED: WORST TOLERANCE STACK-UP, SINGLE FASTENER JOINTS, MOVEMENT IN WORST DIRECTION.

   - RESULTS: ANGULAR MIS-ALIGNMENT OF THE LINE OF SIGHT BETWEEN THE EYE-PIECE AND THE SCANNER MIRROR IS 8.52 ARC MIN.

2. SHELL PRESSURIZATION

   - 0 Δ P CONSIDERED AT INITIAL ALIGNMENT, 5 PSI $\pm$ 0.2 PSI Δ P CONSIDERED ON-ORBIT.

   - RESULTS: ANGULAR MIS-ALIGNMENT OF THE LINE OF SIGHT BETWEEN THE SCANNER MIRROR AND THE FIXED-FOLD MIRROR IS 2.35 ARC MIN. FOR A Δ P OF 5 PSI FOR A Δ P OF 4.8, THE MIS-ALIGNMENT IS 2.26 ARC MIN. AND FOR A Δ P OF 5.2, IT IS 2.45 ARC MIN.

ATS STRUCTURAL ANALYSIS

ATS ALIGNMENT STUDIES

(CONT'D)

DISCUSSION - (CONT'D)

3. 1G CONDITION RELIEF

- o RELEASE OF DEFLECTION OF COMPONENTS IMPARTED BECAUSE OF 1G FIELD DURING VEHICLE INSTALLATION.
- o RESULTS: ANGULAR MIS-ALIGNMENT OF THE LINE OF SIGHT BETWEEN THE EYE-PIECE AND THE OBJECTIVE IS 2.65 ARC SEC.

4. VEHICLE THERMAL DISTORTIONS

- o NOT SIGNIFICANT DUE TO RADIATOR

ATS STRUCTURAL ANALYSIS

FUTURE WORK PLANNED

1. UPDATED STRUCTURAL ANALYSIS OF TELESCOPE, SCANNER AND SHROUD
   - LATEST CONFIGURATION
   - LATEST LOADS
   - THERMAL EFFECTS
   - SHELL PRESSURIZATION EFFECTS

2. ADDITIONAL WEIGHT ORIENTED STRUCTURAL OPTIMIZATION STUDIES TO CONTROL SYSTEM WEIGHT EFFECTIVELY.

3. STRUCTURAL ANALYSIS OF EXTERNAL FIXED-FOLD MIRROR.

4. DETERMINATION OF SHELL FLEXIBILITIES WHEN SHELL IS PRESSURIZED TO 5 PSI.

5. UPDATED ALIGNMENT INFORMATION TO REFLECT LATEST STRUCTURAL CONFIGURATIONS AND ALSO LATEST SHELL FLEXIBILITY INFORMATION.

ATS DESIGN LOADS

THE ATS DESIGN LOAD FACTORS WERE DERIVED FROM THE BIRDCAGE DESIGN LOADS. THE BIRDCAGE DESIGN LOADS ARE AS FOLLOWS:

LOAD CONDITION	LIMIT LOADS (ULT. = 1.4 x LIMIT) Nx (G's)	Ny (G's)	Nz (G's)
MAX. X CONDITION	± 7.0	± 0.5	± 0.5
MAX. Y CONDITION	+ 2.1 - 0.67	± 1.25	± 0.5
MAX Z CONDITION	+ 2.1 - 0.67	± 0.5	± 1.25

REF: MINUTES OF BIRDCAGE TM ON LOADS AND STRUCTURAL COMPATIBILITY (3/28/67)

TO ACCOUNT FOR AMPLIFICATION OF THE LOADS, THE MAX. X CONDITION WAS INCREASED TO ± 10G's. THE REMAINING LOAD FACTORS WERE THEN INCREASED BY THE RATIO OF 10/7. THE DESIGN LOADS ARE THE FOLLOWING:

LOAD CONDITION	LIMIT LOADS (ULT. = 1.4 x LIMIT) Nx (G's)	Ny (G's)	Nz (G's)
MAX. X CONDITION	± 10.0	± 0.72	± 0.72
MAX. Y CONDITION	+ 3.0 - 1.0	± 1.8	± 0.72
MAX Z CONDITION	+ 3.0 - 1.0	± 0.72	± 1.8

PROTECTIVE SHROUD DESIGN LOADS

THE PROTECTIVE SHROUD LIES BETWEEN STATIONS 518 AND 566. THE MAXIMUM LOAD FACTOR FOR A POINT BETWEEN THESE STATIONS WILL BE USED.

REF: SHELL ACCELERATIONS FROM THE MARTIN COMPANY 2ND LOAD CYCLE DATED NOVEMBER 14, 1966.

	LIMIT LOADS (ULT. = 1.4 x LIMIT)		
LOAD CONDITION	AXIAL G's	YAW G's	PITCH G's
LAUNCH	+ 2.8 + 0.59	+ 0.41 - 0.24	+ 0.80 - 0.44
STAGE 0 THRUST TERMINATION	+ 3.6 - 1.8	± 0.05	± 0.05
STAGE I SHUTDOWN	+ 4.1 - 1.3	+ 0.42 - 0.41	NEGLIGIBLE
STAGE II IGNITION	+ 5.6 - 2.7	NEGLIGIBLE	NEGLIGIBLE

THE CONDITIONS CHOSEN WERE MAX. LATERAL G's (LAUNCH) AND MAX. AXIAL G's (STAGE II IGNITION). THESE CONDITIONS ARE SHOWN ON PG. 2-320 OF THE EAR. THEY ARE USED CONSISTENTLY THROUGH THE ANALYSIS OF THE PROTECTIVE SHROUD.

ATS WEIGHT STATUS

	CURRENT ESTIMATE
TELESCOPE	149.22 LB. (74.61 LB.)
EXTERNAL FIXED-FOLD MIRROR	29.50 LB. (14.75 LB.)
PRESSURE WINDOW	8.42 LB. (4.21 LB.)
SCANNER	111.60 LB. (55.8 LB.)
PROTECTIVE SHROUD	43.72 LB. (21.86 LB.)
SUN-SENSOR	1.50 LB. (0.75 LB.)
TOTAL	343.96 LB. (171.98 LB.)

DETAILED BREAKDOWN

TELESCOPE

OBJECTIVE END	25.99	
LOW POWER GROUP	20.79	
SHEAT MOUNT	1.00	
TRANSITION ASSEMBLY	6.88	
PECHAN ASSEMBLY	6.20	
ZOOM ASSEMBLY	5.20	
EYE-PIECE ASSEMBLY	2.80	
ELECTRICAL	5.75	
	74.61 LB.	or 149.22 LB/VEHICLE

EXTERNAL FIXED-FOLD MIRROR

MIRROR	11.00	
BEZEL	2.10	
POTTING	0.87	
FITTINGS	0.78	
	14.75 LB.	or 29.5 LB./VEHICLE

PRESSURE WINDOW

GLASS	4.21	
	4.21 LB.	or 8.42 LB/VEHICLE

DETAILED BREAKDOWN

TRACKING PEDESTAL

PEDESTAL AND HOUSING	6.35		
YOKE	2.28		
MIRROR	11.14		
BEZEL	3.15		
POTTING	0.88		
HARNESS AND CONNECTORS	6.00		
MOTORS, ENCODERS, ETC.	26.00		
	55.80 LB.	or	111.60 LB./VEHICLE

PROTECTIVE SHROUD

STRUCTURE	11.95		
DRIVE	5.86		
INSULATION	2.30		
PAINT AND COATINGS	1.00		
DISCONNECTS AND LAUNCH LOCKS	0.75		
	21.86 LB.	or	43.72 LB./VEHICLE

SUN SENSOR

SUN SENSOR	0.75		
	0.75 LB.	or	1.50 LB./VEHICLE

STRUCTURAL DYNAMIC ANALYSIS

A. THREE COMPONENT DYNAMIC MODELS

TELESCOPE

a. NUMBER OF D.O.F. = 126

b. ALL OPTICAL ELEMENTS MONITORED (12 ELEMENTS)

c. BOUNDARY CONDITION = FREE-FREE

d. TWO ATTACH POINTS TOTALING NINE (9) D.O.F.

e. SIX (6) RIGID BODY MODES

FIXED-FOLD

a. NUMBER OF D.O.F. = 14

b. BOUNDARY CONDITION = FREE-FREE

c. THREE (3) ATTACH POINTS TOTALING NINE (9) D.O.F.

d. SIX (6) RIGID BODY MODES

SCANNER

a. NUMBER OF D.O.F. = 40

b. BOUNDARY CONDITION = FREE-FREE

c. THREE (3) ATTACH POINTS TOTALING EIGHTEEN (18) D.O.F.

d. EIGHT (8) RIGID BODY MODES

STRUCTURAL DYNAMIC ANALYSIS - (cont'd)

B. SUBSYSTEM MODEL

1. THREE (3) COMPONENT MODELS COUPLED THROUGH SHELL STIFFNESS MATRIX.
2. TOTAL D.O.F. = 180
3. MODE SHAPES AND FREQUENCIES WILL BE COMPUTED.

C. COUPLING STIFFNESS MATRIX

PRESSURIZED, NON-PRESSURIZED.

D. OBJECTIVES OF DYNAMIC ANALYSIS

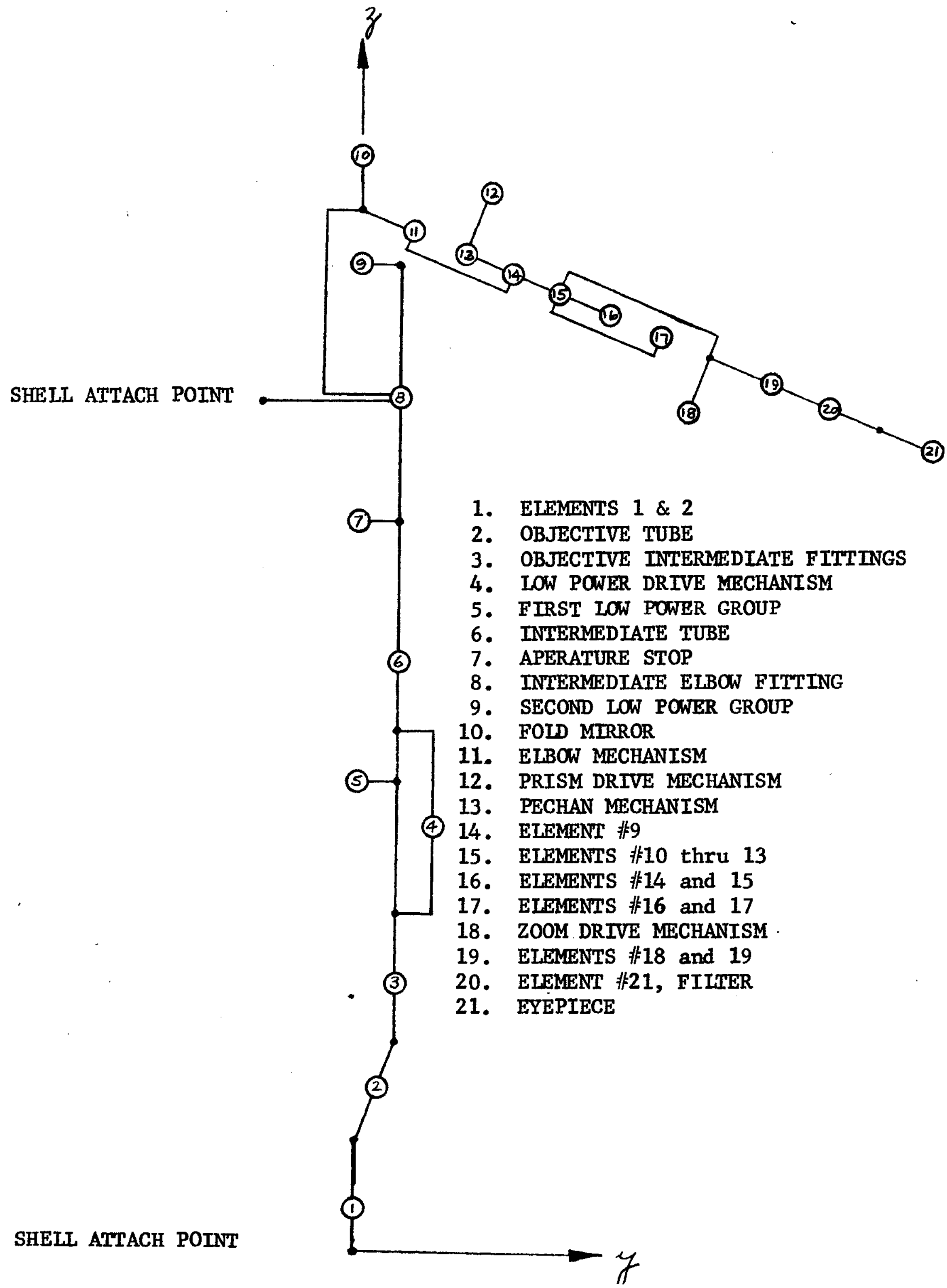
1. EVALUATE DESIGN BY ANALYSIS OF MODE SHAPES (STRUCTURAL INTEGRITY AND OPTICAL PERFORMANCE)
2. EVALUATE EFFECTS OF INTERNAL DISTRUBANCES ON SUBSYSTEM PERFORMANCE.
3. EVALUATE STRUCTURE - CONTROLS STABILITY.
4. EVALUATE EFFECTS OF EXTERNAL DISTRUBANCES ON SUBSYSTEM PERFORMANCE.
5. EVALUATE EFFECTS OF INTERNAL DISTURBANCES ON D SYSTEM.

E. PRESENT STATUS

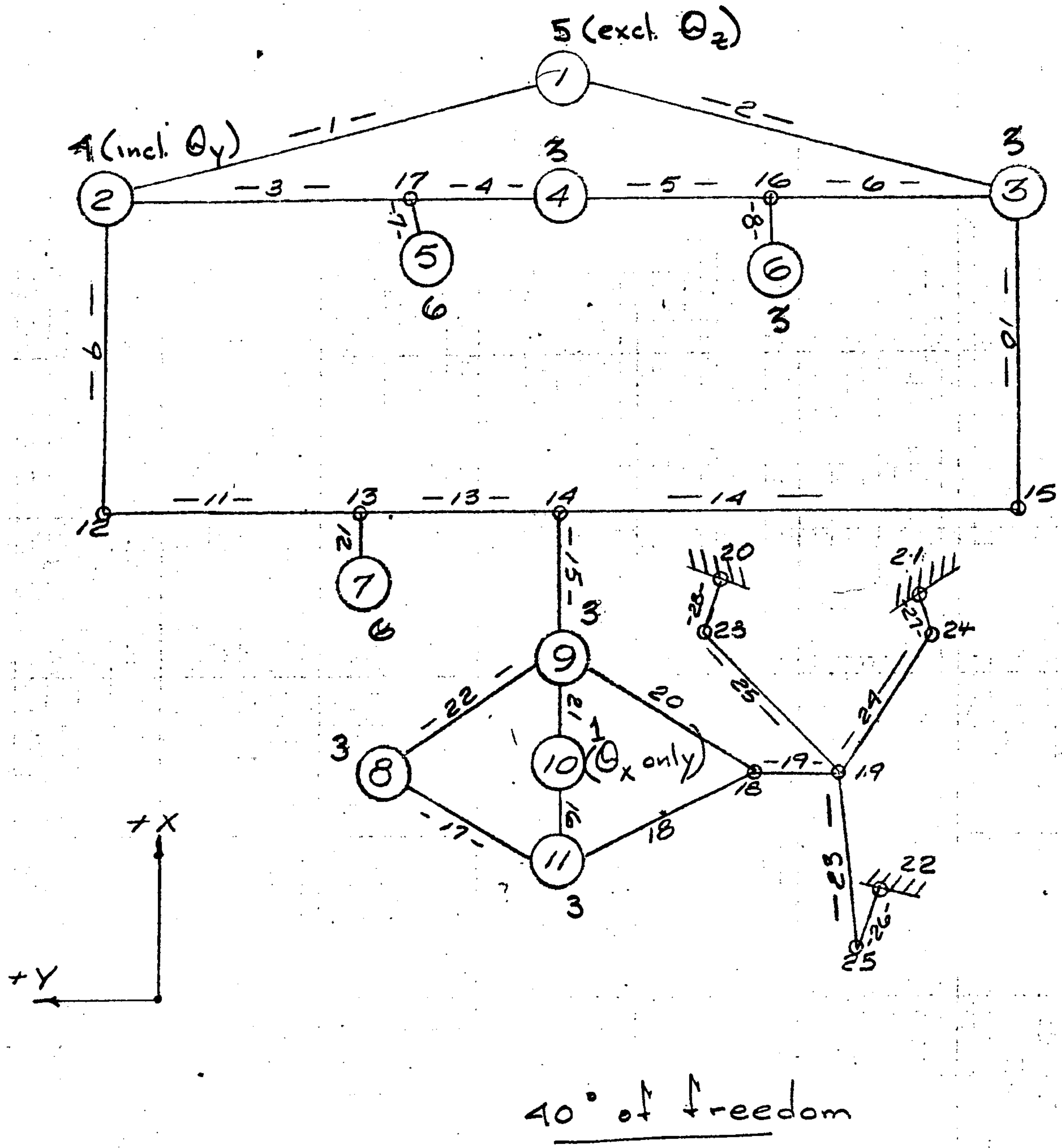
1. TELESCOPE MODEL IS DEFINED AND MASS AND STIFFNESS PROPERTIES CALCULATED. EIGENVALUE RUN IS IMMINENT. (MODE SHAPES AND FREQUENCIES - MARCH 15)
2. SCANNER MODEL IS DEFINED. (MODE SHAPES AND FREQUENCIES - MARCH 22)
3. FIXED-FOLD MODEL IS DEFINED. (MODE SHAPES AND FREQUENCIES - MARCH 22)

SUBSYSTEM ALPHA TELESCOPE

126 DEGREES OF FREEDOM

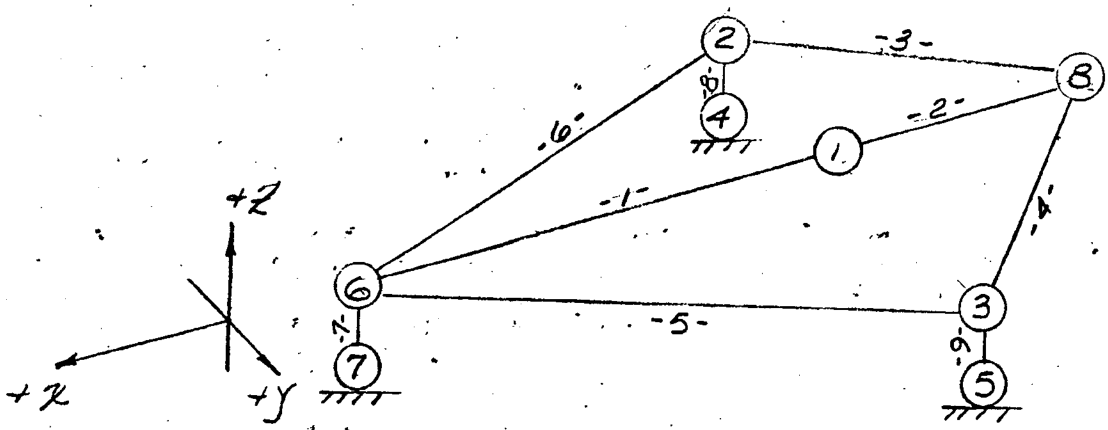


1. ELEMENTS 1 & 2
2. OBJECTIVE TUBE
3. OBJECTIVE INTERMEDIATE FITTINGS
4. LOW POWER DRIVE MECHANISM
5. FIRST LOW POWER GROUP
6. INTERMEDIATE TUBE
7. APERATURE STOP
8. INTERMEDIATE ELBOW FITTING
9. SECOND LOW POWER GROUP
10. FOLD MIRROR
11. ELBOW MECHANISM
12. PRISM DRIVE MECHANISM
13. PECHAN MECHANISM
14. ELEMENT #9
15. ELEMENTS #10 thru 13
16. ELEMENTS #14 and 15
17. ELEMENTS #16 and 17
18. ZOOM DRIVE MECHANISM
19. ELEMENTS #18 and 19
20. ELEMENT #21, FILTER
21. EYEPIECE



SCANNER DYNAMIC MODEL

FIXED-FOLD DYNAMIC MODEL



HISTORY

1. SUBCONTRACTOR FOR ALPHA SUBSYSTEM EXPRESSES NEED FOR SHELL FLEXIBILITY INFORMATION. THE INFORMATION IS NEEDED FOR DESIGN PURPOSES (MIS-ALIGNMENT STUDIES, COMPONENT DYNAMIC ANALYSIS, ETC.).

2. ASSOCIATE CONTRACTOR SUBMITS SHELL DEFLECTION INFORMATION. THIS INFORMATION DOES NOT FILL NEEDS (GIVES NO INDICATION OF SHELL FLEXIBILITIES).

3. ADDITIONAL INFORMATION REQUESTED FROM ASSOCIATE. ASSOCIATE STATES THAT REQUIRED SHELL FLEXIBILITY INFORMATION WOULD NOT BE AVAILABLE PRIOR TO JUNE 30, 1968.

4. DECISION IS MADE THAT GE WILL PERFORM COMPLETE SYSTEM DYNAMIC ANALYSIS USING COMPONENT MODELS GENERATED BY SUBCONTRACTOR AND USING THE PRESSURE SHELL TO TIE THE COMPONENTS TOGETHER.

5. IN ORDER TO PERFORM THE DYNAMIC ANALYSIS AND TO SUPPLY THE SUBCONTRACTOR WITH THE INFORMATION HE NEEDS, IT IS DECIDED THAT GE WILL, USING ASSOCIATE DRAWINGS, DEVELOP A FLEXIBILITY AND STIFFNESS MATRIX REPRESENTING THE SYSTEM MOUNTING POINTS.

PROCEDURE USED TO OBTAIN STIFFNESS MATRIX

1. MODEL PRESSURE SHELL STRUCTURE USING DAC DRAWING# 1B72094

   o DETERMINE MODEL CONFIGURATION

   o DETERMINE SECTION PROPERTIES

   o SET-UP BOUNDARY CONDITIONS.

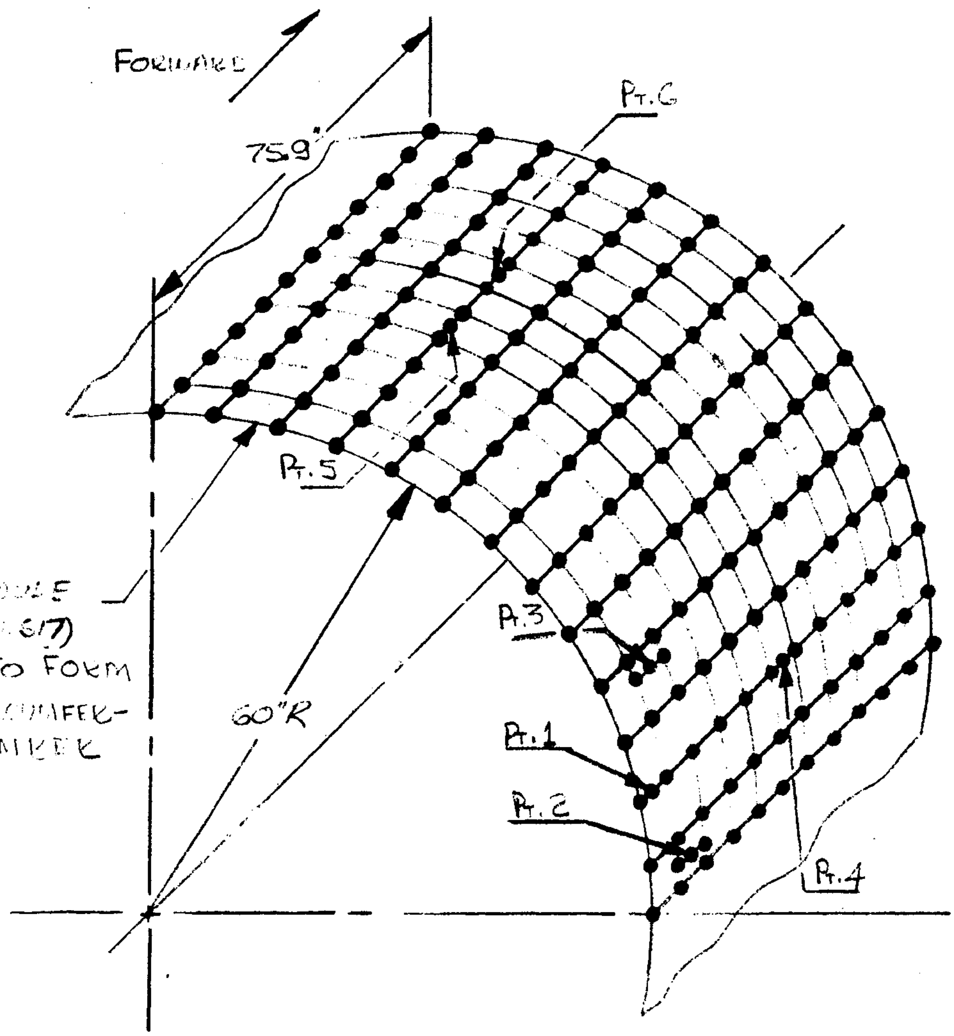
2. APPLY UNIT FORCES AND MOMENTS AT SYSTEM MOUNTING POINTS TO OBTAIN DEFLECTIONS AND ROTATIONS AT EACH MOUNTING POINT. THE FORCES AND MOMENTS ARE APPLIED IN THE RADIAL, TANGENTIAL AND LONGITUDINAL DIRECTIONS TO OBTAIN 6 DEGREES OF FREEDOM FOR EACH POINT. THE "MASS" (MECHANICAL ANALYSIS OF SPACE STRUCTURES) PROGRAM WAS USED TO OBTAIN THE DEFLECTIONS AND ROTATIONS. THE PROGRAM UTILIZES THE GE 635 COMPUTER SYSTEM.

3. THE OUTPUT INFORMATION IS IN THE X, Y, Z COORDINATE SYSTEM. THE OUTPUT IS THEN TRANSFORMED INTO THE RADIAL, TANGENTIAL AND LONGITUDINAL COORDINATE SYSTEM USING A PROGRAM WRITTEN FOR THIS PURPOSE USING THE GE 605 COMPUTER SYSTEM.

4. ASSEMBLE THE TRANSFORMED OUTPUT DATA INTO A 36 x 36 INFLUENCE COEFFICIENT MATRIX (REPRESENTS 6 DEGREES OF FREEDOM AT 6 MOUNTING POINTS).

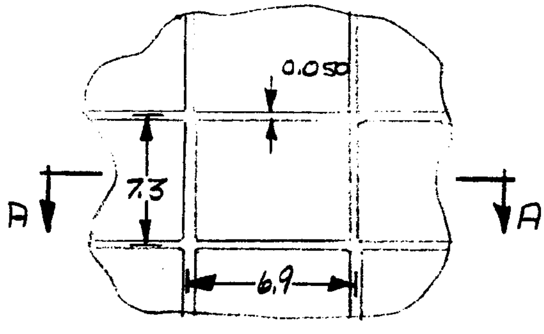
5. INVERT THE INFLUENCE COEFFICIENT MATRIX TO OBTAIN A STIFFNESS MATRIX.

PRESSURE SHELL MODEL (REF. DAC DWGS. 1B72094)

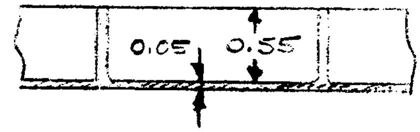


THE LAB MODULE AFT RING (STA. 617) WAS USED TO FORM THE AFT CIRCUMFERENTIAL MEMBER

TYPICAL DETAILS

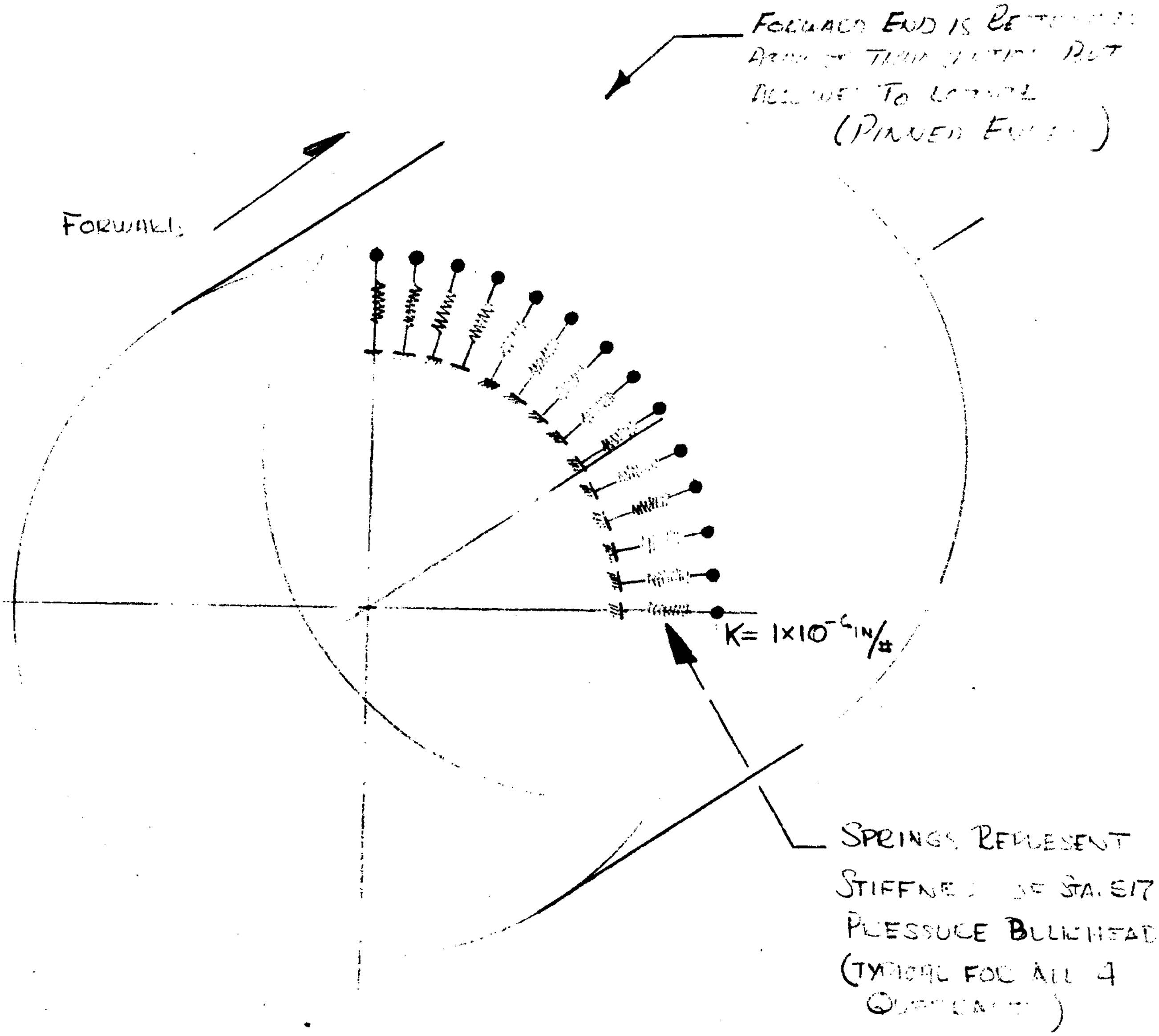


NOTE: IN SOME AREAS THE SKIN WAS CONSIDERED TO BE 0.080" THICK



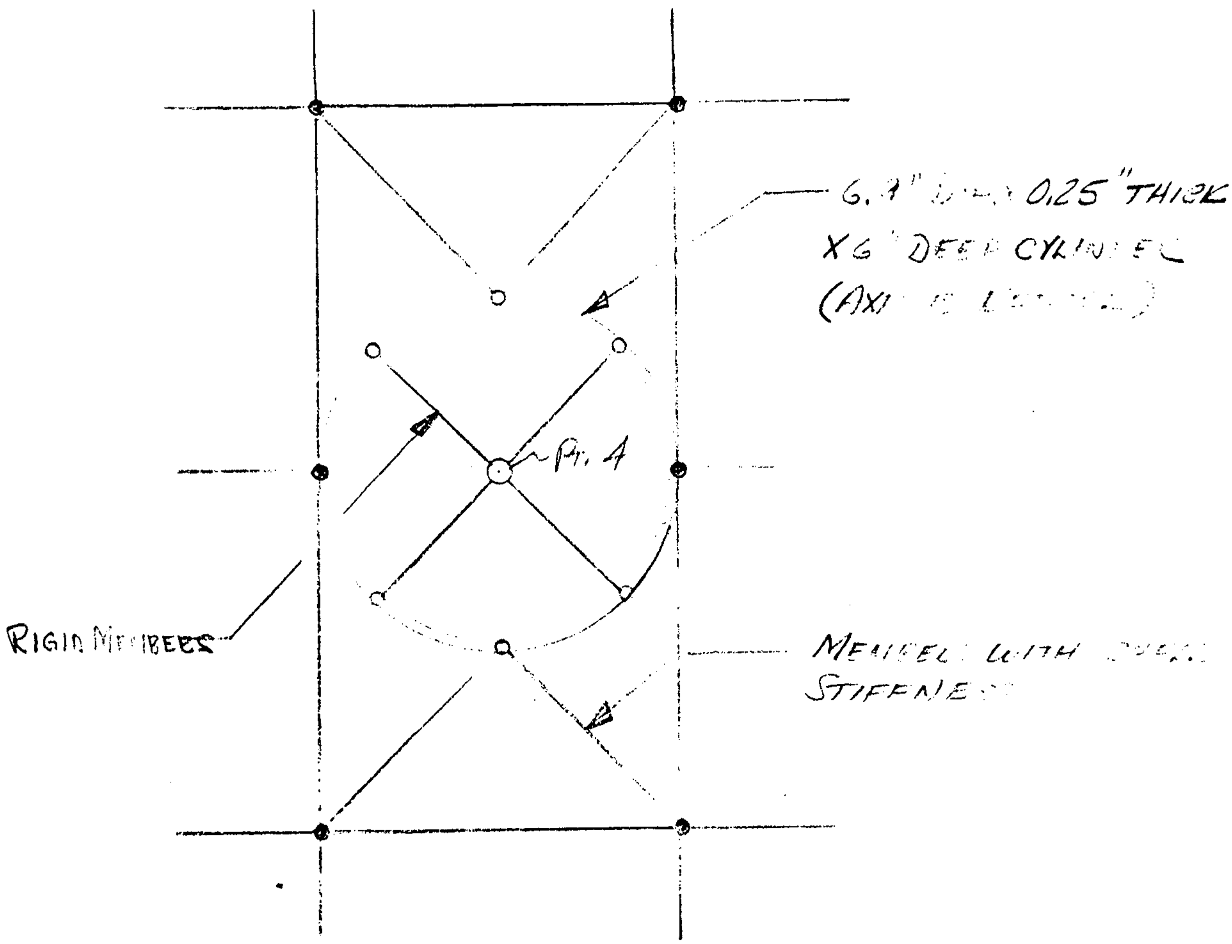
SECTION A-A

BOUNDARY CONDITIONS



NOTE: THE PRESSURE SHELL IS CONSIDERED TO HAVE NO MASS.

PENETRATION FITTING SIMULATION

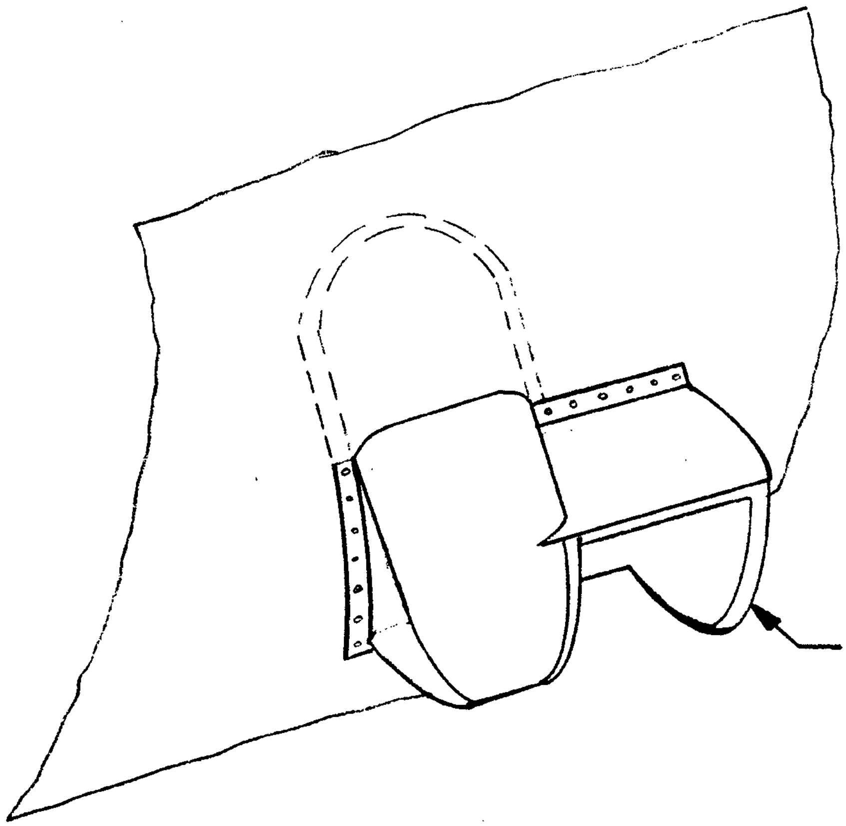


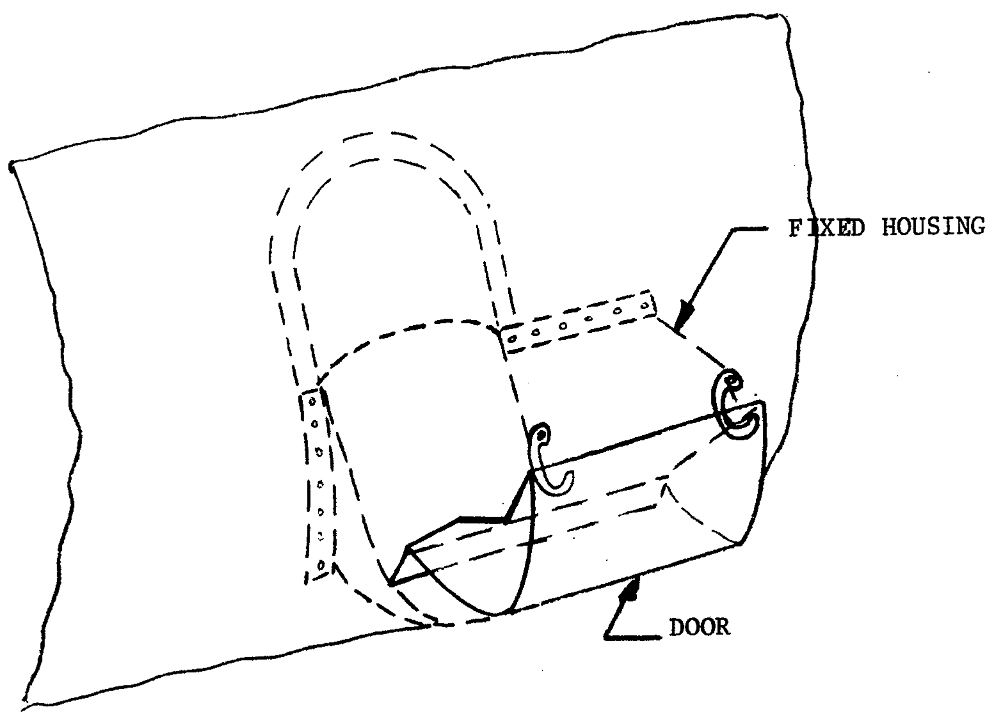
FUTURE ANALYSIS REQUIRED

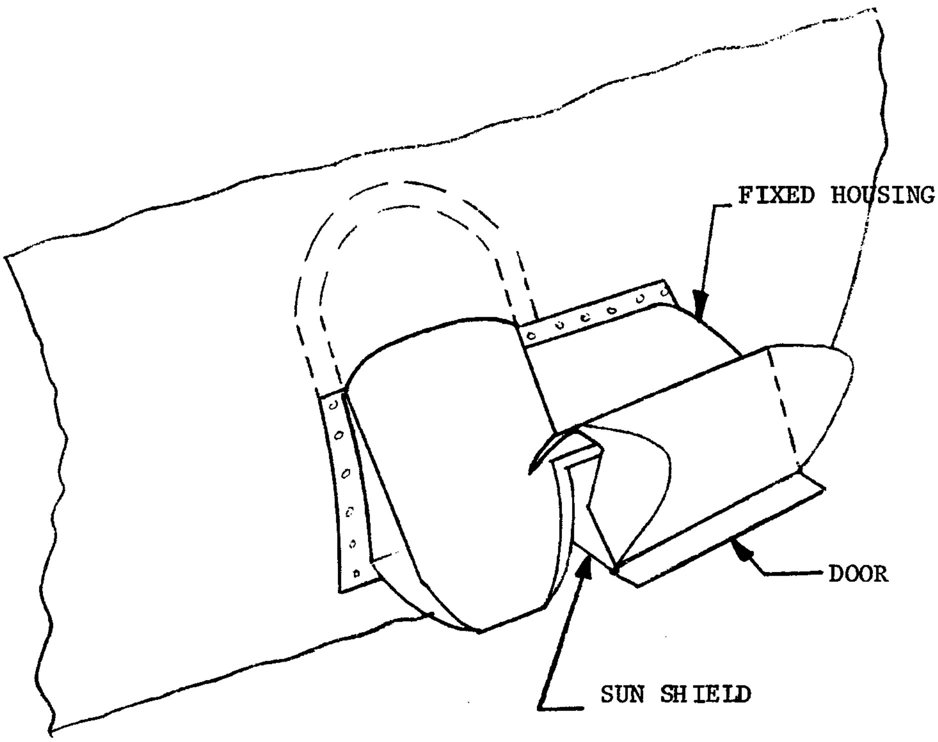
1. SHELL FLEXIBILITIES WHEN SHELL IS PRESSURIZED TO ON-ORBIT PRESSURE OF 5 PSI.

   o INFORMATION NEEDED FOR DYNAMIC ANALYSIS AND ALIGNMENT STUDIES.

2. UPDATING SHELL FLEXIBILITIES TO REFLECT CHANGES TO DACO SHELL.


FIXED HOUSING


FIXED HOUSING
DOOR


FIXED HOUSING
DOOR
SUN SHIELD

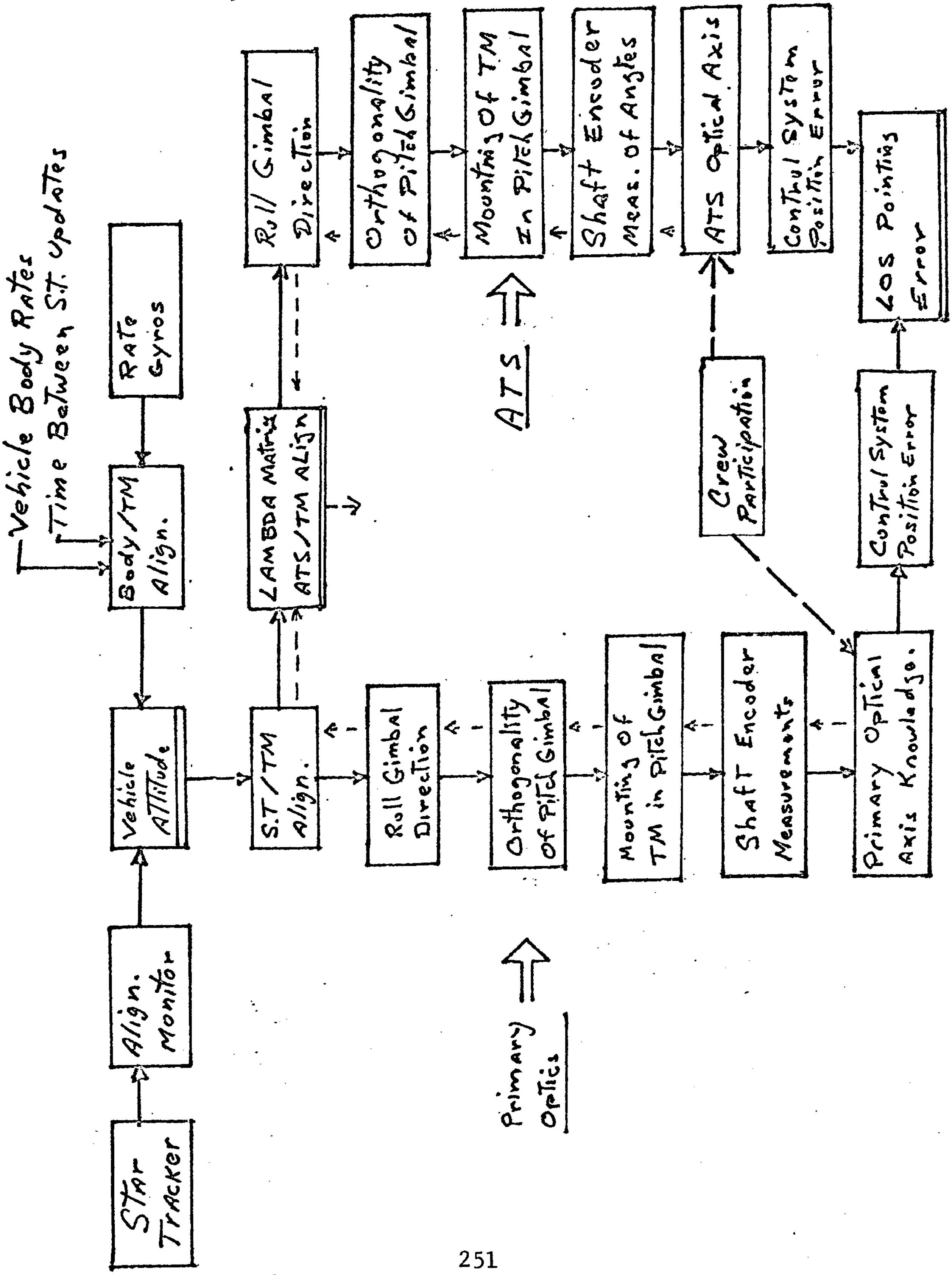
ATS To Primary Optics Boresighting

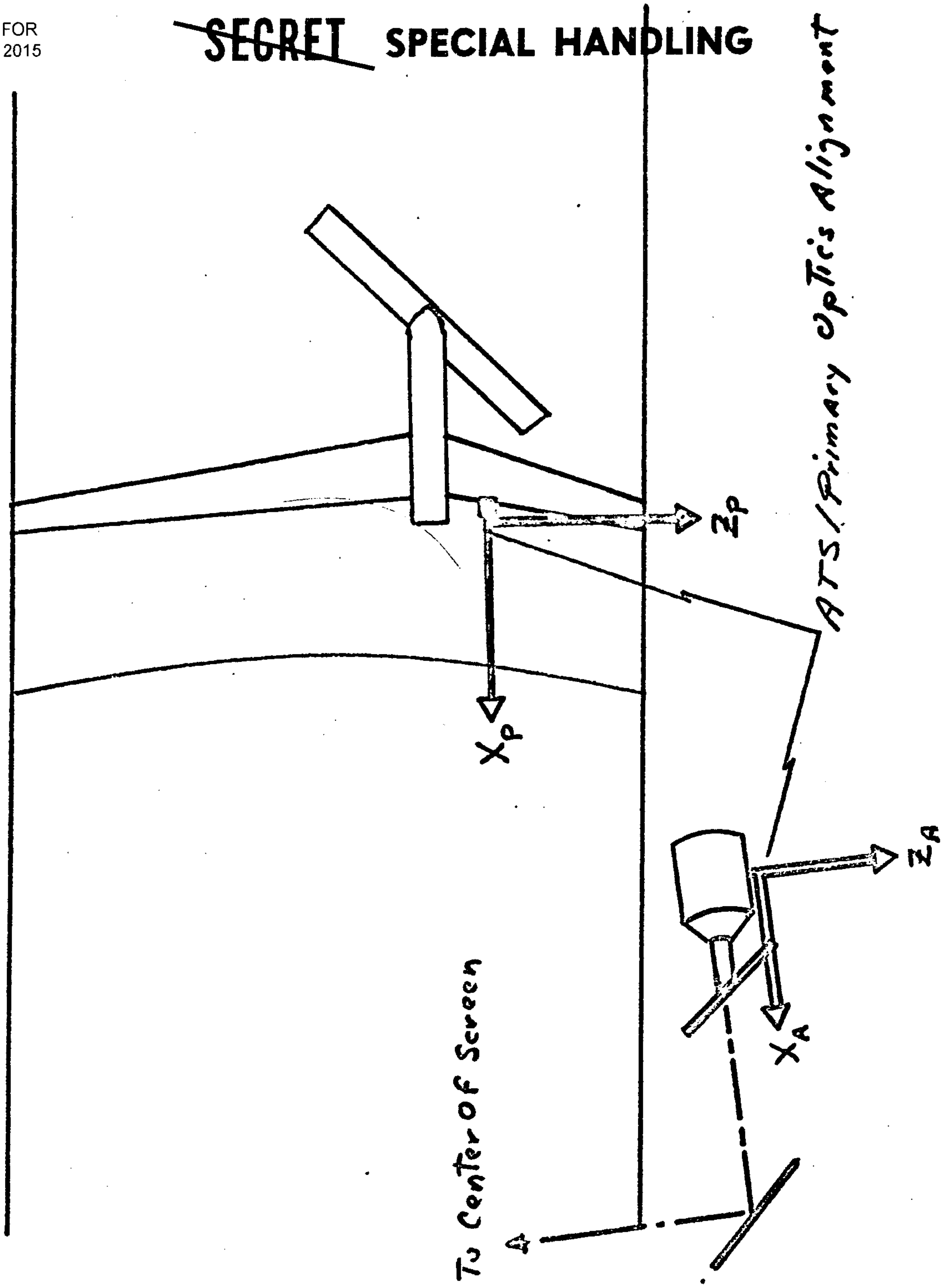
Purpose -- Obtain Alignment Between ATS & Primary optical systems

Procedure -- Center ATS & Primary optics on a suitable Target

Record Gimbal Angles

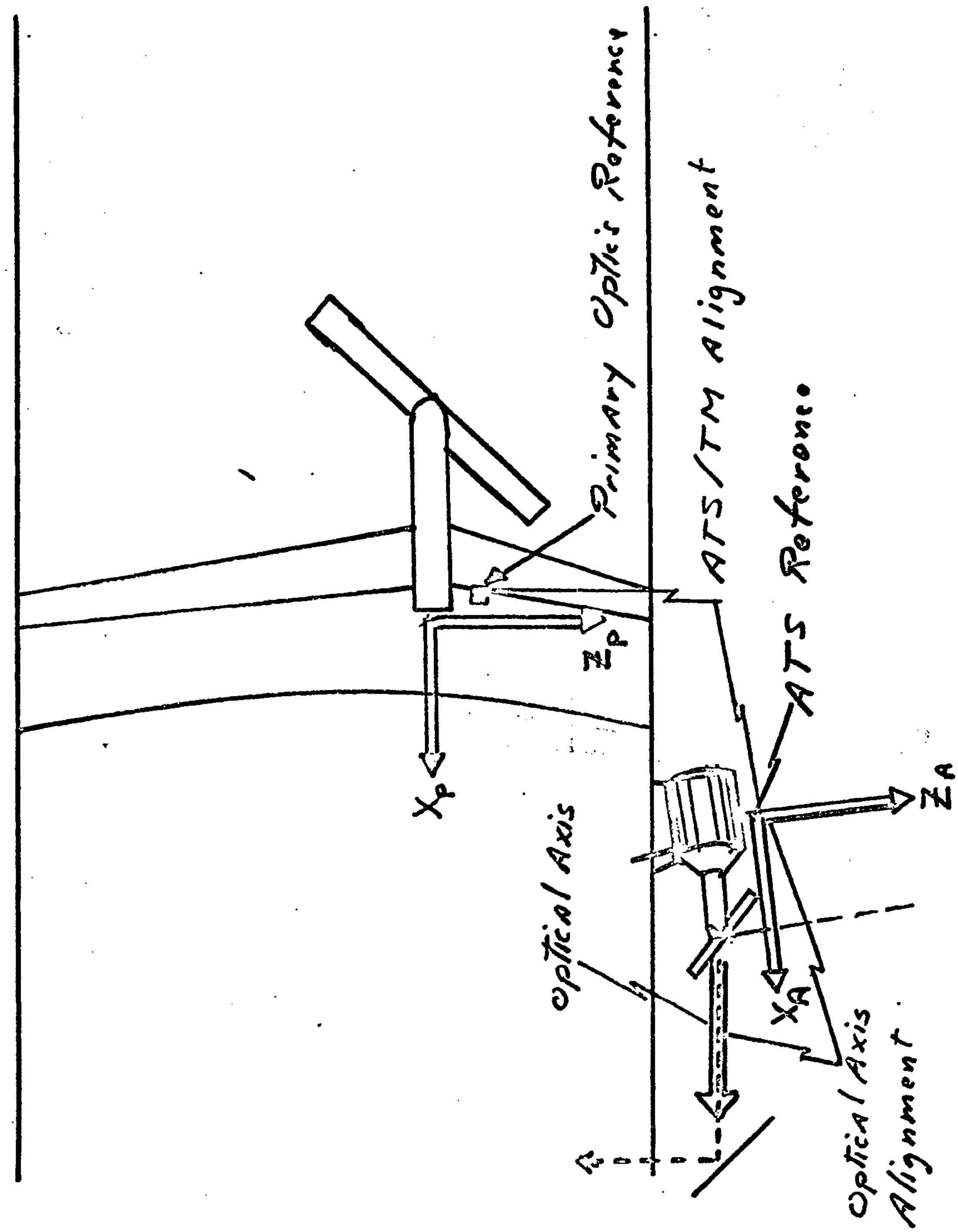
Use Gimbal angle differences to compensate for ATS & Primary optics Alignment Errors


Vehicle Body Rates
Time Between S.T. Updates
Rate Gyros
Body/TM Align.
Star Tracker
Align. Monitor
Vehicle Attitude
S.T./TM Align.
LAMBDA Matrix ATS/TM Align
Roll Gimbal Direction
Orthogonality of Pitch Gimbal
Mounting of TM In Pitch Gimbal
Shaft Encoder Meas. of Angles
ATS Optical Axis
Control System Position Error
LOS Pointing Error
ATS
Crew Participation
Control System Position Error
Roll Gimbal Direction
Orthogonality of Pitch Gimbal
Mounting of TM in Pitch Gimbal
Shaft Encoder Measurements
Primary Optical Axis Knowledge
Primary Optics



Configuration Assumed In Present Boresighting Procedure

Configuration Assumed For Expanded Boresighting Procedure

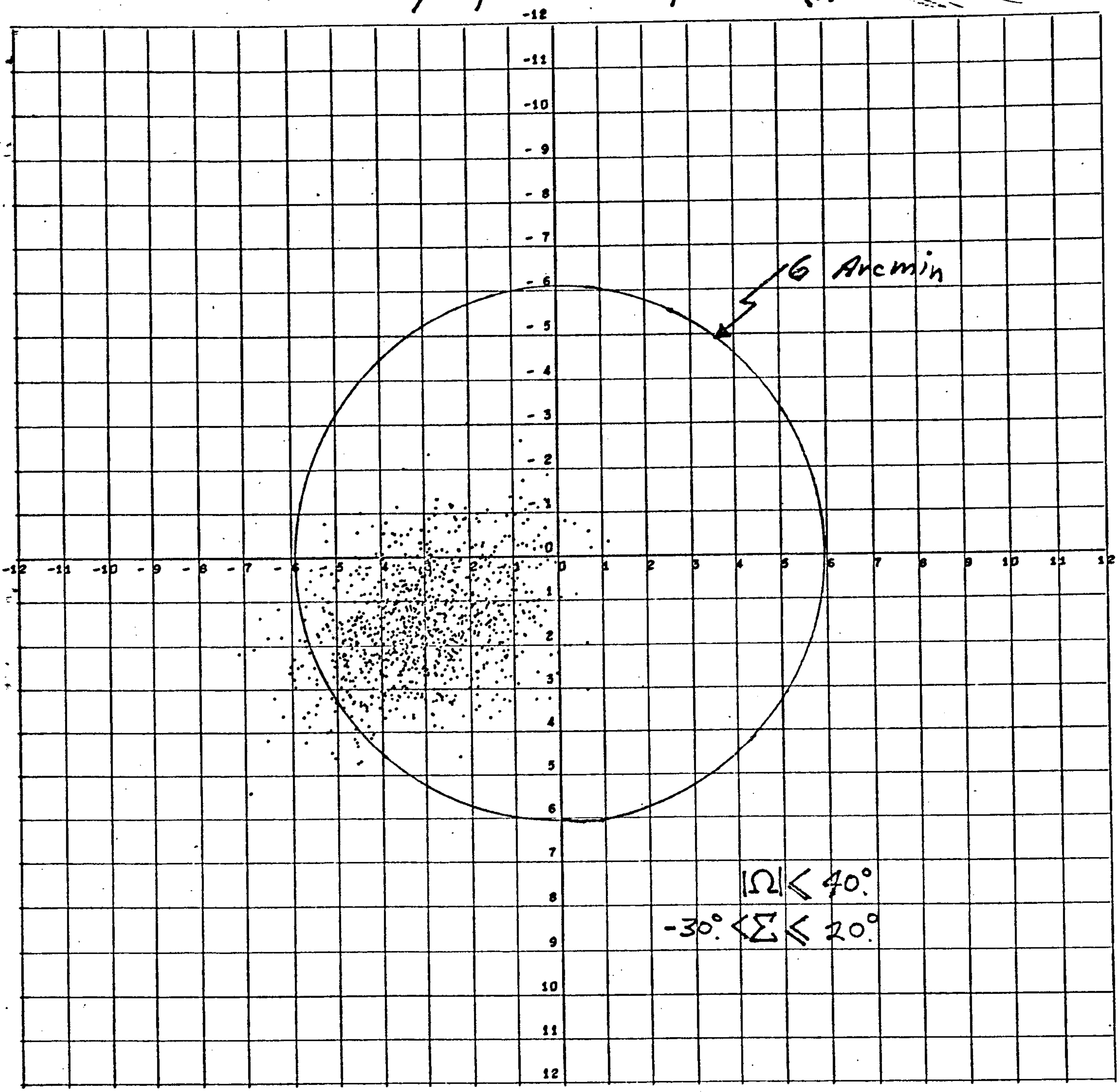


Sensitivity* Of ATS Pointing Error To Constant Errors

Source Of Error		Without Boresighting	2 Target Boresighting	3 Target Boresighting
ATS Roll Gimbal Direction	(Pitch)	2.	0.	0.
	(Yaw)	1.	.28	0.
ATS Optical Axis Direction	(Pitch)	1.	0.	0.
	(Yaw)	1.	.34	0.
ATS/TM Alignment	(Roll)	1.	0.	0.
	(Pitch)	1.	0.	0.
	(Yaw)	0.	0.	0.
Primary Roll Gimbal Direction	(Pitch)	0.	2.	1.37
	(Yaw)	0.	.65	1.10

* (Pointing Error) = (Sensitivity) x (Value Of Error)

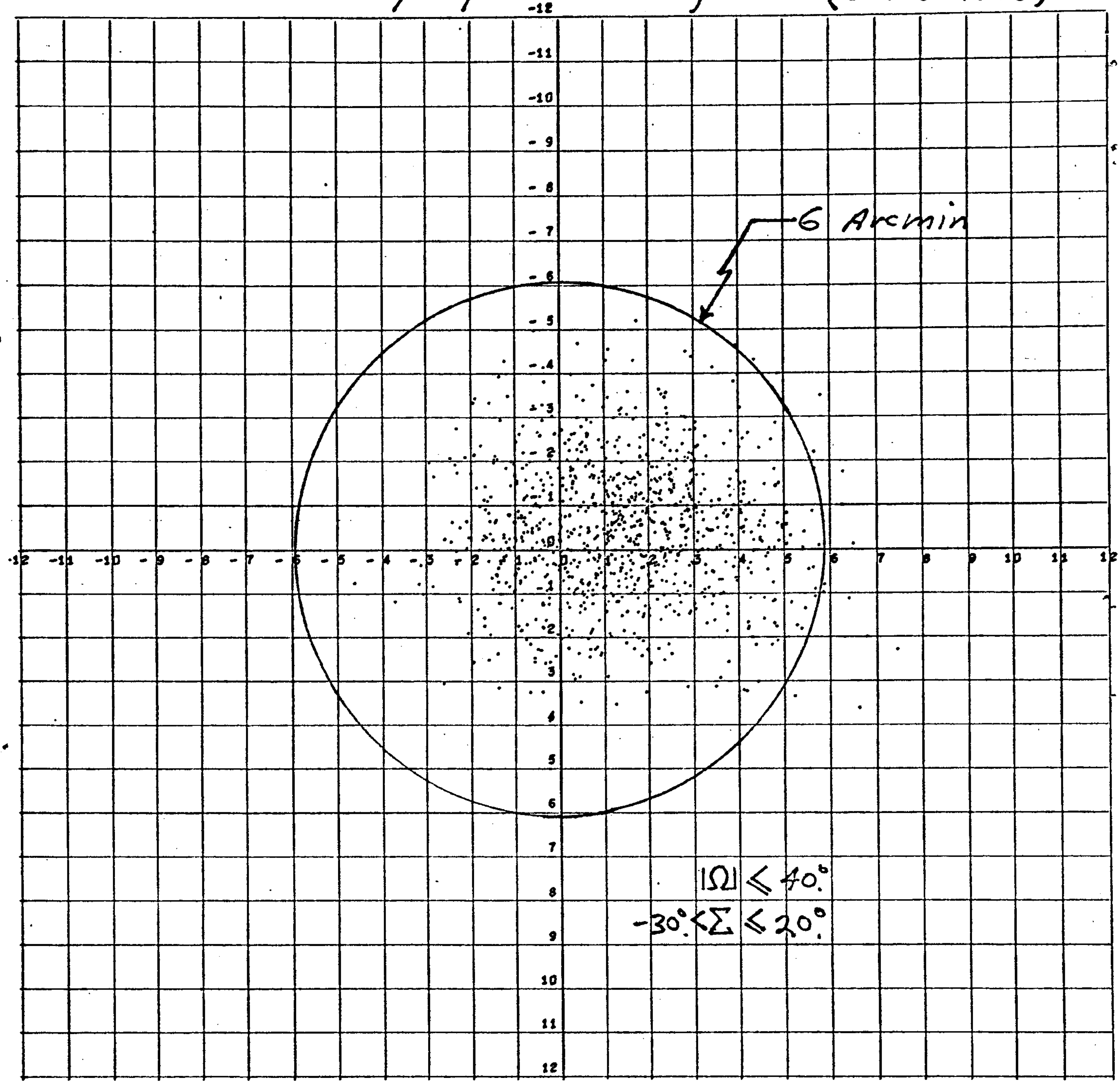
Primary Optics Pointing Error (Automatic Mode)



o Neglects Ephemeris & Target Data

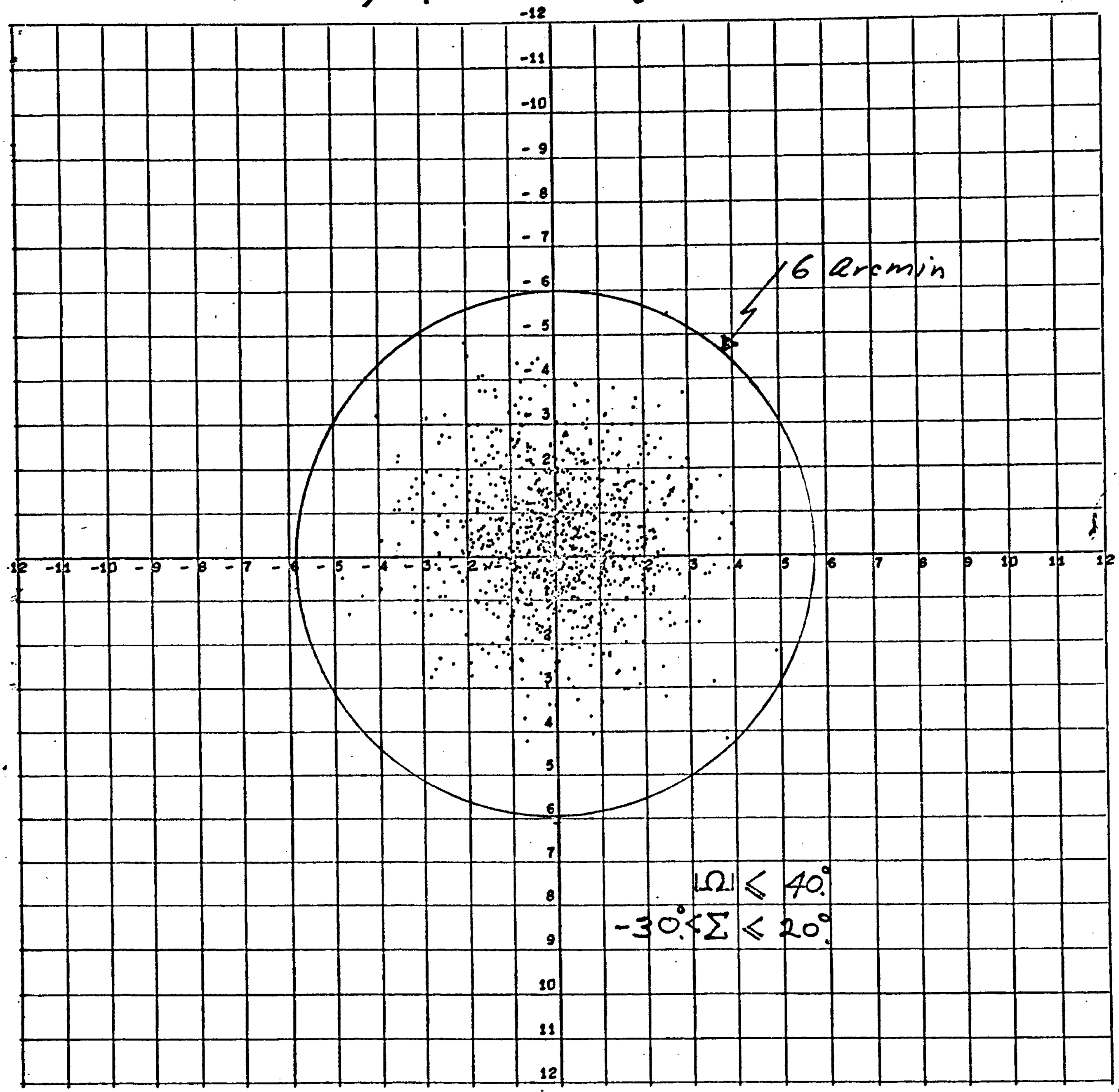
o Two Sigma Error = 5.9 (arcmin.)

Primary Optics Pointing Error (Slave Mode)



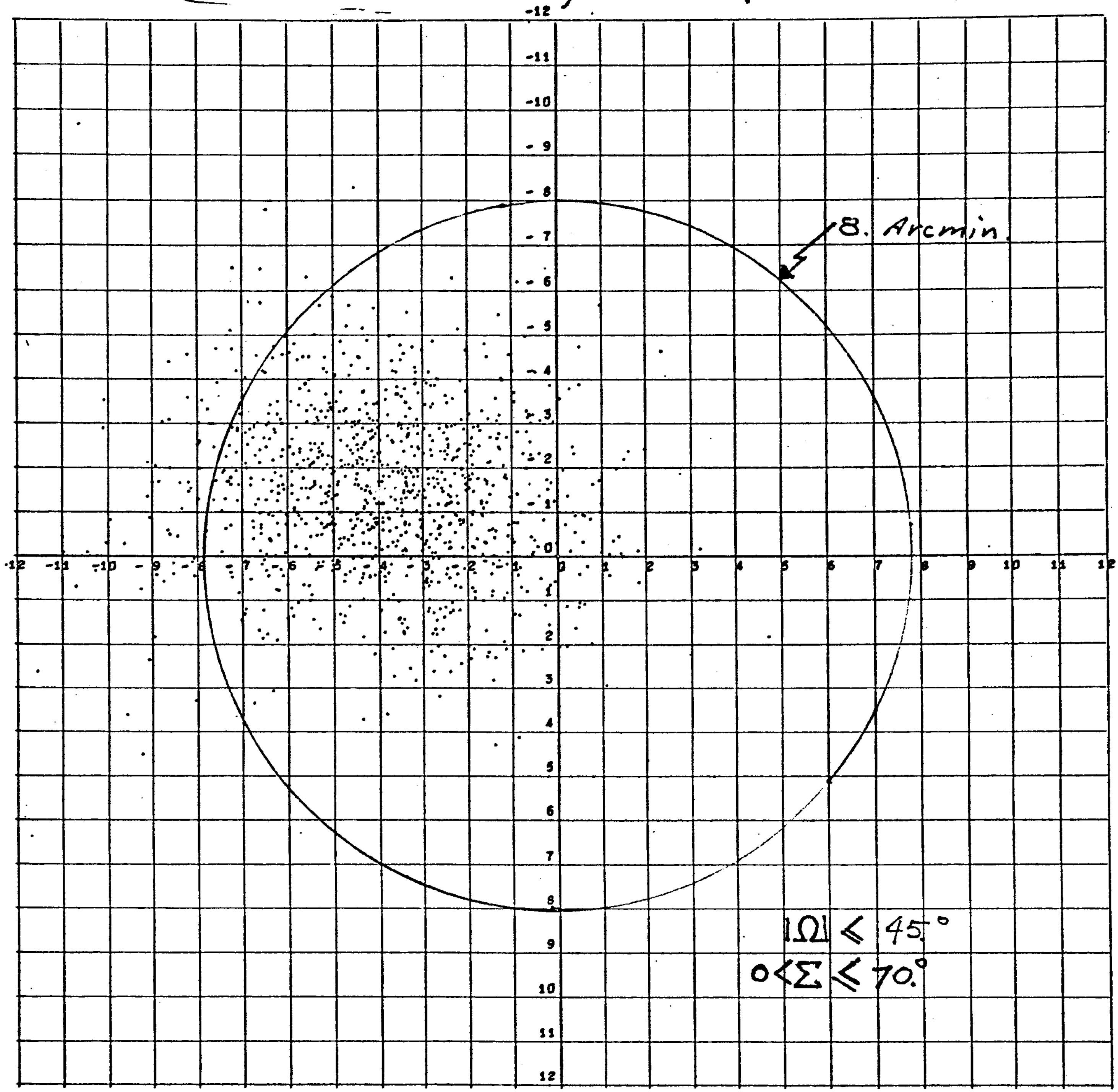
- Assumes 2 Target Boresighting
- Two Sigma Error = 5.0 (arcmin)

Primary Optics Pointing Error. (Slave Mode)



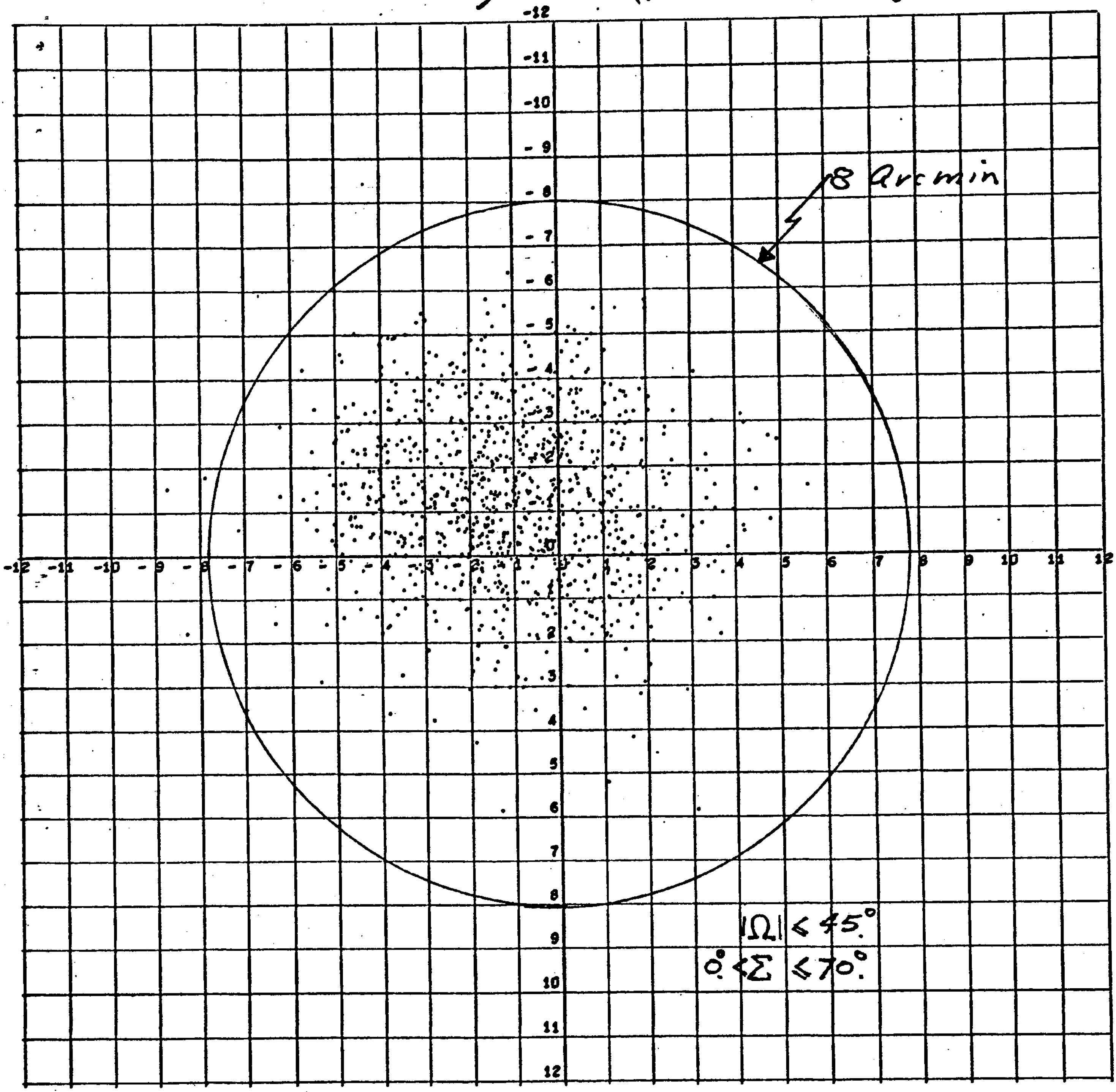
- Assumes Expanded Boresighting Procedure
- 2 Sigma Error = 3.7 arcmin

ATS Pointing Error (Automatic Mode)



- Assumes 2 Target Boresighting
- Neglects Ephemeris & Target Data
- Two Sigma Error = 8.5 (arcmin)

ATS Pointing Error (Automatic Mode)



- Assumes Expanded Boresighting
- 2 Sigma Pointing Error = 5.6 arcmin.
- Neglects Ephemeris & Target DATA

Summary Of Initial Pointing Error.

Mode	Two Target Boresighting **	Three Target Boresighting **
Primary Optics (Automatic) *	5.9 (arc min)	5.9 (arc min)
Primary Optics (Slaved)	5.0 (arcmin.)	3.7 (arcmin.)
ATS (Automatic) *	8.5 (arcmin.)	5.6 (arcmin.)

* -- Assumes Perfect Ephemeris & Target DATA

** -- Pointing Error Is Less Than This Value 95.4% of the time.

α_x --- ATS/TM Alignment (Roll)

α_y --- " " " (Pitch)

α_z --- " " " (Yaw)

b_{yA} --- ATS Optical Axis Alignment (Pitch)

b_{zA} --- " " " " (Yaw)

(Λ)---A matrix used in pointing & Tracking Equations (Relates ATS/TM Alignment)

(b)---A matrix used in pointing & Tracking Equations (Defines ATS Optical Axis)

(Λ) = function of (α_x, α_y, α_z, ATS skew, Primary optics Pitch)

(b) = function of (b_{ya}, b_{za})

Two Target Boresighting Equations

U_I, V_I -- 1 x 3 row vectors = function of ATS Gimbal Angles For Target I.

A_A, B_A -- Constants = function of ATS gimbal angles for Target I.

A_P, B_P -- Constants = function of primary optics gimbal angles & alignment monitor readings.

$$[K] = \begin{bmatrix} U_1 \\ \hline V_1 \\ \hline U_2 \\ \hline V_2 \end{bmatrix}$$

K is a 4 x 3 matrix

$$\begin{Bmatrix} \alpha_x \\ \alpha_y \\ \alpha_z \end{Bmatrix} = \left[[K]^T [K]\right]^{-1} [K]^T \begin{Bmatrix} A_{P_1} - A_{A_1} \\ B_{P_1} - B_{A_1} \\ A_{P_2} - A_{A_2} \\ B_{P_2} - B_{A_2} \end{Bmatrix}$$

Three Target Boresighting Equations

U_I, V_I -- 1 × 5 row vectors = function of ATS Gimbal Angles For Target I.

A_A, B_A -- Constants = function of ATS Gimbal Angles For Target I

A_B, B_P -- Constants = function of Primary Optics Gimbal Angles & Align. Monitor Readings.

$$[K] = \begin{bmatrix} U_1 \\ \hline V_1 \\ \hline U_2 \\ \hline V_2 \\ \hline U_3 \\ \hline V_3 \end{bmatrix}$$

K is a 6×5 matrix

$$\begin{Bmatrix} \alpha_x \\ \alpha_y \\ \alpha_z \\ b_{y_A} \\ b_{z_a} \end{Bmatrix} = \left[[K]^T [K] \right]^{-1} [K]^T \begin{Bmatrix} A_{P_1} - A_{a_1} \\ B_{P_1} - B_{A_1} \\ A_{P_2} - A_{A_2} \\ B_{P_2} - B_{A_2} \\ A_{P_3} - A_{A_3} \\ B_{P_3} - B_{A_3} \end{Bmatrix}$$

ATS Image Derotation

- Required To Cause Image Of In Track Line On Ground To Appear Vertical In Display.
- Required Accuracy = ± 5° In Initial Setting
- Error Apportionment

±.5°	D/A Converter
±.5°	Screen Positioning
±2.0°	Derotation Prism Positioning
±9.°	Command Accuracy (If Attitude Is Neglected)
< 1.°	(Compensating For Attitude) (Gopen)

Computation Of Image Derotation Angle

γ = Derotation Angle = Ω

Ω = Arc cosine $\left[\frac{A}{B} \right]$

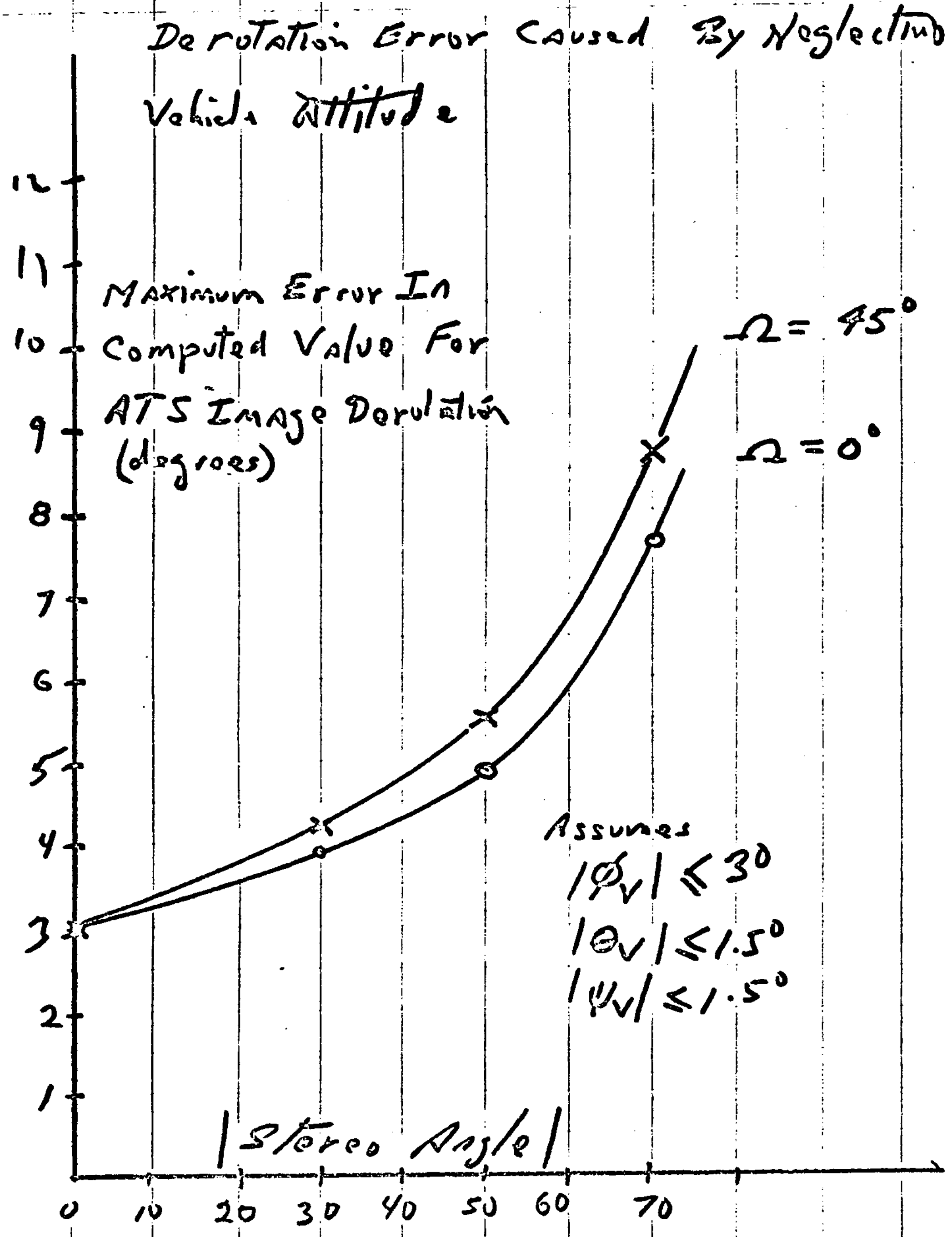
$$A = K_x e_{13} + K_y e_{23} + K_z e_{33}$$

$$B = \sqrt{(K_x e_{12} + K_y e_{22} + K_z e_{32})^2 + (K_x e_{13} + K_y e_{23} + K_z e_{33})^2}$$

K_x, K_y, K_z } Components Of Line Of Sight Vector

e_{ij} -- elements of E matrix (Transformation from the body coordinates to the tracker coordinates)

SE


Derotation Error Caused By Neglecting
Vehicle Attitude
Maximum Error In
Computed Value For
ATS Image Derotation
(degrees)
Ω = 45°
Ω = 0°
Assumes
|φ_V| ≤ 3°
|θ_V| ≤ 1.5°
|ψ_V| ≤ 1.5°
|Stereo Angle|
0 10 20 30 40 50 60 70
1 2 3 4 5 6 7 8 9 10 11 12

Eye Hazard

Airforce Questions pertained to:

a) The ability of the sun shutter to protect against enemy lasers

b) The ability of the sun shutter to protect against specular solar reflections

c) Whether GE considered the transmission characteristics of lens coatings in the eye hazard calculations

GE Comments in reply:

a) The sun shutter will require approximately 50 to 100 milli-seconds to close. This response is approximately the same as the blinking response of the eye and is not believed to provide significant additional protection against lasers and specular reflections

b) GE did not consider the coating properties in the eye hazard analysis, and will accept an action item to do so.

LEAR SIEGLER ACTION ITEMS FROM PDR

I Optical

1. How is cleanliness maintained and what is requirement on Kollmorgen?

   Components cleaned to and assembled in Class 100; afterwards maintained in Class 10,000. Vents small, staggered and fitted with microgrove filters.

2. Optical error analysis and error budget incl. mech. interface.

   Eckert has analysis. Worst case, misalignment adds up to 6.2 mins. of arc (spread over ½" = 0.9 mil = 1 depth of focus distance which = 1 mil) = (or projection lens MTF to be reduced to 72% of aligned condition).

3. Optical Prescription - Dr. Eckert

4. Data from Chicago Miniature on lamp life for OFF-ON vs. constant applied power No significant life difference. Low input may be better for shock and vibration. Permeation is a function of temperature so constant power input might make helium permeation worse.

5. Revise Visual Display Projector such that the image is not transmitted through the film base.

   1) Invert film
   2) Keep module the same but change direction of light through it.

   1) If film is inverted, scratches would then be likely to occur on emulsion side of the film which will definitely destroy information.

      Scratches on the base side may not destroy information due to depth of focus.

   2) If the module remains the same, the projector will have to be redesigned such that the light will pass through the prism, then the base and then the emulsion This redesign is considerable and may result in larger projection. This is under proposed investigation - plans are proposed but not funded.

II Mechanical

1) Furnish GE with stress analysis of the VDP and film module documenting the design accelerations used.

This action item was not answered to the satisfaction of GE. However, due to relocation of the Visual Display Projector to the "D" panel and the subsequent change in mounting, the analysis to date no longer applies.

2) Feasibility of making lamp slides interchangeable

They are now interchangeable.

3) What is weight reduction by going to Beryllium.

The weight saving for each Visual Display Projector by going to Beryllium is 2.1 lb. excluding film module.

The weight saving for each film module is 0.33 lbs.

The total weight saving per vehicle is 9.8 lbs.

4) What is the maximum temperature that the component will see in the standby mode in the event of possible coolant loss?

In the standby mode there is less than 30 milliwatts power dissipation which will cause a negligible temperature rise. If operated continuously at a screen brightness level of 15 foot lamberts with the existing lamp design, the lamp power dissipation will be 6.5 watts and that of the power supply, brightness control, solenoid and arithmetic unit will be 14.2 watts. Of this power, 6.5 watts will be conducted directly to the heat sink.

The assumptions made are that the front plate is bolted to the console at four points through projecting ears, the temperature of the supporting structure is 80° F, the front surface of the VDP is radiating to 80° F and the remaining five surfaces are radiating to 110° F. Cabin pressure is 5 psis and no convection cooling can take place.

The temperature of the lamp envelope was found to stabilize at 290° F. The maximum circuit board temperature was found to be 193° F. Both of these temperatures are permissible but stressing of the electronic components will be a little greater than normal.

5) Drag brake design instead of motor shunt - no funds.

6) Insure torquer lockout during module insertion and removal.

A limit switch was added which is operated by the module locking bolt.

7) Substitute weight breakdown.

This was answered to GE's satisfaction.

III Electrical

1) Lear Siegler will supply schematics to GE. This has been completed. to GE's satisfaction.

2) Supply EMC Plan.

The document has been received by GE and is being reviewed.

3) Voltage/motor size trade off study - no funds.

4) Electronic simplification for aperture contrast ratio 10:1 - no funds.

General

1) GE define maximum depressurization rate.

From 19.0 psiA to 5 ± .2 psiA. at a rate equal to or less than .5 psi/sec.

2) Latest information on "gloved hand" - OPEN.

3) Thermal data for worst case.

This information was sent to Lear Siegler upon which was based their reply to Mechanical Item # 4 above.

4) Revise specification to include proof pressure, leakage, cleanliness of coolant parts.

Pressure requirements were added to specification.

Leakage and cleanliness awaiting answers from systems needs interface with DAC.

5) Maximum/minimum coolant temperature

Maximum temp. - 115° F - VDP non-operating
30 min. max.
100° F - VDP operating
Minimum temp. - 60° F

6) Film module specification is being circulated for signatures.

7) Design constraints for module handle - OPEN

This is related to gloved hand requirement. Concept has been arrived at, at Lear Siegler.

8) Direction on module identification.

Space for label is being included on side opposite magnetic material and also on end containing the handle, such that the module can be identified whether it is in the rack or on the magnetic latch on the console.

9) Direction on need for wrong module indication.

It is needed.

10) Define electrical interface completely.

The missing item was rise time. A 1 microsec. rise time requirement was added to specification.

11) Revise specification to include octal numbering. This has been done. (Estimated weight saving 0.15 lb.)

12) Define range of Alpha numeric brightness. Brightness range defined as 0 to 10,000 ft. lamberts. Brightness as viewed by customer at Lear Siegler was approximately 8000 ft. lamberts.

ANSWERS TO P.D.R. QUESTIONS

Question 63 - Statistical analysis of focus adjustment requirements.

We have not formulated a statistical approach but have devoted considerable effort toward defining the problem.

Some factors are:

1) Module Material

2) Type of film data

3) Temperature environment

4) Mechanical Interfaces

5) Method used to determine resolutions

6) Human factors problems - when is scene in focus - what is good focus.

We have a plan to start Lear Siegler working toward the solutions of some of these problems.

1) Modify test fixture for

   a) Module insertion
   b) Projection lamp
   c) External electronics
   d) Power
   e) Logic

2) Fabricate 1 or 2 film modules including the following:

   a) Beryllium
   b) Film Clamping
   c) Film platen
   d) Drag brake
   e) Handle
   f) Locking Device

3) Prepare two film setups to measure wear, scratching, and effect of projecting image through the base.

   a) With emulsion side away from rollers

   b) With emulsion side on rollers.

   Each will have binary descriptors, consistent with the present brassboard, and also special wear and resolution targets.

Question 64 - Desirability of index marks on focus knob for pre-adjustment.

This is related to question 63 and is related to the necessity for focussing. The drive mechanism has the mechanical stability:

1) Pinned phosphor bronze drive.

2) Teflon plugs on projection lens barrel thread.

3) 1.3 inch diameter knob.

4) 4.1 drive ratio

5) 45^{o} of knob gives .001 inch travel of lens. (full depth of focus).

Question 65 Use of Beryllium in film module.

1) Weight saving per module 0.33 lb.

2) Weight saving per vehicle 5.25 lb.

3) Lower temperature coefficient.

4) Better dimensional stability.

5) Closer tolerance

6) Better fit

7) Reduced focus problem

8) Higher cost (approx. 4X)

Question 14 - Retrieval Time

Provided there are at least three consecutive numbered frames preceding the commanded frame, the retrieval time is as shown .35 + N/100 seconds after receipt of command.

VDP OPTICAL ANALYSIS

I REQUIREMENTS

MAGNIFICATION

½" FILM → 6.5" DIAMETER SCREEN

∴ M∼13

RESOLUTION

ON AXIS	228 LP/MM ON FILM	
	AT 6:1 CONTRAST	
0.9 R_S	204.5 LP/MM ON FILM	
	AT 6:1 CONTRAST	

II SYSTEM

LIGHT SOURCE	FILM BLOCK	PROJECTION LENS	SCREEN

PROJECTION LENS

COOKE TRIPLET 8 PARAMETERS

CAN ADJUST 7 SEIDEL ABERRATIONS

PLUS MAINTAIN DESIRED FOCAL LENGTH

CHOICE OF $f\# = \frac{\text{FOCAL LENGTH}}{\text{DIA. OF ENT. PUPIL}}$

$= 3.5$

THIS CORRESPONDS TO CUT OFF FREQUENCY OF 520 LP/MM

$\gtrsim 2 \times 228$

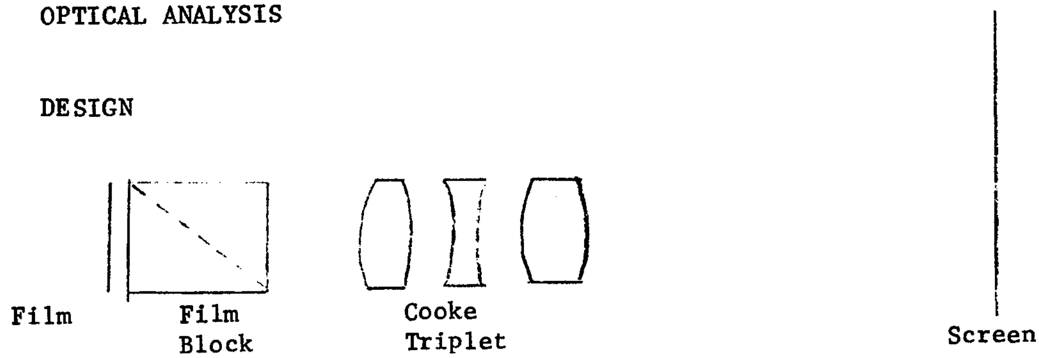
$$\nu = \frac{1}{\lambda f\#} \quad , \lambda = 0.55\ \mu$$

SCREEN - REAR PROJECTION - HIGH

FREQUENCY CUT OFF DUE TO GRAIN SIZE

III OPTICAL ANALYSIS

DESIGN



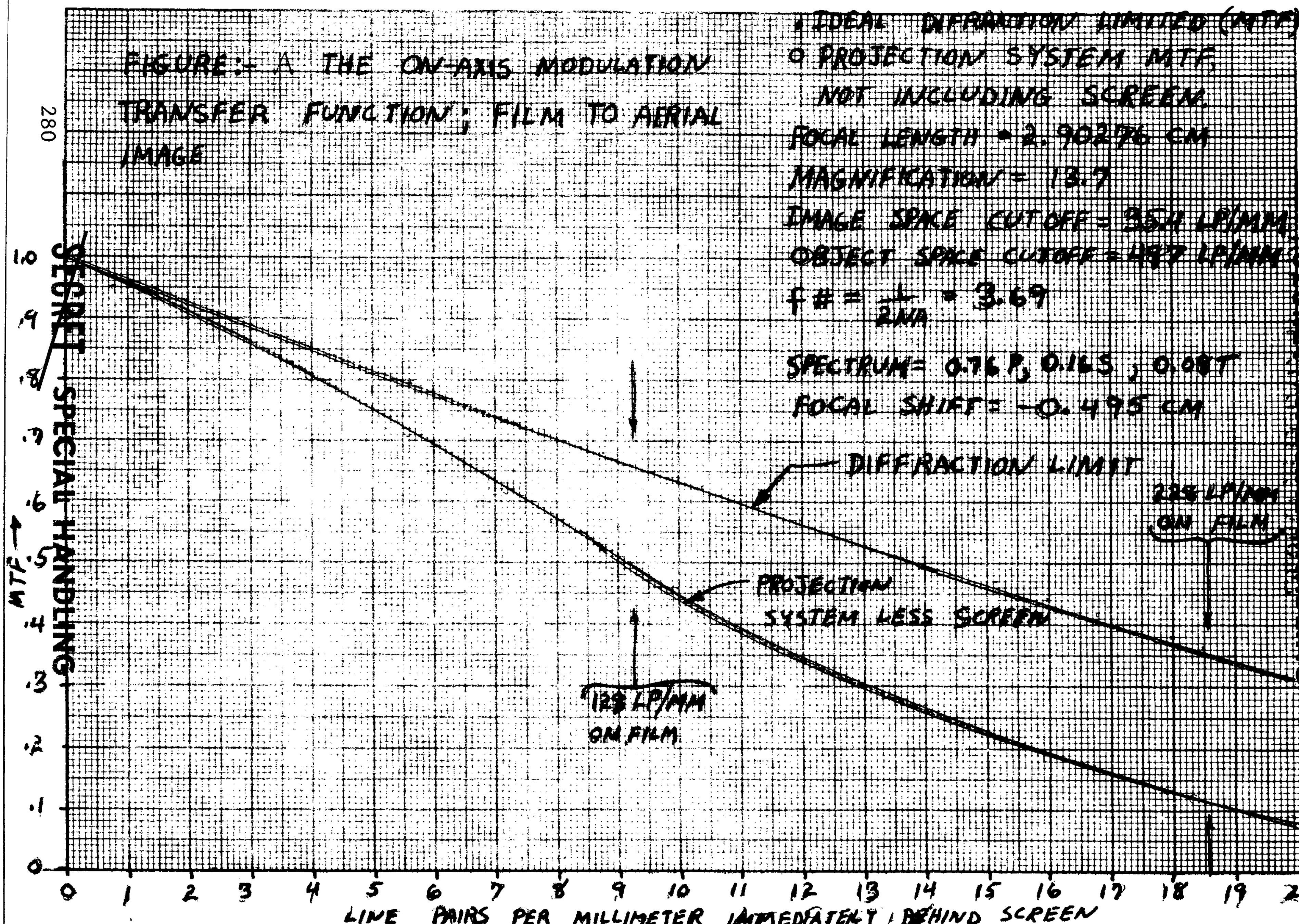
COMPUTATION

RAY TRACING - DETERMINE REFRACTION AT EACH SURFACE

- FROM POINT SOURCE TRACE MANY RAYS (UP TO 750 POSSIBLE BUT 75 USED IN THIS CASE). RAYS ARE UNIFORMLY DISTRIBUTED OVER SURFACE OF ENTRANCE PUPIL.
- THE DISTRIBUTION OF RAY INTERSECTIONS IN IMAGE PLANE YIELDS SPOT DIAGRAM.

- FOURIER TRANSFORMATION OF SPOT DIAGRAM YIELDS MTF WHICH IS GEOMETRIC MTF

- TO INCLUDE DIFFRACTION MULTIPLY BY MTF OF AN ABERRATION FREE DIFFRACTION LIMITED SYSTEM OF THE SAME N.A.



SECRET SPECIAL HANDLING

-11

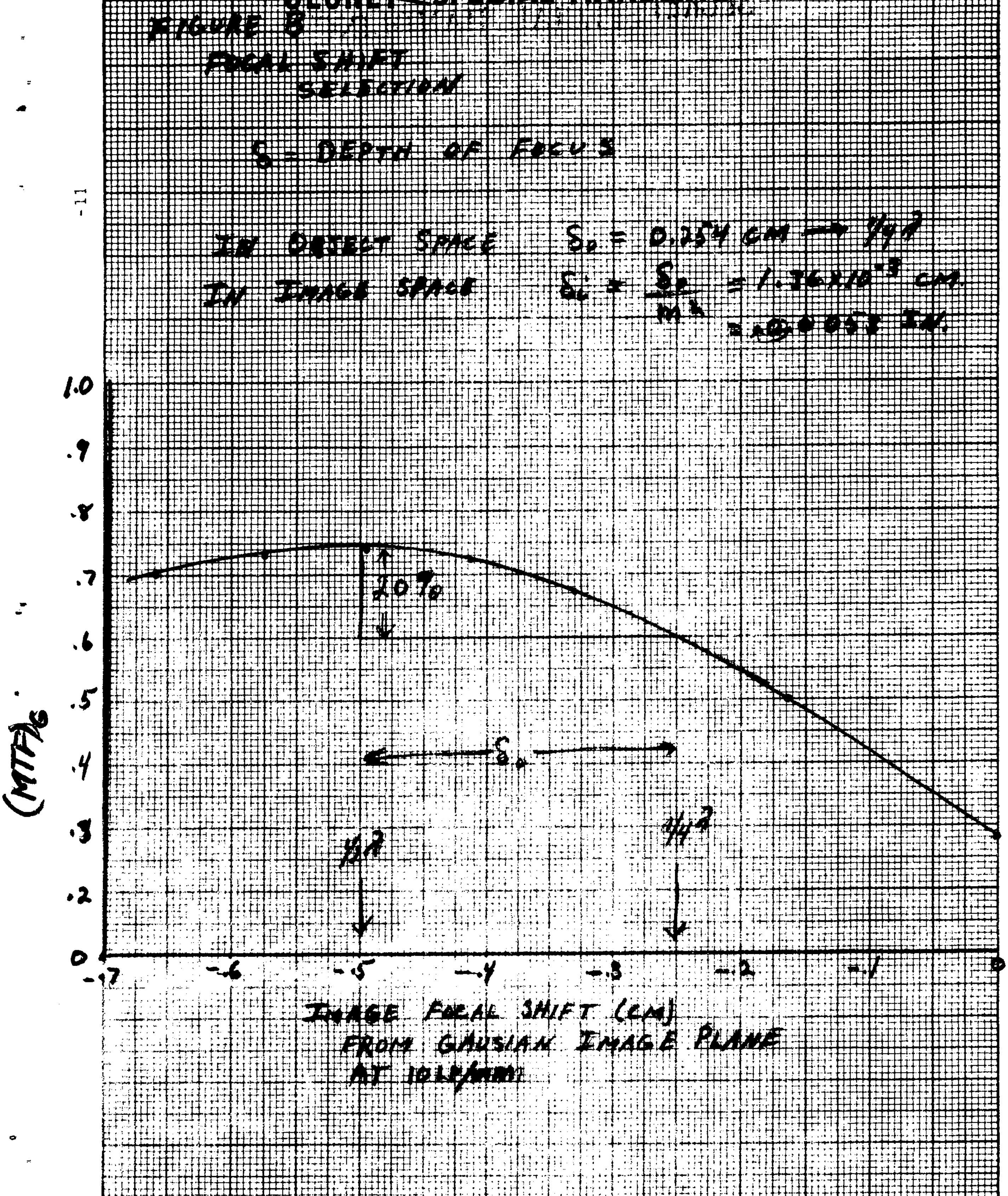
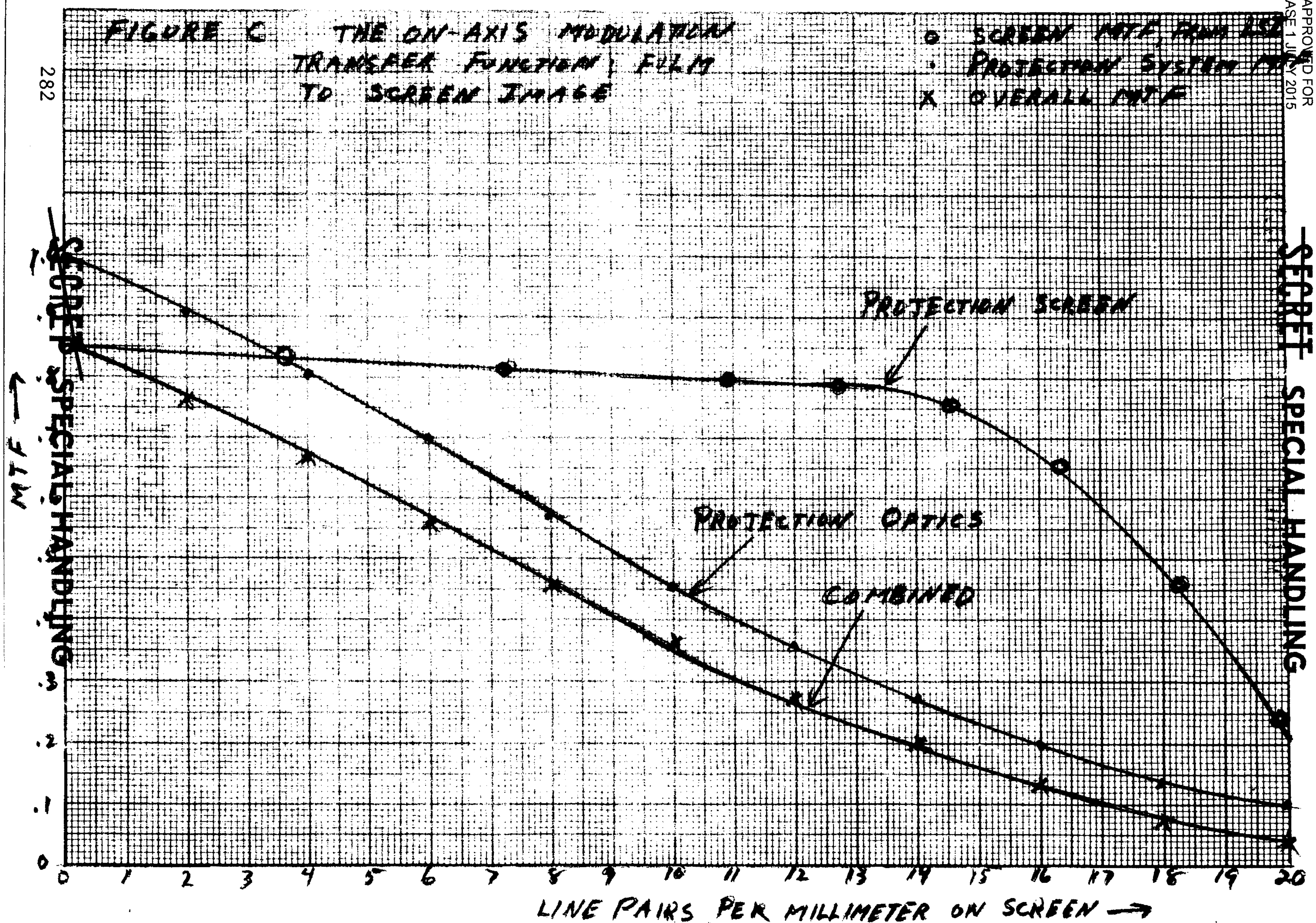
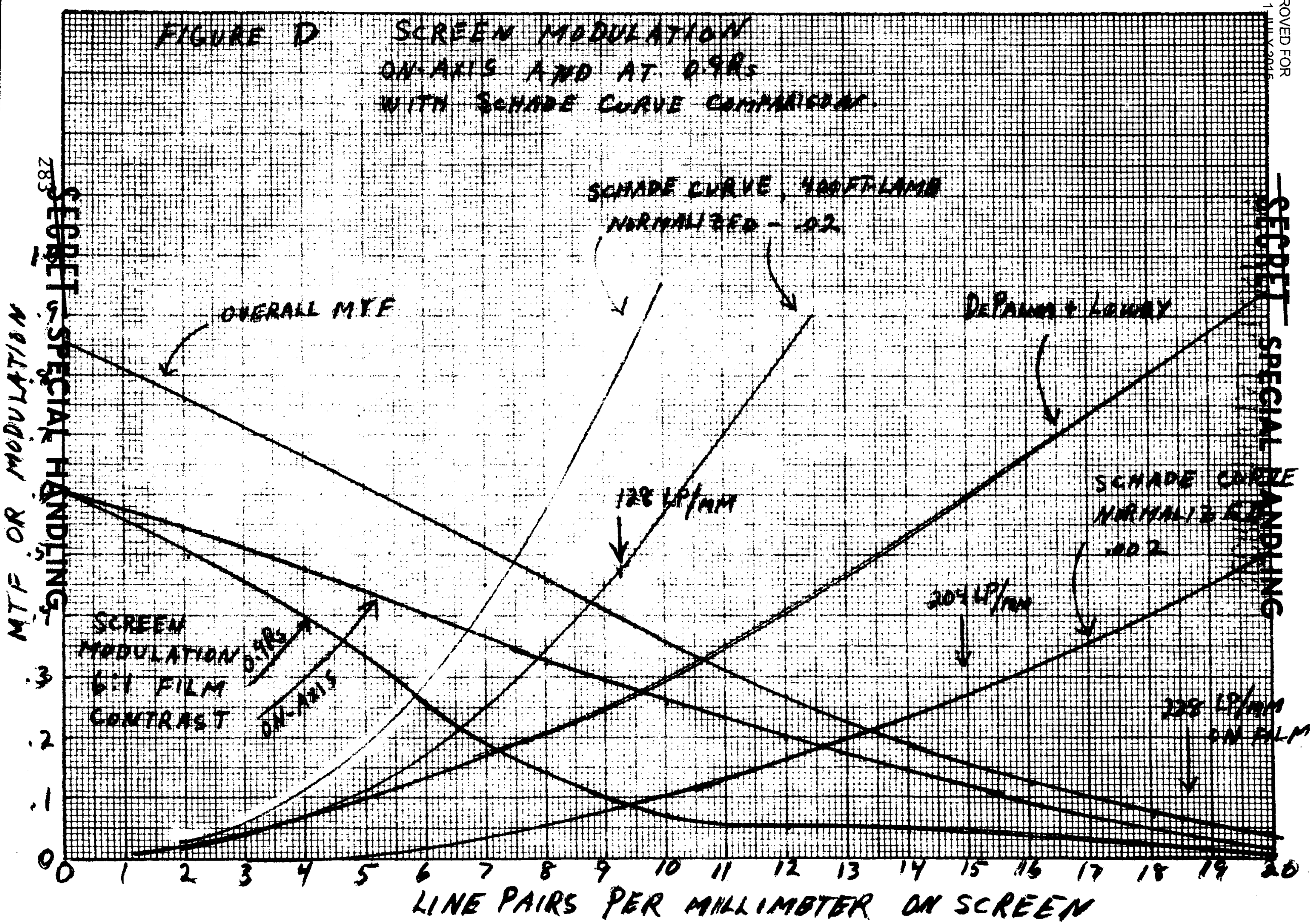


FIGURE 8
FOCAL SHIFT SELECTION
δ = DEPTH OF FOCUS
IN OBJECT SPACE δo = 0.254 CM → 1/4 λ
IN IMAGE SPACE δi = δo/M² = 1.36x10⁻³ CM
1.0
.9
.8
.7
.6
.5
.4
.3
.2
0
(MTF)G
20%
δo
1/2 λ
1/4 λ
-.7
-.6
-.5
-.4
-.3
-.2
-.1
0
IMAGE FOCAL SHIFT (CM)
FROM GAUSIAN IMAGE PLANE
AT 10 LP/MM



~~SECRET~~ SPECIAL HANDLING



SECRET SPECIAL HANDLING

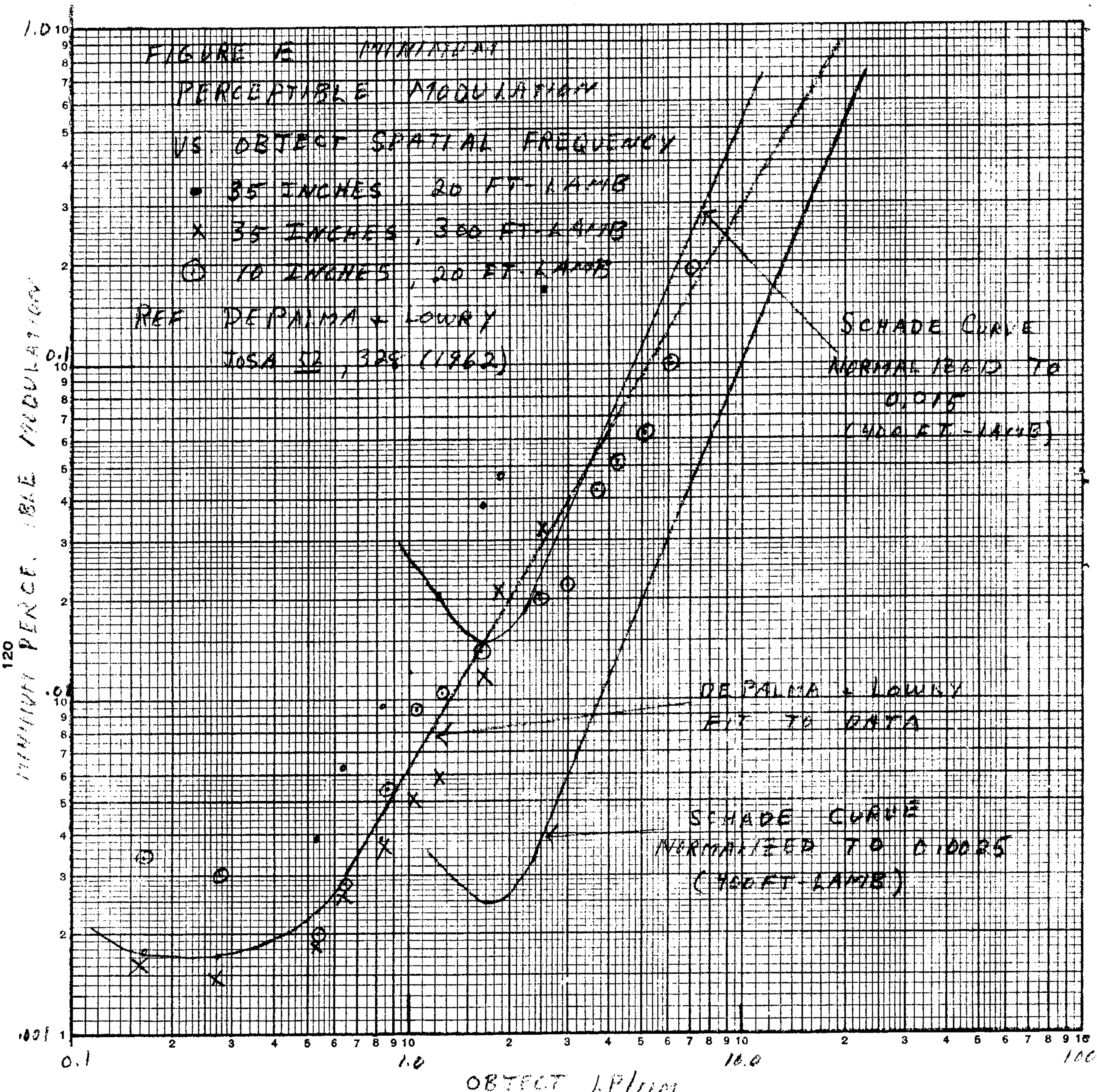
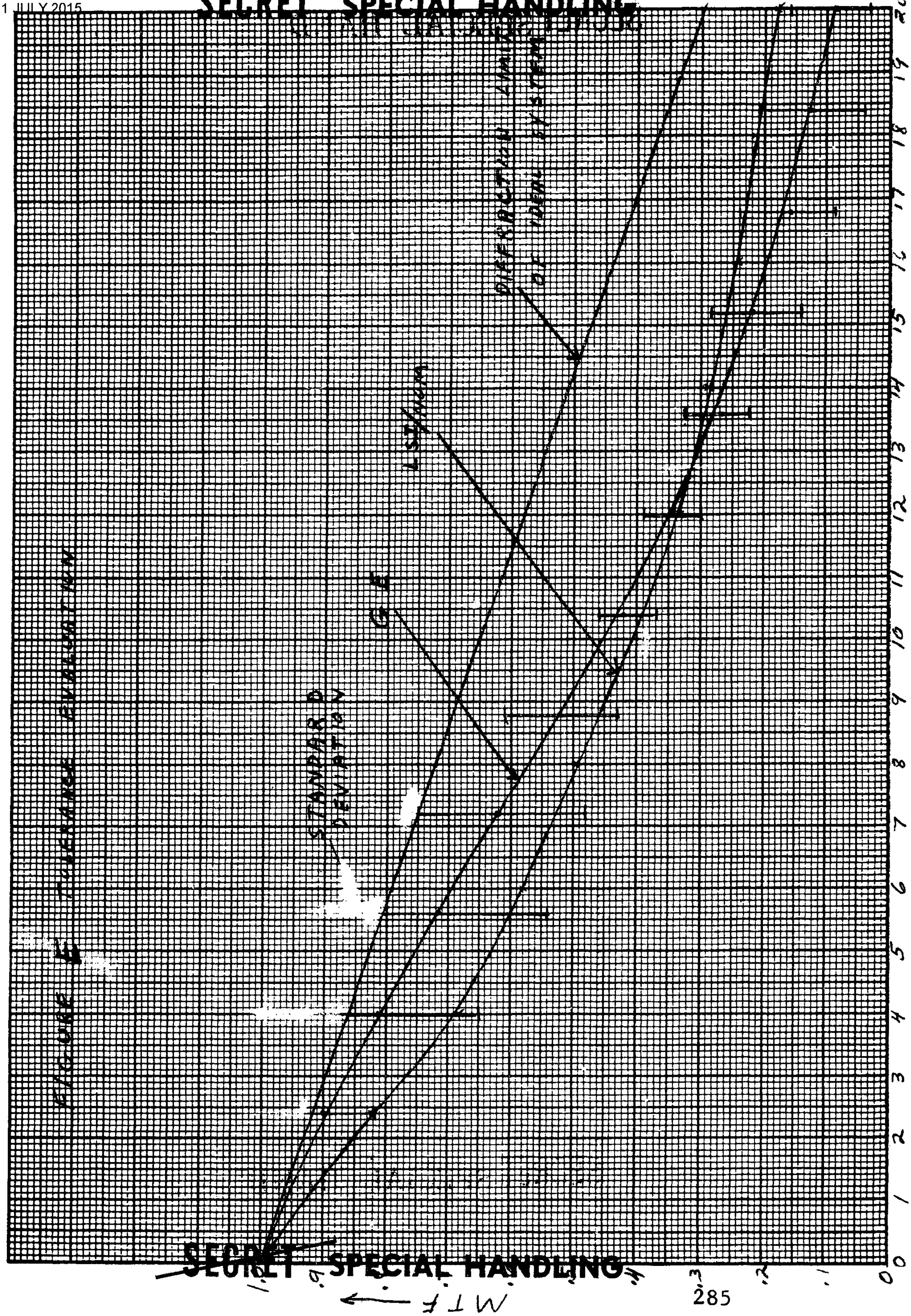


FIGURE E MINIMUM PERCEPTIBLE MODULATION VS OBJECT SPATIAL FREQUENCY
• 35 INCHES, 20 FT-LAMB
X 35 INCHES, 300 FT-LAMB
⊙ 10 INCHES, 20 FT-LAMB
REF DEPALMA + LOWRY
JOSA 52, 328 (1962)
SCHADE CURVE NORMALIZED TO 0.015 (400 FT-LAMB)
DE PALMA + LOWRY FIT TO DATA
SCHADE CURVE NORMALIZED TO 0.0025 (400 FT-LAMB)
1.0
0.1
.01
.001
0.1
1.0
10.0
100
MINIMUM PERCEPTIBLE MODULATION
OBJECT LP/MM

120

FIGURE E


STANDARD DEVIATION
G.E.
DIFFRACTION LIMIT OF IDEAL SYSTEM
LP/MM ON SCREEN →
← MTF
1. .9 .8 .7 .6 .5 .4 .3 .2 .1 0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

-11

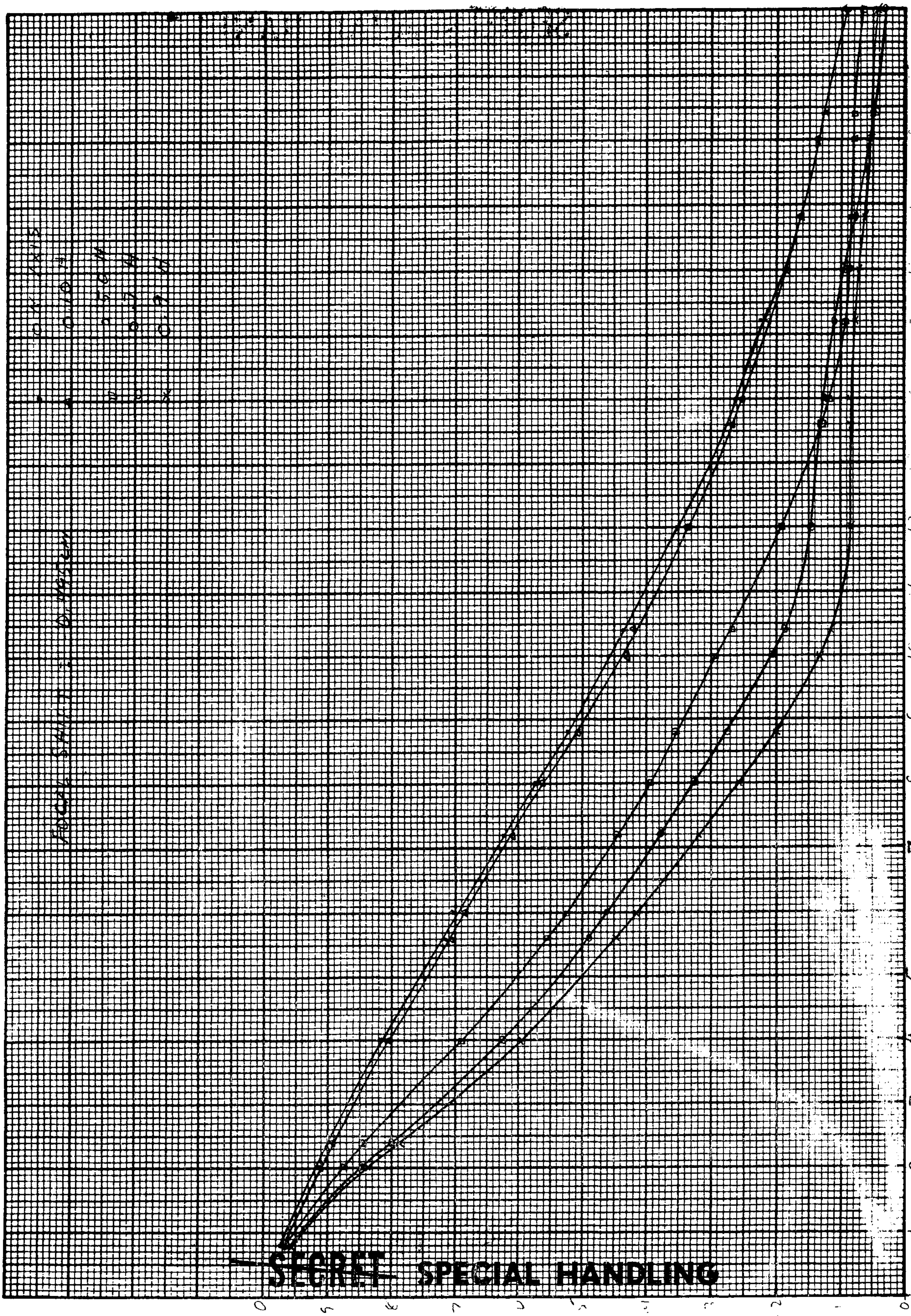


FIG G

CONCLUSIONS

I A X10 MAGNIFIER WILL BE REQUIRED TO MEET THE 228 LP/MM RESOLUTION SPECIFICATION.

II OUR STATISTICAL ANALYSIS USING THE LSI ASSIGNED SPACING AND CURVATURE TOLERANCES AGREES WITH THE LSI DETERMINED NOMINAL PERFORMANCE PREDICTION.

III PRELIMINARY ANALYSIS OF THE ANGULAR TOLERANCES OF THE PRISM, MIRROR, AND SCREEN ARE CONSISTENT WITH THE DETERMINED DEPTH OF FOCUS.

IV DECENTERING AND TILTING OF ALL SURFACES MUST YET BE INVESTIGATED.

V ANALYSIS OF THE CONDENSER SYSTEM MUST YET BE PERFORMED.

DRIVE K ELECTRONICS

MARCH PDR

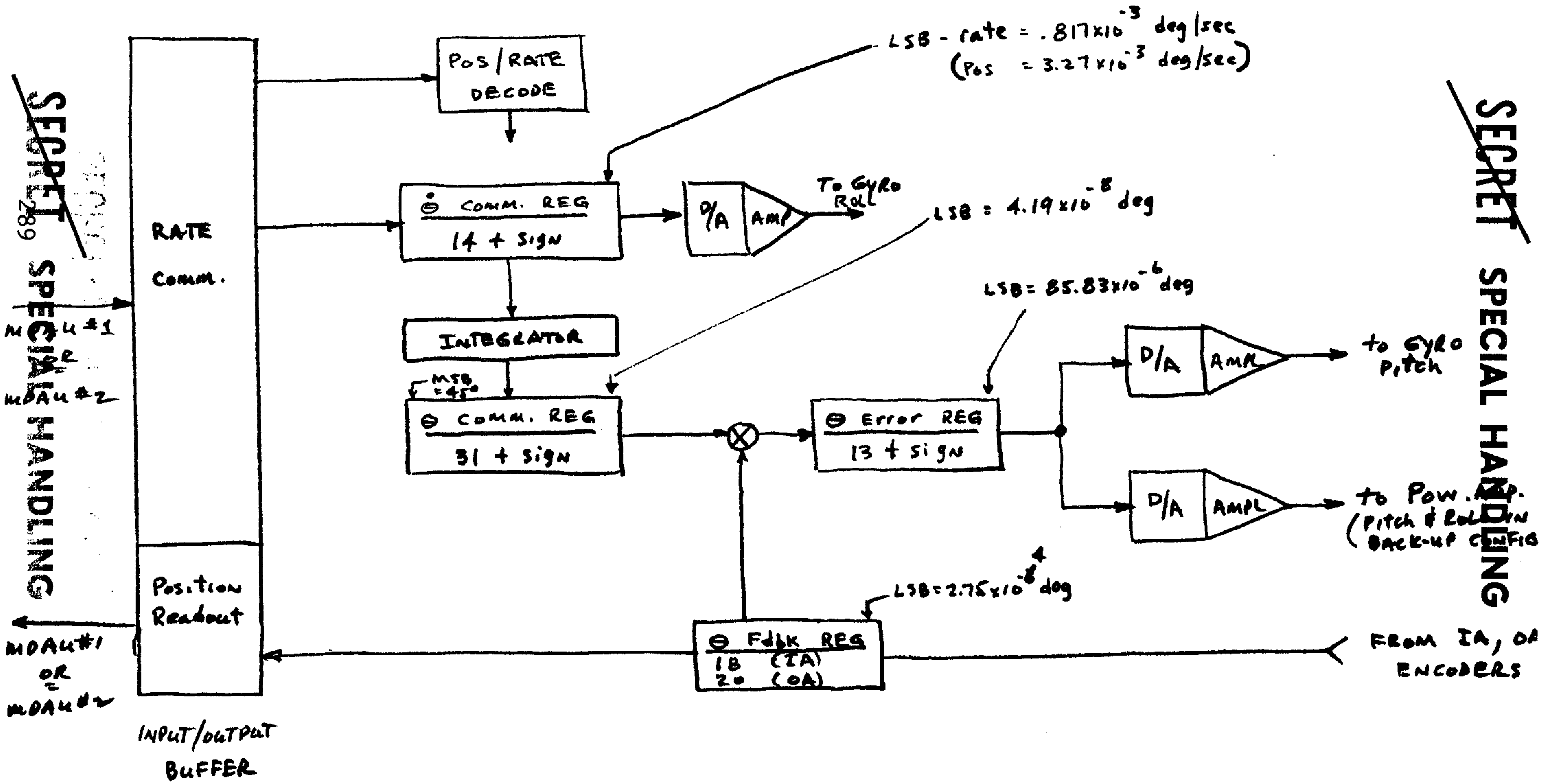
DESIGN FEATURES

- PROVIDES BOTH A PRIMARY AND A HOOK-UP CONFIGURATION IN THE EVENT OF A GYRO FAILURE.
- PROVIDES DIGITAL INTEGRATOR TO COMPUTE POSITION COMMANDS AND DIGITAL SUBTRACTOR TO ESTABLISH POSITION ERROR SIGNAL (APPROX. 175 IC'S).
- PROVIDES CIRCUIT ISOLATION OF CRITICAL AND NON-CRITICAL CIRCUIT FUNCTIONS.
- "BORROWED" CIRCUIT TECHNIQUES/ CIRCUITS FROM DRIVE A ELECTRONICS.
- MODULAR CONSTRUCTION WITH INDIVIDUAL CIRCUIT FUNCTIONS ON SEPARATE REMOVABLE PANELS.
- CAREFUL ATTENTION TO NOISE PERFORMANCE (CIRCUIT DESIGN, SHIELDING, P.S. FILTERING).

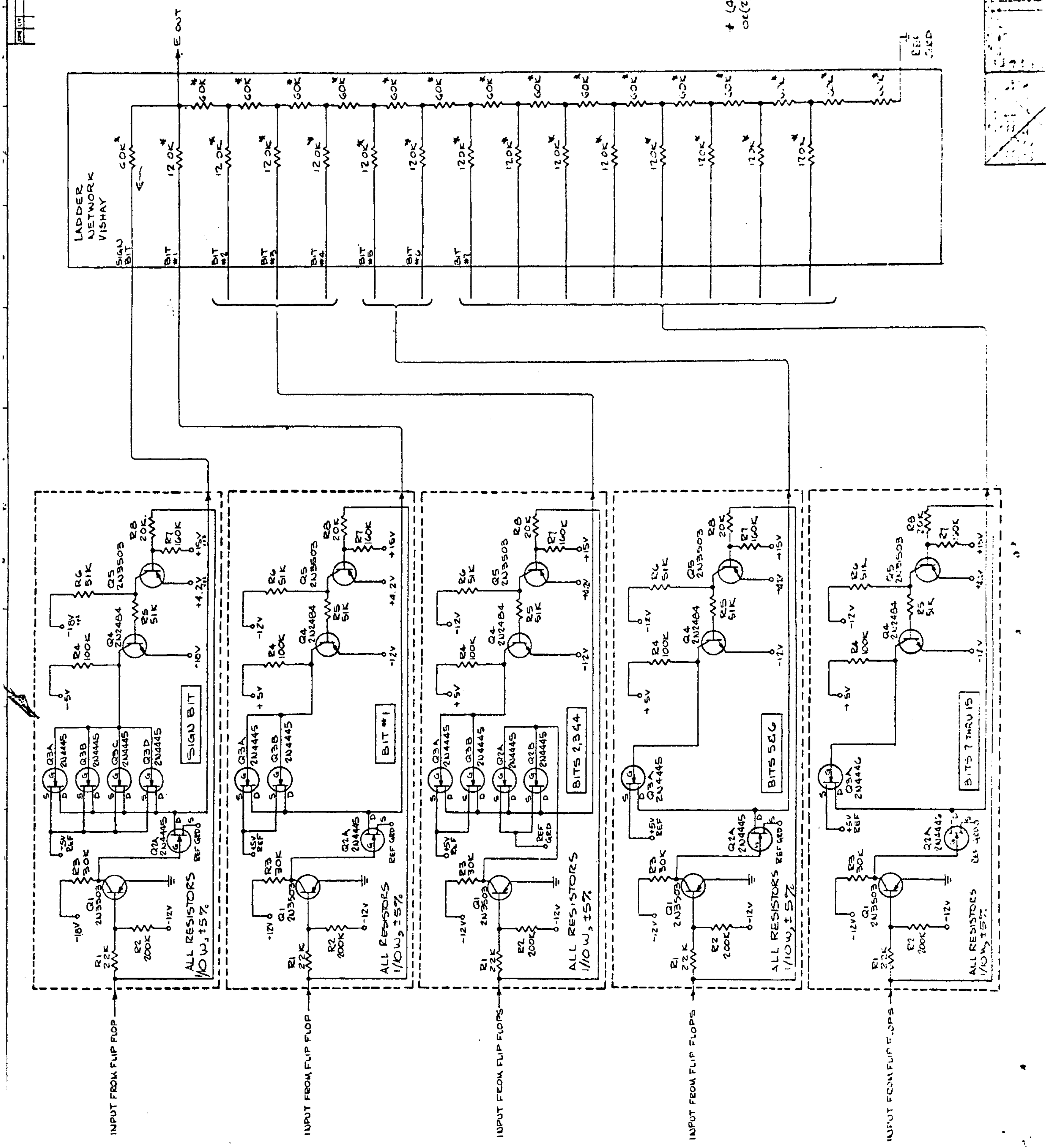
DESIGN STATUS

- PRELIMINARY COMPONENT SPEC WRITTEN.
- BREADBOARD OF MAIN DRIVE ELECTRONICS BUILD AND UNDERGOING FINAL FUNCTIONAL TESTS PRIOR TO INCORPORATION INTO BRASSBOARD.

(2)



DIGITAL PROCESSOR ELECTRONICS


E OUT
LADDER NETWORK VISHAY
SIGN BIT
BIT #1
BIT #2
BIT #3
BIT #4
BIT #5
BIT #6
BIT #7
SIGN BIT
BIT #1
BITS 2,3&4
BITS 5&6
BITS 7 THRU 15
ALL RESISTORS 1/10W, ±5%
INPUT FROM FLIP FLOP
INPUT FROM FLIP FLOPS

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

I. SCOPE

1.1 Scope

This drawing covers the detail requirements for silicon, junction, N-channel field effect transistors selected for use in missile and space vehicle applications. The closest equivalent transistors are:

SUFFIX NUMBER	TYPE NUMBER
P1	2N4445
P2	2N4446
P3	2N4447
P4	2N4448

SPECIFICATION CONTROL DRAWING - NO CHANGE SHALL BE MADE TO THE DESIGN, CONFIGURATION, MATERIAL, PARTS OR MANUFACTURING PROCESS, WITHOUT PRIOR WRITTEN APPROVAL OF MOL DEPARTMENT, PARTS AND APPLICATIONS ENGINEERING.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:
FRACTIONS ± DECIMALS ± ANGLES ±
ALL SURFACES ✓
MATL—

SIGNATURES	DAY	MO	YR
DRAWN [signature]	1	3	67
CHECKED [signature] Englebach	3	3	67
ISSUED [signature]	9	3	67
ENGRG [signature]	6	3	67
MFG			
MATLS			

GENERAL ELECTRIC
MOL DEPT LOC Phila., Pa.

TRANSISTOR, SILICON, JUNCTION, N-CHANNEL, FIELD EFFECT

SIZE	CODE IDENT NO.	
A	23991	R11009

SCALE SHEET 1 OF 12

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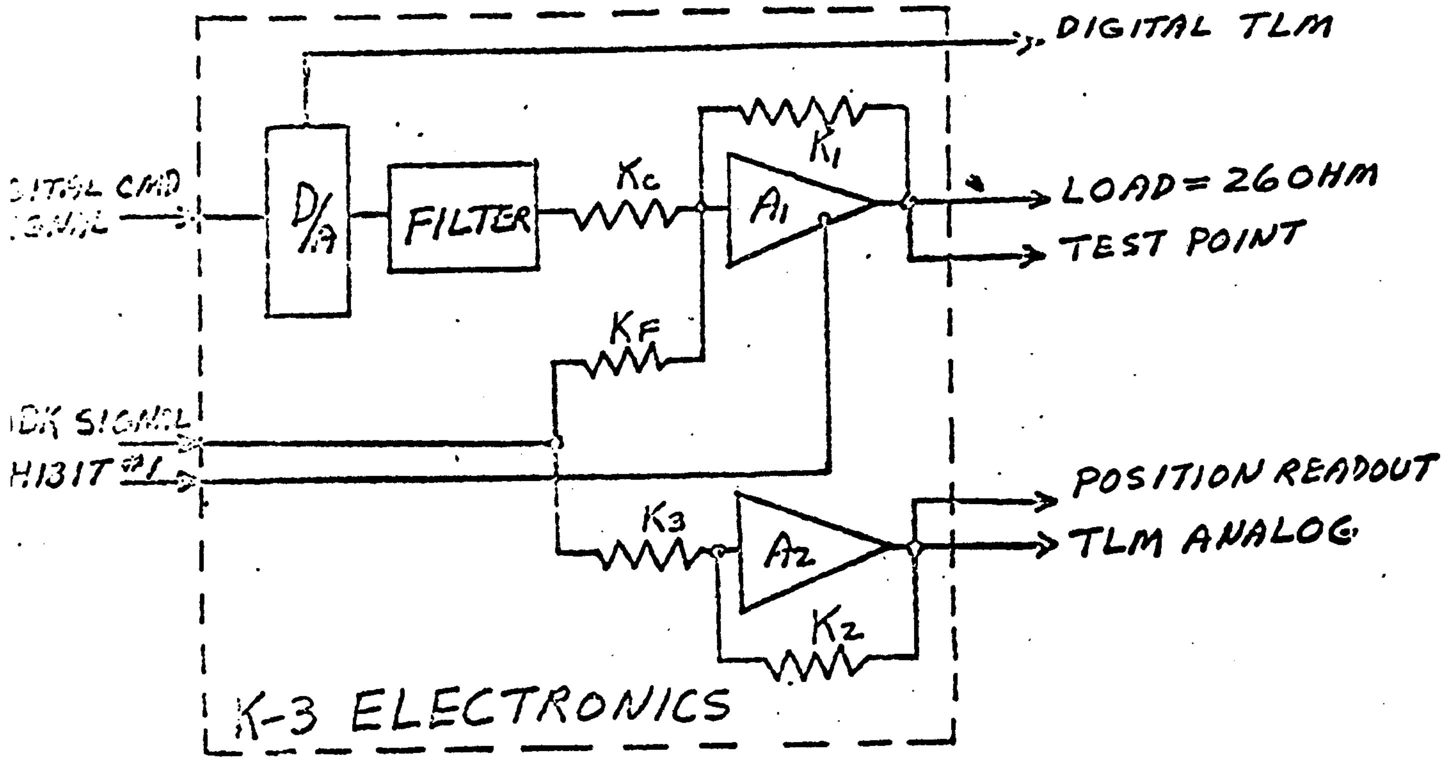
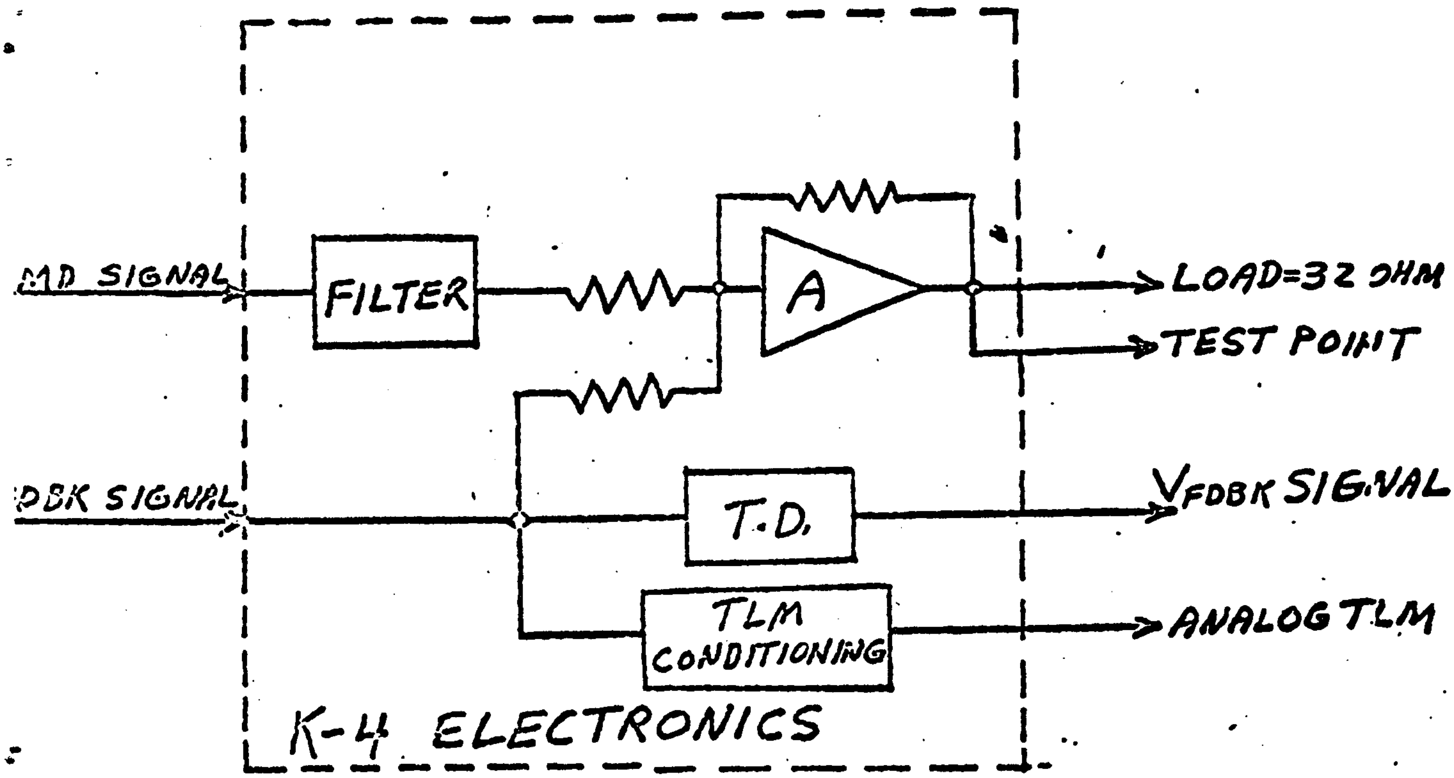


	FILTER	AMPLIFIER 1	AMPLIFIER 2
LINEAR RANGE	±2.0V	±17.5V	V_{IN} −12V, +12V; V_{OUT} 0V, +5V
GAIN	$\frac{1}{s/6+1}$	$K \frac{s/5+1}{s/100+1}$	$\frac{K_2}{K_3} = 0.208$

$$K = \frac{K_1}{K_C} = \frac{K_1}{K_F} = 60\ V/V$$

FIG. II-1 FUNCTIONAL BLOCK DIAGRAM FOR THE K-3 ELECTRONICS



	FILTER	AMPLIFIER
LINEAR RANGE	±2.0V	±17.5V
GAIN	$\frac{0.263}{S/10+1}$	$\frac{(S/9+1)(S/10+1)}{(S/0.9+1)(S/180+1)}$

THRESHOLD DETECTOR

V_{FDBK}	V_{TLM}
< 0V	0.2±0.2V
≥ 0V	3.5±0.5V

FIG I-2 FUNCTIONAL BLOCK DIAGRAM FOR THE K-4 ELECTRONICS

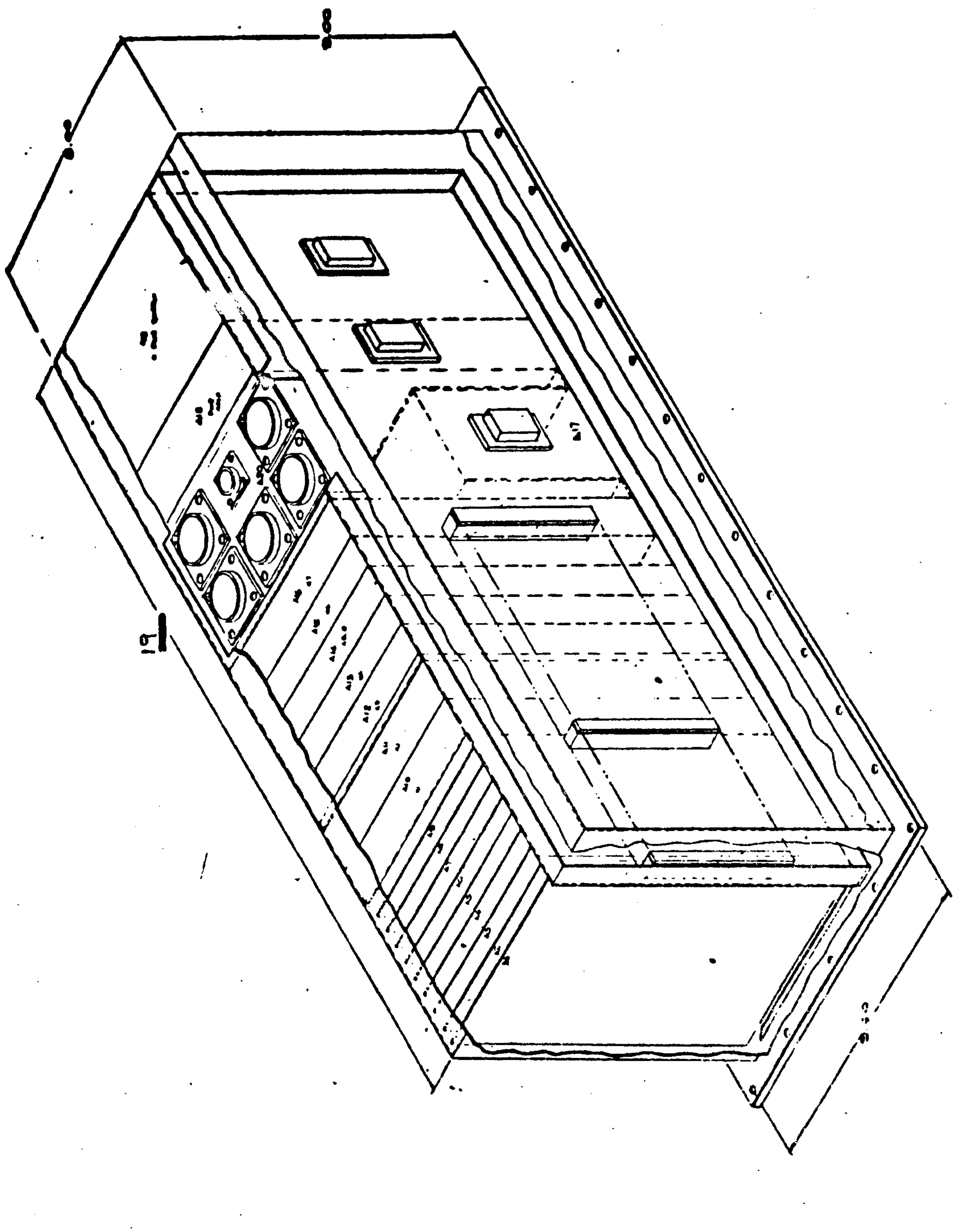


Figure 3-33. Internal Layout of Electronics Package

WEIGHT - SIZE - POWER

	SIZE	WEIGHT	INPUT POWER
MAIN DRIVE K ELECTRONICS (K_0-K_2)	8"x9"x12.5"	20.5 lbs.	Peak 141^W@ 24^V Stby 50^W@ 24^V
INTERNAL MECHANISMS ELECTRONICS (K_3-K_7)	8"x9"x6.5"	16.5 lbs.	Peak 86^W@ 24^V Stby 8^W@ 24^V
TOTAL	8"x9"x19"	37 lbs	Peak 227^W@ 24^V Stby 58^W@ 24^V

POWER BREAKDOWN @ 24^V

o MAIN DRIVE K ELECTRONICS (K_0-K_2

	DISSIPATED	DELIVERED	IMPUT
K_0	9.5 (9.5	0	9.5 (9.5)
K_1	7.2 (4.0)	8 (0)	15.2 (4)
K_2	26.6 (10.5)	58 (5.3)	84.6 (15.8)
$K_{10}a$	20 (5)	12	32 (5)

TOTAL. 141.3 (35) @ 24^V

o INTERNAL MECHANISMS ELECTRONICS (K_3-K_7)

	DISSIPATED	DELIVERED	IMPUT
K_3	3.4 (1.2)	5.5	8.9 (1.2)
K_4	2.8 (.6)	5.5	8.3 (.6)
K_5	2.7 (.6)	24.3	27.0 (.6)
K_6	1.6 (.6)	12.1	13.7 (.6)
K_7	2.2 (.6)	20.8	23.0 (.6)
$K_{10}b$	4.0 (4)	1.0	5.0 (4)

TOTAL. . . . . 85.9 (8) @ 24^V

~~SECRET~~ SPECIAL HANDLING (U)

PROGRAM INFORMATION REQUEST/RELEASE

USE "C" FOR CONFIDENTIAL AND "U" FOR UNCLASSIFIED

FROM	TO
John K. Billings, Manager Electronic Equipment Packaging	W. Nicolini Radnor - Room 160

DATE SENT	DATE INFO. REQUIRED	PROJECT AND REQ. NO.	REFERENCE DIR. NO.
2/23/68			

SUBJECT

DRIVE "K" WEIGHT ANALYSIS

INFORMATION REQUESTED/RELEASED

The Drive "K" weight is 39 lbs. using magnesium structure and 45 lbs. using aluminum structure.

The attached pages contain a weight summary of the 39 lb. flat pack magnesium structure design, the 45 lb. flat pack aluminum structure design and a column showing the difference in weight of the electronic boxes A1 through A19 due to modular design.

Detail calculations substantiating the weights are also attached.

DRIVE "K" WEIGHTS (SUMMARY)	FLAT PACK AL BOXES	MODULAR MAG BOXES		FLAT PACK MAG BOXES
K0 A1 thru A9 (A1-A3 for mod concept)	4.36	3.27	.09	4.36
K1 A10 and A11	5.29	4.82		4.82
K3 A12	2.03	1.79		1.79
K4 A13	2.16	1.92		1.92
K5,8 A14	1.87	1.63		1.63
K6 A15	1.76	1.44		1.44
K7 A16	3.17	2.93		2.93
POWER A19	8.03	7.51		7.51
K2 A18	3.04	2.71		2.71
Subtotal A1 to A19	31.71	28.02		~~29.11~~ 28.11
Structure and Cover	8.04 (24")	4.29 (20")		5.15 (24")
Attachments for cover and other hardware	.50	.50		.50
Harness assembly (includes plugs)	4.37	~~4.37~~ 4.20		4.37
TOTAL	44.62	~~[illegible]~~ 37.01		~~39.13~~ 38.13

J. K. Billings

RECEIVED
FEB 27 1968
T. HOOKER

T. HOOKER
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V. ROSEN
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FORM 1020 R REV. (9-65)

~~SECRET~~ SPECIAL HANDLING

PITCH ENCODER EVALUATION

- OBJECTIVE — DETERMINE THE QUANTIZATION ERROR OF A 19 BIT PITCH ENCODER

- BACKGROUND —
  - 18 BIT PITCH ENCODER QUANTIZATION ERROR GREATLY EXCEEDS THE ALLOCATION
  - 20 BIT ENCODER (WHICH MEETS ALLOCATION) CANNOT BE SUBSTITUTED WITHOUT EXCEEDING THE SPACE ENVELOPE.
  - 19 BIT ENCODER CAN BE FITTED IN THE PRESENT SPACE ENVELOPE.
  - PRELIMINARY EVALUATION OF THE VENDOR ENCODER DATA INDICATES THAT THE 19 BIT ENCODER ERROR IS COMPATIBLE WITH SYSTEM PERFORMANCE REQUIREMENTS OVER MOST OF THE OPERATING RANGE; AND MARGINAL FROM +60° TO +70° (LOS)

• DESCRIPTION OF PRELIMINARY EVALUATION

- EVALUATION BASIS
  - ASSUMPTION THAT THE RELATIONSHIP OF CONTROL LOOP SENSITIVITY, POSITION DISTURBANCE TOLERANCE AND THE SPATIAL HARMONICS OF ENCODER NOISE IS AS SHOWN IN FIGURE 1. (THIS RELATIONSHIP IMPLIES THAT ONLY THE INTERPOLATION ERRORS WILL CAUSE POSITION DISTURBANCES.)
  - 2^{19} ENCODER PULSE POSITION ERROR MEASUREMENT, PROVIDED BY WAYNE-GEORGE. (FIGURES 2 AND 3)
- ENCODER HARMONICS — FIGURE 4
- POSITION ERROR WAVESHAPE — FIGURE 5
- HARMONICS IN POSITION ERROR WAVESHAPE AND RESULTING DISTURBANCE — FIGURE 6

RESULTS of PRELIMINARY EVALUATION

- PITCH QUANTIZATION ERROR (at .3°/sec) = .046, 1σ
- " TORQUE DISTURBANCE ALLOTMENT = .020, 1σ
- " ELECTRONICS NOISE ALLOTMENT = .016, 1σ
- " GYRO NOISE ALLOTMENT = .022, 1σ

TOTAL PITCH DISTURB (@ .3°/SEC) = .0572, 1σ

TOTAL ROLL DITURB. = .0434, 1σ

LOS DIST (@ .3 °/SEC) $= \sqrt{(2\epsilon_p)^2 + \epsilon_R^2}$ = .122, 1σ

= .244, 2σ

- AT HIGHER $\dot{\theta}$, PITCH QUANT ERROR

(EX. at $\theta \leq 60°$, $\dot{\theta} \geq .5$ °/sec

& QUANT ERROR = .027, 1σ

(NOTE: DISTUBANCE ALLOTMENT FROM

EAR

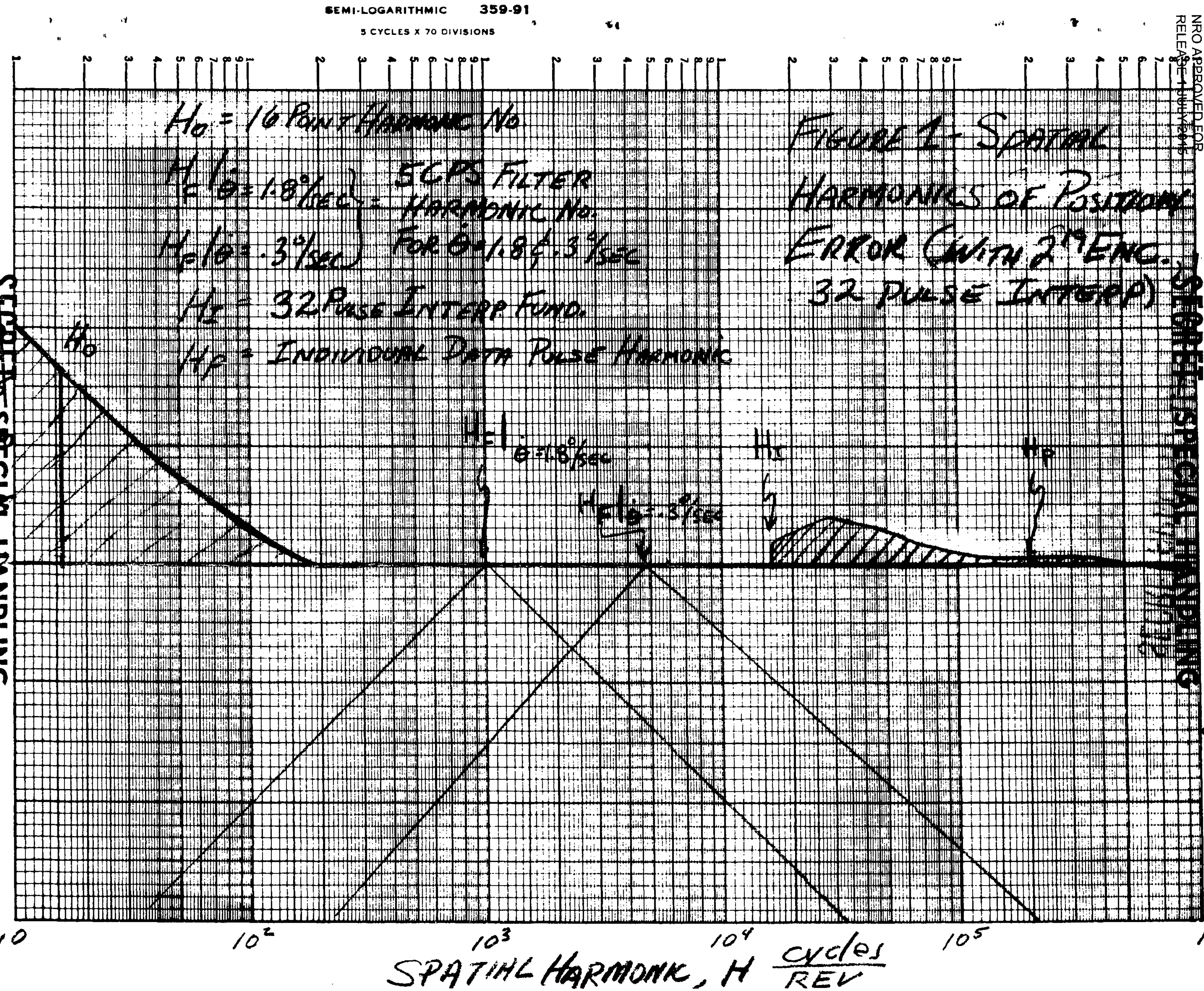
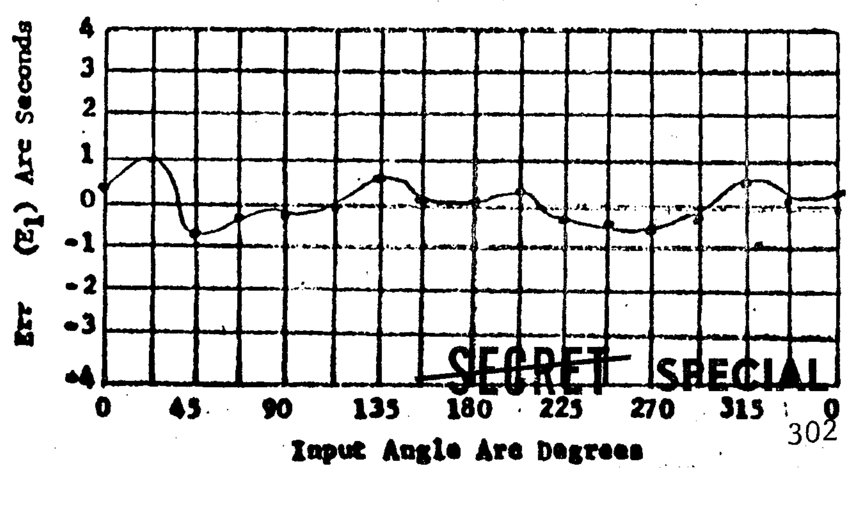

SEMI-LOGARITHMIC 359-91
5 CYCLES X 70 DIVISIONS
H_o = 16 POINT HARMONIC NO
$H_F|_{\dot\theta=1.8°/SEC}$
$H_F|_{\dot\theta=.3°/SEC}$ = 5CPS FILTER HARMONIC NO. FOR $\dot\theta$ = 1.8 & .3°/SEC
H_I = 32 PULSE INTERP FUND.
H_P = INDIVIDUAL DATA PULSE HARMONIC
FIGURE 1 - SPATIAL HARMONICS OF POSITION ERROR (WITH 2ND ENC. 32 PULSE INTERP)
H_o
$H_F|_{\dot\theta=1.8°/sec}$
$H_F|_{\dot\theta=.3°/sec}$
H_I
H_P
PEAK AMPLITUDE
10
10^2
10^3
10^4
10^5
10
SPATIAL HARMONIC, H cycles/REV

TABLE V
RELATIVE BEARING OPTICAL ACCURACY

Set	Facet	AC	$\triangle AC_{\theta}$		FE_{θ}	E_{θ}	E_N	E_N^2	
1	0	3' 20.4	0		0	0	+.194	.038	
2	22.5	19.5	1-2	-.9	+1.7	+.8	+.994	.19	
3	0	20.4							
4	45.0	17.3	3-4	-3.1	+2.3	-.8	-.606	.37	
5	0	20.4							
6	67.5	19.4	5-6	-1.0	+.5	-.5	-.306	.09	
7	0	20.3							
8	90.0	21.5	7-8	+1.2	-1.7	-.5	-.306	.09	
9	0	20.3							
10	112.5	21.7	9-10	+1.4	-1.6	-.2	-.006		
11	0	20.2							
12	135.0	20.3	11-12	+.1	+.3	+.4	+.594	.35	
13	0	20.2							
14	157.5	23.6	13-14	+3.3	-3.4	-.1	+.094	.01	
15	0	20.1							
16	180.0	21.3	15-16	+1.2	-1.3	-.1	+.094	.01	
17	0	20.1							
18	202.5	19.2	17-18	-.9	+1.0	+.1	+.294	.09	
19	0	20.1							
20	225.0	20.6	19-20	+.5	-1.0	-.5	-.306	.09	
21	0	20.1							
22	247.5	18.8	21-22	-1.3	+.7	-.6	-.406	.16	
23	0	20.1							
24	270.0	20.1	23-24	0	-.9	-.9 *	-.706	.50	
25	0	20.0							
26	292.5	22.7	25-26	+2.7	-3.2	-.5	-.306	.09	
27	0	20.0							
28	315.0	19.9	27-28	-.1	+.5	+.4	+.594	.35	
29	0	19.9							
30	337.5	19.5	29-30	-.4	+.3	-.1	+.094	.01	

Peak Error = .85
Standard Deviation = .450

FIGURE 2.



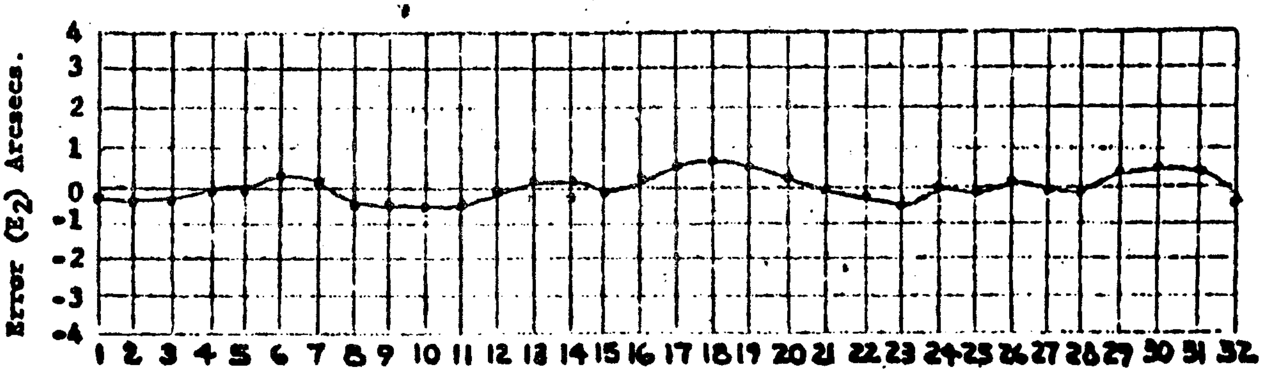
PREPARED BY L. Wolf
APPROVED BY [illegible]
DATE 6-22-67

TABLE VII

RELATIVE BEARING
S/N
0° CYCLE INTERPOLATION ERROR

	AC	AC_θ		TRUE ANGLE	E_N
1	3' 19.9	0	0	0	0
2	22.3	1-2	2.4	2.3	-.1
3	24.7	1-3	4.8	4.9	-.1
4	27.5	1-4	7.6	7.4	+.2
5	30.1	1-5	10.2	10.0	+.2
6	32.7	1-6	12.8	12.4	+.4
7	35.0	1-7	15.1	14.8	+.3
8	37.1	1-8	17.2	17.3	-.1
9	39.5	1-9	19.7	19.8	-.1
10	42.0	1-10	22.1	22.2	-.1
11	44.4	1-11	24.5	24.7	-.2
12	47.3	1-12	27.4	27.2	+.2
13	49.8	1-13	29.9	29.6	+.3
14	52.3	1-14	32.4	32.1	+.3
15	54.6	1-15	34.7	34.6	+.1
16	57.4	1-16	37.5	37.1	+.4
17	4' 0.0	1-17	40.1	39.5	+.6

	AC	AC_θ		TRUE ANGLE	E_N
18	2.7	1-18	42.8	42.0	+.8
19	5.1	1-19	45.2	44.5	+.7
20	7.2	1-20	47.3	46.9	+.4
21	9.5	1-21	49.6	49.4	+.2
22	11.7	1-22	51.8	51.9	-.1
23	14.0	1-23	54.1	54.3	-.2
24	16.9	1-24	57.0	56.8	+.2
25	19.3	1-25	59.4	59.3	+.1
26	21.9	1-26	62.0	61.7	+.3
27	24.2	1-27	64.3	64.2	+.1
28	26.9	1-28	67.0	66.7	+.3
29	29.7	1-29	69.8	69.2	+.6
30	32.2	1-30	72.3	71.6	+.7
31	34.5	1-31	74.6	74.1	+.5
32	36.2	1-32	76.3	76.6	-.3
33	38.7	1-33	78.9	79.1	-.2



SEQUENTIAL CODE TRANSITIONS

Peak Error E_2 .55 **Sec.**

Standard Deviation 2 .287 **Sec RMS**

FIGURE 3

PREPARED BY George Wolf
APPROVED BY [illegible]
DATE 6-22-67

6" disc, at 0° degrees - worst place

$2\frac{1}{4}$

4380-072 Rev. B
Sheet 7 of 9

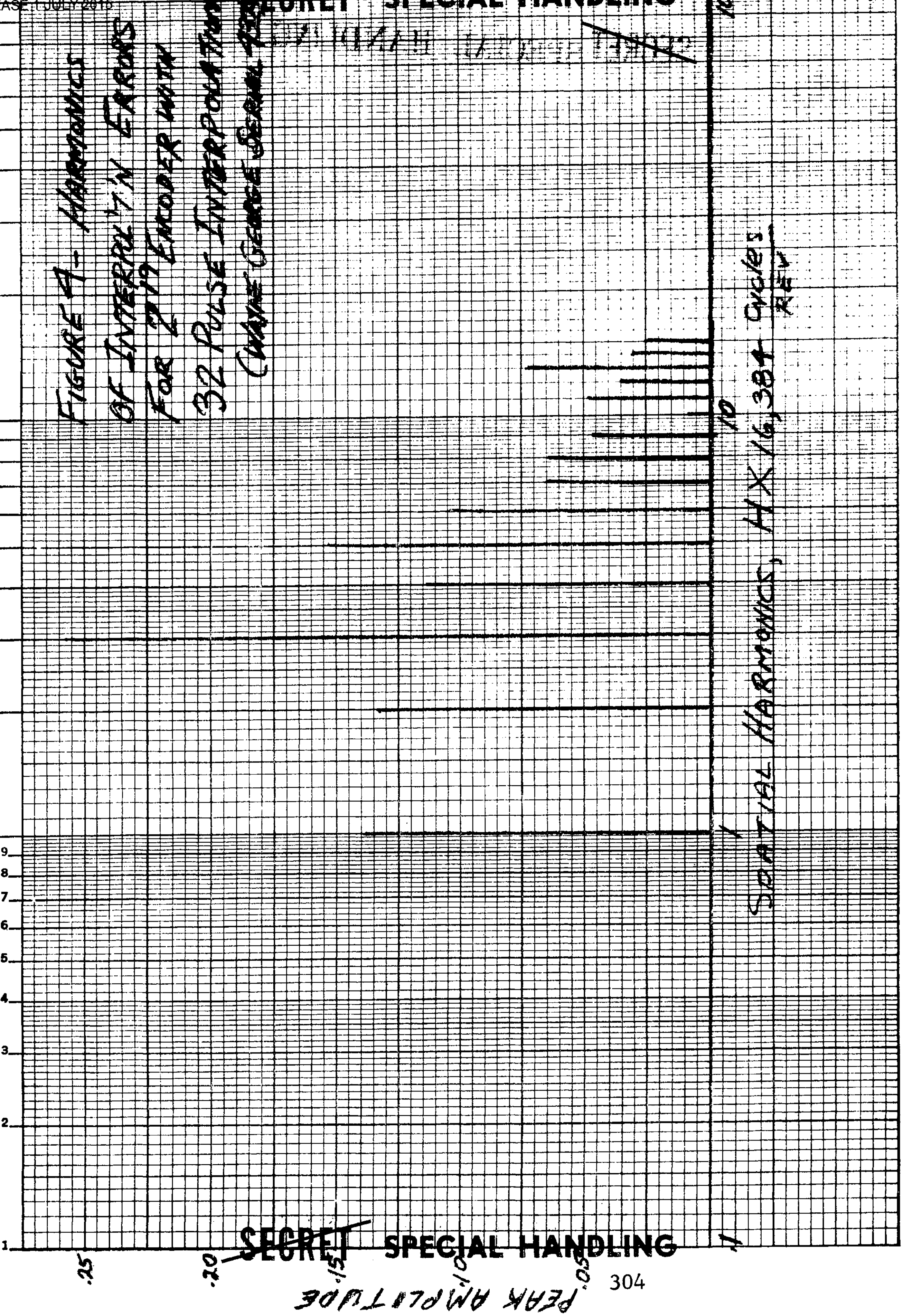


FIGURE 4 - HARMONICS
OF INTERPOL'N ERRORS
FOR 2^19 ENCODER WITH
32 PULSE INTERPOLATION
(WAYNE GEORGE SERIAL ...)
SPATIAL HARMONICS, H X 16,384 Cycles/REV
PEAK AMPLITUDE
.25
.20
.15
.10
.05
1
10
100

71

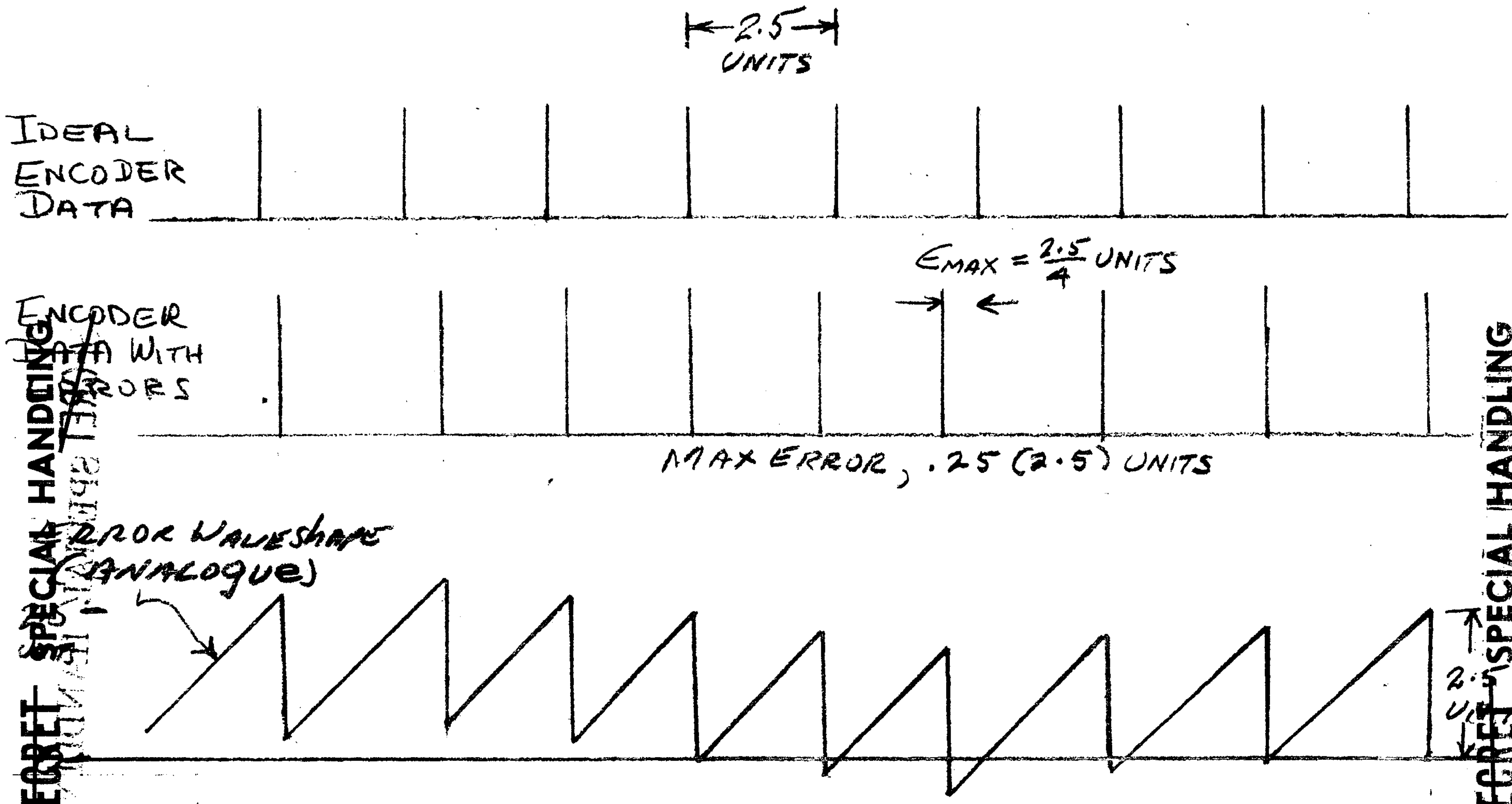


FIGURE 5 POSITION ERROR WAVESHAPE
FOR A SAMPLE ENCODER

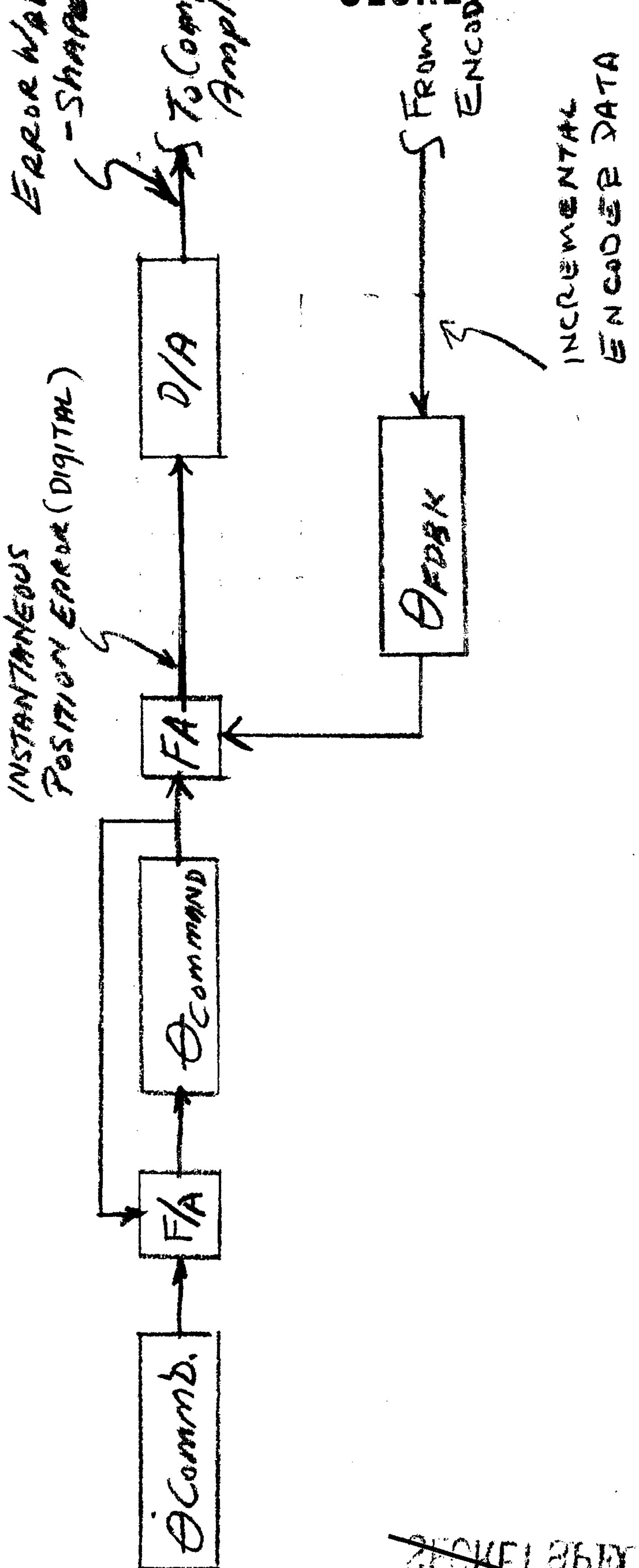
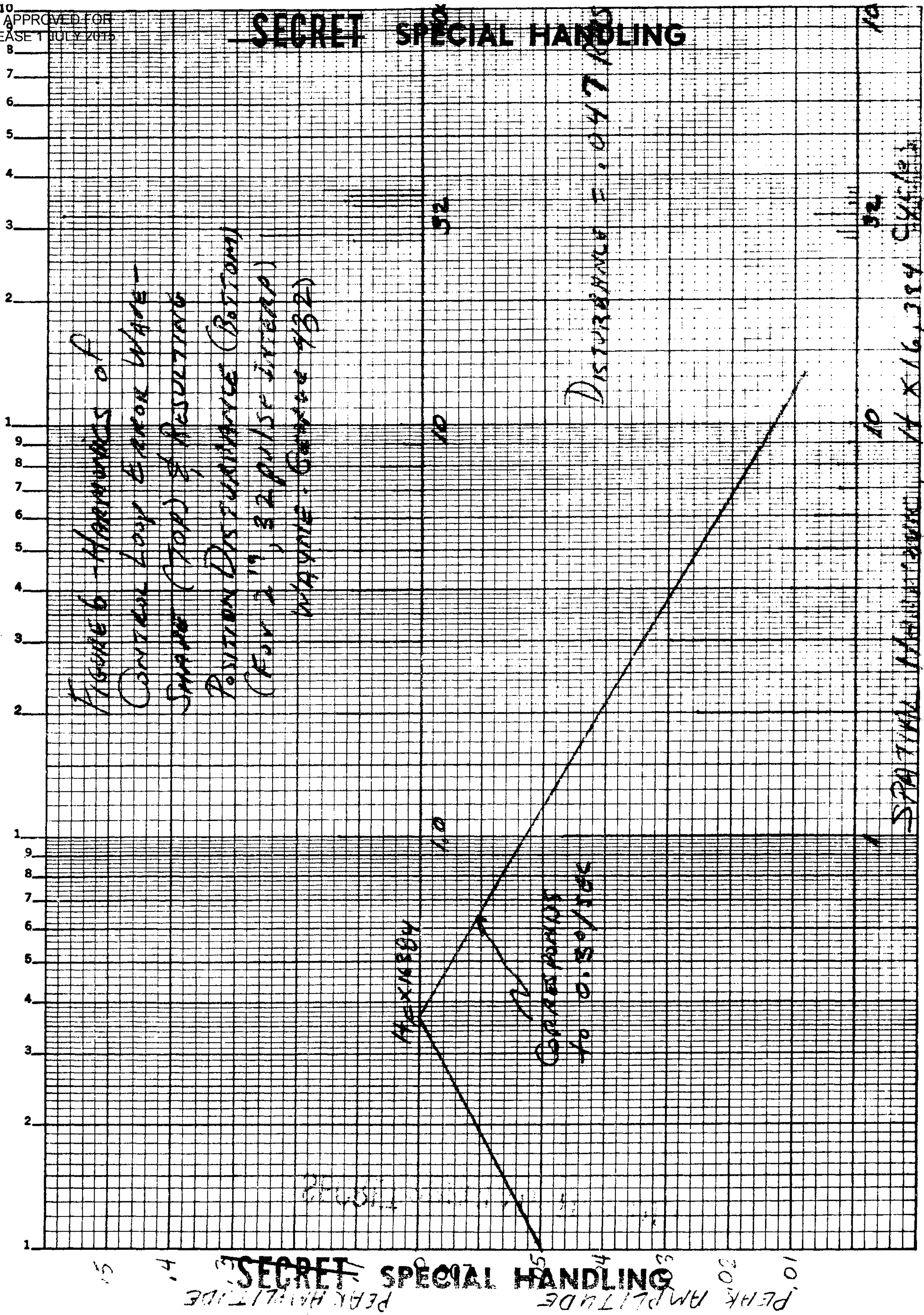


Figure 5 (a) Functional Block Diagram Locating Waveshapes of Figure 5



SECRET SPECIAL HANDLING

TEST PLAN

A - CONFIRM INTERPOLATION HARMONICS ARE VALID

B - CONFIRM SPATIAL HARMONIC DISTURBANCE OF FIGURE 1 IS VALID

OBJECTIVE A - WILL BE ACCOMPLISHED BY PULSE BY PULSE INTERPOLATION ERROR MEASUREMENTS BY THE VENDOR; INTERPOLATION ERROR SEQUENCES AT THE ENDS AND CENTER OF THE OPERATING RANGE WILL BE CHECKED.

OBJECTIVE B - PERFORMED ON THE 20 BIT ENCODER PURCHASED FOR THE BRASSBOARD WITH THE TEST SET-UP OF FIGURE 7

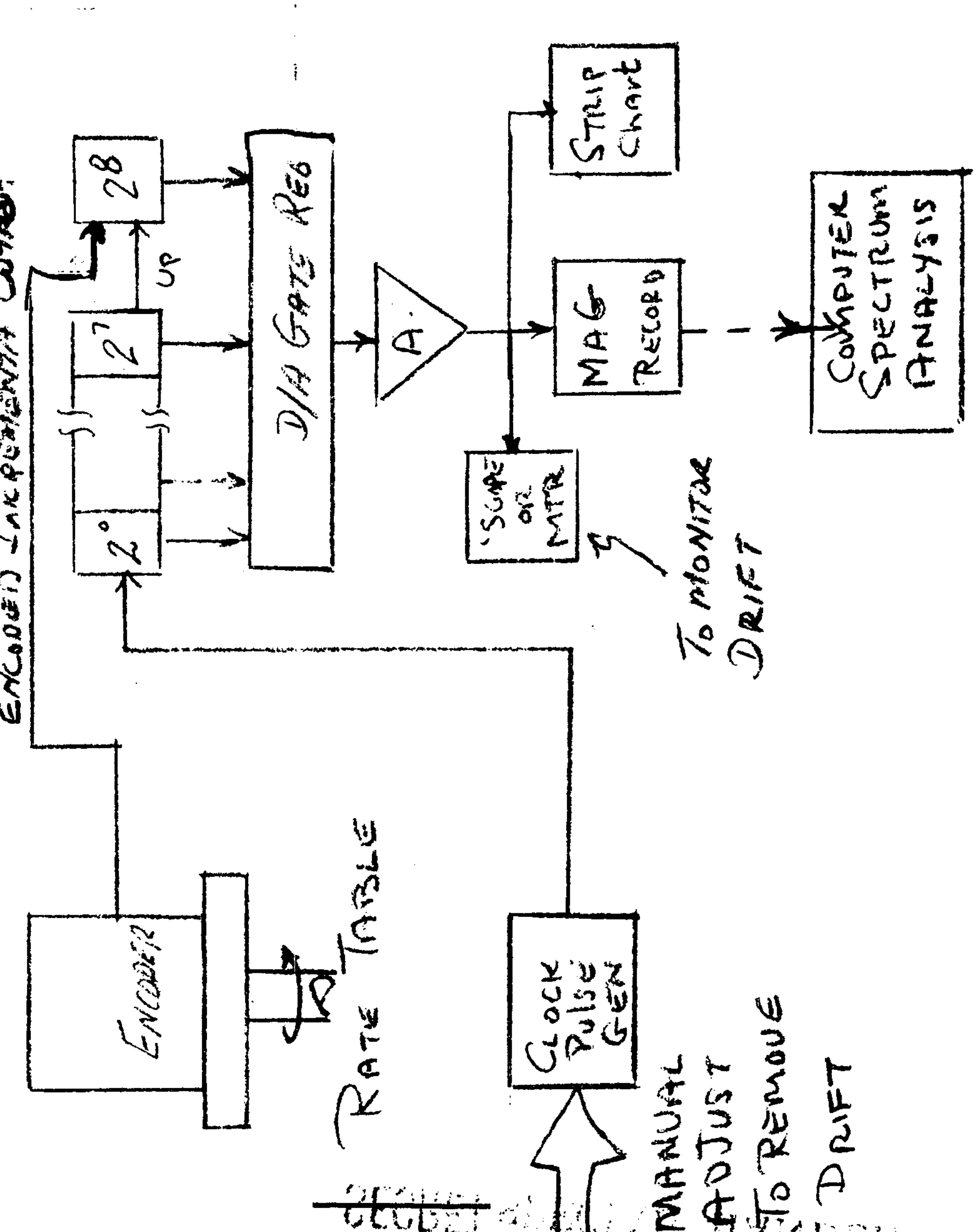


Figure 7 Test Set Up to Determine Encoder Noise Harmonics

KO RATE COMMAND
REGISTER SCALING

I CURRENT BASELINE

SIZE 14 BITS + SIGN

POSITION MODE

TOTAL STORAGE: ±57.6 DEG/SEC.

LSB : 6.54×10^{-3} DEG/SEC.

RATE MODE

TOTAL STORAGE: ±13.4 DEG/SEC

LSB : 8.17×10^{-4} DEG/SEC.

II MODIFICATIONS TO BASE LINE

SIZE 14 BITS + SIGN

POSITION MODE

TOTAL STORAGE: ±57.6 DEG/SEC

LSB : 6.54×10^{-3} DEG/SEC

RATE MODE

TOTAL STORAGE: ± 1.674 DEG/SEC, ±.836 DEG/SEC

LSB : 2.04×10^{-1} DEG/SEC, $.51 \times 10^{-4}$ DEG/S.

INTEGRATOR DRIFT

SOURCE	EFFECT
RATE Command RESOLUTION of 14 μrad/sec	7 μrad/sec
Clock DRIFT (.01%)	≈ 100 μrad/sec @ MAX slew ≈ 2.62 μrad/sec @ 1.5°/sec track ≈ .5 μrad/sec @ 0.3°/SEC TRACK RATE

Brushless

vs

Brush Type

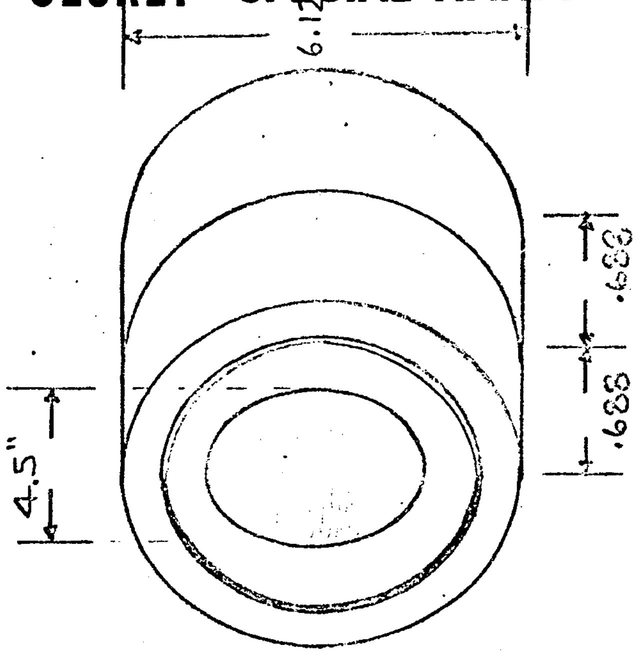
Torque Motors

(Comparison based on Roll T.M.)

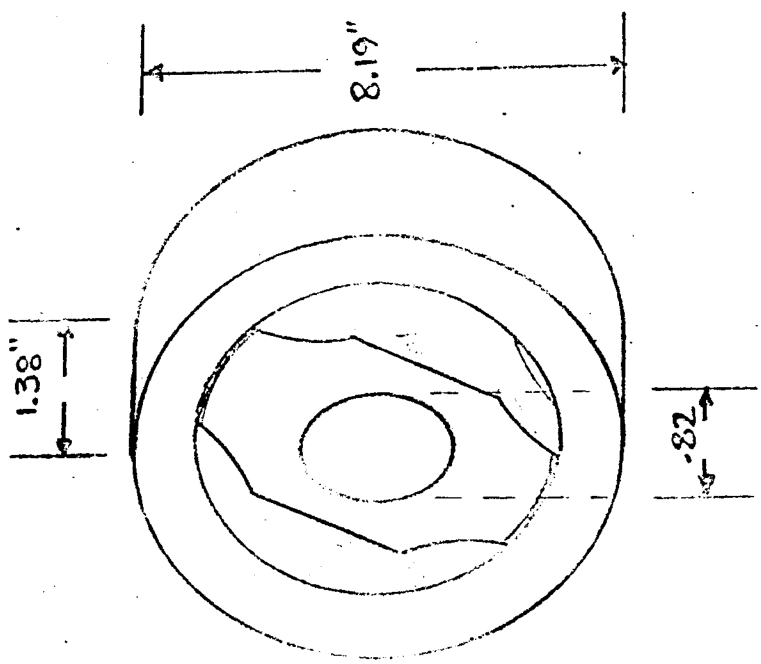
Aeroflex TQ82-W (Brushless	9#	34W Peak
Inland 5403-F ([illegible])	5# to 6#	40W Peak

[illegible] weight [illegible] [illegible] Filters

In addition to catalogue weights



INLAND



AEROFLEX

~~SECRET~~ SPECIAL HANDLING

Additional Considerations

1. Gimbal Design Modifications

2. Complex & Costly Development Testing Evaluate Effect of Cogging (5% on Catalogue Items)

3. Possibility of Special Rotor & Brush Design to Reduce Cogging effects
   (This was Drive II experience)

4. EMI Filter Design
   (Not Supplied by Motor Vendor)

PERIPHERAL DISPLAY

PROBLEM:

- 60° AFOV
- LITERATURE NOT ADEQUATELY SPECIFIC
- HARDWARE LEAD TIME
- COST SCHEDULE RESTRAINTS

REQUIREMENTS:

- Δ TIME TO GROUP DECISION
- TARGET DENSITY INFO
- DISCRETE INFO
  - BENCH MARK TGT
  - MANDATORY TAKE
  - VISUAL RECON
    - (WX ALT)
    - (PRIMARY)
    - (CASETTE CHANGE)

PERIPHERAL DISPLAY

CONCLUSIONS:

- LOW FIDELITY MOCKUP DEMONSTRATED
  - DISPLAY CONVEYS REQUIRED INFO
  - FUTURE GROWTH CAPABILITY
- COLOR (NOT HELPFUL, FIRST LOOK)
- ANGLE (MARGINAL BUT USEABLE)
- ABSENCE OR PRESENCE IMPROVED WITH DISTANCE
- FLASHING, SLIGHTLY HELPFUL
- LIGHTS LOCATED OUTSIDE EP IS AN ADVANTAGE
- UNABLE TO EVALUATE FOCUS RELATIONSHIPS
- UNABLE TO EVALUATE ACCOMMODATION PROBLEM

PLANS

- EVALUATE IN SIMULATION EQUIPMENT
- COORDINATE WITH ITEK

PROTECTION REQUIREMENTS

- DUST COVERS
- KICK PROOF
  - LOCAL
  - SHADE

MONITOR AND ALARM

- SUN PRESENCE (W) C2&8
- DRIVE 'K' OPERABILITY (C_p) (C_B) C2&8
  - INTERNAL TEMP
  - EXTERNAL TEMP
  - POWER
- BETA OPERABILITY (C)
  - RATE X,Y
  - LOCK ON SIGNAL
  - POWER

TELEMETRY

- KEYBOARD CALL UP

<u>'B' PANEL CONTROLS & DISPLAYS</u>

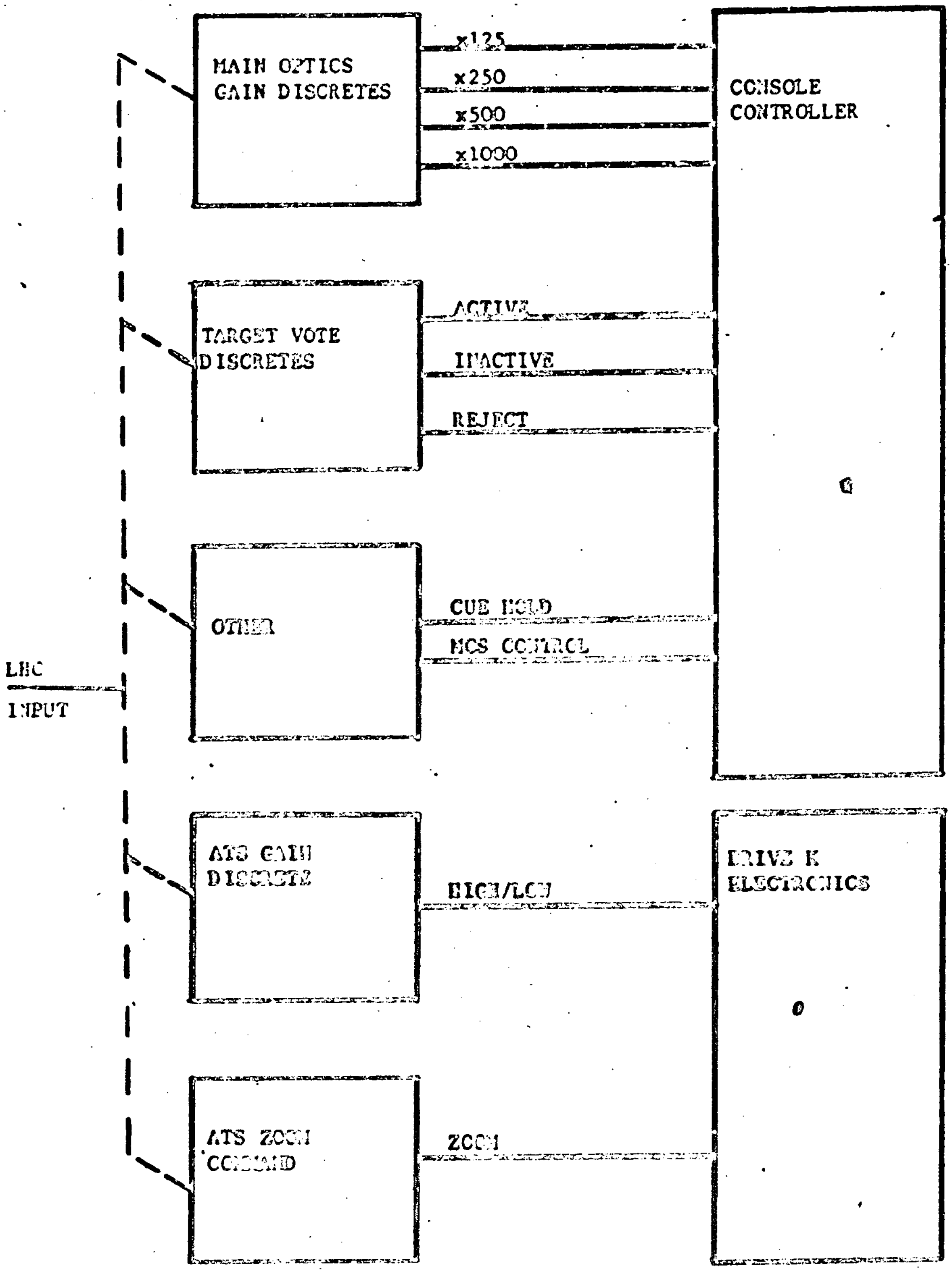
- BACKUP STOW (2.8)
- SCANNER SYNC (2.8) (E.A.)
- ENCODER BULB SELECT
- DERO DISABLE
- ZOOM DISABLE
- MAG DISABLE
- BLANKING SHUTTER PWR
- TEST BS
- BU DOOR OPEN/CLOSE
- ENABLE PYRO
- MECH DISENGAGE
- DOOR RELEASE

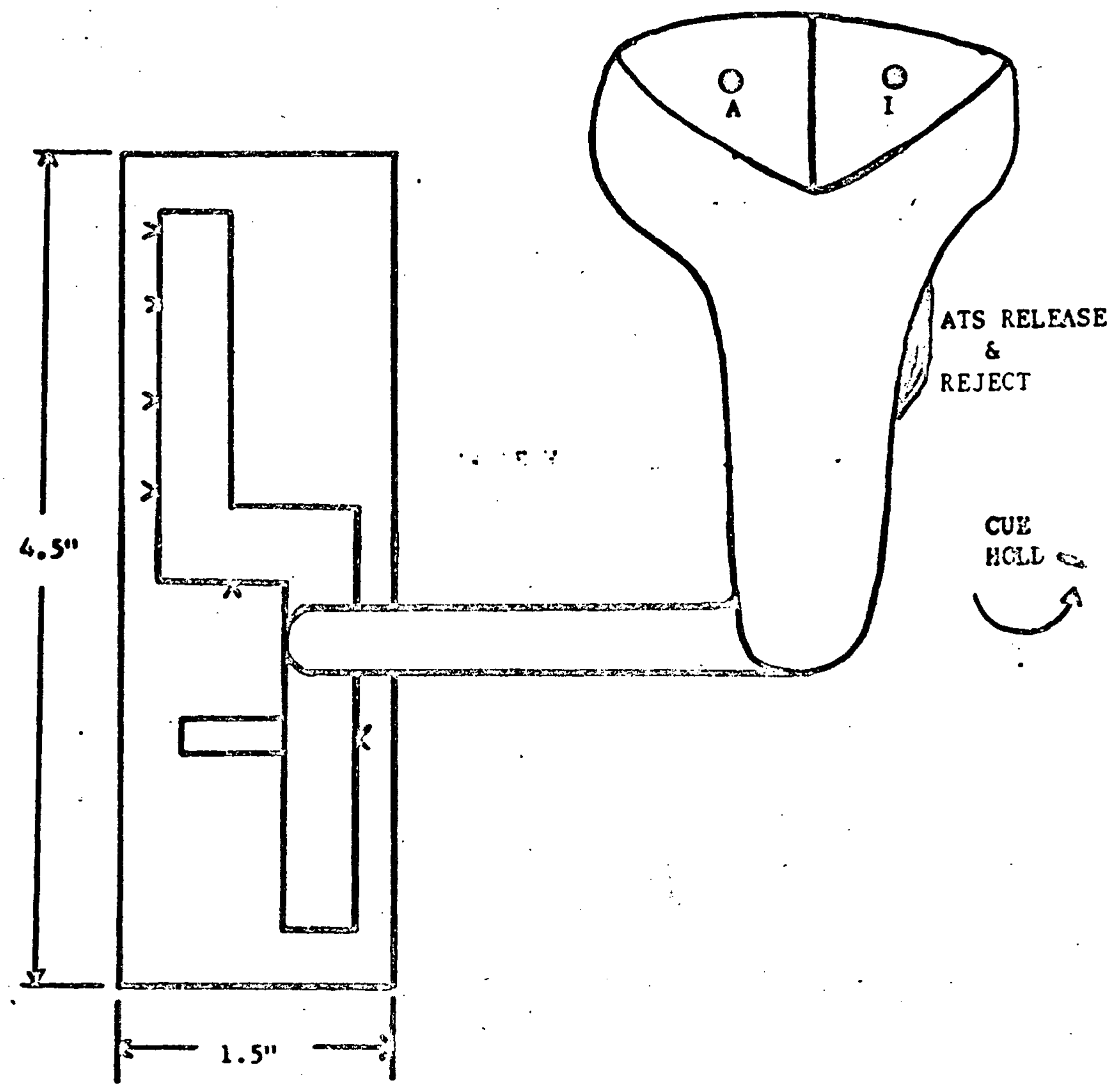
- SCANNER STOW (R.P)
- DOOR FULL OPEN/CLOSE
- SCANNER SYNC
- DOOR INOPERABLE
- ANALOG DOOR PSN

~~SECRET~~ SPECIAL HANDLING

LEFT HAND (MAGNIFICATION) CONTROLLER FUNCTIONS

- CONTROL MAIN OPTICS GAIN
- CONTROL ATS GAIN/ZOOM
- GENERATE TARGET VOTES
- GENERATE CUE HOLD COMMAND
- SWITCH MCS FROM ATS TO MAIN OPTICS
- RELEASE ATS HOLD COMMAND


MAIN OPTICS
GAIN DISCRETES
x125
x250
x500
x1000
CONSOLE
CONTROLLER
TARGET VOTE
DISCRETES
ACTIVE
INACTIVE
REJECT
OTHER
CUE HOLD
MCS CONTROL
LHC
INPUT
ATS GAIN
DISCRETE
HIGH/LOW
DRIVE &
ELECTRONICS
ATS ZOOM
COMMAND
ZOOM

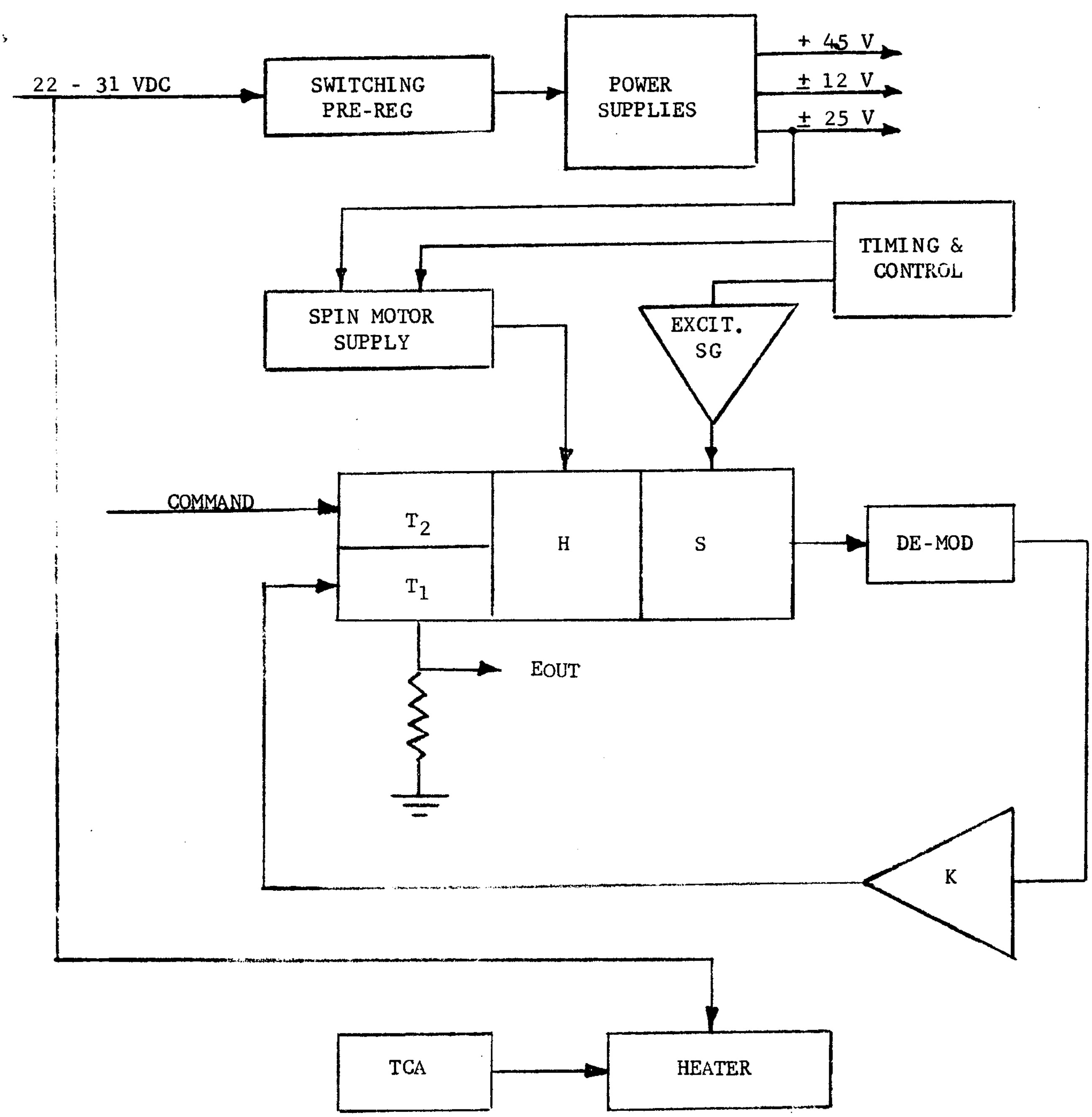


LEFT HAND (MAGNIFICATION) CONTROLLER

DRIVE K GYRO REQUIREMENTS

- CONCEPT: Gas Bearing floated gyro with support electronics, Rate Mode
- SIZE: 85 cubic inches (Gyro plus Electronics Package)
- WEIGHT: 5.1 pounds less Cable
- POWER: 5 watts electronics plus Heater Power
- NOISE: PSD Envelope and RMS Requirement
- FREQUENCY RESPONSE: Third Order with breaks specified
- THERMAL ENVIRONMENT: 0 to 100 degrees F Vacuum Space
- MONITOR FUNCTIONS: 4 TLM Discretes plus Test Points
  - -Overheat
  - -Control Heat
  - -Saturation
  - -Wheel Sync
- MAXIMUM COMMONALITY with Drive A gyro

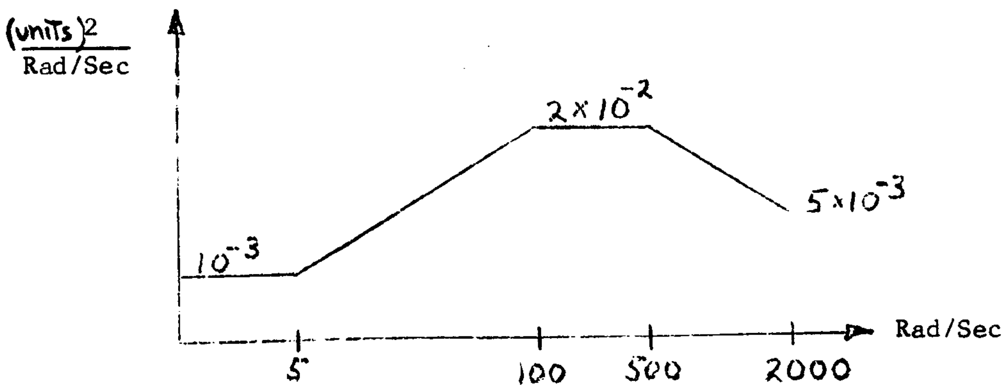
RATE GYRO ASSEMBLY



COMMONALITY STUDIES

I. Gyro PSD envelope and Transfer function specified as a sub-system requirement:

A. PSD Envelope can be met by a Gyro similar to Drive A Gyro.



B. Transfer Function

$$\frac{E(s)}{\omega(s)} = \frac{K}{(as+1)(bs+1)(cs+1)}$$

a = .01 sec (caging loop)

b = .0009 sec (gyro)

c = .0002 sec Max (Electronics)

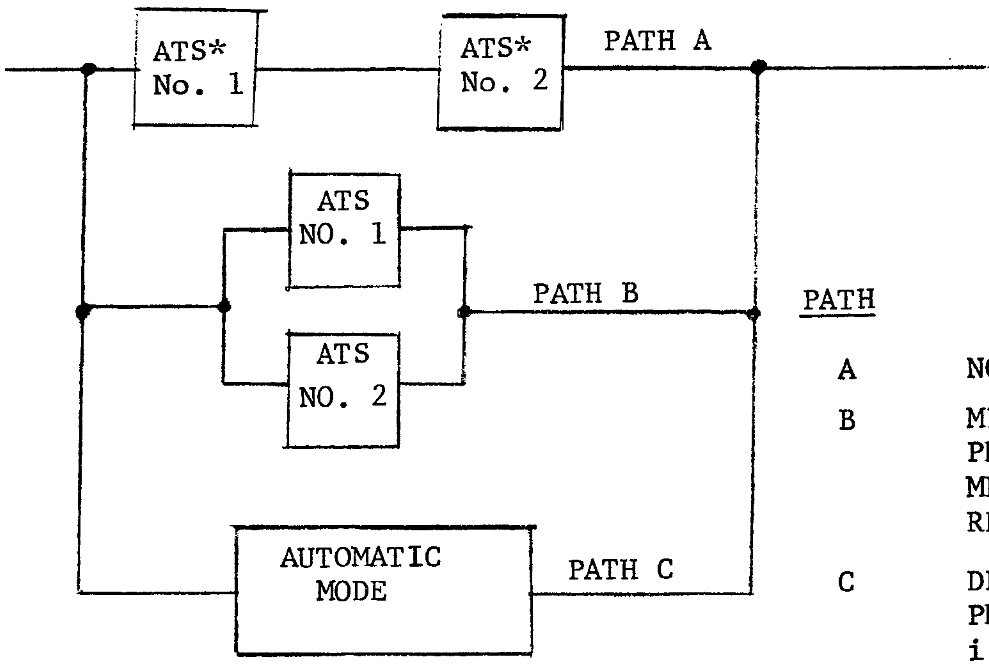
1. Time constants a & c are functions of electronics and adjustable.
2. Time constant b is J/C_D and only C_D is conveniently adjustable. It is a function of fluid viscosity and damping gap.
3. C_D required to be 2.5×10^5 at 160 degrees F versus 5×10^4 at 130 degrees F for Drive A.
4. Maximum commonality by using same gyro as Drive A with different fluid.

ALPHA SUBSYSTEM

- RELIABILITY ANALYSIS
- SAFETY ANALYSIS
- MAINTAINABILITY ANALYSIS

ATS RELIABILITY DESIGN CRITERIA

- COMPLETE LOSS OF THE ATS FUNCTION IS CONSIDERED A FAILURE TO THE GE-AVE M/A SYSTEM EVEN THOUGH A FUNCTIONALLY REDUNDANT MODE EXISTS TO ACHIEVE MOST OF THE MOL OBJECTIVES
- PROBABILITY THAT ONE OF TWO ATS IS PERFORMING SHALL BE 0.999
- RELIABILITY REQUIREMENT FOR EACH ATS SHALL BE 0.98
- BLOCK AND/OR FUNCTIONAL REDUNDANCY WITHIN EACH ATS SHALL BE UTILIZED TO MEET THE 0.999 REQUIREMENT
- THE DESIGN SHALL BE SUCH THAT NO SINGLE FAILURE WILL CAUSE LOSS OF BOTH ATS SUBSYSTEMS
- CREW SHALL BE UTILIZED TO PERFORM BACKUP CONTROL, LIMITED MAINTAINABILITY AND DIAGNOSTIC ANALYSIS WHEN SYSTEM EFFECTIVENESS IS ENHANCED.



PATH	SYSTEM STATE
A	NOMINAL MODE
B	MINIMUM PERMISSIBLE TO MEET SYSTEM REQUIREMENTS
C	DEGRADED MPSS PERFORMANCE i.e., NETHER ATS OPERATING

*EACH ATS INCLUDES ALL EQUIPMENTS NECESSARY TO PERFORM ACQUISITION FUNCTION

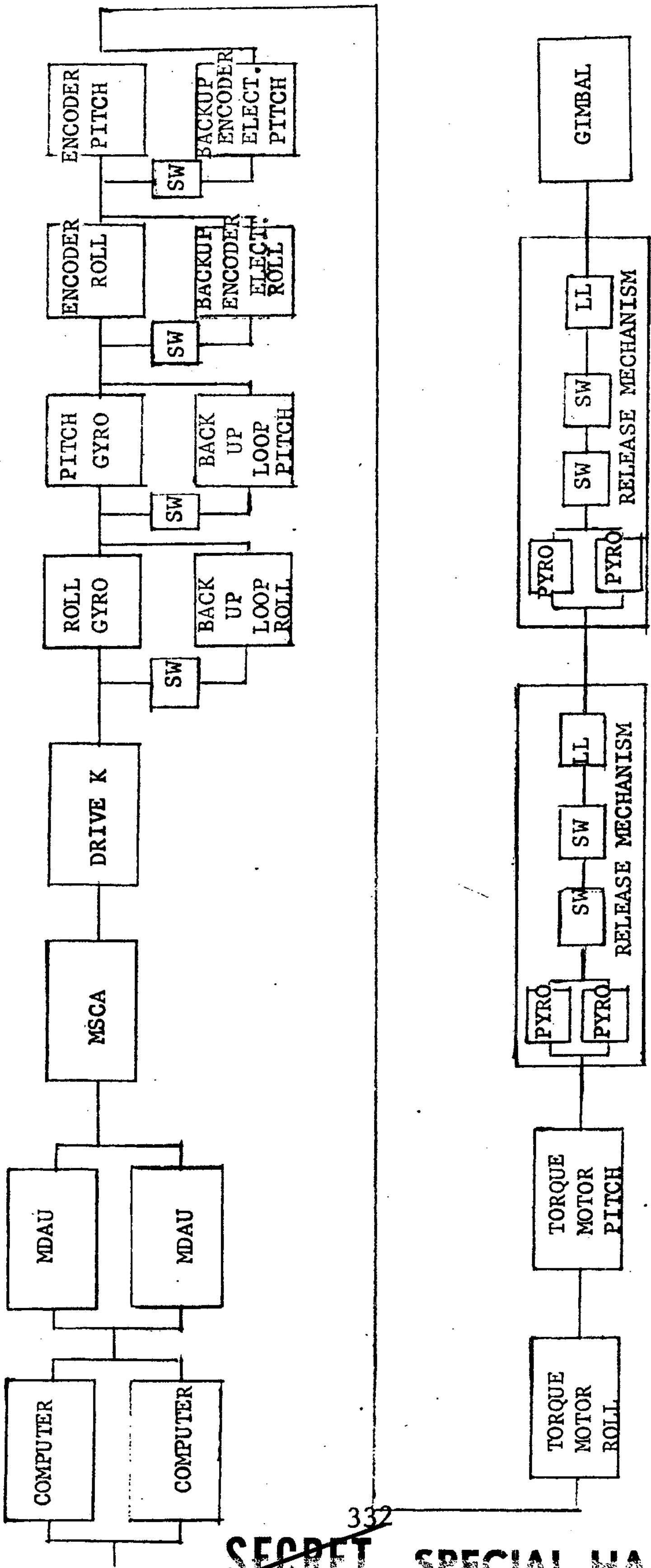
MPSS System Level Reliability Diagram

ACQUIRE AND STUDY CUES IN VDP	ACQUIRE TARGETS	TRACK TARGETS	OPTIMIZE TARGET FOV
FUNCTIONAL FAILURE MODES	FUNCTIONAL FAILURE MODES	FUNCTIONAL FAILURE MODES	FUNCTIONAL FAILURE MODES
-LOSS OF ALPHA-NUMERIC	-LOSS OF POINTING CAPABILITY	-LOSS OF ATS TRACKING CAPABILITY	-FAILURE TO POSITION TARGET
-LOSS OF CUE DISPLAY	-ERRORS IN POINTING	-ERRORS IN TRACKING	-LOSS OF MAGNIFICATION CONTROL
-LOSS OF AUTO CUE COMMANDS	-FAILURE OF SHROUD DOOR TO OPEN		-LOSS OF ZOOM CONTROL
-DEGRADED CUE DATA			-FAILURE OF BLANKING SHUTTER TO CLOSE
			-FAILURE OF BLANKING SHUTTER TO OPEN
			-FAILURE OF SHROUD DOOR TO CLOSE
			-LOSS OF CUE DISPLAY DURING PASS
			-LOSS OF VOTE SELECTION

~~SECRET~~ SPECIAL HANDLING

- CONTINGENCY MODES - / DEGRADED MODES

FUNCTIONAL FAILURE	OPERATIONAL MODE
- LOSS OF CUE DISPLAY	- CONTINUE ATS SURVEILANCE UTILIZING ASTRO. KNOWLEDGE TO IDENTIFY ACTIVITY ON TARGETS PRESENTED IN ATS FOV
- LOSS OF ONE ATS	- GO TO SINGLE OPERATOR MODE, SPECIALIST
- RATE GYRO -	- UTILIZE POSITION LOOP
- LOSS OF COOLING LOOP	- MAJOR FAILURE - LEAKAGE WILL EFFECT COLD PLATES AND ABORT/ABBREVIATE MISSION.
- MAGNIFICATION CONTROL ZOOM CONTROL	- MANUAL OVERRIDES WITH LITTLE OR NO DEGREDATION
- LOSS OF ALPHA-NUMERIC	- LOSS OF REDUNDANT INFORMATION TO CREW
- LOSS OF DEROTATION	- MANUAL OVERRIDE ON PRISM
- LOSS OF PERIPHERAL DISPLAY	- CONTINUE OPERATING - MENTAL COUNTDOWN



RELIABILITY LOGIC DIAGRAM SCANNER CONTROLS AND DRIVES (PER ATS)

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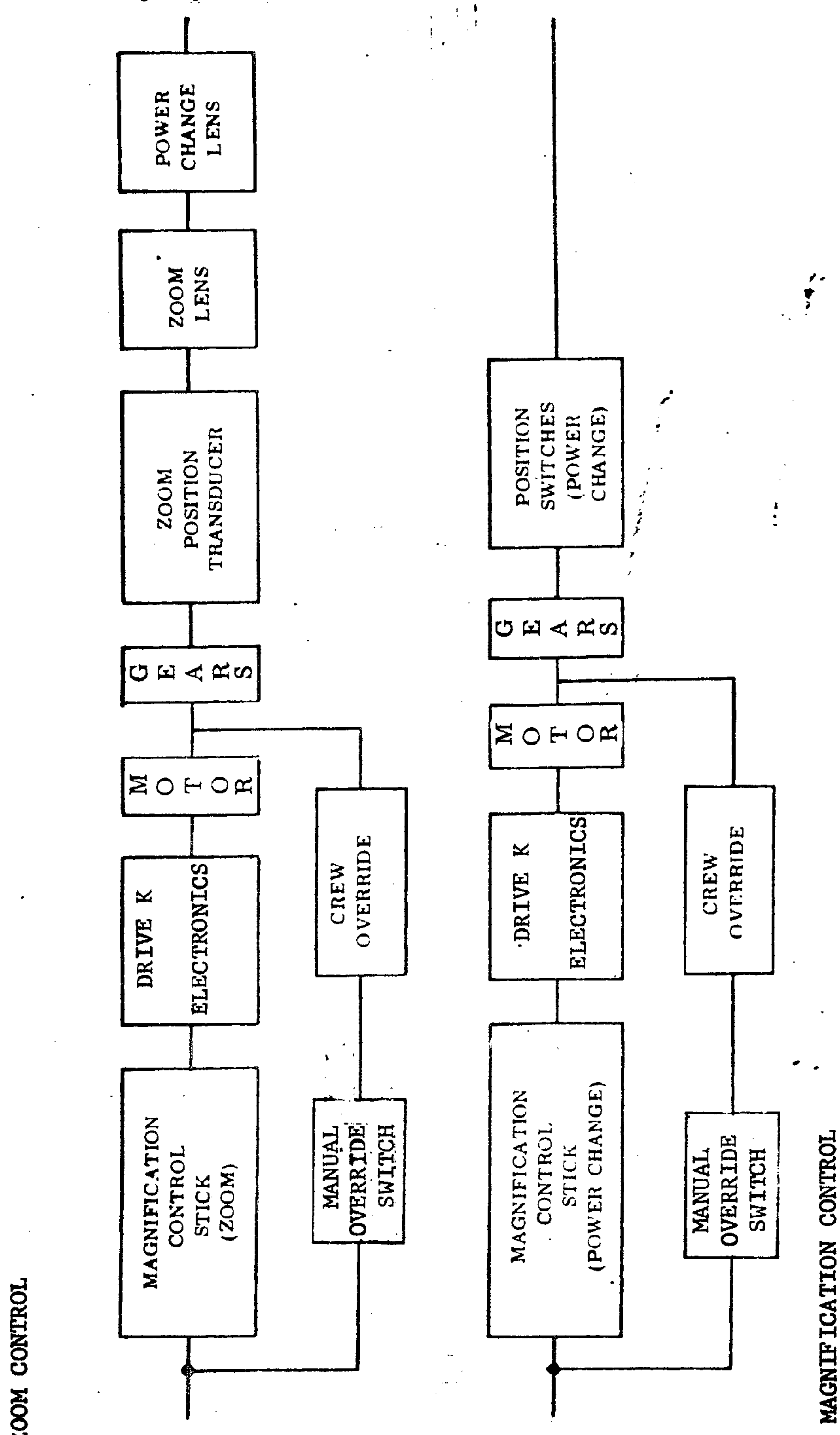
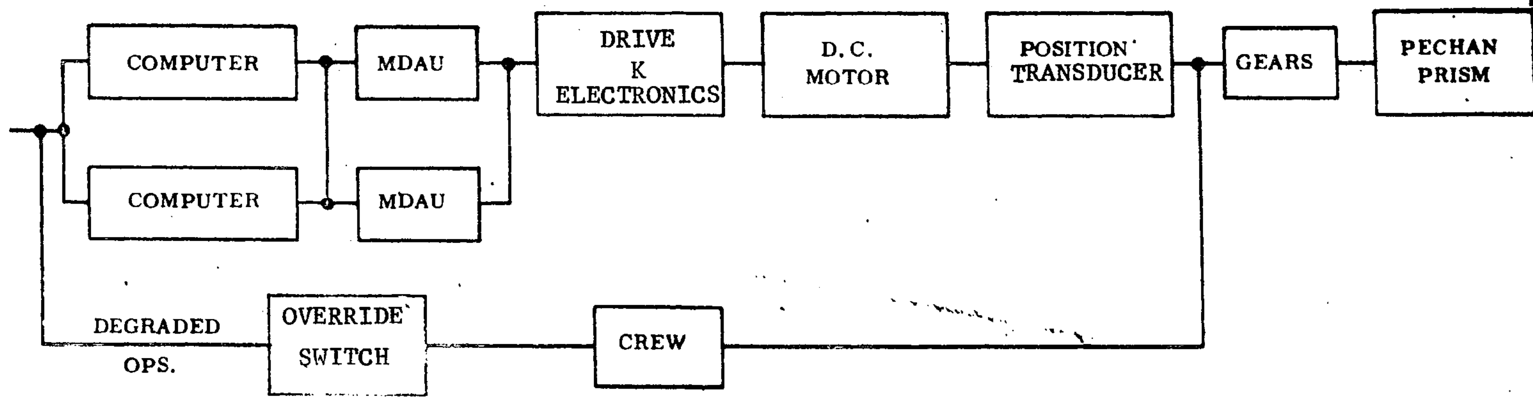


Reliability Logic Diagram - Zoom and Magnification Control (Per ATS)

~~SECRET~~ SPECIAL HANDLING

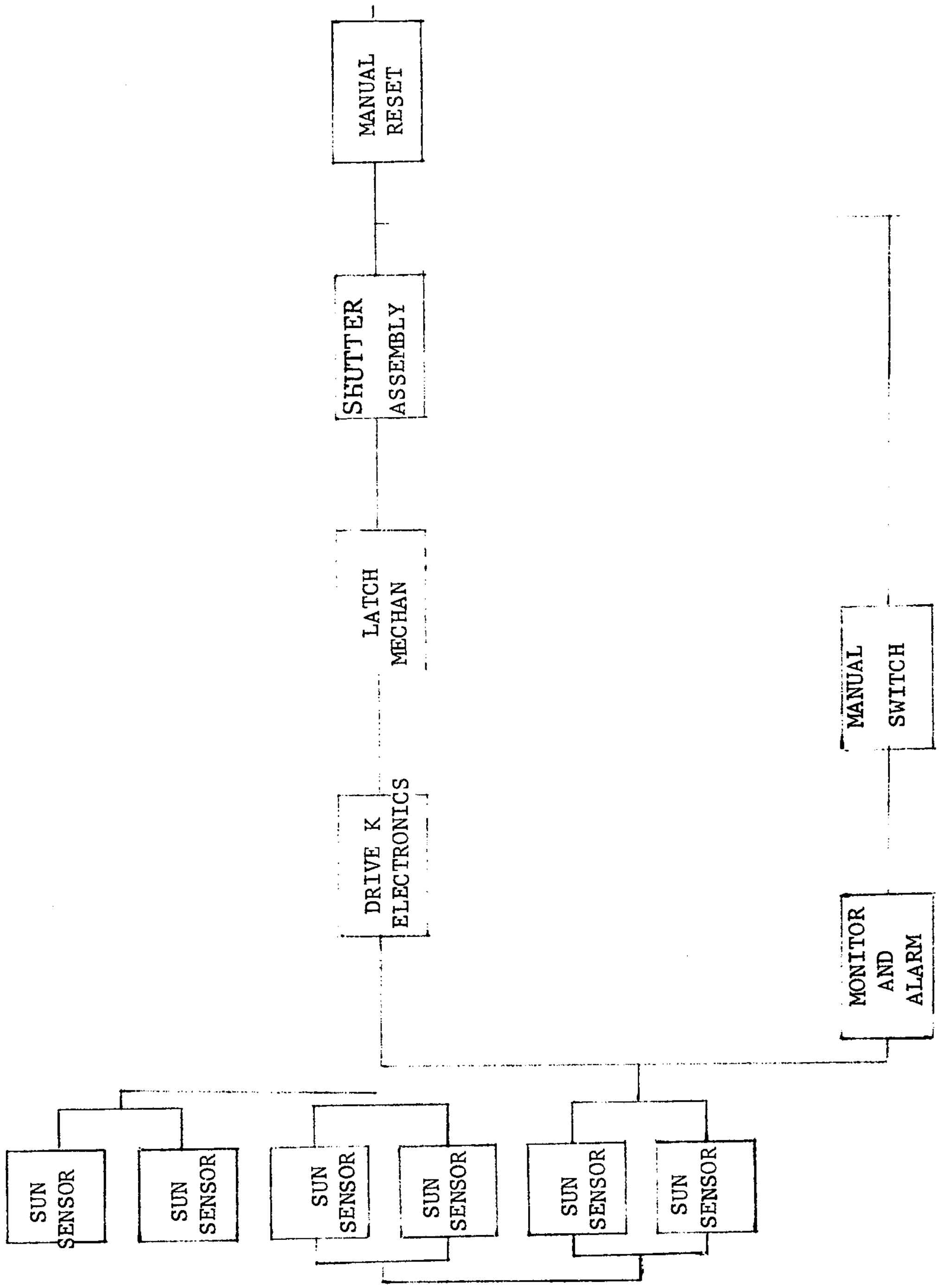
SECRET SPECIAL HANDLING

IMAGE ORIENTATION CONTROL
LOOP
(PER ATS LOOP)



Reliability Logic Diagram - Image Orientation Control Loop (Per ATS Loop)

SECRET SPECIAL HANDLING



RELIABILITY LOGIC DIAGRAM - BLANKING ASSEMBLY (PER ATS)

SUB SYSTEM ALPHA

ITEM NUMBER	ITEM	λ (ppmh/c)	t (hrs/cy)	λt	PREDICTION	APPORTIONMENT	REMARKS / CRITICAL PARTS	λ REQT
	ASSEMBLY	48	58.3	.002800	.997200	.996	FULL AUTOMATIC	86.0
	DRIVE K ELECTRONICS	69.9	65	.004644	.995456	.997		55.9
	ROLL GYRO ASSEMBLY	30	131	.003930	.996070	.995	VENDOR ANALYSIS CONSERVATIVE (51)	60.6
	PITCH GYRO ASSEMBLY	30	131	.003930	.996070	.995	VENDOR ANALYSIS CONSERVATIVE(51)	60.6
	VISUAL DISPLAY PROJECTOR	20	230	.004600	.995400	.997	VALID IF HELIUM ATMOSPHERE DOES NOT AFFECT BULB LIFE	9.0
	EACH SIDE			.019904	.980096	.98		
	ONE OF TWO			.000392	.999608	.999		

SUB-SYSTEM ALPHA-ALTERNATE-UNDEGRADED (NO BACK-UP)

ITEM NUMBER	ITEM	λ (ppmh/k)	t (hrs/cy)	λt	PREDICTION	APPORTIONMENT	REMARKS/CRITICAL PARTS
	ASSEMBLY	48	58.3	.002800	.997200		
	DRIVE K ELECTRONICS	60	65	.003900	.996100		
	ROLL GYRO ASSEMBLY	30	131	.003930	.996070		
	PITCH GYRO ASSEMBLY	30	131	.003930	.996070		
	VDP	20	230	.004600	.995400		
	EACH SIDE			.019160	.980840	.98	
	ONE OF TWO			.000367	.999633	.999	

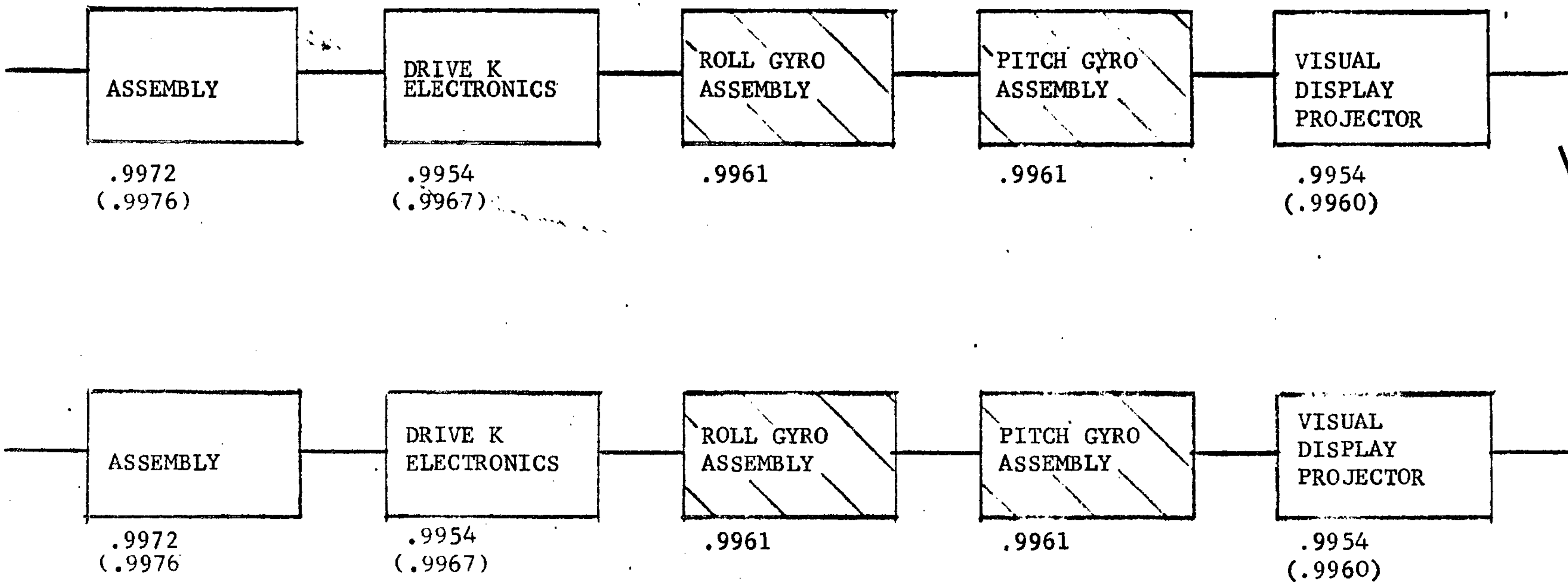
SUB-SYSTEM ALPHA DEGRADED PERFORMANCE

ITEM NUMBER	ITEM	λ (ppmh/c)	t (hrs/cy)	λt	PREDICTION	APPORTIONMENT	REMARKS/CRITICAL PARTS
	ASSEMBLY	45	58.3	.002447	.997553		
	DRIVE K ELECTRONICS	50	65	.003350	.996650		
	ROLL GYRO ASSEMBLY						NOT REQUIRED
	PITCH GYRO ASSEMBLY						NOT REQUIRED
	VISUAL DISPLAY PROJECTOR	18	230	.004140	.995960		MANUAL FRAME SELECTION
	EACH SIDE			.009937	.990063		
	ONE OF TWO			.000100	.9999		

~~SECRET~~ SPECIAL HANDLING

SUB-SYSTEM ALPHA-ALTERNATE-DEGRADED PERFORMANCE WITH & WITHOUT GYRO BACK-UP

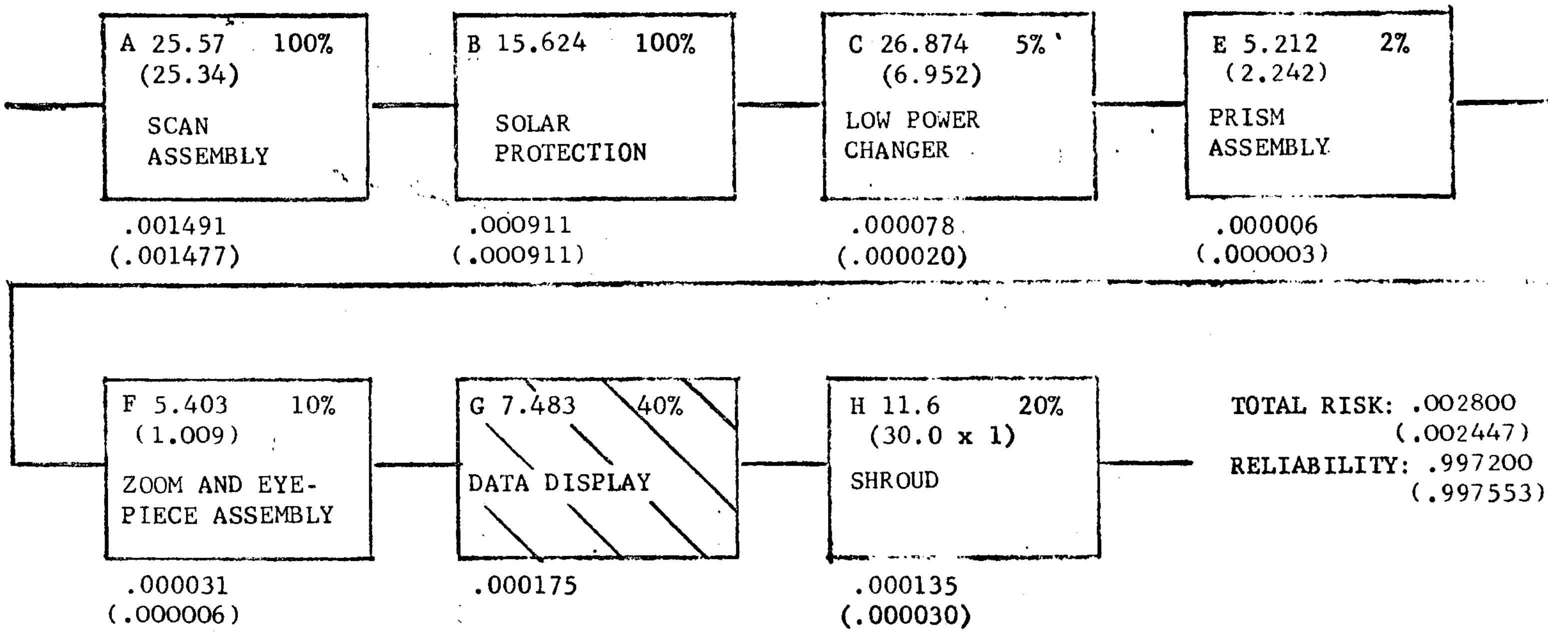
ITEM NUMBER	ITEM	λ (ppmh/c)	t (hrs/cy)	λt	PREDICTN.	APPORTIONMENT	REMARKS / CRITICAL P...
	ASSEMBLY	45	58.3	.002447	.997553		
	DRIVE K ELECTRONICS	60	65	.003900	.996100		
	ROLL GYRO ASSEMBLY	30	131	.003930	.996070		
	PITCH GYRO ASSEMBLY	30	131	.003930	.996070		
	VDP	18	230	.004140	.995860		
	EACH SIDE			.019347	.980653	.98	WITHOUT GYRO BACK-UP
	ONE OF TWO			.000374	.999626	.999	
	ASSEMBLY	45	58.3	.002447	.997553		
	DRIVE K ELECTRONICS	50	65	.003250	.996750		
	P/O DRIVE K & GYRO'S	10/60	65/131	.000005	.999995		RISK SMALL WITH BACK-UP
	VDP	18	230	.004140	.995860		
	EACH SIDE			.009842	.990158	.98	WITH GYRO BACK-UP
	ONE OF TWO			.000097	.999903	.999	



RELIABILITY BLOCK DIAGRAM: ALPHA SUBSYSTEM

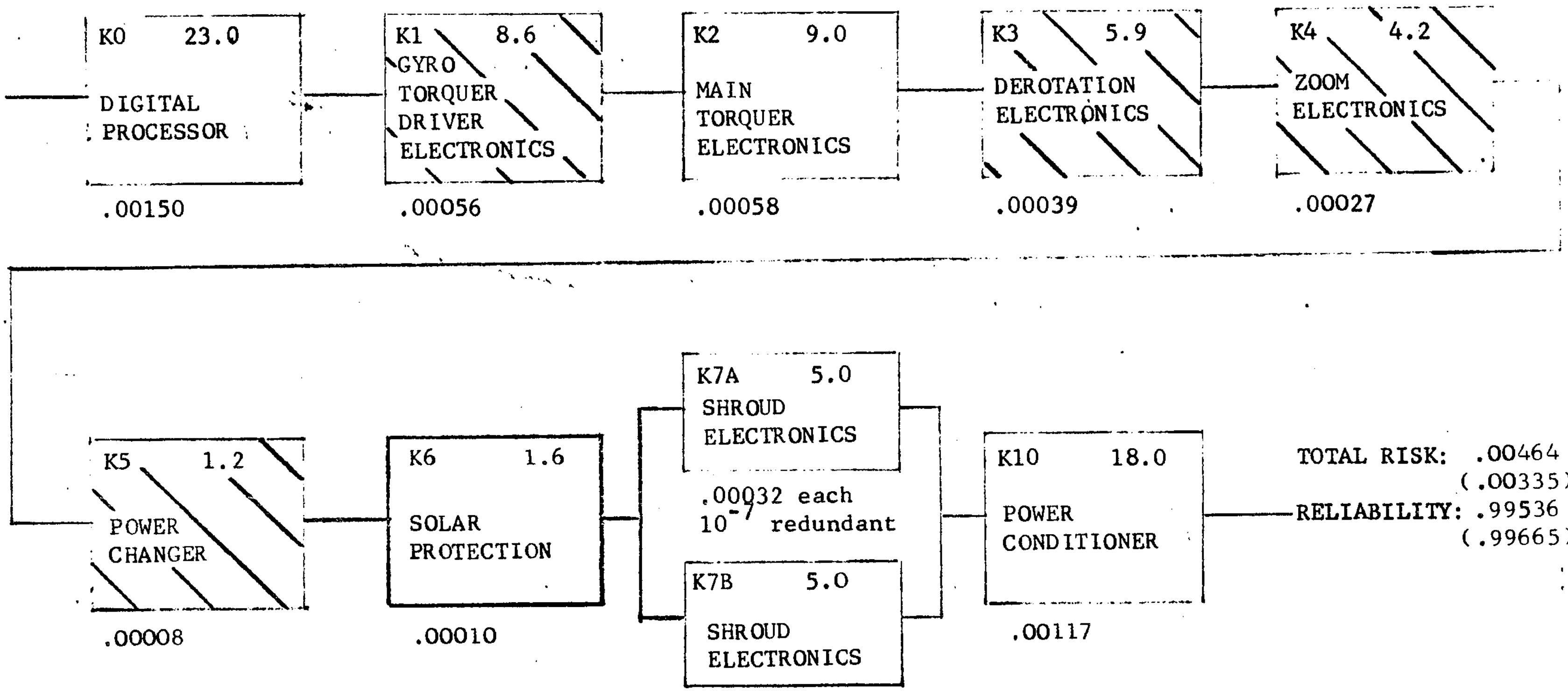
RELIABILITY: .980096 Each side
(.990063)
.999608 One of two
(.999900)

NOTE: Component reliabilities are provided below the blocks. Parenthetic numbers indicate degraded mode reliability. Cross-hatched blocks are not required for degraded operation.



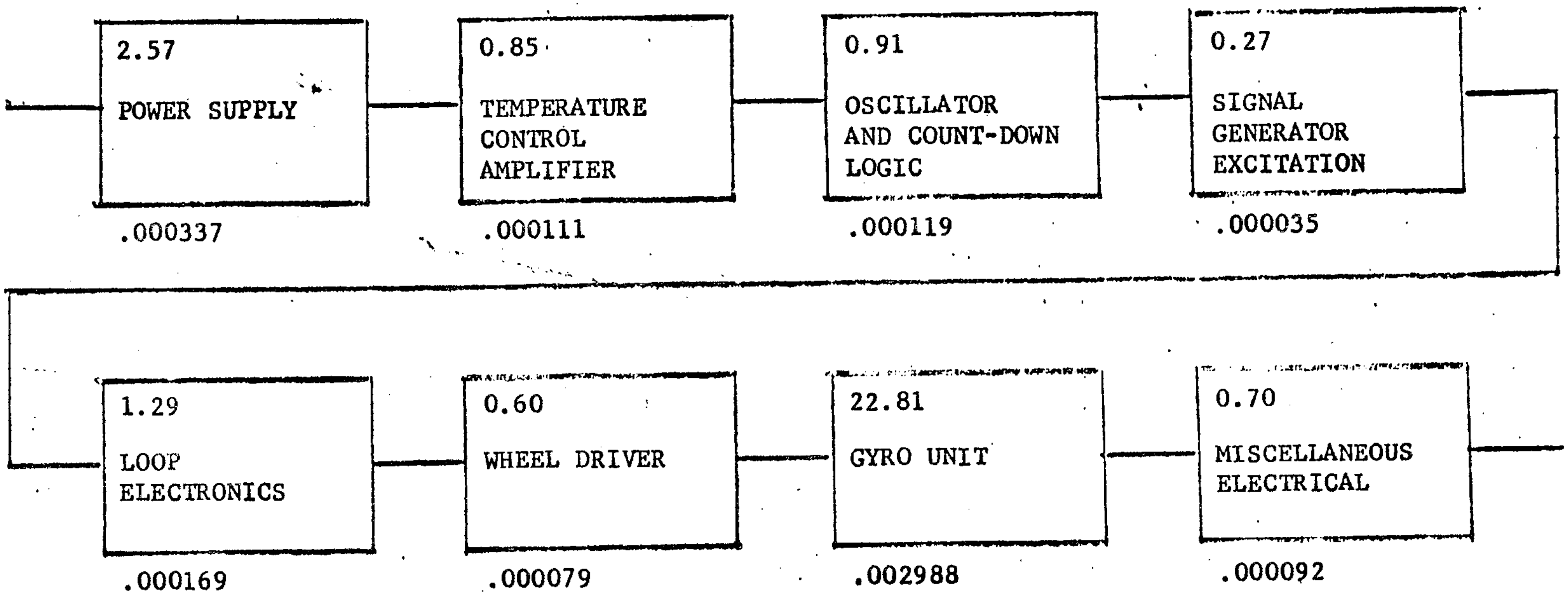
RELIABILITY BLOCK DIAGRAM: OPTICAL ASSEMBLY

NOTE: Failure rates (failures per million hours) and duty cycles are provided in the blocks. Probabilities of failure (risk) are noted below the blocks. Parenthetic numbers indicate degraded mode reliability. Cross-hatched blocks are not required for degraded operation.



RELIABILITY BLOCK DIAGRAM: DRIVE K ELECTRONICS

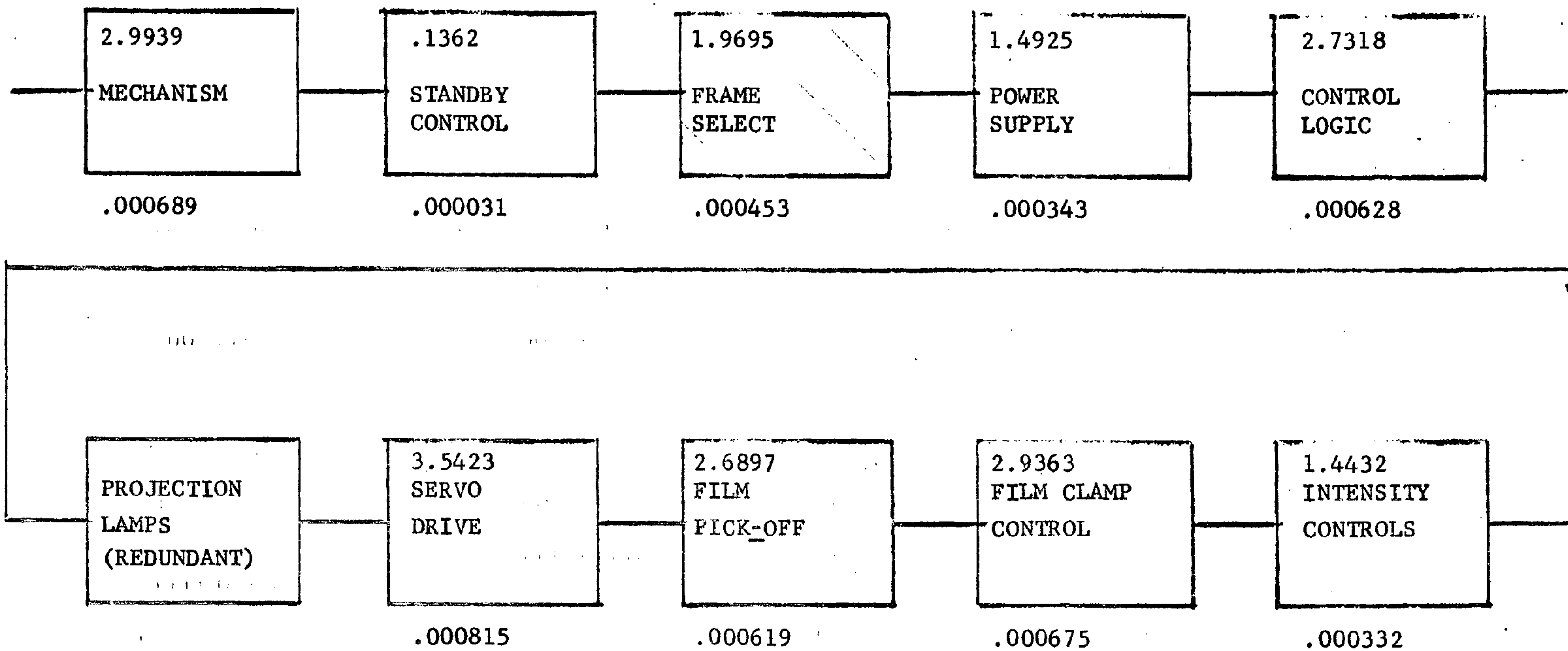
NOTE: Failure rates (falures per million hours) are provided in the blocks. Probabilities of failure (risk) are noted below the blocks. Parenthetic numbers indicate degraded mode reliability. Cross-hatched blocks are not required for degraded operation.



RELIABILITY BLOCK DIAGRAM: GYRO ASSEMBLY

TOTAL RISK: .003930
RELIABILITY: .996070

NOTE: Failure rates (failures per million hours) are provided in the blocks. Probabilities of failure (risk) are noted below the blocks. The gyro assemblies are not required in degraded operation.



TOTAL RISK: .004585
(.004132)
RELIABILITY: .995415
(.995868)

RELIABILITY BLOCK DIAGRAM: VISUAL DISPLAY PROJECTOR

NOTE: Failure rates (failures per million hours) are provided in the blocks. Probabilities of failure (risk) are noted below the blocks. Parenthetic numbers indicate degraded mode reliability. Cross-hatched blocks are not required for degraded operation.

~~SECRET~~ SPECIAL HANDLING

SAFETY - HMEA'S

HMEA	VDP
ITEM NUMBER:	HEAT SINK
ASSUMED FAILURE:	LOSS OF COOLANT
POSSIBLE CAUSES:	VIBRATION, SHOCK, OVERSTRESS (DURING LAUNCH)
SYMPTOMS AND CONSEQUENCES:	
	MINOR DEGRADATION IN VDP DISPLAYS
COMPENSATING PROVISIONS AND RESULTS:	
	DESIGN MARGIN AND OVER-PRESSURE TEST
POSSIBLE COMPENSATING PROVISIONS:	
	LEAK TEST ON PAD
	DAC MONITORS PRESSURE
EFFECT ON SYSTEM:	RELEASE OF EXCESSIVE AMOUNT OF COOLANT AND CONSEQUENT LOSS OF MISSION
PROBABILITY OF FAILURE:	LESS THAN 1 PER 10^6 MISSIONS
HAZARD CLASS:	GE-AVE: III
	MOL: POTENTIALLY IV
RECOMMENDATIONS:	NO CHANGE IN VDP COOLING REQUIRED SINCE COMPONENT DESIGN IS CONSISTENT WITH PROGRAM COOLANT LOOP DESIGN CONCEPT

HMEA	VDP
ITEM NUMBER:	VIEWING SCREEN
ASSUMED FAILURE:	BREAKAGE
POSSIBLE CAUSES:	IMPACT

SYMPTOMS AND CONSEQUENCES:

LOSS OF VIEWING SCREEN AND POTENTIAL INJURY TO CREW

COMPENSATING PROVISIONS AND RESULTS:

NONE

POSSIBLE COMPENSATING PROVISIONS:

GLASS SCREEN REPLACED WITH LEXAN

PROBABILITY OF FAILURE:	NEGLIGIBLE WITH CORRECTION
HAZARD CLASS:	III PRIOR TO CORRECTION I WITH CORRECTION
RECOMMENDATIONS:	WITH LEXAN CHANGE DESIGN IS ADEQUATE

HMEA ALPHA SUBSYSTEM

ITEM NUMBER: BLANKING

ASSUMED FAILURE: INOPERATIVE

POSSIBLE CAUSES: SPRING, SENSING

SYMPTOMS AND CONSEQUENCES:

SOLAR IMPINGEMENT - SAFETY HAZARD TO ASTRONAUT

COMPENSATING PROVISIONS AND RESULTS:

REDUNDANT SENSORS
MONITOR AND ALARM (VISUAL AND AUDIO)
ACTS FAILURE NECESSARY (SOP SHOULD COMPENSATE)

POSSIBLE COMPENSATING PROVISIONS:

INCREASED REDUNDANCY SUCH AS DRIVE K ELECTRONICS
LOGIC, SOLENOID, SPRING, SHUTTER

PROBABILITY OF OCCURRENCE:

EQUIPMENT RELIABILITY .000478
(REQUIRES DOUBLE FAILURE)

HAZARD CLASS: III

RECOMMENDATIONS: DESIGN CONSIDERED ADEQUATE
NO CHANGE NECESSARY

HMEA	ASSEMBLY
ITEM	BLANKING
ASSUMED FAILURE:	NO DESIGN COMPENSATION FOR SPECULAR REFLECTANCE
POSSIBLE CAUSES:	NO REQUIREMENT IN CURRENT DESIGN CONCEPT
SYMPTOMS AND CONSEQUENCES:	CORNEA DAMAGE RESULTING IN PERMANENT DAMAGE TO CREWMAN
COMPENSATING PROVISIONS AND RESULTS:	NONE IDENTIFIED
POSSIBLE COMPENSATING PROVISIONS:	GROUND COMPUTER CALCULATING SUN ANGLES RELATIVE TO ATS AND IDENTIFYING INHIBIT AREAS
EFFECT ON MISSION:	POSSIBLE MISSION TERMINATION DUE TO CREW INJURY
PROB. OF OCCURRENCE:	CONSIDERED NEGLIGIBLE
HAZARD CLASS:	III
RECOMMENDATIONS:	CONTINUE WITH CURRENT DESIGN CONCEPT -

1. $\overline{M}$ REQ'TS ON MOL

2. $\overline{M}$ REQ'TS ON ALPHA COMPONENTS

3. STATUS OF DESIGN IN MEETING THESE REQUIREMENTS

4. MAWS

5. PROBLEM AREAS

MAJOR $\bar{M}$ REQUIREMENTS ON MOL

GROUND

ANY SINGLE L/P MAINTENANCE ACTIVITY TIME CONSTRAINED TO $<$ 24 HR FOR 99% OF EXPECTED MALFUNCTIONS, INCLUDING FAULT ISOLATION, REPAIR AND REVALIDATION 99.2% $<$ 44 HRS.

ON ORBIT

1. ANY SINGLE ON ORBIT CORRECTIVE MAINTENANCE ACTIVITY TIME CONSTRAINED TO TBD (15 MIN.) FOR 90% OF CORRECTIBLE MALFUNCTIONS
2. TOTAL PREVENTIVE MAINTENANCE TIME FOR MISSION MUST NOT EXCEED 50 MIN.

MAJOR $\bar{M}$ REQUIREMENTS ON MOL - CONT.

3. TO ACHIEVE MISSION SUCCESS ONLY PRIMARY MAINTENANCE ACTIVITIES WILL BE REQUIRED. PRIMARY MAINTENANCE CONSISTS OF AND IS LIMITED TO -

1) SWITCHING TO REDUNDANT FUNCTION
2) ALIGNING
3) ADJUSTING
4) CALIBRATING

$\overline{M}$ REQUIREMENT ON ALPHA COMPONENTS

COMPONENT	GROUND CAPABILITY	GROUND MAX TTR	ON ORBIT CAPABILITY	ON ORBIT MAX TTR
VDP	YES	24	NO	
- BULB	YES	24	YES	< .25
FILM MODULE	YES	1	TBD	TBD
SUPPORT STRUCTURE	NO	> 44	NO	---
HARNESS PEN SET	~~YES~~	~~> 44~~	NO	---
SCANNER	YES	44	NO	---
GYROS	(Refer to Scanner)		YES	< .25
ENCODER ELECT.	(Refer to Scanner)		YES	< .25
REMAINDER OF SCANNER ASSY.	(Refer to Scanner)		NO	---
WINDOW	NO	> 44	NO	---
TELESCOPE	YES	44	YES	< .25
PECHAN PRISM CONT.	(Refer to Telescope)		YES	< .25
ZOOM POSITION CONTROL	(Refer to Telescope)		YES	< .25
MAG. POSITION CONTROL	(Refer to Telescope)		YES	< .25
DRIVE K ELEC.	YES	24	YES	TBD
MAG. CON. STICK	YES	24	YES	TBD
FOLDING MIRROR	NO	> 44	NO	---
SHROUD DOOR & DRIVE	YES	44	YES	< .25
HEADREST	YES	24	NO	---

NOTE: MAX TTR in hours

COMPONENT		TECHNICAL REQUIREMENTS	SOLUTION		FACILITIES	PROCEDURES	TIME (HRS.)	NO. OF PEOPLE	COMMENTS
NAME	CDL #		NOMENCLATURE	CEI #					
Drive K Electronics	A17.02	A. A means is required to transport a spare Drive K Electronics (DKE) assembly to Launch Site	TBD	TBD		1. Notify Base Spares of need for spare DKE assembly	0.10	1	Allow 1 hour for delivery of spare DKE assembly
		B. A means is required to gain access to faulty DKE assembly in console 2C (or 8C)	Screwdriver Size TBD	TBD		2. Request DACO to remove power from TBD Note Omit step 3 if this procedure has already been performed	0.10	1	Allow TBD hours for DACO to remove power
		C. A means is required to remove faulty DKE assembly from console 2C (or 8C)	Screwdriver Size TBD	TBD		3. Request DACO to install handling device in LM	0.1	1	Allow 1 hour for DACO to to install handling device in LM
		D. A means is required to remove faulty DKE assembly from LM and transfer new DKE assembly into LM	DACO Handling Device	TBD		4. Using screwdriver, loosen captive fasteners holding panel 2C (or 8C) and swing panel outward	0.1	1	
						5. Loosen and remove six (6) cable connectors from front panel of DKE assembly	0.1	1	
		E. A means is required to install new DKE assembly in console 2C (or 8C)	Screwdriver Size TBD	TBD		6. Using screwdriver, loosen captive screws attaching DKE assembly to cold plates and remove DKE assembly from console	0.1	1	
		F. A means is required to validate new DKE assembly	TBD						
		G. A means is required to return faulty DKE assembly to Level 3 maintenance facility	TBD			7. Request DACO to remove faulty DKE assembly from LM with handling device	0.1	1	Allow DACO 0.5 hour to remove DKE assembly from LM
						8. Request DACO to transfer new DKE assembly into LM	0.1	1	Allow DACO 0.5 hour to transfer DKE assembly into LM
						9. Using screwdriver, install new DKE assembly on cold plate in console 2 (or 8)	0.1	1	
						10. Connect six (6) connectors to front panel of DKE assembly	0.1	1	
						11. Close front panel of console 2C (or 8C) and using screwdriver, tighten captive screws to secure panel	0.1	1	

COMPONENT		TECHNICAL REQUIREMENTS	SOLUTION		FACILITIES	PROCEDURES	TIME (HRS.)	NO. OF PEOPLE	COMMENTS
NAME	CDL #		NOMENCLATURE	CEI #					
Drive K Electronics (Cont.)	A17.02					12. Request DACO to restore power to TBD	0.1	1	Allow DACO (TBD) hours to restore power
						13. Perform validation procedures for new DKE assembly	TBD	TBD	
						14. Return faulty DKE assembly to Level 3 maintenance facility Note Omit step 15 if further maintenance activities are to be conducted in LM	TBD	TBD	
						15. Request DACO to remove handling device	0.1	1	Allow DACO 1 hour to remove handling device

PROBLEM AREAS

L/S MAINTENANCE OF

1. SCANNER

2. TELESCOPE

EFFECTIVENESS = f (QUANTITY, QUALITY)

QUALITY

. REQUIRES ONLY ONE ATS AND P.O. FOR BORESIGHTING

∴ NO LOSS IN QUALITY

QUANTITY

. CAPABILITY EXISTS FOR SWITCHING THE PROGRAMMED TARGETS FROM ONE ATS TO THE OTHER

. PROB OF AN ACTIVE CLOUD FREE TARGET - 2.4%

- PROB OF AN ACTIVE TARGET 6%
- PROB OF CLOUD FREE TARGET 40%

. PROB OF USING ATS 2 FOR ACTIVE TARGETS - .5%

- ATS 1 AND ATS 2 LOOK AT TARGETS WITHIN A 1 - 2^{o} AVERAGE ROLL ANGLE DIFFERENCE
  - THEREFORE A TWO DEGREE OR 50% OVERLAP EXISTS
  - IF ATS-1 HAS CLOUD COVER THEN 50% OF ATS-2 FOV HAS CLOUD COVER

. EXPECTED NUMBER OF ACTIVE TARGETS ON ATS-2 - 22.5 TOTAL MISSION

- BASED UPON 90^{o} ORBIT (CAPT. MC CLAYS)
- 5000 TARGETS IN ATS 2 FOR 30 DAYS

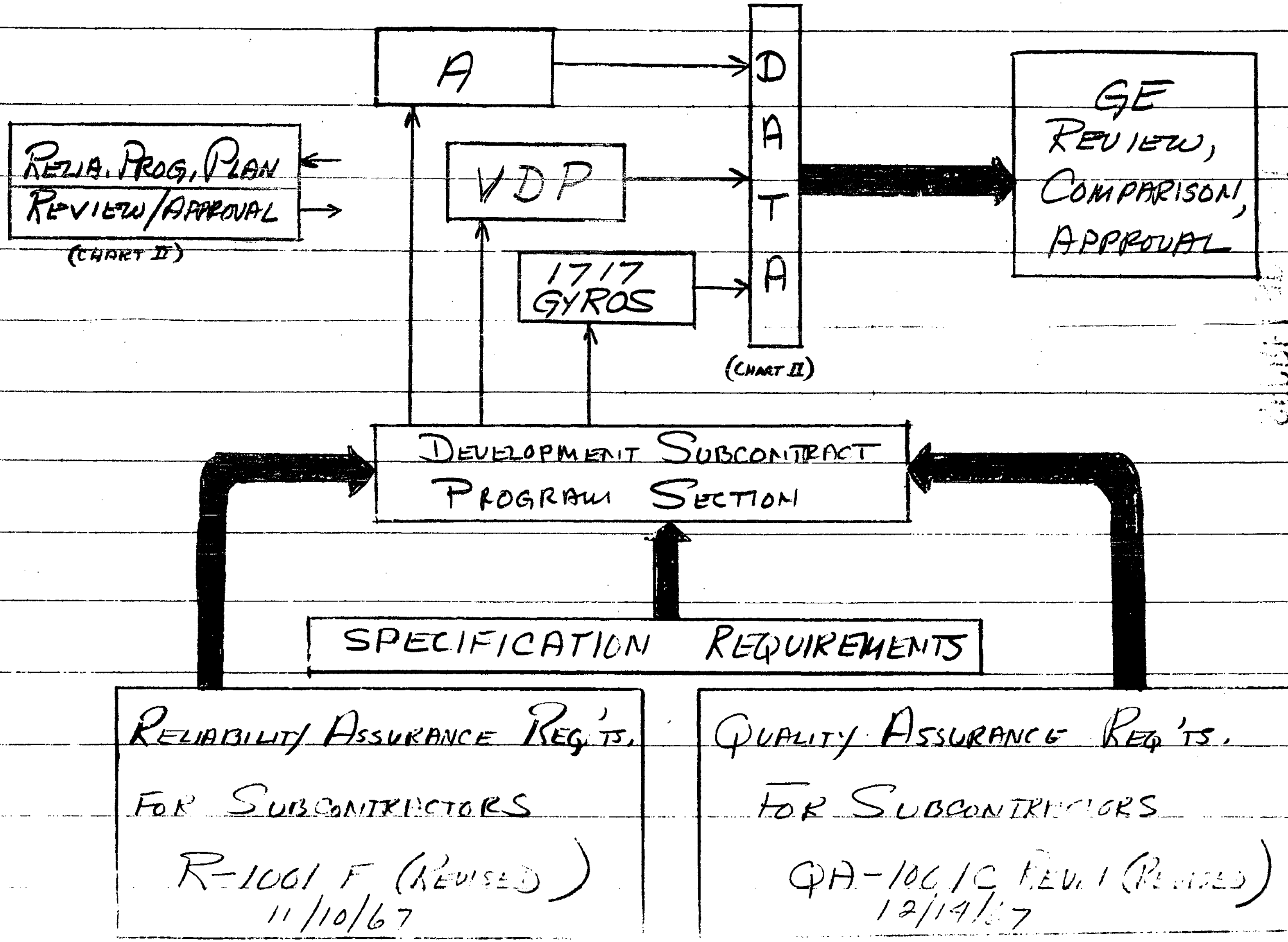
II

RELIABILITY & QUALITY CONTROL DATA SUBMITTALS TO GE

DATA ITEM (CDRL NO.)	1ST SUBMITTAL	2ND SUBMITTAL	3RD SUBMITTAL	G.E. ACTION	FOLLOW-UP WITH S/C
RELIABILITY/ PROGRAM PLAN	PART OF PROPOSAL	20 DAYS ARO	AS REQ'D.	REV/APP COMPLETED	AUDIT
RELIA. & SAFETY ANALYSIS REPORT (MSM-R-112)	3 WEEKS PRIOR TO PDR	MIDWAY BETWEEN PDR—MFG. REL.	PRIOR TO MFG. RELEASE	CENTRALIZED REVIEW, COMPARISON, AND APPROVAL	PDR CDR AUDIT
FAILURE REPORTS/ FAIL. ANAL. " (MSM-R-102)	AS REQUIRED			"	AS REQ. AUDIT
REQUESTS FOR PARTS, MAT'LS, PROC. APPROVALS (GE-MOL-S-126)	AS REQUIRED			"	CONSULTATION AS REQ. AUDIT
Q.C. PROCEDURES (GE-[illegible]-R-1[illegible])	30 DAYS PRIOR TO CDR	—	—	"	CDR SURVEILLANCE AUDIT

I

RELIABILITY/Q.C. INTEGRATED CONTROLS — ACTIVITY FLOW



ALPHA SUBSYSTEM

DRIVE K GYRO

- ON/OFF OPERATION IS PLANNED

  OPERATING TIME 131 HOURS INCLUDING 12 MINUTE WARM-UP PERIODS

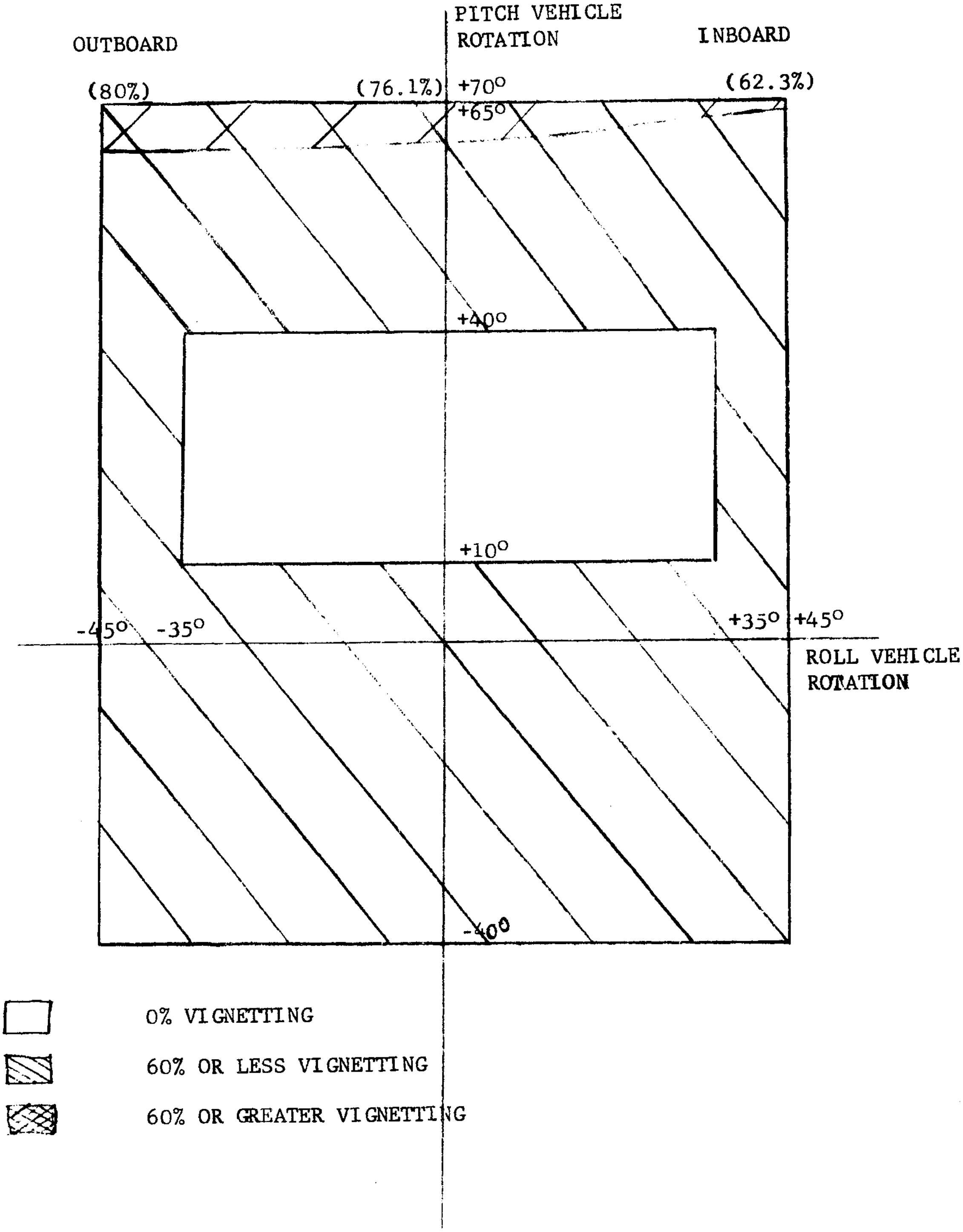
- HONEYWELL FORESEES NO PROBLEM ASSOCIATED WITH ON/OFF OPERATION

  ADEQUATE DEMONSTRATION MUST BE PROVIDED DURING DEVELOPMENT, QUALIFICATION AND PRODUCTION TESTING

- GYRO FAILURE RATE IS NOT AFFECTED DUE TO ON/OFF OPERATION (BASED UPON ABOVE DEMONSTRATION.). PROBABILITY OF FAILURE IS REDUCED.

NOTE: DOCUMENTATION OF VERBAL RESPONSE TO QUESTION BY F. HOWARD

PROBLEMS AND UNRESOLVED AREAS


PITCH VEHICLE ROTATION
OUTBOARD
INBOARD
(80%)
(76.1%)
+70°
(62.3%)
+65°
+40°
+10°
-45°
-35°
+35°
+45°
ROLL VEHICLE ROTATION
-40°
0% VIGNETTING
60% OR LESS VIGNETTING
60% OR GREATER VIGNETTING

SCANNER CAGING AND STOW TECHNIQUE DURING GROUND, LAUNCH, AND ORBITAL ENVIRONMENT APPROACHES INCLUDE:

A. MECHANICAL LATCH

B. MAGNETIC CLASP

C. ACTIVE CAGING THROUGH ENCODER

D. PYROTECHNIC

SIZING OF ANY TECHNIQUE COMPLICATED BY ROLL GIMBAL UNBALANCE

THERMAL DUTY CYCLE SPECIFIED UPON ITEK

A. ASSUMES SEVERE OPERATIONAL RESTRICTIONS

B. SHOULD BE EXPANDED TO INCLUDE DUMPING HEAT TO COLD EARTH OR SPACE

C. ANALYSIS MUST STILL BE PERFORMED TO IDENTIFY OPERATIONAL RESTRICTIONS IF ANY.

VENTING OF OBJECTIVE/WINDOW AIR SPACE

A. CLEARLY AN OPERATIONAL PROBLEM (SCENE OR RETICULE DEGRADATION)

B. SOLUTIONS:

1. MANUAL VALVE REQUIREING CREW ACCESS

2. SOLENOID VALVE

3. CALIBRATED LEAK

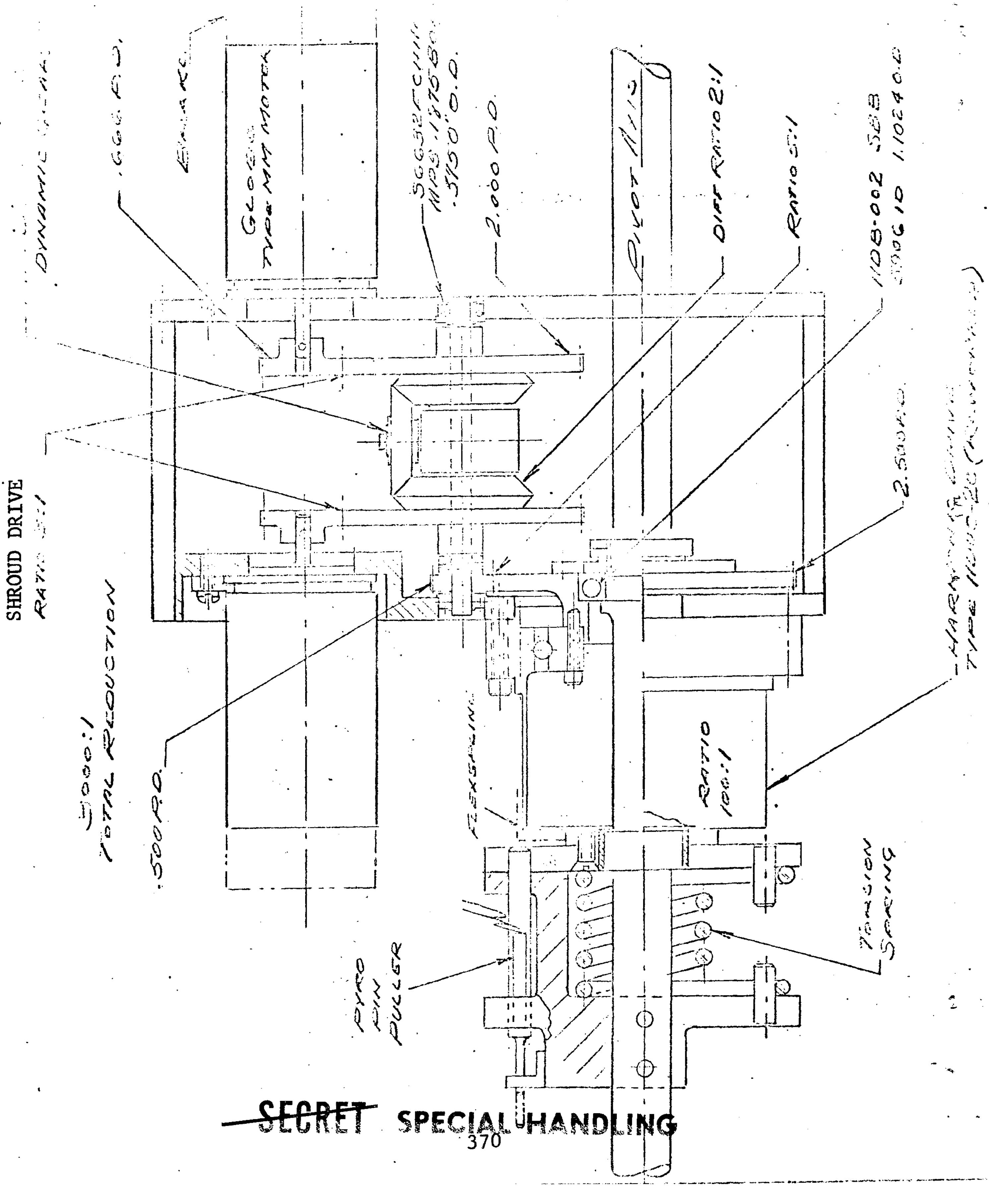
ACTS/WASTE PROTECTION WHILE SHROUD IS OPEN

A. EVALUATE IMPACT AT TULAHOMA TEST

B. OBTAIN IF AGREEMENT WITH DAC FOR INHIBIT

VALUE ENGINEERING CHANGE PROPOSAL

SUGGESTION:	ELIMINATE VDP MANUAL FRAME SELECTOR
REASON:	DUPLICATION OF FUNCTION PROVIDED BY KEYBOARD
IMPACT:	NONE
SAVINGS:	$100,000 ROM


SHROUD DRIVE
3000:1
TOTAL REDUCTION
.500 P.D.
DYNAMIC
2.000 P.D.
PIVOT AXIS
DIFF RATIO 2:1
1108-002
2.500 P.D.
RATIO
100:1
TORSION
SPRING
PYRO
PIN
PULLER

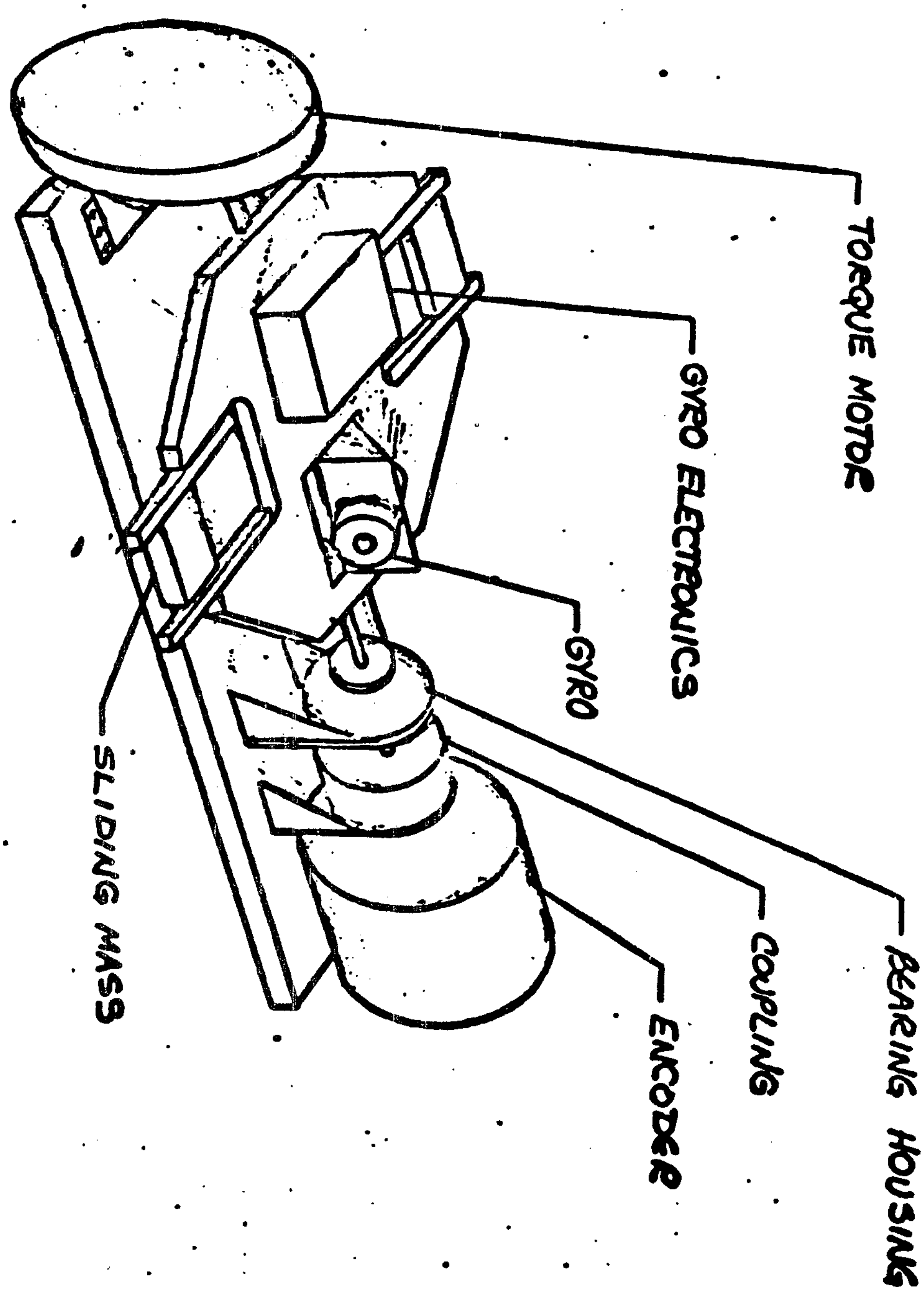
DEVELOPMENT PLAN

SUBSYSTEM ALPHA CONTROLS

- BRASSBOARD
- DSS

DRIVE K BRASSBOARD

- PURPOSE
- CONFIGURATION
- SCHEDULE
- STATUS



DRIVE K BRASSBOARD

MILESTONE SCHEDULE

MOL DK BRASSBOARD (NAME) — ENGINEERING PROPOSAL/PROGRAM

FORM I-9511 REV. (2-61)

PAGE 1 OF 1

SECRET SPECIAL HANDLING

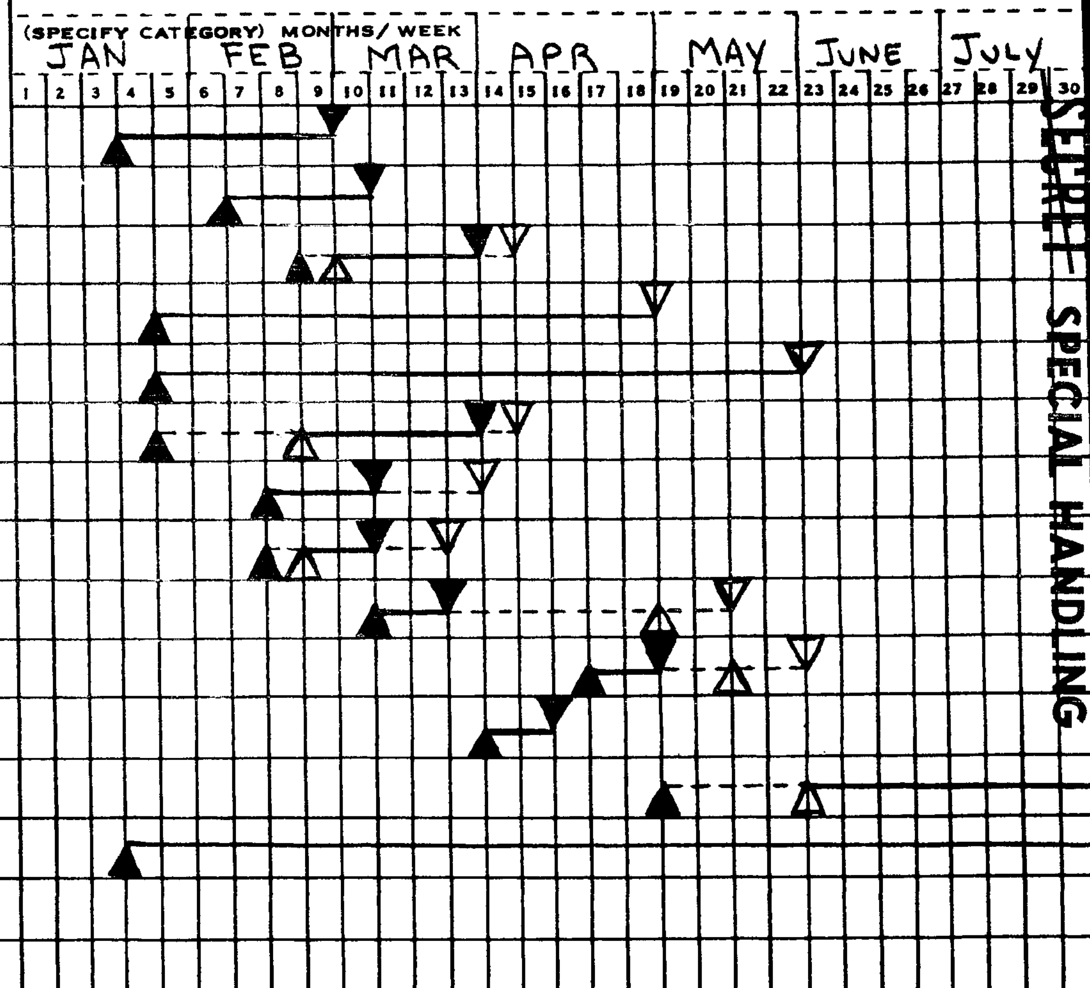
"B" LEVEL OPER. NO.	OPER. NAME	PREPARED BY	DATE	APPROVED BY	DATE	ISSUE NO.
7270	NAV, GUID, & CONTROL	DONALD SMALDONE	1-22-68			

TASK NO.	SUB-TASK NO.	DESCRIPTION OF DETAIL MILESTONES
		DESIGN BRASSBOARD
		ORDER MATERIALS
		FABRICATE PARTS
		PROCURE GYRO
		PROCURE ENCODER
		PROCURE TORQUE MOTORS
		FABRICATE DK ELECTRONICS
		FABRICATE HARNESSES
		GYRO SYSTEM C/O
		SYSTEM C/O & TROUBLESHOOT
		BRSBOARD MECHANICAL ASSEMBLY
		BRASSBOARD TESTS START
		REPORTS

ELAPSED TIME SCHEDULE

(INDICATE YEARS)

(SPECIFY CATEGORY) MONTHS/WEEK



△ START ▽ COMPLETE ▭ TIME PERIOD OF WORK

PREVIOUS SCHEDULE
---- DENOTES SLIP

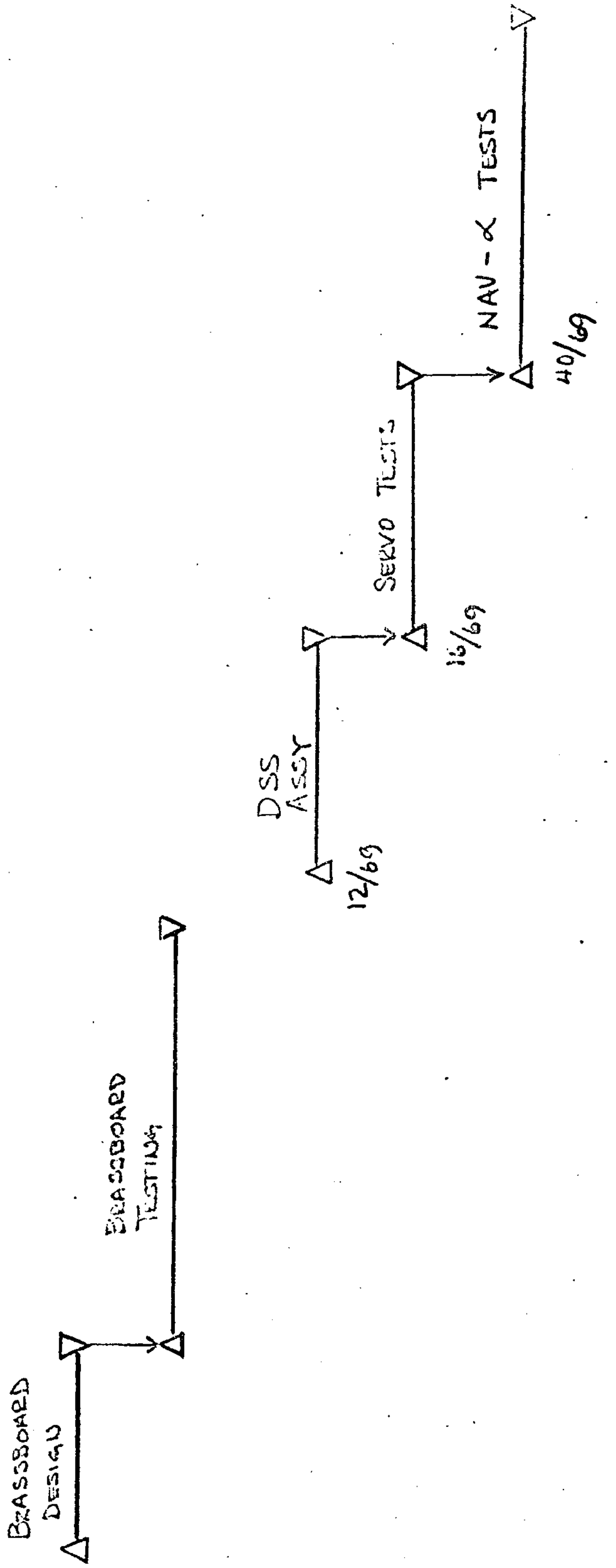
⇩ MAJOR ITEM EVENT (REPORT, HARDWARE DELIVERY, FLIGHT TEST, ETC.) – INDICATE ITEM NAME NEXT TO ARROW.

SECRET SPECIAL HANDLING

DSS

- PROTOTYPE HARDWARE
- SOFTWARE
- INTERFACES
- PERFORMANCE VERIFICATION
- LIMITED EMI
- POWER USAGE & INTERRUPT

DEVELOPMENT SCHEDULE



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