RE-ORDER NO. 68-337

20584-QR7

15 July 1968

Contract Number 951529

Seventh Quarterly Progress Report
For Period April 1, 1968 to July 1, 1968

STERILIZABLE WIDE ANGLE GAS BEARING GYRO FGG334S

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Agency under Contract NAS 7-100

Prepared by: J. M. Bremer
J. M. Bremer
Senior Development Engineer

Approved by: S. J. Korzenowski
S. J. Korzenowski
Project Engineer

R. G. Baldwin
R. G. Baldwin
Section Head

T. W. Garvey
T. W. Garvey
Program Administrator

Honeywell Inc.
Aerospace Division
Minneapolis, Minnesota

1 of 18

NOTICE

2

ABSTRACT

This document is the seventh Quarterly Progress Report, covering the period 1 April 1968 to 1 July 1968, for the Wide Angle Gas Bearing Gyroscope FGG344S, submitted in accordance with contract No. 951529. This report defines progress to date and technical problems encountered and solved.

CONTENTS

		Page
SECTION I	PROGRESS, PROBLEMS AND FURUTRE PLANS	1
	Progress	1
	Problems	1
	Future Plans (Eighth Quarter)	2
SECTION II	DISCUSSION	3
	Gimbal Shield	3
	Contamination Investigation	6
	Windings Change	7
	Gyro Performance, General	7
	Gyro 1 Performance	8
	Gyro 2 Performance (S/N B2)	8
	Gyro 3 Performance	8
	Gyro 4 Performance	11
	Gyro 5 Performance	11
	Design Status	11
SECTION III	SCHEDULE	14

ILLUSTRATIONS

Figure		Page
1	Field Strength Around Gimbal	4
2	Field Strength in Gyro Spin Axis - Output Axis Plane	5
3	Balance Torque History - Gyro 2	9
4	Anisoelastic Coefficient versus Frequency - Gyro 2	10
5	Gyro Outline Dimensions GG334S	12
6	Schematic, GG334S	13
7	Gyro Build Schedule	14

SECTION I
PROGRESS, PROBLEMS AND FUTURE PLANS

PROGRESS

- Additional magnetic shielding was added in the gimbal
- Organic and particulate contamination investigation was completed
- Four gimbal and spinmotor assemblies were completed, incorporating additional magnetic shielding
- Four gyros were tested; one gyro was shipped

PROBLEMS

- Delays have occurred requiring teardown and rebuild of the following units:
  - Gyro 1 - Operating temperature 190°F
  - Gyro 3 - Balance pan malfunction
  - Gyro 4 - Cracked dither plate
- A large hairline crack was located in the gimbal for Gyro 5 after sealing, necessitating a new gimbal cup and causing a pushout of the schedule.

FUTURE PLANS (EIGHTH QUARTER)

- Completion of gyro build
- Shipment of two gyros
- Completion of the major part of the test program on the remaining two gyros

SECTION II
DISCUSSION

GIMBAL SHIELD

A mu-metal shield has been incorporated into the gimbal at the coil cup end to reduce the interaction between the motor and torque generator magnetics. This shield will serve to improve the runup-to-runup stability which had proved to be unacceptable in the test results on the preliminary gyro build.

The 800-cycle flux density, at the outside surface of the gimbal in the plane of the spin axis, was measured for three different stator configurations:

1) A stator without end cans
2) A stator with inconel end cans
3) A stator with mu-metal end cans

The result of these measurements is shown in Figure 1. Note that the greatest flux density occurs in the plane of the rotor hysteresis ring due to leakage through the ring. Since the H-ring is a permanent magnet material, its permeability is low. Note also that the mu-metal end cans reduce the end turn flux but do not affect the flux leakage through the H-ring.

Flux density measurements were made on the torquer end of the gimbal as shown in Figure 2. Three configurations were also mapped.

1) Without either the external or internal shield
2) With the regular external shield in place
3) With both the external shield and the 0.005-inch-thick internal shield

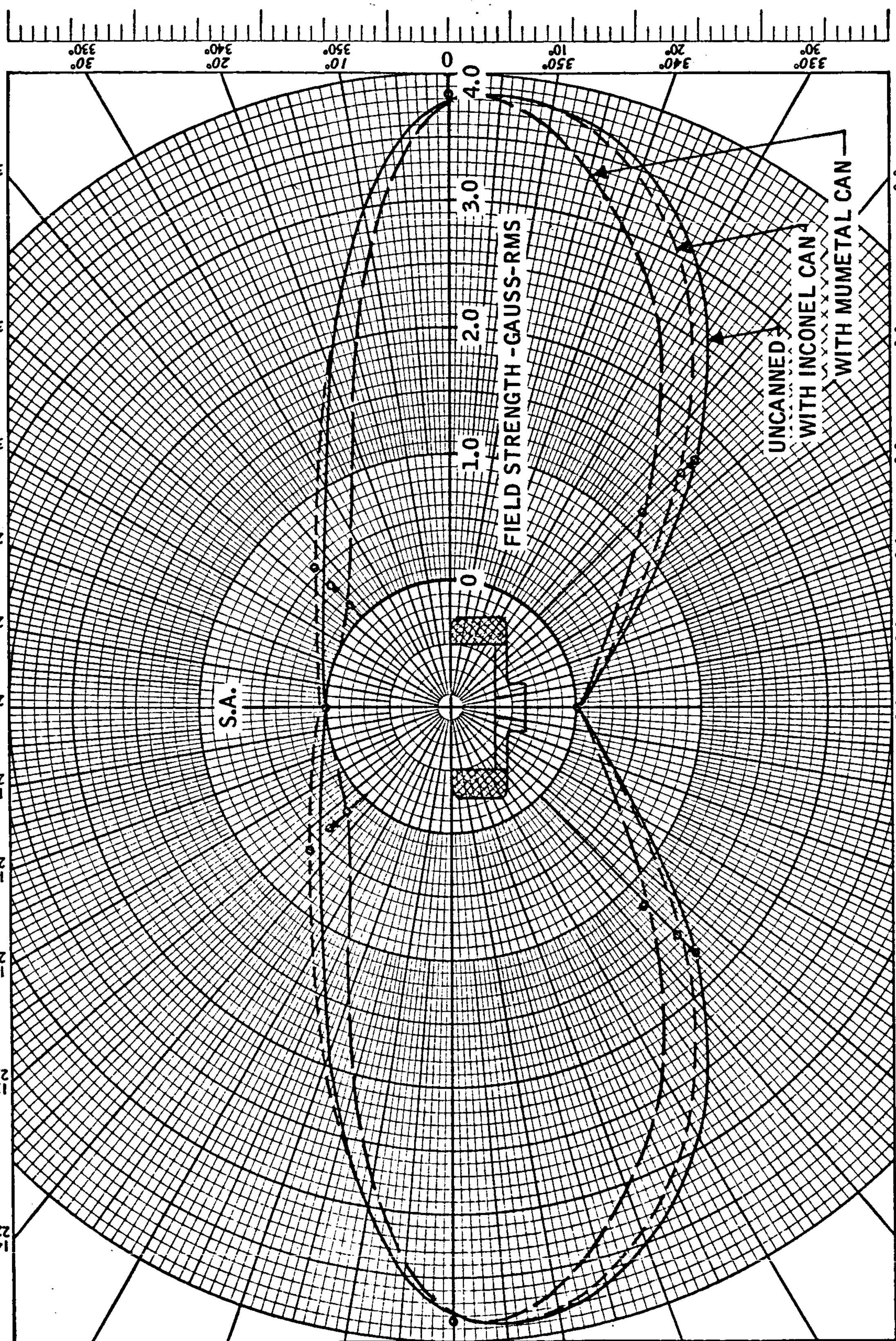


Figure 1. Field Strength Around Gimbal

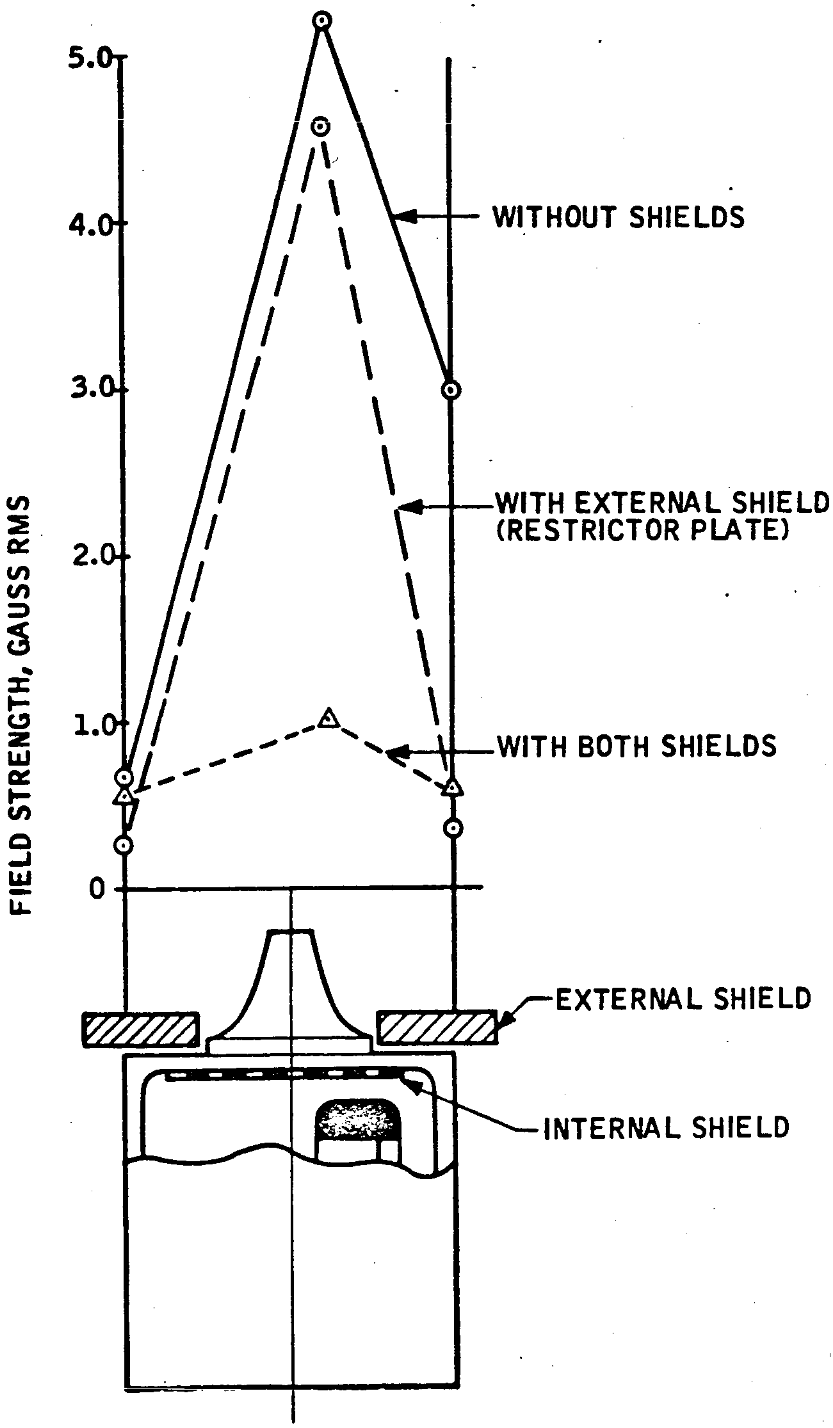


Figure 2. Field Strength in Gyro Spin Axis - Output Axis Plane

Since the external shield has a large center hole to clear the gimbal snout, it is not effective in shielding the flux leakage from the spinmotor. The internal shield attenuated the leakage flux by a factor of 5.5.

The nonsymmetry apparent in both Figures 1 and 2 is due to the stator being slightly off center with respect to the center line of the gimbal.

CONTAMINATION INVESTIGATION

The investigation to determine the sources of contamination which contribute to spinmotor lockup has been completed, the sources identified, and appropriate design changes made. No evidence of contamination has been found in GG334S spinmotor, and no starting abnormalities have occurred since moisture lockup was eliminated. Specific identification of the contamination in the GG159E preliminary build spinmotor has been discussed in Quarterly Report 20584-QR6. Other results are as follows:

- The lockup of specific gas bearing motors was due to organic particulate contamination and not vapor-condensed materials.
- The contamination is associated with bonding and encapsulating materials in the motor stator.
- Gas analysis of a sample filled gimbal showed the gas fill procedure used on the product line to be satisfactory.
- Materials presently used in spinmotor fabrication compare favorably with alternate materials tested either as used or with some additional processing. No material changes are anticipated.

WINDINGS CHANGE

To provide maximum assurance that motor performance will remain within specification limits, a stator winding change has been incorporated in all but Gyro 1. As a result, sync margin, start margin, and power consumption has increased. A comparison of motor parameters between Gyro 1 and the other four gyros is tabulated below:

	Gyro 1	New Stator
Power @ 26V (watts)	2.8	3.8
Min Start (volts)	21.0	17.0
Min Sync (volts)	23.0	19.5
Run Up Time (sec)	26.0	14.0
Run Down Time (sec)	63.0	56.0

GYRO PERFORMANCE, GENERAL

Four of the five gyros to be built on this program were submitted to test during this period. One gyro, S/N B2, was shipped. The other three gyros, 1, 3 and 4, malfunctioned, each in a different way, and were disassembled for repair. The gyros will be back in test early during the next report period.

Test results on three of these gyros indicate that the design is performing well. These units exhibited low draft rates, fast response time and good repeatability. The runup-to-runup stability of these units has been consistently 0.05 °/hr rms (approximately). The gimbal shield has thus been an effective improvement, reducing this from the previous 0.3°hr rms. The fourth gyro exhibited the characteristically erratic behavior which results from a poor fill or similar suspension related problem.

GYRO 1 PERFORMANCE

Gyro 1 was submitted to evaluation and, although it was immediately determined that the operating temperature had been set too high (+190°F), the unit was tested to verify the overall design. Significant results obtained were:

Damping		2.88×10^5 dyne-cm-sec
Spinmotor Power		2.73 watts
Random Drift	OAV (1σ)	0.005°/hr rms
	IAV (1σ)	0.004°/hr rms

The gyro has been disassembled and will be rebuilt to correct the operating temperature, a repair which will be accomplished by addition of a small weight to the gimbal.

GYRO 2 PERFORMANCE (S/N B2)

Gyro 2 was tested and the results transmitted to JPL for review. The gyro was accepted on the basis of the test results and the unit was delivered 1 July, 1968. Balance-torque history of this unit is presented in Figure 3 and anisoelastic coefficient versus frequency is shown in Figure 4.

GYRO 3 PERFORMANCE

Gyro 3 was submitted to evaluation for an initial check of performance parameters. The results of the testing indicated the gyro was performing well.

An attempt was then made to balance the g-sensitive drift using the balance pan. Unfortunately, the gyro could not be balanced and the gyro was disassembled and corrective action is being taken to allow compensation of the g-sensitive torques.

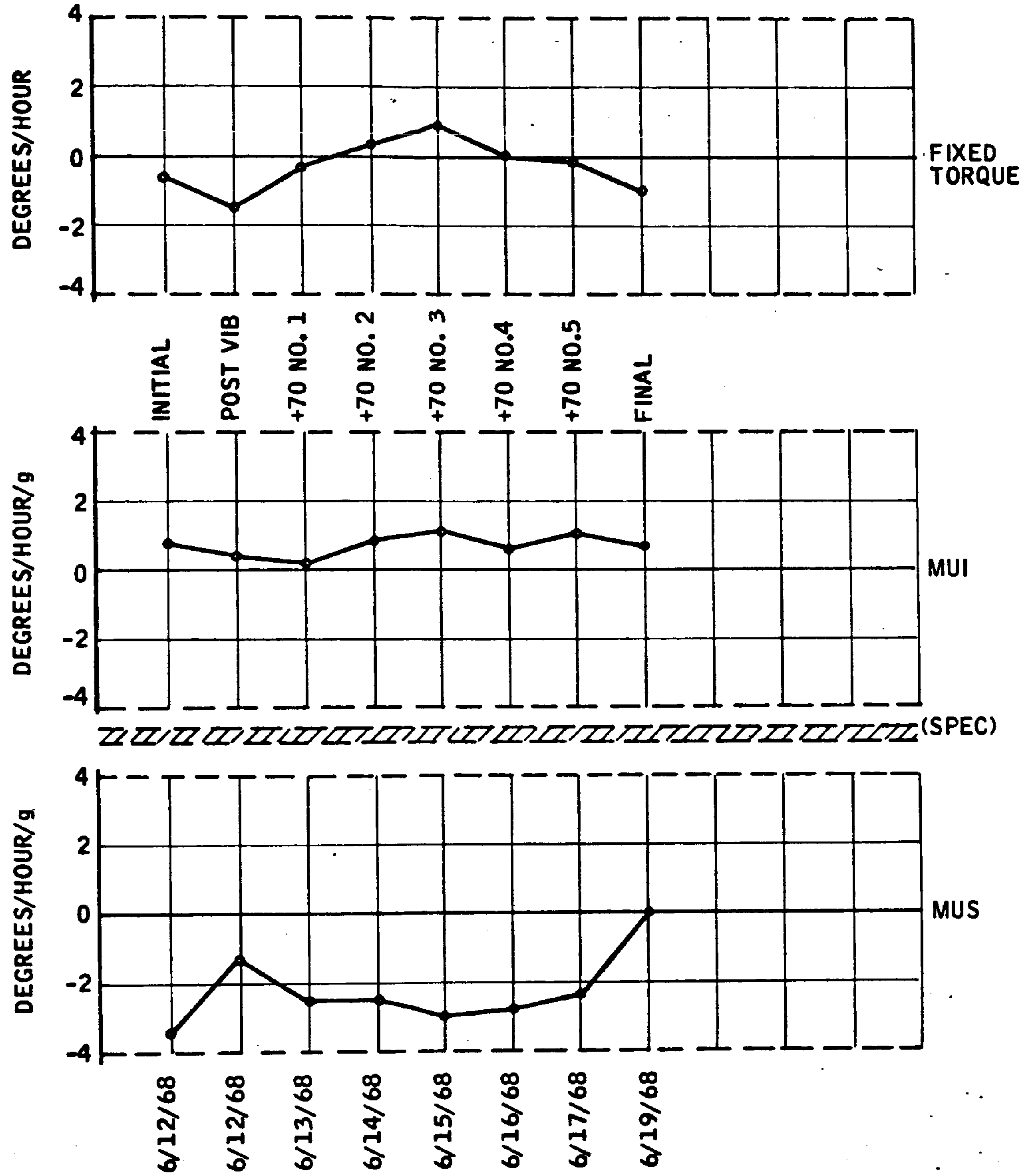


Figure 3. Balance Torque History - Gyro 2

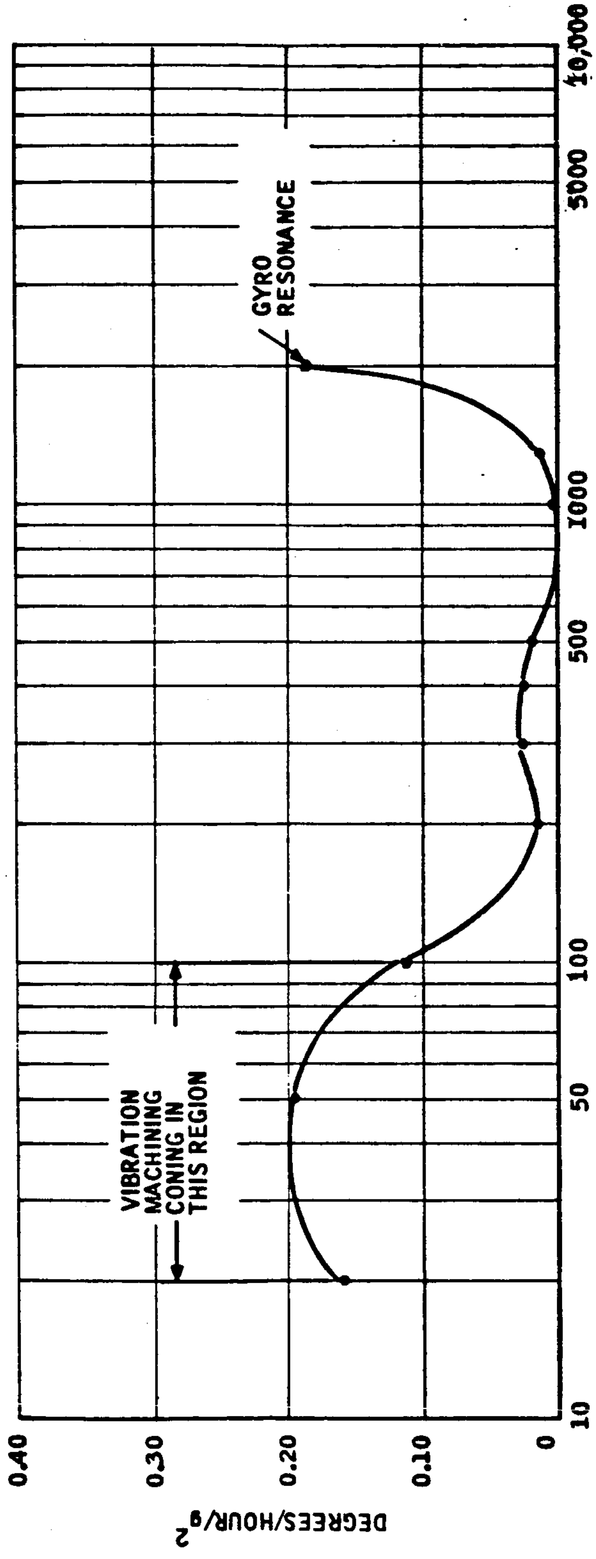


Figure 4. Ansioelastic Coefficient versus Frequency - Gyro 2

GYRO 4 PERFORMANCE

Gyro 4 exhibited erratic behavior after the gyro attitude was changed. This resulted in non-repeatability as high as 1.0°/hr and a drift trace which required almost 30 minutes to stabilize. Visual examination of the unit after it had been disassembled revealed that one dither plate was cracked in three places, most probably during the build operation. The dither plate has been replaced and the gyro is being rebuilt.

GYRO 5 PERFORMANCE

Gyro 5 has been delayed due to a large hairline crack which developed in the gimbal cup. The unit had been sealed as a gimbal-spinmotor assembly when the spinmotor developed erratic starting behavior. Analysis of the spinmotor parts after the gimbal was opened revealed evidence of chemical attack on the momentum ring.

The initial assumption was that the motor had not been cleaned properly during assembly, but when the crack was located under high-power magnification, it became obvious that the cleaning solutions used to final clean the gimbal had entered the gimbal and caused the momentum ring corrosion.

The spinmotor parts have been recleaned and reassembled and a new gimbal is in process.

DESIGN STATUS

With the shipment of the first gyro, the design has been fixed, and the control drawings and Engineering Specification released. The outline dimension of the released gyro is presented in Figure 5, and the schematic diagram is presented in Figure 6.

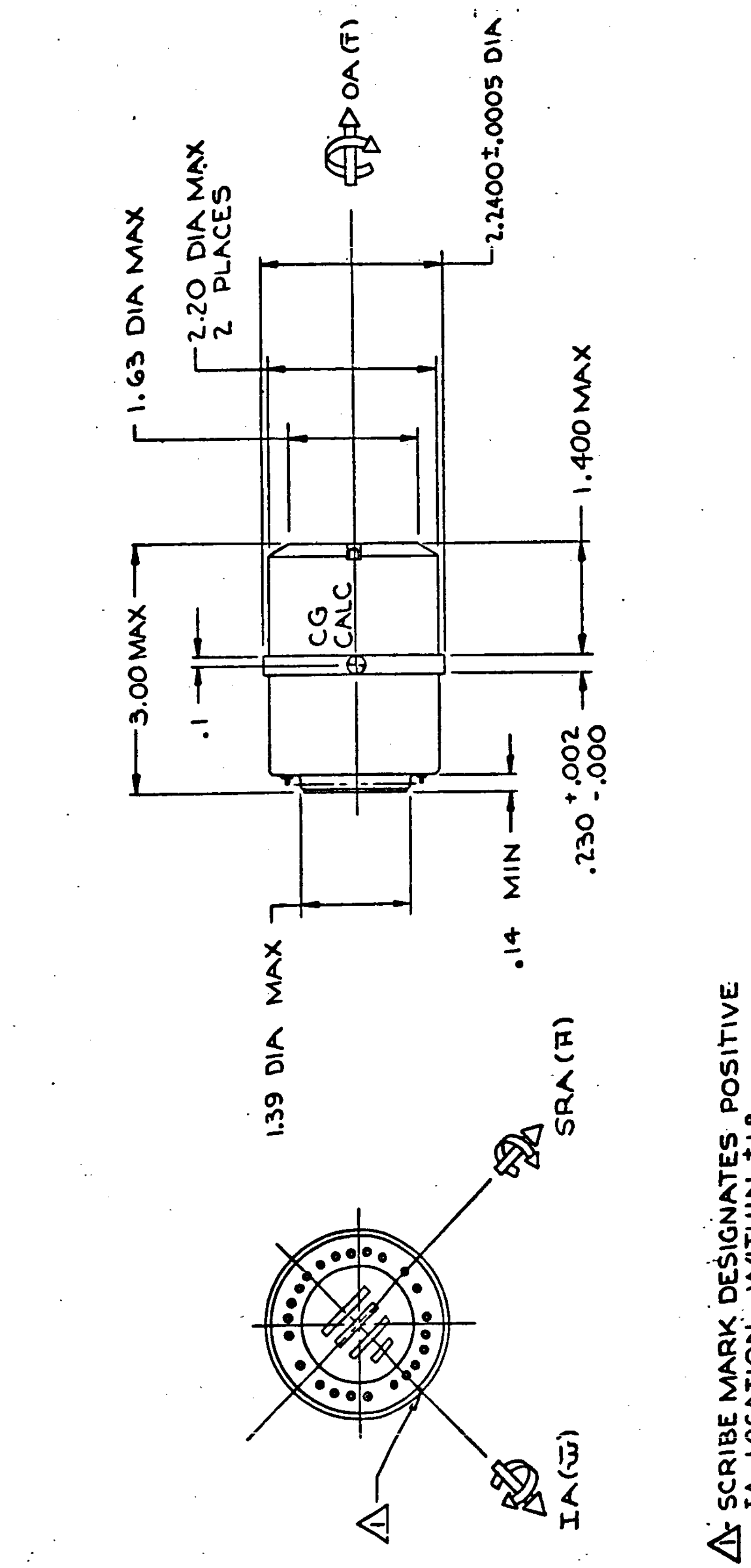
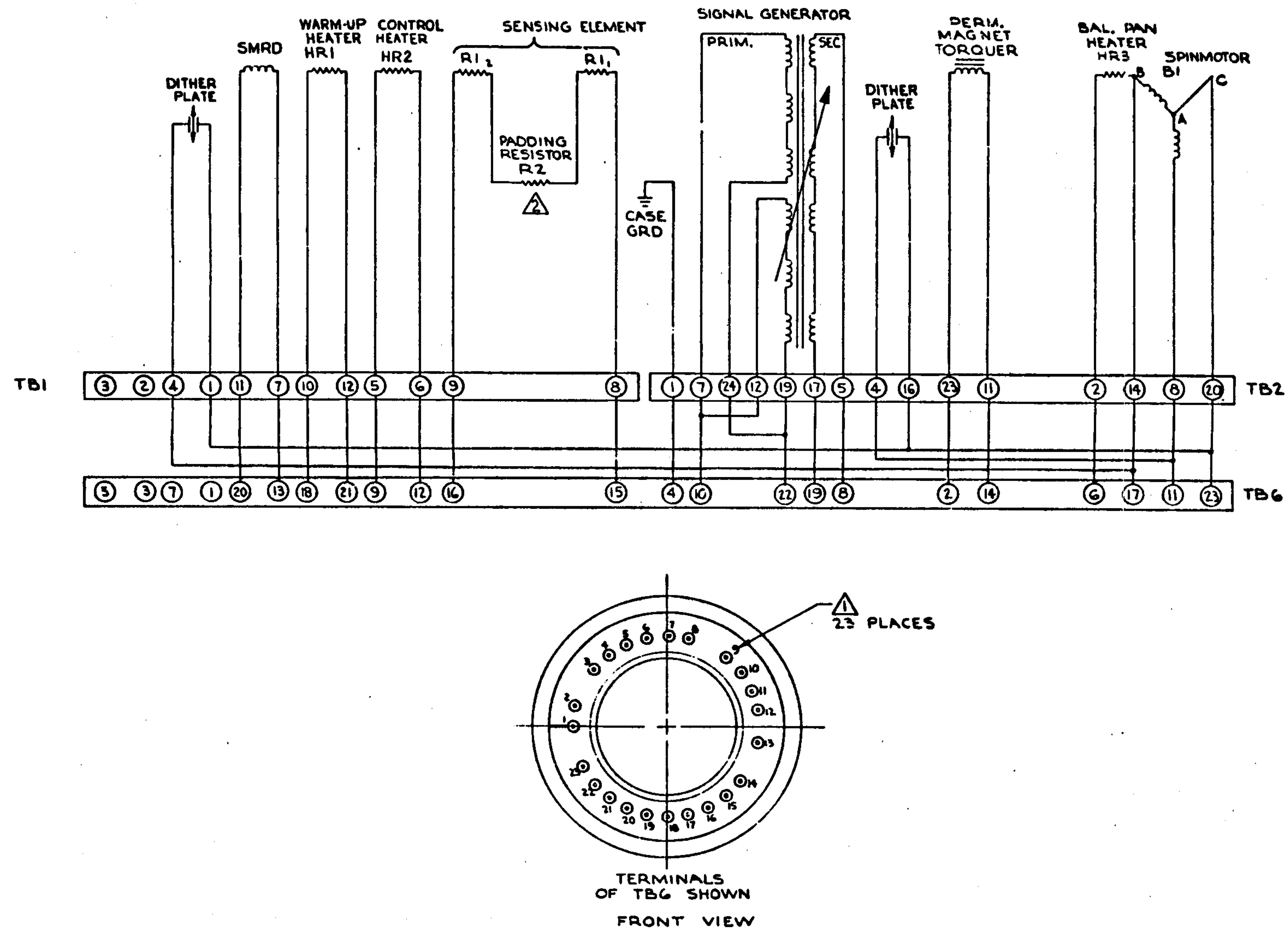


Figure 5. Gyro Outline Dimensions, GG334S



2 RESISTANCE AS REQD

1 NUMBERS ARE FOR REF ONLY AND DO NOT APPEAR ON PART

Figure 6. Schematic, GG334S

SECTION III
SCHEDULE

The gyros will be built and tested in accordance with the schedule shown. The first gyro (No. 2) was shipped as scheduled 1 July, 1968. Figure 7 shows the build and test schedule for the remaining units. The numbers used here to designate the individual gyros were arbitrarily assigned when the gyros were in the build process. To avoid confusion, these designations consistently refer to specific hardware, both in this report and in future reports.

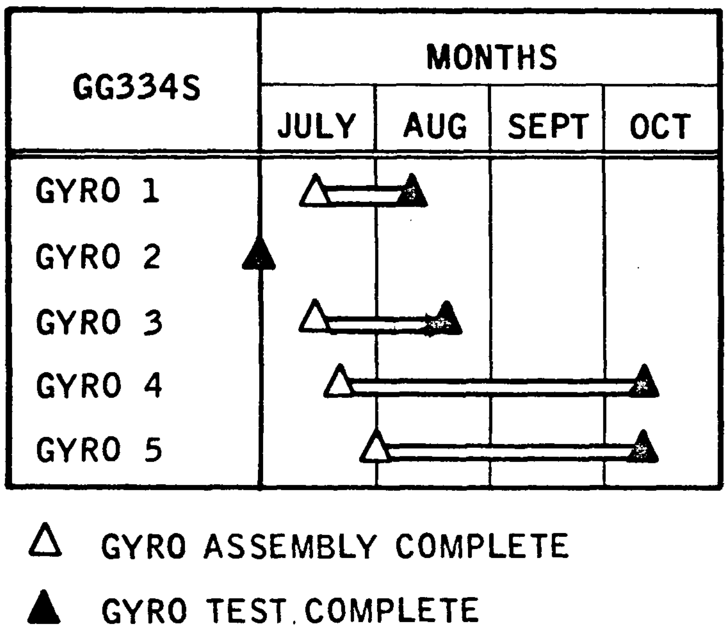


Figure 7. Gyro Build Schedule