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FINAL REPORT
FOR
C702543 ALPHA III BALL BEARING GYROSCOPE
MOTOR STERILIZATION PROGRAM

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Prepared for:

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California

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KEARFOTT SYSTEMS DIVISION
SINGER-GENERAL PRECISION, INC.
KEARFOTT GROUP
Wayne, New Jersey

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TECHNICAL CONTENT STATEMENT

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ABSTRACT

This report is concerned with a program to evaluate the heat sterilization capabilities of the Kearfott Systems Division (KSD) C702543 ALPHA III ball bearing gyroscope motor. The program was divided into two phases. The first phase deals with heat sterilization of the motor piece parts and subassemblies.

The primary intent of the first phase was to detect any adverse temperature effects at the subassembly level that might be overlooked on the completed motor. The second phase dealt with the effects of heat sterilization on motor performance and life.

All heat sterilization tests were performed as described in paragraphs 4.3.5 and 4.1.b (excluding step 3); test tolerances in accordance with paragraph 3.9, except sub-paragraph 3.9.b shall read "assembly level tests ±2.5C"; heat sterilization procedure in accordance with paragraph 4.3.2 (excluding steps 2 and 5) of JPL specification VOL-50503-GTS Environmental Specification, Type Approval and Flight Acceptance Test Procedure for the Heat Sterilization and Ethylene Oxide Decontamination Environment.

These exceptions were mutually agreed upon by JPL and KSD. Essentially, they consist of eliminating the ethylene oxide (ETO) decontamination requirement on the assembly level and related nitrogen flush, and changing the oven temperature requirements from ±1°C to 2.5°C.

The ETO requirement on the assembly level was eliminated in the interest of cost economy and the fact that the effects of the heat sterilization cycle were what was important.

The temperature requirement was loosened since the available temperature chambers at KSD were not within ±1°C accuracy.

Before and after heat sterilization, visual, mechanical, electrical and chemical tests were performed to analyze the effects of high temperature on the motor.

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1. GLOSSARY

There are no non-standard abbreviations in this report.

2. INTRODUCTION

This is the final report on the C702543 ALPHA III ball bearing gyroscope motor sterilization program which began July 15, 1968. The program was divided into two phases:

- The first phase dealt with the heat sterilization of motor piece-parts and subassemblies at 135-degrees C for a total of six cycles at 70-hours each. The purpose of this phase was to detect any adverse temperature effects at the subassembly level that might be overlooked on the completed motor.
- During the second phase, two motor assemblies were built up and sterilized at the same conditions as the piece-parts. After each sterilization cycle, the motors were placed on test to see if performance was effected. On completion of the 6 sterilization cycles the motors were placed on a 2000 hour life test.

The 2000 hour life test was completed in November 1968.

3. TECHNICAL DISCUSSION

Work on the sterilization program began on 14 July 1967. (Because of KSD vacation shutdown, no real work started until the week of August 6th). During that week the planning phase was completed and target dates set for each critical milestone on the program. The actual completion dates are shown in Table I.

TABLE I

COMPLETION DATES OF CRITICAL MILESTONES

ITEM NO.	CRITICAL MILESTONE	COMPLETION DATE
1	Project Kickoff	7 August 1967
2	Preparation of Environmental Test Plan	18 August 1967
3	Procurement of Parts and Sterilization Containers	30 August 1967
4	Chemical Analysis of Lubricants	30 August 1967
5	Preparation of Containers for Test	6 September 1967
6	Preparation of Hardware, Bearings and Lubrication for Sterilization	13 September 1967
7	Sterilization of Motor Parts	18 October 1967
8	Post-Sterilization Tests	1 November 1967
9	Minor Design Changes and Preliminary Checkout	22 November 1967
10	Assemble (2) Motors and Run-In	1 January 1968
11	Start Sterilization of Motors	25 April 1968
12	Complete Sterilization of Motors	15 July 1968
13	Start Life Test (2000 hr. max.)	1 August 1968
14	Life Test Completed	22 October 1968

3.1 PHASE I

Prior to any sterilization exposure, the motor design was analyzed for possible problem areas that could result from the high temperature. One area of concern was the various cements used on the gyro motor. The cement manufacturers were contacted to determine if the duration and temperature of the sterilization could be successfully survived. To the best knowledge available, it was found that all the cements should be adequate with the possible exception of the Epon 828 with hardener "D" used on the P-6 rotor laminations. The vendor (Shell) recommended using the Epon 828 with hardener "Z" for this application and therefore, this change was instituted prior to piece part sterilization.

As per the JPL Statement of Work, the following hardware was subjected to the Phase I component level sterilization:

- Flywheel matched set with cemented outer races.
- Stator-shaft subassembly with cemented inner races.
- Impregnated bearing outer races in hermetically sealed containers.
- Samples of lubricants in hermetically sealed containers.

The results obtained from the component level sterilization are as follows:

- All cement joints were found to be strong and well bonded. There were no signs of cracking, bleeding, or growth of cement at any joint. A change in cement color at the bearing bonds had occurred but this had been predicted by the manufacturer and had been expected.
- The push force necessary to fracture the cement bond of both the bearing outer race and the stator assembly was greater after sterilization than that measured on a sample lot of test pieces not sterilized. It appears that the long exposure to the high sterilization temperature actually increased the cement bond strength.

- The sterilization had no effect on the stator assembly.
- The actual piece parts were unaffected by the sterilization.
- Chemical analyses on three lubricants (SR-40, SR-60 and KG-80) conducted on before-and-after sterilization same-lot samples, indicated no changes had occurred due to the exposure to the sterilization. An IR analysis, viscosity check, and refractive index check were performed on each sample.
- Three outer race assemblies, impregnated and centrifuged by the standard ALPHA III procedure, each with a different lubricant and each hermetically sealed in a controlled volume container, experienced an average weight loss by evaporation of 13 % after sterilization. Each container had been evacuated and filled with one-quarter atmosphere of helium, again by the standard ALPHA III procedure. It is difficult to determine how significant the 13 % change is. The best indication is the fact that the motors performed well after sterilization indicating that the change was not large enough to affect motor performance.

  It should be pointed out that most Kearfott floated gyro motors are temperature cycled in 1/4 atmosphere of helium at approximately 200°F. Therefore, it appears that the lubricant in these gyro motors must also evaporate. A more reasonable comparison therefore might be the difference in evaporation between 200°F and 275°F (sterilization temp.). Unfortunately, no data is available on the evaporation rate at 200°F.

3.2 PHASE II

According to the JPL Statement of Work, two gyro motor assemblies were to be fabricated incorporating changes found necessary from the Phase I effort. The motor and container (same as a motor-float), assembly and run-in, were to be in accordance with standard KSD procedures. The final container data, which includes run-up and run-down time performance electrical performance, and power jag performance, would serve as a pre-sterilization reference. Six sterilization cycles were to be performed. Following each cycle a minimum of 100 hours of run-in was to be accrued and the above performance monitored. Any motor which passed the 6 sterilization cycles was to be placed on a 2000 hour life test or until failure, whichever occurred first.

3.2.1 MOTOR ASSEMBLY AND RUN-IN

Prior to motor assembly, the four spin bearings used, were selected from a quantity of 8, based on a 40X inspection. The bearings were processed following standard procedures and impregnated with SR-60 lubricant. The gyro motors were assembled and run-in following standard procedures with the exception of an increased number of bearing visuals. No problems were encountered during assembly and run-in, and both gyro motors were processed on a one-time-through basis with no disassembly or re-starts necessary. Each gyro motor was run-in for 186 hours prior to installation into the containers.

3.2.2 CONTAINER ASSEMBLY AND RUN-IN

The motors were installed into the sterilization containers and hermetically sealed. No major problems were encountered. Container No. 7, however, was disassembled and recycled to correct a header leak. The containers were evacuated and filled with one-quarter atmosphere of helium. The containers were immersed in an oil bath and the fluid temperature maintained at 115°F. Motor No. 7 was run an additional 145 hours, for a total run-in time (motor and container) of 331 hours before the first sterilization cycle. Similarly, motor No. 11 was run an additional 156 hours for a total run-in time of 342 hours. Motor performance and power jag data at the completion of the container run-in are presented as a pre-sterilization reference.

3.2.3 HEAT STERILIZATION CYCLES

Each container was subjected to 6 heat sterilization cycles, which were performed by the Environmental Lab. Following each heat cycle the gyro motors were run for a minimum of 100 hours each and performance monitored at regular intervals.

3.2.4 LIFE TEST

Both gyro motors survived the sterilization and run-in cycles and both were placed on life test. During the life test, performance was monitored at regular intervals. The 2000 hour life test was completed on 22 October 1968, with both units successfully achieving this requirement.

3.2.5 PRESENTATION OF DATA

Tables II and III present the motor performance characteristics:

- After container run-in (pre-sterilization reference).
- After each sterilization cycle; prior to, and at the end of the 100 hour run.
- After completion of life test.

Figures 1 and 2 present the rundown time history (60-0 RDT and total RDT) throughout the motor, container, and sterilization cycle runs, as well as throughout the life test.

Figures 3 through 12, and 13 through 22, present the power jag history of Motor No. 7 and Motor No. 11 respectively. Figures 3 and 13 present the power jag of No. 7 and No. 11 at the completion of container run-in and serve as the pre-sterilization reference. Each jag represents approximately 12 minutes (out of 1 hour in most cases) of jag time selected as being typical of its own particular run. The scale factor for each jag is as follows:

- Horizontal - 2 major divisions = 0.5 milliamps
- Vertical - 3 major divisions = 1.0 minutes

Each power jag is referenced by the hour of run-in time at which it was taken after each sterilization cycle and during life test. Along with each jag is the rundown time measured at that particular run. The original full length power jags are on file with the Gyro Motor Group at KSD.

3.2.6 DISCUSSION OF DATA

Both gyro motors successfully achieved the program objectives. Each motor accumulated a total of approximately 3000 hours of running time throughout the program. The electrical performance of the two gyro motors was unaffected by the sterilization and stable throughout the life tests.

The 60-0 and total rundown time, while fluctuating slightly during the sterilization cycle runs, were relatively stable during the life tests with the exception of one period during the life test of Motor No. 11.

In general, the power jag performance of both gyro motors was quite good even though the data does trend toward "hashier" traces at the latter stages of the life tests. Based on past experience, relating motor power jag performance to gyro drift performance, the gyro would still be acceptable from this standpoint.

3.3 FINAL MOTOR - VISUAL

At the conclusion of life testing, the gyro motors were removed from their respective containers for a visual examination. The motor bearings were examined without motor disassembly.

While it is difficult to visually rate a bearing after 3000 hours of running, the condition of the bearings can be considered, at least, good. The bearing retainers have become darker in color, however they appear to still retain lubricant. The balls appear shiny and clear. While there is no large scale lubricant breakdown or varnishing, there does appear to be some slight sling-off from the inner race track area on at least two of the four sides. The inner race tracks appear to have good wetting, but it would be safe to say, that upon disassembly some tracking will be evident.

It is even more difficult to give a valid estimate of remaining life. It is the personal judgement of the writer, that had the gyro motors remained on life test, considerably more (in excess of 1000 hours) running time could have been accrued before failure (the inability of the gyro motors to reach and maintain synchronism). This judgement is based on the relatively stable performance of the gyro motors as well as the visual condition of the bearings.

TABLE II

PERFORMANCE CHARACTERISTICS MOTOR NO. 7

CHARACTERISTIC	* AFTER CONTAINER RUNIN	AFTER 1ST STERILIZATION CYCLE		AFTER 2ND STERILIZATION CYCLE		AFTER 3RD STERILIZATION CYCLE		AFTER 4TH STERILIZATION CYCLE		AFTER 5TH STERILIZATION CYCLE		AFTER 6TH STERILIZATION CYCLE		AFTER LIFE TEST
DATE	4/25/68	5/3/68	5/10/68	5/17/68	5/24/68	5/31/68	6/7/68	6/14/68	6/21/68	7/1/68	7/6/68	7/15/68	7/22/68	10/22/68
HOURS THIS RUN	331	0	102	0	102	0	101	0	101	0	104	0	156	2012
STARTING POWER (W)	3.03	3.00	3.05	3.00	3.02	3.02	2.94	2.93	2.96	3.0	2.93	2.97	2.93	3.0
RUNNING POWER (W)	1.76	1.80	1.78	1.75	1.87	1.87	1.78	1.87	1.75	1.75	1.73	1.77	1.76	1.87
STARTING CURRENT* (A)	0.107	0.107	0.107	0.107	0.107	0.107	0.105	0.105	0.105	0.107	0.105	0.106	0.105	0.106
RUNNING CURRENT* (A)	0.090	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.091	0.092	0.091	0.092	0.091	0.092
TIME TO SYNCH (SEC)	18.1	18.2	17.6	17.8	17.6	18.0	18.2	17.9	17.9	18.1	18.2	18.0	18.0	18.5
800→720 RDT (SEC)	6.1	6.5	6.9	6.8	7.1	6.9	6.95	6.85	6.85	6.85	6.8	6.7	6.6	6.3
720→800 RUT (SEC)	2.4	2.35	2.25	2.35	2.25	2.35	2.4	2.35	2.3	2.4	2.4	2.4	2.45	2.4
60→0 RDT (SEC)	13.7	10.8	15.7	13.8	14.1	14.7	15.2	15.3	15.3	15.6	14.3	15.1	14.1	14.0
TOTAL RDT (SEC)	102.2	107.5	121.6	116	124.4	128.4	128.6	128.3	122	130.3	119.1	126.1	122.1	105.1
TOTAL ACCUMULATED RUNNING HOURS	331	331	433	433	535	535	636	636	737	737	841	841	977	3009

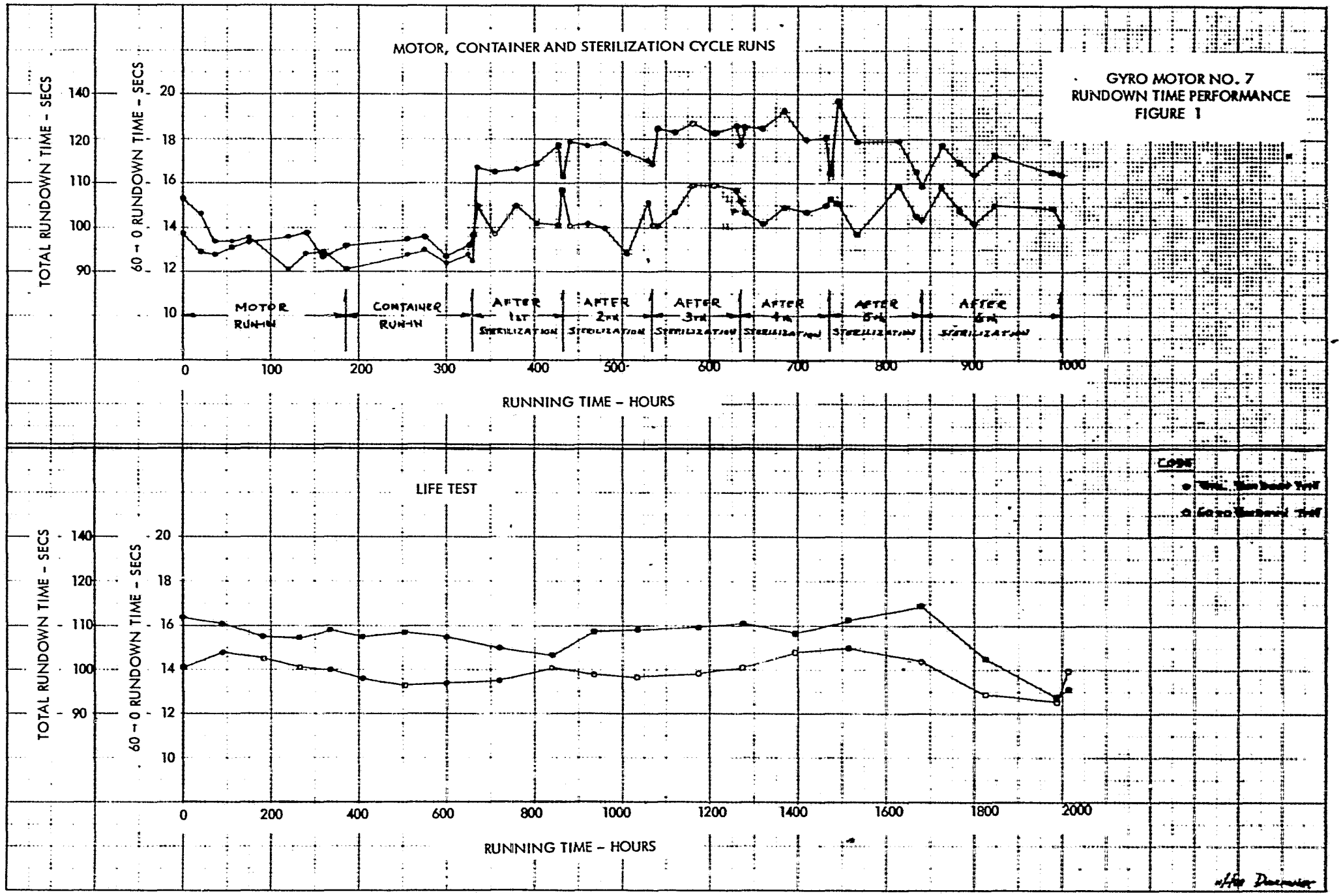
* AVERAGE VALUES

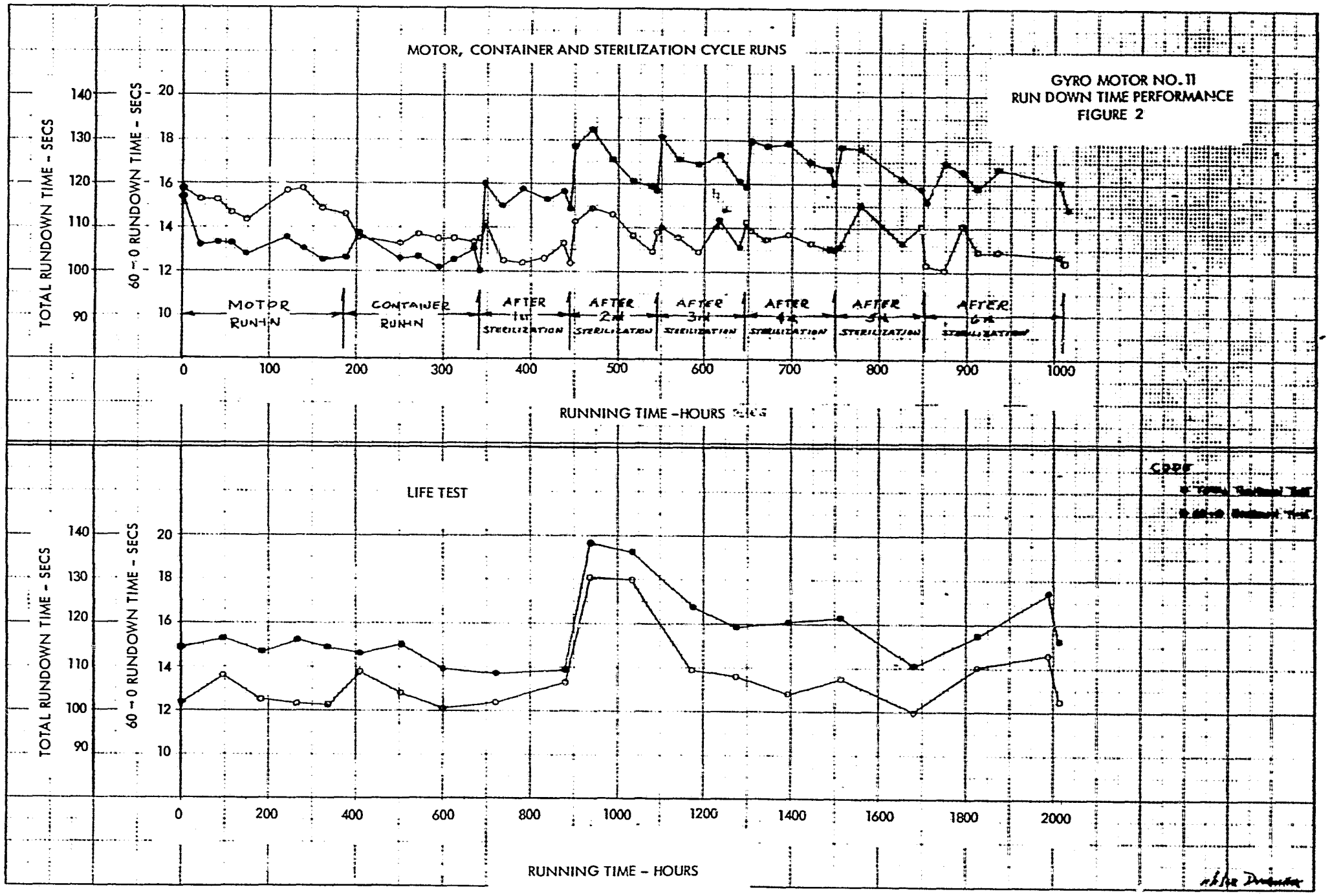
TABLE III

PERFORMANCE CHARACTEPISTICS MOTOR NO. 11

CHARACTERISTIC	* AFTER CONTAINER RUNIN	AFTER 1ST STERILIZATION CYCLE		AFTER 2ND STERILIZATION CYCLE		AFTER 3RD STERILIZATION CYCLE		AFTER 4TH STERILIZATION CYCLE		AFTER 5TH STERILIZATION CYCLE		AFTER 6TH STERILIZATION CYCLE		AFTER LIFE TEST
DATE	4/25/68	5/3/68	5/10/68	5/17/68	5/24/68	5/31/68	6/7/68	6/14/68	6/21/68	7/1/68	7/6/68	7/15/68	7/22/68	10/22/68
HOURS THIS RUN	342	0	102	0	102	0	101	0	101	0	104	0	156	2012
STARTING POWER (W)	2.96	3.06	3.03	3.04	3.01	3.06	2.99	2.95	2.93	2.99	2.94	2.97	2.92	3.0
RUNNING POWER (W)	1.68	1.88	1.73	1.85	1.74	1.78	1.71	1.74	1.71	1.78	1.74	1.75	1.74	1.75
STARTING CURRENT* (A)	0.107	0.109	0.107	0.108	0.107	0.109	0.105	0.106	0.106	0.106	0.105	0.106	0.105	0.107
RUNNING CURRENT* (A)	0.090	0.093	0.092	0.095	0.092	0.094	0.092	0.093	0.091	0.094	0.091	0.093	0.091	0.092
TIME TO SYNCH (SEC)	17.2	17.7	16.9	17.6	16.8	17.4	17.4	17.2	17.0	17.5	17.5	17.5	17.3	17.9
800→720 RDT (SEC)	6.1	5.6	6.4	5.55	6.55	6.0	6.7	6.55	6.6	6.55	6.6	6.3	6.45	6.3
720→800 RUT (SEC)	2.25	2.45	2.3	2.45	2.25	2.35	2.3	2.3	2.35	2.4	2.35	2.45	2.4	2.45
60→0 RDT (SEC)	13.5	11.0	12.4	12.1	13.8	12.1	14.3	11.8	13.0	11.4	12.3	11.6	12.4	12.5
TOTAL RDT (SEC)	100	106	114.2	104.2	118.7	115.2	119.1	121.5	120	123.2	116	115.2	114.2	116.1
TOTAL ACCUMULATED RUNNING HOURS	342	342	444	444	546	546	647	647	748	748	852	852	1008	3020

* AVERAGE VALUES

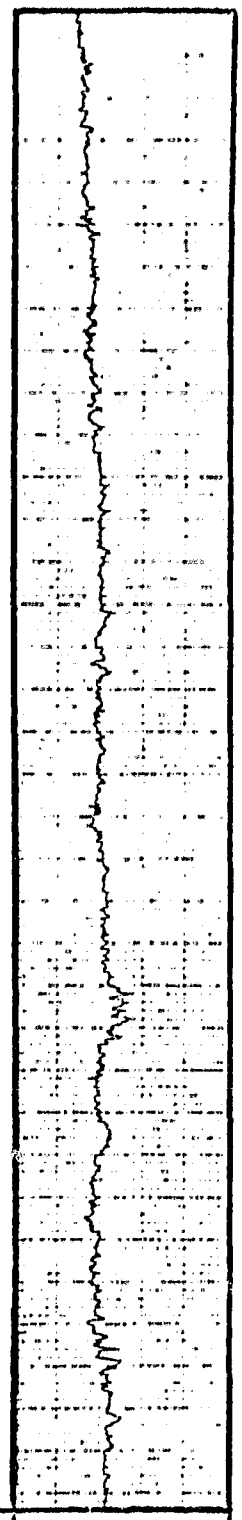

MOTOR, CONTAINER AND STERILIZATION CYCLE RUNS
GYRO MOTOR NO. 7
RUNDOWN TIME PERFORMANCE
FIGURE 1
TOTAL RUNDOWN TIME - SECS
60 - 0 RUNDOWN TIME - SECS
140
120
110
100
90
20
18
16
14
12
10
MOTOR RUN-IN
CONTAINER RUN-IN
AFTER 1ST STERILIZATION
AFTER 2ND STERILIZATION
AFTER 3RD STERILIZATION
AFTER 4TH STERILIZATION
AFTER 5TH STERILIZATION
AFTER 6TH STERILIZATION
0
100
200
300
400
500
600
700
800
900
1000
RUNNING TIME - HOURS
LIFE TEST
TOTAL RUNDOWN TIME - SECS
60 - 0 RUNDOWN TIME - SECS
140
120
110
100
90
20
18
16
14
12
10
0
200
400
600
800
1000
1200
1400
1600
1800
2000
RUNNING TIME - HOURS


MOTOR, CONTAINER AND STERILIZATION CYCLE RUNS
GYRO MOTOR NO. 11
RUN DOWN TIME PERFORMANCE
FIGURE 2
TOTAL RUNDOWN TIME - SECS
60 - 0 RUNDOWN TIME - SECS
MOTOR RUN-IN
CONTAINER RUN-IN
AFTER 1st STERILIZATION
AFTER 2nd STERILIZATION
AFTER 3rd STERILIZATION
AFTER 4th STERILIZATION
AFTER 5th STERILIZATION
AFTER 6th STERILIZATION
RUNNING TIME - HOURS
LIFE TEST
RUNNING TIME - HOURS

GYRO MCTOR NO. 7

MOTOR RUNDOWN TIME AND "POWER TAG" PERFORMANCE

FINAL CHECK FOLLOWING CONTAINER RUNIN



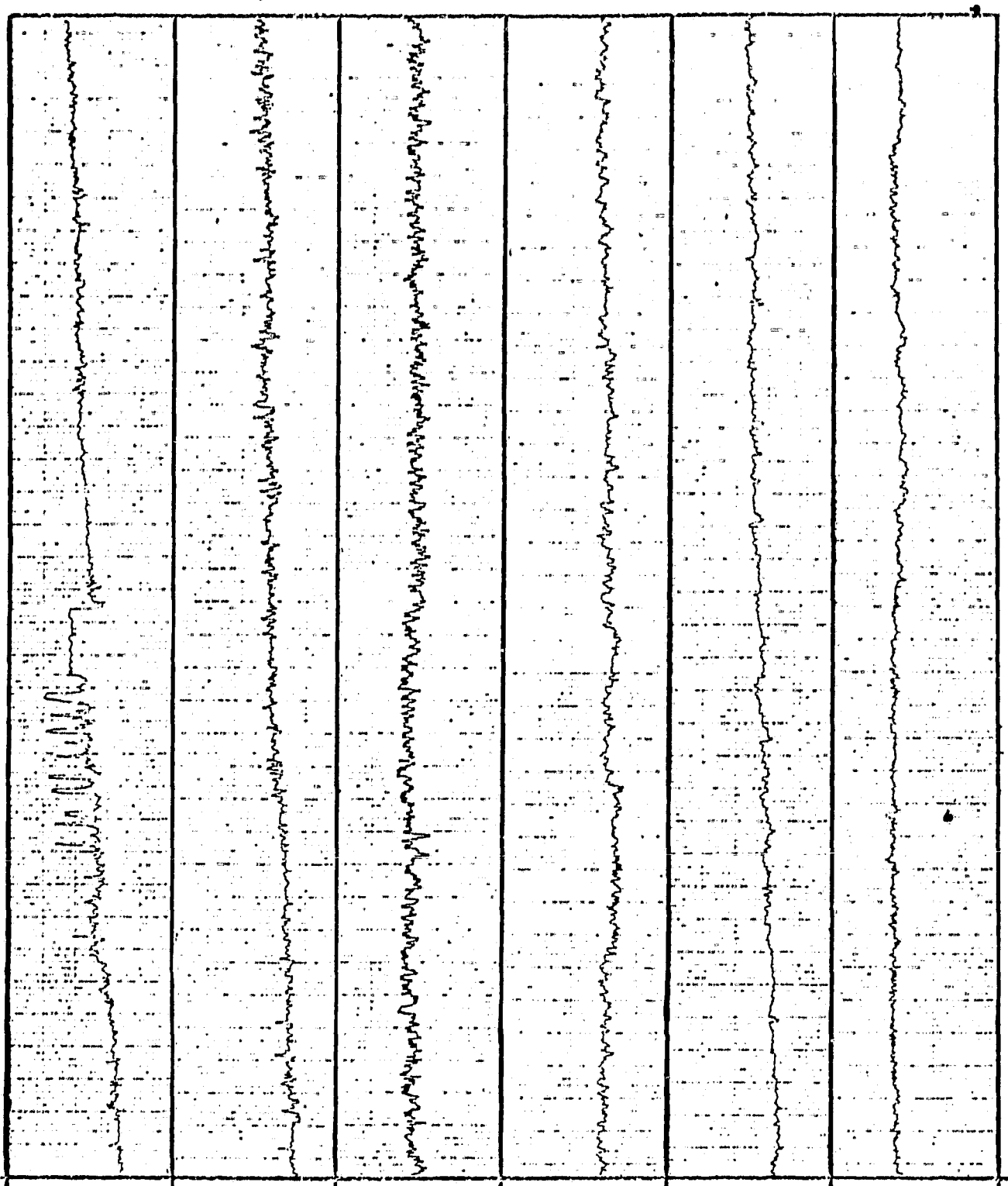
DATE	4/25/68
HOURS RUN	331
800 → 720 RDT	6.1
TOTAL RDT	102.2
60 → 0 RDT	13.7

FIGURE 3

GYRO MOTOR NO. 7

MOTOR RUNDOWN TIME AND "POWER TAG" PERFORMANCE

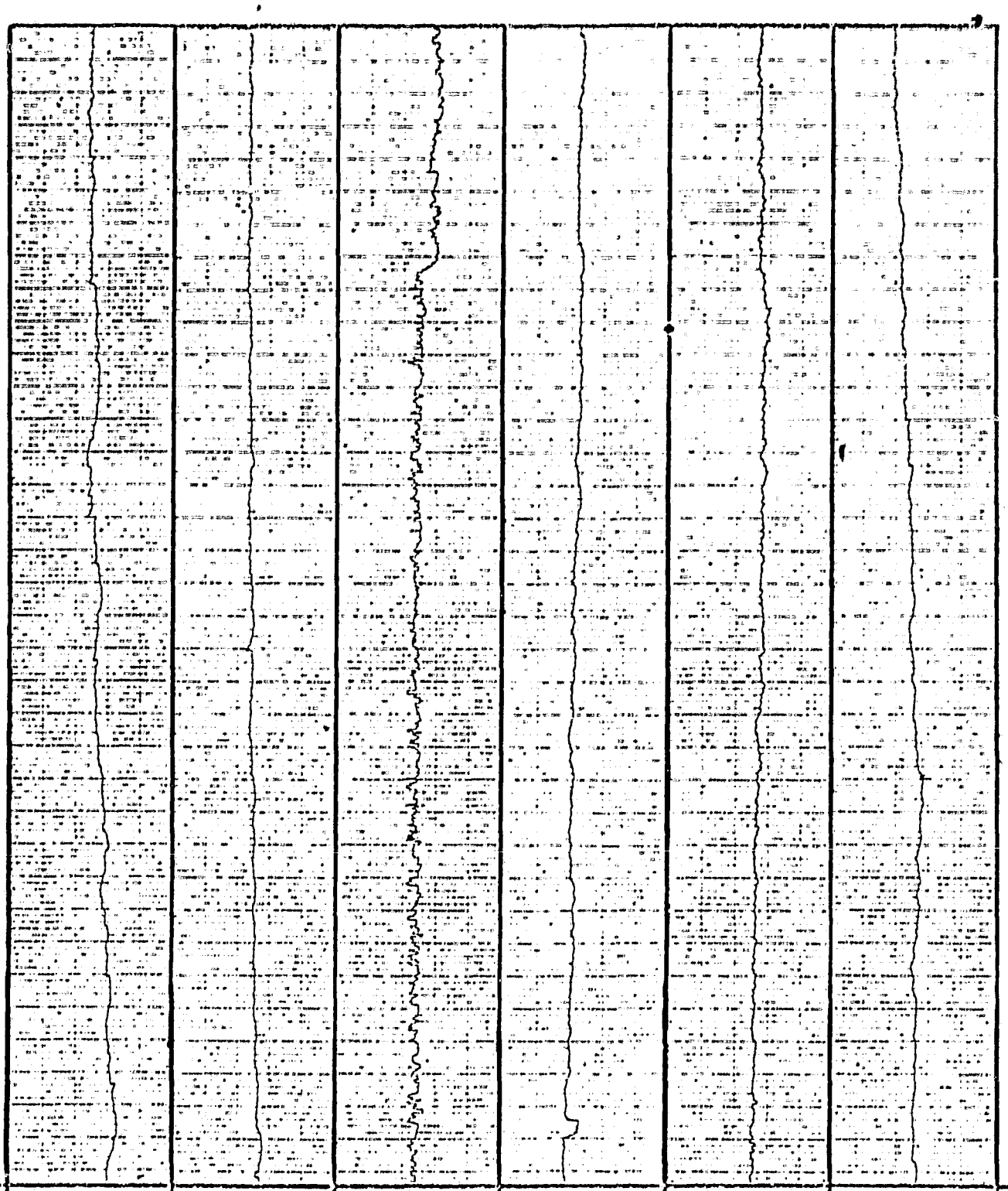
FOLLOWING 1ST STERILIZATION CYCLE



DATE	5/3/68	5/6/68	5/7/68	5/8/68	5/9/68	5/10/68	5/10/68
HOURS RUN	-0-	5	24	48	72	96	102
800→720 RDT	6.5	7.0	6.7	6.8	7.0	6.8	6.9
TOTAL RDT	107.5	123.4	122.6	123.0	124.5	128.8	121.6
60→0 RDT	10.8	15.0	13.7	15.0	14.2	14.1	15.7

FIGURE 4

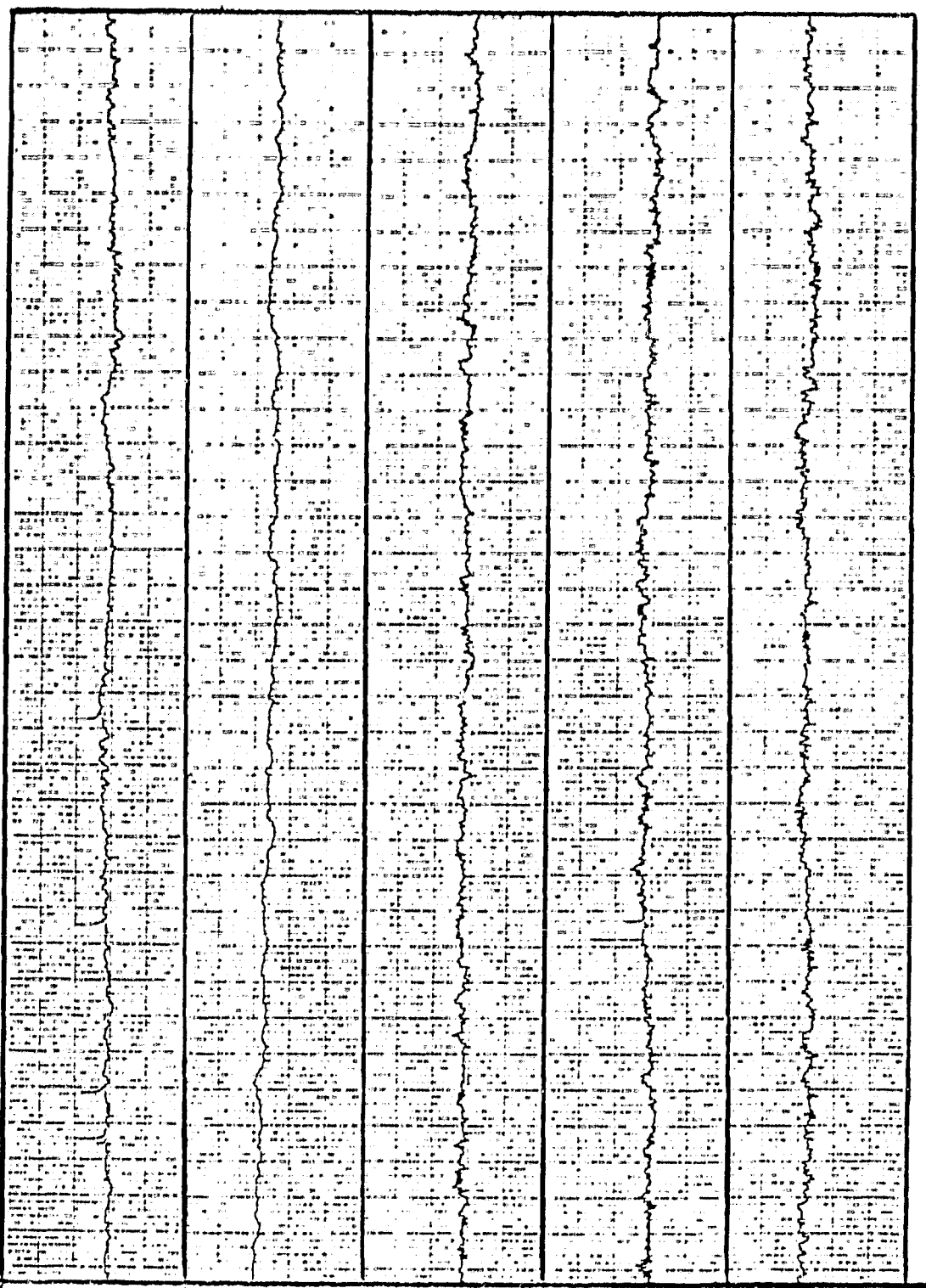
GYRO MOTOR NO.7
MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE
FOLLOWING 2ND STERILIZATION CYCLE



DATE	5/17/68	5/20/68	5/21/68	5/22/68	5/23/68	5/24/68	5/24/68
HOURS RUN	-0-	5	25	49	73	97	102
800→720 RDT	6.8	6.9	7.1	7.0	7.0	7.0	7.1
TOTAL RDT	116	129.5	128.6	129	126.8	125.1	124.4
60→0 RDT	13.8	14.1	14.2	14.0	12.8	15.2	14.1

FIGURE 5

GYRO MOTOR NO. 7
MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE
FOLLOWING 3RD STERILIZATION CYCLE



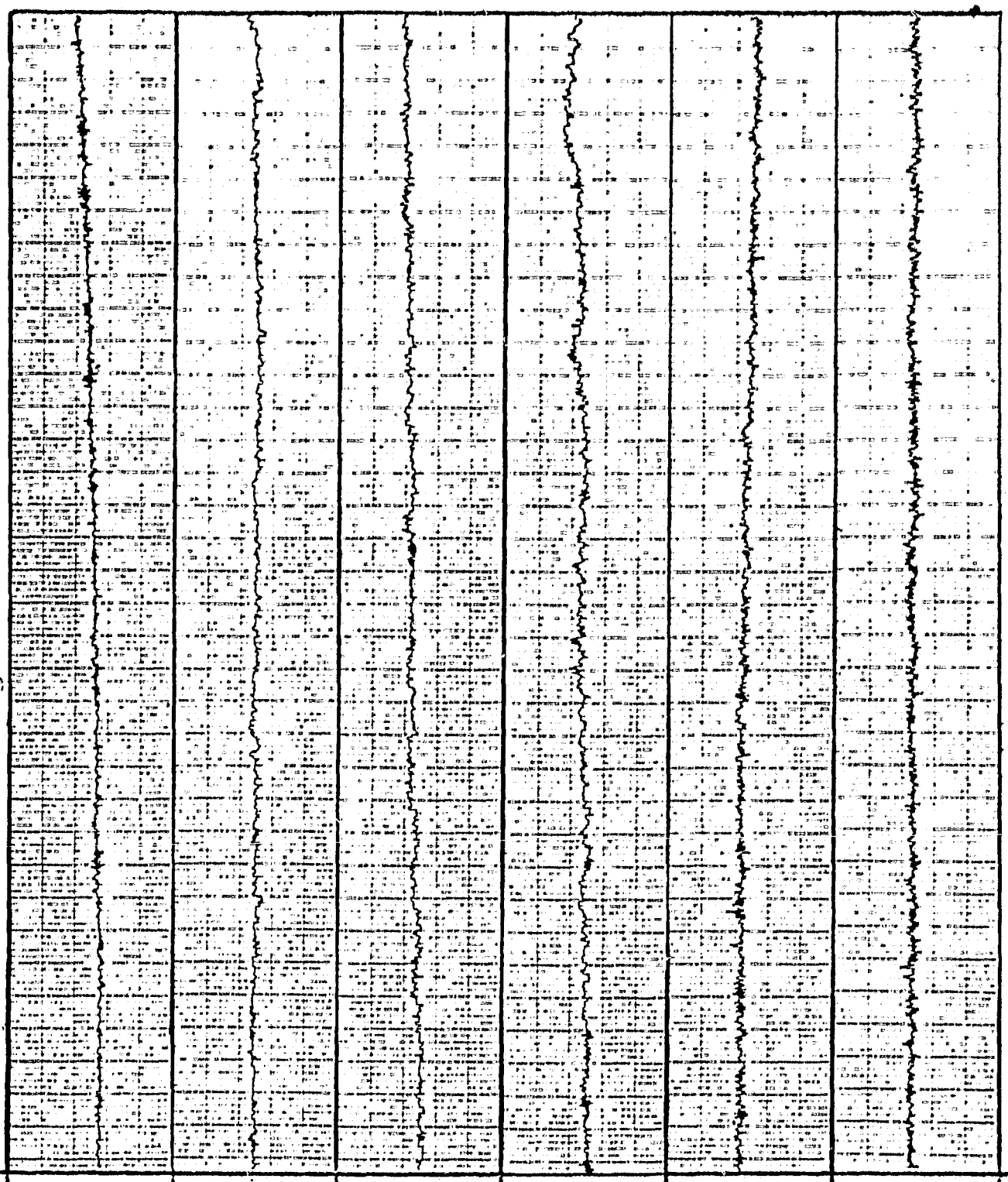
DATE	5/31/68	6/4/68	6/5/68	6/6/68	6/7/68	6/7/68
HOURS RUN	-0-	23	47	71	95	101
800 → 720 RDT	6.9	7.1	7.1	6.9	7.1	6.95
TOTAL RDT	128.4	131.6	133.5	131.3	133.1	128.6
60 → 0 RDT	14.7	14.7	15.9	15.9	15.7	15.2

FIGURE 6

GYRO MOTOR NO. 7

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

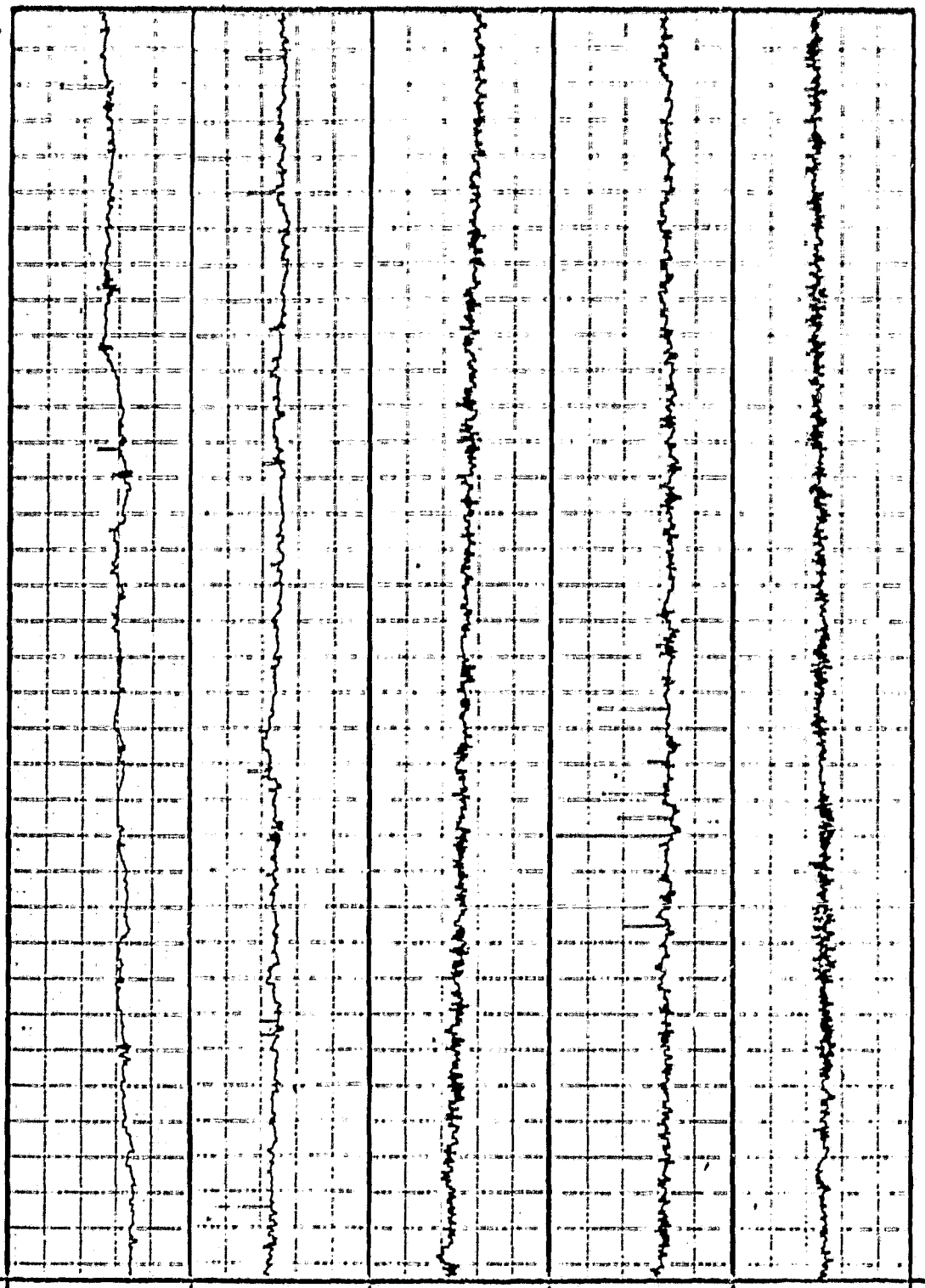
FOLLOWING 4TH STERILIZATION CYCLE



DATE	6/14/68	6/17/68	6/18/68	6/19/68	6/20/68	6/21/68	6/21/68
HOURS RUN	-0-	5	24	48	72	96	101
800→720 RDT	6.85	7.1	7.1	7.1	7.1	6.8	6.85
TOTAL RDT	128.5	132.9	132.4	136.3	129.9	130.2	122
60→0 RDT	15.3	14.7	14.5	14.9	14.7	15.0	15.3

FIGURE 7

GYRO MOTOR NO. 7
MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE
FOLLOWING 5TH STERILIZATION CYCLE



DATE	7/1/68	7/2/68	7/3/68	7/5/68	7/6/68	7/6/68
HOURS RUN	-0-	6	30	78	101	104
800→720 RDT	6.85	7.1	7.1	6.9	6.8	6.8
TOTAL RDT	130.3	138.7	129.4	129.7	122.9	119.1
60→0 RDT	15.6	15.1	13.7	15.9	14.5	14.3

FIGURE 8

GYRO MOTOR NO. 7
MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE
FOLLOWING 6TH STERILIZATION CYCLE



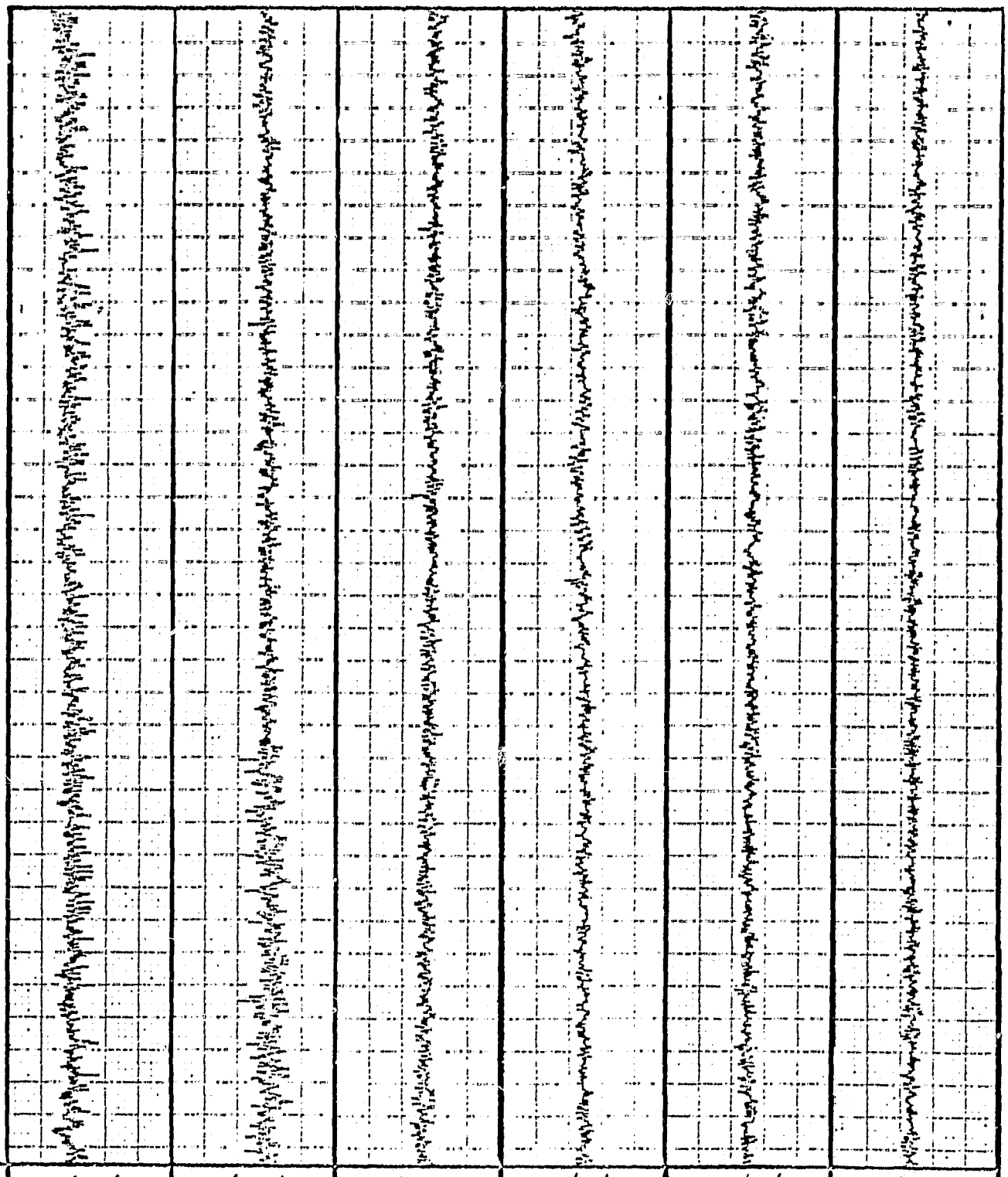
DATE	7/15/68	7/16/68	7/17/68	7/18/68	7/19/68	7/22/68	7/22/68
HOURS RUN	-0-	22	42	60	82	153	156
800-720 RDT	6.7	6.9	6.8	6.7	6.8	6.6	6.6
TOTAL RDT	126.1	128.9	124.9	122.0	126.4	122.6	122.1
60→0 RDT	15.1	15.8	14.8	14.2	15.0	14.9	14.1

FIGURE 9

GYRO MOTOR NO. 7

MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE

DURING LIFE TEST



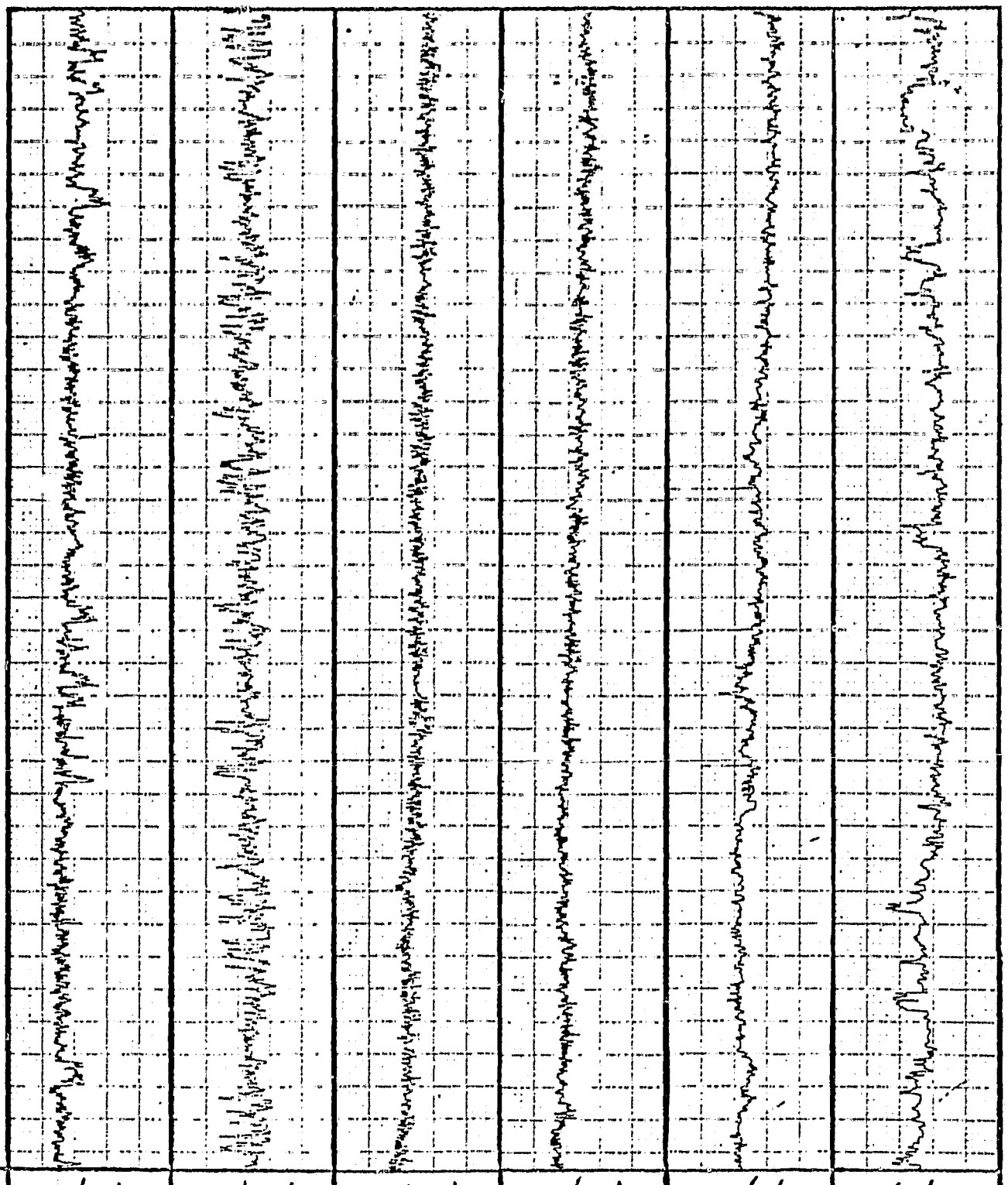
DATE	7/26/68	7/30/68	8/2/68	8/5/68	8/8/68	8/12/68
HOURS RUN	96	192	264	336	408	504
800→720 RDT	6.75	6.6	6.8	6.8	6.6	6.75
TOTAL RDT	120.6	117.7	117.4	119.1	117.4	118.6
60→0 RDT	14.8	14.5	14.1	14.0	13.6	13.3

FIGURE 10

GYRO MOTOR NO. 7

MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE

DURING LIFE TEST



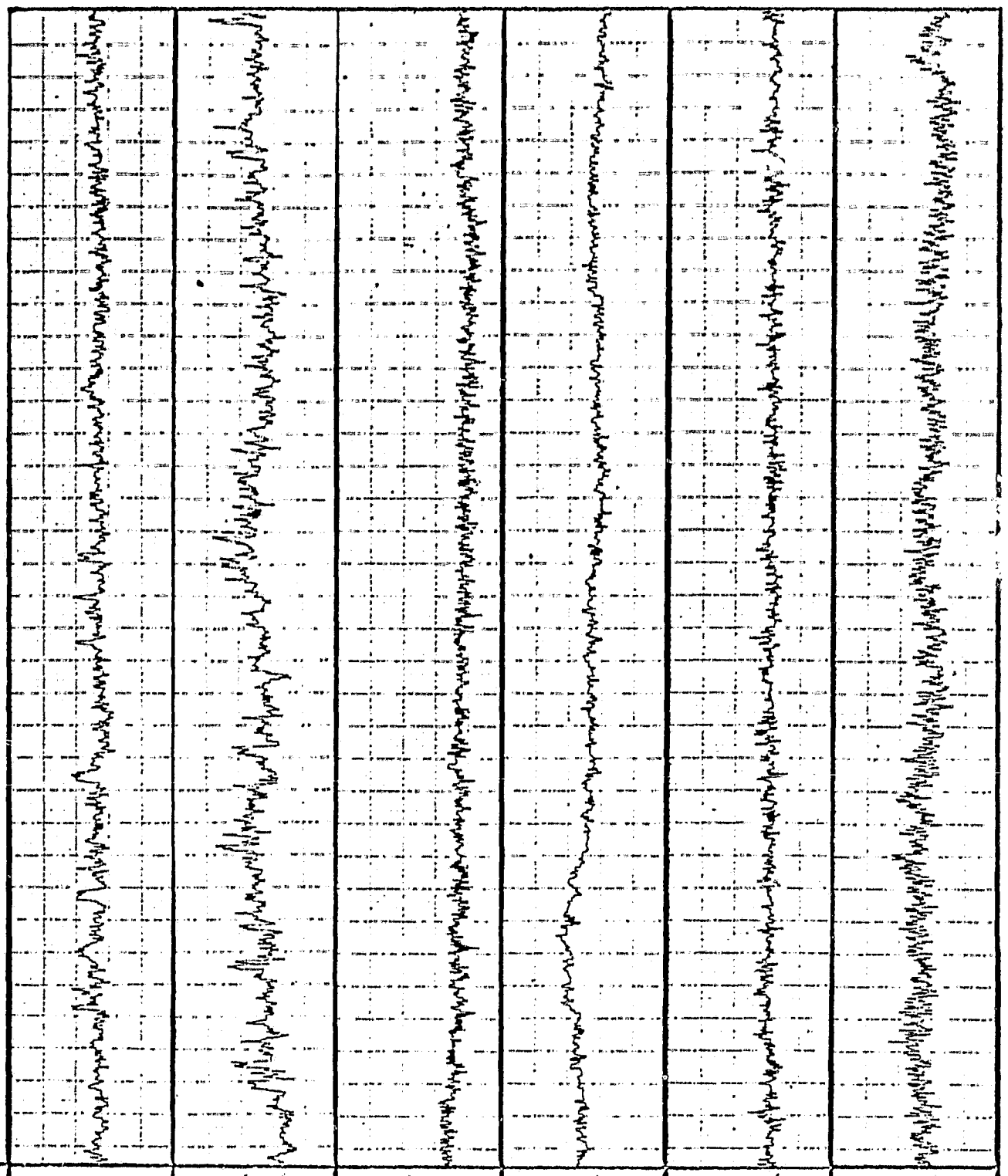
DATE	8/16/68	8/21/68	8/26/68	8/30/68	9/3/68	9/9/68
HOURS RUN	600	720	840	936	1032	1176
80V→720 RDT	6.8	6.6	6.7	6.5	6.6	6.7
TOTAL RDT	117.4	115	113.3	118.8	119.1	119.8
60→0 RDT	13.4	13.5	14.1	13.3	13.7	13.8

FIGURE 11

GYRO MOTOR NO. 7

MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE

DURING LIFE TEST



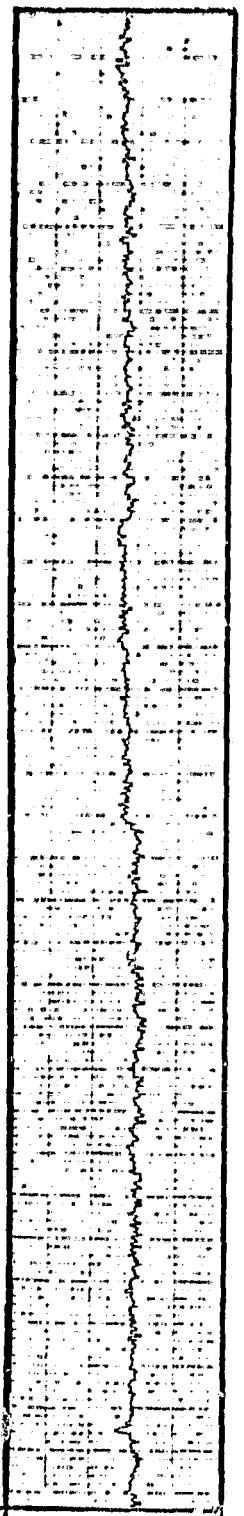
DATE	9/13/68	9/18/68	9/23/68	10/3/68	10/14/68	10/22/68
HOURS RUN	1272	1392	1512	1680	1824	2012
800→720 RDT	6.7	6.5	6.6	6.7	6.5	6.3
TOTAL RDT	120.4	118.4	121.4	124.8	112.8	105.7
60→0 RDT	14.1	14.8	15.0	14.4	12.9	14.0

FIGURE 12

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

FINAL CHECK FOLLOWING CONTAINER RUNIN



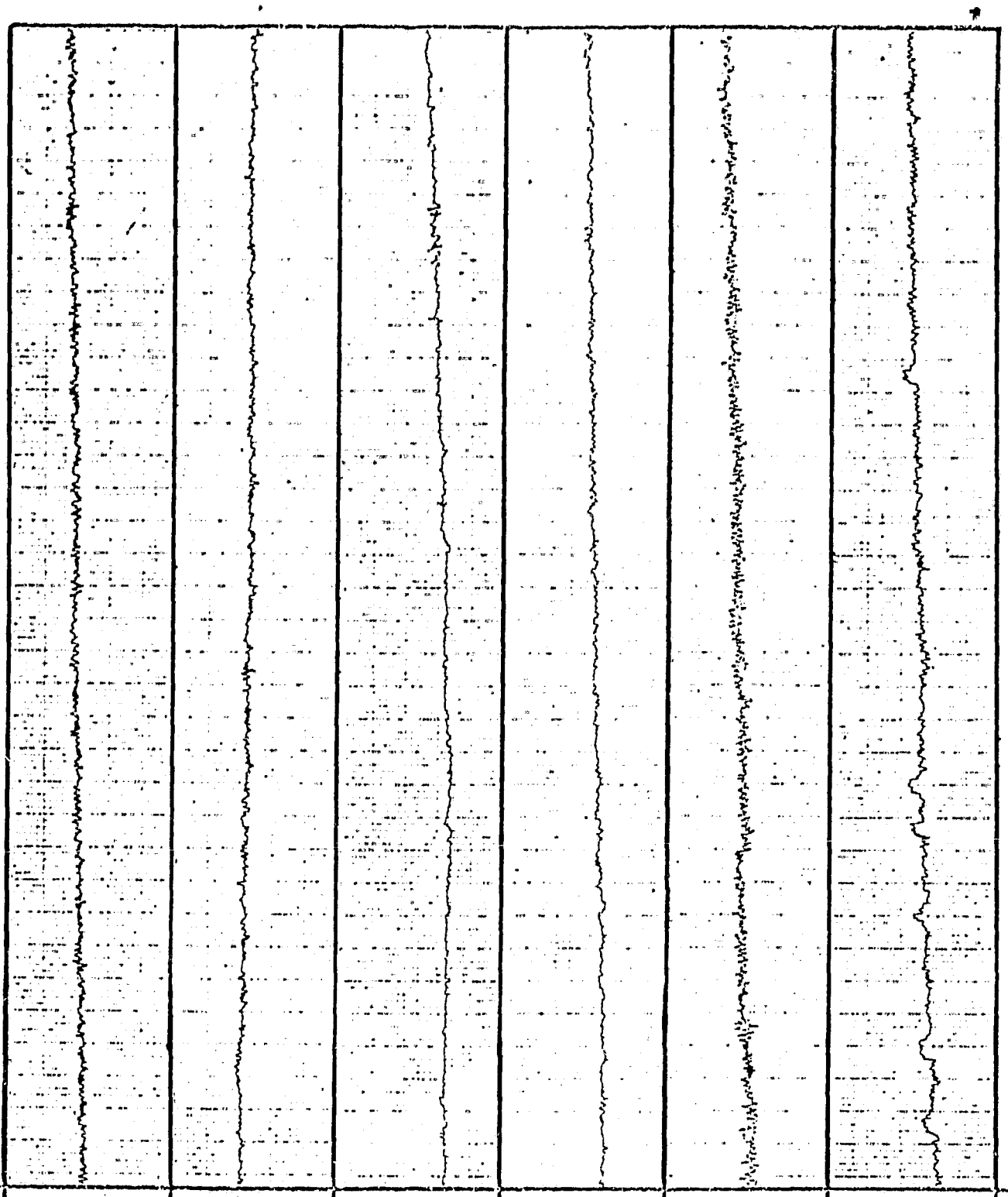
DATE	4/25/68
HOURS RUN	342
800→720 RDT	6.1
TOTAL RDT	100
60→0 RDT	13.5

FIGURE 13

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

FOLLOWING 1ST STERILIZATION CYCLE



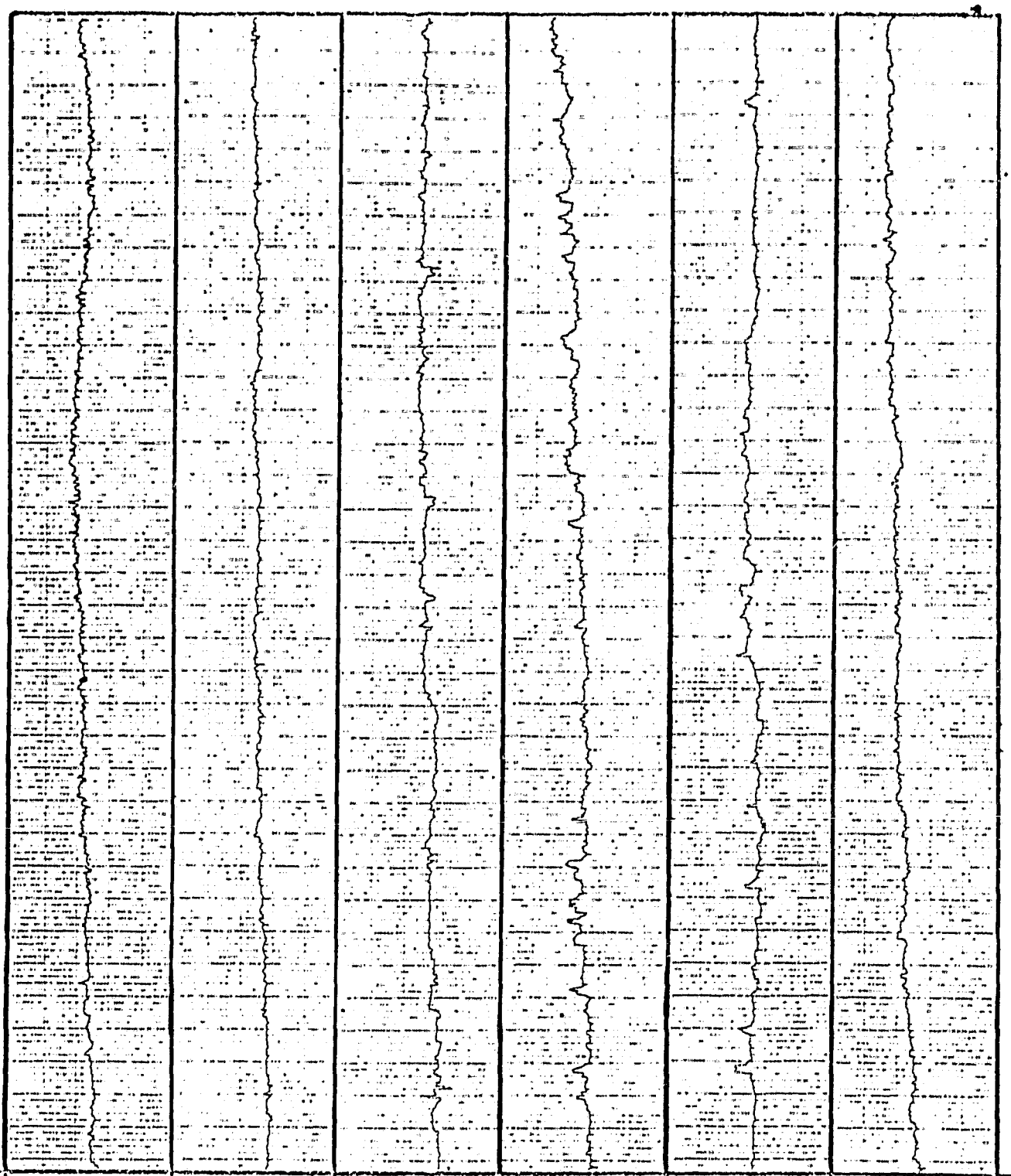
DATE	5/3/68	5/6/68	5/7/68	5/8/68	5/9/68	5/10/68	5/11/68
HOURS RUN	-0-	5	24	48	72	96	102
800→720 RDT	5.6	6.5	6.3	6.2	6.6	6.5	6.4
TOTAL RDT	106	120	115	118.9	116.7	118.1	114.2
60→0 RDT	11.0	14.2	12.5	12.4	12.6	13.3	12.4

FIGURE 14

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

FOLLOWING 2ND STERILIZATION CYCLE



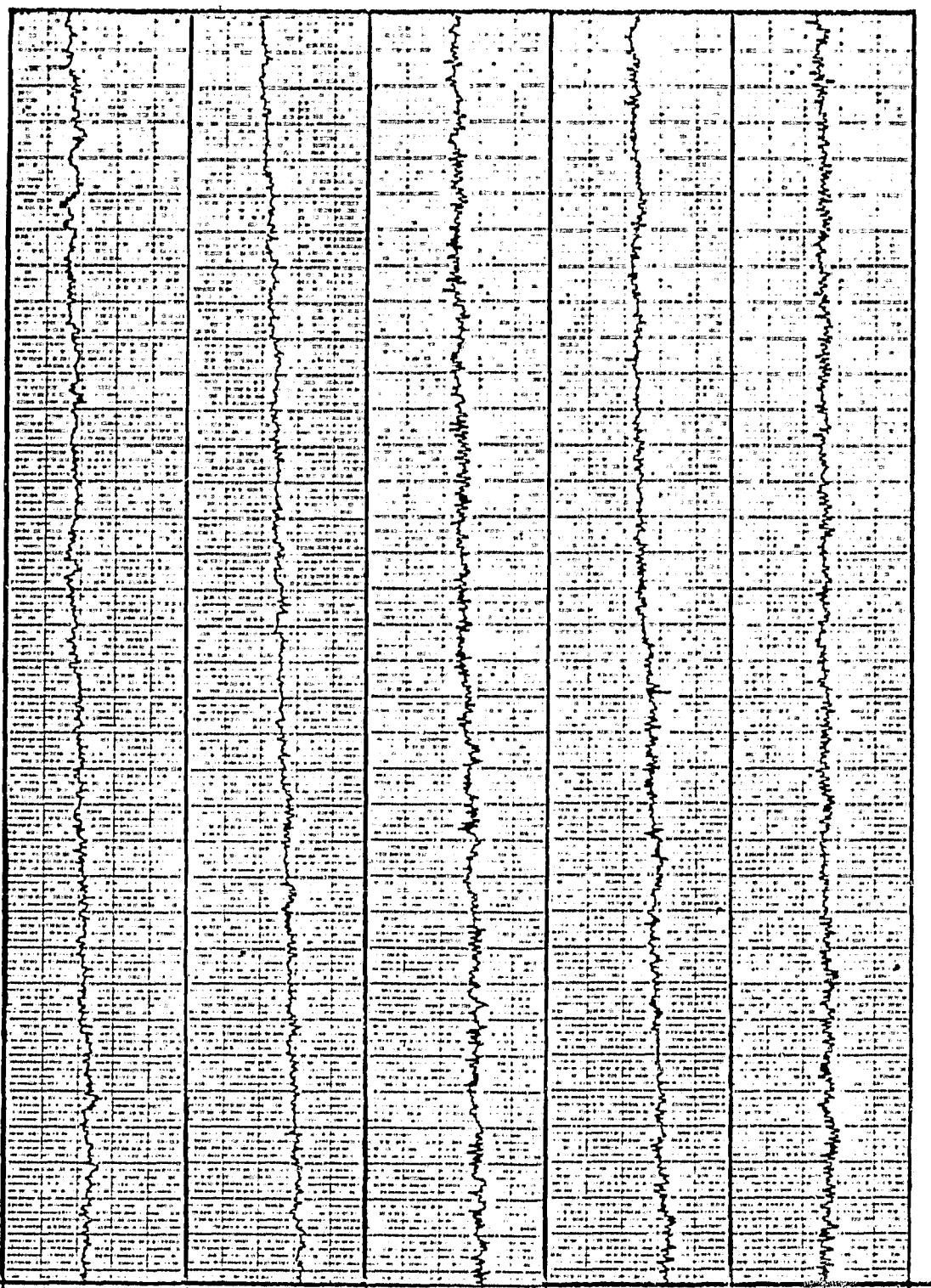
DATE	5/17/68	5/20/68	5/21/68	5/22/68	5/23/68	5/24/68	5/24/68
HOURS RUN	-0-	5	25	49	73	97	102
800→720 RDT	5.55	6.3	6.8	6.6	6.5	6.4	6.55
TOTAL RDT	104.2	128.9	132.6	125.6	120.9	119.8	118.7
60→0 RDT	12.1	14.3	14.9	14.6	13.6	12.9	13.8

FIGURE 15

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

FOLLOWING 3RD STERILIZATION CYCLE



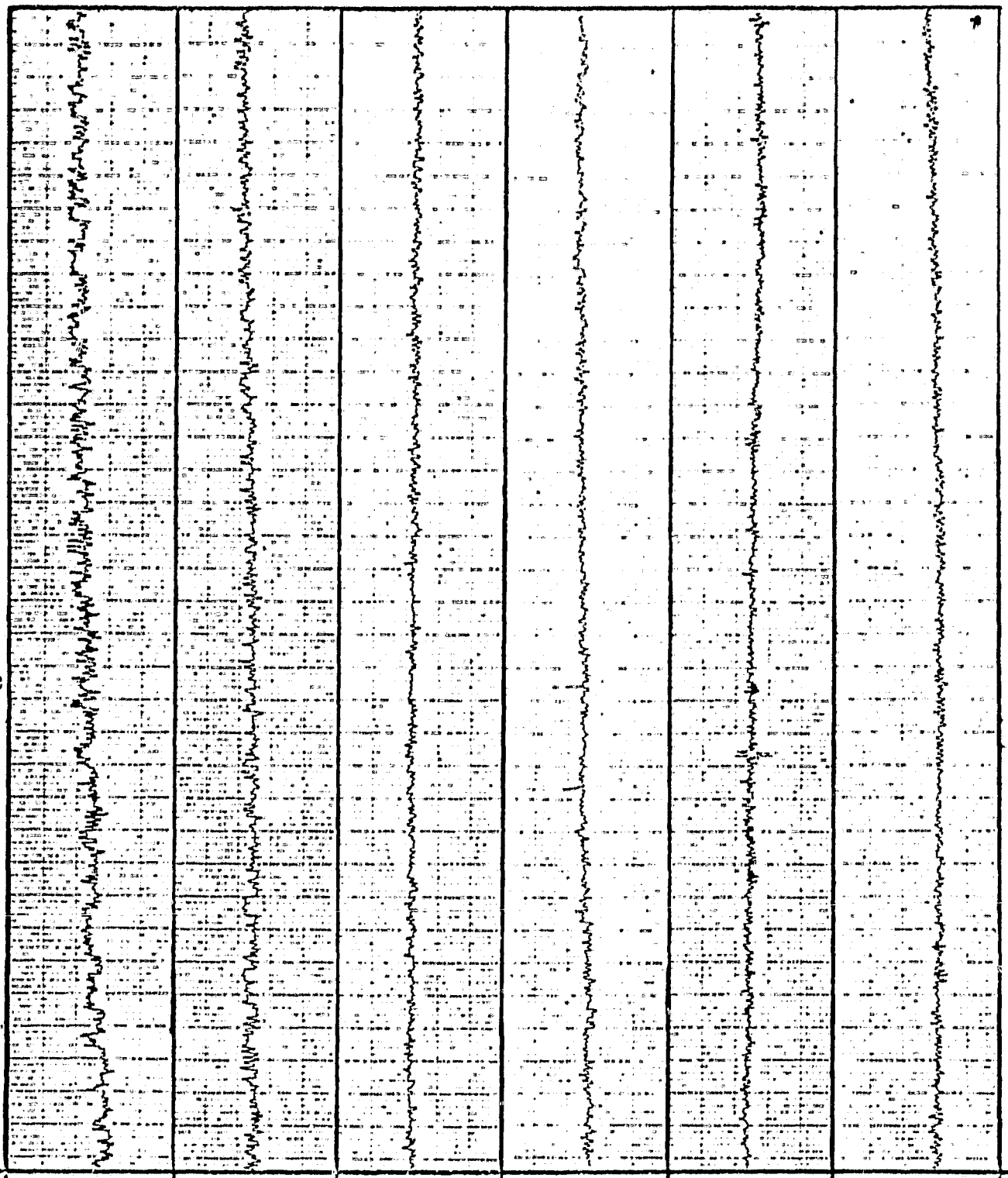
DATE	5/31/68	6/4/68	6/5/68	6/6/68	6/7/68	6/7/68
HOURS RUN	-0-	2.3	47	71	95	101
900→720 RDT	6.0	7.0	6.8	6.8	6.8	6.7
TOTAL RDT	115.2	125.5	124.6	125.8	120.4	119.1
60→0 RDT	12.1	13.6	12.9	14.4	13.1	14.3

FIGURE 16

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

FOLLOWING 4TH STERILIZATION CYCLE



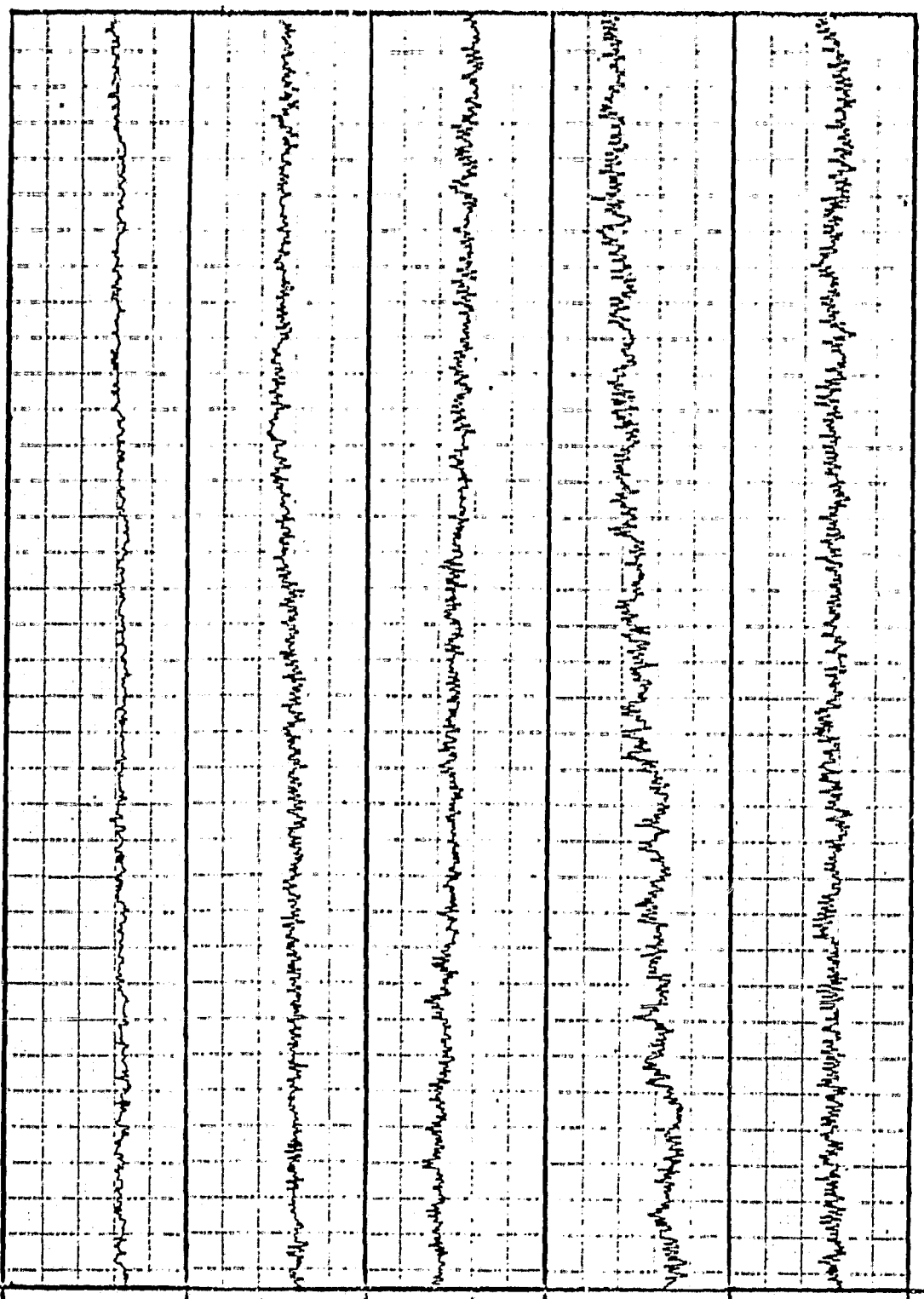
DATE	6/14/68	6/17/68	6/18/68	6/19/68	6/20/68	6/21/68	6/21/68
HOURS RUN	-0-	5	24	48	72	96	101
800+720 RDT	6.55	7.0	6.9	6.9	6.9	6.7	6.6
TOTAL RDT	121.5	129.9	128.9	129.3	125.0	123.2	120
60→0 RDT	11.8	13.9	13.4	13.7	13.3	13.0	13.0

FIGURE 17

GYRO MOTOR NO. 11

MOTOR RUN-DOWN TIME AND "POWER JAG" PERFORMANCE

FOLLOWING 5TH STERILIZATION CYCLE

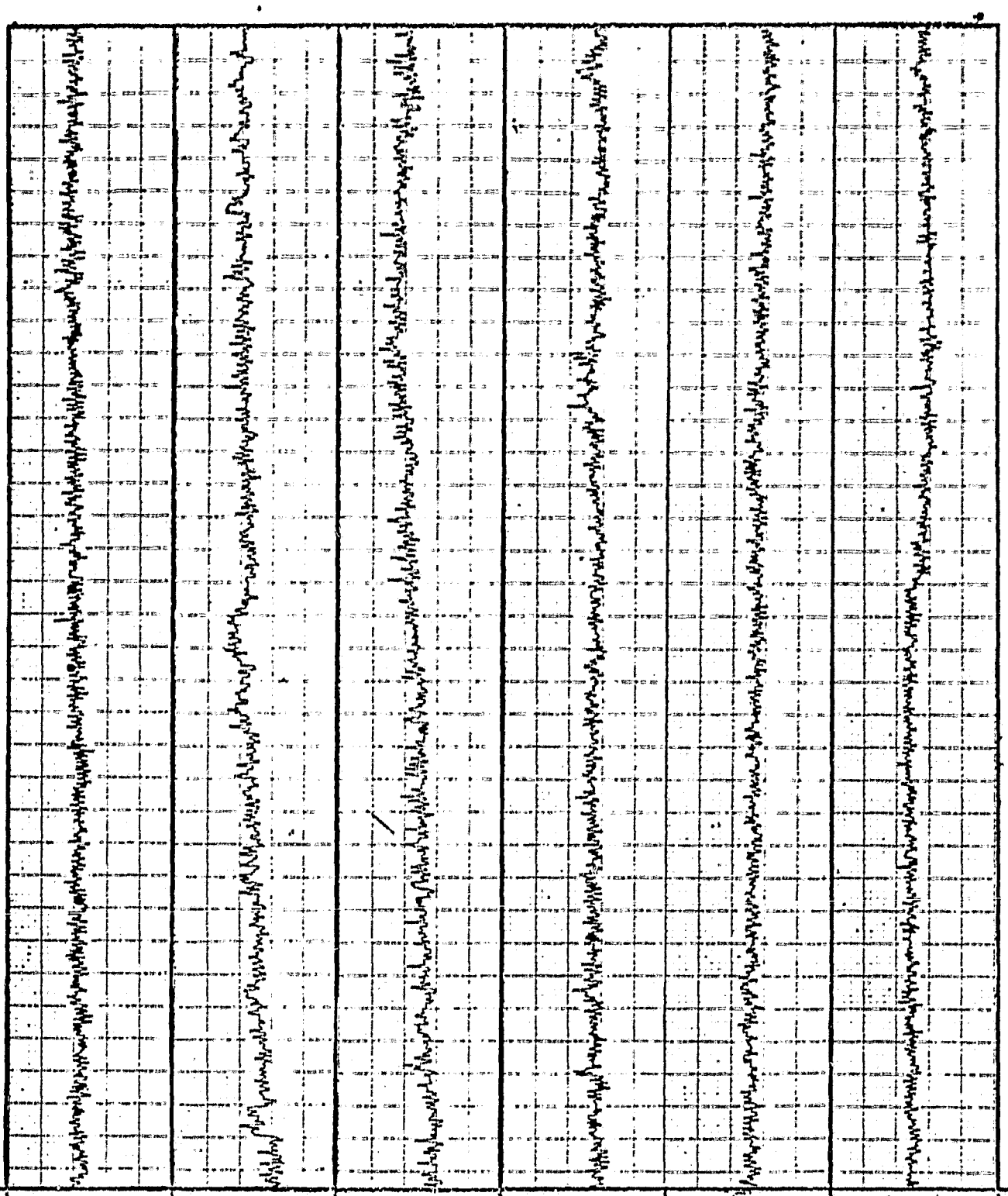


DATE	7/1/68	7/2/68	7/3/68	7/5/68	7/6/68	7/6/68
HOURS RUN	-0-	6	30	78	101	104
800→720 RDT	6.55	6.9	6.7	6.6	6.6	6.6
TOTAL RDT	123.2	128.6	128.1	121.1	119.1	116
60→0 RDT	11.4	13.2	15.0	13.3	14.3	12.3

FIGURE 18

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE FOLLOWING 6TH STERILIZATION CYCLE

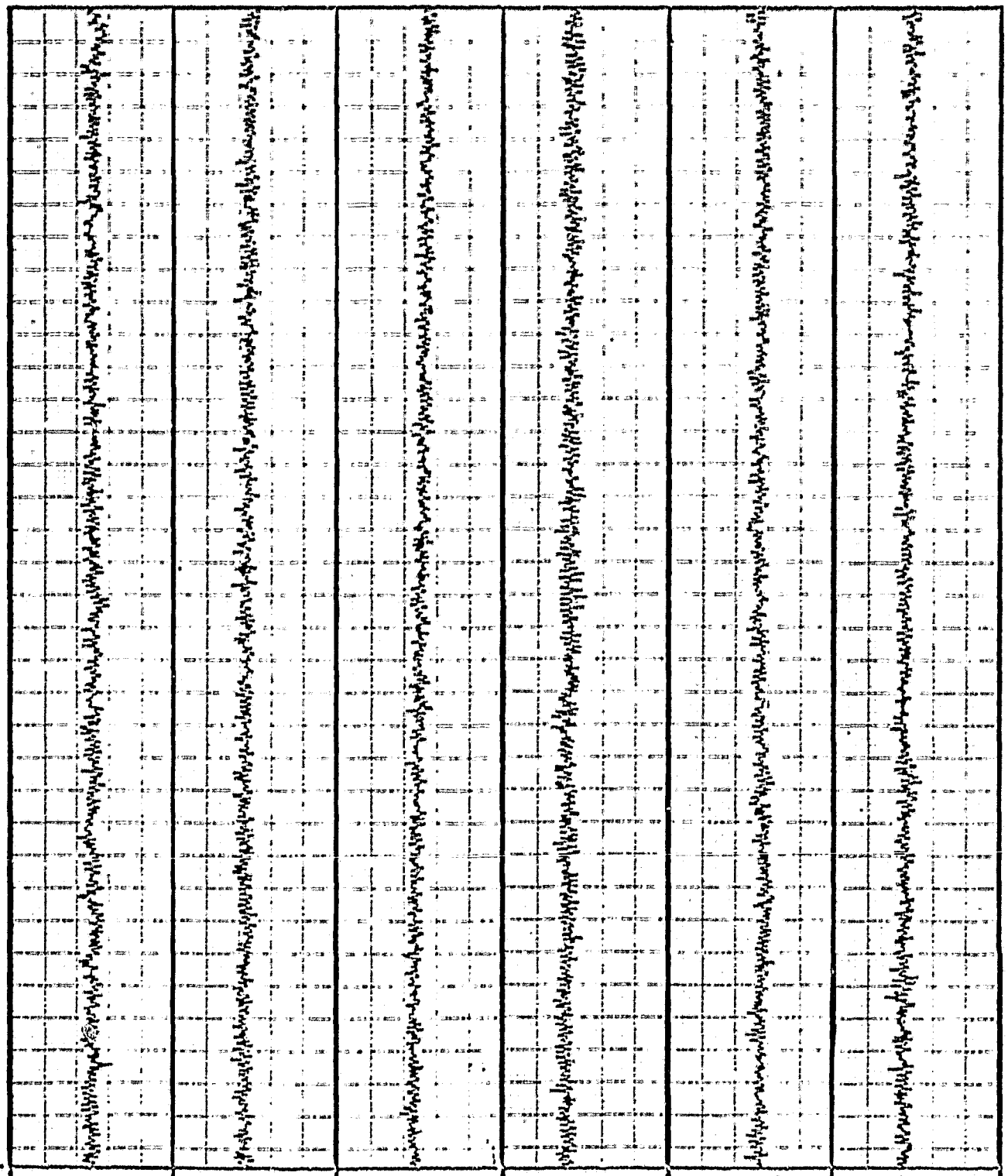


DATE	7/15/68	7/16/68	7/17/68	7/18/68	7/19/68	7/22/68	7/22/68
HOURS RUN	-0-	22	42	60	82	153	156
800→720 RDT	6.3	6.8	6.6	6.3	6.5	6.3	6.45
TOTAL RDT	115.2	124.9	123.0	119.1	123.5	120.7	114.2
60→0 RDT	11.6	12.1	14.1	12.9	12.9	12.7	12.4

FIGURE 19

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE DURING LIFE TEST

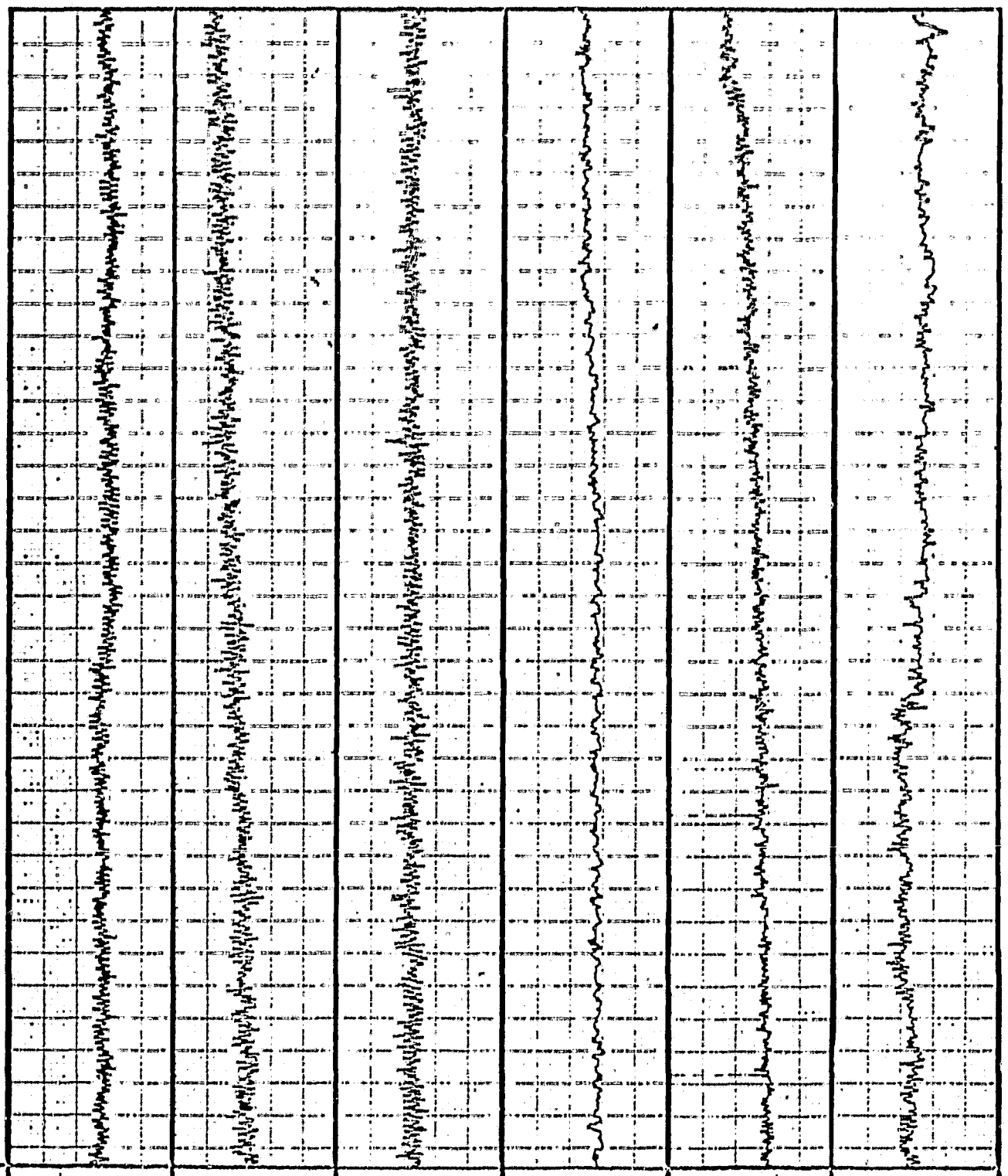


DATE	7/26/68	7/30/68	8/2/68	8/5/68	8/8/68	8/12/68
HOURS RUN	96	192	264	336	408	504
800→720 RDT	6.45	6.35	6.35	6.1	6.45	6.3
TOTAL RDT	116.6	113.7	116.2	114.9	113.4	115.3
60→0 RDT	13.6	12.5	12.3	12.3	13.8	12.8

FIGURE 20

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND POWER JAG PERFORMANCE DURING LIFE TEST



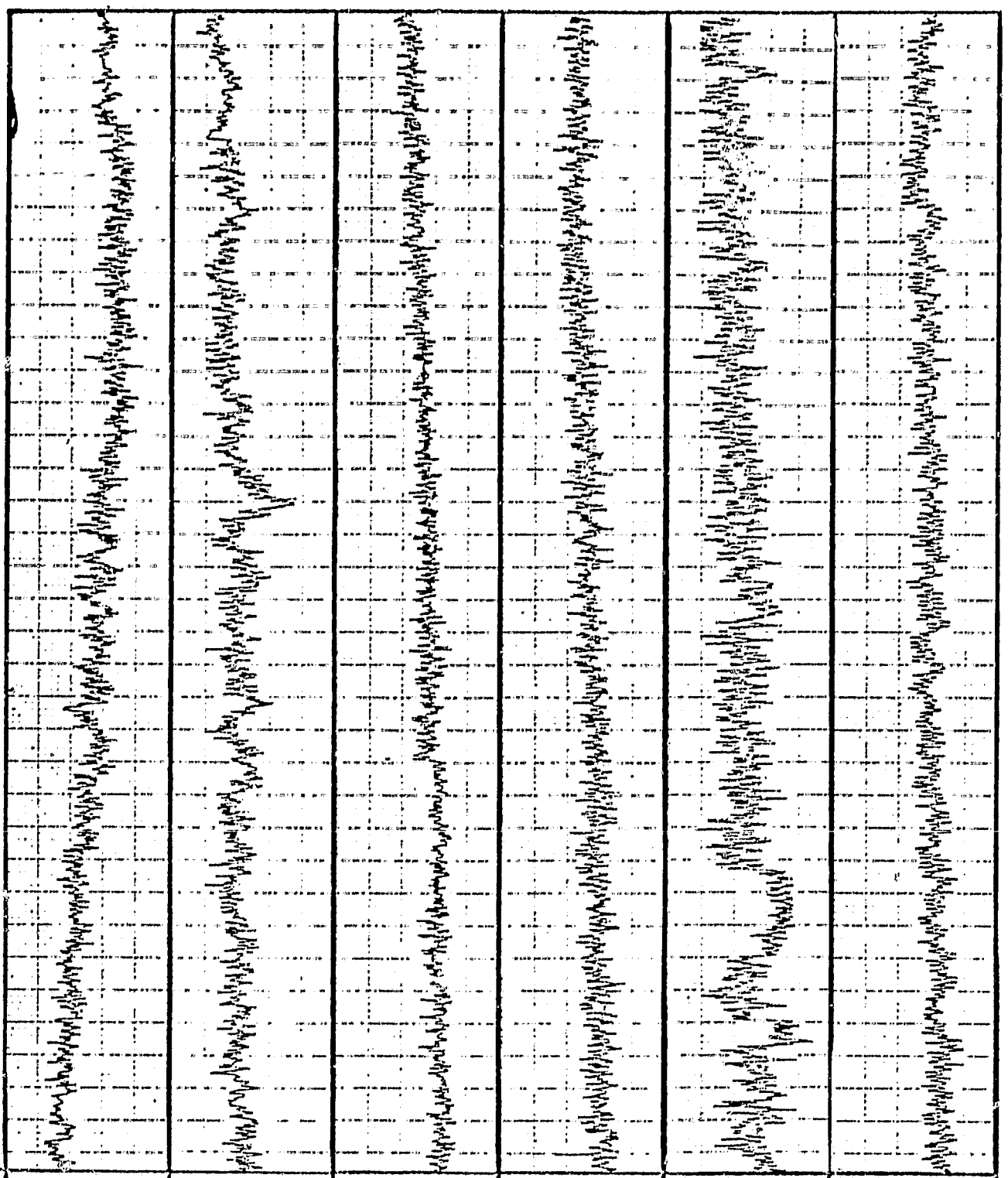
DATE	8/16/68	8/21/68	8/26/68	8/30/68	9/3/68	9/9/68
HOURS RUN	600	720	840	936	1032	1176
ECCA 720 EDT	6.2	6.2	6.1	6.7	5.9	6.9
TOTAL EDT	109.8	105.8	109.7	138.2	136.6	123.9
ECCA 0 EDT	12.1	12.4	13.3	18.1	18.0	13.9

FIGURE 21

GYRO MOTOR NO. 11

MOTOR RUNDOWN TIME AND "POWER JAG" PERFORMANCE

DURING LIFE TEST



DATE	9/13/68	9/18/68	9/23/68	10/8/68	10/14/68	10/22/68
HOURS RUN	1272	1392	1512	1680	1824	2012
800→720 RDT	6.8	6.5	6.4	6.4	6.6	6.3
TOTAL RDT	119.2	120.7	121.6	110.9	117.3	116.1
60→0 RDT	13.6	12.8	13.5	12.0	14.0	12.5

FIGURE 22

4. CONCLUSIONS

The results indicate that the two gyro motors have successfully passed the six sterilization cycles and the 2000 hour life test which followed these cycles.

It may be concluded, therefore, that the present ALPHA III gyro motor, without modifications, can safely withstand the JPL sterilization requirement.

5. RECOMMENDATIONS

This sterilization effort has proven that the ALPHA III gyro motor is capable of withstanding six sterilization cycles. It is therefore recommended that this sterilization program be carried a step further to encompass the entire gyro. The effect of the sterilization cycles on the various gyro parameters must be obtained since, in actual practice the entire gyro would be sterilized and not just the gyro motor.

A follow-on program similar to the motor sterilization program is suggested for the gyro. In this program the ability of the gyro piece parts to withstand the sterilization temperature would be evaluated. These parts would be external to the gyro motor since this report proves that the gyro motor can safely withstand sterilization.

The gyro assembly would be tested both before being submitted to sterilization, during each cycle, and again upon completion of all sterlilization cycles. Comparing the gyro drift performance would determine if sterilization had caused any detrimental effect to gyro performance.

6. NEW TECHNOLOGY

There are no new technological advances to report.

7. BIBLIOGRAPHY

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- Quarterly Progress Report No. 2 for C702543 ALPHA III Ball Bearing Gyroscope Motor Sterilization Program, dated 15 February 1968.
- Quarterly Progress Report No. 3 for C702543 ALPHA III Ball Bearing Gyroscope Motor Sterilization Program, dated 15 May 1968.
- Quarterly Progress Report No. 4 for C702543 ALPHA III Ball Bearing Gyroscope Motor Sterilization Program, dated 15 August 1968.

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