([illegible]) HY[illegible]STATIC FLUID BEARING [illegible] Final [illegible] (Bendix Corp.) 31 p HC $3.7[illegible] CSCL 17G

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G3/35 22387

Bendix Guidance Systems Division

HYDROSTATIC FLUID
BEARING GYRO

CONTRACT NO.
NAS-8-24414

PHASE VI

FINAL REPORT

MARCH 1975

HYDROSTATIC FLUID BEARING GYRO

CONTRACT NO. NAS-8-24414

PHASE VI FINAL REPORT

MARCH 1975

Prepared by: _______________
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THE BENDIX CORPORATION
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07608

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SECTION I
SCOPE OF WORK

The objective of Phase VI of this program was to design, fabricate, and test a thermal control assembly capable of precisely controlling the LDG-540 Gyro case temperature at 50^{o}C over an ambient environmental range of 23^{o}C and atmospheric pressure to 5^{o}C and a vacuum of 1 x 10^{-5} torr.

The thermal control assembly was to be a hermetically sealed enclosure about the LDG-540 Gyro with envelope dimensions not to exceed those of the Saturn K8-AB5 Gyro. The heaters were to be capable of delivering 30 watts at 28 V.D.C. and have dual temperature sensors rated at 750 ohms at 50^{o}C.

All six (6) LDG-540 Gyros, developed in Phase V of this program, will be equipped with a fine control heater and a resistance thermometer to monitor the gyro case temperature. All six gyros will then be interchangeable in the thermal control assembly (2783520-2) by means of simple assembly techniques.

Testing of the thermal control assembly will be performed over the specified environmental range to insure design integrity.

SECTION II
SUMMARY OF PROGRAM ACCOMPLISHMENTS

The LDG-540 Gyro Thermal Control Assembly (2783520-2) is shown in Figures 1., 2., 3., and 4.

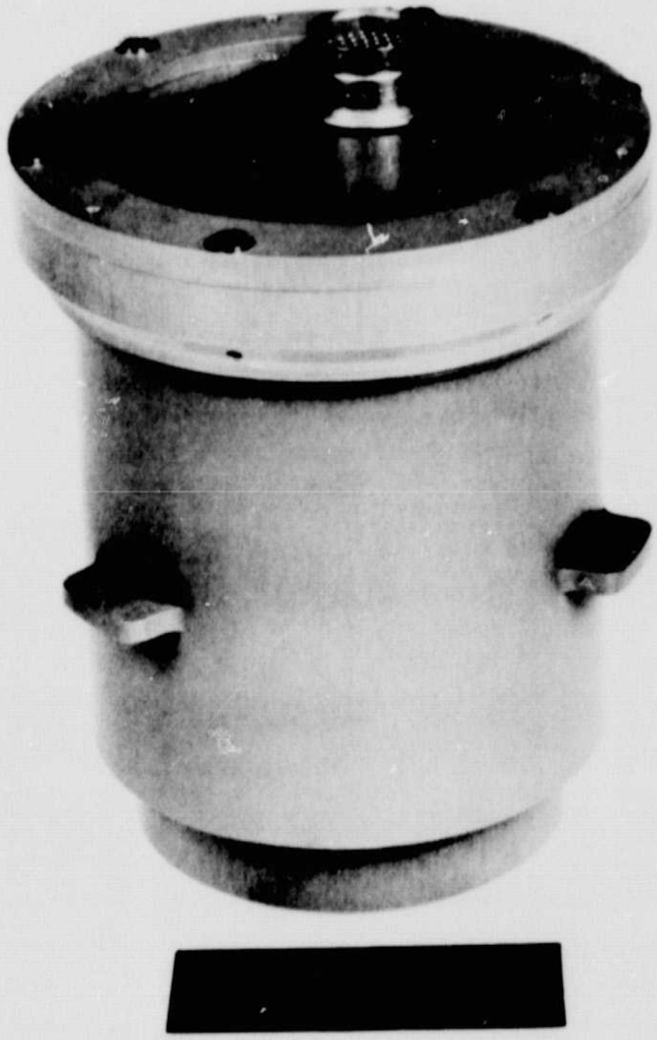
The precise control of the gyro case temperature was accomplished by designing the thermal control assembly to function as a temperature controlled oven within which the gyro, the gyro case heater and sensors, and the fine temperature controller are situated.

The test results were quite favorable and indicate that the thermal control assembly is capable of maintaining gyro case temperature stability of $56.6^{\circ}C$ with a total deviation no greater than $\pm 0.06^{\circ}C$ over an ambient range of $+ 23^{\circ}C$ and one atmosphere to $-2^{\circ}C$ and 2.4×10^{-7} torr.

A summary of the test data appears in Figures 5., 6., and 7.

The thermal control assembly was also designed as a hermetically sealed unit and has a leak rate of 3×10^{-8} std. cc of Helium/sec.

Four (4) of the six (6) LDG-540 Gyros, developed in Phase V of this program, have been fitted with a fine control heater and a resistance thermometer. Fine control heaters and resistance thermometers are available to N.A.S.A. for the two remaining gyros and will be installed when the units are returned to Bendix GSD.



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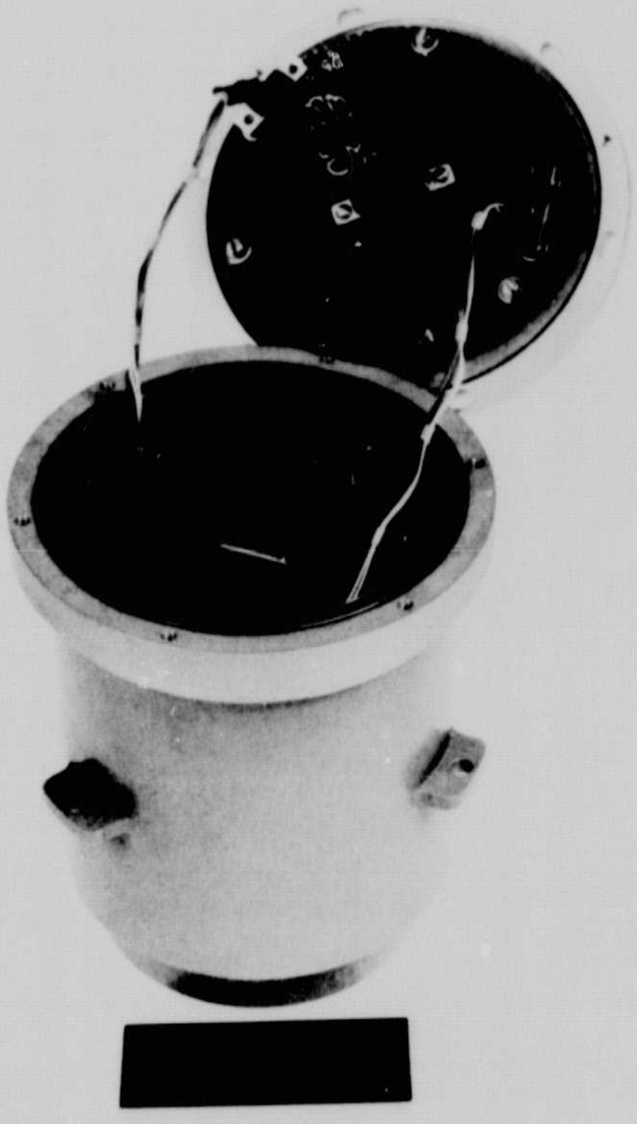

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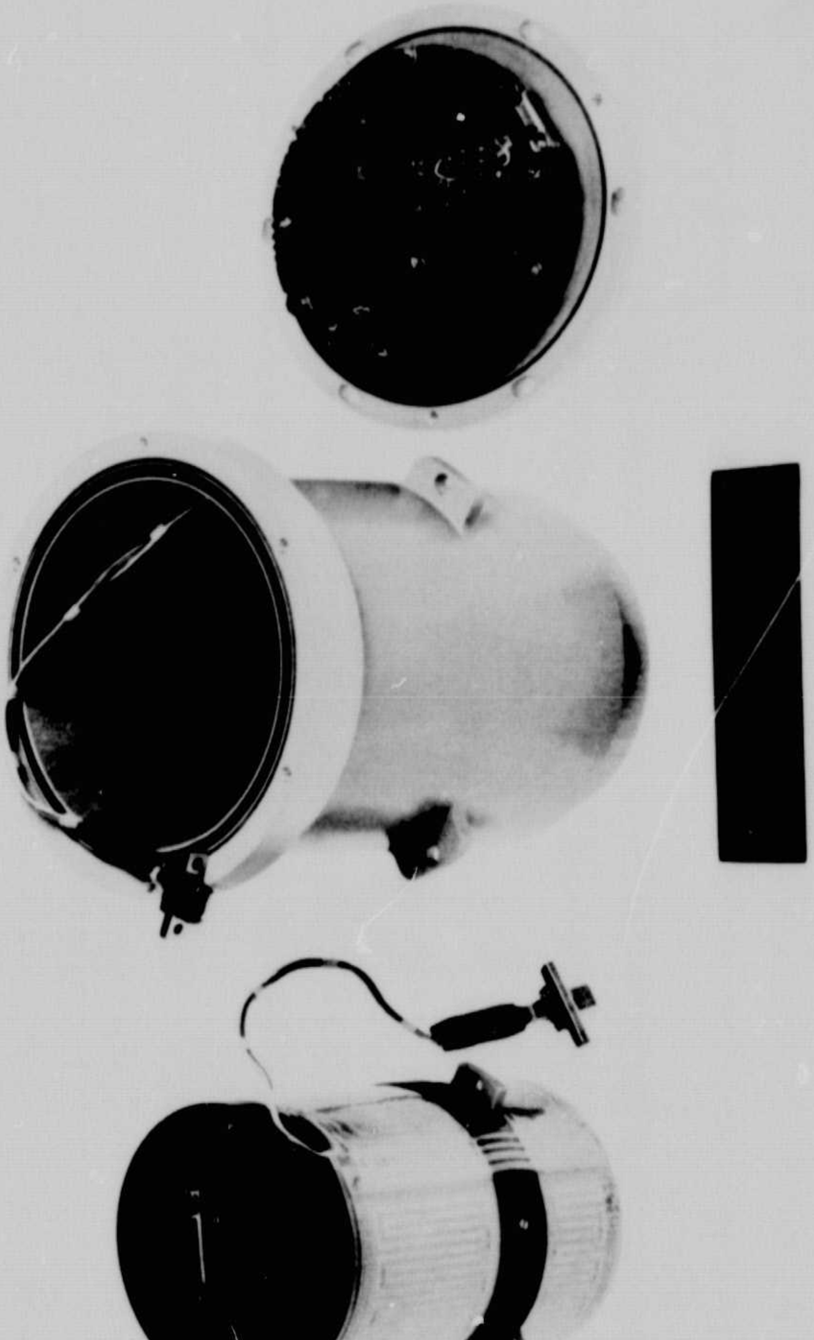

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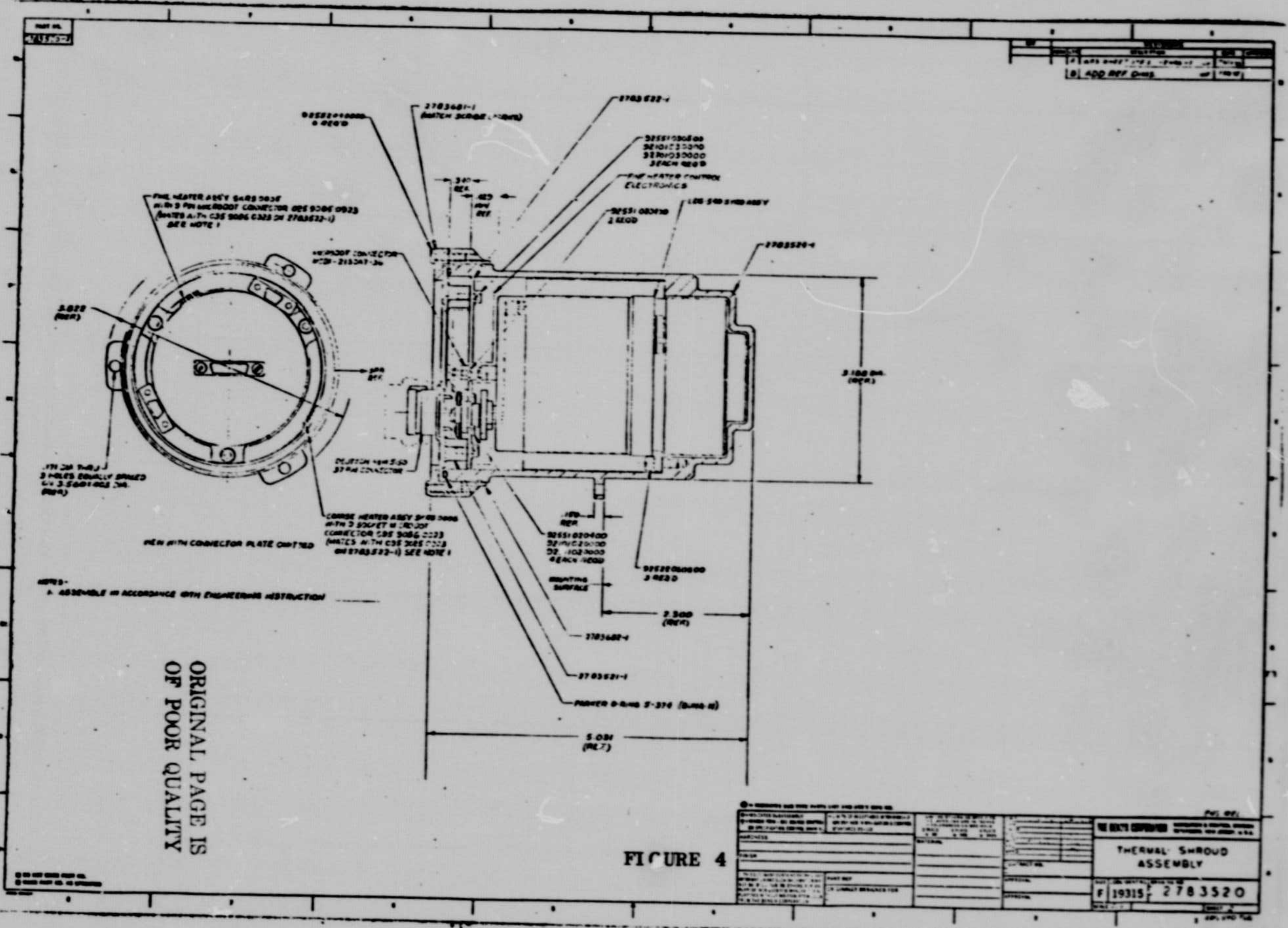

FIGURE 4

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HEATER POWER, HEATER DUTY CYCLE, AND TOTAL HEATER POWER FOR THE LDG - 540 GYRO THERMAL CONTROL ASSEMBLY (2783520-2) AT INITIAL WARM-UP AND AT GYRO CASE THERMAL STABILIZATION FOR VARIOUS AMBIENT CONDITIONS

	TEST TIME	VACUUM CHAMBER		GYRO CASE TEMP.	COARSE HEATER		FINE HEATER		TOTAL HEATER POWER *
		COLD-PLATE TEMP.	VAC. PRESS		DUTY CYCLE	POWER	DUTY CYCLE	POWER	
	(MIN.)	(^{o}C)	($X10^{-7}$ TORR)	(^{o}C)	(%)	(WATTS)	(%)	(WATTS)	(WATTS)
VAC. TEST	0.1	+20	3.7	+20.5	100.0	21.06	100.0	5.26	26.32
	45.0	+22	3.7	+56.7	9.1	1.92	63.3	3.33	5.25
	115.0	+ 5	2.3	+56.6	48.7	10.26	54.4	2.86	13.12
	150.0	- 1	2.3	+56.6	68.3	14.38	65.4	3.44	17.82
		ROOM							
		TEMP.	PRESS.						
		(^{o}C)	(ATM)						
ATM. TEST	0.1	+23.3	1	+25.7	100.0	29.77	100.0	4.59	34.36
	90.0	+23.3	1	+56.5	28.2	8.40	42.0	1.93	10.33

* TOTAL HEATER POWER = COARSE HEATER POWER + FINE HEATER POWER.

FIGURE 5

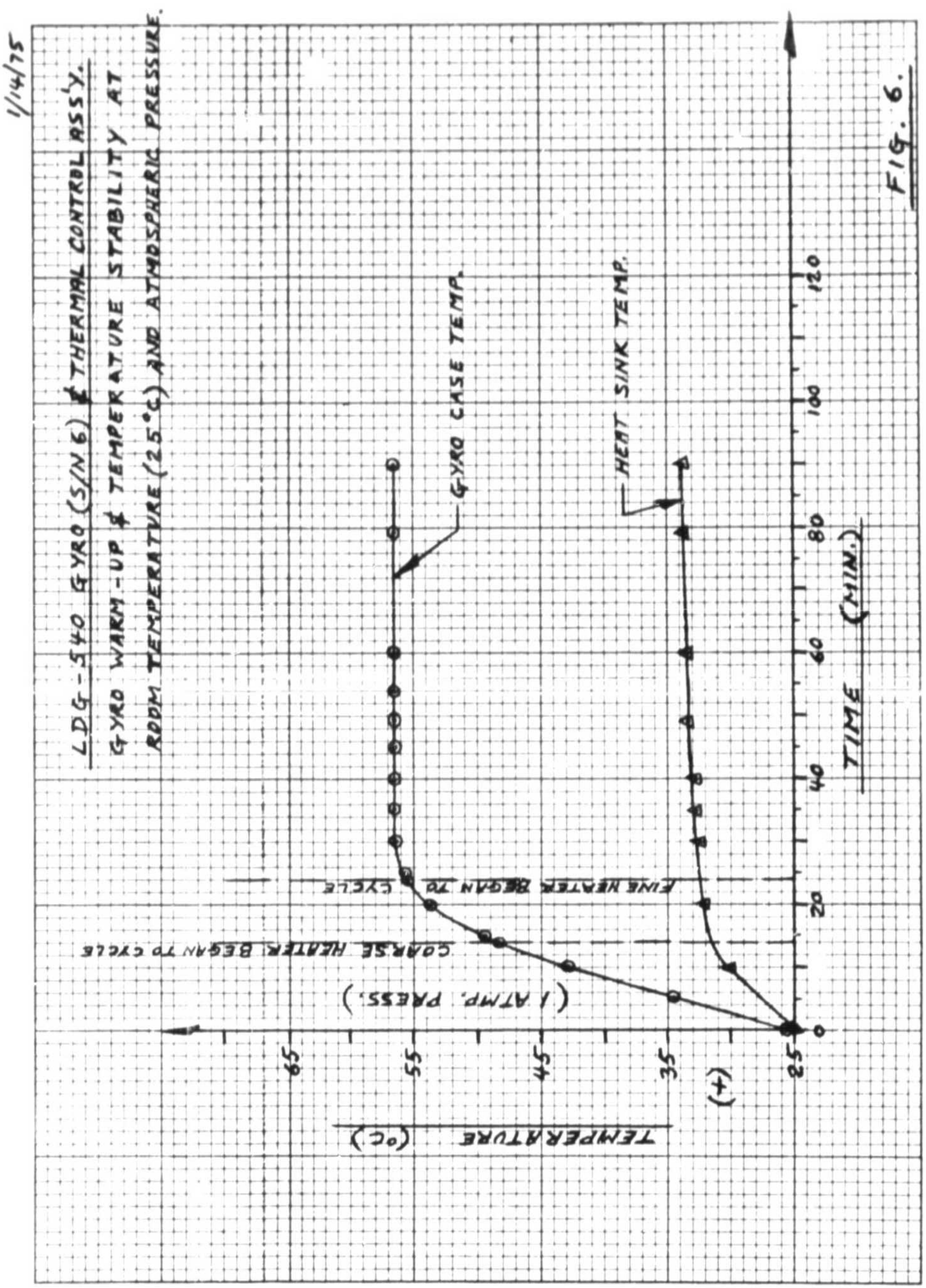

1/14/75
LDG-540 GYRO (S/N 6) & THERMAL CONTROL ASS'Y.
GYRO WARM-UP & TEMPERATURE STABILITY AT
ROOM TEMPERATURE (25°C) AND ATMOSPHERIC PRESSURE.
GYRO CASE TEMP.
HEAT SINK TEMP.
(1 ATMP. PRESS.)
COARSE HEATER BEGAN TO CYCLE
FINE HEATER BEGAN TO CYCLE
TEMPERATURE (°C)
(+)
25
35
45
55
65
0
20
40
60
80
100
120
TIME (MIN.)

FIG. 6.

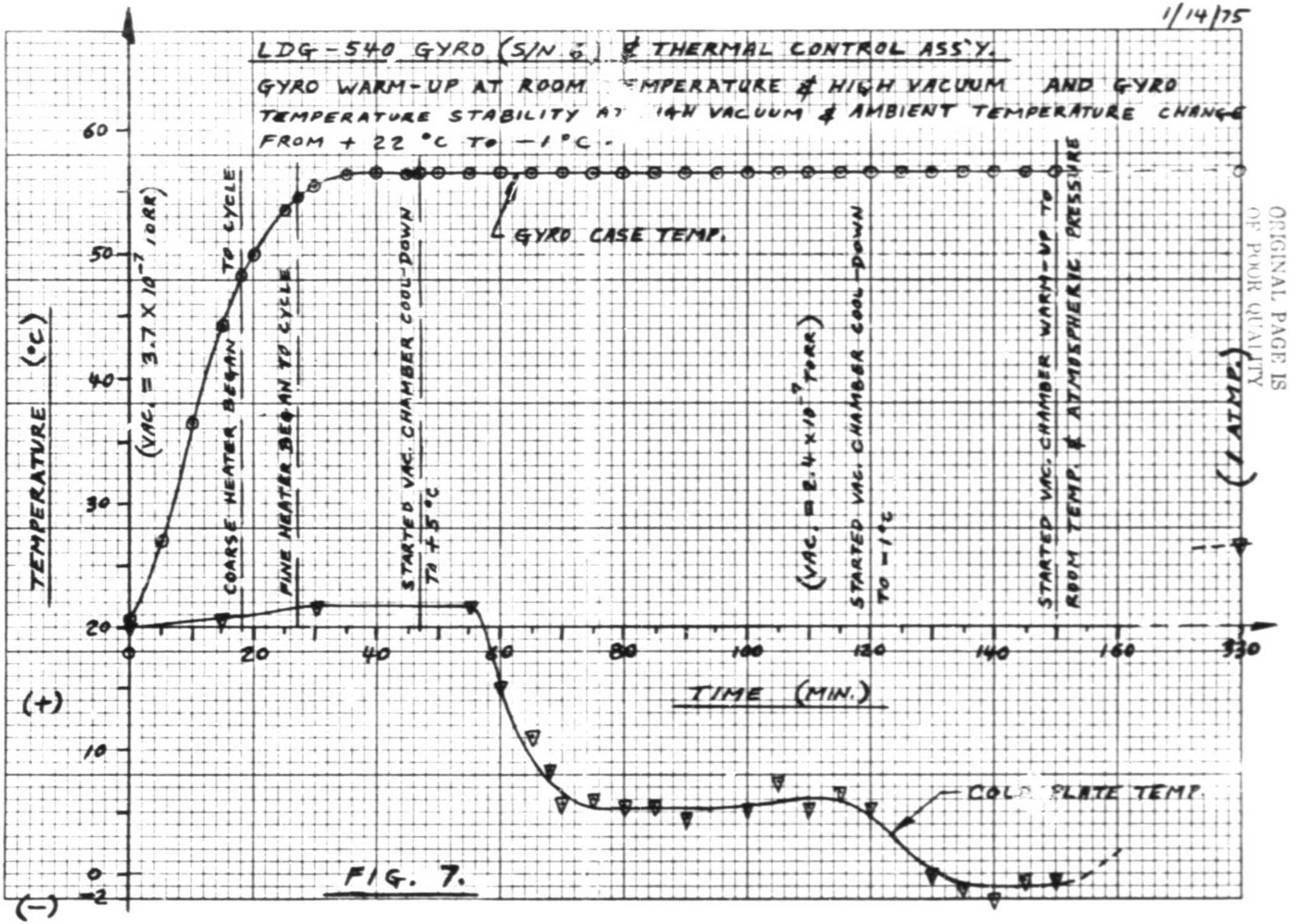

1/14/75
LDG-540 GYRO (S/N 6) & THERMAL CONTROL ASS'Y.
GYRO WARM-UP AT ROOM TEMPERATURE & HIGH VACUUM AND GYRO TEMPERATURE STABILITY AT HIGH VACUUM & AMBIENT TEMPERATURE CHANGE FROM + 22 °C TO −1 °C.
TEMPERATURE (°C)
(+)
(−)
60
50
40
30
20
10
0
−2
(VAC. = 3.7 X 10⁻⁷ TORR)
COARSE HEATER BEGAN TO CYCLE
FINE HEATER BEGAN TO CYCLE
STARTED VAC. CHAMBER COOL-DOWN TO + 5 °C
GYRO CASE TEMP.
(VAC. = 2.4 x 10⁻⁷ TORR)
STARTED VAC. CHAMBER COOL-DOWN TO −1 °C
STARTED VAC. CHAMBER WARM-UP TO ROOM TEMP. & ATMOSPHERIC PRESSURE
(1 ATMP.)
0
20
40
60
80
100
120
140
160
330
TIME (MIN.)
COLD PLATE TEMP.

FIG. 7.

SECTION III
TECHNICAL DISCUSSION

During preliminary design of the thermal control assembly, the LDG-540 Gyro was mounted on a heat sink (Saturn Air Bearing test fixture X1801596) and the gyro pump and spin motors were energized with no heater power to the gyro. After thermal stabilization at 24°C room temperature and atmospheric pressure, the gyro case temperature was 49.8°C. In order to precisely control the gyro case temperature, a temperature of 56.6°C was selected as the stabilizing temperature for the gyro case. This temperature is 6.8°C higher than that recorded with no heater power applied to the gyro.

The thermal control housing and cover, the coarse heater and sensors, and the coarse temperature controller were designed to function as a temperature controlled oven within which the LDG-540 Gyro, the fine heater and sensors, and the fine temperature controller are contained. The coarse heater and its temperature controller insure that the gyro is heated to somewhat below 56.6°C. The fine heater and its temperature controller regulate the gyro case temperature precisely at 56.6°C.

Both the fine control heater on the gyro and the coarse control heater on the thermal control assembly are 30 watt heaters at 28 V.D.C. The fine heater has a maximum rated heater power of 96 watts and the coarse heater is rated at 116 watts, maximum. The fine heater is operated at 12 V.D.C. and the coarse heater at 26 to 28 V.D.C.

SECTION IV
CONCLUSIONS AND RECOMMENDATIONS

The thermal control assembly was operated in an environment which ranged from room temperature and atmospheric pressure to $-2^{o}C$ and a vacuum of 2.4×10^{-7} torr. Throughout this range, the assembly maintained the gyro case at $56.6^{o}C$ with a total deviation no greater than $\pm$ $0.06^{o}C$.

The time required for the thermal control assembly to heat the gyro case from room temperature to $55.6^{o}C$ ($1^{o}C$ below the stabilization temperature) was 24.5 minutes for the atmospheric test and 31 minutes for the vacuum test. However, this difference in stabilization time can be attributed to the fact that during the vacuum test, the coarse heater operated at only 26 V.D.C. and 0.9 amp., while it functioned at 28 V.D.C. and 1.07 amp. throughout the atmospheric test. Also, the initial case temperature of the gyro was $5.2^{o}C$ lower for the vacuum test than it was for the atmospheric test.

Total heater power during initial warm-up, at $+20^{o}C$ coldplate temperature and 3.7×10^{-7} torr vacuum pressure, was 26.3 watts. After gyro case thermal stability was attained, the total heater power decreased to 5.2 watts. At this point, the duty cycles for the coarse and fine heaters were 9.1% and 63.3%, respectively. At ambient environments of $+5^{o}C$ coldplate/2.3×10^{-7} torr and $-1^{o}C$ coldplate/2.3×10^{-7} torr and the gyro case stabilized at $56.6^{o}C$, the total heater powers were 13.1 watts and 17.8 watts, respectively. The duty cycles of the coarse and fine heaters at the $-1^{o}C$ coldplate condition were respectively 68.3% and 65.4%.

SECTION IV (CONTINUED)

Total heater power during initial warm-up, at an ambient environment of 23.3°C and atmospheric pressure, was 34.4 watts. The total heater power decreased to 10.3 watts after the gyro case stabilized at 56.5°C. The heater duty cycles for the coarse and fine heaters, at this condition were respectively 28.2% and 42.0%.

Engineering Report #MT-37,037, included in Section V of this report, covers the test procedure and results in more detail.

SECTION V

APPENDIX

TO: Engineering File MT 37,037 Issue: Revision A

From: E. Y. Brello Date: January 28, 1975

LDG-540 GYRO
THERMAL CONTROL
ASSEMBLY (2783520-2)
EVALUATION

Prepared by: Eli Y. Brello
E. Y. Brello

Approved by: W. H. Ficken
W. H. Ficken

THE BENDIX CORPORATION
GUIDANCE SYSTEMS DIVISION
TETERBORO, NEW JERSEY

LK

The purpose of this test was to verify that the thermal control assembly for the LDG-540 gyro was capable of maintaining a gyro case temperature of 56.6°C over an ambient range of 23°C and one atmosphere to 5°C and 1×10^{-5} torr.

The test results were quite favorable and indicate that the thermal control assembly is capable of maintaining gyro case temperature stability of 56.6°C with a total deviation no greater than ± 0.06°C over an ambient range of +23°C and one atmosphere to -2°C and 2.4×10^{-7} torr.

During preliminary design of the thermal control assembly, the gyro was mounted on the heat sink to be used during test evaluation. The gyro pump and spin motors were energized and after thermal stabilization, with no heater power to the gyro, the gyro case temperature was 49.8°C at a room temperature of 24.1°C. Therefore, the temperature control assembly was designed to maintain a gyro case temperature of 56.6°C instead of 50°C as specified in contract #NAS 8-24414.

In essence, the thermal control housing, coarse heater, and controller create a temperature controlled oven within which the LDG-540 gyro, the gyro case heater and sensor, and the fine temperature controller are situated, thereby allowing the more precise control of the gyro case temperature. The assembly can also be operated with external coarse controller and heater only. However, it has not been evaluated in this mode.

Figure A shows a sketch of the LDG-540 gyro in its thermal control housing. The fine control heater, with its dual temperature sensors, is wrapped around the O.D. of the gyro. The coarse control heater (also equipped with dual temperature sensors) is cemented to the I.D. of the thermal control housing. Both are 30 watt heaters at 28 VDC. The fine heater, on the gyro, has a maximum rated heater power of 96 watts and the coarse heater is rated at 116 watts, maximum. The fine heater is operated at 12 VDC and the coarse heater at 26 to 28 VDC. To monitor the gyro case temperature, a resistance thermometer was cemented to the gyro case at the pump end of the unit. The Hybrid fine temperature controller is mounted on the inside of the thermal control housing cover. The thermal control housing forms a hermetic seal about the gyro. The coarse temperature controller is external to the thermal control housing and is not part of the assembly.

The first part of this test was run at room temperature (23.3^{o}C) and atmospheric pressure. Gyro S/N 6 was mounted on a holding fixture as shown in Figure B. After the gyro case (7), heat sink (11), and room temperatures were recorded, the gyro fluid pump, spin motor, fine heater (12 VDC) and coarse heater (28 VDC) were energized. The heater currents were 0.42 amp and 1.07 amp, respectively. The gyro case temperature (7) and the heat sink temperature (11) were monitored at 5 min. intervals until the gyro case temperature stabilized. The coarse heater started cycling 14 minutes after the test was started and the fine heater started to cycle 10 minutes later. Thirty (30) minutes after the start of the test, the gyro case temperature reached 56.3^{o}C and ten (10) minutes later the case temperature stabilized at 56.5^{o}C. At this temperature the coarse heater had a duty cycle of 28.2% and power of 8.4 watts. The fine heater drew 1.9 watts of power and had a duty cycle of 42.0%. See Data Sheet I and Curve I.

The second part of this test was run in a thermal vacuum chamber. Figure C is a sketch of the test set-up showing the temperature points monitored during the test. The chamber was initially pumped down to a vacuum of 3.7 x 10^{-7} torr. The cold plate (1) and gyro case (7) temperatures were 20.0^{o}C and 20.5^{o}C, respectively. Power to the gyro pump, spin motor, fine heater (12 VDC) and coarse heater (26 VDC) were then turned on. After 18 minutes of operation, the coarse heater started to cycle and 9 minutes later the fine heater began to cycle. The gyro case temperature stabilized at 56.6^{o}C forty (40) minutes after the start of test. Curves I and II are plots of gyro case temperature vs time for the atmospheric and vacuum tests, respectively. The slopes of each curve, during warm-up, are basically the same. The coarse heater had a 4 minute longer 100% duty cycle during the warm-up period of the vacuum test than it did during the corresponding warm-up period of the atmospheric test. However, the coarse heater operated at only 26 VDC and 0.9 amp during the vacuum test while it functioned at 28 VDC and 1.07 amp throughout the atmospheric test. Also, the gyro had a 5.2^{o}C lower gyro case temperature, prior to warm-up, for the vacuum test than it did for the atmospheric test.

After the gyro case temperature stabilized, the chamber was cooled-down to $5^{o}C$ and then down to $0^{o}C$. Throughout this temperature drop, the heaters maintained a gyro case temperature of $56.62 \pm 0.05^{o}C$. The data is tabulated on Data Sheet II and plotted on Curve II.

Data Sheet III summarizes the steady state results of the vacuum and atmospheric tests. It should be noted that the total heater power during the $23.3^{o}C$/1 atmosphere test was twice that at the $22^{o}C/3.7 \times 10^{-7}$ torr test.

At a gyro case temperature of $56.6^{o}C$ and an ambient environment of $5^{o}C$ and 2.3×10^{-7} torr, the coarse heater had a duty cycle of 48.7% and power of 10.8 watts. The fine heater drew 2.7 watts and had a duty cycle of 54.4%.

In conclusion, the thermal control assembly is quite capable of maintaining a gyro case temperature of 56.6 $\pm 0.05^{o}C$ over an ambient range of $23^{o}C$/1 atmosphere to $5^{o}C/2.4 \times 10^{-7}$ torr with maximum power of 13.5 watts and maximum heater duty cycle of 50%.

A 8375A Digital Multimeter, manufactured by the John Fluke Co., was used to monitor the gyro case temperature. Caution should be taken in selecting a meter as any current will heat the resistance thermometer temperature readings.

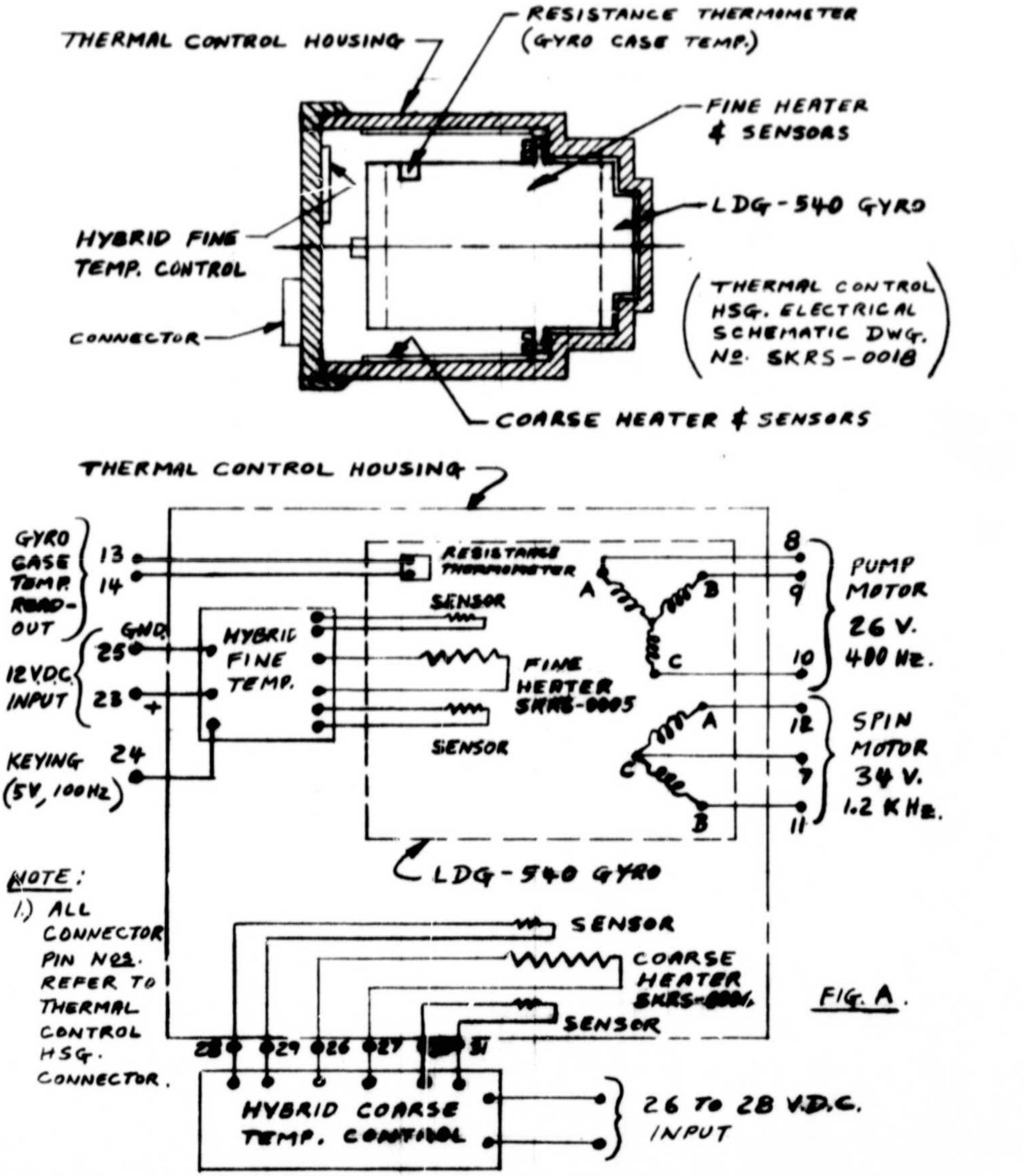
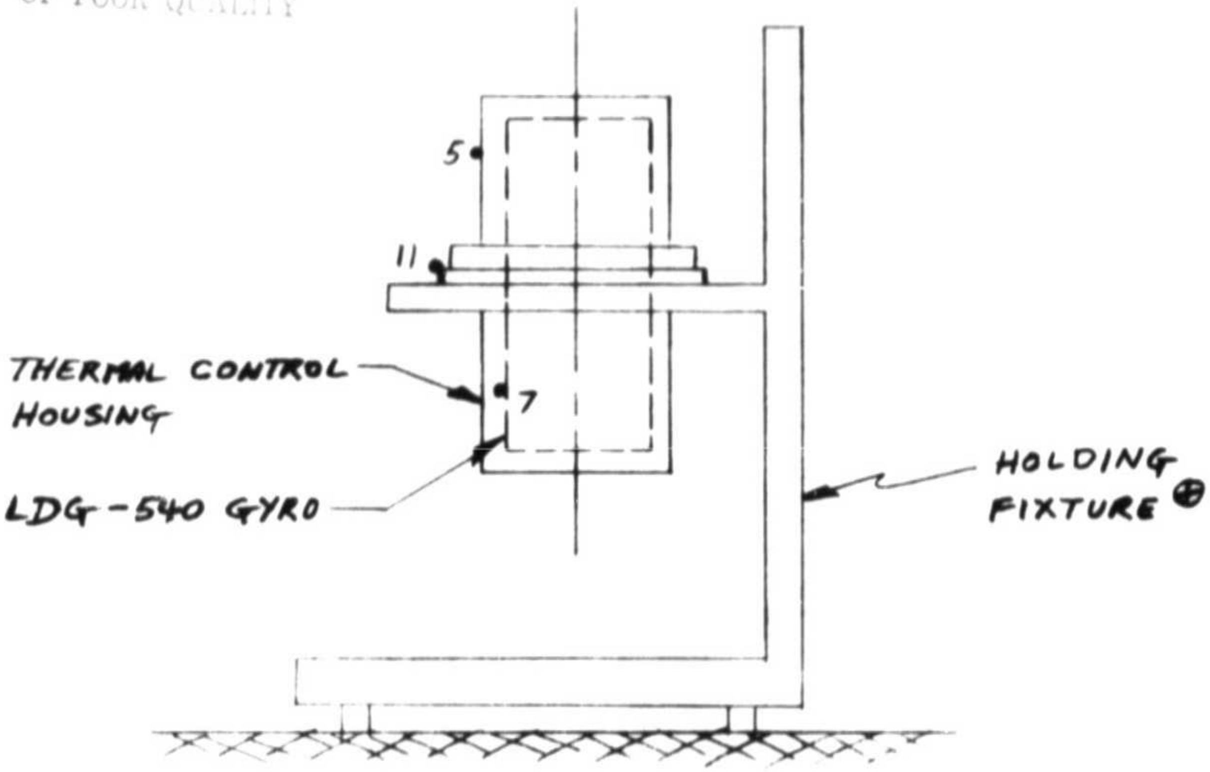


FIG. A. SKETCH OF GYRO IN THERMAL CONTROL HOUSING SHOWING LOCATION OF FINE & COARSE HEATERS, HEATER SENSORS, FINE TEMP. CONTROL, & GYRO CASE RESISTANCE THERMOMETER AND EXCITATIONS FOR HEATERS, FLUID PUMP MOTOR, & GYRO SPIN MOTOR.

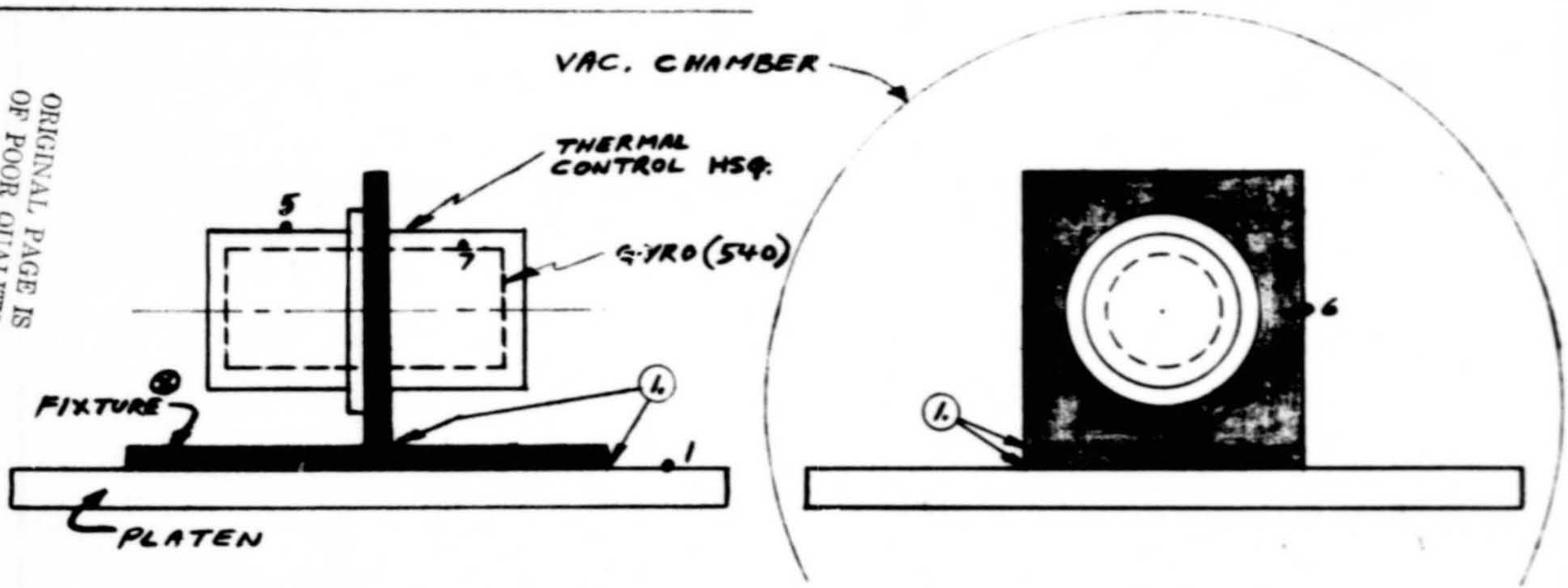


TEMPERATURE POINTS:

5 — THERMAL CONTROL HOUSING
7 — GYRO CASE
11 — HEAT SINK

⊕ — FIXTURE DRAWING NO.
X1801596 AIR BEARING TEST FIXTURE
SKRS-0011 ADAPTOR — FUNCTIONAL T/S

FIG. B ROOM TEMPERATURE/ATMOSPHERIC PRESSURE TEST SET-UP SHOWING TEMPERATURE POINTS.



TEMPERATURE POINTS :

1 — PLATEN

5 — THERMAL CONTROL HSG.

7 — GYRO CASE

6 — FIXTURE SIDE

⊗ - FIXTURE DRAWING NO.
SKRS-0012 PLATE, MOUNT
& SKRS-0013 PLATE, BUTT

NOTE : (1.) THERMAL CONDUCTING GREASE APPLIED BETWEEN TOP SURFACE OF PLATEN AND BOTTOM SURFACE OF FIXTURE BASE AND BETWEEN FIXTURE BASE AND BRACKET INTERFACE.

FIG. C. VACUUM CHAMBER TEST SET-UP SHOWING TEMPERATURE POINTS.

[illegible]

(DATA SHEET I)

DATE	TIME	GYRO CASE TEMPERATURE (7.)			COARSE HEATER		FINE HEATER		HEAT SINK TEMP. (11)	REMARKS
	(MIN.)	(Ω)	(°C)	(°F)	DUTY CYCLE (%)	POWER (WATTS)	DUTY CYCLE (%)	POWER (WATTS)	(°C)	
8 JAN. 75	0 ⊛	677.7	25.7	78.2	(28 V.D.C.	@ 1.07 AMP)	(12 V.D.C.	@ 0.42 AMP)	25.0	ROOM TEMP. = 23.3°C &
	5	704.7	34.7	94.5					27.8	ATMOSPHERIC PRESS.
	10	730.0	43.0	109.4					30.2	
	14	746.7	48.4	119.1	HEATER STARTED TO CYCLE (0 TO 1.07 AMP)					
	15	750.3	49.5	121.2						
	20	763.0	53.6	128.4					32.1	
	24	769.0	55.47	131.85			HEATER STARTED TO CYCLE (0 TO 0.42 AMP)			
	25	769.7	55.68	132.22						
	30	771.5	56.26	133.27					32.4	
	35	772.1	56.45	133.61					32.8	
	40	772.3	56.52	133.74					32.8	
	45	772.4	56.54	133.77						
	49	772.4	56.54	133.77					33.3	
	54	772.4	56.54	133.77						
	60	772.4	56.54	133.77					33.3	
	79	772.5	56.57	133.83					33.7	
	90	772.4	56.54	133.77	28.2	8.4	42.0	1.9	33.8	THERMAL CONTROL HS4. TEMP.(5) = 42.0°C

⊛ AFTER TEMPERATURE READINGS WERE RECORDED, THE GYRO PUMP, SPIN MOTOR, FINE HEATER, & COARSE HEATER WERE ENERGIZED.

S ET

LDG - GYRO (S/N 6) WARM-UP & TEMPERATURE STABILITY AT HIGH VACUUM.

(DATA SHEET II)

DATE	TIME (MIN.)	GYRO CASE TEMPERATURE (7.) (Ω)	(°C)	(°F)	COARSE HEATER DUTY CYCLE (%)	COARSE HEATER POWER (WATTS)	FINE HEATER DUTY CYCLE (%)	FINE HEATER POWER (WATTS)	COARSE HEATER SENS. #1. (°C)	COARSE HEATER SENS. #2. (°C)	VACUUM CHAMBER COLD PLATE TEMP. (1.) (°C)	VACUUM CHAMBER PRESSURE	FLT. SIDE TEMP (6.) (°C)
14 JAN 75	0 ⊛	662.4	20.5	68.9	(26 V.D.C. @	.9 AMP)	(12 V.D.C. @	.45 AMP)	663.2Ω 20.8°C	663.8Ω 21.0°C	20.0	3.7×10^{-7} TORR	20.6
	5	681.3	26.9	80.4									
	10	709.5	36.3	97.3									
	15	733.6	44.2	111.5					734.0Ω 44.3°C	731.3Ω 43.4°C	20.6		30.0
	18	746.6	48.4	119.0	HEATER STARTED TO CYCLE (0 TO .91 AMP.)				739.0Ω 45.9°C	736.0Ω 44.9°C			
	20	751.9	50.0	122.1									
	25	762.9	53.5	128.4									
	27	766.4	54.6	130.4			HEATER STARTED TO CYCLE (0 TO .44 AMP.)						
	30	769.0	55.47	131.85					742.3Ω 47.0°C	734.7Ω 44.5°C	21.7		31.7
	35	771.6	56.29	133.32									
	40	772.5	56.57	133.83									
	45	772.7	56.64	133.95	9.1	2.0	63.3	3.2	742.7Ω 47.1°C	734.4Ω 44.4°C			32.2
	47	772.8	56.67	134.01	(STARTED COOL-DOWN TO 5°C)								
	50	772.8	56.67	134.01									
	55	772.8	56.67	134.01							21.7		
	60	772.8	56.67	134.01							15.0		
	65	772.8	56.67	134.01							11.1		
	68										8.3		
	70	772.7	56.64	133.95							5.8		
	75	772.6	56.61	133.90							6.1		23.3
	80	772.6	56.61	133.90							5.6		
	85	772.6	56.61	133.90							5.6		
	90	772.6	56.61	133.90							4.4		22.2
	95	772.6	56.61	133.90									

LDG - GYRO (S/N 6) WARM-UP & TEMPERATURE STABILITY AT HIGH VACUUM.

(DATA SHEET II)

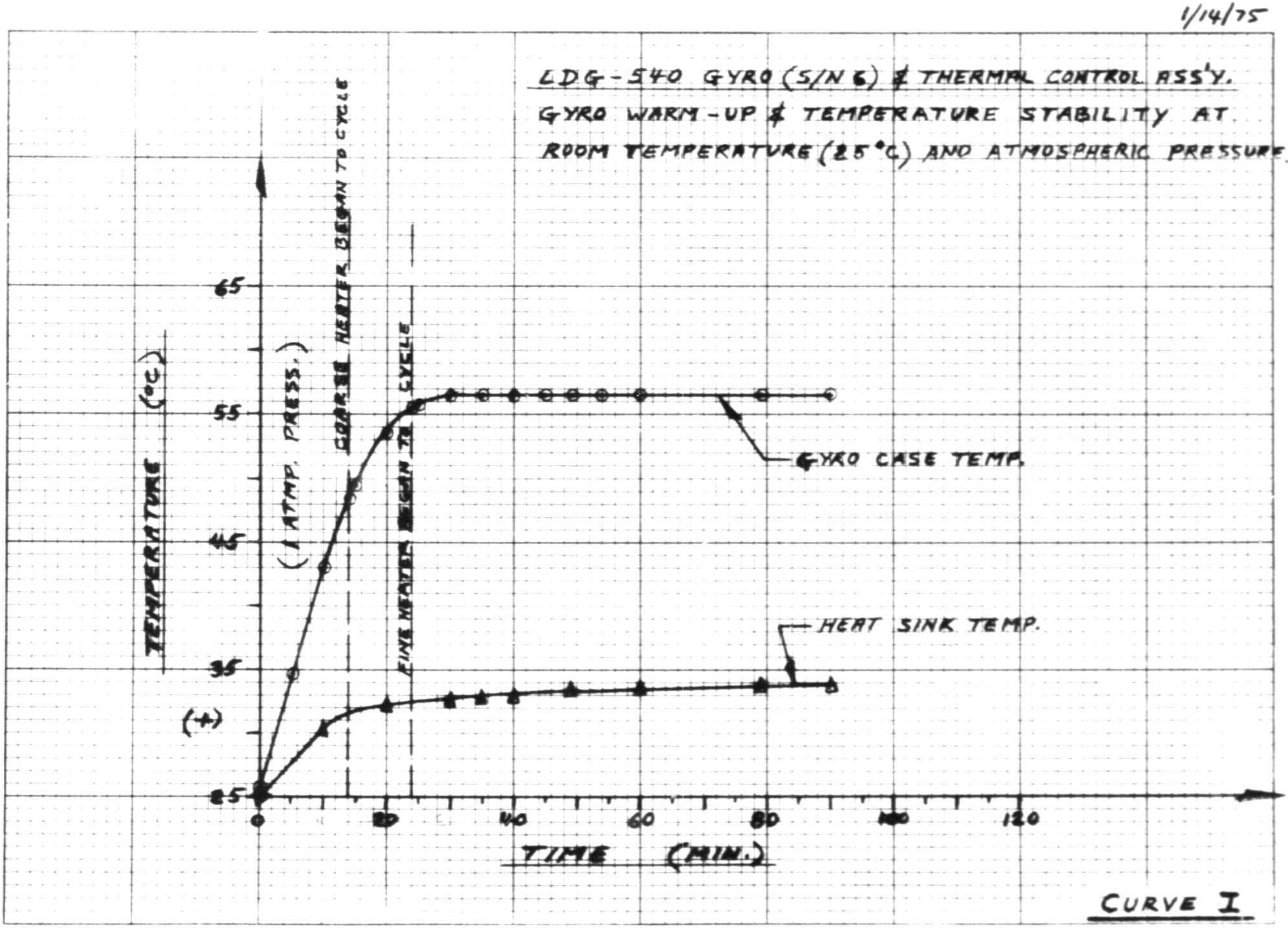
DATE	TIME (MIN.)	GYRO CASE TEMPERATURE (7.) (Ω)	(°C)	(°F)	COARSE HEATER DUTY CYCLE (%)	COARSE HEATER POWER (WATTS)	FINE HEATER DUTY CYCLE (%)	FINE HEATER POWER (WATTS)	COARSE HEATER SENS. #1. (°C)	COARSE HEATER SENS. #2. (°C)	VACUUM CHAMBER COLD PLATE TEMP. (1.) (°C)	VACUUM CHAMBER PRESSURE	FIXT. SIDE TEMP (6) (°C)
14 JAN. 75	100	772.6	56.61	133.90							5.3		
	105	772.6	56.61	133.90							7.5		
	110	772.6	56.61	133.90							5.3	2.4×10^{-7} TORR	
	115	772.6	56.61	133.90	48.7	10.8	54.4	2.7			6.7		
	120	772.6	56.61	133.90	(STARTED COOL-DOWN TO 0°C)						5.3		23.3
	125												
	130	772.6	56.61	133.90							0.0		
	135	772.5	56.57	133.83							−1.1		19.4
	140	772.5	56.57	133.83							−2.0		
	145	772.6	56.61	133.90							−0.6		
	150	772.5	56.57	133.83	68.3	15.1	65.4	3.3			−0.6		19.4
	151	(STARTED WARM-UP TO 22°C & STD. ATMOSPHERE)											
	↓												
	330	772.5	56.57	133.83							26.7	1 ATM.	

⊛ AFTER TEMPERATURE READINGS WERE RECORDED, THE GYRO PUMP, SPIN MOTOR, FINE HEATER, & COARSE HEATER WERE ENERGIZED.

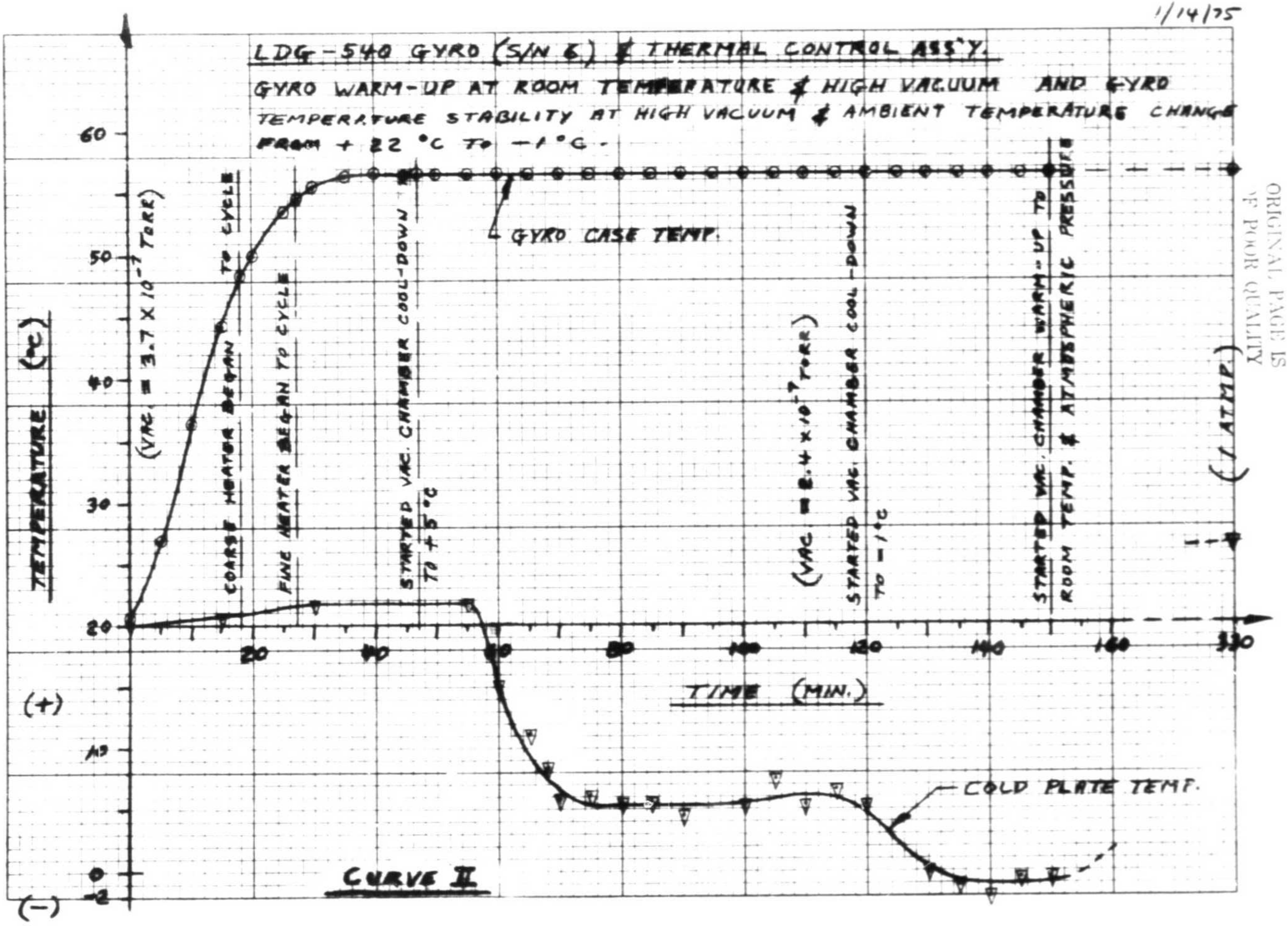
DATA SHEET III

STEADY STATE RESULTS

	VAC. CHAMBER		GYRO							
	COLD PLATE TEMP. (1) (°C)	VAC. PRESS. (TORR)	THERMAL CONTROL HOUSING TEMP. (5) (°C)	CASE TEMP. (7) (°C)	COARSE HEATER DUTY CYCLE (%)	COARSE HEATER POWER (WATTS)	FINE HEATER DUTY CYCLE (%)	FINE HEATER POWER (WATTS)	TOTAL HEATER POWER (WATTS)
VAC. TEST	+22	3.7×10^{-7}	+42.5	+56.7	9.1	2.0	63.3	3.2	5.2
VAC. TEST	+5	2.3×10^{-7}	+42.5	+56.6	48.7	10.8	54.4	2.7	13.5
VAC. TEST	−1	2.3×10^{-7}	+43.0	+56.6	68.3	15.1	65.4	3.3	18.4
	RM. TEMP.	PRESS.							
ATMP. TEST	+23.3 °C	1 ATMP.	+42.0	+56.5	28.2	8.4	42.0	1.9	10.3


1/14/75
LDG-540 GYRO (S/N 6) & THERMAL CONTROL ASS'Y.
GYRO WARM-UP & TEMPERATURE STABILITY AT
ROOM TEMPERATURE (25°C) AND ATMOSPHERIC PRESSURE
TEMPERATURE (°C)
(+)
25
35
45
55
65
(1 ATMP. PRESS.)
COARSE HEATER BEGAN TO CYCLE
FINE HEATER BEGAN TO CYCLE
GYRO CASE TEMP.
HEAT SINK TEMP.
0
20
40
60
80
100
120
TIME (MIN.)
CURVE I

1/14/75


LDG-540 GYRO (S/N 6) & THERMAL CONTROL ASS'Y.
GYRO WARM-UP AT ROOM TEMPERATURE & HIGH VACUUM AND GYRO TEMPERATURE STABILITY AT HIGH VACUUM & AMBIENT TEMPERATURE CHANGE FROM + 22 °C TO −1 °C.
TEMPERATURE (°C)
(VAC. = 3.7 X 10⁻⁷ TORR)
COARSE HEATER BEGAN TO CYCLE
FINE HEATER BEGAN TO CYCLE
STARTED VAC. CHAMBER COOL-DOWN TO + 5 °C
GYRO CASE TEMP.
(VAC. = 2.4 X 10⁻⁷ TORR)
STARTED VAC. CHAMBER COOL-DOWN TO −1 °C
STARTED VAC. CHAMBER WARM-UP TO ROOM TEMP. & ATMOSPHERIC PRESSURE
(1 ATMP.)
COLD PLATE TEMP.
TIME (MIN.)
CURVE II
(+)
(−)
60
50
40
30
20
10
0
−2
20
40
60
80
100
120
140
160
330