Bendix
Aerospace Systems Division

NO.	REV. NO.
ATM-1001	

PSE Anomalies ALSEP 4

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DATE 12 April 1971

This ATM provides the results of an investigation of the PSE anomalies which occurred during the ALSEP 4 Lunar Mission.

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1.0 INTRODUCTION

During the first 45 days of ALSEP 4 Lunar Operation, the following anomalies were noted and reported to BxA.

1.1 Long Period Vertical oscillation and saturation off scale at filter-in operation.

1.2 "Y" motor turn on delayed intermittently.

1.3 Heater auto on minimum condition causes additional heating over heater off condition at lunar noon.

2.0 LONG PERIOD VERTICAL FILTER IN ANOMALY

The Long Period Seismometers have been designed to have two modes of operation, Filter Out and Filter In.

1. The Filter Out mode provides feedback to the seismometer for all periods of operation. This produces an instrument of approximately 2.5 second natural period and under damped. This mode of operation was designed for high stability and rapid response to be used at set up and leveling.

2. The Filter In mode provides selected feedback to the seismometer by inserting a 1,000 second time constant filter in the feedback loop. This produces an instrument of approximately 15 second natural period and critically damped. This mode of operation will give a long period seismic output and a stable DC response tidal output.

The anomalous condition occurs when the filter in command is received, the vertical seismometer starts long period oscillations of increasing amplitude and finaly saturates the output to full scale deflection.

2.1 Data Analysis (Reference Figures 2.1 through 2.6)

The data reviewed at BxA indicates nine attempts at filter-in operation. The first two times the filter in command was used, the sensor temperature was off scale low, and the operation of the seismometer was similar for each command. The LP output, at -30 db, shows a long period oscillation going to positive saturation, then drifting to center when a small positive pulse occurs followed by the LP output signal going to negative

saturation. The tide output then goes to negative saturation and stays there while the LP output goes to positive saturation then returns slowly to center. At filter out command the tide output goes immediately to positive saturation then both the LP and tide output go to negative saturation, then to normal filter-out operation.

The third time the filter in command was used, 037:16:31:10, the sensor temperature was 113°F and rising. The LP output, at 0 db, shows a normal instrument operation until the LP calibration command caused a negative going output that cycled to saturation, through midscale and then back to center. The next LP calibration command produced a normal calibration pulse indicating a period of about 10 to 11 seconds and normal damping. At 27 minutes after filter in command, oscillations started and the vertical outputs repeated the operation of the first two filter-in commands.

The fourth, fifth and sixth filter-in commands all produced results similar to the first two commands. These commands were repeated when the tide output was negative, centered and positive.

The seventh filer-in command was left in the filter in state to operate for a longer time. After the initial oscillation and saturation of LP and tide outputs, similar to the previous conditions, the tide output shows a drift from negative to positive at a rate equal to the time constant of the feedback filter. After the tide output reaches positive saturation there is a positive to negative saturation in about one second, simultaneously the LP output shows a center to negative saturation followed by a negative to positive saturation, then a drift to center. This cycle repeated in 16 minutes and then the filter was commanded to filter-out producing the same results as the previous filter-out commands.

The final two filter-in commands, number eight and nine, produced instrument operation similar to previous times except the LP output did not return to center after saturation but remained at a positive saturation condition between negative pulses when tide output went to negative saturation.

This data analysis is from the records represented by Figures 2.1 through 2.6. These are playbacks at .125 MM/sec and show a condensed view of the problem. Most of this analysis is from copies of data records made by BxA at the meeting with Mr. W. LeCroix and Mr. W. McDonald at MSC Houston on 5 March 1971. Playbacks at 1 MM/sec of pertinent times

were requested but arrived at BxA with the DL-06, Tidal Z, data missing and run at 10 MM/sec. This data was not of much value without the anomalous tide data. Another request was made for this data, however, the data has not been received as of this writing.

2.2 Circuit Analysis (Reference Figure 2.7)

The feedback filter electronics were analyzed to identify possible areas where a component change could affect the LPZ operation in the filter-in mode. The four potential areas reported in the Interim Report dated 29 March 1971 and additional analysis follow:

1. Polarized capacitor C8 could become reverse biased if the output of AR1 (operational amplifier) becomes more negative than -7.5 v. CR1 limits the reverse bias to -.7; however, if CR1 fails, the capacitor may be damaged.

This reverse bias condition would lead to a leakage in the capacitor and at filter-in command would cause the tide output to slowly go negative and drive the seismometer and demodulator output in a positive direction. This is not the condition of Apollo 14 anomaly.

2. If CR2 fails open, the voltage across C8 may approach the maximum rating for the capacitor. More importantly, the effective capacitance becomes that of C7, thereby changing the time constant by a factor of 100.

This again is not the condition of Apollo 14 as the feedback filter time constant seems to be normal, especially with negative to positive changes.

3. A degradation at the input stage of AR2 could cause an excessive bias current when the filter is switched in, causing an offset in AR2 due to the drop across the filter resistor.

In this case the results would be similar to leakage in the C8 capacitor but not necessarily with the same polarities.

4. If R13 is driven from a low power gate or flip-flop (9041 or 9040), it is possible that excessive leakage may turn the driver of Q2 partially on. This would cause a low time constant for the feedback filter and result in more seismic data on the tide output.

However, it has been determined that the driver for R13 is the collector of a transistor operating between +12 and -12 v and therefore is not a source of the problem.

2.3 Conclusion

The data analysis implies that the Apollo 14 vertical seismometer has a long natural period and is unstable, however, the data of the third filter-in command sent on 037:16:30:00 does not completely support this contention. During filter-in operation, the seismometer exhibited stable operation and an abnormal negative L. P. cal response and a normal positive L. P. cal response. After approximately 27 minutes of operation the seismometer exhibits an unstable response and drifts into saturation.

Past testing of this seismometer in earth configuration, lunar masses removed, has shown that unstable operation will occur when the period is adjusted to 8, 10 or as much as 12 seconds for some instruments. These periods would be about 20, 25 and 30 seconds for lunar operation. The difference of period vs unstable operation is a function of the mechanical configuration of the individual seismometers.

The tide output going from positive saturation to negative saturation in about one second could be caused by the FET switch used for filter-in, filter-out operation. For filter-in operation the Q2 transistor is cut off and gate of FET is at -12 v through the diode and R14. The FET is at pinch off with the gate at -12v and, therefore, looks like an open circuit. When the FET gate and source achieve equal voltages the FET is turned on and shorts resistors, R10 and R51, placing the circuit in filter-out operation.

A close study of the data indicates that the seismic output goes to a negative saturation condition. This could cause the source and gate of the FET filter switch to achieve equal voltage and thus cause a filter out condition where the tide output would go to a negative saturation in less than one second. The tide output being negative would cause a feedback signal to the seismometer and drive the seismometer in a positive direction causing the seismic output to go positive and allow the FET filter switch to open for filter-in operation. This would result in the seismic output being in a positive saturated condition while the tide output is negative and going positive at a rate equal to the time constant of feedback filter or about 1,000 seconds. Now when the tide output achieved a level equal to the seismic output this would allow the seismometer to go negative causing the seismic output to go to negative saturation and start the cycle all over.

From the above, it appears that the problem could be either mechanical or electrical; however, the data records are not sufficiently detailed to allow conclusive identification.

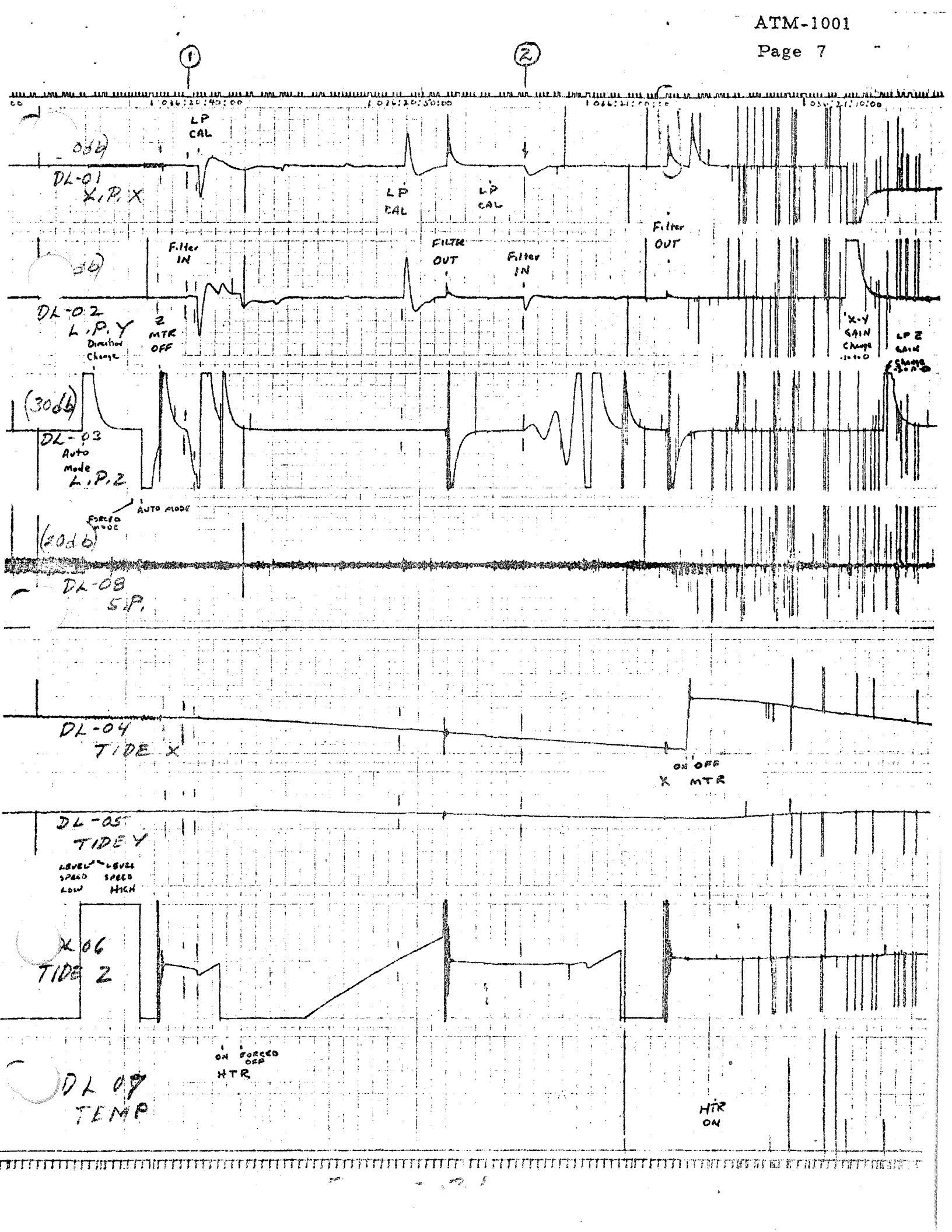
2.4 Recommendation

The ALSEP 4 PSE Sensor SN04 is presently operating in the filter-out mode and presenting satisfactory information.

Further study of this anomaly is recommended to establish by test using the engineering model parts that the filter-in, filter-out oscillatory condition can occur. Also, further study of unstable conditions with a normal, 15 second, or shorter natural period of the vertical seismometer is recommended.

A possible recommendation would be to shorten the period of the ALSEP 4 PSE sensor SN04 vertical seismometer by driving the X & Y axes off level to verify stable operation of the vertical seismometer with a filter-in period of 8 to 10 seconds.

This condition has not been noted on any units under test. The unstable condition has only been noted when the periods have been set abnormally long.


1
2
LP CAL
LP CAL
LP CAL
Filter IN
FILTER OUT
Filter IN
Filter OUT
DL-01 X, P, X
DL-02 L, P, Y
Direction Change
Z MTR OFF
X-Y GAIN Change
LP Z GAIN Change
(30db)
DL-03 Auto Mode L, P, Z
FORCED MODE
AUTO MODE
(20db)
DL-08 S.P.
DL-04 TIDE X
ON OFF X MTR
DL-05 TIDE Y
LEVEL SPEED LOW
LEVEL SPEED HIGH
DL-06 TIDE Z
ON FORCED OFF HTR
DL-07 TEMP
HTR ON

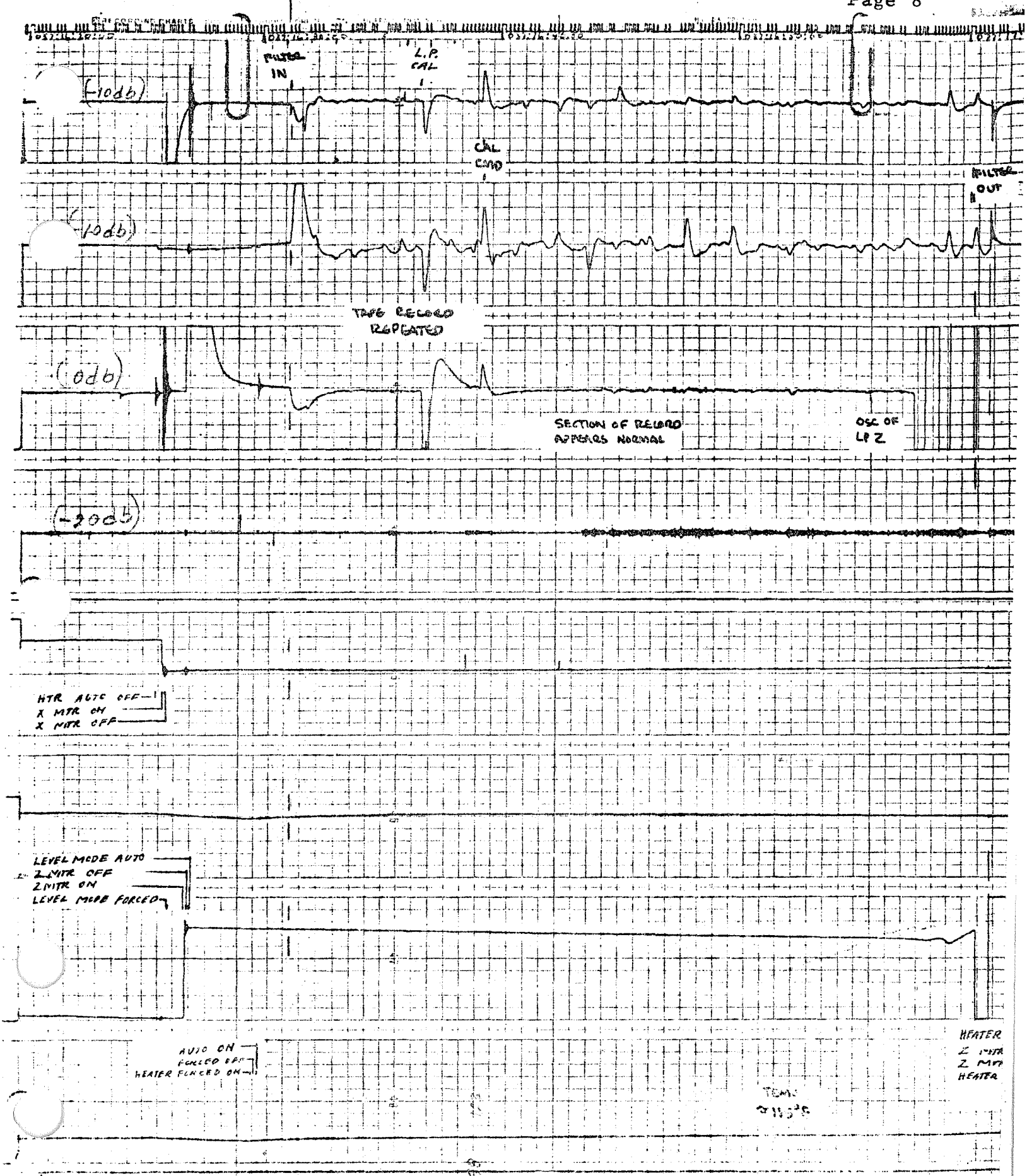

3
FILTER IN
L.P. CAL
(-10db)
CAL END
FILTER OUT
(-10db)
TAPE RECORD REPEATED
(0db)
SECTION OF RECORD APPEARS NORMAL
OSC OF LP Z
(-20db)
HTR AUTO OFF
X MTR ON
X MTR OFF
LEVEL MODE AUTO
Z MTR OFF
Z MTR ON
LEVEL MODE FORCED
AUTO ON
FORCED OFF
HEATER FORCED ON
HEATER
Z MTR
Z MTR
HEATER

FIGURE 2.2

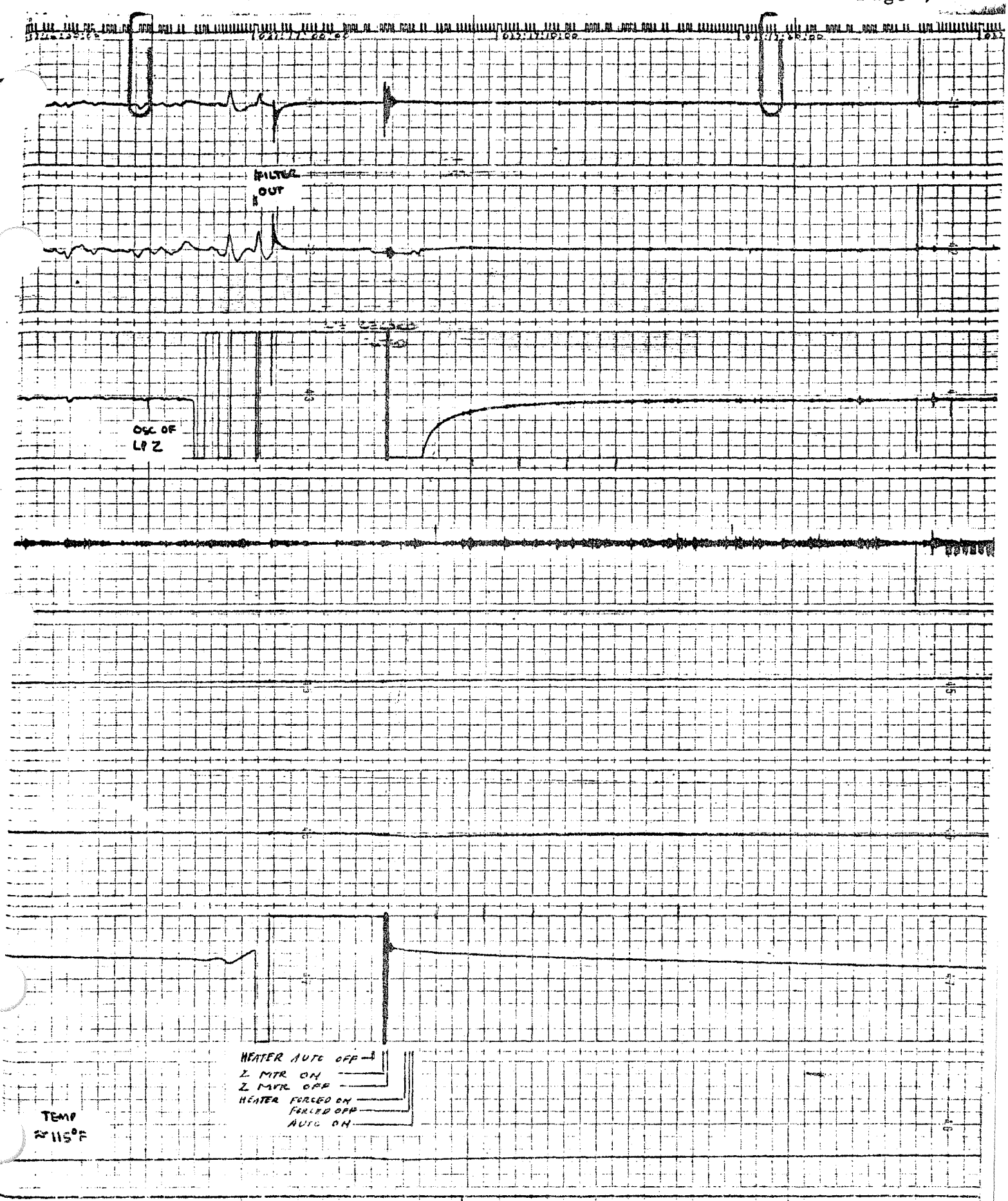

FILTER OUT
OSC OF LP Z
HEATER AUTO OFF
Z MTR ON
Z MTR OFF
HEATER FORCED ON
FORCED OFF
AUTO ON
TEMP ≈ 115°F

FIGURE 2.3

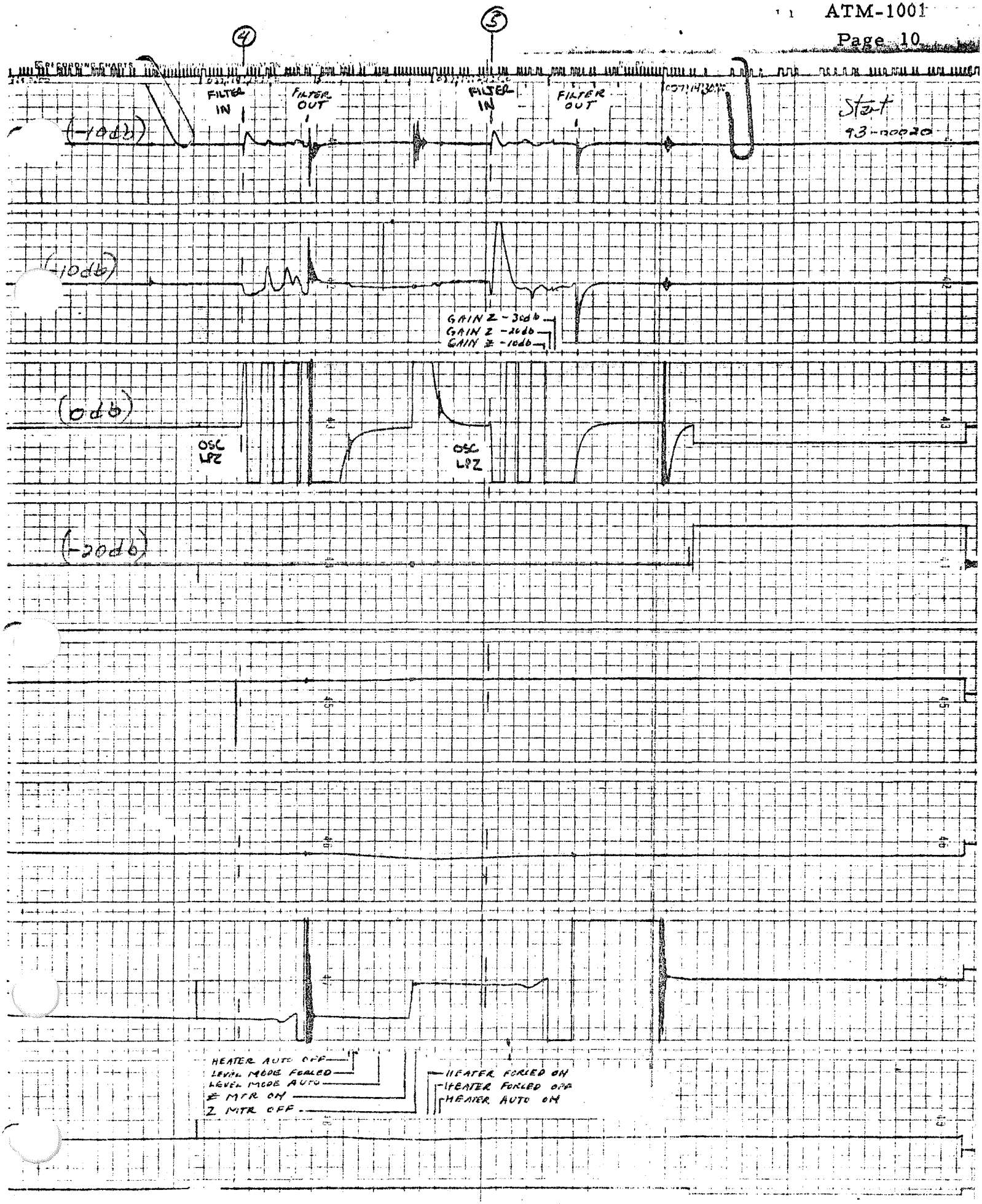

4
5
FILTER IN
FILTER OUT
FILTER IN
FILTER OUT
Start
93-00020
(-10db)
(-10db)
GAIN Z -30db
GAIN Z -20db
GAIN Z -10db
(0db)
OSC LPZ
OSC LPZ
(-20db)
HEATER AUTO OFF
LEVEL MODE FORCED
LEVEL MODE AUTO
Z MTR ON
Z MTR OFF
HEATER FORCED ON
HEATER FORCED OFF
HEATER AUTO ON

FIGURE 2.4

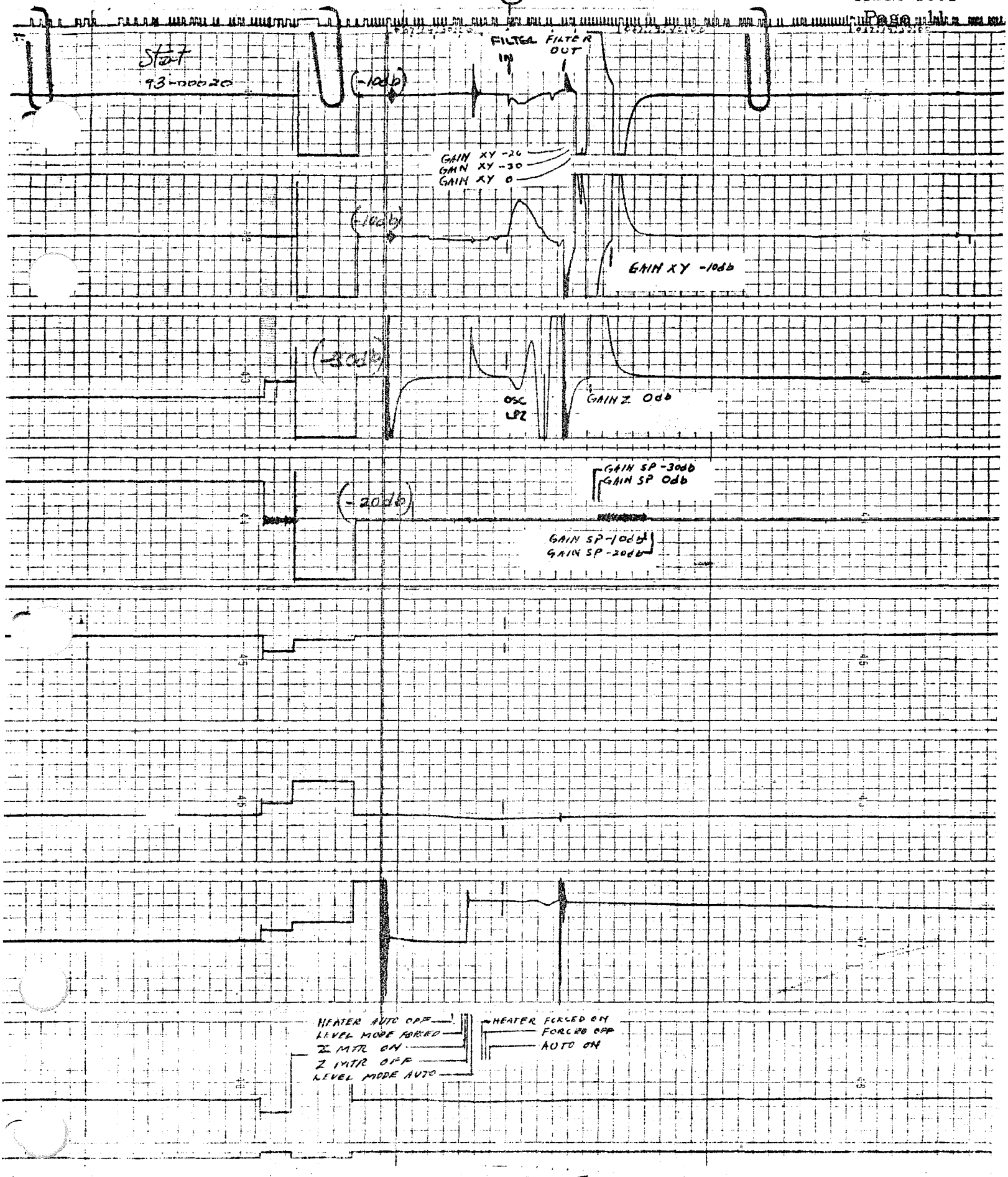

Start
93-00020
(-10db)
FILTER IN
FILTER OUT
GAIN XY -20
GAIN XY -30
GAIN XY 0
(-10db)
GAIN XY -10db
(-30db)
OSC LPZ
GAIN Z 0db
GAIN SP -30db
GAIN SP 0db
(-20db)
GAIN SP -10db
GAIN SP -20db
HEATER AUTO OFF
LEVEL MODE FORCED
Z MTR ON
Z MTR OFF
LEVEL MODE AUTO
HEATER FORCED ON
FORCED OFF
AUTO ON

FIGURE 2.5

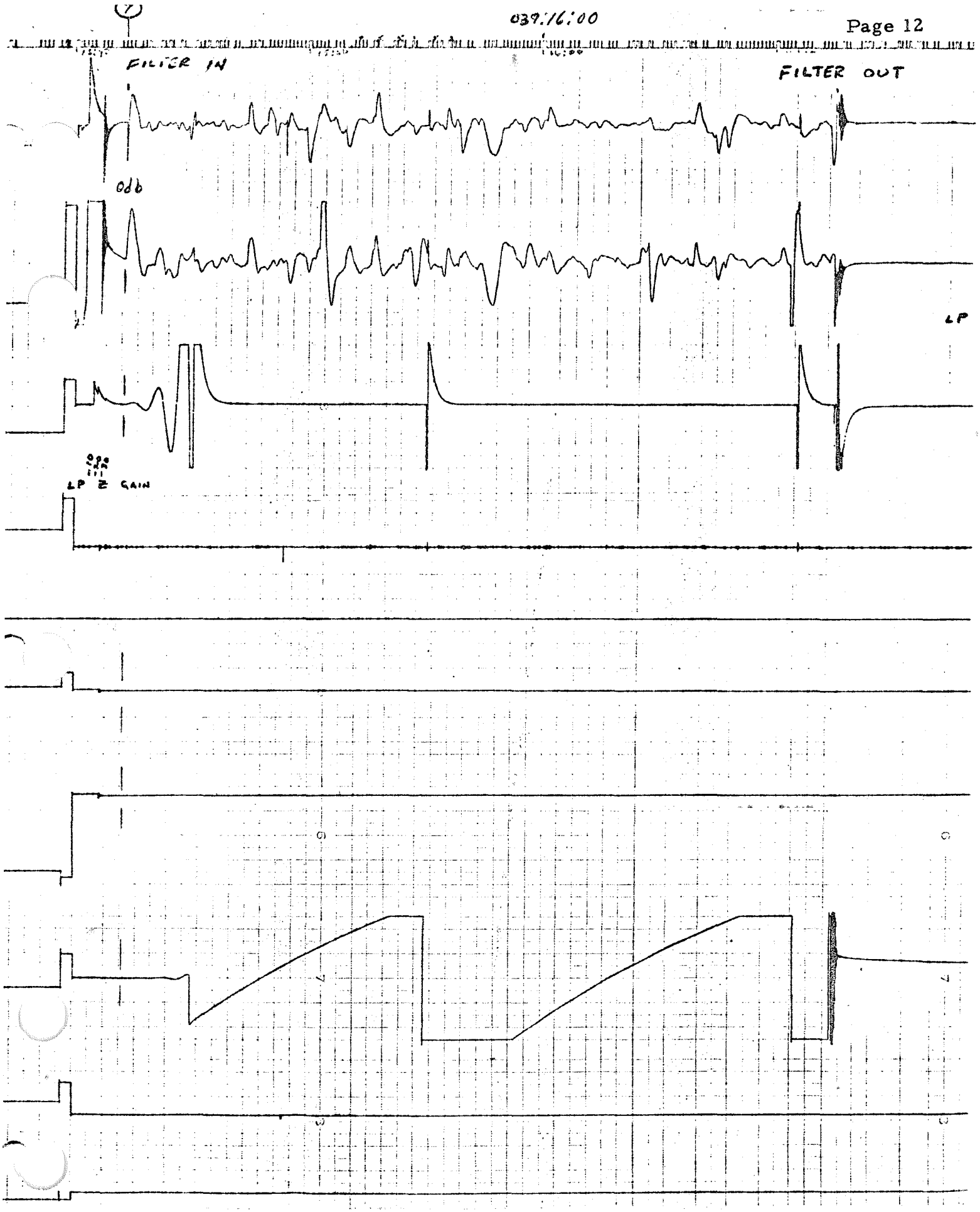


FIGURE 2.6

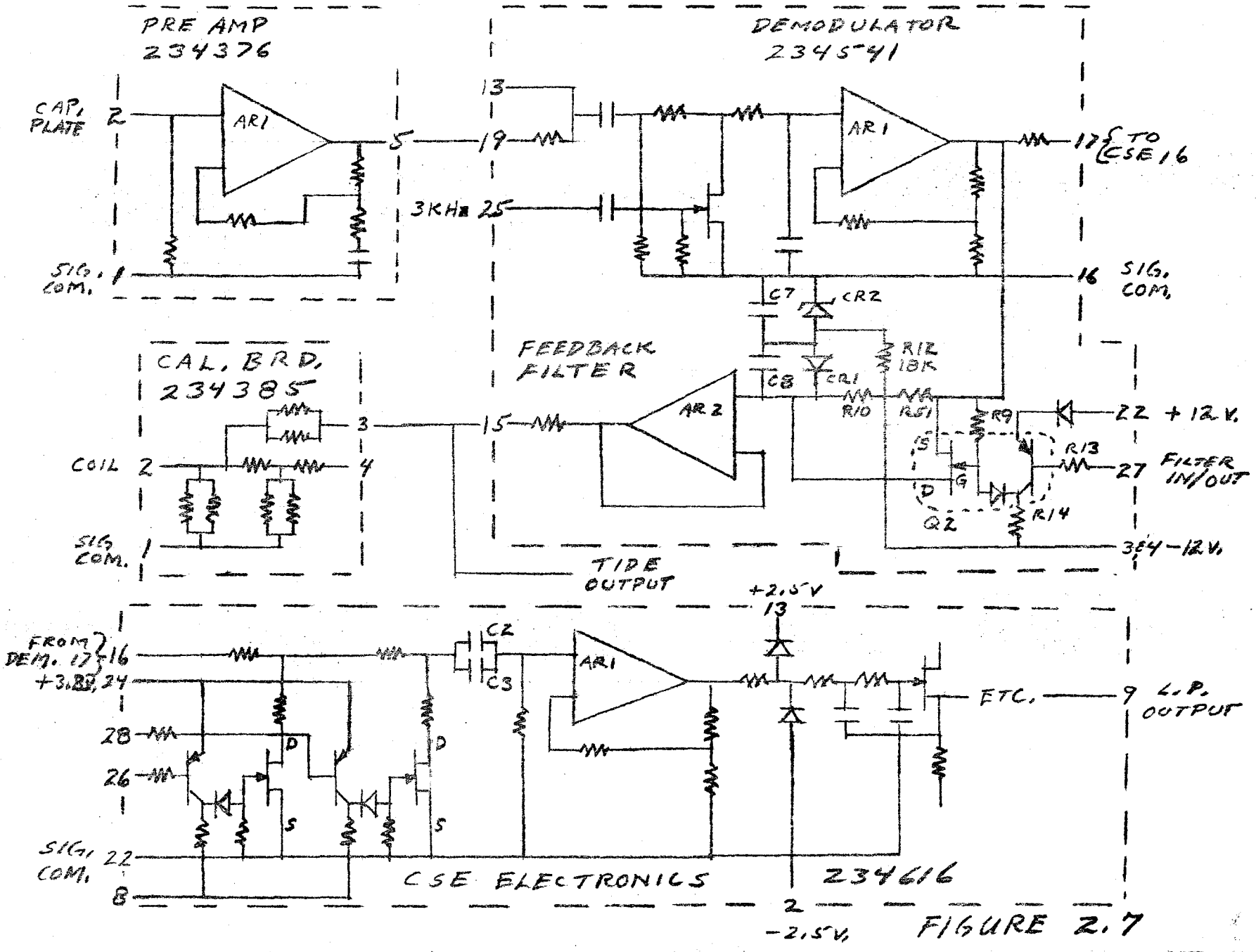

PRE AMP
234376
DEMODULATOR
234541
CAP. PLATE
SIG. COM.
AR1
3KHz
TO CSE 16
SIG. COM.
C7
CR2
C8
CR1
R11 18K
R10
R11
R9
22 +12 V.
R13
27 FILTER IN/OUT
R14
Q2
34 -12 V.
FEEDBACK FILTER
AR2
CAL. BRD. 23485
COIL
SIG. COM.
TIDE OUTPUT
+2.5 V
FROM DEM. 17
+3.8V, 24
C2
C3
ETC.
9 L.P. OUTPUT
SIG. COM.
CSE ELECTRONICS
234616
-2.5 V.

FIGURE 2.7

3.0 Y MOTOR LEVELING PROBLEM

The PSE long period sensors (X, Y, and Z) are positioned by leveling motors actuated on command. The Apollo 14 PSE Y leveling operation has been intermittent; however, by repeated command transmissions leveling has been performed as required.

3.1 Data Analysis

The Y axis leveling problem has been exhibited and noted on the mission records, in two ways; however, the two are different degrees of one problem. The first noted is that the Y axis does not level in response to the Y motor turn-on command (Octal 071). This condition accounted for 9 of the 13 Y leveling problems examined in this analysis. In most cases where this problem existed and time data records were available to study, a response can be seen on the Short Period Z Seismometer and Long Period Y Seismometer data (Figure 3.1). The response occurs at leveling turn-on and turn-off times. There is no apparent change in the System Reserve Power during the motor turn-on period which indicates that power was not being applied to the motor. During a normal motor leveling sequence a change of approximately 3 watts can be noted in the System Reserve Power when sampling coincides with the motor on command (Figures 3.1a, 3.2a & 3.3a). Also during the periods when the Y motor would not level, 3 forced leveling commands were sent. Of the 3, only 1 caused the motor to operate.

The second manner in which the problem was noted was a delay between the time the motor on command was sent and the time the Y axis leveled. This occurred 4 times and the delay time ranged from approximately 20 seconds to 5 minutes. The turn-on indication was again noted on the SPZ and LPY data. In 2 of the delayed occurrences for which records were available, there appears to be a disturbance or oscillation just prior to the motor starting to level (Figures 3.2 and 3.3).

The Y axis leveling command was sent 5 times with the Heater in auto-on mode. There were 3 motor leveling problems during this sequence. Circuit design and operating procedures allow one or the other to be operated at a time, not both together.

3.2 Conclusion

From the indications noted on the data records, the delayed leveling, and non-effect of forced leveling, the problem appears to be in or just prior to the motor relay circuit (Q6, Q8, or K1 with related components). The condition could be a malfunctioning multivibrator due to a component value change or a change in the actuating point of the motor relay.

All of the motor leveling problems in this analysis occurred during Lunar day which could lead to a heat problem but the instrument temperatures from the data records do not indicate this condition. Figure 5 shows a relationship between Lunar Day, instrument temperature, and Central Station Electronic temperature near the PSE electronics.

Due to the complexity of the circuits and type of problem, it is not practical to try to duplicate the problem in test by component substitution. The intermittent operation is considered random in nature since the X and Z motors have basicly the same circuits, as well as the PSE's of Apollo 11 and 12, and none have had malfunctions in leveling.

3.3 Recommendation

The Y leveling function, although intermittent, can be performed. Since no apparent design or acceptance test deficiency can be found and since a total of 12 similar levelings have functioned properly, no further effort on this problem is recommended. It is recommended when commanding the Apollo 14 PSE Y axis that:

1. The auto mode be used as opposed to forced mode.
2. Switch the leveling motor on and off by command.
3. Heater to the off mode during the leveling sequence.

Figures

Figure 3.1 Y Motor ON-OFF Sequence for Day 040,Hour 05

Figure 3.1a Reserve Power vs Time for Day 040, Hour 05

Figure 3.2 Y Motor ON-OFF Sequence for Day 047, Hour 14

Figure 3.2a Reserve Power vs Time for Day 047, Hour 14

Figure 3.3 Y Motor ON-OFF Sequence for Day 048, Hour 18

Figure 3.3a Reserve Power vs Time for Day 048, Hour 18

Figure 3.4 Compiled Data for All Y Motor ON-OFF Sequences for the Period Studied

Figure 3.5 Temperatures - Y Motor Leveling Problems vs Lunar Time

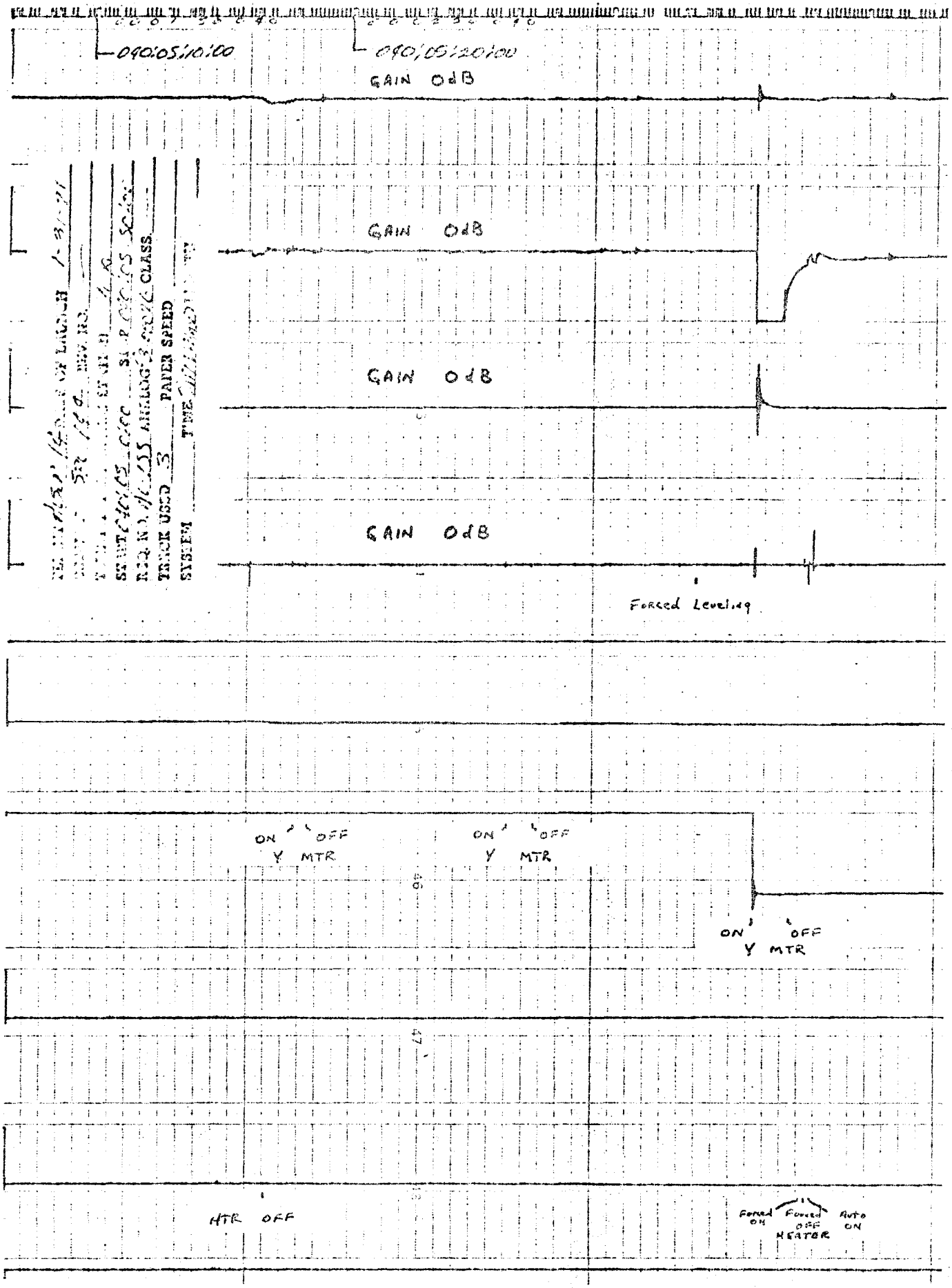

090:05:10:00
090:05:20:00
GAIN 0dB
GAIN 0dB
GAIN 0dB
GAIN 0dB
Forced Leveling
ON OFF
Y MTR
ON OFF
Y MTR
ON OFF
Y MTR
HTR OFF
Forced ON
Forced OFF
HEATER
Auto ON

Figure 3.1

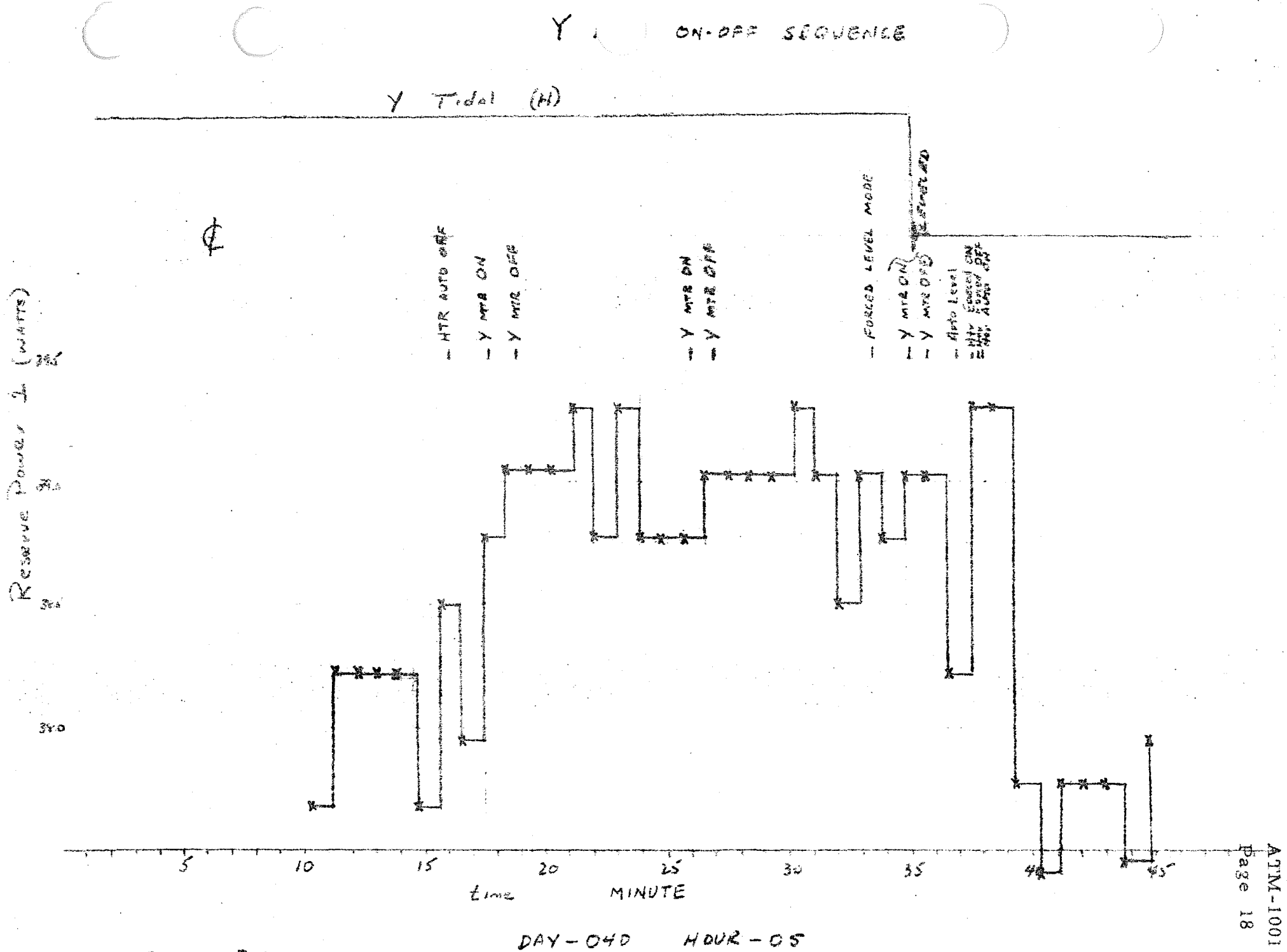

Y ON-OFF SEQUENCE
Y Tidal (H)
- HTR AUTO OFF
- Y HTR ON
- Y HTR OFF
- Y HTR ON
- Y HTR OFF
- FORCED LEVEL MODE
- Y HTR ON
- Y HTR OFF
- Auto Level
Reserve Power (WATTS)
time
MINUTE
DAY - 040 HOUR - 05

Figure 3.1a

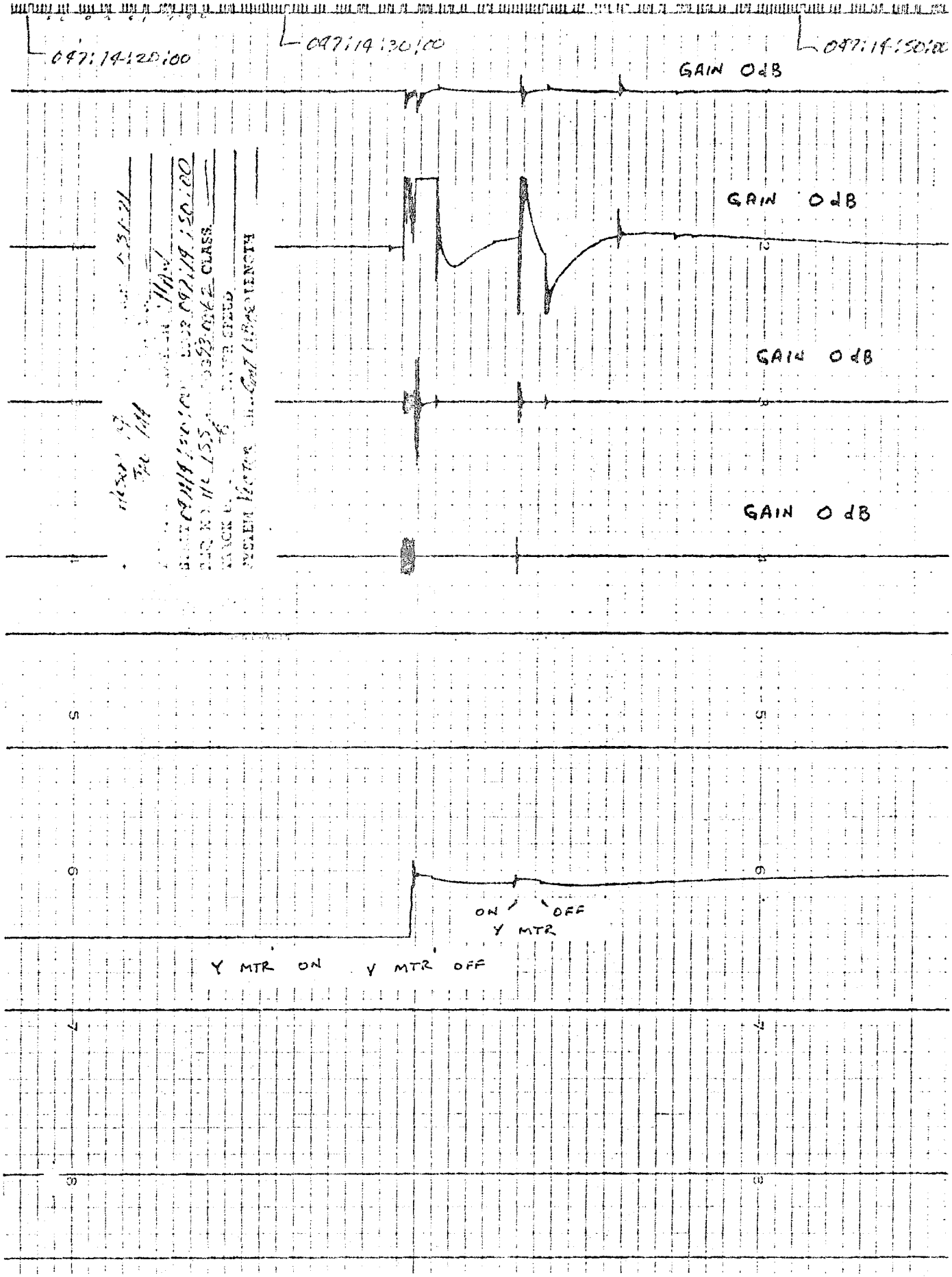
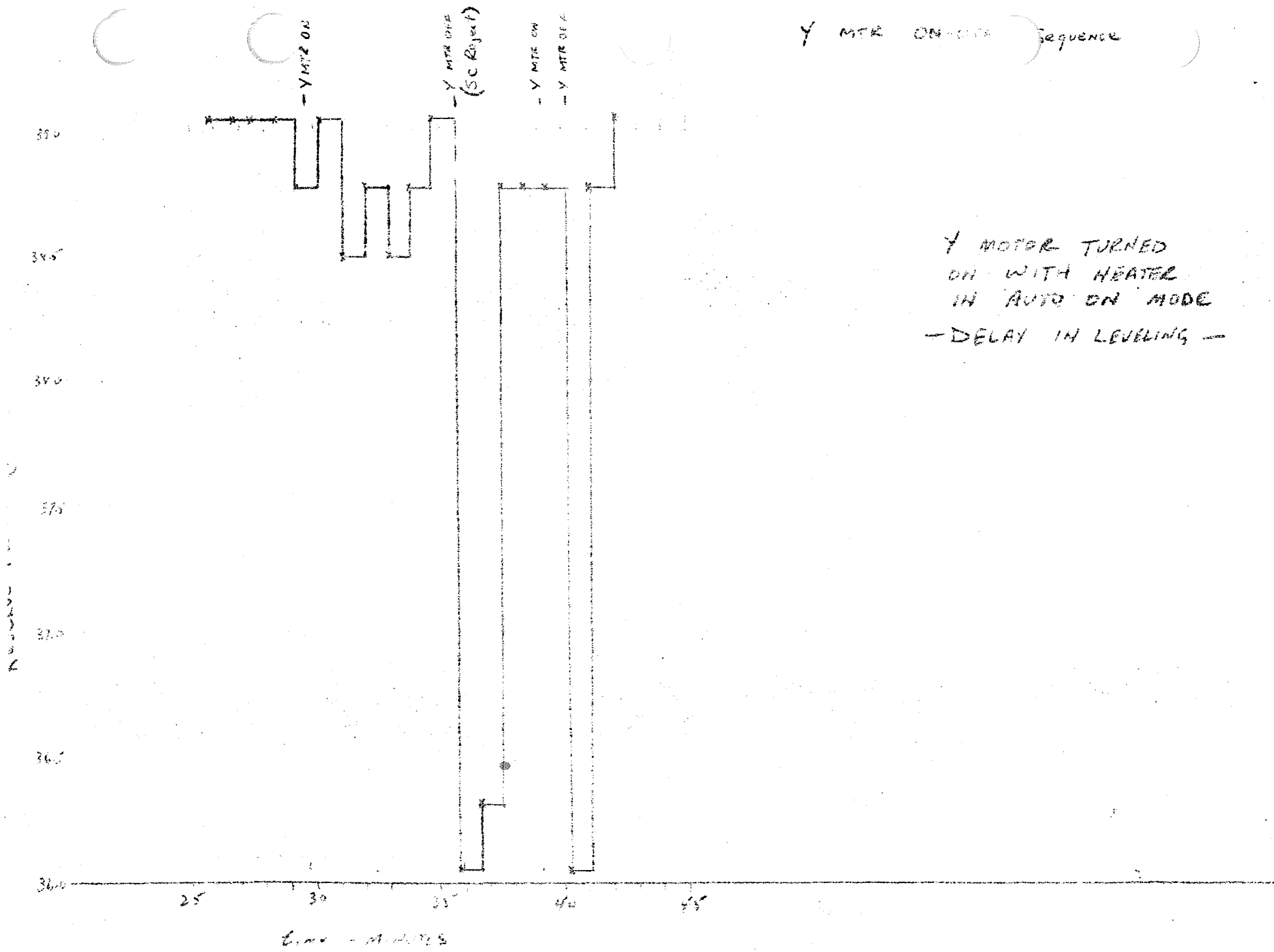

097:14:20:00
097:14:30:00
097:14:50:00
GAIN 0dB
GAIN 0dB
GAIN 0dB
GAIN 0dB
ON
OFF
Y MTR
Y MTR ON
Y MTR OFF

Figure 3.2



Y MTR ON-[illegible] Sequence

DAY - 047 HOUR - 14

Figure 3.2a

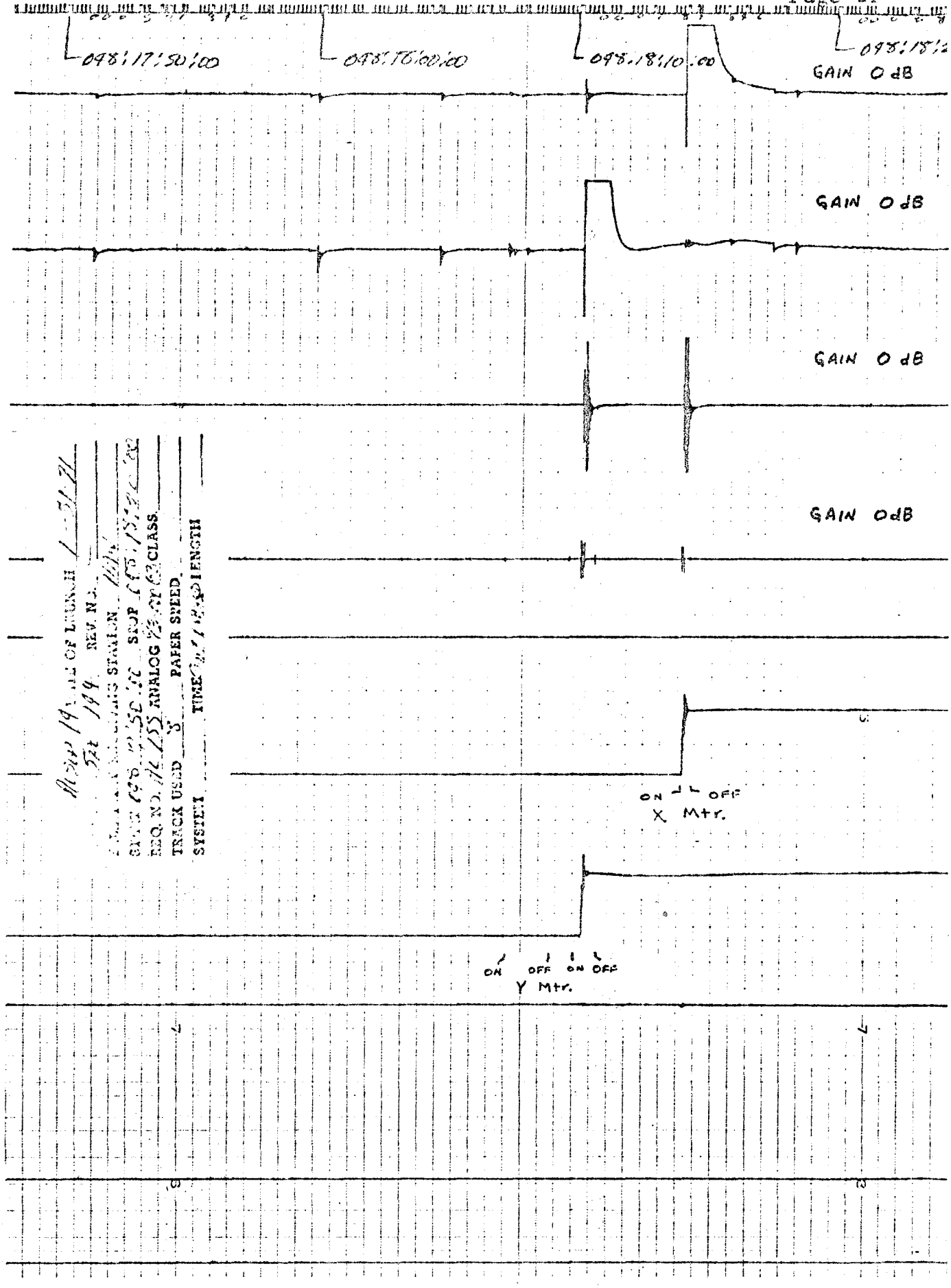

098:17:50:00
098:18:00:00
098:18:10:00
GAIN 0 dB
GAIN 0 dB
GAIN 0 dB
GAIN 0dB
ON OFF
X Mtr.
ON OFF ON OFF
Y Mtr.

Figure 3.3

Y MTR ON-OFF SEQUENCE

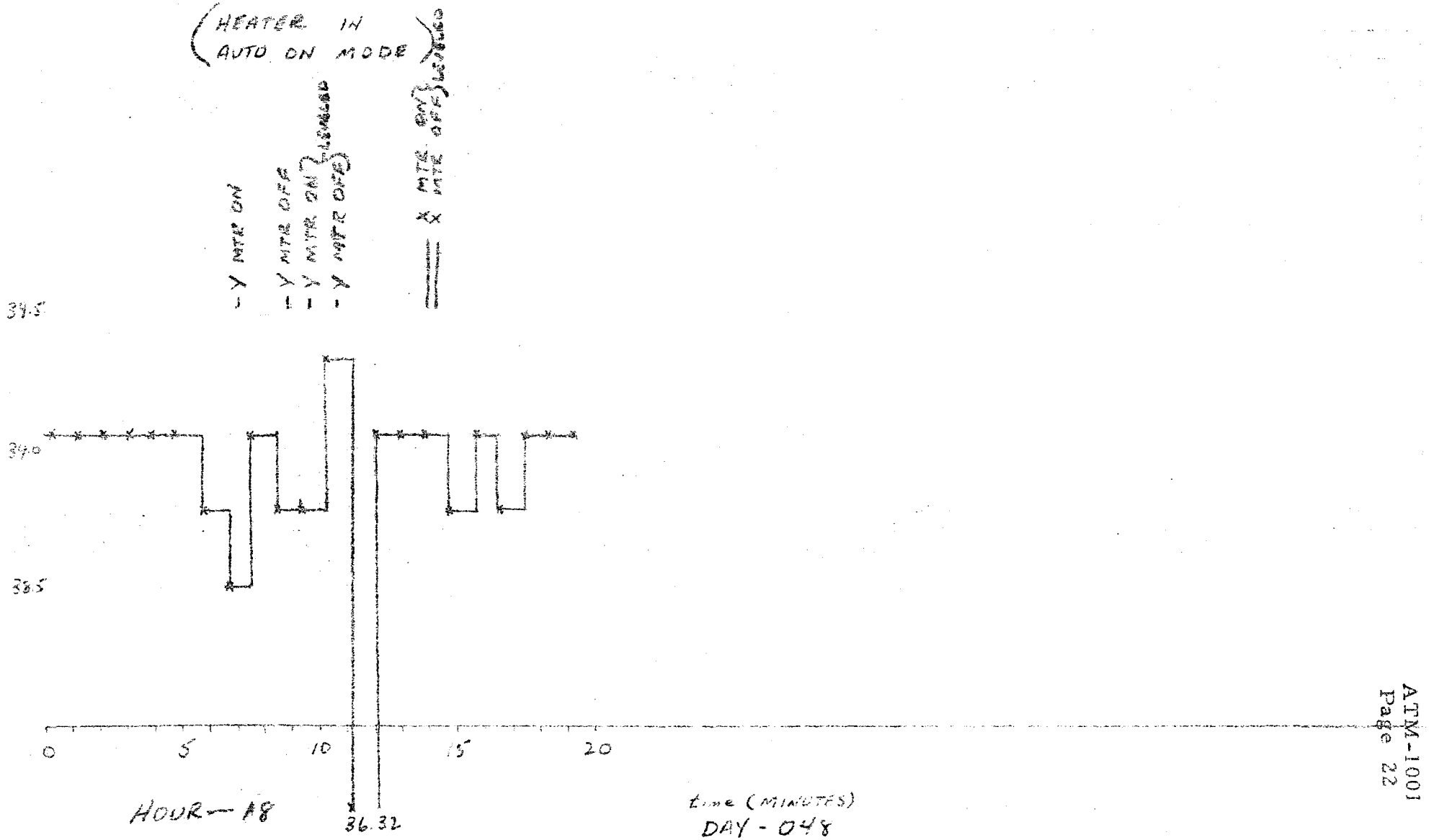


Figure 3.3a

Figure 3.4 Compiled Y Motor Data

TURN ON TIME				TURN OFF TIME				TOTAL ON TIME		LEVEL CONDITION		HEATER MODE	LEVELING MODE	INSTRUMENT TEMPERATURE °F	HEATER POWER	RESERVE POWER	POWER CHANGE		AT OS TEMPERATURE	Y TIDAL		COMMAND LOG COMMENTS
DAY	HR	MIN	SEC	DAY	HR	MIN	SEC	MIN	SEC	OK	PROBLEM			First Indication After Turn ON		Before Turn ON / After Turn OFF	During Turn ON	Δ PWR		Before Turn ON	After Turn OFF	
036	19	51	50	036	19	56	27	4	37	X		OFF	AUTO	(L)		46.44 / 46.44	43.69	-2.75	64.3	H	1.54	
037	06	17	35	037	06	18	30		55	X		OFF	AUTO	(L)		47.35 / 46.71	44.37	-2.50	66.6	-21.22*	2.38	
037	14	23	40	037	14	23	42		02	X		OFF	FORCED	109.10 *		53.95 / 48.61	—	5.16	79.1	-13.19	4.81	
038	00	15	15	038	00	15	36		21	X		OFF	AUTO	124.09		40.14 / 37.41	—	-2.73	85.0	-19.23	1.54	
038	15	37	00	038	15	37	02		02		COMMAND DID NOT LEVEL	OFF	AUTO	124.56		39.05 / 39.86	—	.81	95.4	12.79	10.81	
038	15	37	50	038	15	37	53		03		COMMAND DID NOT LEVEL	OFF	AUTO	124.56		39.86 / 39.59	—	.27	95.4	10.81	10.71	
038	17	16	30	038	17	17	40	1	10	X		OFF	AUTO	124.73		33.41 / 29.59	36.14	3.55	96.0	11.20	-0.60	
040	05	17	45	040	05	18	15		30		COMMAND DID NOT LEVEL	OFF	AUTO	125.33		39.77 / 39.05	—	.24	114.2	H	H	no action
040	05	26	00	040	05	27	00	1	00		COMMAND DID NOT LEVEL	OFF	AUTO	125.16		39.77 / 39.05	39.05	.24	114.2	H	H	no action
040	05	35	05	040	05	35	40		35	X		OFF	FORCED	125.00		39.05 / 38.33	38.45	.62	114.2	H	-5.65	
041	06	34	50	041	06	40	02	5	12		COMMAND DID NOT LEVEL	OFF	FORCED/AUTO LEVELING	125.90		41.33 / 40.63	40.41	.82	107.3	-7.00	-7.65	
041	16	49	01	041	16	50	52	1	51		30 Second delay before attempting to level	OFF	AUTO	125.33		39.50 / 39.05	36.32	2.73	110.1	10.71	-0.55	Space Light Report
047	11	41	05	047	11	43	45	6	40		COMMAND DID NOT LEVEL	OFF	AUTO	125.10		40.41 / 39.86	39.59	.82	94.8	L	L	no go
047	11	49	10	047	11	54	35	5	25		COMMAND DID NOT LEVEL	OFF	AUTO	124.83		40.14 / 39.86	39.32	.82	94.8	L	L	no go
047	11	56	00	047	12	16	00	20	00		COMMAND DID NOT LEVEL	OFF	AUTO/FORCED	124.66		39.86 / 40.14	40.4	.32	94.8	L	L	
047	14	29	45	047	14	35	55	6	10		5 minute delay before leveling	AUTO ON	AUTO	125.10		38.77 / 36.32	36.04	2.73	93.5	L	-3.97	+3° to S.R.
047	14	39	07	047	14	40	10	1	03	X		AUTO ON	AUTO	125.10		38.77 / 38.77	36.04	2.73	92.8	-4.71	-4.66	
048	18	07	10	048	18	08	50	1	40		COMMAND DID NOT LEVEL	AUTO ON	AUTO	124.79		39.50 / 38.77	39.05	.55	76.8	-33.63*	-33.30*	dark and clear no change in RIP
048	18	09	40	048	18	10	40	1	00		30 Second delay before leveling	AUTO ON	AUTO	124.79		38.77 / 38.05	36.32	2.73	77.5	-23.59*	-0.05	Good Quote pass
049	19	53	00	049	19	53	30		30	X		AUTO ON	AUTO	124.56		36.86 / 34.13	—	2.73	57.0	-24.34*	0.79	HR Switch On
050	18	33	50	050	18	34	10		20	X		OFF	AUTO	123.59 *		38.23 / 37.32	—	.54	21.4	-19.01	0.49	
053	19	05	00	053	19	05	40		40	X		OFF	AUTO	123.36 *		33.31 / 32.95	33.14	.16	12.7	L	-0.64	went first time
061	22	42	00	061	22	42	20		20	X		OFF	AUTO									no problem
066	13	37	50	066	13	38	42		52		30 Second delay before leveling	OFF	AUTO									[illegible]
067	20	36	50	067	20	37	22		32	X		AUTO ON	AUTO									[illegible] no problem

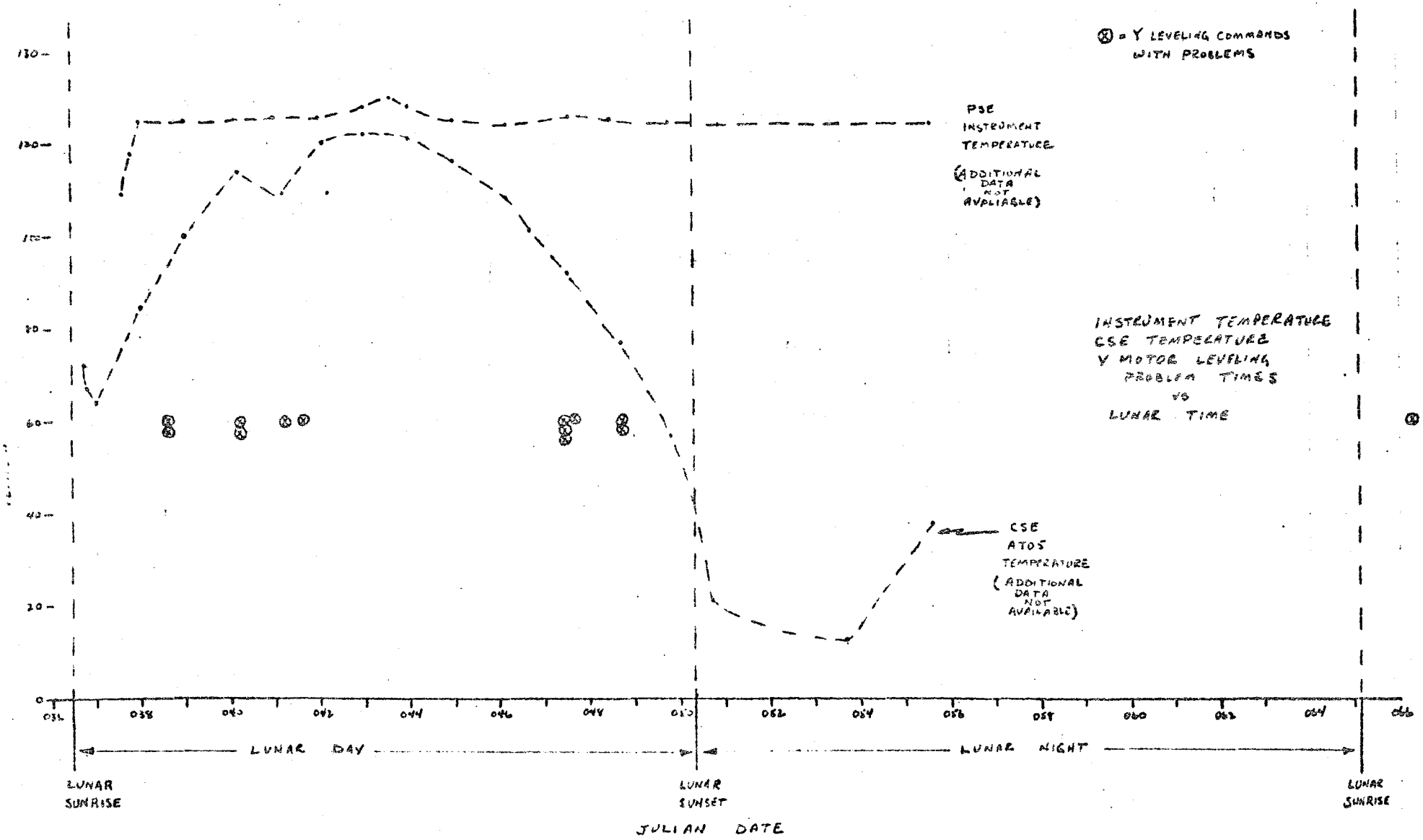

⊗ = Y LEVELING COMMANDS WITH PROBLEMS
PSE INSTRUMENT TEMPERATURE
(ADDITIONAL DATA NOT AVAILABLE)
INSTRUMENT TEMPERATURE
CSE TEMPERATURE
Y MOTOR LEVELING PROBLEM TIMES
VS
LUNAR TIME
CSE ATOS TEMPERATURE
(ADDITIONAL DATA NOT AVAILABLE)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
035
036
037
038
039
040
041
042
043
044
045
046
047
048
049
050
051
052
053
054
055
056
057
058
059
060
061
062
063
064
065
LUNAR DAY
LUNAR NIGHT
LUNAR SUNRISE
LUNAR SUNSET
LUNAR SUNRISE
JULIAN DATE

Figure 3.5

Figure 3.4 Compiled Y Motor Data

TURN ON TIME				TURN OFF TIME				TOTAL ON TIME		LEVEL CONDITION		HEATER MODE	LEVELING MODE	INSTRUMENT TEMPERATURE °F First Position After Turn On	HEATER POWER	RESERVE POWER Before Turn On / After Turn Off	POWER CHANGE During Turn On	Δ PWR	AT DS TEMPERATURE	Y TIDAL Before Turn On	Y TIDAL After Turn Off	COMMAND LOG COMMENTS
DAY	HR	MIN	SEC	DAY	HR	MIN	SEC	MIN	SEC	OK	PROBLEM											
036	19	51	50	036	19	56	27	4	37	X		OFF	AUTO	(L)		46.44 / 44.44	43.69	-2.75	62.3	H	1.54	
037	06	17	35	037	06	18	30		55	X		OFF	AUTO	(L)		47.55 / 46.71	44.37	-2.50	66.6	-21.23*	2.38	
037	14	23	40	037	14	23	42		02	X		OFF	FORCED	109.10 *		48.48 / 48.61	—	5.16	74.1	-13.19	4.81	
038	00	15	15	038	00	15	36		21	X		OFF	AUTO	124.09		40.14 / 37.41	—	-2.73	85.0	-16.23	1.54	
038	15	37	00	038	15	37	02		02			OFF	AUTO	124.56		39.05 / 39.86	—	.81	95.4	12.79	10.81	
038	15	37	50	038	15	37	53		03			OFF	AUTO	124.56		39.86 / 39.59	—	.27	95.4	10.81	10.71	
038	17	16	30	038	17	17	40	1	10	X		OFF	AUTO	124.73		35.41 / 39.89	3.04	3.55	96.0	H 50	-0.60	
040	05	17	45	040	05	18	15		30			OFF	AUTO	125.33		37.77 / 37.05	—	.24	114.2	H	H	no action
040	05	26	00	040	05	27	00	1	00			OFF	AUTO	125.16		37.77 / 37.05	37.05	.24	114.2	H	H	no action
040	05	35	05	040	05	35	40		35	X		OFF	FORCED	125.00		37.05 / 36.13	36.05	.92	114.2	H	-5.25	
041	06	34	50	041	06	40	02	5	12			OFF	FORCED / HEAT PULSING	125.40		41.23 / 40.09	40.41	.82	107.3	-7.04	-7.69	
041	16	49	01	041	16	50	52	1	51			OFF	AUTO	125.33		39.50 / 39.05	36.32	2.73	110.1	10.71	-0.55	Space Lab 1 flight
047	11	41	05	047	11	47	45	6	40			OFF	AUTO	125.10		40.41 / 39.36	39.59	.82	94.8	L	L	no go
047	11	49	101	047	11	54	35	5	25			OFF	AUTO	124.83		40.14 / 39.36	39.32	.82	94.8	L	L	no go
047	11	56	00	047	12	16	00	20	00			OFF	AUTO/FORCED	124.66		39.86 / 40.14	40.14	.28	94.8	L	L	
047	14	29	45	047	14	35	55	6	10			AUTO ON	AUTO	125.10		38.77 / 36.32	36.04	2.73	93.5	L	-3.97	+3 hr [illegible]
047	14	39	07	047	14	40	10	1	03	X		AUTO ON	AUTO	125.10		38.77 / 38.77	36.04	2.73	93.8	-4.71	-4.66	
048	18	07	10	048	18	08	50	1	40			AUTO ON	AUTO	124.77		39.50 / 39.77	39.05	.55	76.8	-23.45*	-23.50*	did not start on command - C/O
048	18	09	40	048	18	10	40	1	00			AUTO ON	AUTO	124.77		39.77 / 39.05	36.32	2.73	77.5	-23.50*	-0.05	Lost - Switch pos
049	19	53	00	049	19	53	30		30	X		AUTO ON	AUTO	124.56		36.96 / 36.68	—	2.73	57.0	-24.34*	0.79	HR was On
050	18	33	50	050	18	34	10		20	X		OFF	AUTO	123.59 *		37.05 / 37.51	—	.54	21.4	-17.05	0.99	
053	19	05	00	053	19	05	40		40	X		OFF	AUTO	123.26 *		33.87 / 33.15	33.14	.16	12.7	L	-0.64	can't find time
061	22	42	00	061	22	42	20		20	X		OFF	AUTO									no problem
066	13	37	50	066	13	38	42		52			OFF	AUTO									[illegible]
067	20	36	50	067	20	37	22		32	X		AUTO ON	AUTO									[illegible] no problem

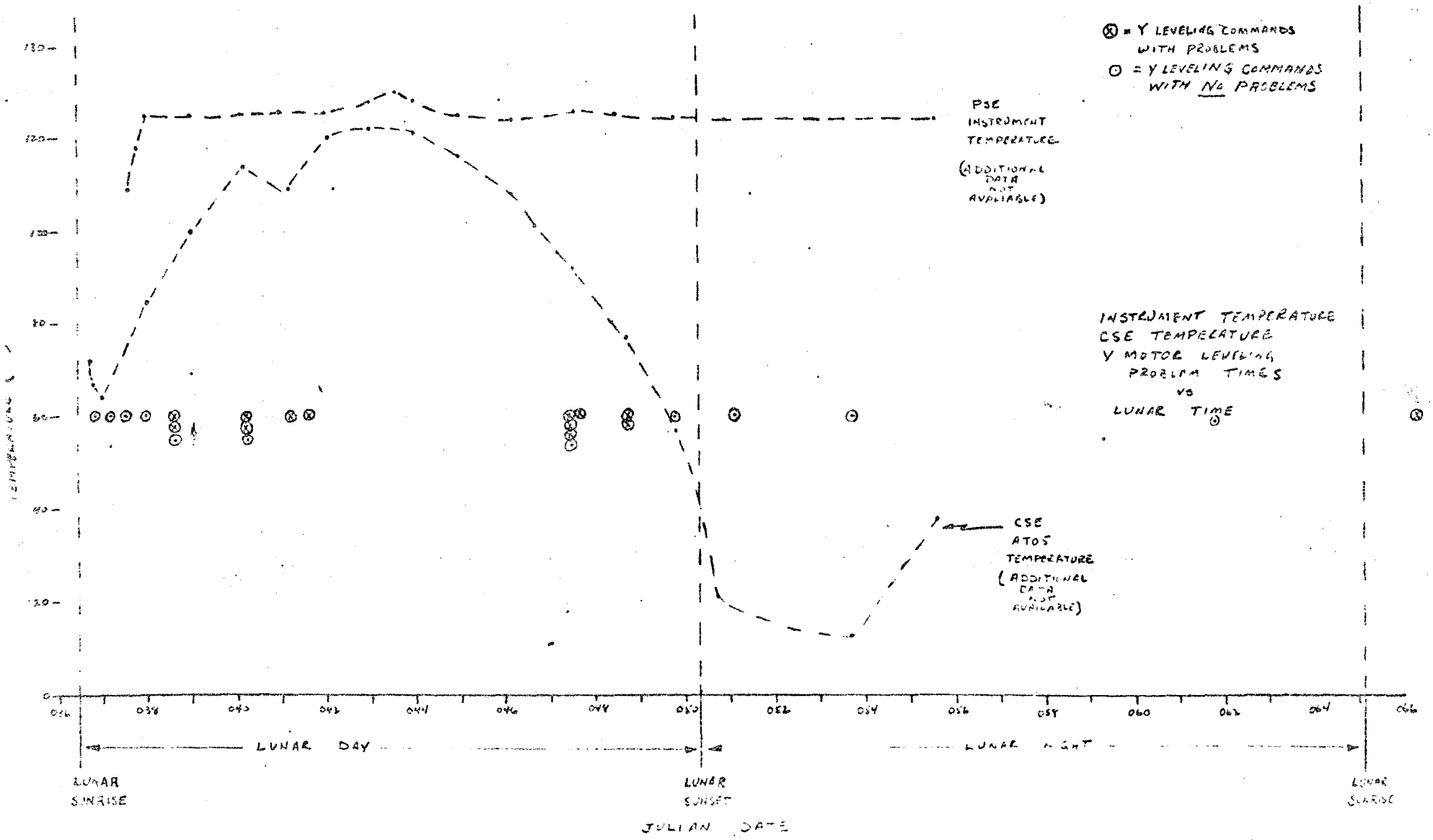
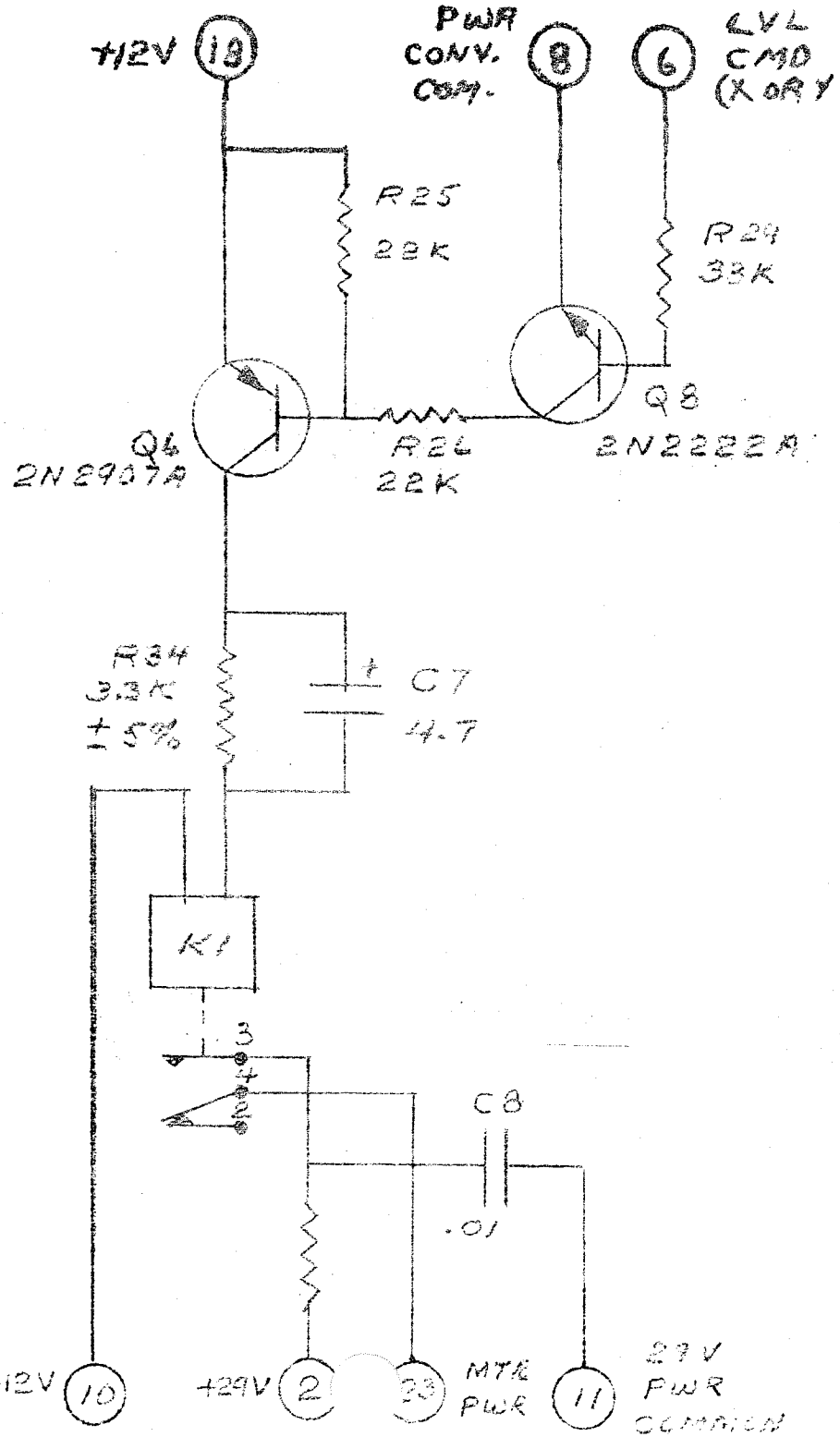

⊗ = Y LEVELING COMMANDS WITH PROBLEMS
⊙ = Y LEVELING COMMANDS WITH NO PROBLEMS
PSE INSTRUMENT TEMPERATURE
(ADDITIONAL DATA NOT AVAILABLE)
INSTRUMENT TEMPERATURE
CSE TEMPERATURE
Y MOTOR LEVELING PROBLEM TIMES
VS
LUNAR TIME
CSE ATOS TEMPERATURE
(ADDITIONAL DATA NOT AVAILABLE)
LUNAR DAY
LUNAR NIGHT
LUNAR SUNRISE
LUNAR SUNSET
LUNAR SUNRISE
JULIAN DATE

Figure 3.5


+12V
19
PWR CONV. COM.
8
6
LVL CMD (X OR Y
R25
22K
R29
33K
Q4
2N2907A
R24
22K
Q8
2N2222A
R34
3.3K
±5%
C7
4.7
K1
3
4
2
C8
.01
-12V
10
+29V
2
23
MTR PWR
11
27V PWR COMMON

4.0 AUTO-HEATER MINIMUM POWER CONDITION

The PSE thermal control proportional heater is designed to provide a maximum of 5 watts at a sensor temperature of 124°F and a power which approaches zero at 126°F. The anomalous condition noted on the Apollo 14 PSE was that: (1) the sensor temperature exceeded the expected temperature at lunar noon (but did not exceed specification) and (2) a sharp decrease in temperature occurred when the heater was turned off. Both items (1) and (2) indicate that the minimum power provided by the proportioned heater is larger than that noted in previous acceptance tests.

4.1 Data Analysis

The data was reviewed and 10 points were selected for power analysis where the heater operation had been commanded from Auto On to Auto Off or Off to Auto On. The reserve power (CS2) was reviewed for a period before and after the command to derive a change in power due to heater on-off function. This data resulted in a power vs temperature curve for the auto heater mode, reference Figure 4.1. The data from the last thermal test (BXA 2338829) performed on the unit is also shown on Figure 4.1. These two curves indicate a change in performance of the thermal circuit.

All previous temperature calibration data are shown on Figure 4.2. A review of the analog vs temperature data on print out from lunar operation is also shown on this figure. This indicates that the present conversion used is the data of 4-19-68 per Teledyne T-13102.

Using the calibration data of 8-10-70 vs the data of 4-19-68 as a correction factor, the power vs temperature data from the lunar operation was modified and the results are shown on Figure 4.3 and the data points of 8-10-70 are indicated. This curve now shows good correlation with the last run thermal test, with the exception of the minimum power condition.

4.2 Circuit Analysis

An analysis of the control circuit on the "W" board (PN 2344708) was performed and identified a potential area where leakage current within the Darlington power control stage, could possibly be of the order of 50 nano-amperes at 25°C. This leakage current could theoretically

increase with temperature and transistor gain to the order of 2.3 milliamperes at 52°C resulting in a possible power output of 67 milliwatts which is in the area of the anomaly.

As a result of this analysis a test was conducted using an engineering model W board assembly to determine if the analysis conclusion was supportable by test. The results of this test show the leakage current of the power control circuitry to be below 0.1 microamperes below 40°C rising to 17.3 microamperes at 52°C, resulting in a possible power output of 0.5 milliwatts. This value remained stable after a one hour soak period. In this test with the engineering model hardware, the leakage current would not account for the Apollo 14 sensor heating problem.

4.3 Conclusion

The analysis of the data from the lunar operation indicates that the present computer temperature data is using the data provided by Teledyne T-13102 of 4-19-68. (Midscale at 123.60°F and 0.15 volts per degree Fahrenheit). When this data is converted to the data of BXA 2338829 of 8-10-70 (midscale at 123.75°F and 0.10 volts per degree Fahrenheit), the power vs temperature curves of lunar operation and last test agree except at the minimum power condition.

Any leakage in the power control circuitry of Q18, Q21 on the "W" board, reference Figure 4.4, will cause an increase in the minimum power condition, however, this leakage will also cause an offset in the power vs temperature data which was not observed in the Apollo 14 data. Therefore, the shift in minimum power is not due to leakage in the power control circuitry. A second potential cause, a change in component characteristics of the multivibrator control circuit of the "Y" board, could limit the off time of the system and not allow a complete auto-off to occur. This condition has not been noted during testing and has not been reproduced on any models now available.

4.4 Recommendations

Lunar noon thermal performance of the Apollo 14 PSE sensor has been regulated to near the set point by commanding the heater to an off condition. It does not appear that the heater performance is changing with time and thus this method of control can be continued. Testing of available models does not indicate a performance similar to that of the Apollo 14 instrument, thus, no change in design is recommended. Further, a review of the testing performed indicates no change in the testing methods is required.

To further define the cause of the Apollo 14 anomaly, it is recommended that additional engineering tests be performed on the multivibrator control circuit, tests in which components are altered in an attempt to simulate the Apollo 14 condition.

A second thermal control condition noted on the second lunar day was that in the heater off mode of operation. A rise in temperature to approximately 130°F was caused by the solar input. This temperature change can be reduced by additional insulation on the side wall of the thermal shroud. The side wall contains 10 layers of double sided aluminized mylar compared to the shroud skirt of 20 layers of single sided aluminized mylar. Both the side wall and the skirt have a top layer of aluminized teflon. Shroud changes to increase the side wall insulation have been previously proposed.

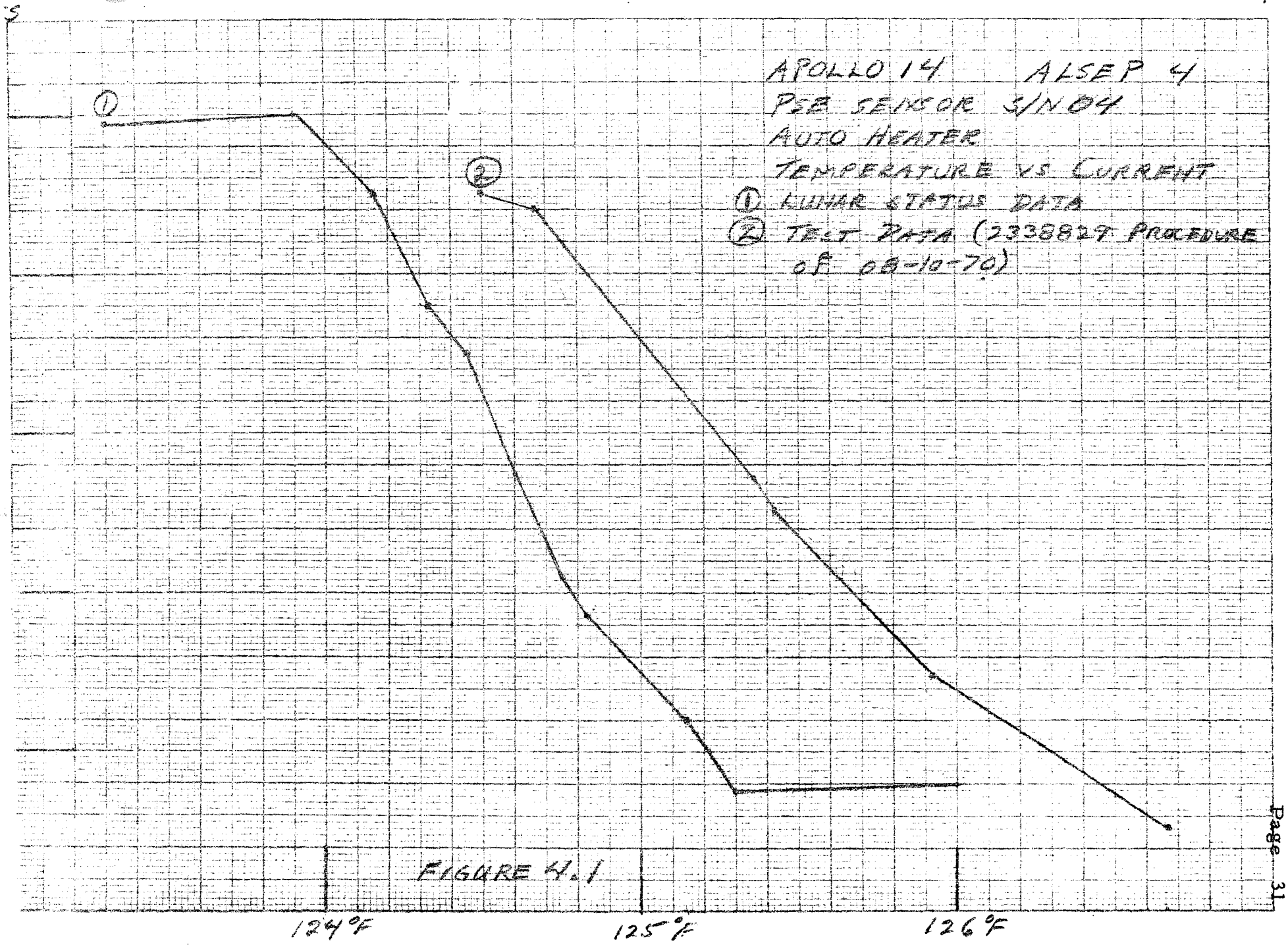

APOLLO 14 ALSEP 4
PSE SENSOR S/N 04
AUTO HEATER
TEMPERATURE VS CURRENT
① LUNAR STATUS DATA
② TEST DATA (2338827 PROCEDURE of 08-10-70)
124°F
125°F
126°F

FIGURE 4.1

K&E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

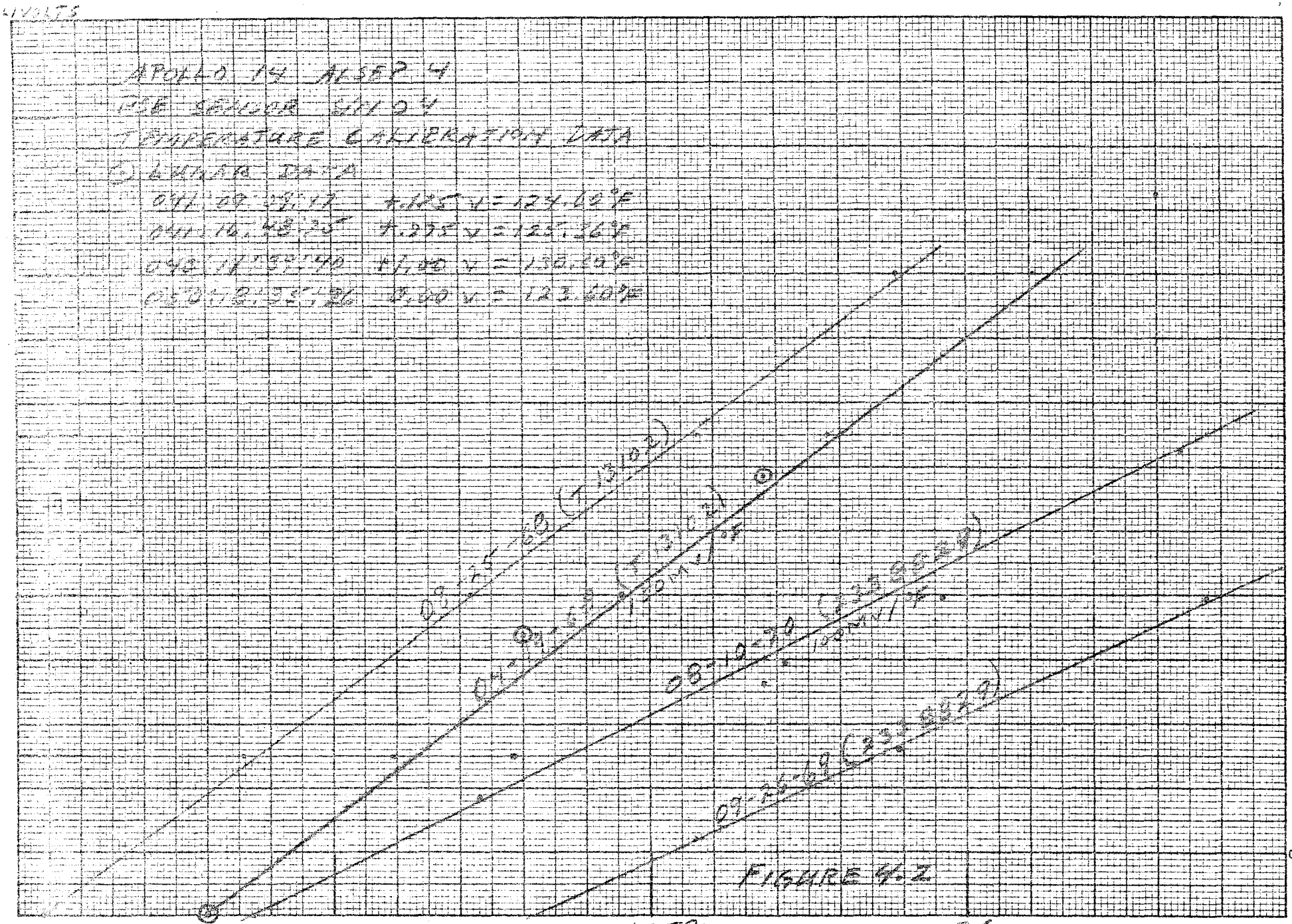


FIGURE 4.2

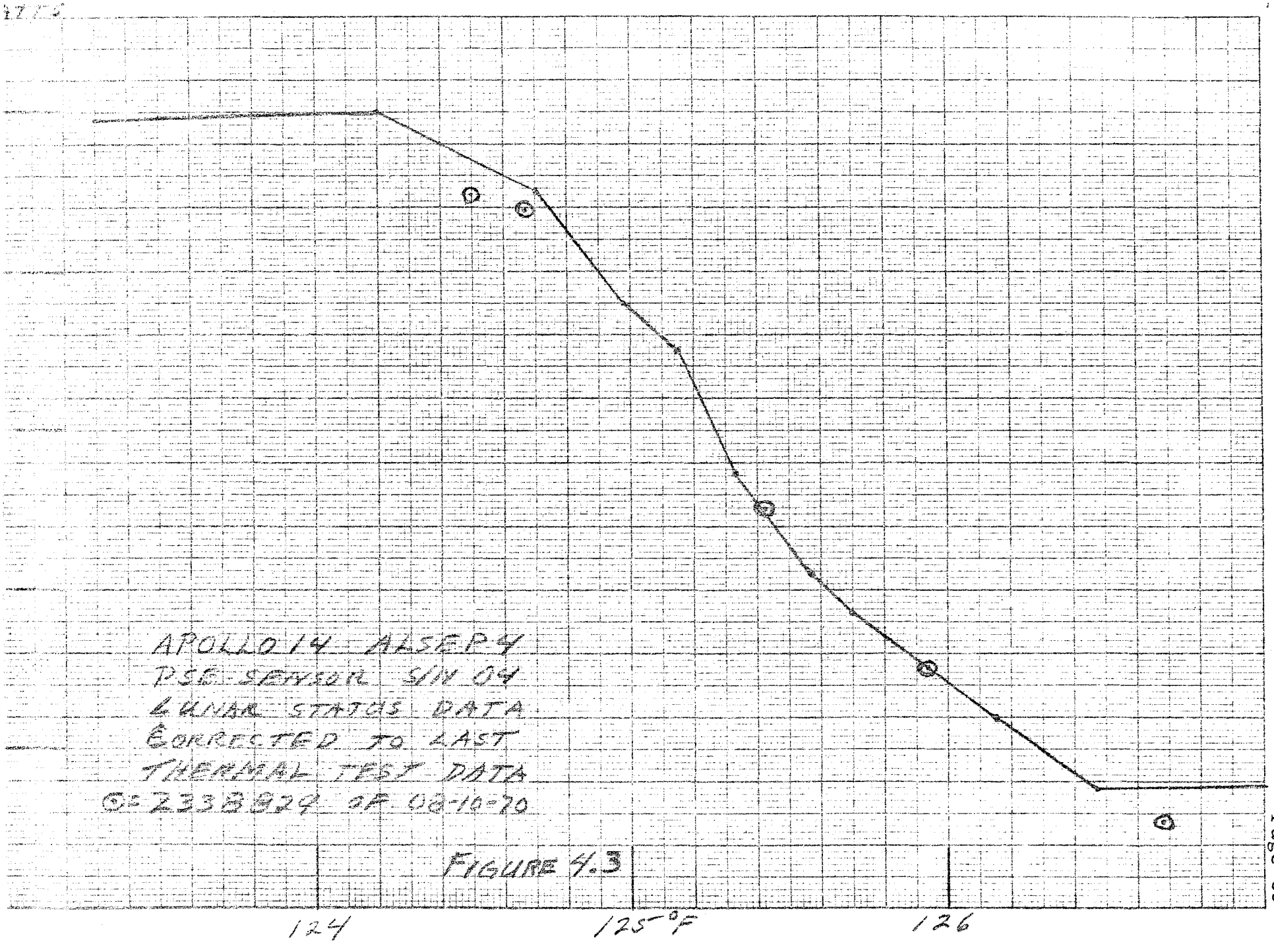
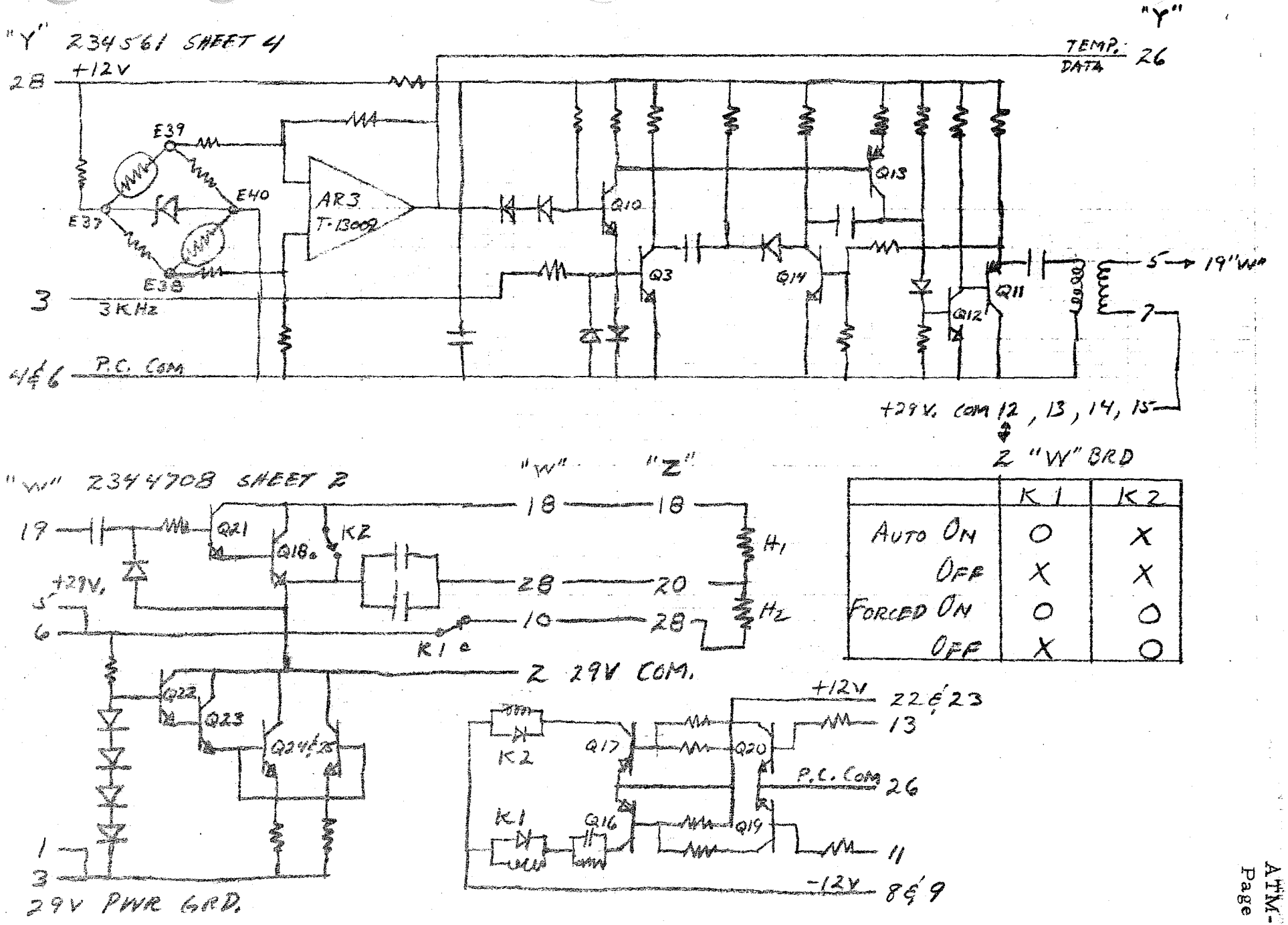

APOLLO 14 ALSEP 4
PSE- SEISER S/N 04
LUNAR STATES DATA
CORRECTED TO LAST
THERMAL TEST DATA
@ 2338829 OF 08-10-70
124
125 °F
126

FIGURE 4.3



	K1	K2
AUTO ON	O	X
OFF	X	X
FORCED ON	O	O
OFF	X	O

FIGURE 4.4