

DOT 1226

FHWA CONTRACT NO.  
DTFH61-86-Z-00047

THIRTY MPH BROADSIDE  
IMPACT OF A MINI-SIZED VEHICLE  
AND A BREAKAWAY LUMINAIRE SUPPORT

TEST RESULTS REPORT.

TEST NUMBER 1785-SI#8-88

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16. Abstract This report documents the full scale side impact test of a 1981 Plymouth Champ impacting into a breakaway luminaire support. The impact speed was 30 mi/h and the impact angle was broadside with the impact point aligned with the driver's shoulder. The impacted pole was a slip base mounted steel unit with mast arm and luminaire. The slip base was fastened together with no clamp load.  The pole broke away with a low change in velocity of the vehicle with some intrusion of the pole into the passenger compartment. The crush was approximately half of that observed with clamped slip base poles. Dummy parameters were moderate in magnitude.			
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## 1.0 SUMMARY AND CONCLUSIONS

This test investigated the impact severity of a minicompact sedan (1,800S) during a low speed broadside collision with a breakaway luminaire support. The test vehicle was a 1981 Plymouth Champ. The breakaway luminaire support was a 30 foot steel pole with a California type 31 slip base. The pole included a mast arm and surrogate luminaire and was clamped at the slip plate with loose bolts or no bolt tension.

The test vehicle momentum change due to impacting the pole at a speed of 29.6 mi/h (13.24 m/s) was 450 lb-sec. The velocity change corresponding to the observed vehicle momentum change was 4.9 mi/h or 7.2 ft/sec. The integrity of the vehicle was maintained throughout the test with the exception of the drivers door being crushed in. Maximum residual crush of the side of the vehicle was 7.5 inches.

Vehicle acceleration data was processed to determine the impact velocity of a hypothetical front seat passenger against the vehicle interior in accordance with the flail space model recommended in NCHRP 230. The lateral impact velocity of the hypothetical occupant using the flail space model approach with a one foot threshold was 7.1 ft/sec. This lateral impact velocity is within the design limit of 20 ft/sec (6.10 m/s) specified for lateral impacts of other forms of highway safety appurtances in NCHRP 230.

The acceleration data from the anthropomorphic dummy was also analyzed using NHTSA techniques to determine impact severity based on thoracic measurements. Results of this analysis indicate that from the standpoint of thoracic injuries the occupant suffered a very mild injury as measured on the American Association of Automotive Medicine's Abbreviated Injury Scale

(AIS). The probability of an injury level of AIS greater than 3, was 4 percent. The probability of AIS greater than 4 or 5 was 0 percent. This value, based on the T12Y, LLRY and LURY accelerometers, is well within the basic design goal for occupant responses of an AIS less than or equal to 3.0. Analysis of the acceleration data from the head of the anthropomorphic dummy yielded a Head Injury Criteria (HIC) of 1996. This result is greater than the limit specified in FMVSS 208. It should be noted that HIC's obtained during side impacts may not measure the head injury correctly since the head form of the dummy was designed for frontal impacts.

A summary of the test conditions and results for this full scale crash test are given in Table 1.

Table 1  
 Summary of Test Conditions and  
 Results for Test Number 1785-SI#8-88

1.	Contract Number/FOIL Test No.	DTFH61-86-Z-00047/88S009
2.	Date of Test	June 1, 1988
3.	Test Vehicle	Plymouth Champ, 1981
4.	Delivered Vehicle Weight	1885 lbs
5.	Vehicle Weight, Test Inertial Planned Actual	1,800 ±50 lbs 1,848 lbs
6.	Vehicle Weight, Gross Static Actual (One Occupant)	2,008 lbs
7.	Number of Occupants	One
8.	Occupant Type	Anthropomorphic Dummy, 50th Percentile Male, Side Impact Thorax-SN120
9.	Occupant Location	Driver Seat
10.	Occupant Restraint	Unrestrained
11.	Test Article	Breakaway Luminaire Support
12.	Support Length (w/o Base)	30 ft
13.	Support Material	Steel
14.	Support Weight (w/Base, mast arm and luminaire)	416 lbs
15.	Base Type	Triangular Slip Base, 3-Bolt (Type 31)
16.	Slip Plane Mounting Height Above Grade	4 in
17.	Bolt Circle	14 in
18.	Bolt Size	1 in - 8 NC x 5 in long
19.	Bolt Load (Strain Gaged)	loose
20.	Foundation	FOIL Impact Foundation
21.	Ground Conditions	Dry

Table 1 (Cont'd)  
 Summary of Test Conditions and  
 Results for Test Number 1785-SI#8-88

22.	Impact Speed, Observed	29.6 mi/h
23.	Speed Reduction Acceleration Data, TRC 191	4.9 mi/h
24.	Exit Speed	24.7 mi/h
25.	Impact Point, Observed	Left Door, Driver Location, (28" behind cg)
26.	Traffic Accident Data, TAD	9-LP-2
27.	Vehicle Damage Index, VDI	09LPAN2
28.	Hypothetical Occupant Impact Velocity (NCHRP 230)	
	Design Limit	20 ft/sec
	Observed (1' flail)	7.11 ft/sec
	Observed (.5' actual)	7.48 ft/sec
29.	Hypothetical Occupant Ride-down Acceleration (NCHRP 230)	
	Design Limit	15.00 g
	Observed, (1' flail)	1.99 g
	Observed, (.5' actual)	2.72 g
30.	Actual Occupant Impact Velocity	
	Limit (NCHRP 230)	30 ft/sec
	Observed (Head hit pole)	43.4 ft/sec
31.	Head Injury Criteria (HIC)	
	Design Limit	1000
	Driver, Observed	1996
32.	Upper Spine Acceleration Data	
	Acceleration with Duration Greater than .003 sec	72 g's
	CSI	230
33.	TTI-86, age=0	91
34.	Thoracic Injury	
	Fatal Injury	6.00
	Probability of:	
	AIS greater than 3	4%
	AIS greater than 4	0%
	AIS greater than 5	0%
35.	Momentum Change from Pole	450 lb-sec

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1 lb = .454 kg	1 lb-sec = 4.448 N-s	1 in = .0254 m
1 ft = .3048 m	1 ft-kip = 1,355 N-m	

## 2.0 OBJECTIVE

The objective of this test was to investigate the impact severity of a minicompact sedan (1,800S) during a low speed broadside collision with a breakaway luminaire support. This test is the eighth of a series of eight full scale crash tests to be conducted. The planned and actual test matrix is shown in Table 2.

The vehicle used for this test was a 1981 Plymouth Champ. A triaxial accelerometer package was mounted on the lateral centerline of the vehicle near the longitudinal location of the center of gravity of the vehicle in its inertial test configuration. The data from these accelerometers were used to measure vehicle impact behavior and occupant injury potential based upon criteria set forth in TRC 191 and NCHRP 230. One rate gyro was also mounted to the accelerometer block to measure yaw rate. The vehicle also was instrumented with a contact switch mounted on the left door to permit vehicle and occupant data to be measured relative to the time of impact.

The vehicle contained one instrumented 50th percentile male anthropomorphic test dummy equipped with a thorax specifically designed for side impacts. The test dummy (serial no. 120) was positioned in the driver seat and was unrestrained. The data from the triaxial accelerometer sensor assembly in the head of the test dummy was used to evaluate the Head Injury Criteria (HIC). The data obtained from the triaxial accelerometer sensor assemblies located in the upper and lower parts of the spine and in the pelvis of the occupant were used to evaluate severity indices and maximum sustained accelerations experienced by the occupant in the respective locations in accordance with SAE Information Report J885a. The data obtained from the accelerometers located on the ribs of the occupant were used to evaluate the maximum sustained accelerations experienced by the occupant

Table 2

Test Matrix for Side Impact Test Series

<u>Test Number</u>	<u>Angle</u> <sup>1</sup>	<u>Location</u> <sup>2</sup>	<u>Article</u> <sup>3</sup>
1 (1 actual)	90	0	Slipbase
2 (2 actual)	90	0	T-base
3 (6 actual)	90	+12"	Slipbase
4 (5 actual)	90	-12"	Slipbase
5 (7 actual)	90	+24"	Slipbase
6	90	-6 or -24"	Slipbase
7	60	0	Slipbase
8	120	0	Slipbase
3 actual	90	0	Slipbase
4 actual	90	0	Slipbase
8 actual	90	0	Non-clamp Slipbase

<sup>1</sup> 90° = Broadside on Drivers Door  
 60° = Front of Vehicle Leading

<sup>2</sup> 0" = Centered on Occupant  
 + = Forward of Occupant  
 - = Rearward of Occupant

<sup>3</sup>Slipbase pole w/30' pole mast arm and surrogate luminaire.

T-base Union Metal 2849 w/40' steel pole, mast arm and surrogate luminaire.

Notes:

All tests to be run at 30 mph impact speed.

All test vehicles to be Dodge Colts or Plymouth Champs.

All vehicles to have 1 SID in driver's position.

Test number indicates planned test number and actual test number.

Planned tests 6,7 and 8 were not conducted in this test program.

in the respective locations. In addition, thoracic injury parameters associated with side impact conditions were analyzed using NHTSA techniques to determine occupant injury.

The breakaway luminaire support was chosen since it was known to induce a momentum change during frontal impacts which was considered very acceptable. The objective was to determine what level and type of injury could be expected during a side impact collision with one of the better performing hardware devices on the highway system. In this test the clamp load on the base was set to zero by using loose bolts. This was done to simulate a best condition slip base pole, where the force to activate should be next to zero. This would leave only the inertial load of accelerating the pole away from the car as the major force acting on the car.

### 3.0 APPURTENANCE DESCRIPTION

The physical properties of the breakaway luminaire support are contained in table 3. The breakaway luminaire support incorporated a triangular 3-bolt slip base which is based on a design of the California Type 31 support. The slip base was positioned so impact would occur against an edge which had two bolts aligned. The luminaire support had a mast arm attached during this test as well as a steel weight attached to the end of the arm. The slip base was clamped together with three bolts which were not tightened. Mechanical properties of the pole are shown in Figure 1.

Table 3  
Properties of Test Pole

Manufacturer:	Ameron
Material:	Steel
Weight:	416 lbs
Height, c.g.:	21 ft
Top diameter:	3-1/2 in
Bottom diameter:	7.5 in
Mast Arm Length:	15 ft - 9 in.
Luminaire Height:	35 ft - 10 in.
Luminaire Weight:	51 lbs
Base Type:	California Type 31 slip base
Number of bolts:	3
Size:	1 in diameter
Bolt Clamp Load:	loose

LUMINAIRE SUPPORT PARAMETERS  
SLIP BASE WITH TRUSS MAST ARM

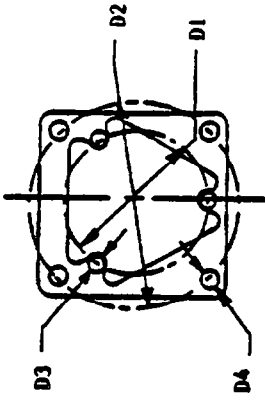
Manufacturer: Ameron Part Nos \_\_\_\_\_

Ref. FOIL Tests: \_\_\_\_\_

Completed By: C. Brown Dates: 7/1/87

WEIGHTS (LB)

Poles: 275 (W1)  
Mast Arms: 90 (W2)  
Luminaires: 51 (W3)  
Total Assys: 416 (WT)



MEASURED LENGTHS (IN)

Mounting Heights: 36' (H1) No. Slip Bolts: 3  
Pole Heights: 30'3" (H2) Slip BC Dia (in): 14 (D1)  
Pole CB Heights: 12'4" (H6) Dia of Slip Bolts (in): 1 (D3)  
Mast Arm CB Hts: 33'2" (H5) No. Foundation Bolts: 3  
Mast Arm CB Offsets: 6' (L2) Found BC Dia (in): 14 (D2)  
Lumin CB Hts: 35'10" (H4) Dia Found Bolt (in): 1 (D4)  
Lumin CB Offsets: 15'9" (L1) 8 Bolt Clamp Force (lb): LOOSE  
Stub Ht: 4.0 (H7) Keeper Plate, Y/N: Y

SOLE PARAMETERS

Base Dia (in): 7.5 Wall Thick (in): .125  
Tip Dia (in): 3.5 Materials: Steel

TOTAL ASSEMBLY CB LOCATION (IN)

Total Assy CB Ht = 21' (H3)  
Total Assy CB Offset = 3'4" (L3)

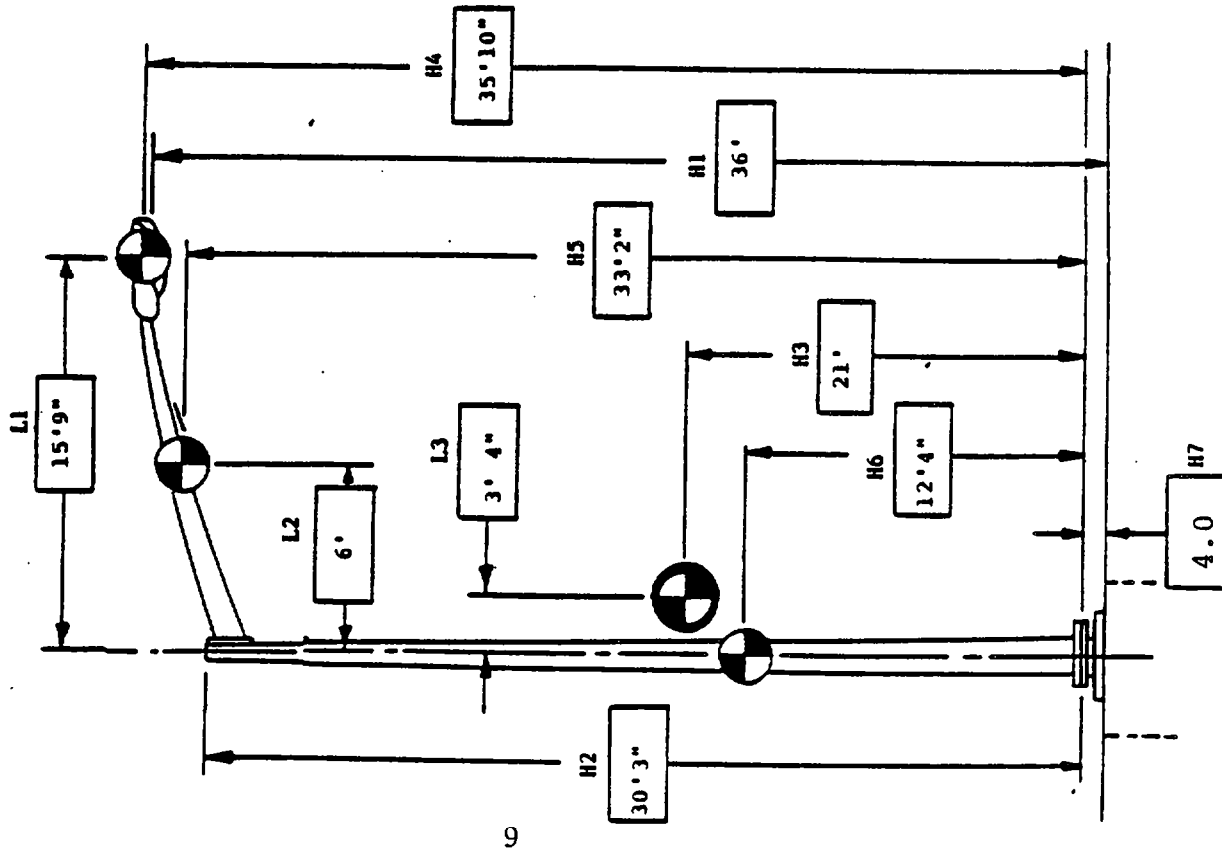


Figure 1. Mechanical Properties of Pole

#### 4.0 VEHICLE DESCRIPTION

The test vehicle was a 1981 Plymouth Champ. The weight of the vehicle prior to incorporating the instrumentation for the test was 1885 lbs. The test inertial weight for the vehicle was 1848 lbs and the gross static weight when the occupant was included in the vehicle was 2008 lbs. The longitudinal center of gravity of the vehicle without the occupant was located approximately 32 inches behind the centerline of the front axle. The weight and inertial data of the vehicle in its as delivered and instrumented configuration are given in table 4. Inertial data was measured using the IMD.

The vehicle was equipped with a triaxial accelerometer package mounted on the lateral centerline of the vehicle at the longitudinal location of the center of gravity. One rate gyro was also installed to the same mounting block to measure yaw rate. The vehicle was also equipped with a contact switch mounted on the left door to permit vehicle and occupant data to be measured relative to the time of impact. A second triaxial accelerometer package was attached to the floor board located in front of the front right hand seat. Two gyros were also attached to this block to measure yaw and roll rates. This data was collected using the FOIL data system. The test vehicle is shown in Figure 2.

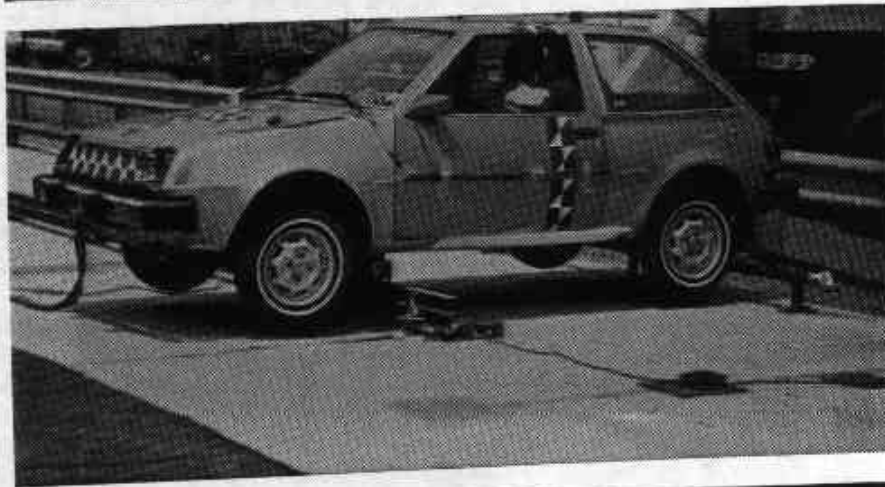
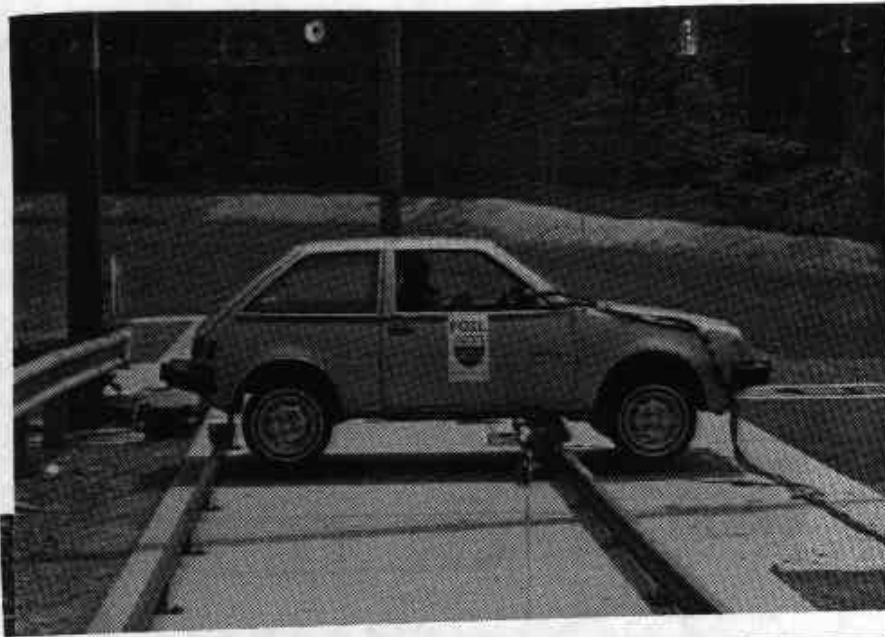


Figure 2. Pre-test Photos of Vehicle

Table 4  
Cg and Inertial Data for Test Vehicle

Vehicle	1981 Plymouth Champ
Serial Number	JP3BE343XBU417802
Build Date	December 1980
Delivered Weight	1885 lbs
Delivered cg-x	32" behind front axle center line
Delivered cg-y	at vehicle centerline
Delivered cg-z	19.8" above ground
Delivered Roll Inertia	197 slug-ft <sup>2</sup>
Delivered Pitch Inertia	794 slug-ft <sup>2</sup>
Delivered Yaw Inertia	875 slug-ft <sup>2</sup>
As tested weight, inertial	1848 lbs
As tested weight, gross	2008 lbs
As tested cg-x	32" behind front axle centerline
As tested cg-y	at vehicle centerline
As tested cg-z	19.4" above ground
As tested Roll Inertia	217 Slug-ft <sup>2</sup>
As tested Pitch Inertia	823 Slug-ft <sup>2</sup>
As tested Yaw Inertia	846 Slug-ft <sup>2</sup>

## 5.0 TEST INSTRUMENTATION

Film data of the test was taken as described in table 5. Transducer data was recorded as listed in table 6. The transducer data was collected in analog form on a Honeywell 5600C recorder at 60 ips. The multiplexed data and the 32 kHz control signal were recorded in direct mode with a bandpass of 300 Hz to 300 kHz. The multiplexed data was played back through SAE Class 1000 filters and each channel was digitized at 8,000 Hz as required by the contract. A digital data tape was created in accordance with the specifications defined by NHTSA. The test data was analyzed on a DEC 11/70 using the ENSCO general purpose highway research analysis programs. The 32 kHz control signal was initiated approximately 2.0 seconds prior to the vehicle impacting the luminaire support. This control signal was used to externally trigger the digitizing unit and automatically synchronize all data channels. The signal conditioning unit onboard the vehicle was a Series 300 FM data multiplexer manufactured by Metraplex Corporation. The instrumentation used to collect the transducer data during the test conformed with SAE Recommended Practice J211b. Data from additional accelerometers located in front of the right front seat was recorded using the FOIL data system.

Table 5

## Description of Film Data Acquisition System

<u>Camera</u>	<u>Model</u>	<u>Position</u>	<u>Speed Setting</u>	<u>Lens</u>
1	Redlake, Locam	Rt. Side	500 pps	16 mm
2	Redlake, Locam	Rt. Side	500 pps	100 mm
3	Redlake, Locam	Front Rt.	500 pps	16 mm
4	Redlake, Locam	Front Rt.	500 pps	100 mm
5	Redlake, Locam	Front Lt.	500 pps	16 mm
6	Redlake, Locam	Front Lt.	500 pps	100 mm
7	Redlake, Locam	Onboard	500 pps	5.7 mm
8	Redlake, Locam	Overhead	500 pps	10 mm
9	Redlake, Locam	Side view	500 pps	16 mm
10	Bolex	Documen- tation	24 pps	Zoom

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pps - Pictures per second

Table 6  
Transducer Data Description

Channel No.	Channel Description
1	Left Lower Rib Accel., LLRYG1
2	USTXG1
3	Left upper Rib Accel., LURYG1
4	Upper Spine Accel., T01XG1
5	Upper Spine Accel., T01YG1
6	Upper Spine Accel., T01ZG1
7	Lower Spine Accel, T12XG1
8	Lower Spine Accel, T12YG1
9	Lower Spine Accel, T12ZG1
10	LSTXG1
11	Left Lower Rib Accel., LLRYGA
12	Left Upper Rib, Accel., LURYGA
13	Head Accel, X
14	Head Accel, Y
15	Head Accel, Z
16	Pelvis Accel, X
17	Pelvis Accel, Y
18	Pelvis Accel, Z
19	Vehicle Accel., cg-x
20	Vehicle Accel., cg-y
21	Driver Door, Impact Marker
22	Vehicle c.g., Roll Rate
23	Vehicle c.g., Yaw Rate
24	Vehicle Accel., cg-z

## 6.0 TEST RESULTS

The impact conditions were 29.59 mph (13.24 m/s) at a point on the left door aligned with the occupant, 28 in (.71 m) behind the longitudinal location of the center of gravity of the vehicle measured without the dummy in the vehicle. The vehicle had a  $5.5^{\circ}$  roll angle as it leaned toward the test pole due to the side sliding forces acting on the tires. The maximum residual crush of the vehicle at the impact point was 7.5 inches (.19 m). Photographs of the vehicle and luminaire support after the collision event are shown in Figure 3.

After the initial separation from the vehicle the luminaire support rotated up and over the test vehicle with the top of the pole hitting the ground about 1.08 seconds after impact. Just prior to impact with the ground, the center portion of the pole impacted the roof of the car. As the support rotated away, vehicle yawed counter clockwise, continued forward away from the impact area after yawing a total of about  $45^{\circ}$ . The vehicle did not pitch or roll very much but remained stable during this transition. The final resting position of the vehicle was about 36 feet downstream and 8 ft to the right of the impact point with the pole resting on the roof. The top of the pole was just past the end of the runway. The residual test vehicle crush measured using the 6 point NHTSA guide is given in Table 7. See figure 4 for reference.



Figure 3. Post-Test Photos of Vehicle

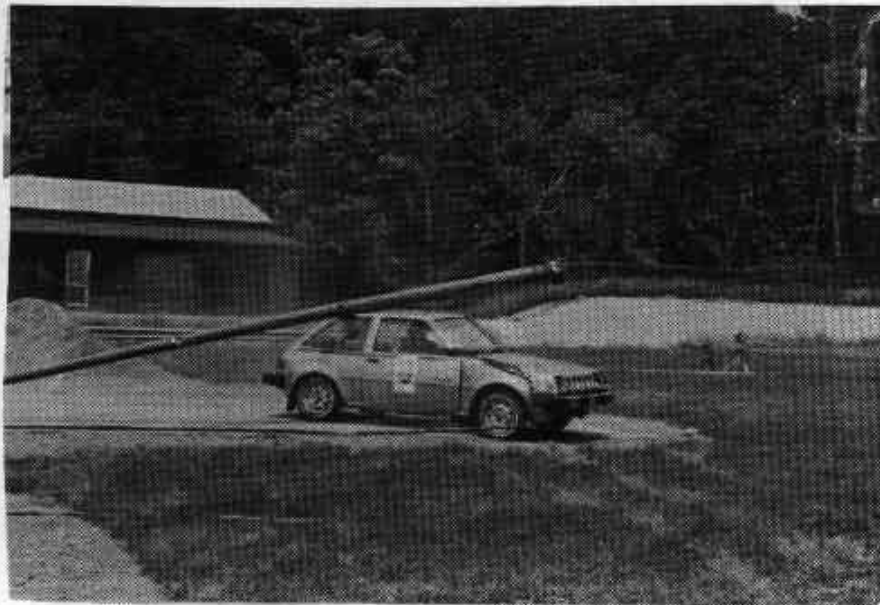


Figure 3 (Con't). Post-Test Photographs of Vehicle

Table 7  
Residual Vehicle Crush

C1	=	0.0 in	L	=	64 in
C2	=	2.5 in	D	=	-19 in
C3	=	6.0 in	Maximum crush	=	7.5 in
C4	=	5.0 in			
C5	=	3.0 in			
C6	=	0.0 in			

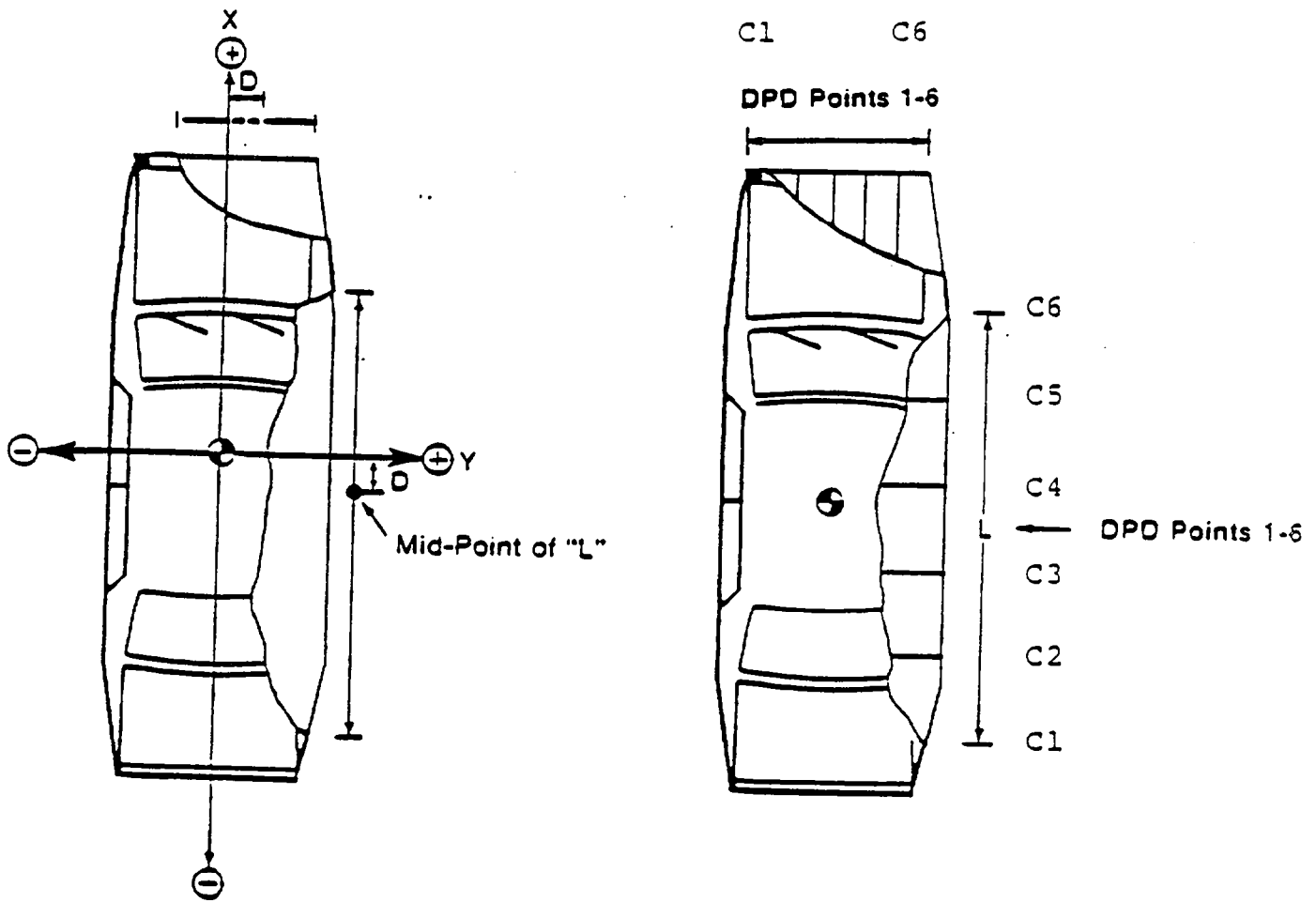


Figure 4. NHTSA Vehicle Damage Measurements

## 7.0 TEST ANALYSIS

Data from this test were evaluated using several techniques. The pre-impact speed was determined from the high speed film information. The signals from the accelerometers mounted at the center of gravity of the vehicle were debiased and filtered at SAE Class 60 and integrated to yield the change in the speed of the vehicle during the test in accordance with TRC 191. Those signals were also filtered at SAE Class 180 and processed to yield the associated occupant injury parameters in accordance with NCHRP 230.

The data from the triaxial accelerometer sensor assembly in the head of the test dummy was filtered at SAE Class 1000 and used to evaluate the HIC. The data obtained from the triaxial accelerometer sensor assemblies located in the upper spine of the occupant was filtered at SAE Class 180 and was used to evaluate severity indices and maximum sustained accelerations experienced by the occupant. The data obtained from the accelerometers located on the ribs of the occupant were filtered at SAE Class 180. In addition, thoracic injury parameters associated with side impact conditions were analyzed using NHTSA techniques to determine side impact occupant injury.

### 7.1 IMPACT VELOCITY ANALYSIS

The speed that the test vehicle impacted the luminaire support was determined from the high speed films and speed trap. Results from the speed analysis of the film data are contained in Table 8.

Table 8  
 Test Vehicle Impact Speed Evaluation  
 Using High Speed film Analysis

<u>Camera</u>	<u>Position</u>	<u>Impact Speed (ft/sec)</u>	<u>Impact Speed (mph)</u>
1	Right Side	43.9	29.9
2	Right Side	<u>42.9</u>	<u>29.2</u>
Avg		43.4	29.6

A speed trap was installed to measure the speed of the vehicle as it left the end of the mono-rail. During this test the speed trap indicated a speed of 31.13 mph. Assuming a slide distance of 5.5 ft and a coefficient of .8, the scrub off energy is computed to be 9.6 kip ft. Subtracting this from the kinetic energy at the end of the rail and then computing the speed at the end of the slide zone produces an impact speed of 42.1 ft/sec. This is in agreement with the film data and thus confirms the film measurements.

Based upon the results of this analysis, the speed of the vehicle upon impacting the support was 29.6 mph (13.24 m/sec).

## 7.2 ANALYSIS OF VEHICLE MOUNTED ACCELEROMETERS

The data collected from the accelerometers mounted to the vehicle were filtered at SAE Class 60 and 180 per TRC 191 and NCHRP 230 requirements, respectively. The acceleration traces obtained with the use of the SAE Class 60 ( $f_c = 100$  Hz) filtering technique are presented in figures A1 through A2. The acceleration traces obtained with the use of the SAE Class 180 ( $f_c = 300$  Hz) filtering technique are presented in figures A3 through A4. Figure A5 presents the impact marker channel. Figures A6 and A7 contain the yaw rate gyro data filtered at 100 Hz and 10 Hz (SAE Class 60 and 6). Figure A8 presents the yaw angle of this plot.

The resulting change in velocity and momentum change of the vehicle based upon integrating the lateral Class 60 acceleration signal in the fixed vehicle coordinate system was 7.2 ft/sec and 450 lb-sec, respectively. This does not account for the tire sliding forces since the accelerometer signal was debiased during the slide zone. The approximate change in velocity due to the sliding is 2.5 ft/sec. Thus the overall velocity change and momentum change of the vehicle due to the pole and tire sliding are 9.7 ft/sec and 606 lb-sec.

Analysis of the impact velocity of a hypothetical front seat passenger against the vehicle interior, calculated from the vehicle lateral Class 180 acceleration yielded the results shown in Table 9. Using the standard one foot flail distance, a hypothetical front seat occupant would have impacted the interior of the vehicle in the lateral direction at an approximate impact velocity of 7.11 ft/sec (2.16 m/s) based upon data filtered at SAE Class 180. This lateral impact velocity is within the design limit of 20 ft/sec (6.10 m/s) specified for other forms of highway safety appurtenances in NCHRP 230.

The highest ridedown acceleration after the hypothetical front seat passenger impacted the interior of the vehicle was 1.99 g's using a 10 ms average of the lateral acceleration data filtered at SAE Class 180. This ridedown deceleration is within the design limits of 15 g's specified in NCHRP 230.

Table 9

Change in Velocities and Ride Down  
Acceleration From Analysis of Class 180  
Data Using NCHRP 230 Technique

<u>Flail Distance</u>	<u>Change in Velocity (ft/sec)</u>	<u>Ride Down Acceleration (g's)</u>
1.0 ft	-7.11	1.99
.50 ft	-7.48	- 2.72

Based upon this analysis NCHRP 230 indicates that the accident was within design limits for the hypothetical occupant.

7.3 LUMINAIRE TEST OBSERVABLES

There was no pole data to report on.

7.4 HEAD INJURY CRITERIA EVALUATION

The data obtained from the three accelerometers located in the head of the occupant during the test were filtered at SAE Class 1000 and combined to yield a resultant acceleration occurring during the impact event. The HIC was evaluated in accordance with the procedures outlined in FMVSS 208. The acceleration traces and resultant obtained with the use of the SAE Class 1000 ( $f_c = 1,650$  Hz) filtering techniques are presented in Figures A9 through A12. The results of the HIC evaluation calculated for the occupant during this test is shown in table 10. Comparing the results to the acceptable limit of 1000 indicates that the collision event produced a head injury approximately double the acceptable limit.

Table 10  
Head Injury Criteria

	<u>Driver</u>
HIC	1946
t(Start)	.026125 sec
t(Stop)	.027625 sec
t(Duration)	.00150 sec

### 7.5 OCCUPANT SEVERITY INDEX EVALUATION

The data obtained from the triaxial accelerometer packages located in the upper spine (T01), lower spine (T12), all left ribs and the sternum were filtered at SAE Class 180. The T01, T12 and pelvis data was combined to yield a resultant acceleration occurring during the impact event. The severity index for each was evaluated in accordance with SAE Information Report J885a. In addition, the maximum resultant acceleration whose cumulative duration is not less than 3 milliseconds was evaluated for the same location in accordance with FMVSS 208. The upper spine was selected to evaluate chest parameters since it was the closest data to the location of standard chest accelerometers. The CSI was 230 and the maximum acceleration was 72 g's at 27.7 milliseconds. These results should not be compared directly with the design limits for the severity index of 1000 and sustained acceleration level of 60g specified in FMVSS 208 since none of the accelerometers are located at the center of gravity of the upper thorax location. The CSI and max acceleration in data for the pelvis was 64 and 25 g's at 29.3 msec. The T12 data produced a CSI of 124 and a maximum chest of 60 at 26.7 milliseconds.

The acceleration traces and associated resultants obtained with the use of the SAE Class 180 ( $f_c = 300$  Hz) filtering techniques are presented in Figures A13 through A16 for the upper spine (T01) location, Figures A17 through A20 for the lower spine (T12) location, Figures A21 through A24 for the pelvis and Figure A25 for the sternum location. 300 Hz data traces for the rib accelerometers are presented in Figures A26 through A29.

7.6 THORACIC INJURY EVALUATION

The data obtained from the accelerometers mounted at the T01Y T12Y, LLRY and LURY location within the thorax of the occupant was filtered using NHTSA FIR filter and presented in Figure A30 through A35.

The Thoracic Trauma Index (TTI) was computed using the following relationship:

$$TTI = 1.4 * Age + .5 * (T12Y + MAX (LURY, LLRY)) * (Mass/165)$$

The following data was determined from the FIR filtered data:

T01Y	-	-67 g's
T12Y	-	-48 g's
LURY01	-	-132 g's
LURYGA	-	-135 g's
LLRY01	-	-85 g's
LLRYGA	-	-87 g's

The two rib data points were averaged together to obtain 134 g's for the upper and 86'g for the lower rib. A matrix of the AIS values for the TTI-86 values for ages 0, 23 and 41 is represented in Table 11. See figure 5 for TTI values.

TABLE 11  
Matrix of TTI- 86 vs AIS Values

<u>Age</u>	<u>TTI-86</u>	<u>Probability of Inquiry</u>		
		<u>AIS +3</u>	<u>AIS +4</u>	<u>AIS + 5</u>
0	91	3%	0%	0%
23	123	47%	4%	0%
41	148	74%	23%	2%

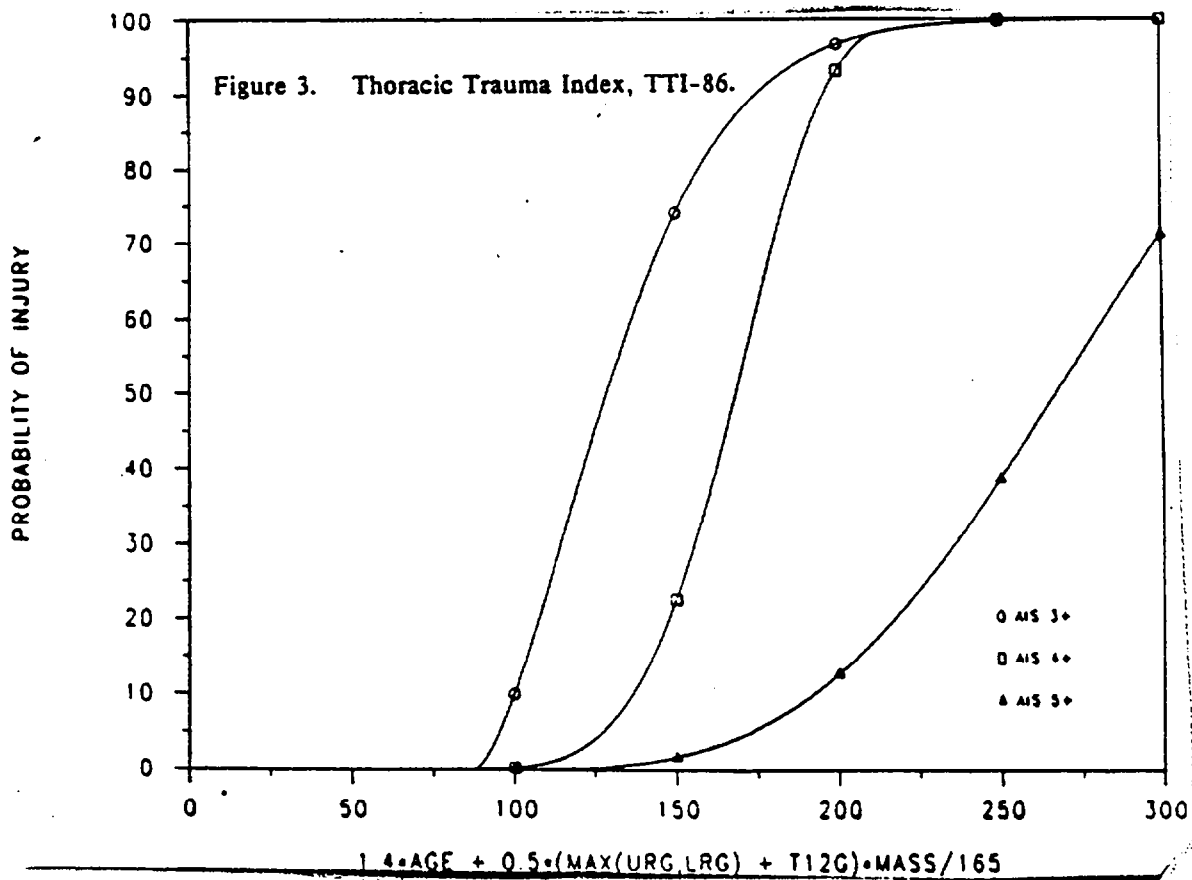


Figure 5. Thoracic Trauma Index Scale

## 7.7 VEHICLE ENERGY BALANCE

An energy balance was not performed since the post test pole dynamics data was not available.

## 8.0 SAFETY ASSESSMENT OF TEST

This section of the report assesses the safety performance of the luminaire and vehicle during the impact. The assessment is made in accordance with NCHRP 230 shown in Figure 6.

### STRUCTURAL ADEQUACY

The test pole readily activated in the predicted manner. There was however, some penetration of the passenger compartment due to the nature of the test. No undue hazard was generated to other traffic.

### OCCUPANT RISK

Occupant risk is rated as most likely serious. This was due to the impact location of the pole on the vehicle causing the occupant head to hit the pole. HIC, CSI and max chest accelerations were outside the limits. The thoracic injury indicated a mild accident rating with a low or zero probability of an AIS greater than 3, 4 or 5.

The NCHRP 230 flail space model data was evaluated and found to be less than the limit and design values. The flail space model was designed to predict injury in cases where no intrusion occurs near the occupant. The NCHRP 230 flail space data indicated a safe test.

### VEHICLE TRAJECTORY

Vehicle trajectory after the test was acceptable.

OVERALL RATING

This pole/vehicle combination with the discussed impact conditions would have to be rated unacceptable due to intrusion of the occupant compartment and a high HIC value.

Evaluation Factors	Evaluation Criteria	Matrix Test Conditions (see Table 3)
Structural Adequacy	A. Test article shall smoothly redirect the vehicle; the vehicle shall not penetrate or go over the installation although controlled lateral deflection of the test article is acceptable.	10, 11, 12, 30, 40
	B. The test article shall readily activate in a predictable manner by breaking away or yielding.	60, 61, 62, 63
	C. Acceptable test article performance may be by redirection, controlled penetration, or controlled stopping of the vehicle	41, 42, 43, 44, 45, 50, 51, 52, 53, 54
	D. Detached elements, fragments or other debris from the test article shall not penetrate or show potential for penetrating the passenger compartment or present undue hazard to other traffic.	All
Occupant Risk	E. The vehicle shall remain upright during and after collision although moderate roll, pitching and yawing are acceptable. Integrity of the passenger compartment must be maintained with essentially no deformation or intrusion.	All
	F. Impact velocity of hypothetical front seat passenger against vehicle interior, calculated from vehicle accelerations and 24 in. (0.61m) forward and 12 in. (0.30m) lateral displacements, shall be less than: $\frac{\text{Occupant Impact Velocity-fps}}{\begin{matrix} \text{Longitudinal} & \text{Lateral} \\ 40/F_1 & 30/F_2 \end{matrix}}$ and vehicle highest 10 ms average accelerations subsequent to instant of hypothetical passenger impact should be less than: $\frac{\text{Occupant Ridedown Accelerations—g's}}{\begin{matrix} \text{Longitudinal} & \text{Lateral} \\ 20/F_3 & 20/F_4 \end{matrix}}$ where $F_1, F_2, F_3,$ and $F_4$ are appropriate acceptance factors (see Table 8, Chapter 4 for suggested values).	11, 12, 41, 42, 43, 44, 45, 50, 51, 52, 54, 60, 61, 62, 63
	G. (Supplementary) Anthropometric dummy responses should be less than those specified by FMVSS 208, i.e., resultant chest acceleration of 60g, Head Injury Criteria of 1000, and femur force of 2250 lb (10 kN) and by FMVSS 214, i.e., resultant chest acceleration of 60 g, Head Injury Criteria of 1000 and occupant lateral impact velocity of 30 fps (9.1 m/s).	11, 12, 41, 42, 43, 44, 45, 50, 51, 52, 54, 60, 61, 62, 63
Vehicle Trajectory	H. After collision, the vehicle trajectory and final stopping position shall intrude a minimum distance, if at all, into adjacent traffic lanes.	All
	I. In test where the vehicle is judged to be redirected into or stopped while in adjacent traffic lanes, vehicle speed change during test article collision should be less than 15 mph and the exit angle from the test article should be less than 60 percent of test impact angle, both measured at time of vehicle loss of contact with test device.	10, 11, 12, 30, 40, 42, 44, 53
	J. Vehicle trajectory behind the test article is acceptable.	41, 42, 43, 44, 45, 50, 51, 53, 54, 60, 61, 62, 63

Figure 6. NCHRP 230 Safety Evaluation Guidelines

## 9.0 REFERENCES

1. "Side Impact Test Plan", Rev. 1, J. Hinch, FHWA Contract DTFH61-86-2-00047, November 86.
2. "Test Results Report, Bogie Testing," Task G, Hinch, J.A., Manhard, G. A., and Owings, R. P., Contract DTFH61-81-C-00036, July 1985
3. "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances," National Cooperative Highway Research Program Report 230, March 1981.
4. "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances," Transportation Research Circular 191, February 1978.
5. "Occupant Crash Protection in Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses," Code of Federal Regulations, Title 49, Transportation, Part 571, Motor Vehicle Safety Standard No. 208.
6. "Vehicle Damage Scale for Traffic Accident Investigators," Traffic Accident Data Project Technical Bulletin No. 1, National Safety Council, 1971.
7. "Collision Deformation Classification," Recommended Practice J224a, Society of Automotive Engineers, New York, February 1971.
8. "Human Tolerance To Impact Conditions As Related to Motor Vehicle Design," Information Report J885a, Society of Automotive Engineers, New York, December 1966.
9. "Standard Plans," California Department of Transportation, January 1981, pp. 209.
10. "Dynamic Crash Test Information Reference Guide," Version II, Automated Sciences Group, Inc., Silver Spring, Maryland, January 1, 1982.
10. "Instrumentation for Impact Tests," Recommended Practice J211b, Society of Automotive Engineers, New York, December 1974.
12. "Safer Sign and Luminaire Supports," Owings, R. P., et al, Final Report, ENSCO, Inc., Contract No. DOT-FH-11-8118, October 1975.
13. "Development of Dummy and Injury Index for NHTSA's Thoracic Side Impact Protection Research Program," R. Eppinger, J. Marcus, and R. Morgan, SAE Report No. 840885.

APPENDIX A  
DATA PLOTS

ENSO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 18 VEHICLE X  
 FILTER CUTOFF FREQ: 100 PEAKS -0.53 , 5.30

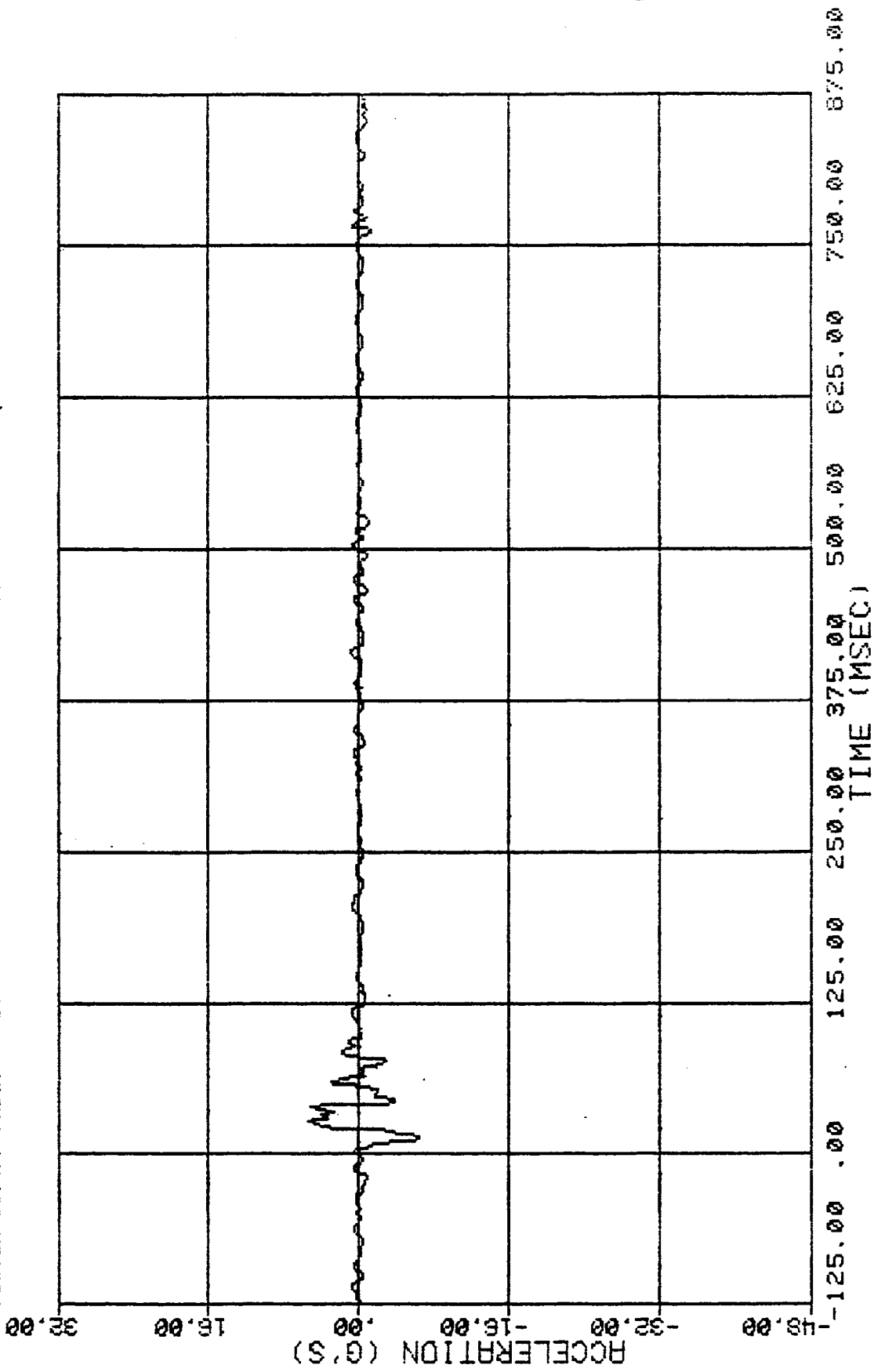


Figure A1. Vehicle X Acceleration, 100 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 19    VEHICLE Y  
 FILTER CUTOFF FREQ:    100    PEAKS    -25.86 ,    26.47

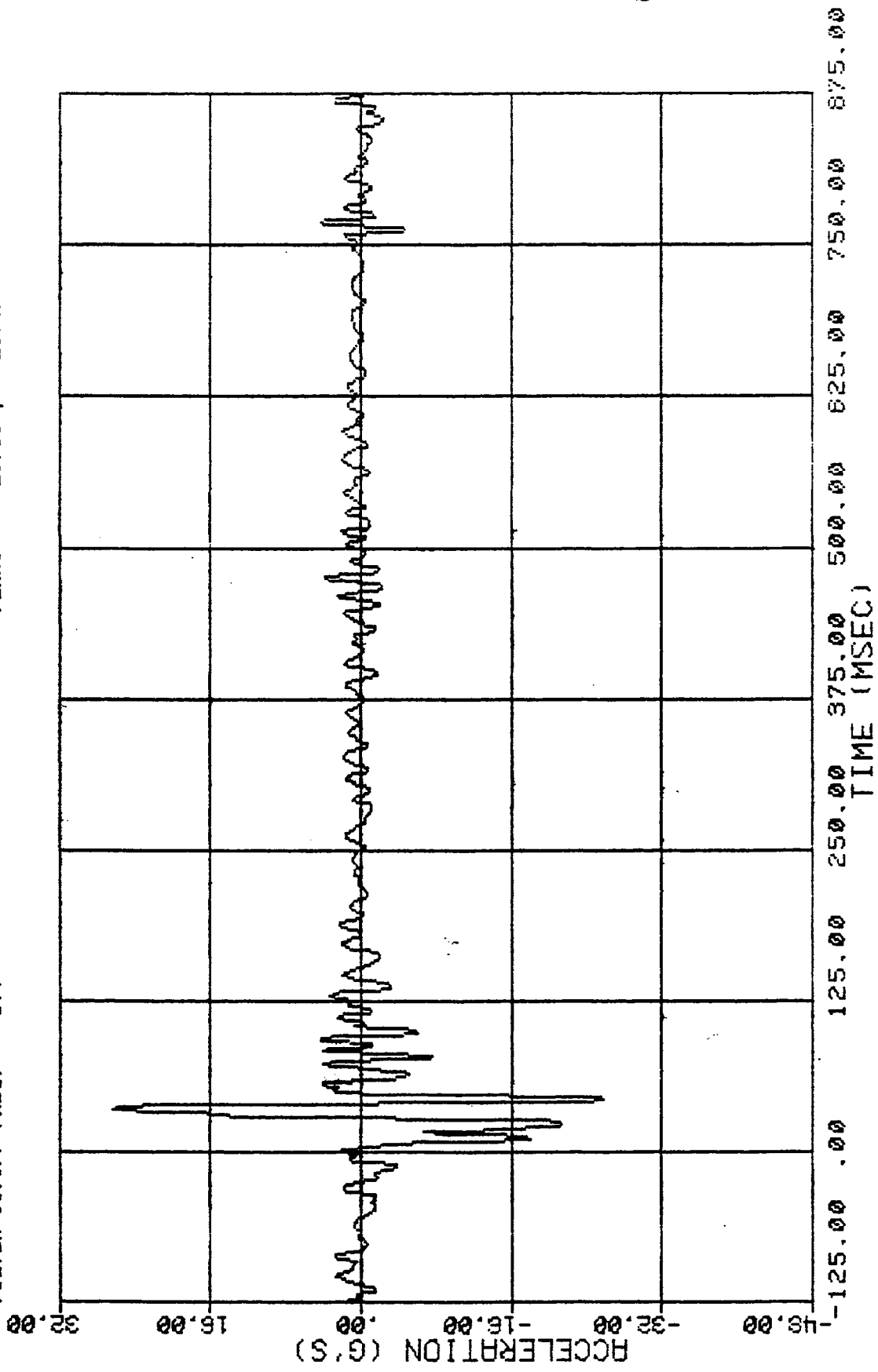


Figure A2. Vehicle Y Acceleration, 100 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 18    VEHICLE X  
 FILTER CUTOFF FREQ: 300    PEAKS    -8.84 ,    13.69

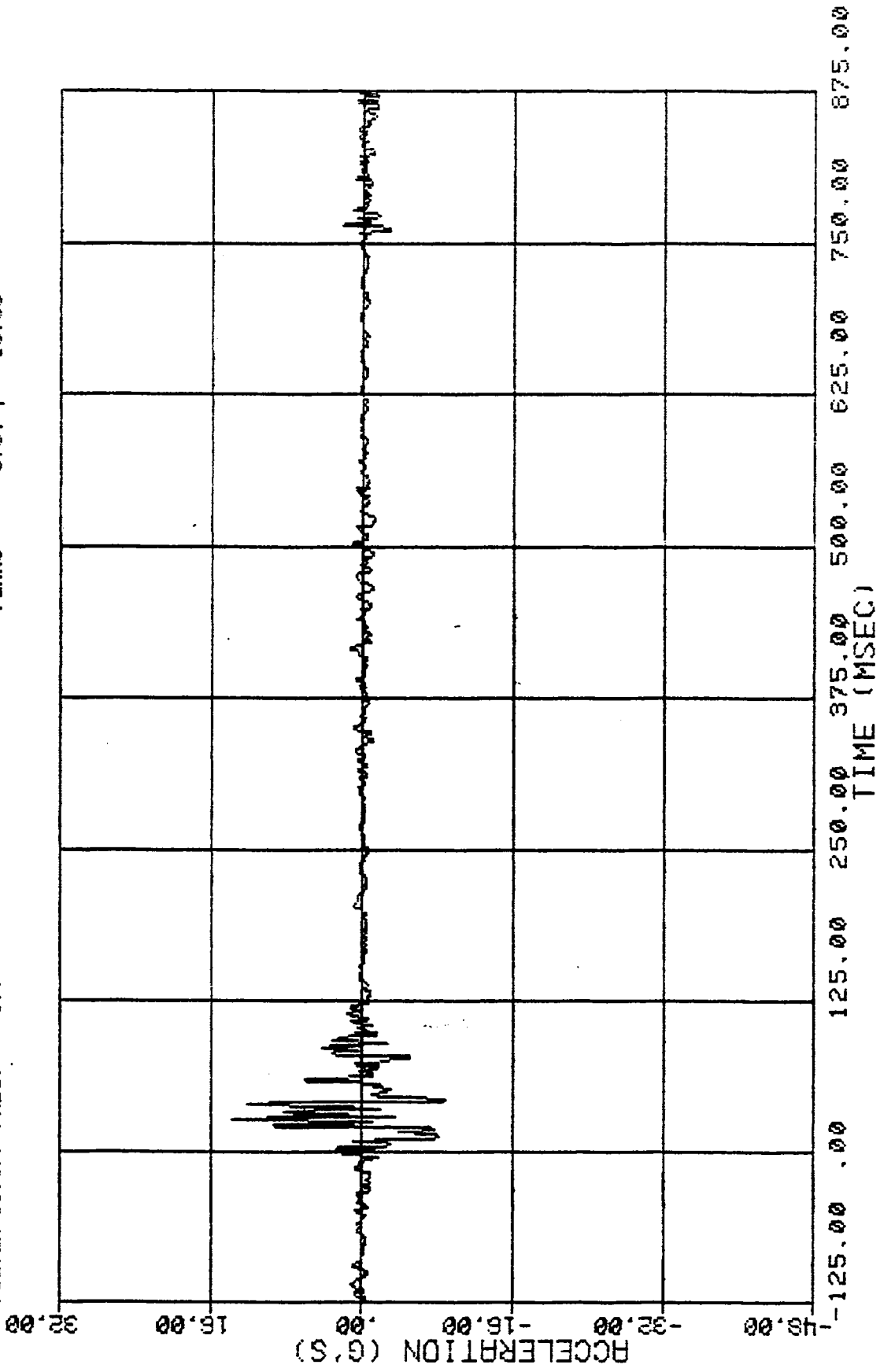


Figure A3. Vehicle X Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 19    VEHICLE Y  
 FILTER CUTOFF FREQ: 300    PEAKS    -36.80 ,    30.15

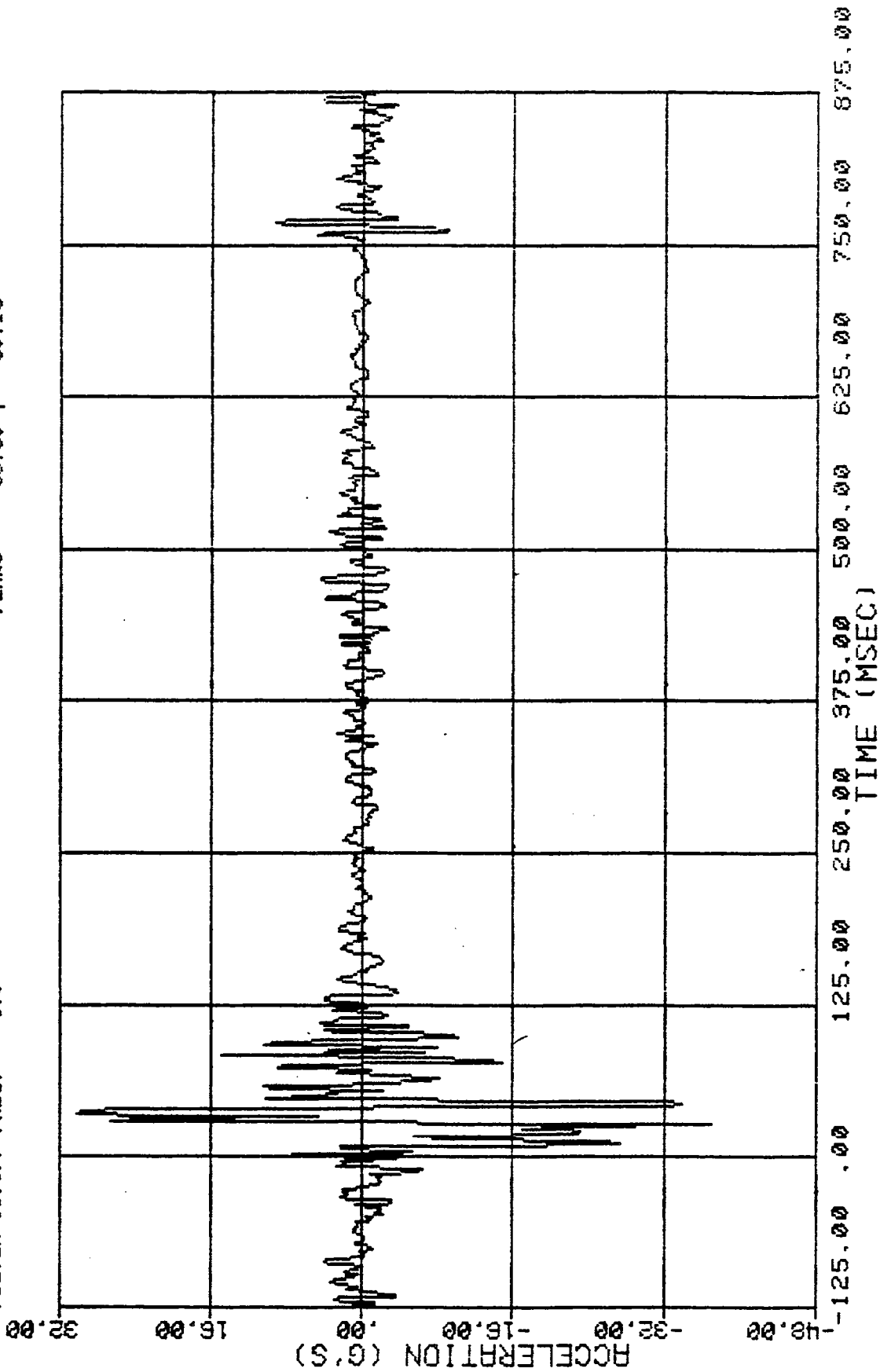


Figure A4. Vehicle Y Acceleration, 300 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 20 IMPACT  
 FILTER CUTOFF FREQ: 1650 PEAKS -0.24 , 9.84

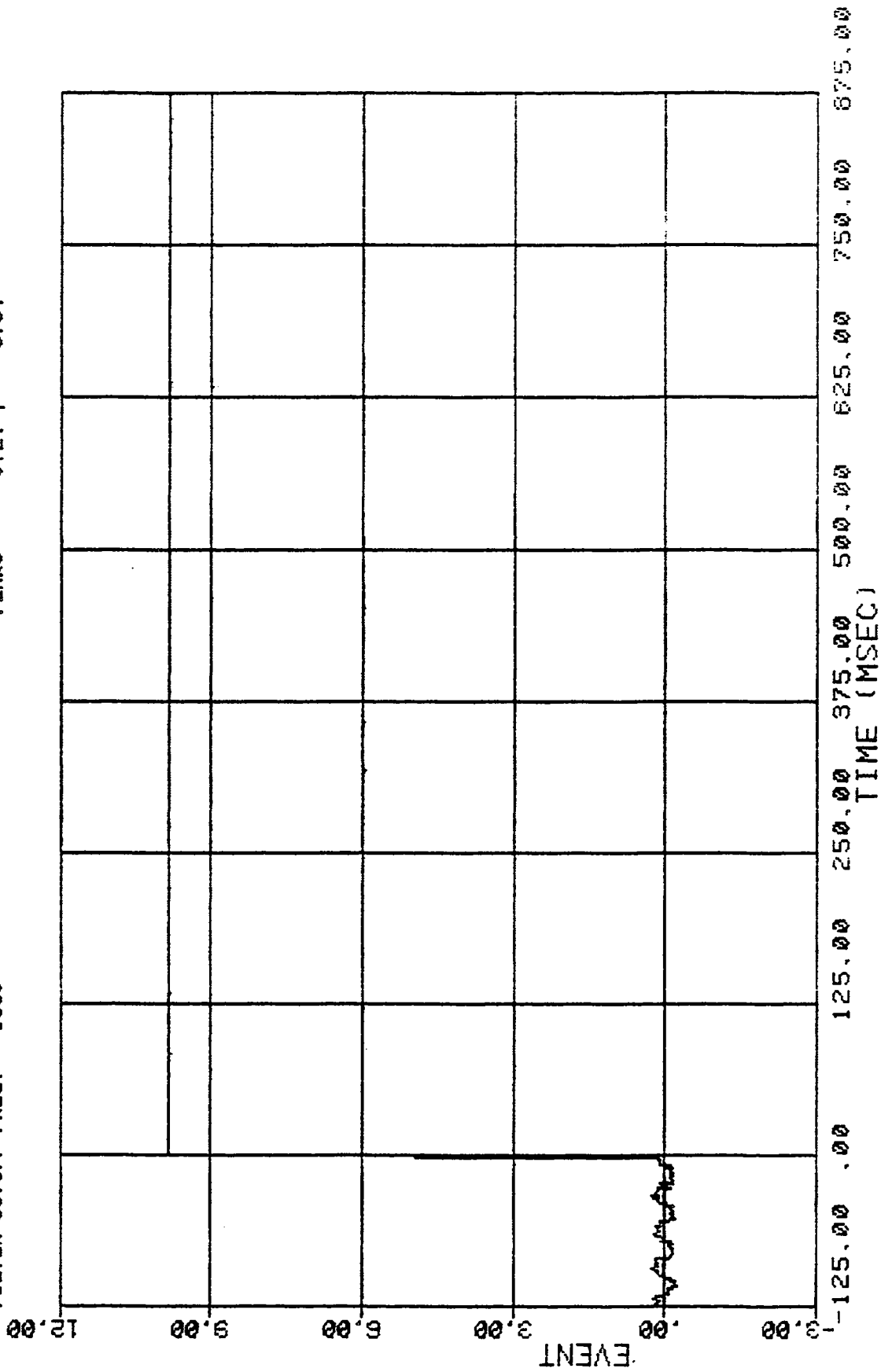


Figure A5. Vehicle Impact Marker

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 21 VEHICLE YAW RATE  
 FILTER CUTOFF FREQ: 100 PEAKS -130.04 , 129.21

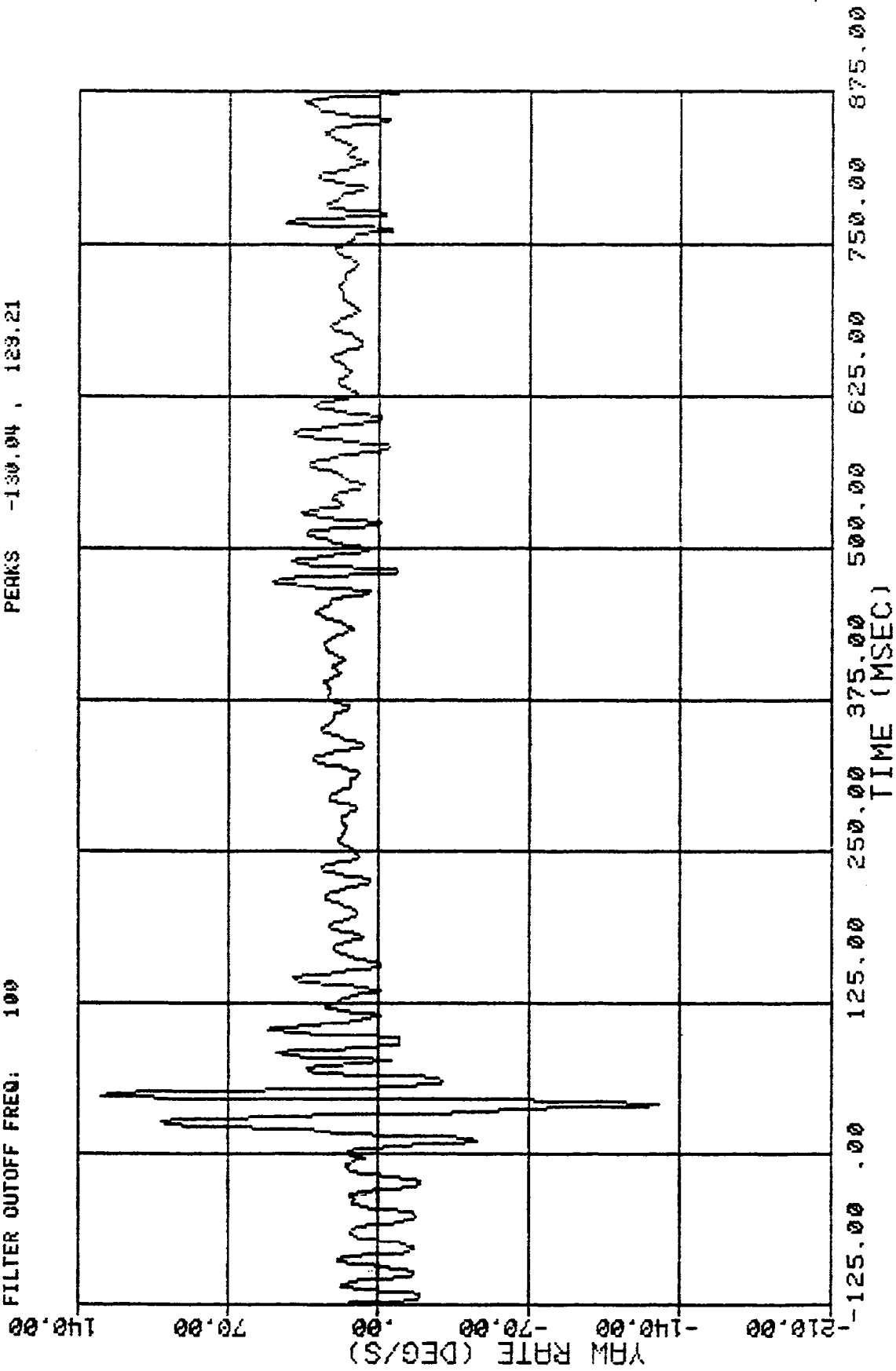


Figure A6. Vehicle Yaw Rate, 100 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-0-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 0    VEHICLE YAW (INTEGRATED)  
 FILTER CUTOFF FREQ: 10    PEAKS 0.01 , 13.68

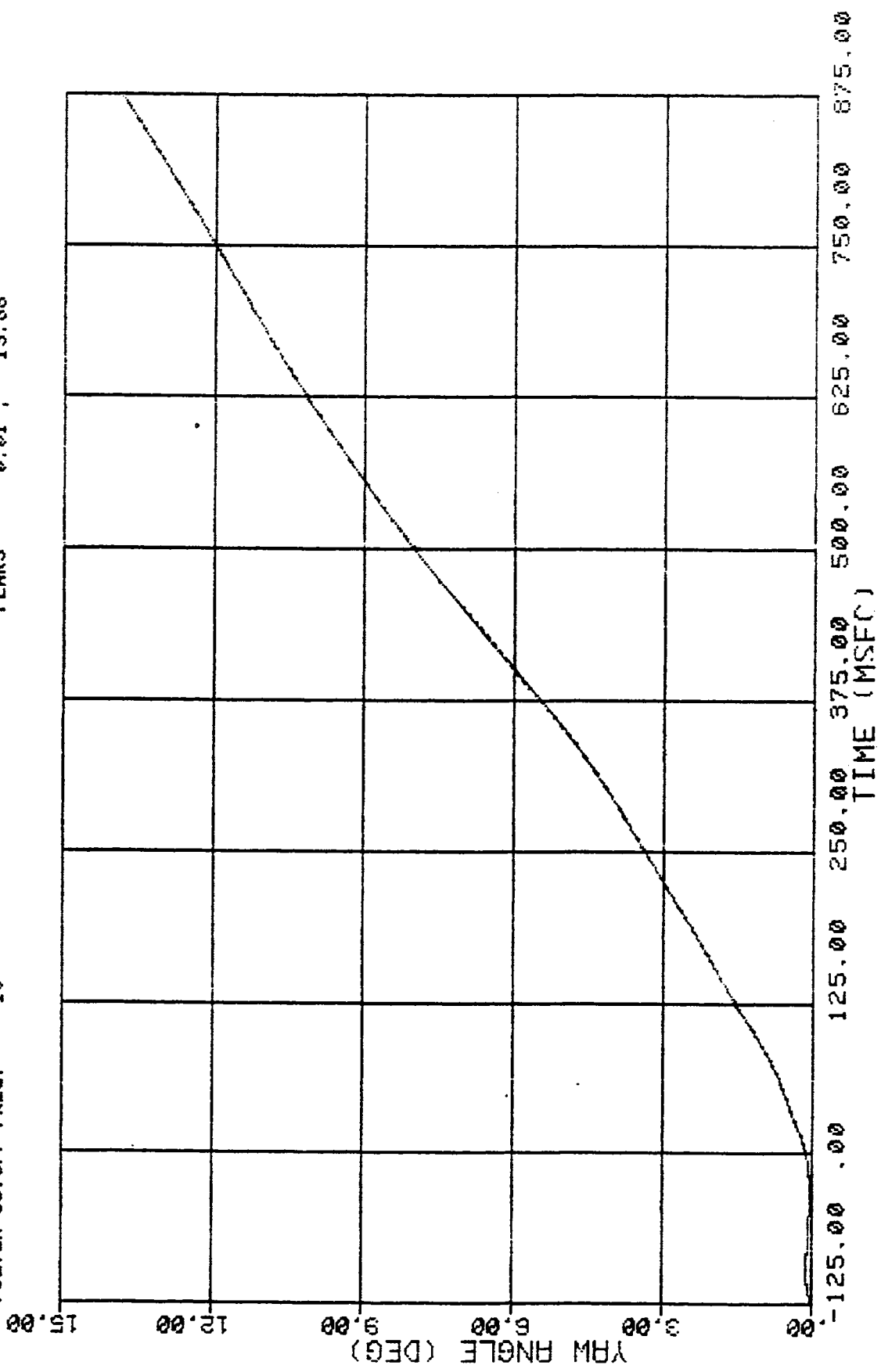


Figure A8. Vehicle Yaw Angle, 10 Hz

ENSOO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 21 VEHICLE YAW RATE  
 FILTER CUTOFF FREQ: 10 PEAKS -1.44 , 20.78

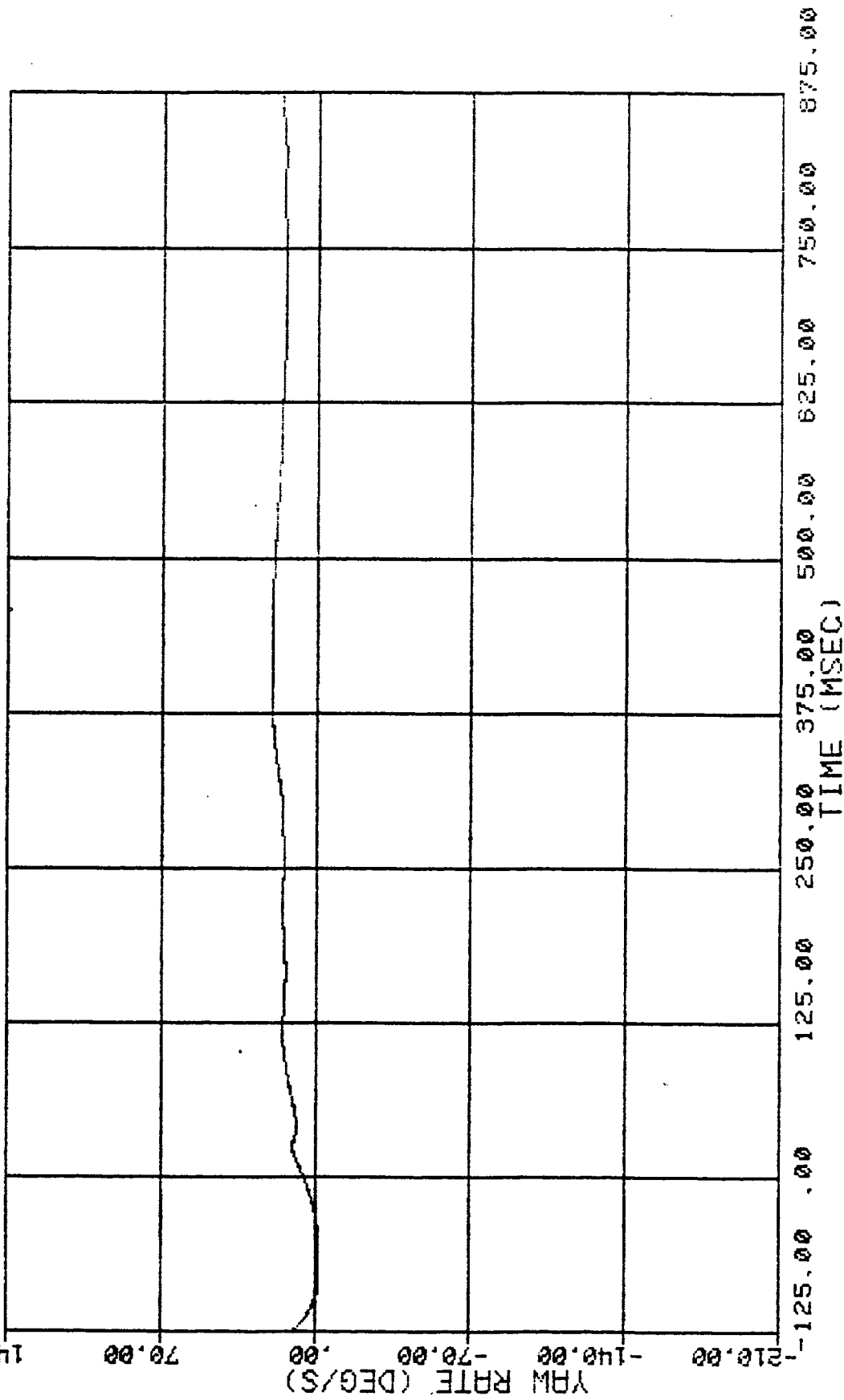


Figure A7. Vehicle Yaw Raw, 10 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST \* 1786-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 12    HEAD X  
 FILTER CUTOFF FREQ. 1650    PEAKS    -76.00 ,    6.60

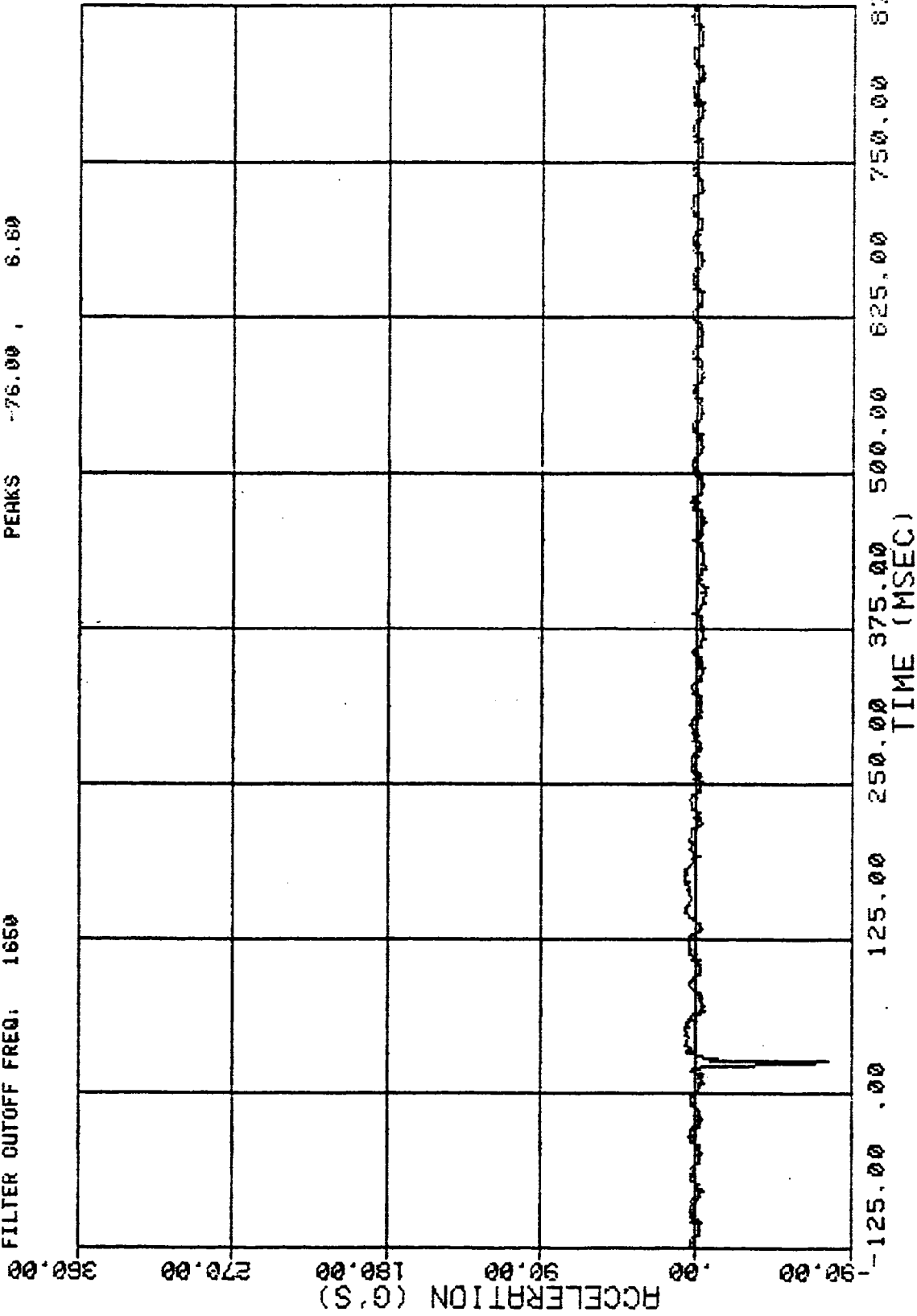


Figure A9. Head X Acceleration, 1650 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 13 HEAD Y  
 FILTER CUTOFF FREQ: 1650 PEAKS -11.17, 340.06

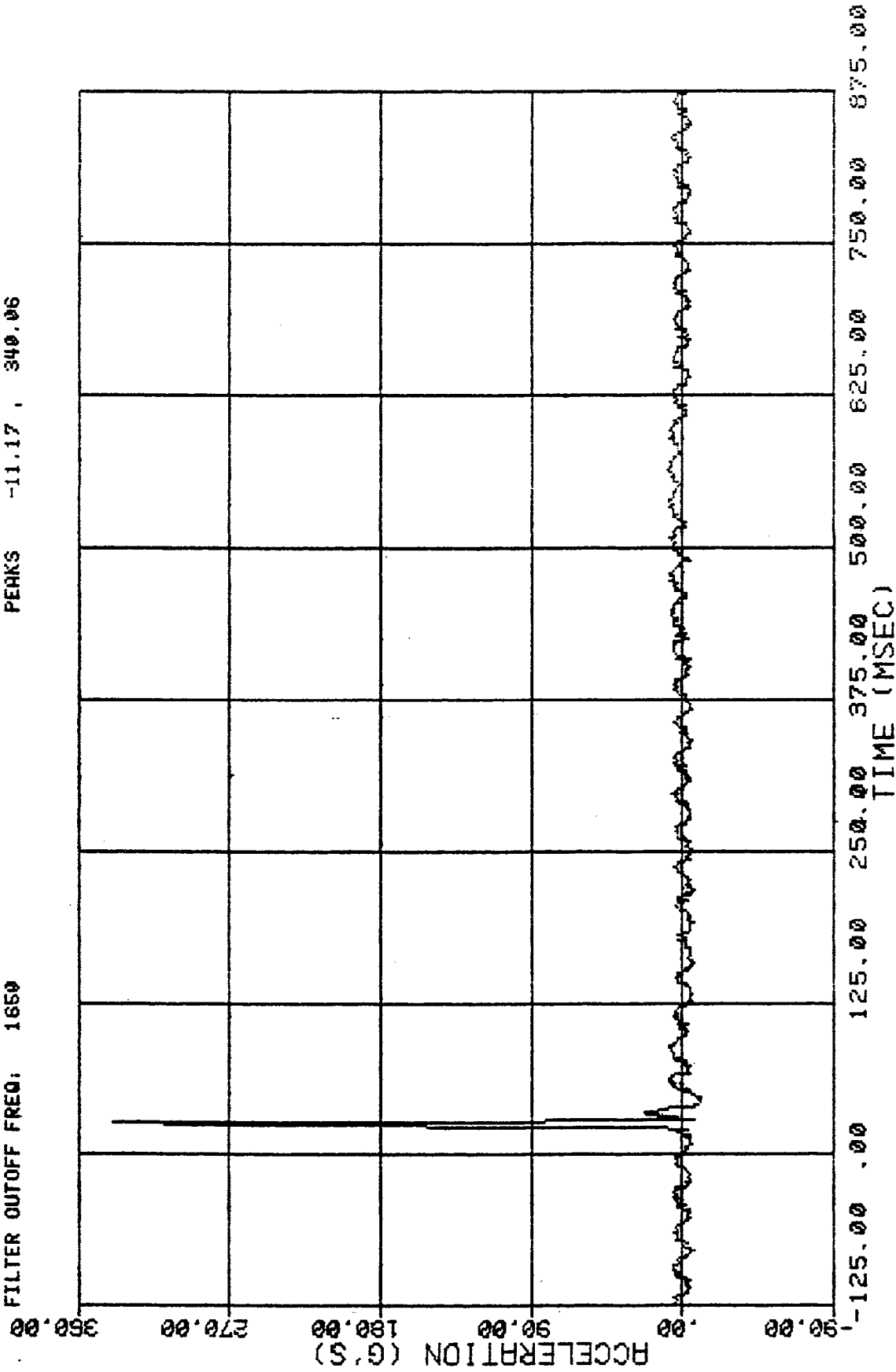
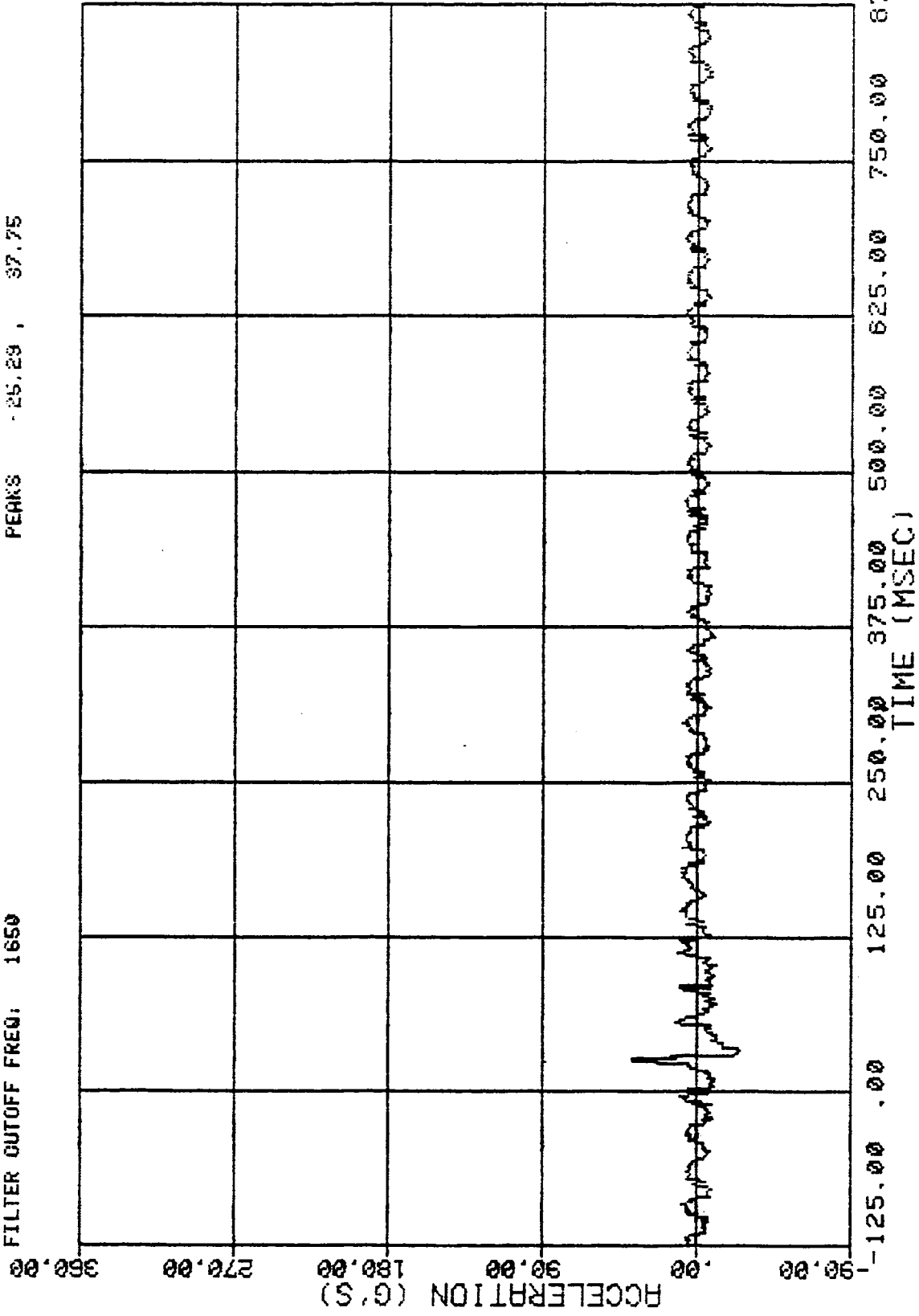


Figure A10. Head Y Acceleration, 1650 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 14 HEAD Z  
 FILTER CUTOFF FREQ. 1650 PEAKS -25.29 , 37.75



All. Head Z Acceleration, 1650 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-66-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 0 HEAD RESULTANT PEAKS 2.23 349.53  
 FILTER CUTOFF FREQ: 1650

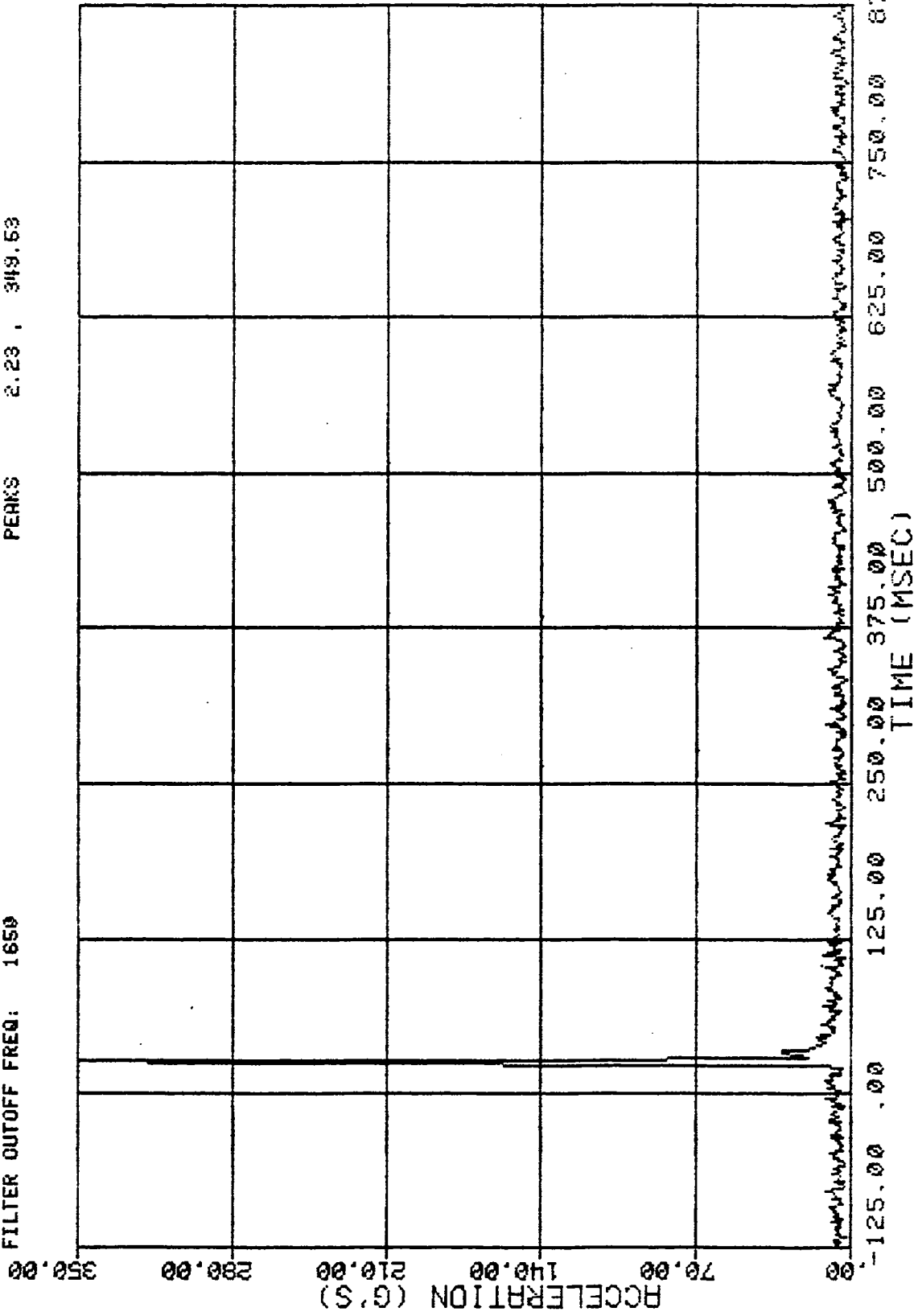


Figure A12. Head Resultant Acceleration, 1650 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-66-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 4    T01X  
 FILTER CUTOFF FREQ: 300    PEAKS -13.61 , 12.38

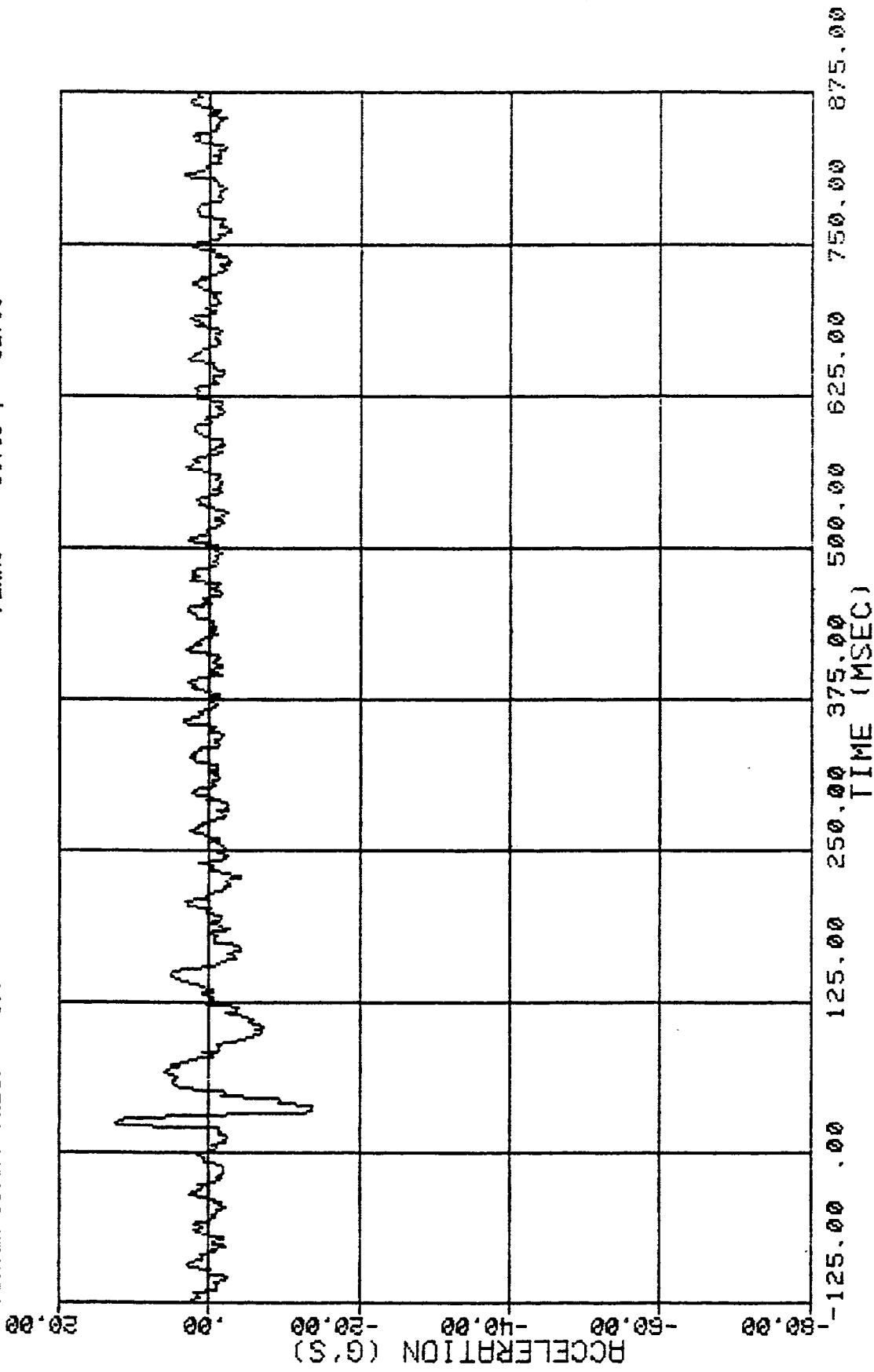


Figure A13. T01 - X Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 3    T01Y  
 FILTER CUTOFF FREQ: 300    PEAKS -70.76 , 12.01

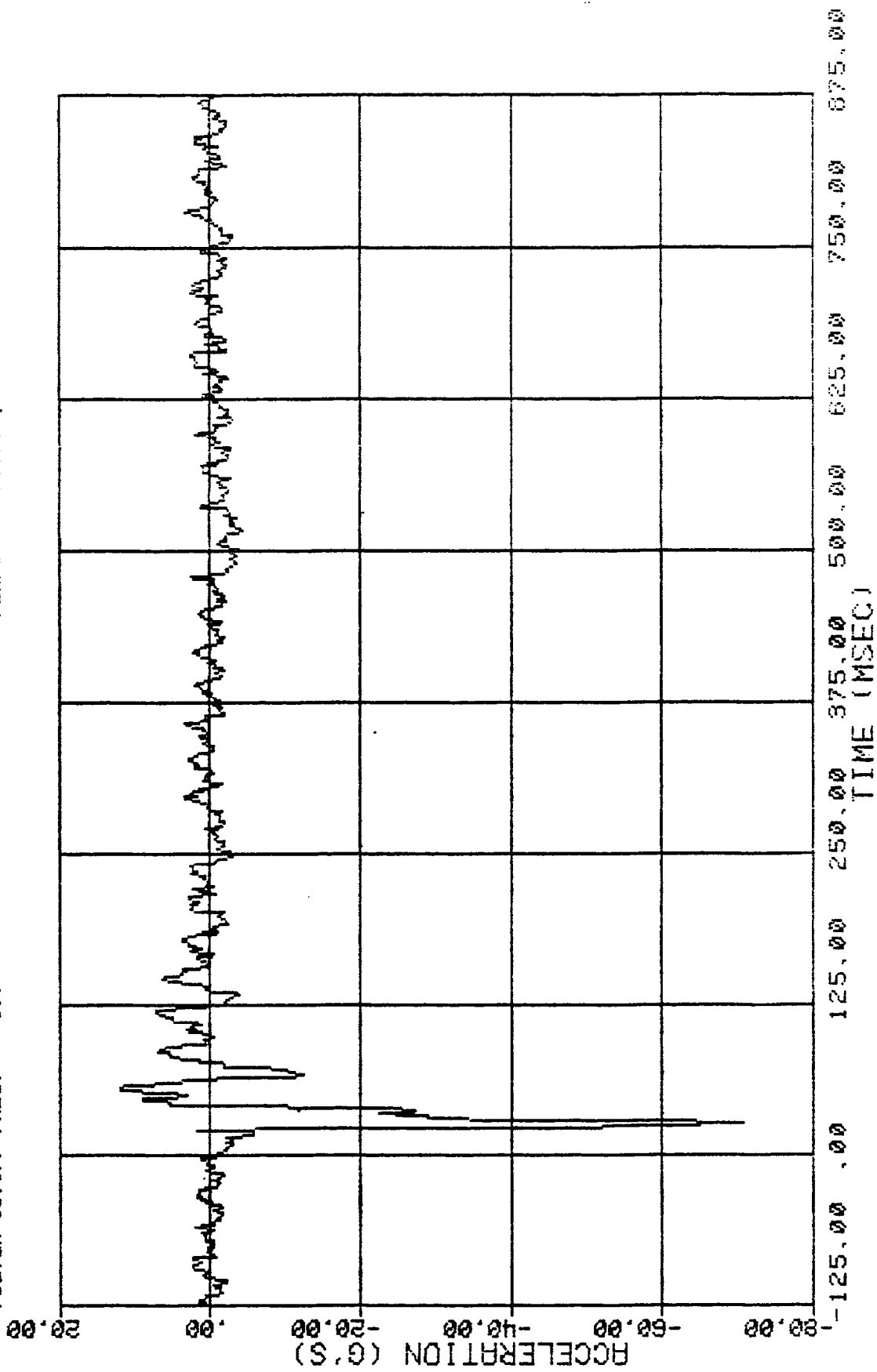


Figure A14. T01 - Y Acceleration, 300 Hz

ENSO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 5 T01Z  
 FILTER CUTOFF FREQ: 300 PEAKS -0.83 , 12.62

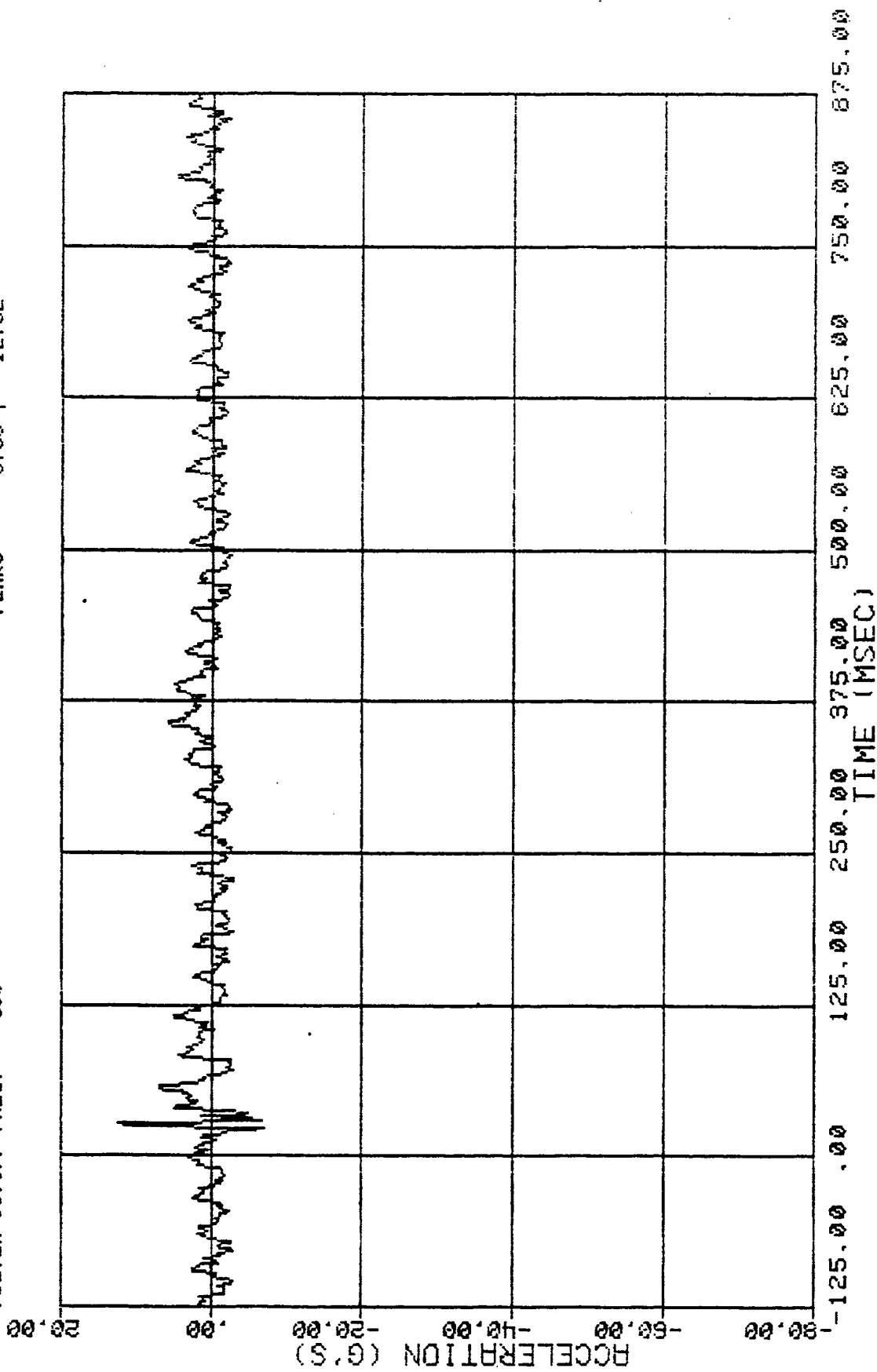


Figure A15. T01 - Z Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL #    T01 RESULTANT  
 FILTER CUTOFF FREQ:    300    PEAKS    0.38 ,    72.34

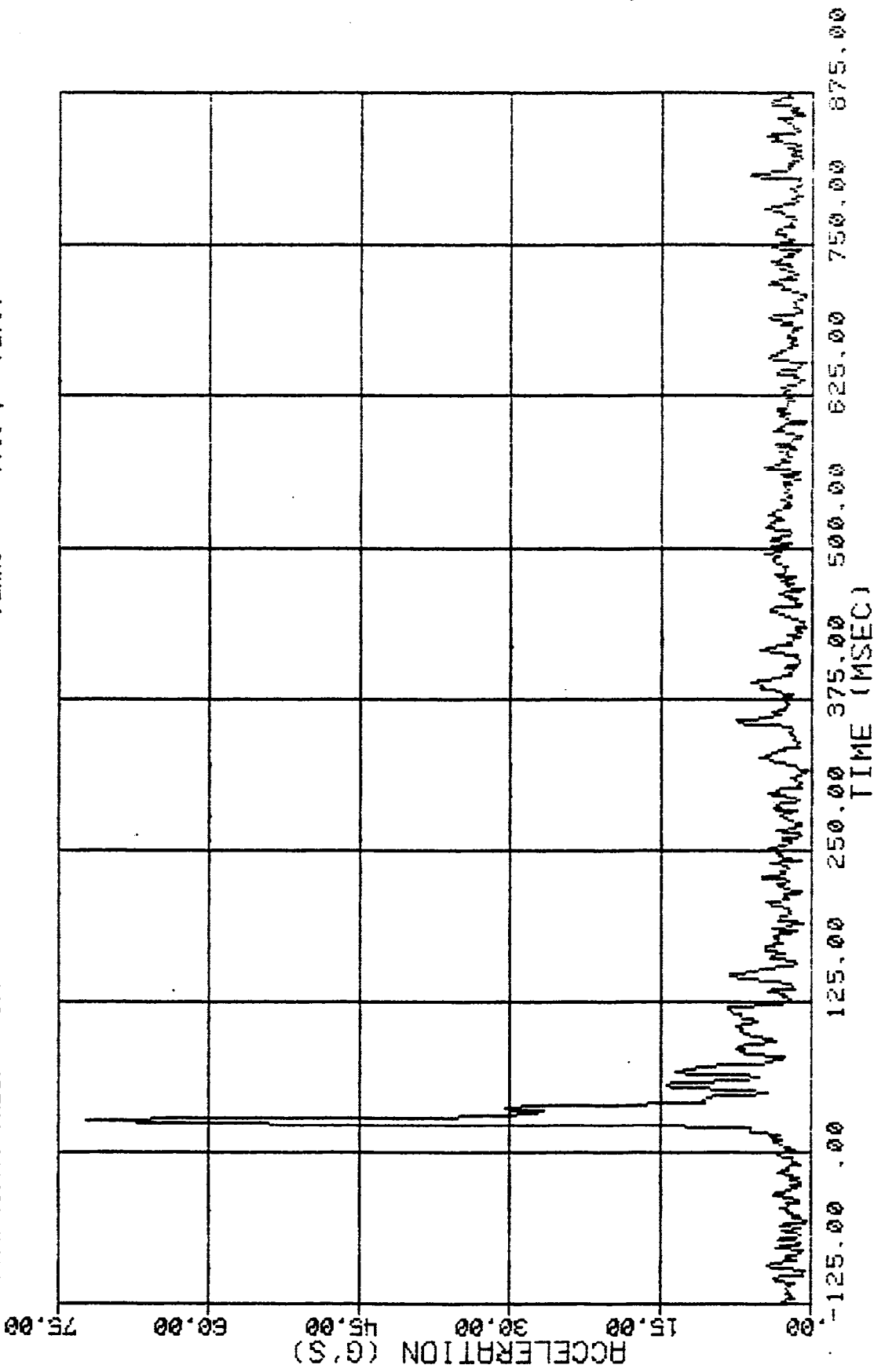


Figure A16. T01 Resultant Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-S1-8-88  
 30 MI/H BROADSIDE IMPACT OF S1 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL    6    T12X  
 FILTER CUTOFF FREQ.    300    PERKS    -31.57    24.53

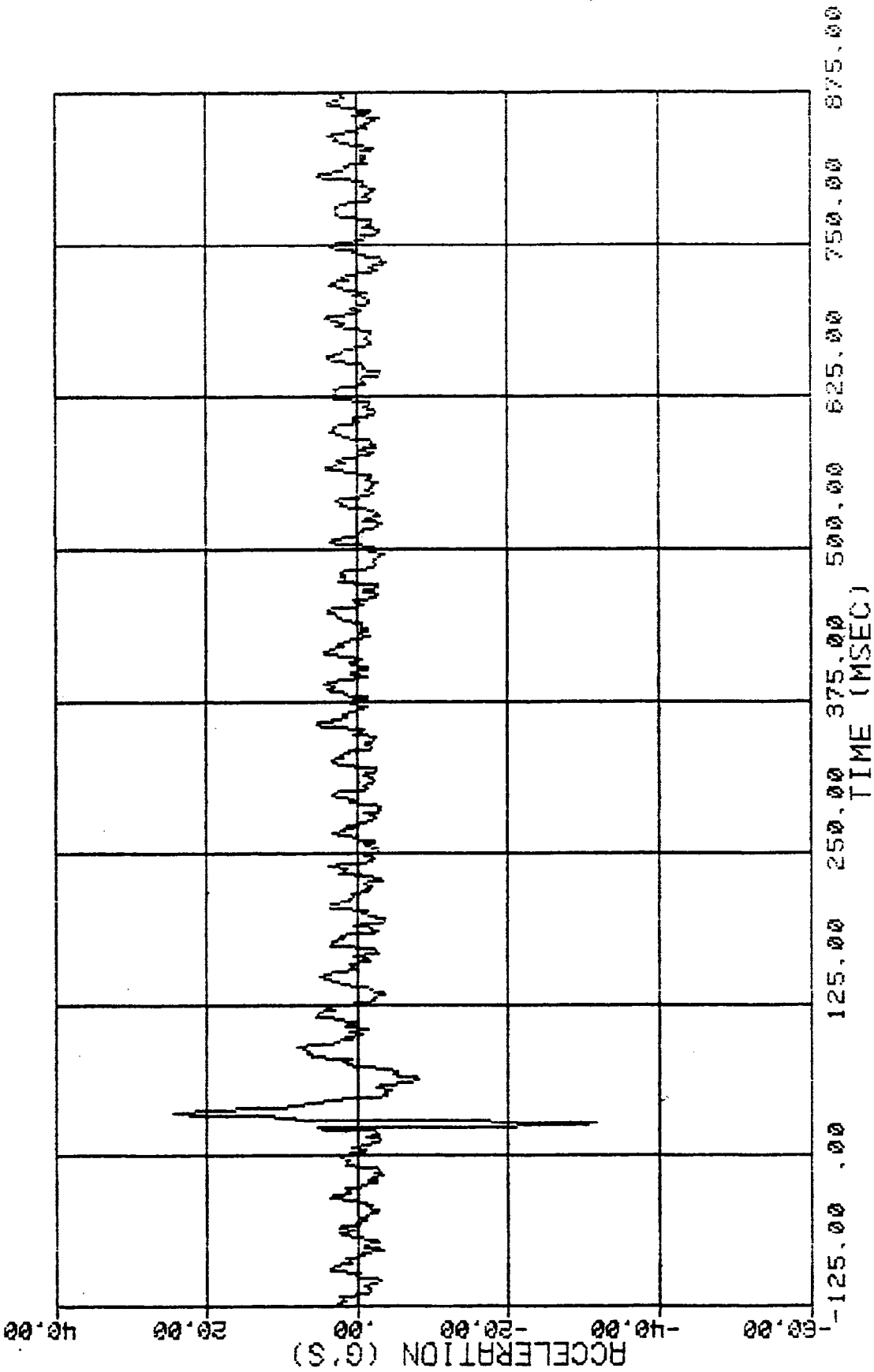


Figure A17. T12 - X Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST \* 1785-SI-0-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL    7    T12Y  
 FILTER CUTOFF FREQ:    300    PEAKS    -50.51 ,    11.58

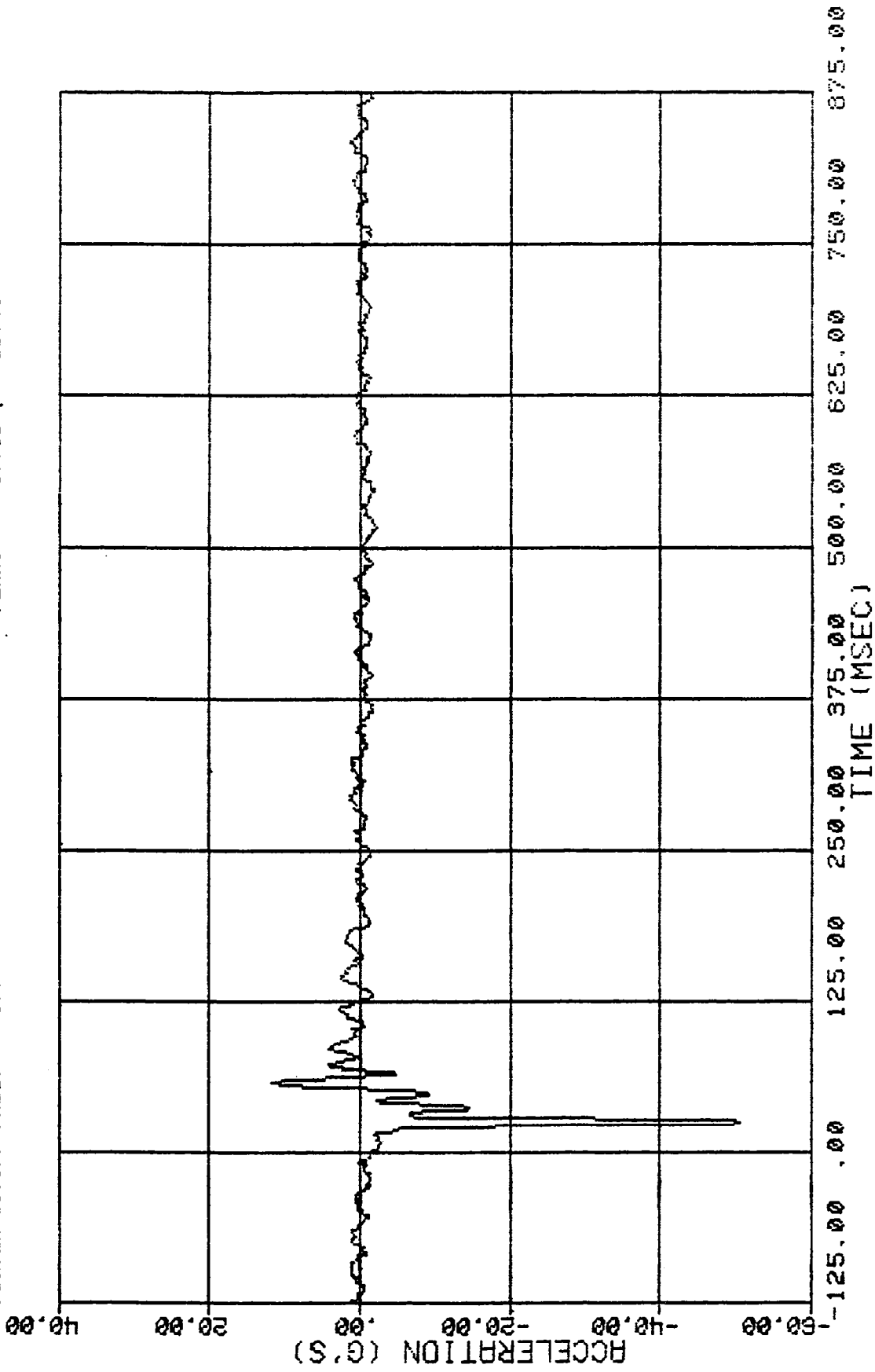


Figure A18. T12 - Y Acceleration, 300 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF S1 FLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 8 T12Z PERKS -6.39 , 13.05  
 FILTER CUTOFF FREQ: 300

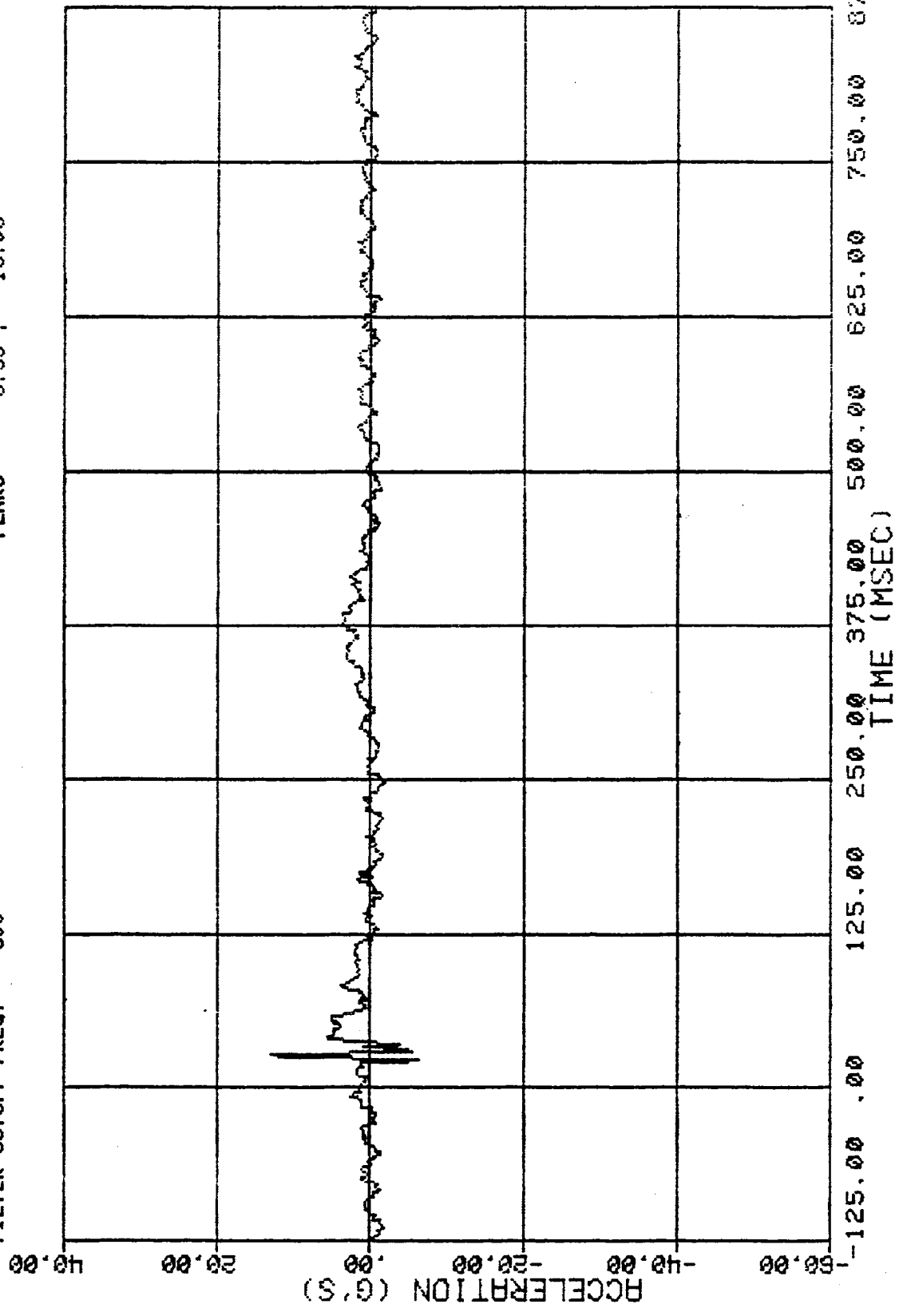


Figure A19. T12 - Z Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH OHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL #    T12 RESULTANT  
 FILTER CUTOFF FREQ:    300    PEAKS    0.33 ,    60.16

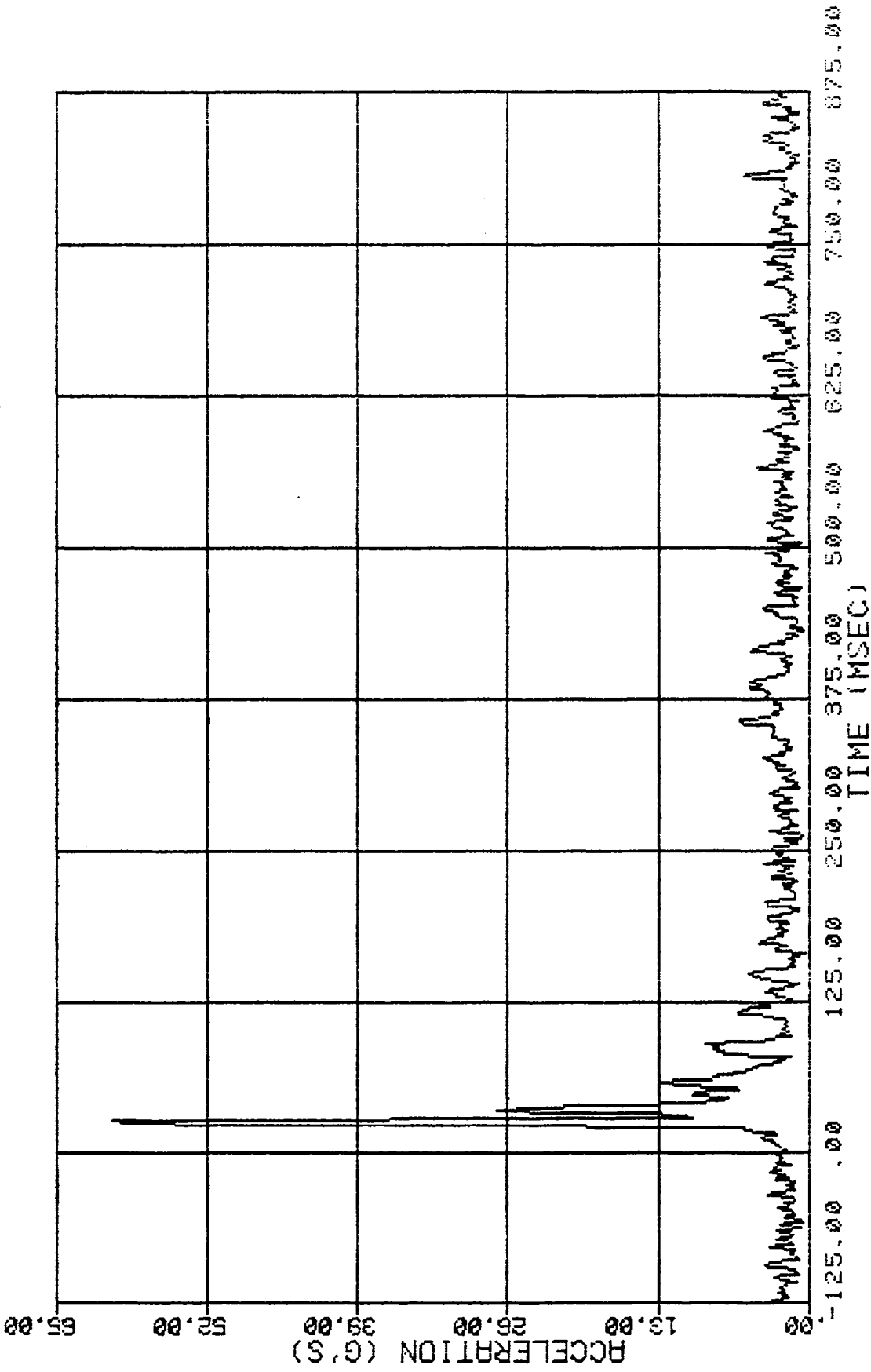


Figure A20. T12 Resultant Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYWOOD CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 15    PELVIS X  
 FILTER CUTOFF FREQ: 300    PEAKS    -6.56 ,    8.74

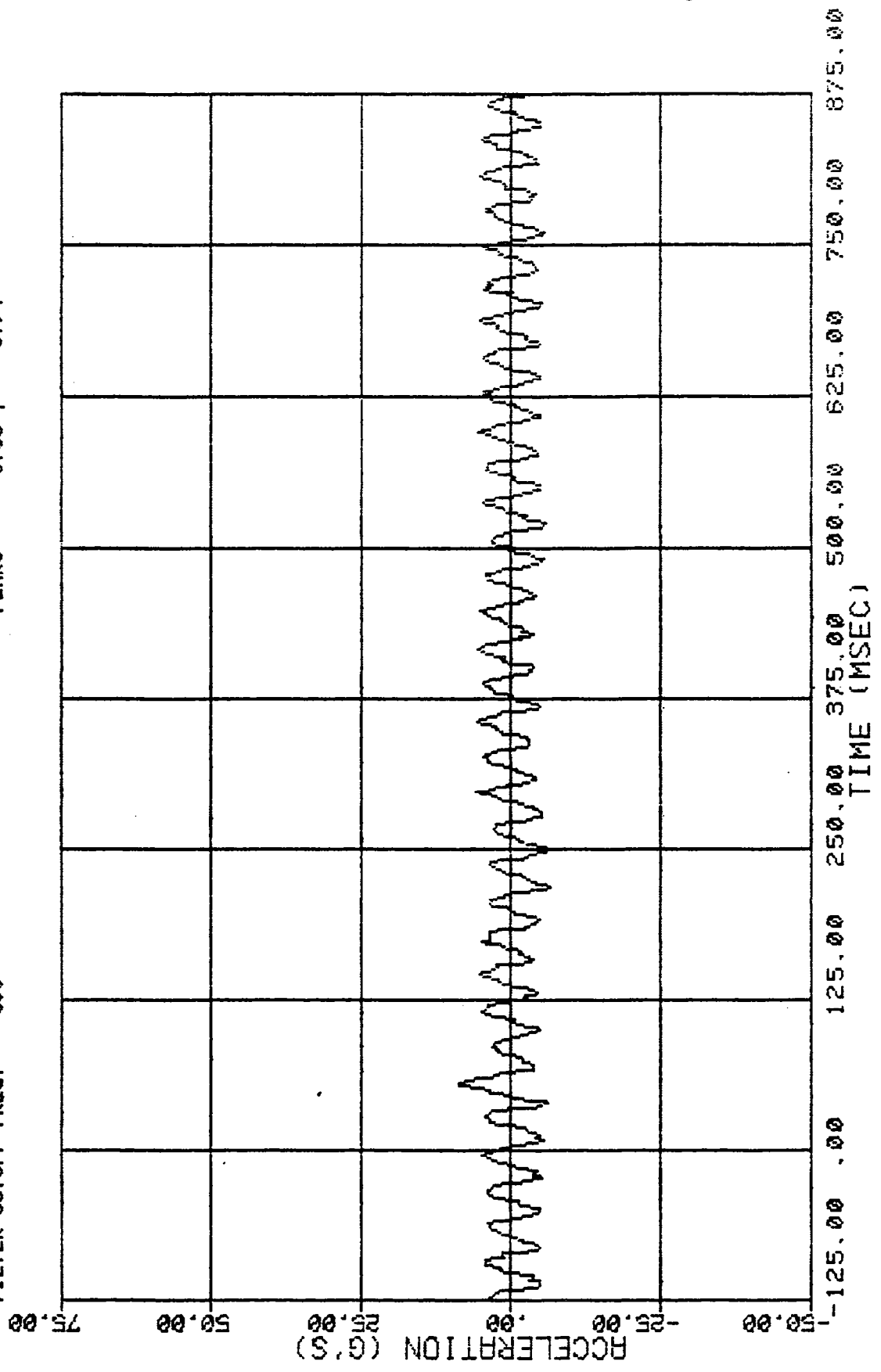


Figure A21. Pelvis X Acceleration, 300 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-0-88  
 30 MI/H BROADSIDE IMPACT OF S1 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 16 PELVIS Y  
 FILTER CUTOFF FREQ: 300 PEAKS -24.32 , 8.52

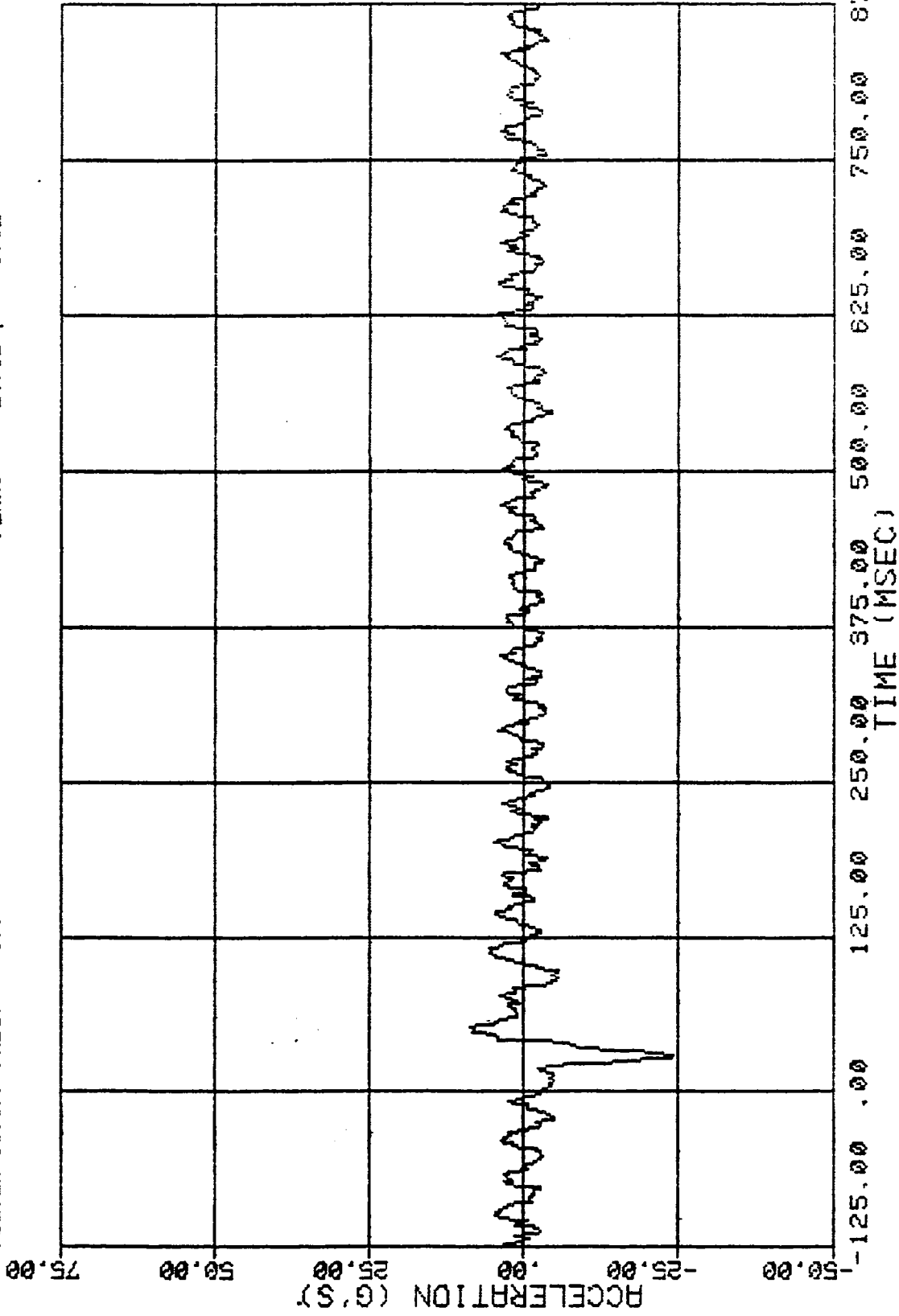


Figure A22. Pelvis Y Acceleration, 300 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-66-2-00047 TEST # 1765-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 17 PELVIS Z  
 FILTER CUTOFF FREQ: 300 PEAKS -8.64 , 9.81

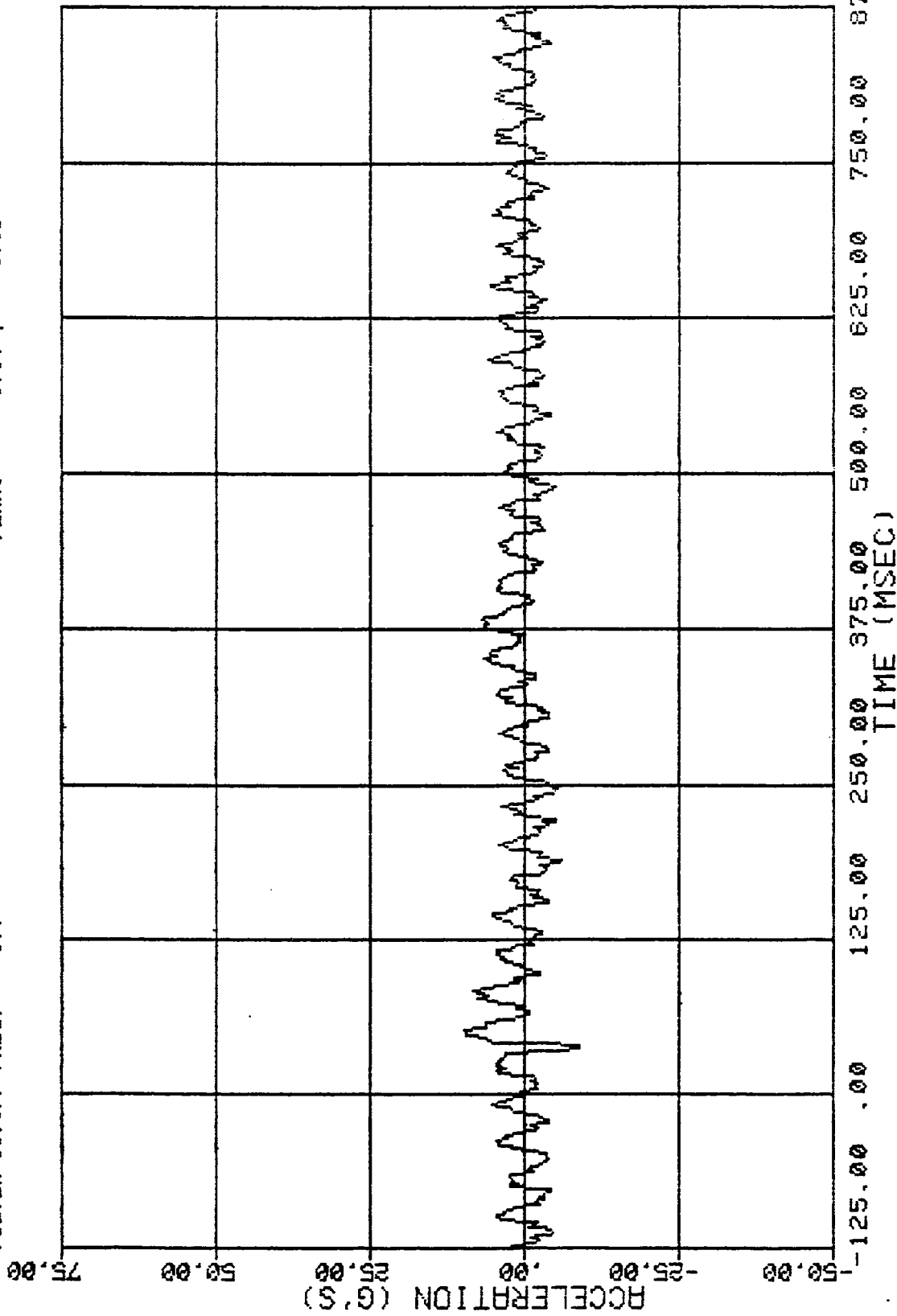


Figure 23. Pelvis Z Acceleration, 300 Hz

ENSCO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 0    PELVIS RESULTANT  
 FILTER CUTOFF FREQ: 300    PEAKS    1.05 ,    24.92

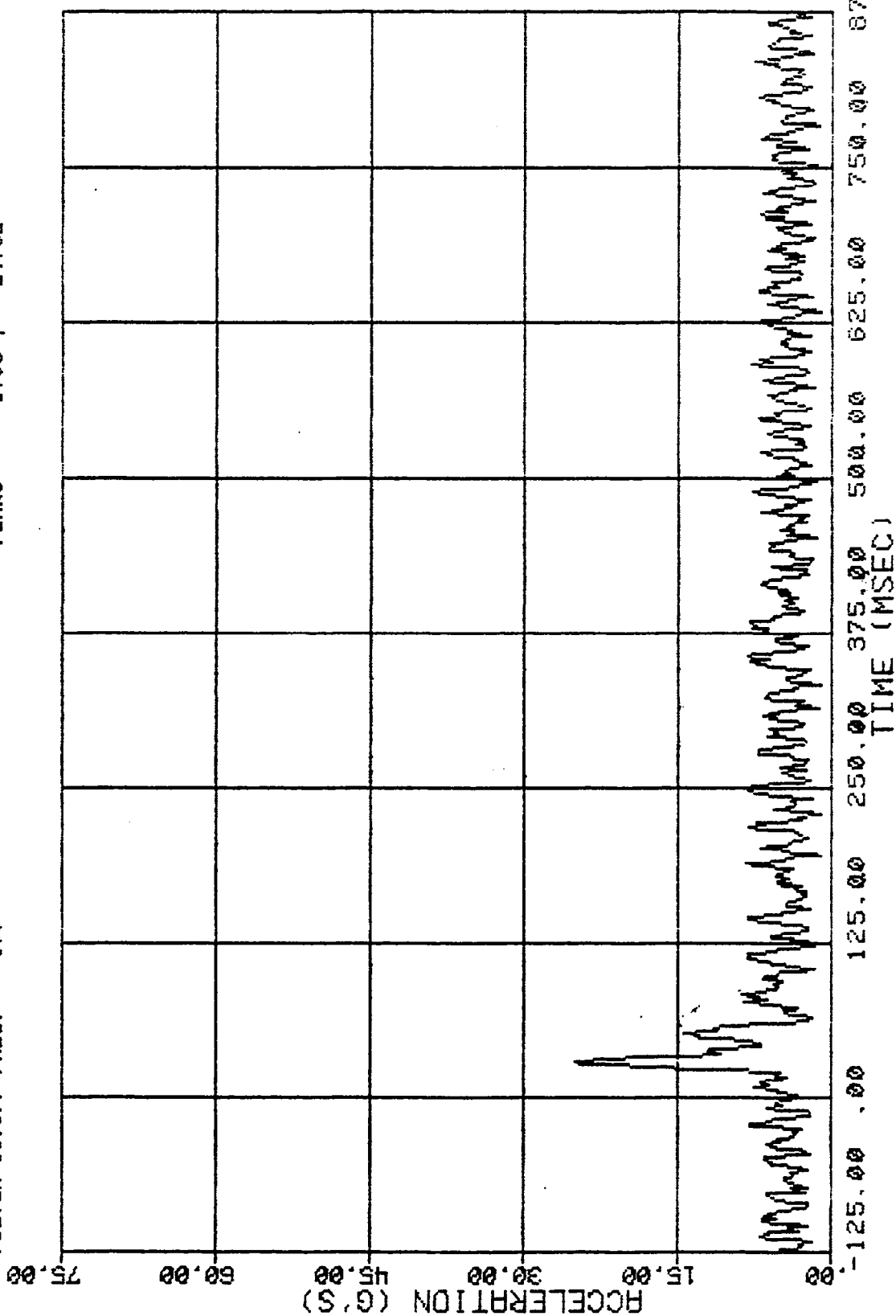


Figure A24. Pelvis Resultant Acceleration, 300 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH OHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 9 LSTX  
 FILTER CUTOFF FREQ: 300 PEAKS -47.07 , 50.71

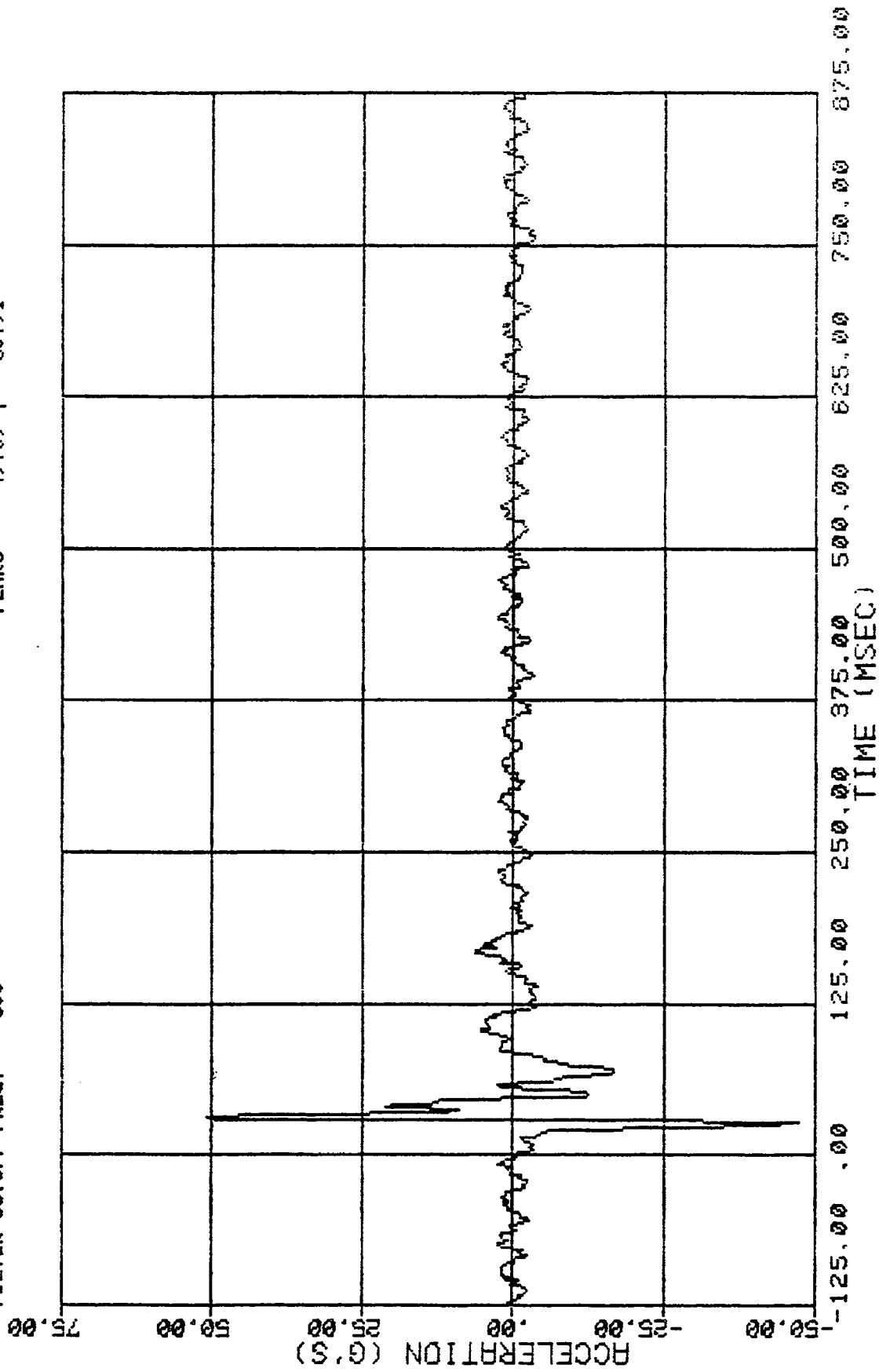


Figure A25. LST - X Acceleration, 300 Hz

ENSO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 1 LLRY01 PEAKS -60.65 , 108.17  
 FILTER CUTOFF FREQ: 300

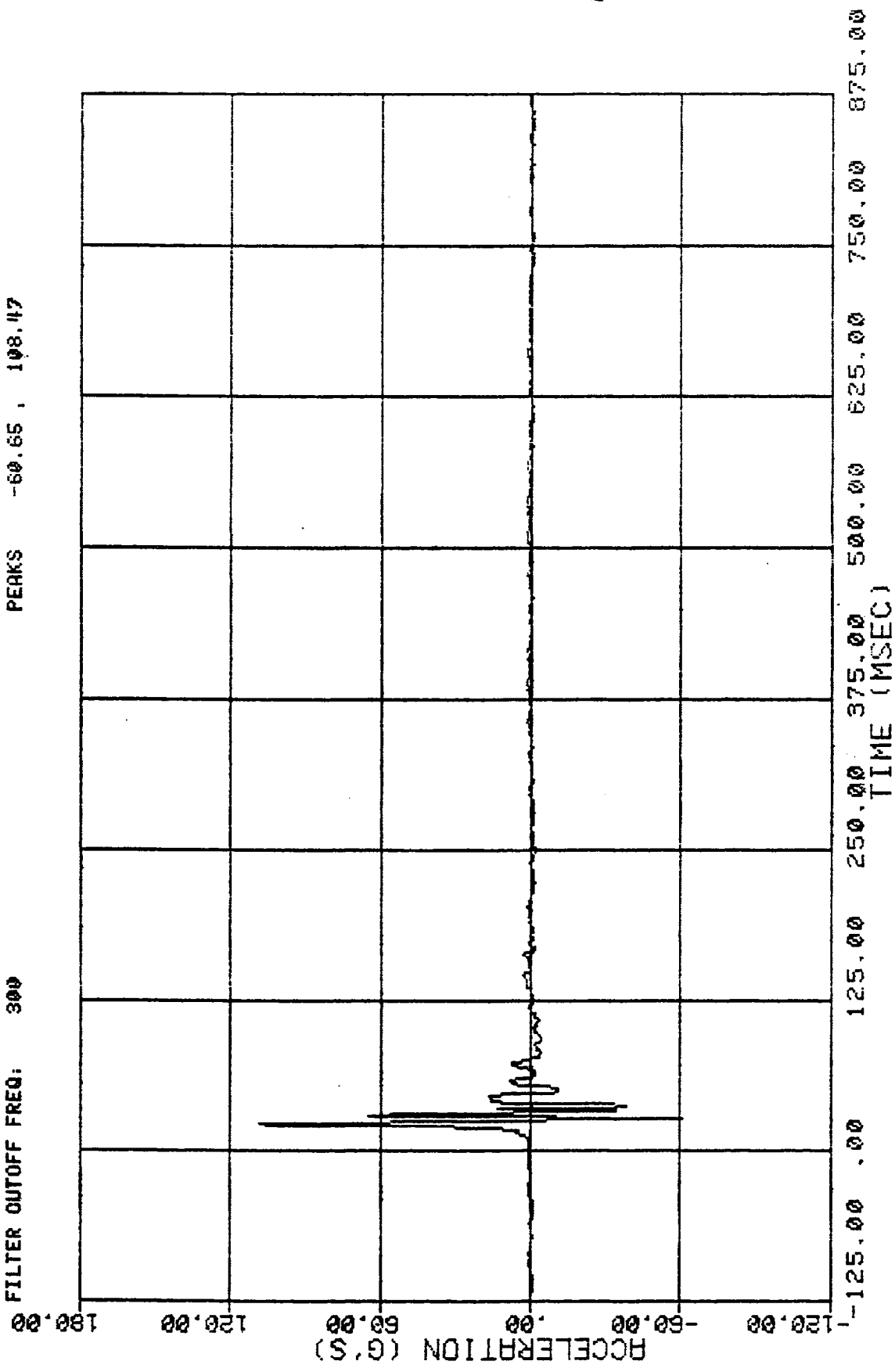


Figure A26. LLR - Y01 Acceleration, 300 Hz

ENSO, INC. CONTRACT NUMBER DTFH61-86-2-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 10 LLRY0A  
 FILTER CUTOFF FREQ: 300 PEAKS --57.09 , 112.61

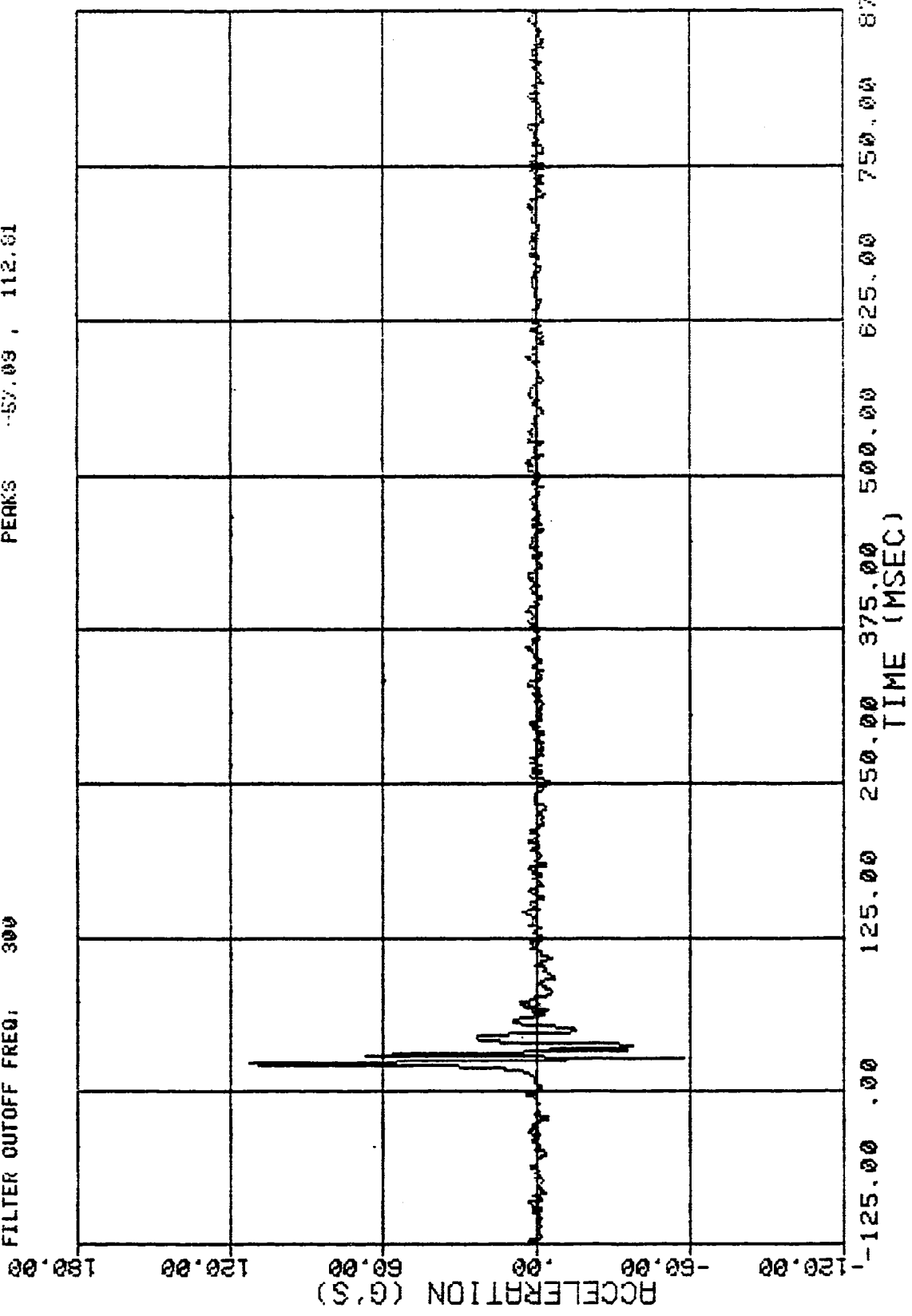


Figure A27. LLR - YGA Acceleration, 300 Hz

ENSCO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 FLYMOOTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 2 LURY01 PEAKS -94.24 , 165.57  
 FILTER CUTOFF FREQ: 300

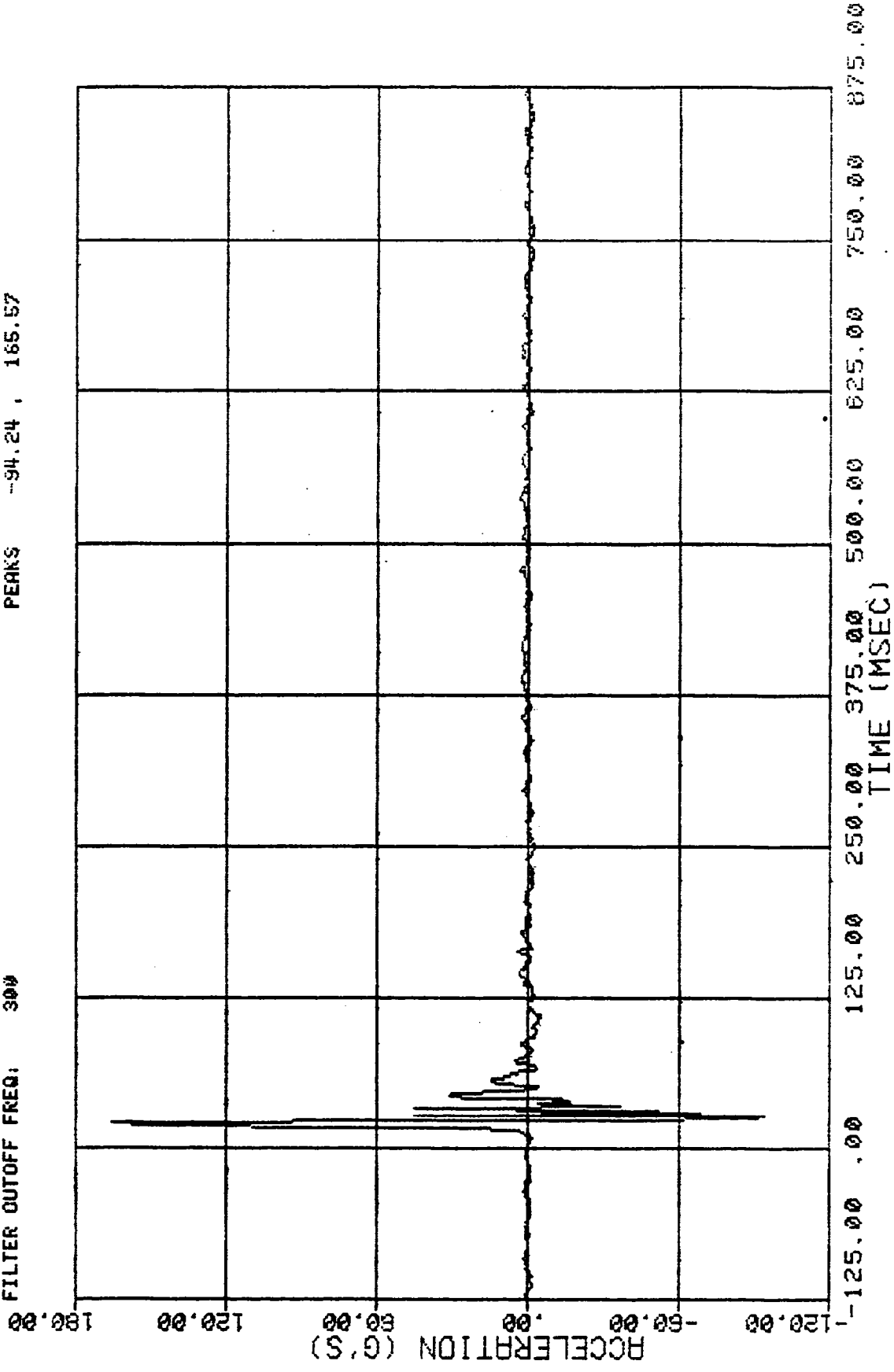


Figure A28. LUR - YG1 Acceleration, 300 Hz

ENSOO, I.N.O. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI./H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 11 LURY0A  
 FILTER CUTOFF FREQ: 300 PEAKS -106.79 , 167.34

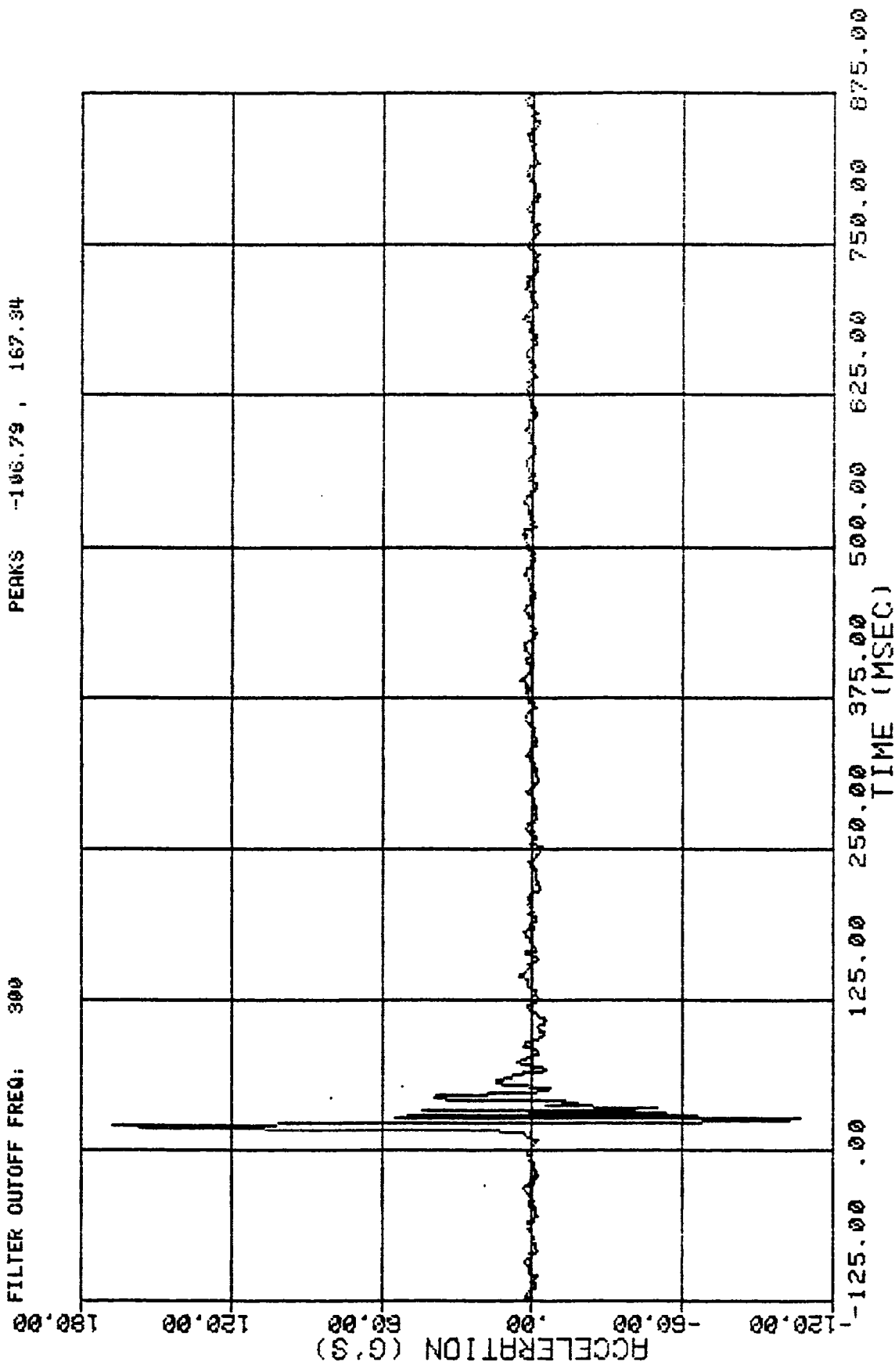


Figure A29. LUR - YGA Acceleration, 300 Hz

ENSOO, INC.    CONTRACT NUMBER    DTFH61-86-Z-00047    TEST # 1785-SI-8-83  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH OHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 3    T01Y NHTSA FIR FILTER  
 FILTER CUTOFF FREQ.    0    PEAKS    -66.93 ,    14.95

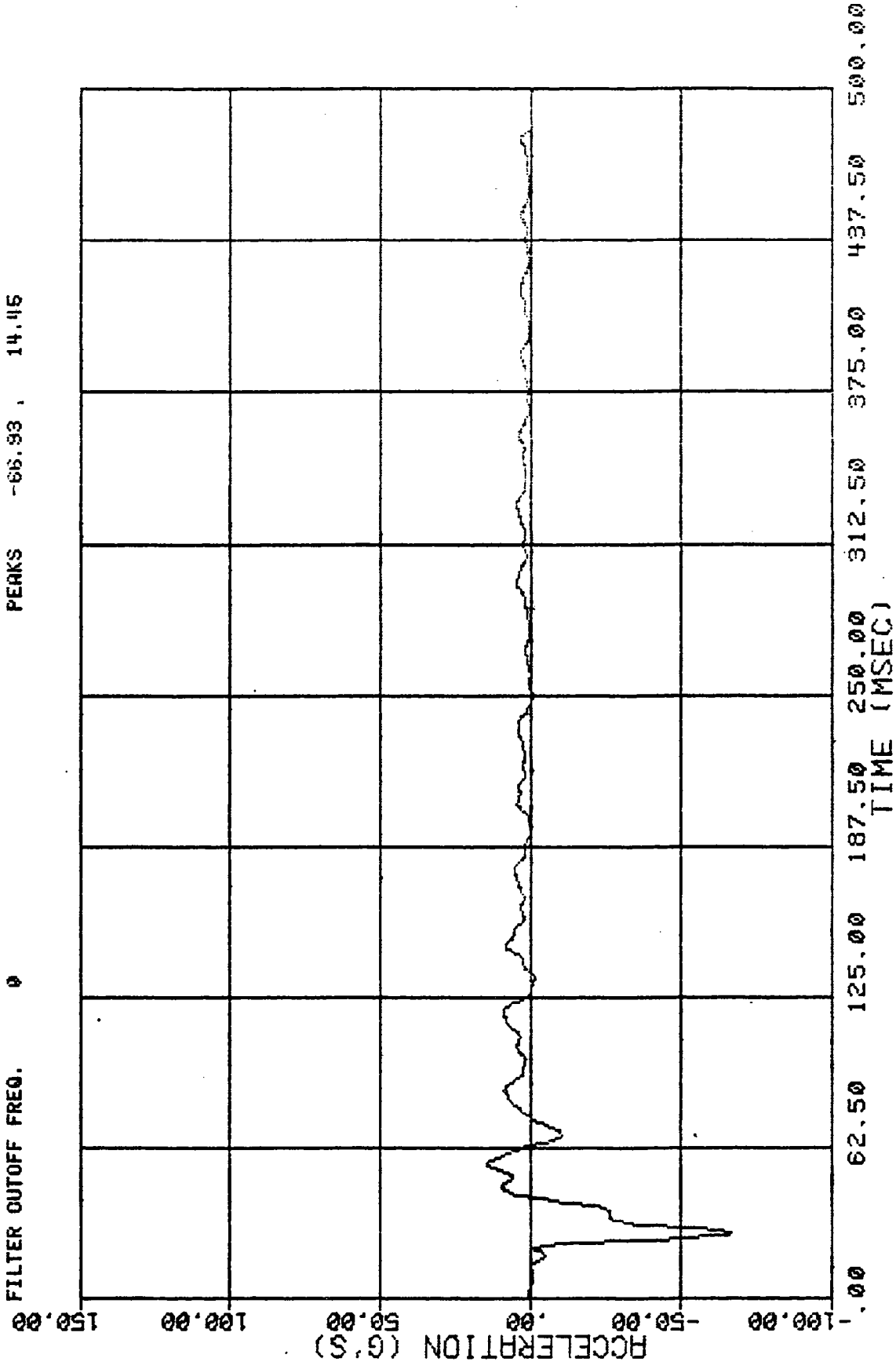


Figure A30. T01 - Y Acceleration, FIR Filter

ENSCO, INC.    CONTRACT NUMBER    DTF61-86-Z-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 7    T12Y NHTSA FIR FILTER  
 FILTER CUTOFF FREQ.    0    PEAKS    -47.75 ,    13.32

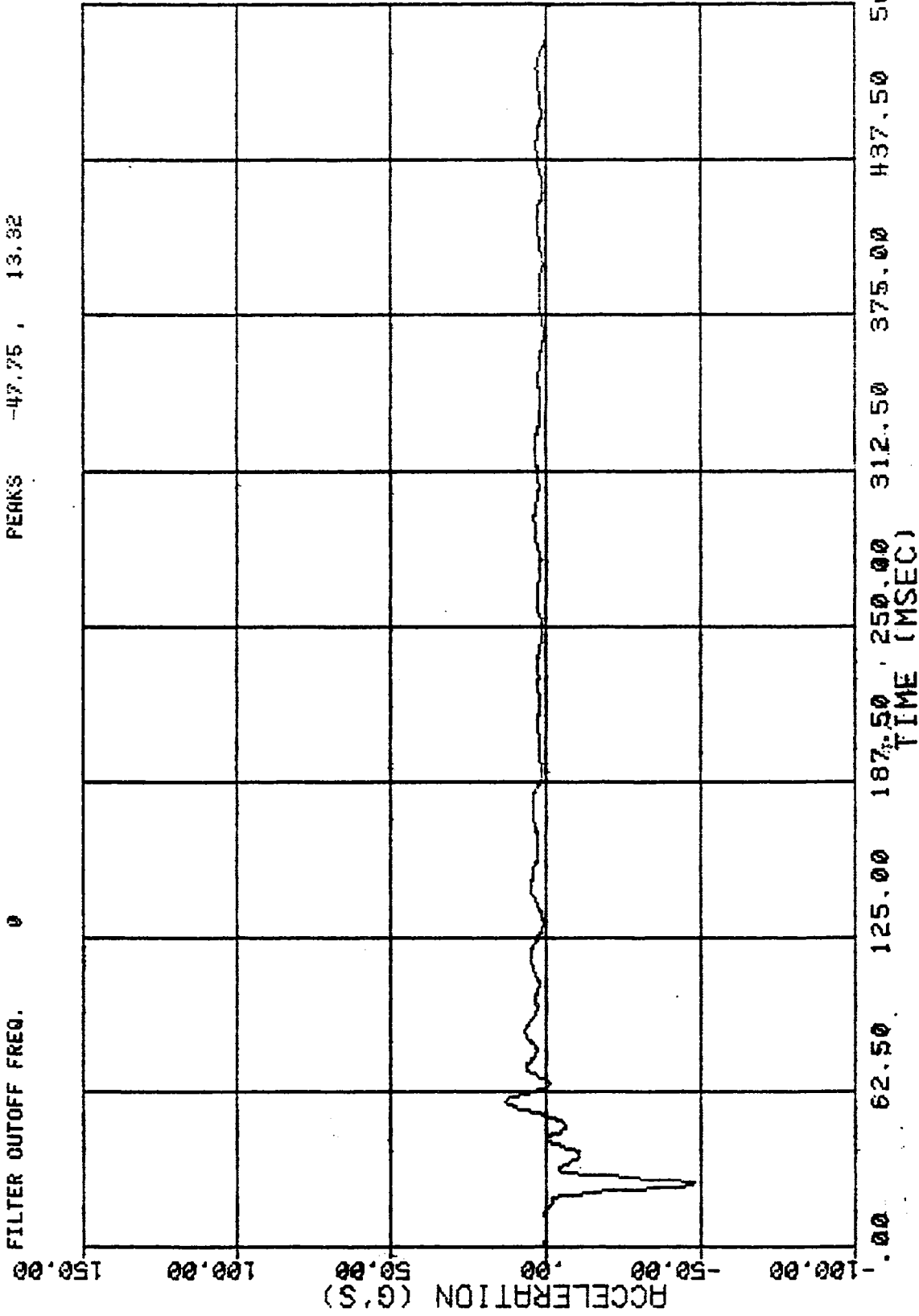


Figure A31. T12 - Y Acceleration, FIR Filter

ENSCO, INC.      CONTRACT NUMBER    DTFH61-86-2-00047      TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 1    LLRY01    NHTSA FIR FILTER  
 FILTER CUTOFF FREQ.    0      PEAKS    -22.58    ,    84.57

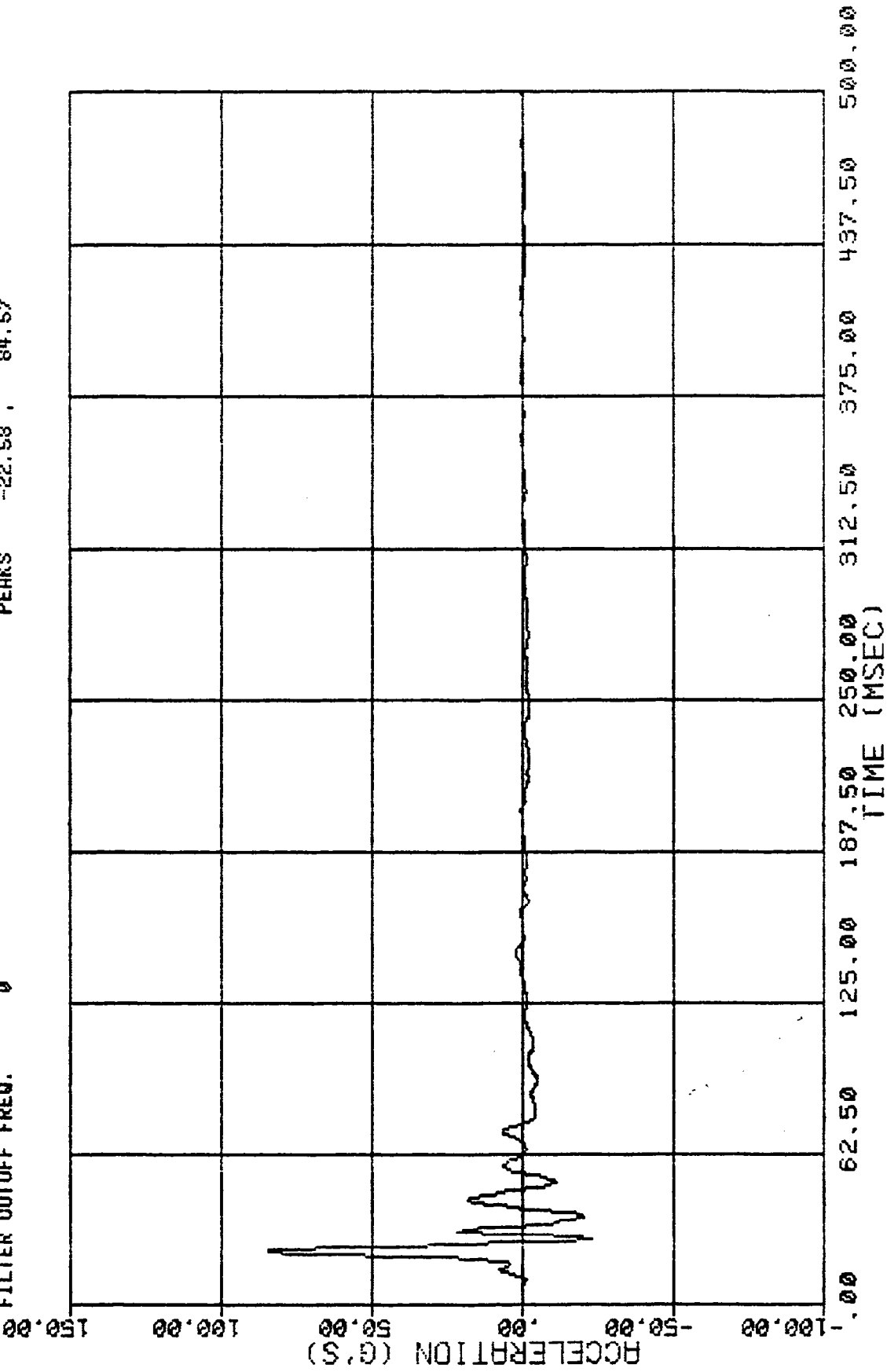


Figure 32. LLR - Y01 Acceleration, FIR Filter

ENSO, INC. CONTRACT NUMBER DTFH61-86-Z-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 10 LLRY9A NHTSA FIR FILTER PEAKS -29.60 , 87.19  
 FILTER CUTOFF FREQ. 0

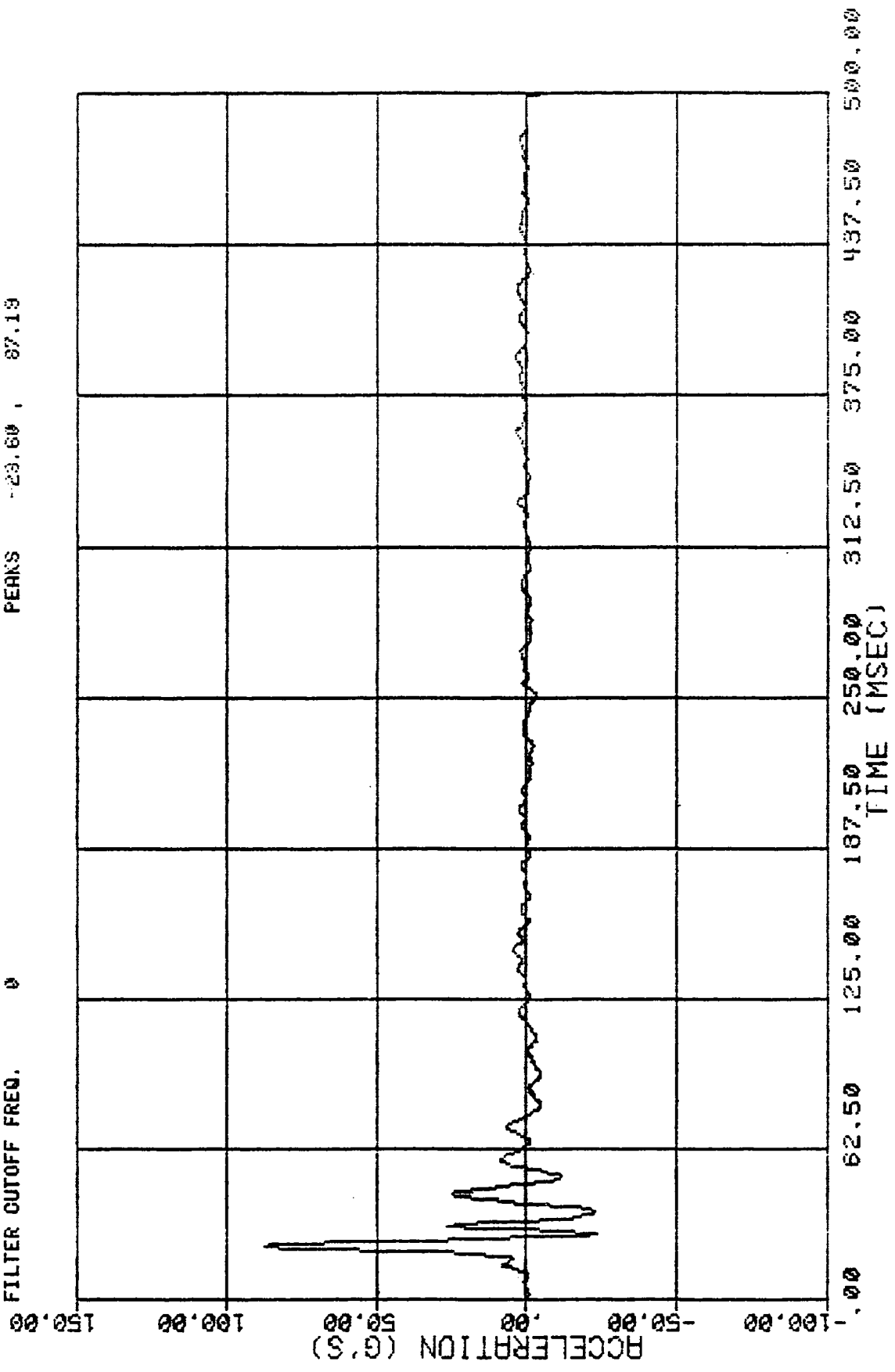


Figure A33. LLR-YGA Acceleration, FIR Filter

ENSCO, INC. CONTRACT NUMBER DTFH61-86-2-00047 TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 2 LURY01 NHTSA FIR FILTER PEAKS -50.70 , 131.77  
 FILTER CUTOFF FREQ. 0

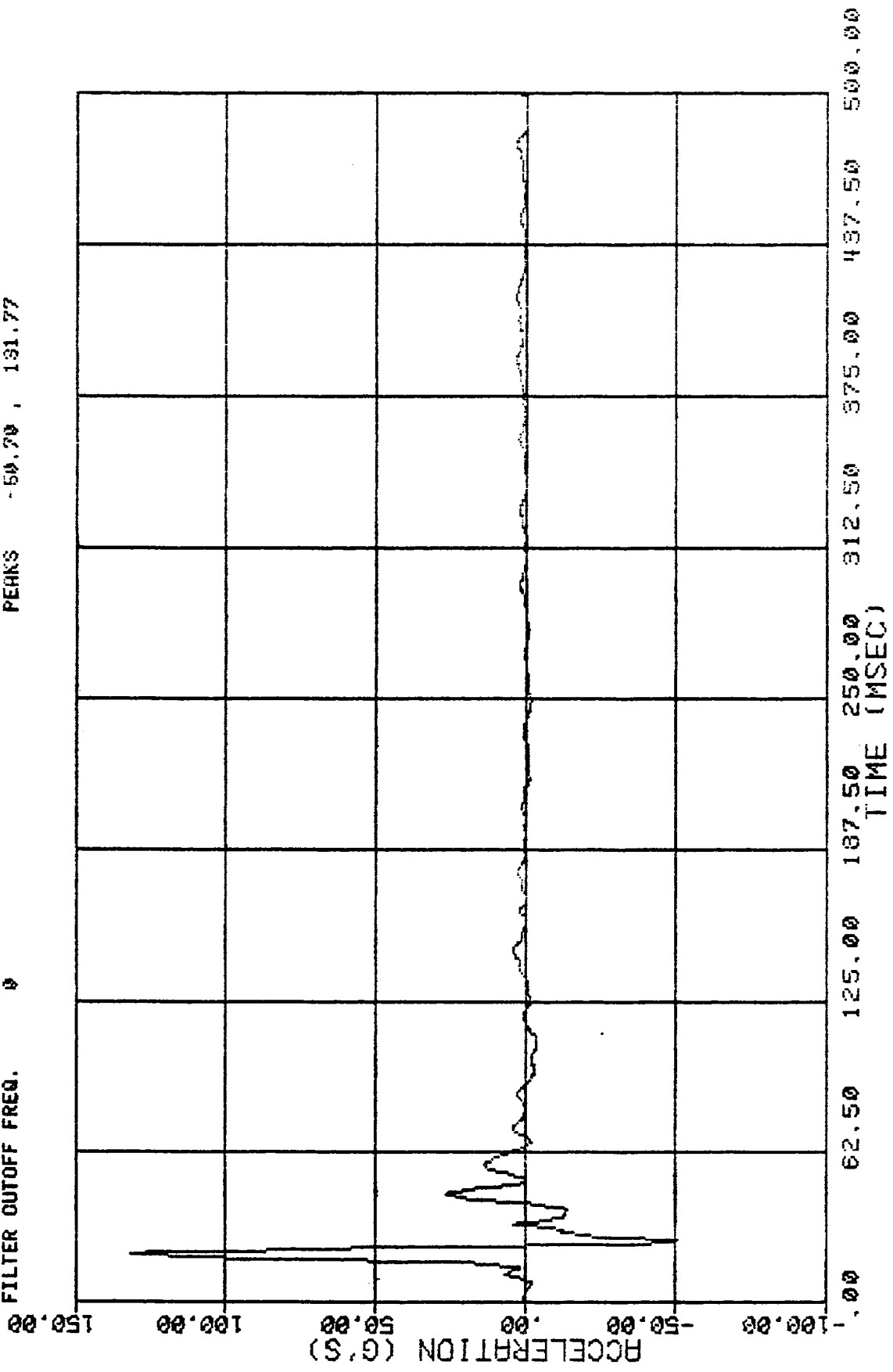


Figure A34. LUR -YG1 Acceleration, FIR Filter

ENSOO, INC.    CONTRACT NUMBER    DTFH61-86-2-00047    TEST # 1785-SI-8-88  
 30 MI/H BROADSIDE IMPACT OF 81 PLYMOUTH CHAMP INTO LUMINAIRE SUPPORT  
 CHANNEL 11    LURYGA    NHTSA FIR FILTER  
 FILTER CUTOFF FREQ.    9    PEAKS    -55.56 ,    135.07

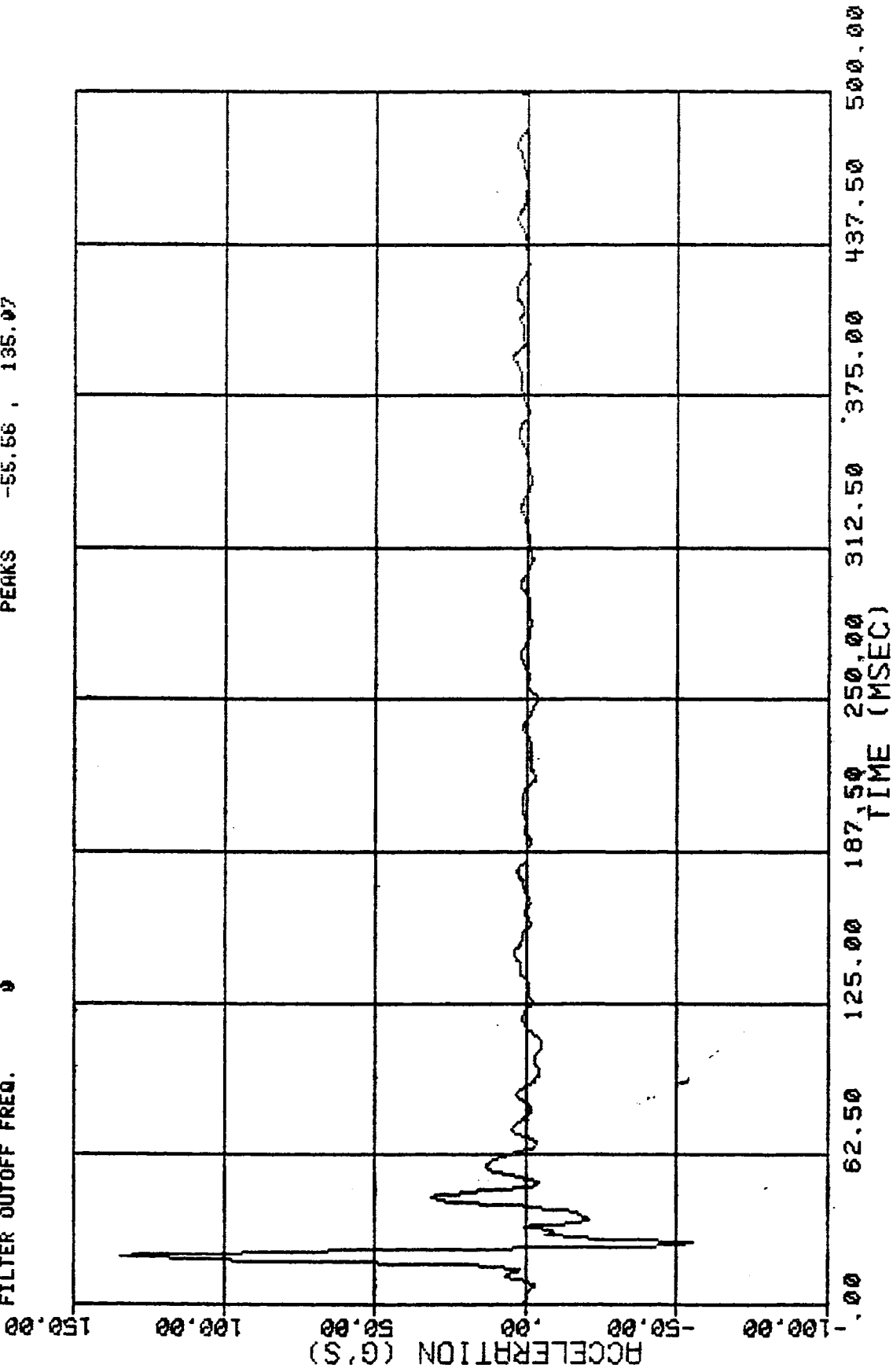


Figure A35. LUR \_ YGA Acceleration, FIR Filter