JET PROPULSION LABORATORY

INTEROFFICE MEMORANDUM
VOYAGER SCT-86-088

28 March 1986

TO: G. Hanover

FROM: E. Wahl

SUBJECT: Reconstruction of B752 Uranus Limb Track Maneuver.

SUMMARY

The AGC mini-ASCAL data was used for spacecraft attitude determination. The first mini-ASCAL was used to determine the attitude at the time of celestial sensor to gyro handover and the second mini-ASCAL was used to determine the uncompensated gyro drift rates of +0.015°/Hr in pitch and -0.016°/Hr in yaw.

Gyro drift rates determined by comparison with celestial sensor data gave pitch of +0.014, yaw of -0.018, and roll of +0.01°/Hr. The attitude of the spacecraft for the limb track maneuver was reconstructed using uncompensated gyro drift rates of +0.015, -0.016, and +0.01°/Hr in pitch, yaw, and roll respectively. This was transmitted to RSDT as file 22 on tape UH0002 on 3/25/86. Control error consists of the uncompensated drift rates plus limit cycle position.

DISCUSSION OF RECONSTRUCTION

Input Data. The maneuver commands are given in Table 1, plots of the gyro data in Figure 1 and plots of celestial sensor data in Figure 2. All are annotated to indicate the principle maneuver events. The gyro and celestial sensor telemetry data was edited to remove incorrect "0" data. The gyro data was edited for the commanded turn start and stops. The behavior during this time was normal. Estimates of the uncompensated gyro drift rates based on comparison of celestial sensor and gyro sensor data for the near encounter time period are given in Table 2a and 2b. Arithmetric and time averages of these values of uncompensated drift are +0.014°/Hr for pitch, -0.018°/Hr for yaw, and +0.01°/Hr for roll.

Procedure and Results. The limb track maneuver was reconstructed from 024/18:55:00 through 025/00:13:38.

Using uncompensated drift rates of +0.014, -0.18, and +0.01 resulted in celestial and gyro attitude differences of 0.15° at the time of sun acquisition, CC7SS1 command, Figure 3. The drift rates which result in a gyro and celestial sensor match at the CC7SS1 are +0.0265, +0.0035 and +0.01 for pitch, yaw and roll respectively. Since there may be light scattering from Uranus and/or Uranus rings into the celestial sensor at this time, this difference was not considered appropriate for determining drift rates. Instead, the AGC mini-ASCAL data was used to determine the

spacecraft attitude. The uncompensated drift rate was determined by a reconstruction best matching the AGC data for the second mini-ASCAL. The initial attitude of the spacecraft at the time of all axis inertial was determined by the attitude given by the first mini-ASCAL.

The AGC data from the tracking IDR was used as the source of actual (measured) AGC data. This was compared with the predicted AGC data based on the reconstructed attitude. The standard deviation of the difference between the actual and predicted AGC data for the second mini-ASCAL is shown in Figure 4 as a function of assumed pitch and yaw uncompensated drift rates. The best match is obtained for a pitch of +0.018 and yaw of -0.025 with roll of +0.01. Using these values of drift, the initial attitude of the spacecraft at the time of all axis inertial AC7MDP6 was adjusted to minimize the error between predicted and measured AGC for the first mini-ASCAL. The adjustment in attitude was 0.00° in pitch, and +0.014° in yaw, Table 3. This gave a standard deviation of 0.177. Using this attitude, the pitch and yaw uncompensated drift rates that cause the predicted and measured AGC data for the second mini-ASCAL to minimize the standard deviation was determined to be +0.015 and -0.016, Figure 5. The standard deviation was 0.170. The above procedure was repeated, that is the first mini-ASCAL analysis was rerun with these values of drift rates with no significant change in results. Plots of the AGC, Earth position, and differences between predicted and measured AGC are shown in Figures 6 and 7 for the first and second mini-ASCAL respectively.

The uncompensated gyro drift rates derived from a time weighted average of drift rates determined from celestial sensor data are close in value to the drift rates determined by matching the AGC as shown in Table 4.

The shift of +.014° in initial yaw attitude at gyro handover with uncompensated drifts of +0.016 in pitch, -0.018 in yaw, and +0.01 in roll give predicted AGC data that agrees very well with the measured AGC data. Using this initial attitude and set of Gyro drift rates, the attitude of the spacecraft was reconstructed for the limb track maneuver to generate the final products.

Products. The reconstruction attitude was stored as file 22 on Tape UH0002 and delivered to RSDT on 3/25/86.

Control Error. The difference between the actual attitude and maneuver design attitude is shown in Figure 8. This shows the normal response with uncompensated pitch and yaw drift rate errors of +0.016 and -0.018°/hr, respectively.

The slope of the pitch, yaw, and roll gyro positions in Figure 8 match the values assumed for the calculation as they should.

EW:srh

Distribution

Voyager/Div. 34 MOS 1 & 2 List

TABLE I.

MANUEVER COMMANDS

```
READ-ONLY MODE
CASE UPPER ASSUMED
ED 16R1A-WED-03/19/86-16:23:46-(0,)
EDIT
```

ADD 1 Sec to all times

1:	AC7SSB	3	-038			86-024/17:56:00.000
2:	AC7SSB	4	+211			86-024/17:56:00.000
3:	AC7MDP	6			AAI	86-024/18:56:00.000
4:	AC7VCD	2	+012850			86-024/19:07:12.000
5:	AC7VCD	2	-012850			86-024/19:08:36.000
6:	AC7VCD	2	+012850		FIRST	86-024/19:11:24.000
7:	AC7VCD	2	+000000		MINI	86-024/19:12:48.000
8:	AC7VCD	1	+012850		ASCAL	86-024/19:13:36.000
9:	AC7VCD	1	-012850			86-024/19:15:00.000
10:	AC7VCD	1	+012850			86-024/19:17:48.000
11:	AC7VCD	1	+000000			86-024/19:19:12.000
12:	AC7VCD	1	-007341			86-024/20:36:31.000
13:	AC7VCD	2	+000424			86-024/20:36:31.000
14:	AC7VCD	1	-005379			86-024/20:48:13.000
15:	AC7VCD	2	-002792			86-024/20:48:13.000
16:	AC7VCD	1	-001768			86-024/20:59:07.000
17:	AC7VCD	2	-005679			86-024/20:59:07.000
18:	AC7VCD	1	+003203			86-024/21:08:37.000
19:	AC7VCD	2	-006043			86-024/21:08:37.000
20:	AC7VCD	1	+006509			86-024/21:17:37.000
21:	AC7VCD	2	-002453		LIMB	86-024/21:17:37.000
22:	AC7VCD	1	+005687		TRACKING	86-024/21:26:25.000
23:	AC7VCD	2	+002354			86-024/21:26:25.000
24:	AC7VCD	1	+002395			86-024/21:36:01.000
25:	AC7VCD	2	+005274			86-024/21:36:01.000
26:	AC7VCD	1	-000663			86-024/21:47:55.000
27:	AC7VCD	2	+005900			86-024/21:47:55.000
28:	AC7VCD	1	+000000			86-024/21:59:31.000
29:	AC7VCD	2	+000000			86-024/21:59:31.000
30:	AC7VCD	2	+012850			86-024/23:30:24.000
31:	AC7VCD	2	-012850			86-024/23:31:48.000
32:	AC7VCD	2	+012850			86-024/23:34:36.000
33:	AC7VCD	2	+000000		SECOND	86-024/23:36:00.000
34:	AC7VCD	1	+012850		MINI	86-024/23:36:48.000
35:	AC7VCD	1	-012850		ASCAL	86-024/23:38:12.000
36:	AC7VCD	1	+012850			86-024/23:41:00.000
37:	AC7VCD	1	+000000			86-024/23:42:24.000
38:	AC7TCD	311	004213			86-025/00:03:12.000
39:	AC7SSB	3	+026			86-025/00:05:36.000
40:	AC7SSB	4	+216			86-025/00:05:36.000
41:	CC7SS	1			CELESTIAL	86-025/00:09:55.000
42:	USESS	1			REACQ.	86-025/00:09:56.000
43:	CC7CT	07				86-025/00:11:35.000

```
EOF:43
END ED, NO CORRECTIONS APPLIED

*ENV CAT2

ENV-05 03/19-16:23 MD-     LIB-CAT2    RLIB-RLIBS

*XQT RASREC
```

Table 2a
Uncompensated Drift Rates Estimates - G. Hanover

Uncomp. Drift Rate, °/h Pitch	Yaw	ΔTime Interval	Time Interval	Calculation Method
0.01220	0.00870	3.000	0455 to 0755 ERT	by slope
0.01970	0.02870	3.400	0755 to 1119 ERT	by slope
0.00630	0.01260	1.330	0935 to 1055 SCE	by slope
0.01150	0.01200	3.100	0834 to 1141 SCE	by Δ gyro/cel sensor
0.01500	0.03900	2.160	1141 to 1401 SCE	by Δ gyro/cel sensor
0.01690	0.00960	1.850	1401 to 1605 SCE	by Δ gyro/cel sensor
0.03780	0.04700	0.750	0810 to 1856 SCE	by slope
0.00890	0.03560	1.000	1756 to 1856 SCE	by Δ gyro/cel sensor
0.02500	0.02222	1.000	1920 to 1955 SCE	by slope
0.00760	0.02150	3.500	0230 to 0600 ERT	by slope
0.01370	0.02880	3.000	0530 to 0830 ERT	by slope
0.01393	0.02079		Time weighted ave	

Table 2b
Uncompensated Drift Rates - T. Weeks
(by slope calculation method)

Uncomp. Drift Rate, °/h Pitch	Yaw	Time Interval	Time Interval
0.00778	0.01323	2.000	-
0.00971	0.00316	2.000	0930 to 1130
0.02736	0.00789	2.000	1200 to 1400
0.02105	0.00463	0.830	1510 to 1600
0.00421	0.02210	0.667	1815 to 1855
0.00988	0.01111	1.160	1915 to 2025
0.00933	0.02058	1.000	-
0.01354	0.01042		Time weighted ave
0.01383	0.01802		Time weighted ave of Tables 1 & 2

Fig. 6. Attitude Control
% Error & HGA Offset

Table 3
Initial Attitude

	Earth		Limit Cycle Position		
	S/C Clock	S/C Cone	P	Y	R
Estimated Handover	194.5330	.1236	0°	-.0355°	.0033°
Modified Handover	193.147	.1247	0°	-.0216°	.0033°

Table 4
Uncompensated Drift Rates

Source	Pitch	Yaw
Celestial Sensors	+0.014	-0.018
AGC Data	+0.015	-0.016

FIGURE 1. TCMB13 GYRO TLEMETRY

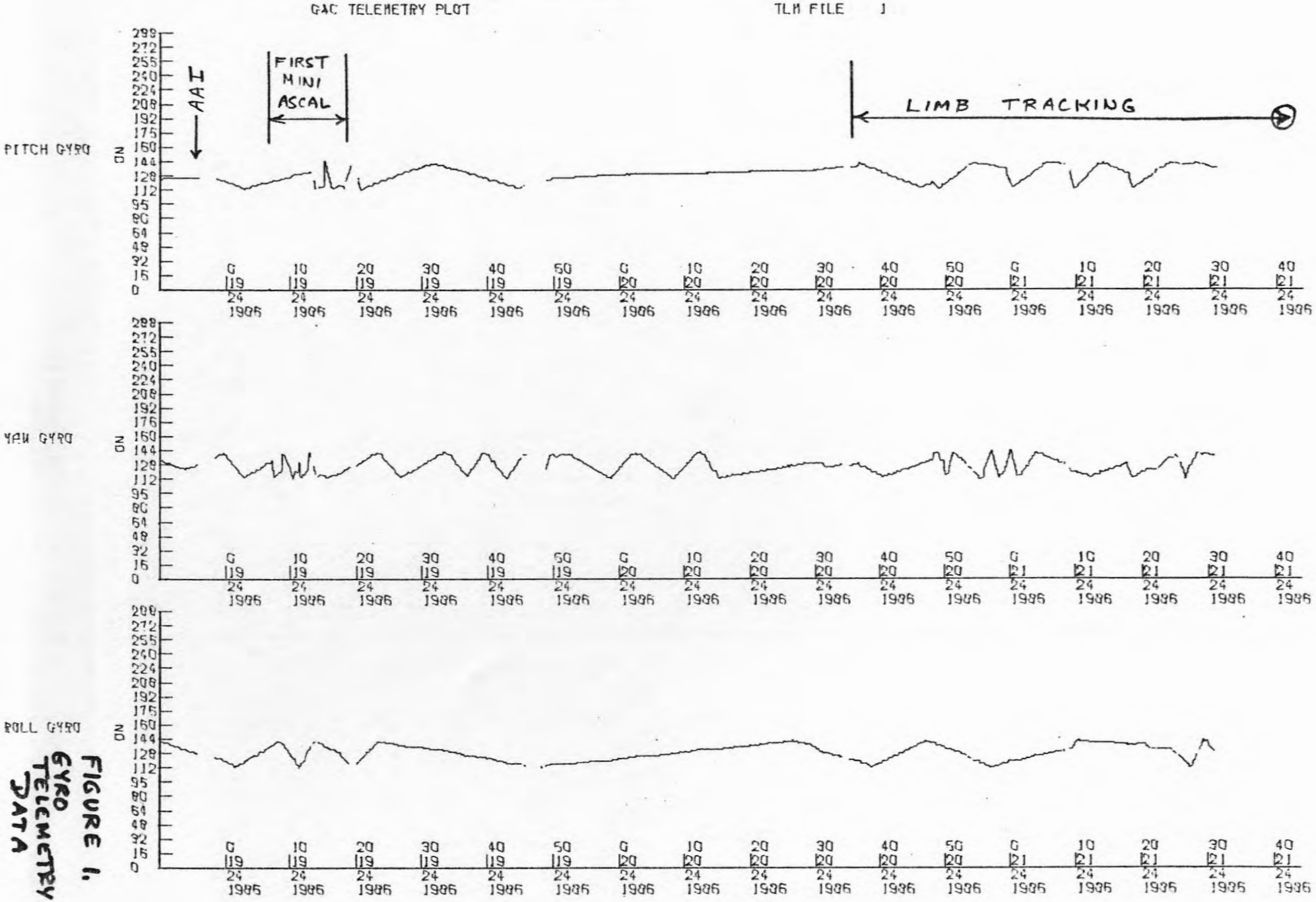

FIGURE 1. GYRO TELEMETRY DATA

FIG 1 CONT'D. TCMB13 GYRO TLEMETRY

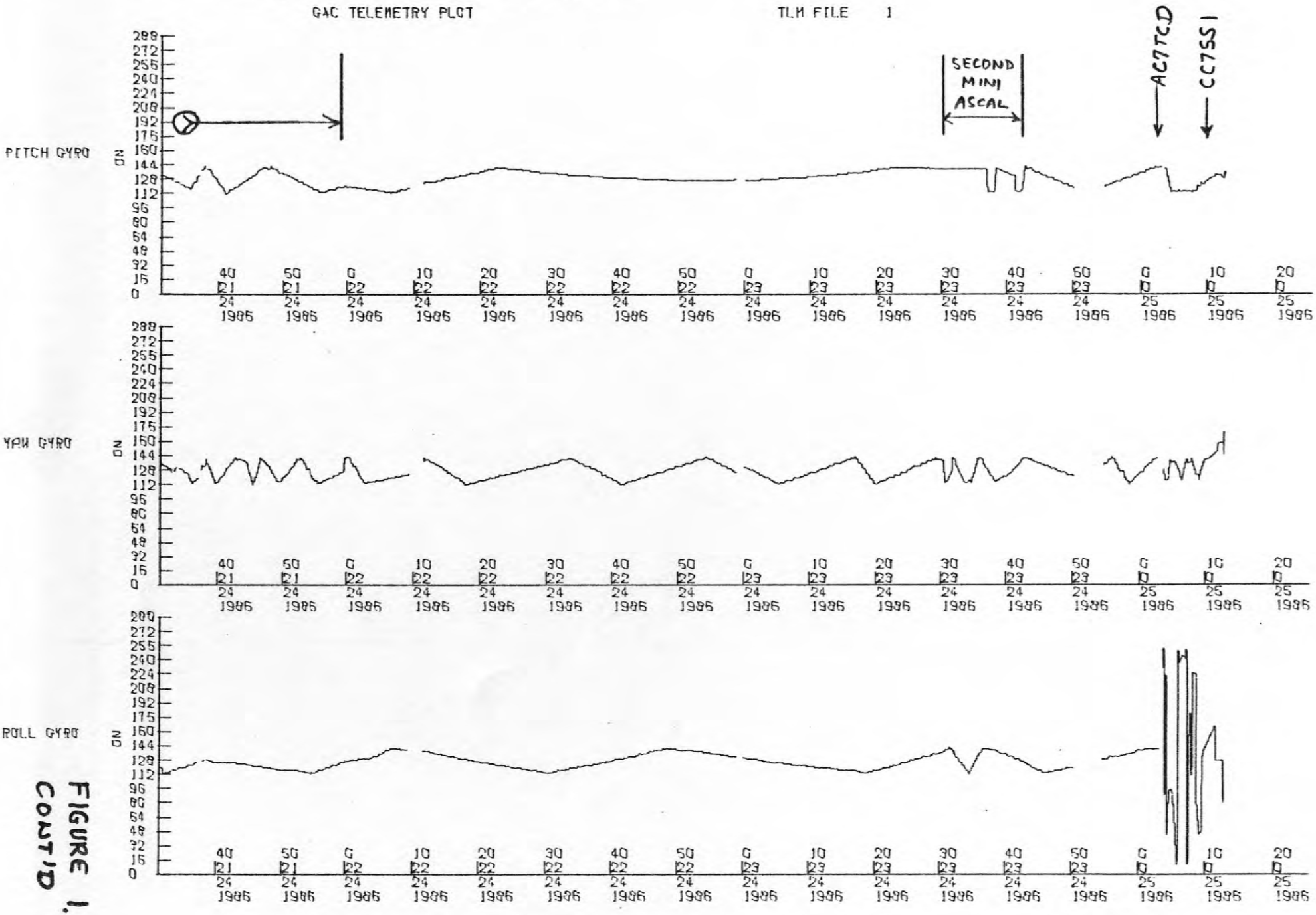

FIGURE 1. CONT'D

FIGURE 2. CELESTIAL TELEMETRY DATA

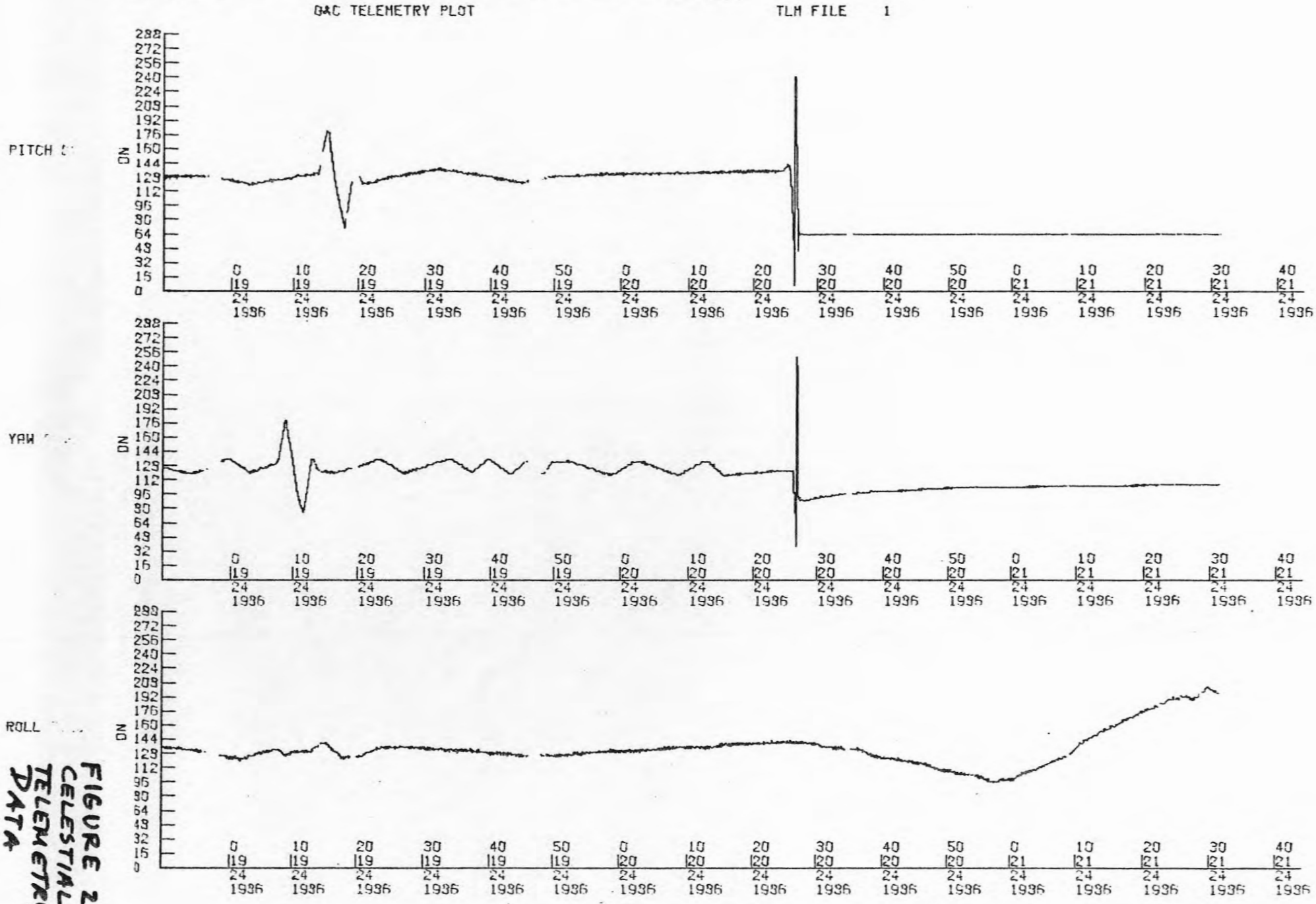

FIGURE 2. CELESTIAL TELEMETRY DATA

FIGURE 2. CONT'D

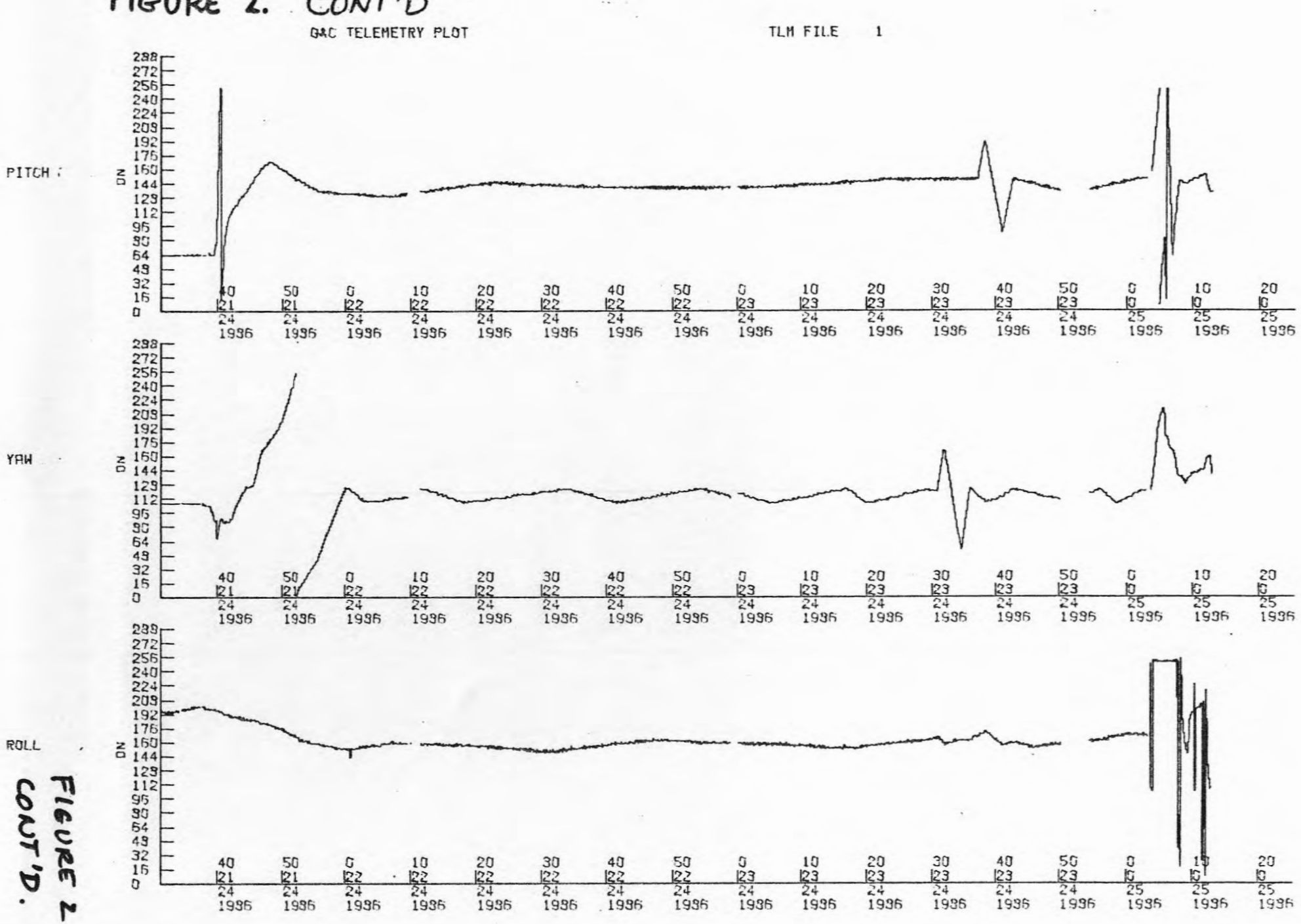

FIGURE 2 CONT'D.

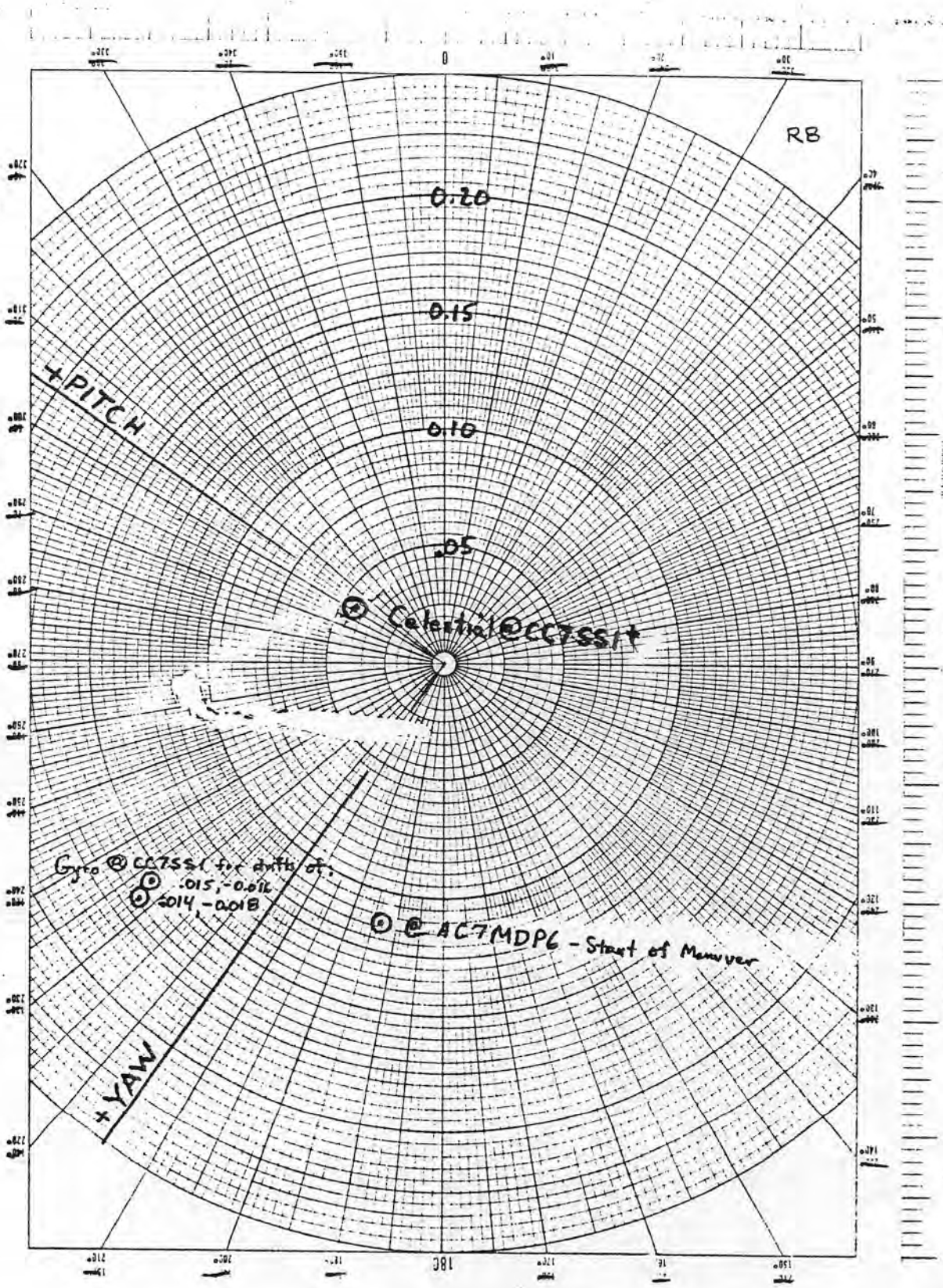

Figure 3. Earth Position, S/C Clock Cone

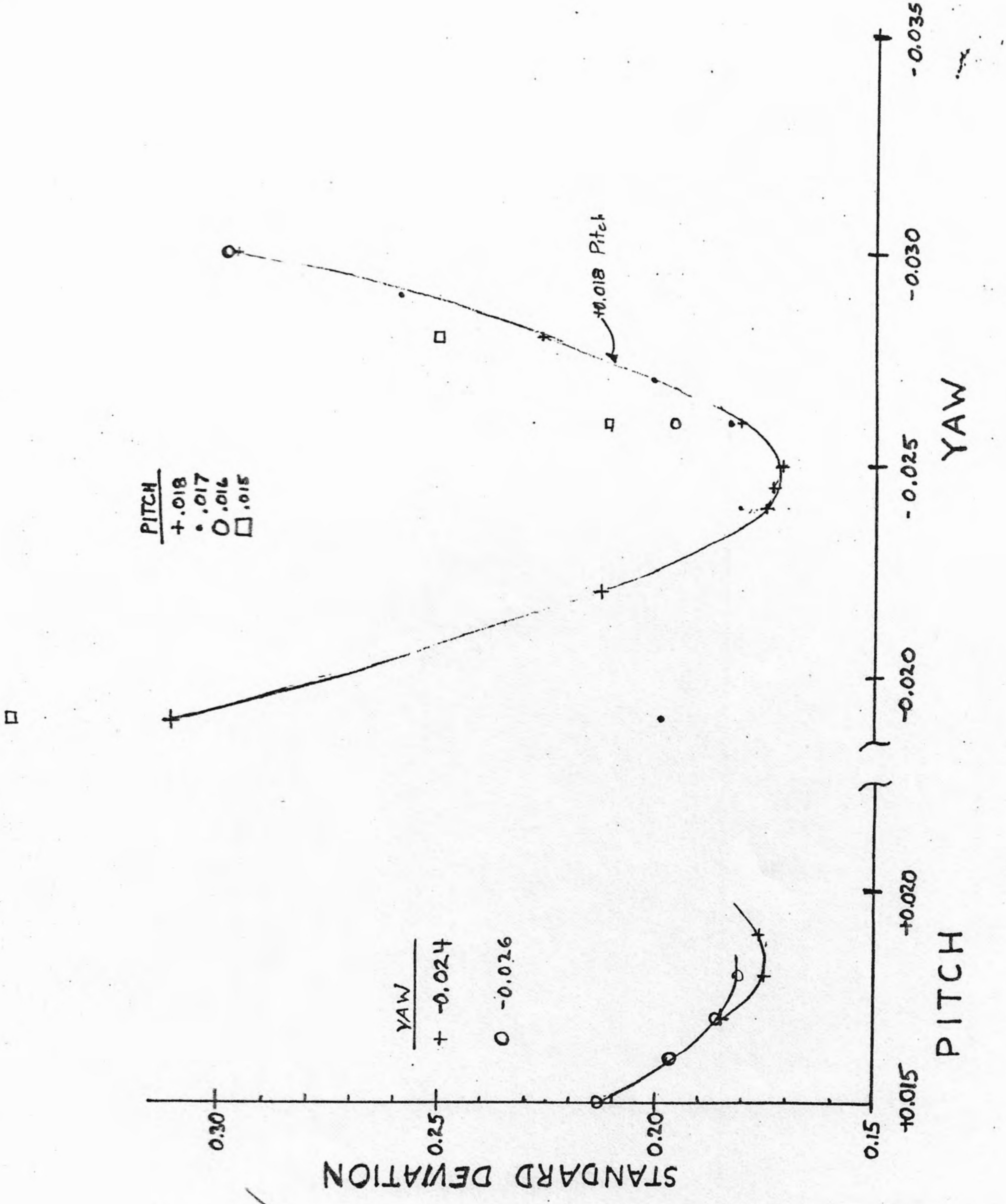

Figure 4. Standard deviation for difference between predicted and measured AGC data for verious assumed gyro uncompensated drift rates for second mini-ASCAL. Unadjusted initial attitude.

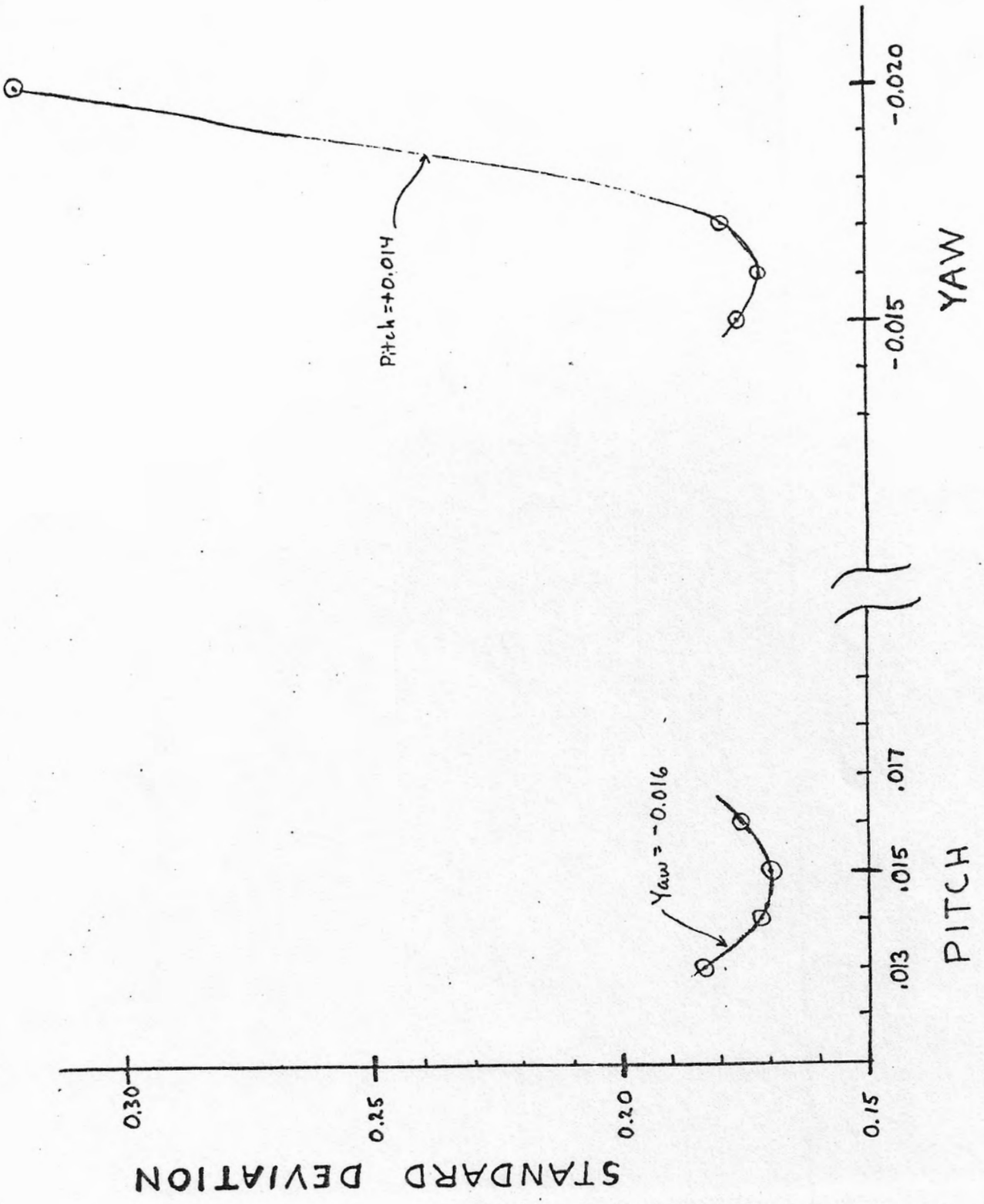

Figure 5. Standard deviation for difference between predicted and measured AGC data for various assumed gyro uncompensated drift rates for second mini-ASCAL. Initial attitude adjusted to match first mini-ASCAL data.

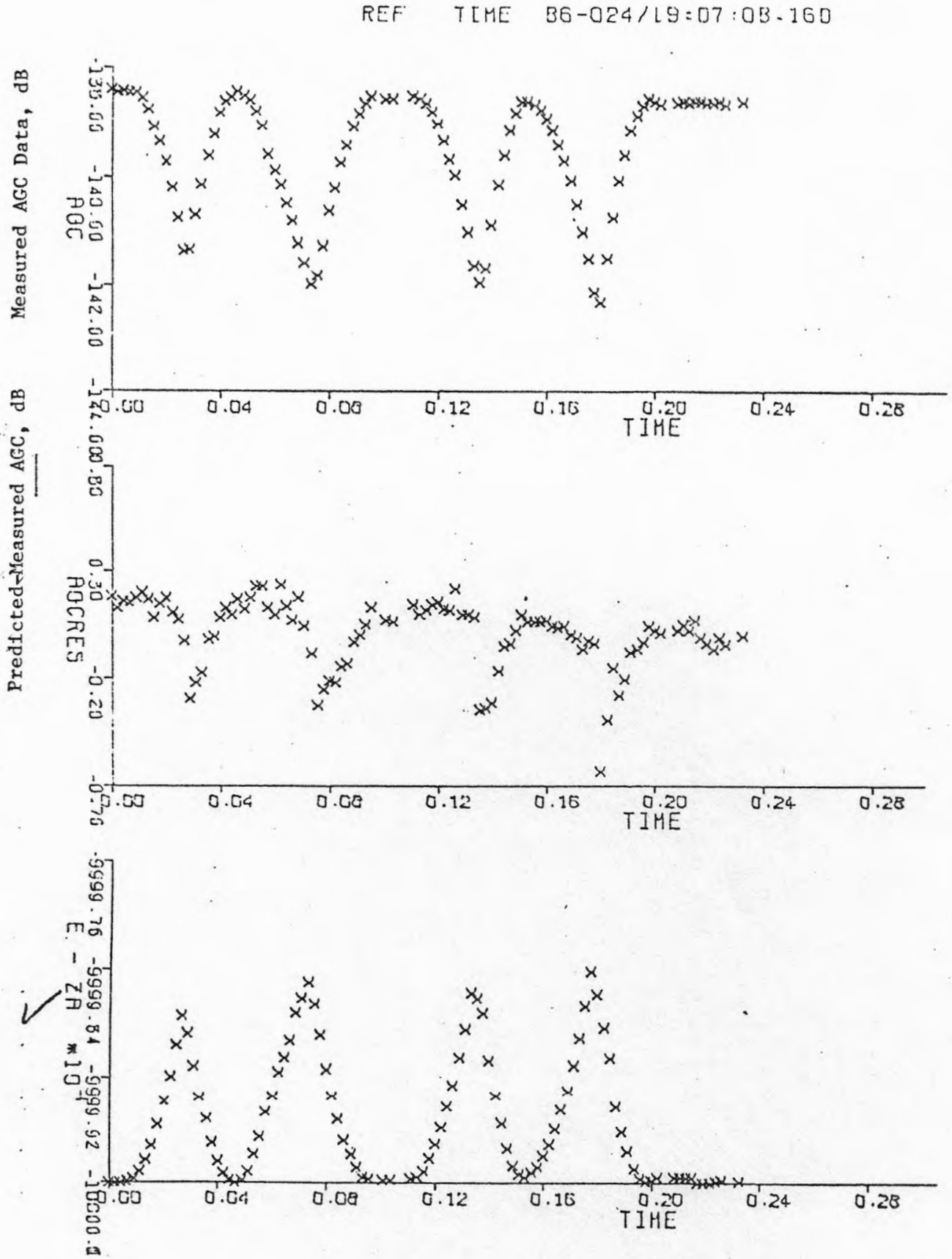

Figure 6. Predicted and Measured AGC Data for First Mini-ASCAL

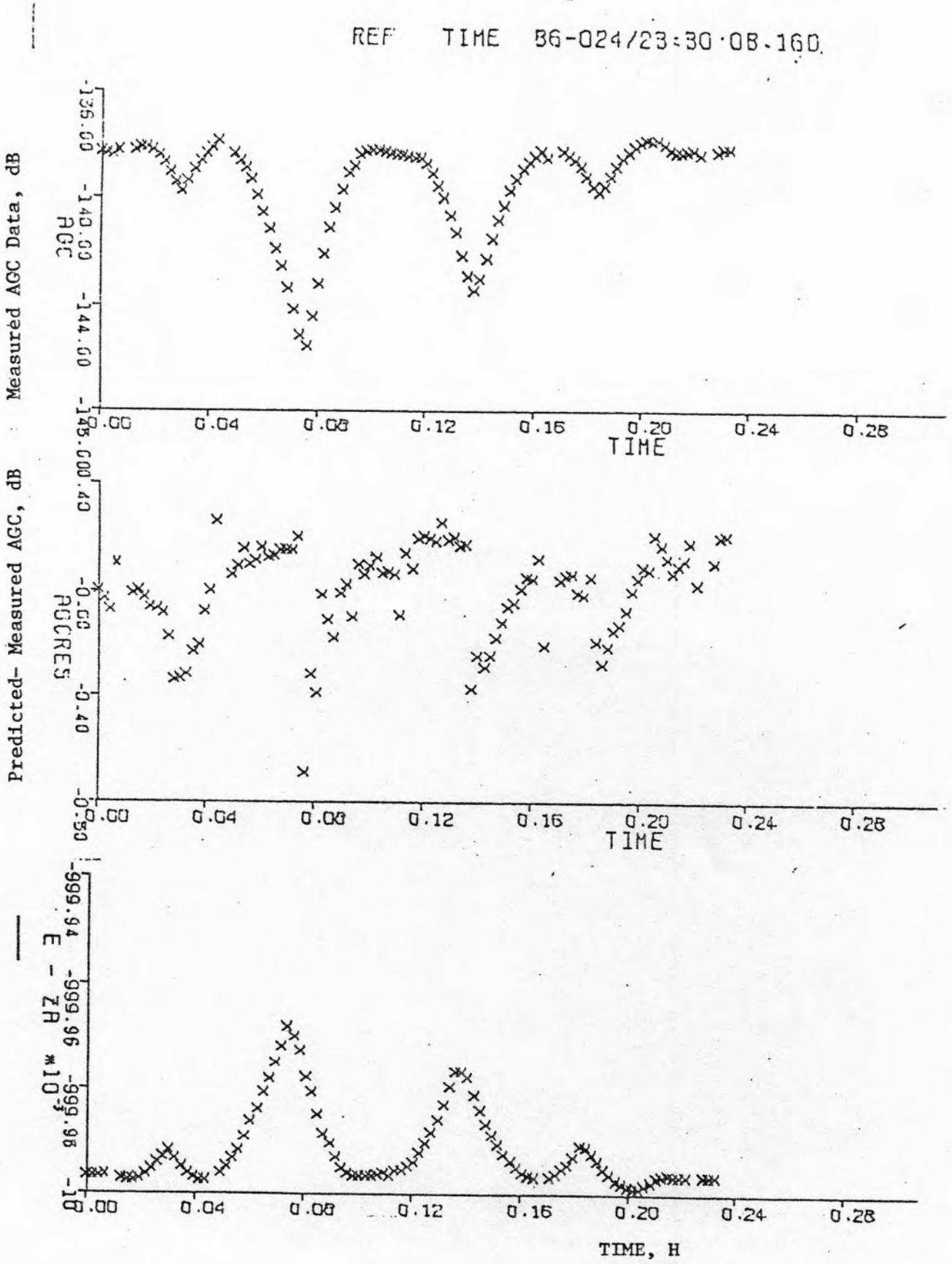

Figure 7. Predicted and Measured AGC Data for Second Mini-ASCAL