

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PROCESSED STRONG-MOTION RECORDS FROM THE IMPERIAL
WILDLIFE LIQUEFACTION ARRAY, IMPERIAL COUNTY, CALIFORNIA,
RECORDED DURING THE SUPERSTITION HILLS EARTHQUAKES, NOVEMBER 24, 1987

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This report is preliminary and has not been reviewed for conformity with US Geological Survey editorial standards. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

PREFACE

This report contains the computer-processed results of the accelerograms from the Imperial Wildlife Liquefaction Array recorded during the Superstition Hills earthquakes of November 24, 1987 (MS=6.2 at 0154 Gmt and MS=6.6 at 1315 Gmt). The array is a station of the U.S. Geological Survey's National Strong-Motion Instrumentation Network. Other stations recorded both events but are not included here. Preparation of the pore pressure records is described. A companion tape to this report, containing all processed results, is available from the National Geophysical Data Center, NOAA, 325 Broadway (Mail Code E/GC11), Boulder, Colorado 80303.

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 SUPERSTITION HILLS EARTHQUAKES OF NOVEMBER 24, 1987
 MS=6.2 AT 0154, MS=6.6 AT 1315
 IMPERIAL WILDLIFE LIQUEFACTION ARRAY

Station location, and component directions	Page no. for plots of four processing steps*			
	1	2	3	4
<u>MS=6.2, 0154 Gmt</u>				
Surface; 360, Up, 090	20	36	80	94
Downhole; 360, Up, 090 (Approx.)	22	42	83	97
<u>MS=6.6, 1315 Gmt</u>				
Surface; 360, Up, 090	24	48	86	100
Downhole: 360, Up, 090 (Approx.)	29	63	89	103

*Processing stages and plot format:

1. Uncorrected accelerogram
2. Corrected acceleration, velocity, displacement
3. Response spectrum; tripartite plot
4. Fourier amplitude spectrum; log plot.

Note: In column 1, each accelerogram plot contains all three components.
 In columns 2, 3, 4, the indicated page number refers to the first
 of three components for this record.

INTRODUCTION

The two largest earthquakes in the Superstition Hills, California, region on November 24, 1987 were an MS=6.2 event at 0154 Gmt and an MS=6.6 mainshock at 1315 Gmt. Strong-motion accelerograms were recorded at more than 40 National Strong-Motion Instrumentation Network (NSMIN) stations, operated by the U.S. Geological Survey, in the greater Imperial Valley region.

Twenty-four stations were triggered by the MS=6.2 event, and six of these had peak horizontal accelerations greater than 0.1 g. Maximum recorded peak horizontal acceleration was 0.22 g at Calipatria (26-km epicentral distance). Accelerographs at 39 NSMIN stations were triggered by the MS=6.6 event, with 24 stations exceeding 0.1 g. These stations are located within 60 km of the epicenter. Maximum recorded peak horizontal acceleration was 0.91 g at the closest station (Superstition Mountain, Site 8), at an epicentral distance of 7 km. Copies of the records and tabulated peak accelerations are included in Porcella and others (1987).

The records from these two events obtained at the Imperial Wildlife Liquefaction Array provide a unique opportunity to study the ground accelerations below and above a liquefying layer of silty sand. Pore-pressure transducers indicate that in the MS=6.6 event the vertical effective stresses on the sand grains were reduced to zero. This report contains the results of processing the film accelerograms recorded at the array during both events. Computer plots of uncorrected acceleration, corrected acceleration, velocity and displacement, Fourier amplitude spectra, and response spectra are included in Appendices 1-4. A companion tape is available from the National Geophysical Data Center (See Preface).

Processing of the Superstition Hills earthquakes data from other stations is continuing, including those with higher accelerations and smaller epicentral distances. The total number of digitized data channels is expected to be 18 from the MS=6.2 event, selected from the 78 data channels triggered at 24 stations, and 78 from the MS=6.6 event, selected from the 120 data channels triggered at 39 NSMIN stations. Earthquake data are listed in Table 1, and the epicenters and stations are indicated in Figure 1.

Specific data on the Liquefaction Array station are listed in Table 2. The downhole accelerometers are at a depth of 24.6 ft (7.5 m). The liquefiable silty sand layer lies between depths of 8.2 and 22.3 ft (2.5 and 6.8 m). The pore pressure transducers are at depths of 9.5, 10.0, 13.1, 16.5, 21.5, and 39.4 ft (2.9, 3, 4, 5, 6.6, and 12 m), installed in equally-spaced holes drilled on the circumference of a 30.0 ft (9.1-m) diameter circle. The downhole accelerometer bore hole is at the circle's center (Bennett and others, 1984).

PROCESSING FOR UNCORRECTED DATA

The original film records, 7 in wide, were contact printed onto direct positive mylar film. Exposure and developing times were selected to produce a contrast between black trace and clear background that was satisfactory for subsequent digitizing. There were no unacceptably faint traces.

The record of the MS=6.2 event is 68 s; the first 30 s were prepared for

digitizing (Figure 2). Amplitudes had dropped to, at most, 0.03 g by this time. No pore pressure increase was recorded during this event. The record of the MS=6.6 event, on the other hand, is 97 s. Since the rise in pore pressure took about 90 s, and simultaneous fluctuations were occurring in pore pressure and surface acceleration throughout the record, the complete record duration was digitized (Figure 3).

To accommodate the requirements of the commercial digitizer (a computer-controlled trace-following laser scanner, with a digitizing window 6 cm wide and 12 cm long), each of the records is treated as though it were 3 horizontal panels extending the entire length. Each panel is digitized in frames of 9.5-cm length divided by butting lines inscribed on the digitized copy. These lines are digitized at the beginning and end of each frame, and are used, together with their intersections with reference traces, to reassemble the individual frames of data.

The digitizing machine has a least count of 1 micron (10^{-6} meter) and an accuracy, in the RMS sense while digitizing a straight line, of ± 3 to ± 15 microns, depending on the clarity of the edges of the line and the line thickness (Fletcher and others, 1980). Overall accuracy of the optics is maintained by digitizing a square grid annually, or at appropriate intervals, and performing a suitable optical correction on every digitized point.

The raw data is almost equispaced at approximately 600 samples per cm (that is, 600 samples per second of record time), although higher densities are required around the sharpest peaks.

The first processing steps are (Converse, 1984):

1. Reassemble the data from one horizontal panel digitized in successive 9.5-sec frames, into X-Y coordinates for the entire digitized record duration.
2. Use the separately reassembled time marks to adjust all X coordinates to seconds, starting with 0.0 s at the initiation of digitizing.
3. Subtract from each data trace (whether acceleration or pore pressure) the nearest reference trace.
4. Subtract the calculated applicable mean value. In the case of the acceleration traces, this provides data with close to zero amplitudes at the start of the time history. The pore pressure histories require an additional constant to ensure the initial pore pressure is that of the hydrostatic head, or to ensure the initial excess pore pressure is zero.
5. Scale for units of seconds and cm/sec/sec (acceleration). The resulting acceleration data, having had no direct and specific alteration of their frequency content, have long been called uncorrected acceleration. The pore pressures are scaled to psi.

PROCESSING PROCEDURES - CORRECTED DATA

Event at 0154, MS=6.2

ACCELEROGRAMS

High-frequency limit. The default high-frequency correction algorithm includes an instrument correction using instrumental constants for effective natural frequency and damping, a high-frequency low-pass filter rolling off at 50 Hz with termination at 100 Hz, and decimation to 200 sps.

Low-frequency, or long-period, limit. The records from the Imperial Wildlife Liquefaction Array were digitized and processed before other records from this event were prepared for processing. The filter selection was therefore based on a comparison of the resulting displacements at the surface and downhole locations, the indications of noise from the Fourier amplitude spectra, and experience with similar records from other events. An initial selection of 2 s was based on the apparent rupture duration, as determined from the strong-motion duration of the records. Filters of 4 s and 8 s were also tried, searching for the long period at which noise of different amounts in the surface and downhole records would cause their resultant displacements to diverge, or lose their coherency. No such indication was found even with the 8 s filter, as can be seen in the acceleration, velocity, and displacement comparison in Figure 4, which shows the plots for surface and downhole locations in the north direction. Although this comparison indicates that the 8 s filter (0.125 Hz high-pass) might be satisfactory, a decision to continue analyses with the corresponding displacements must await a more thorough analysis of the other close-in records from this event. At this stage a more conservative estimate of the long-period limit is 2 s, the initial selection, and the appendices contain plots of corrected analyses using this value. The Fourier amplitude spectra show that the surface and downhole motions in the north direction are virtually identical between 0.2 and 1.2 Hz, and that between 2 and 20 Hz the surface motion is amplified by up to 10 times (in the vicinity of 4 Hz). The pressure transducers indicate that no pore pressure increase was occurring during this event; this amplification over the frequency range 2-20 Hz is not associated with any liquefaction effects.

PORE PRESSURES

Although the pore pressures were digitized, they show no increases due to liquefaction, and are not included in this report.

Event at 1316, MS=6.6

ACCELEROGRAMS

High-frequency limit. The default high-frequency correction that was used for the earlier event was repeated here, with roll-off at 50 Hz.

Low-frequency or long-period limit. Several factors contributed to the selection of 0.25 Hz as the low-frequency cut, corresponding to a long period limit of 4 s.

1. There is clearly evident 3-s content in the uncorrected 360° component

surface ground motion between 30 and 36 s, and this has been retained with a 4-s filter.

2. The tripartite response spectra, calculated subsequently, showed long-period characteristics at 2 and 4 s that, in our experience, indicated no contamination with long-period noise.
3. The Fourier amplitude spectrum plots, for 0.5 and 0.25 Hz low-frequency filters, showed no low-frequency noise characteristics.
4. Since the smaller magnitude first shock (MS=6.2) was corrected using 2 s, it seems reasonable to expect that longer-period motions would be present at significant amplitudes in this MS=6.6 event.
5. Since the duration of digitized record was 98 s, there was no upper restriction to the choice of the long-period limit provided by the record duration.
6. The faulting duration is difficult to estimate from the uncorrected plot, because the duration of strong motion is not well defined there.

It might be that future processing of nearby stations will confirm that much longer periods may be studied satisfactorily from these records. The uncorrected data provides the source from which these future investigations can proceed.

The choice of a long-period limit greater than 4 s has no significant effect on the results in this liquefaction array investigation. During the rise in pore pressures beyond 13 s into the record, the prominent ground motions have periods in the range of 0.5 s to 3 s, and the phase lag between prominent peaks of horizontal ground acceleration at the downhole and surface locations is of the order of 0.2 s. The significant periods are therefore retained completely by any long-period limit of 4 s or greater.

PORE PRESSURES

High-frequency limit. The low signal amplitudes and the digitizer noise levels at high frequencies caused signal-to-noise ratio deterioration during the default 50-Hz high-frequency filtering. A filter at 12.5 Hz, with termination at 25 Hz, was therefore used.

Low-frequency limit. Because the final offset was a significant goal of the processing, no low-frequency filtering was performed. The pore pressures are plotted in Figure 5. We have used the routine AGRAM processing for "uncorrected data" in which the average pore pressure has been set to zero. To recover excess pore pressures, the initial amplitudes should be adjusted to zero with an additive constant for each trace. Total pore pressure requires the further addition of the hydrostatic head, depending on the depth below the water table (see Table 2).

Tabulated Values

Table 3 contains the peak ground motions at the various processing stages described in the above sections. The scaled peak accelerations are from

Porcella and others (1987) who scaled them from the original film records. The uncorrected peak accelerations are obtained from the digitized records and the corrected peak acceleration, velocity, and displacement occur after filtering for high- and low-frequency noise. The low-frequency cut (and corresponding period) is listed in the last column. The specific direction of the peak motions is not of particular importance, though a peak in the opposite direction to the listed component direction is indicated for the digitized data with a minus sign.

ACKNOWLEDGMENTS

The authors wish to thank those who installed and maintain the liquefaction array, and who, over hours of record keeping, photographic printing, digitizing, typing, programming, and report preparation, have contributed to the quality of the basic recorded data at the Imperial Wildlife Liquefaction Array and the subsequent usefulness of the data in this report.

REFERENCES

- Bennett, M. J., P. V. McLaughlin, J. S. Sarmiento, and T. L. Youd, 1984, Geotechnical investigation of liquefaction sites, Imperial Valley, California: U.S. Geological Survey Open-File Report 84-252, 103 p.
- Converse, April (1984). AGRAM, a series of computer programs for processing digitized strong-motion accelerograms, version 2.0: U.S. Geological Survey Open-File Report 84-525, 112 p.
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- Holzer, Thomas L., T. Leslie Youd, and Michael J. Bennett (1988). In situ measurement of pore pressure build-up during liquefaction: presented at 20th Joint Meeting, US-Japan Panel on Wind and Seismic Effects, NBS, Gaithersburg, Maryland, May 1988.
- Porcella, R., E. Etheredge, R. Maley, and J. Switzer (1987). Strong-motion data from the Superstition Hills earthquakes of 0154 and 1315 (GMT), November 24, 1987: U.S. Geological Survey Open-File Report 87-672, 56 p.

TABLE 1. EARTHQUAKE DATA*

	First event	Second event
Magnitude MS	6.2	6.6
Magnitude M_L (Richter M)	5.8	6.1
Origin time: PST	23 Nov 1987 1754:14.5 s	24 Nov 1987 0515:56.4 s
GMT	24 Nov 1987 0154:14.5 s	24 Nov 1987 1315:56.4 s
Record trigger time**	0154:19.92 s	1316:03.40 s
Epicenter: N. Lat.	33.083	33.010
W. Long.	115.775	115.840

*From Preliminary Determination of Epicenters, published by the U.S. Geological Survey.

**From WWVB radio time.

TABLE 2. STATION DATA

Imperial Wildlife Liquefaction Array

Coordinates:	33.10 N lat., 115.53 W. long.
Epicenter distance:	24 km, 1st event; 32 km, 2nd event
Fault distance (surface rupture):	27 km, 2nd event
Site geology:	Saturated Holocene flood plain sediments (2.5 m silt, overlying 4.3 m silty sand, overlying dense extensive sedimentary deposits (Bennett and others, 1984). Water table at 1.2 m depth (Holzer and others, 1988)).
Instrumentation:	3 triaxial accelerometers at surface; 3 triaxial accelerometers at depth of 7.5 m; 6 pore pressure transducers at depths of 2.9, 3, 4, 5, 6.6 and 12 m.

TABLE 3. RECORD DATA AND PROCESSED RESULTS

IMPERIAL WILDLIFE LIQUEFACTION ARRAY

24 Nov 87 0154 Gmt	Comp Dir'n	Scaled peak accln (g)	Uncorr. peak accln (cm/s/s)	Corrected			Low-frequency long-period cut (Hz), (s)
				Accln (cm/s/s)	Vel (cm/s)	Displ (cm)	
Surface	360	.13	-132.14	-130.94	-13.84	5.61	0.125, 8
	Up	.18	-189.79	-179.96	-4.75	2.48	
	090	.13	129.31	129.39	13.02	-9.86	
Downhole*	360	.08	-81.77	-80.88	-12.85	5.59	
	Up	.09	80.69	80.35	-4.89	2.33	
	090	.08	-75.51	-73.85	10.56	-9.06	
Surface	360			-128.60	-13.62	-4.54	0.25, 4
	Up			-178.82	-4.93	1.04	
	090			128.07	-10.84	-3.11	
Downhole	360			-78.95	-12.20	-4.58	
	Up			79.60	-5.03	1.01	
	090			-72.36	-7.88	-2.55	
Surface	360			-125.16	-8.90	-1.91	0.5, 2 (selected for this report)
	Up			-176.21	-4.61	-0.78	
	090			125.99	-8.29	1.47	
Downhole	360			-76.81	-6.94	-1.74	
	Up			83.22	-4.64	-0.78	
	090			66.33	5.30	1.28	

TABLE 3 - continued

24 Nov '87 1315 Gmt	Comp Dir'n	Scaled peak accln	Uncorr. peak accln	Corrected			Low-frequency long-period cut
				Accln	Vel	Displ	
Surface	360	.21	-205.81	-201.15	30.49	11.74	.25, 4 (Selected for this report)
	Up	.44	-436.55	-414.81	5.34	-1.40	
	090	.19	-184.06	-179.52	-22.93	11.32	
Downhole*	360	.16	-171.52	-168.63	-21.78	-5.00	
	Up	.11	103.32	99.67	-3.8	-1.41	
	090	.11	104.62	103.29	13.76	4.54	
Surface	360			195.12	-18.39	4.59	.5, 2
	Up			-414.30	-5.19	0.46	
	090			-184.78	-11.87	2.86	
Downhole	360			-162.82	-15.24	-1.95	
	Up			100.60	-3.83	0.39	
	090			103.21	-8.63	-1.48	

*The downhole directions are not known exactly, but are close to these nominal surface sensor directions

Figure Captions

1. Location of epicenters and the Liquefaction Array in the Imperial Valley, California.
2. Copy of the 30-s film record from the 24 November 1987 0154 MS=6.2 event. The top 6 data traces are acceleration; the 3 downhole traces are at a depth of 24.6 ft (7.5 m). The lower 6 data traces are pore pressure histories; P6 through P1 are at depths of 39.4, 9.5, 13.1, 21.5, 10.0, and 16.5 ft (12, 2.9, 4, 6.6, 3, and 5 m). The film is prepared for digitization in 3 frames. Horizontal division into 3 panels not shown. This copy is photo-reduced; the 10-s interval is initially 10 cm long.
3. Copy of the 97-s film record from the 24 November 1987 1315 MS=6.6 event. Traces are described in Figure 2. Digitization was performed over 10 frames.
4. Surface and downhole acceleration, velocity, and displacement in the North direction for the 0154 MS=6.2 event, after filtering with a long-period limit of 8 s. The displacements particularly are very similar, indicating that future analyses might well use 8-s filtered data. This report contains 2-s filtered data for this event.
5. Pore pressure values from default AGRAM processing during the 2nd event, MS=6.6. Piezometer depths are 39.4, 9.5, 21.6, 9.8, and 16.4 ft (12, 2.9, 6.6, 3, and 5 m). Piezometer P4 did not operate. For excess pore pressure, initial amplitudes should be moved to zero.

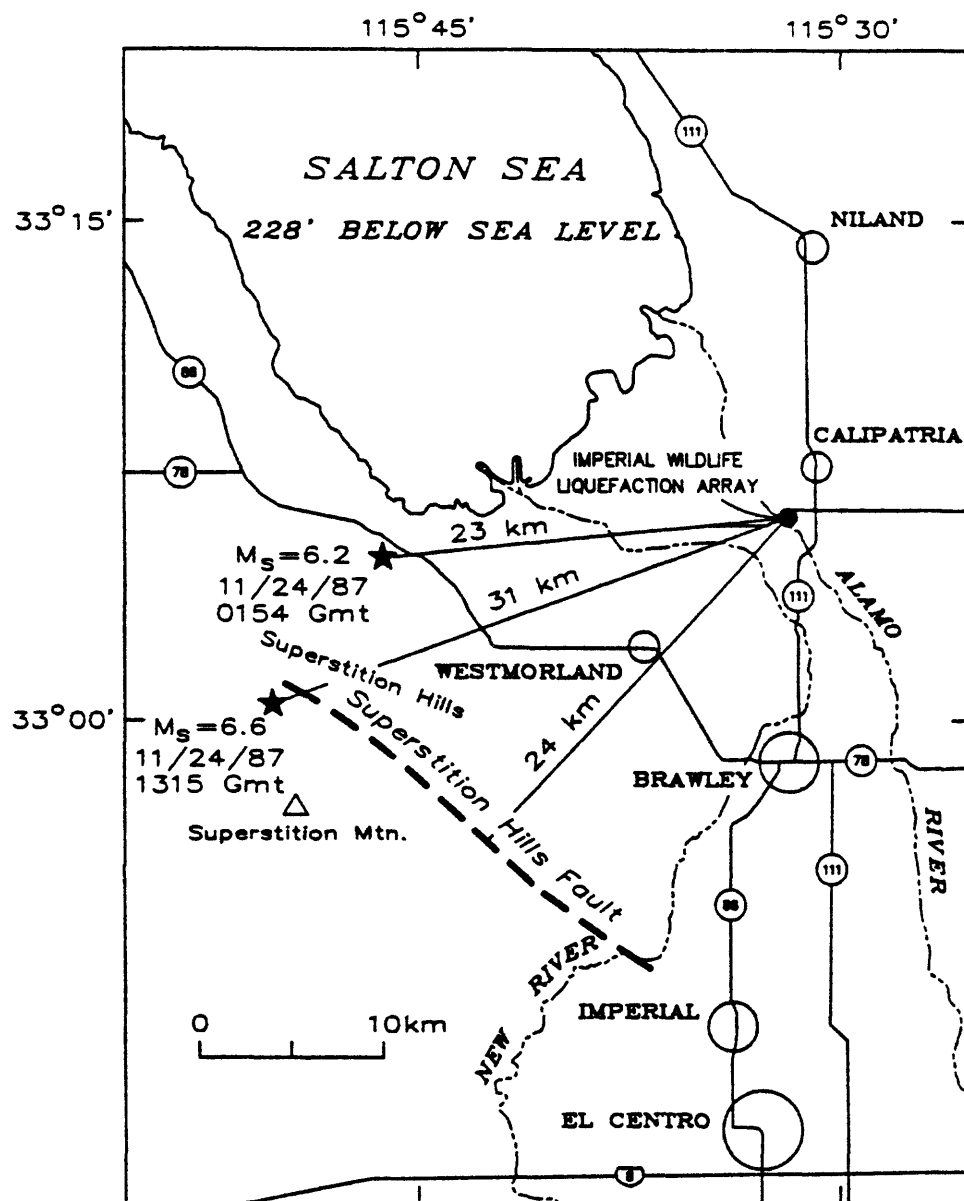
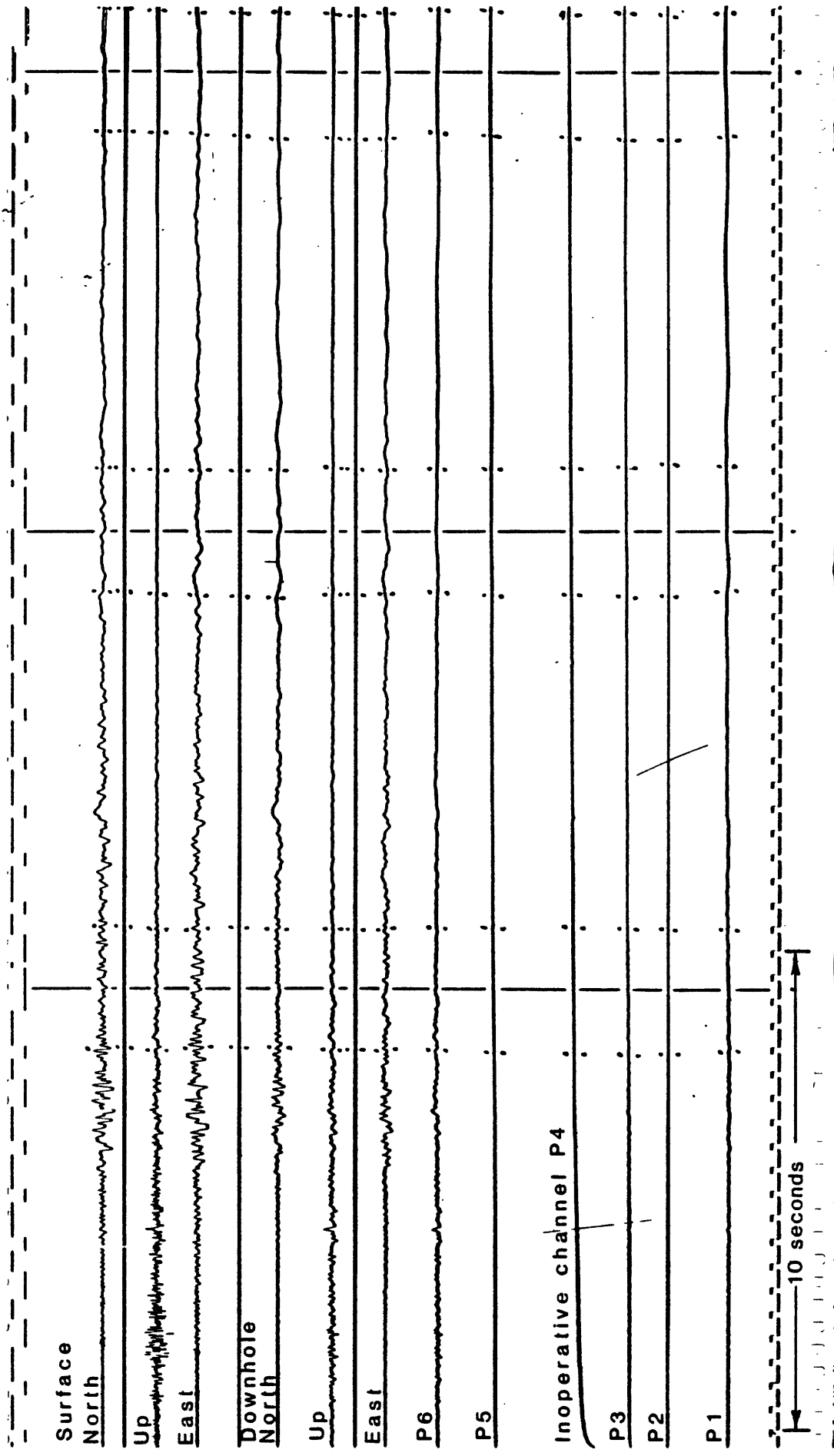


Figure 1

Trigger time for 1st. event:
 Nov 24, 1987 01hr 54m 19.92s Gmt



FRAME 3

FRAME 2

Figure 2

FRAME 1

Trigger time for 2nd. event:

Nov 24, 1987 13hr 16m 3.40s Gmt

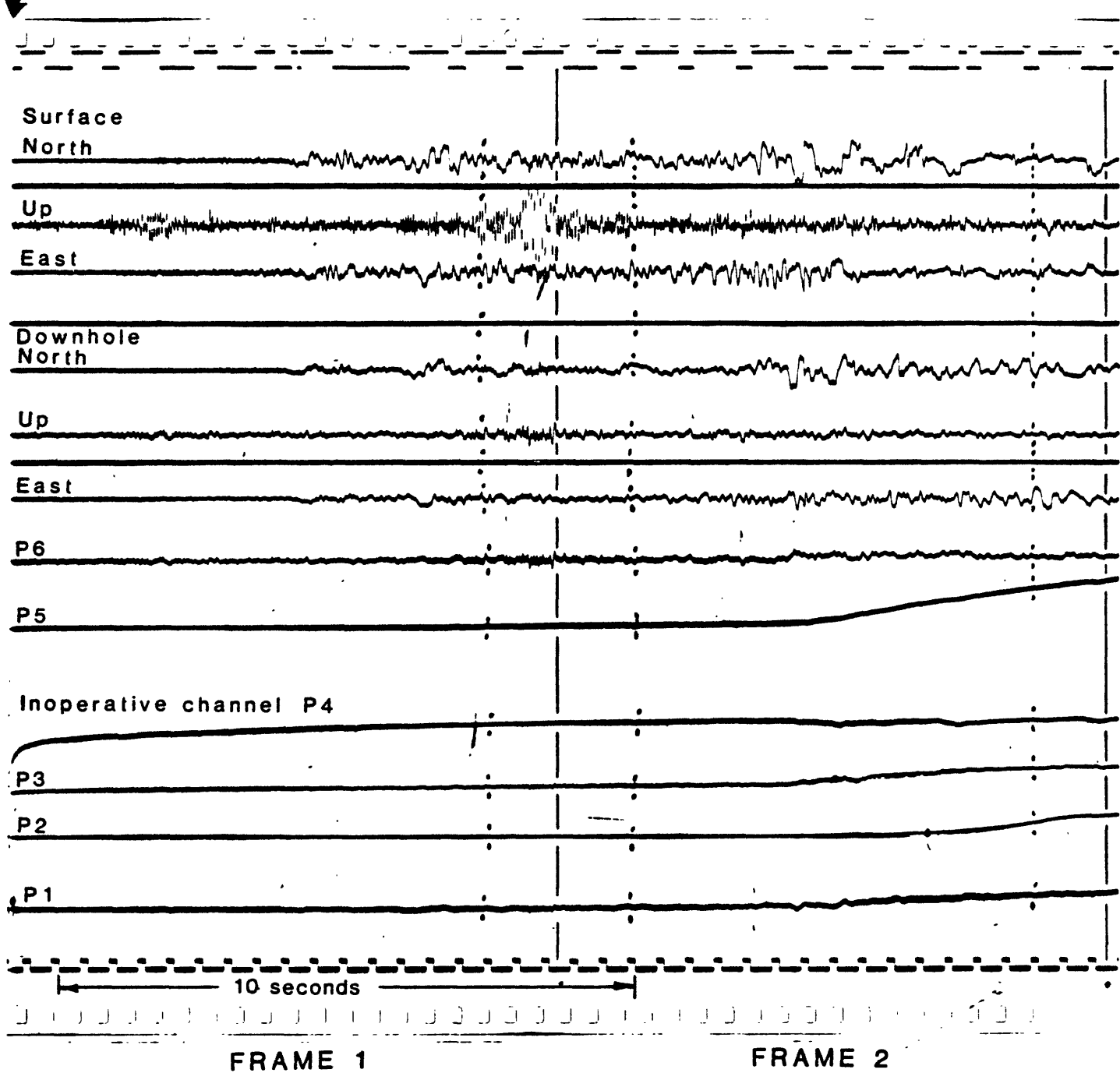
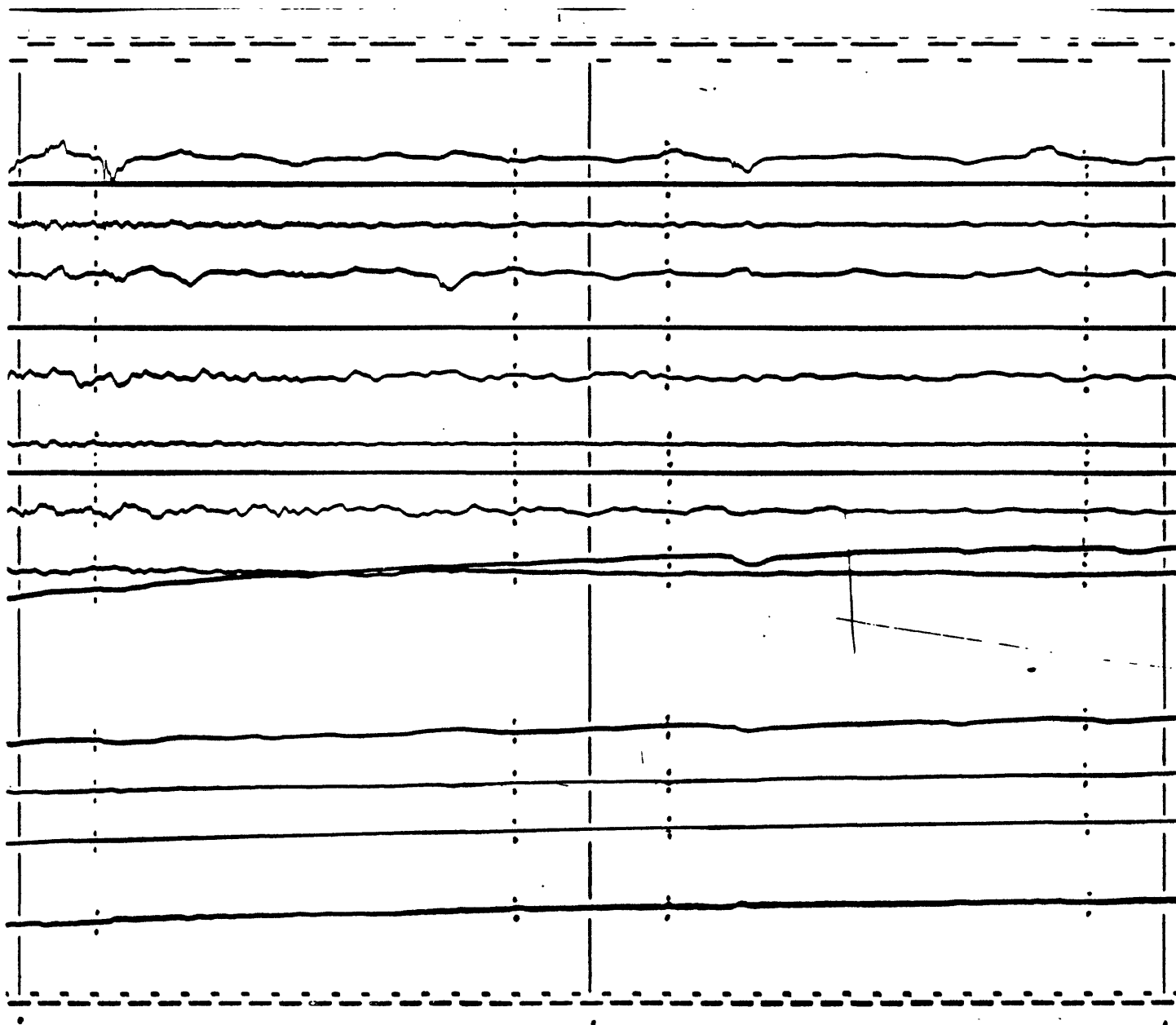


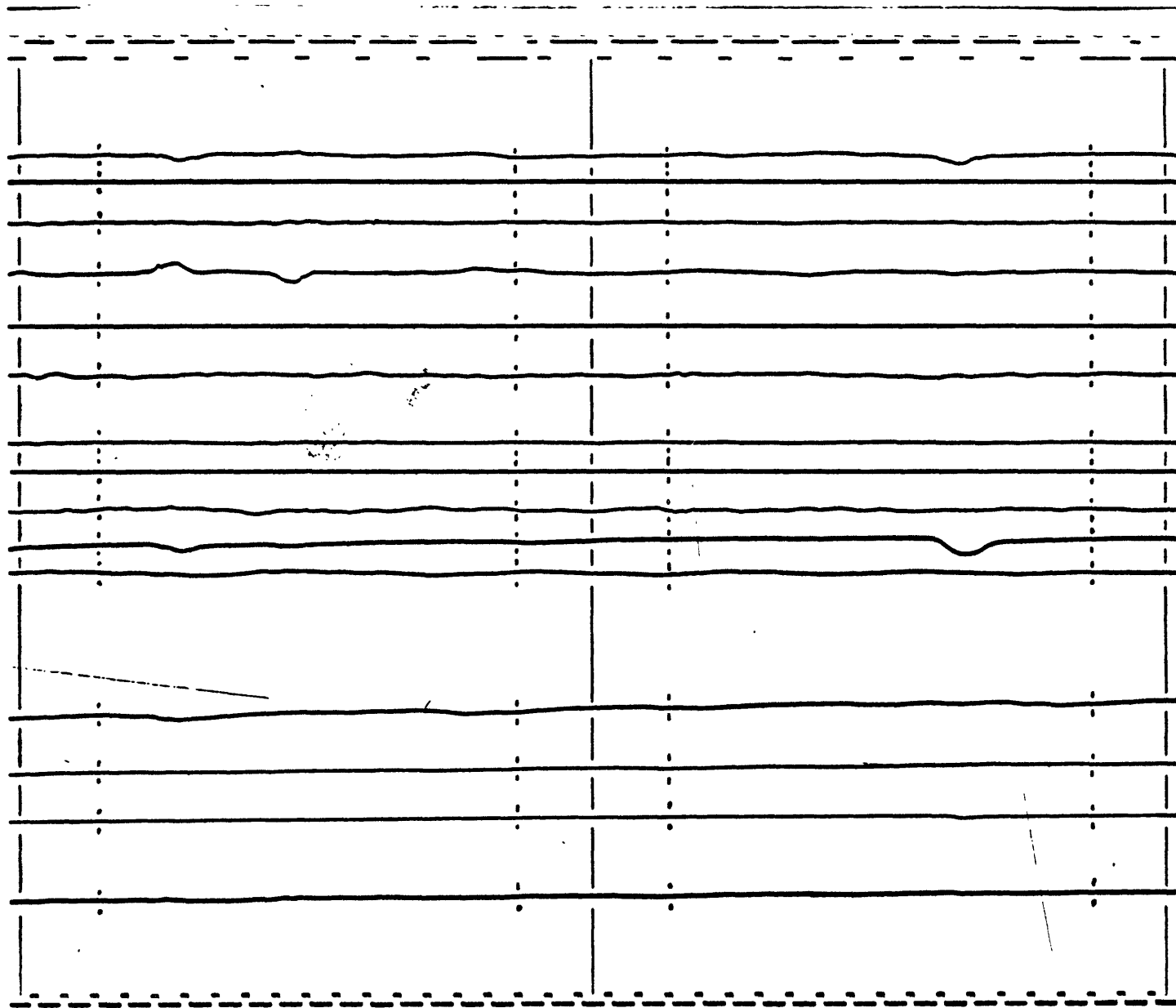
Figure 3



FRAME 3

FRAME 4

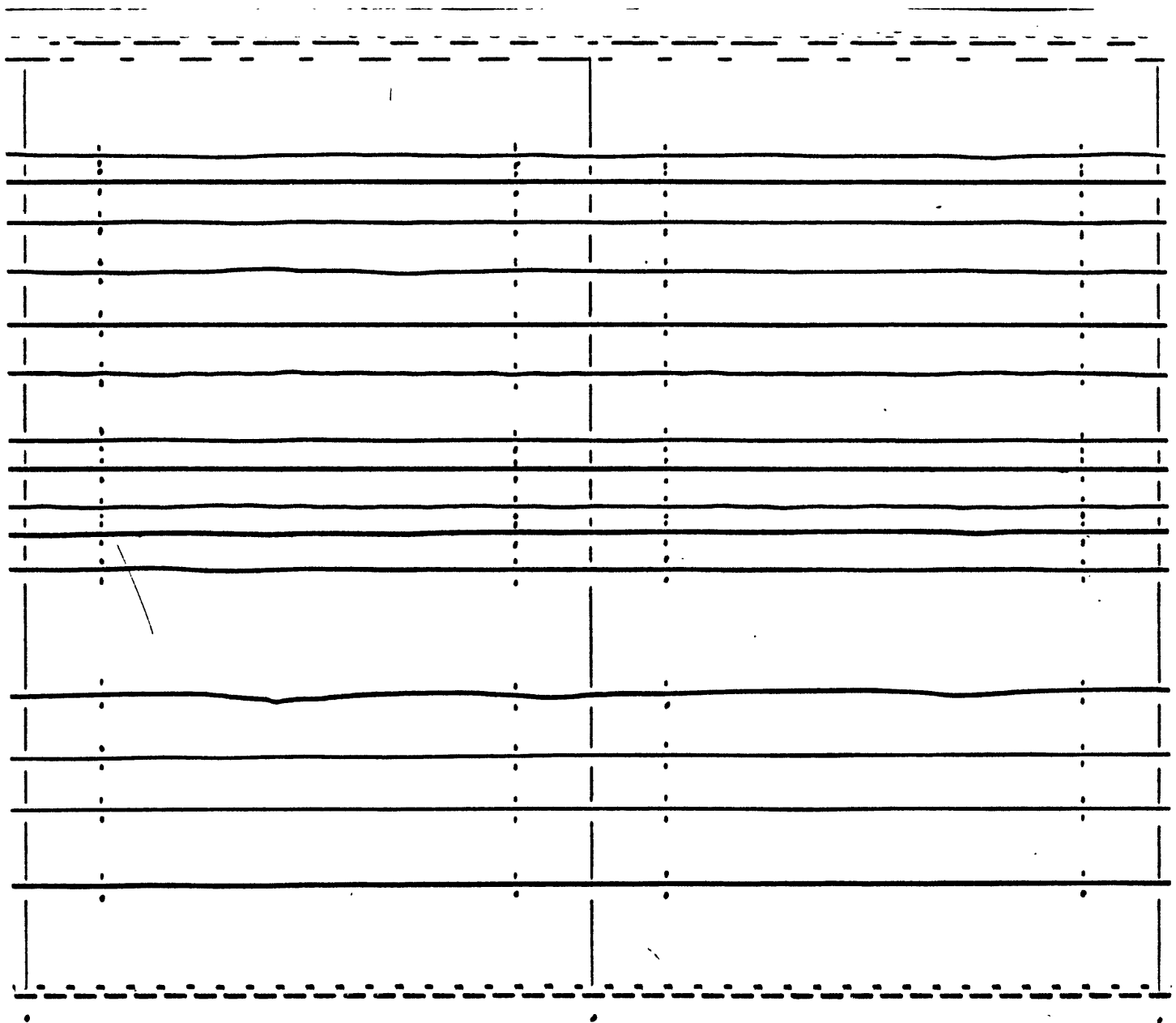
Figure 3 - continued



FRAME 5

FRAME 6

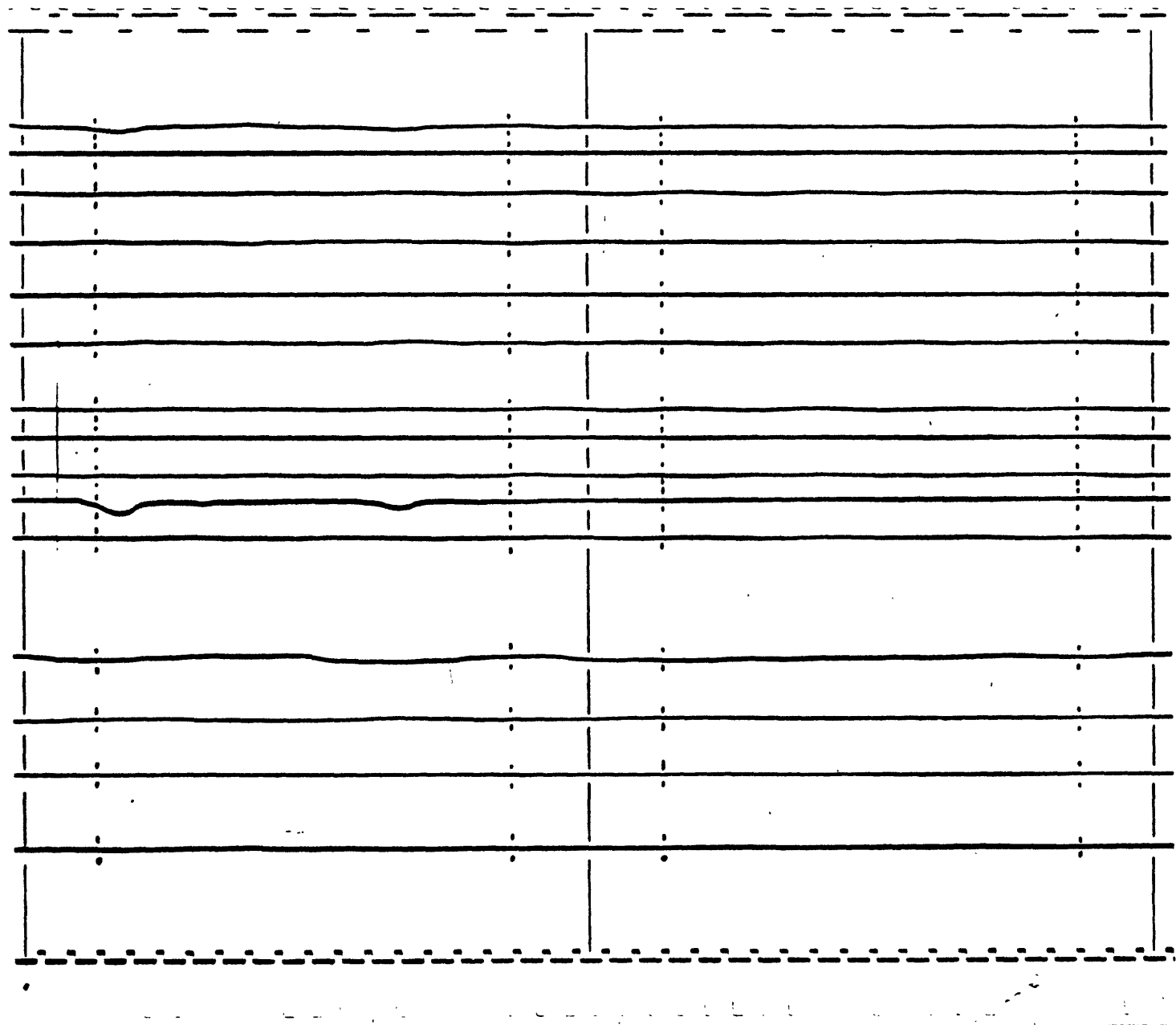
Figure 3 - continued



FRAME 7

FRAME 8

Figure 3 - continued

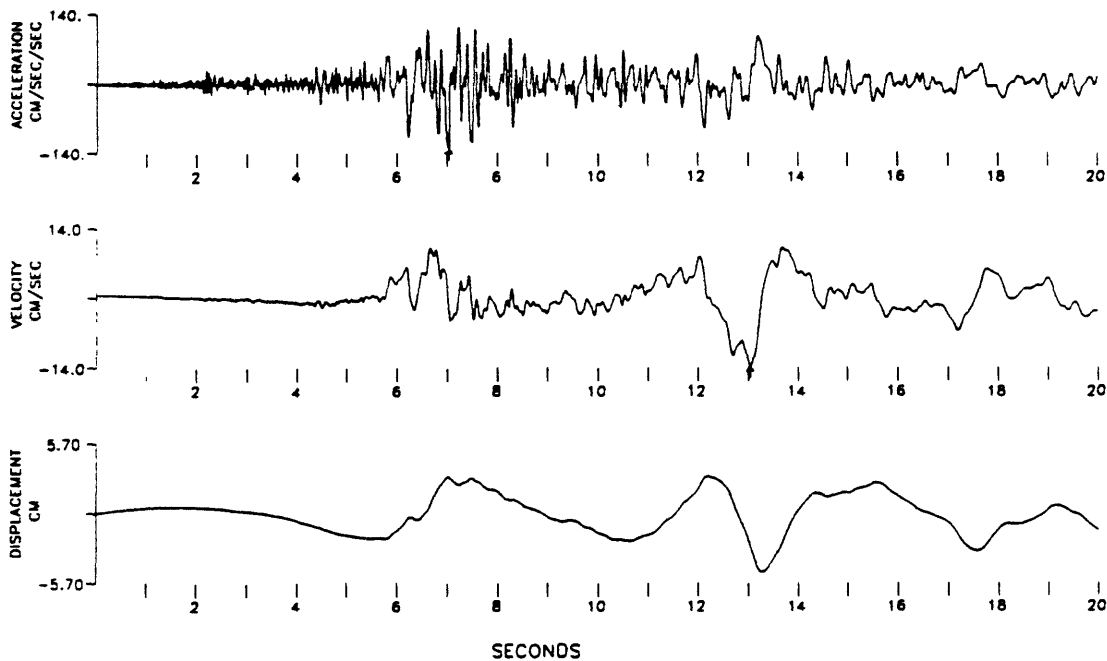


FRAME 9

FRAME 10

Figure 3 - continued

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
360 DEGREES
EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
BUTTERWORTH AT .125 HZ, ORDER 4
PEAK VALUES: ACCEL=-130.94 CM/SEC/SEC, VELOCITY=-13.84 CM/SEC, DISPL=5.51 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 6.7 M DOWNHOLE
360 DEGREES, APPROX.
EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
BUTTERWORTH AT .125 HZ, ORDER 4
PEAK VALUES: ACCEL=-80.88 CM/SEC/SEC, VELOCITY=-12.85 CM/SEC, DISPL=5.59 CM

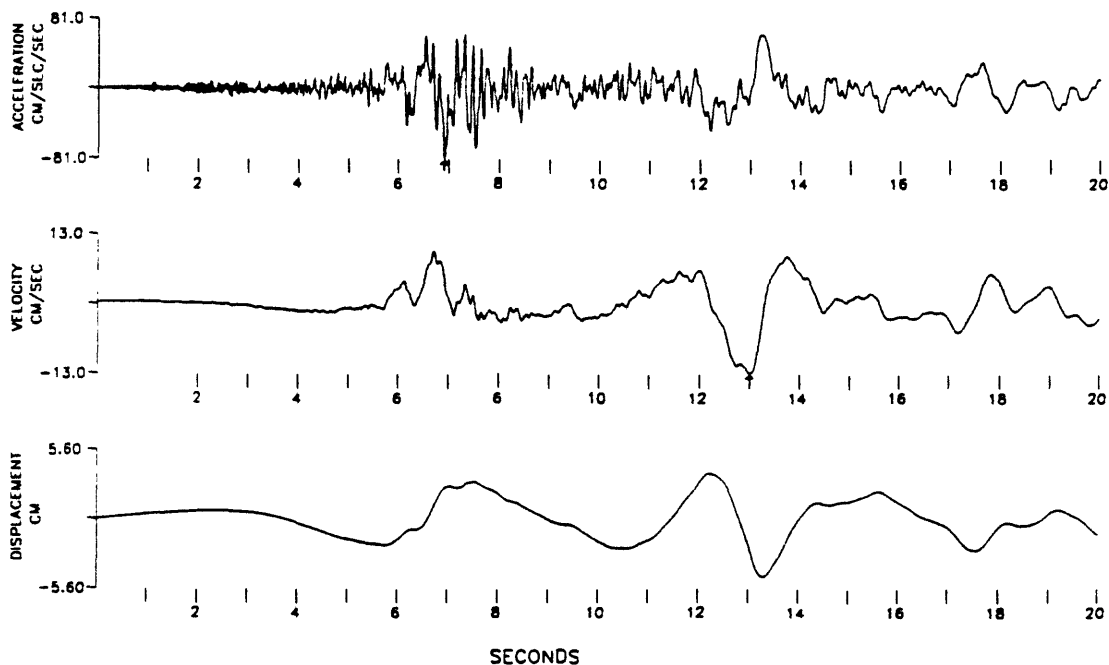
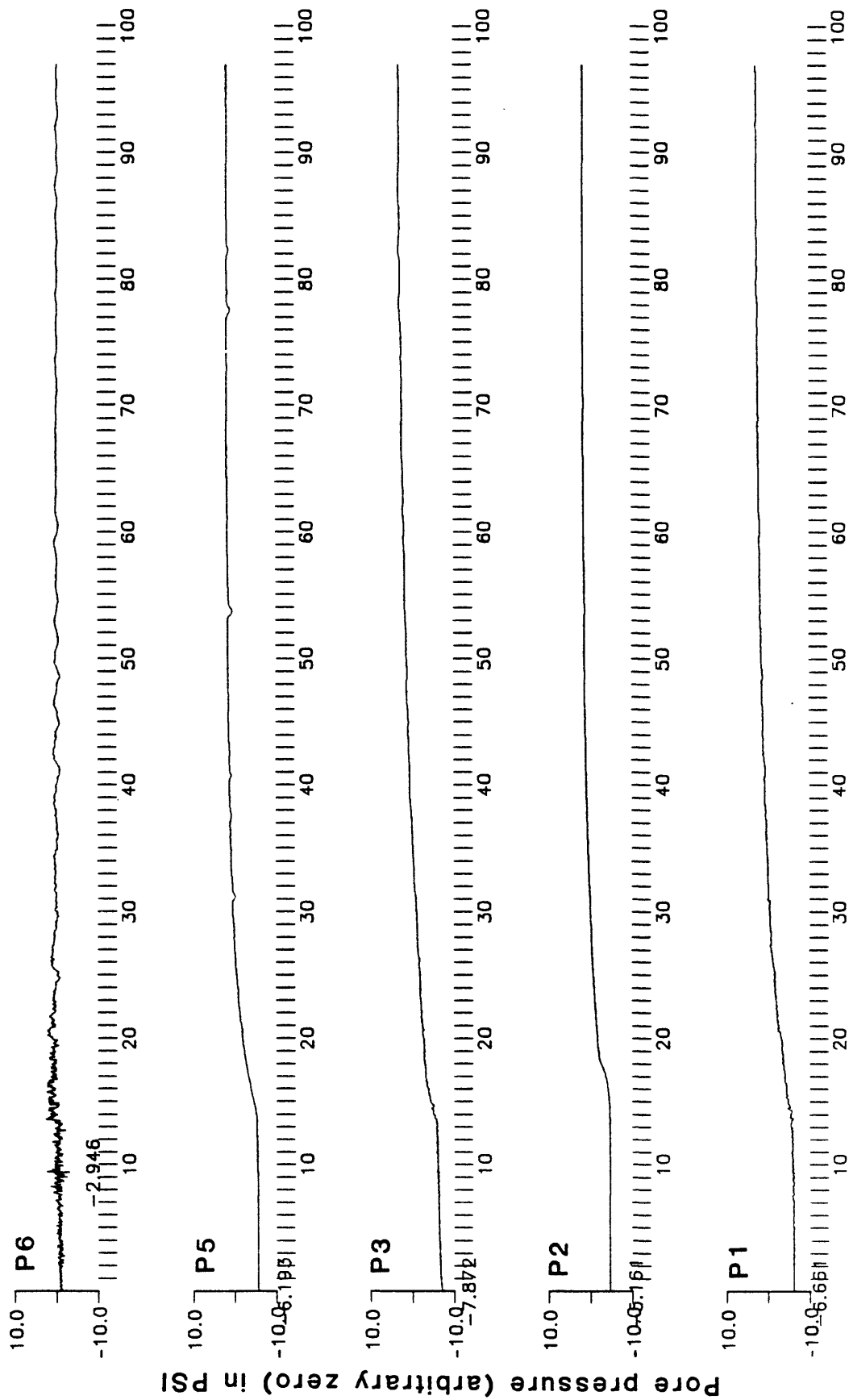


Figure 4

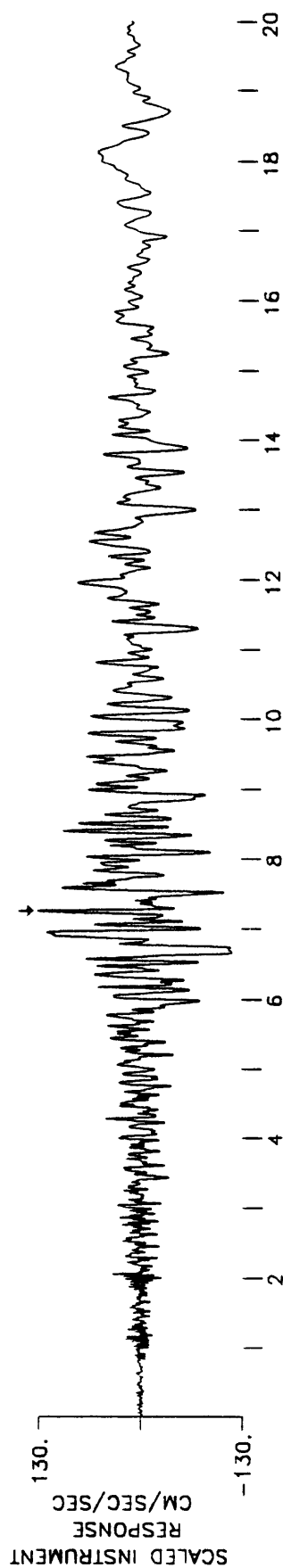
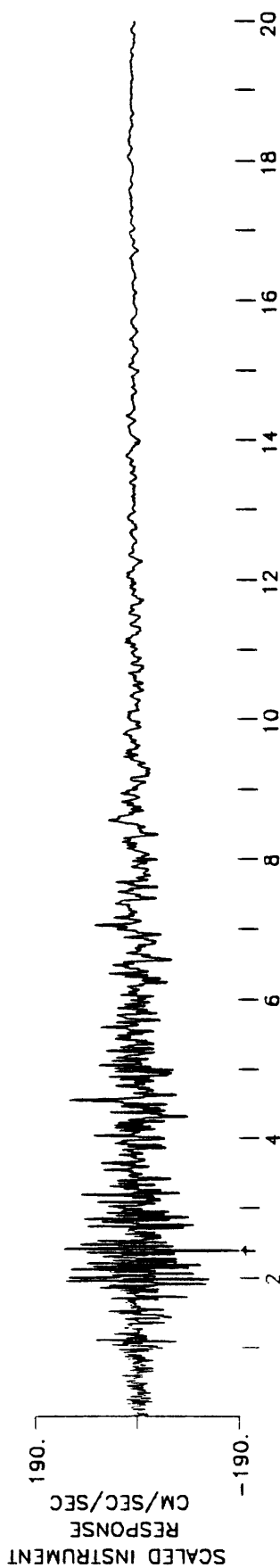
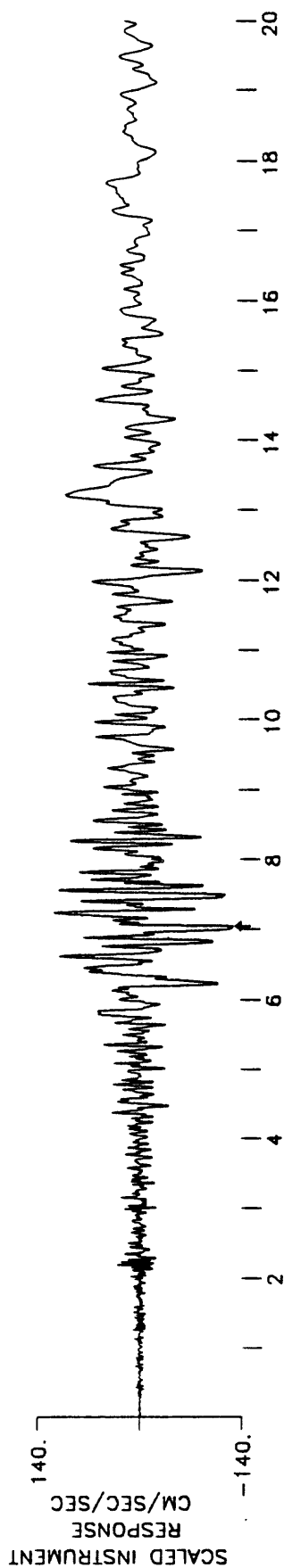
WILDLIFE LIQUEFACTION ARRAY, TRACES 7,8,10,11,12
 PIEZOMETERS: P6, P5, P3, P2, P1
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT



SECONDS
 Figure 5

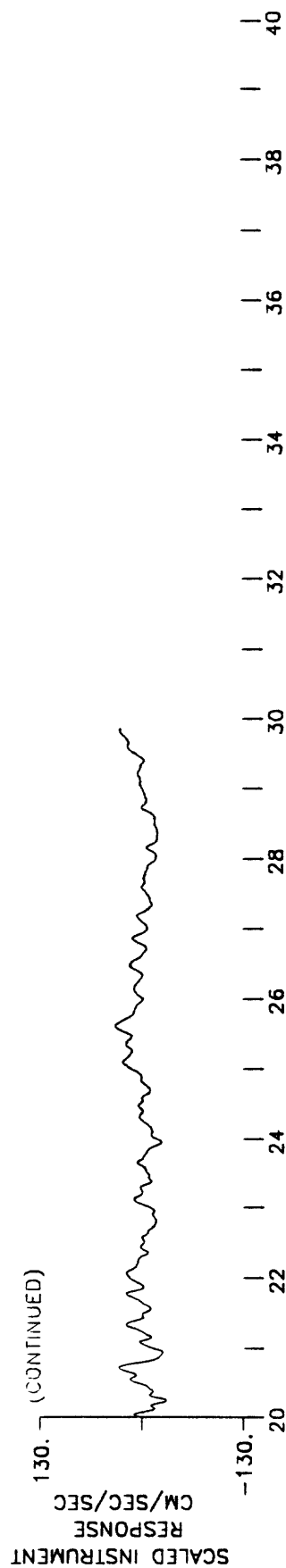
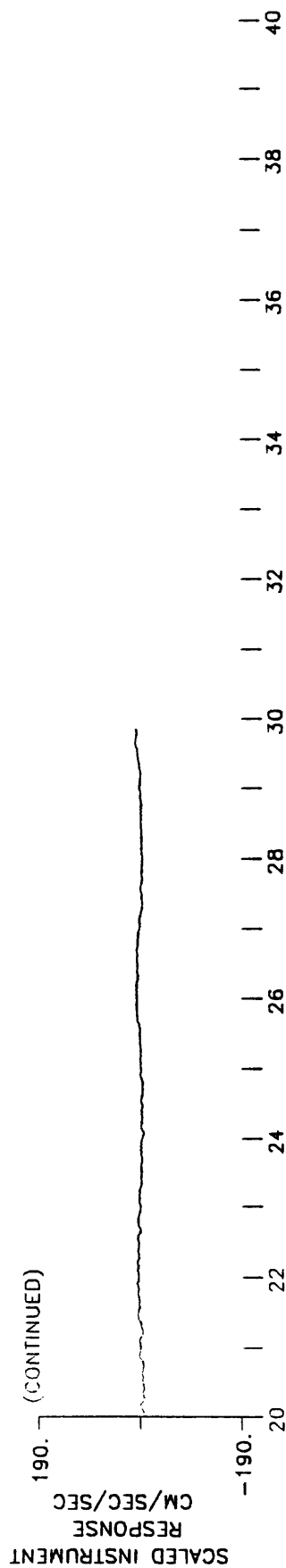
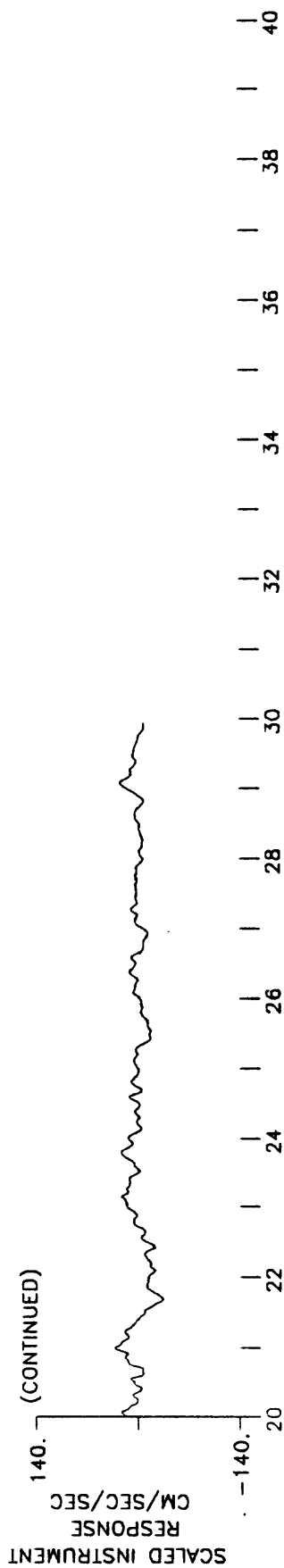
APPENDIX 1
UNCORRECTED ACCELEROGRAM

UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 PEAK VALUES(CM/SEC/SEC): -132.14 -189.79 129.31



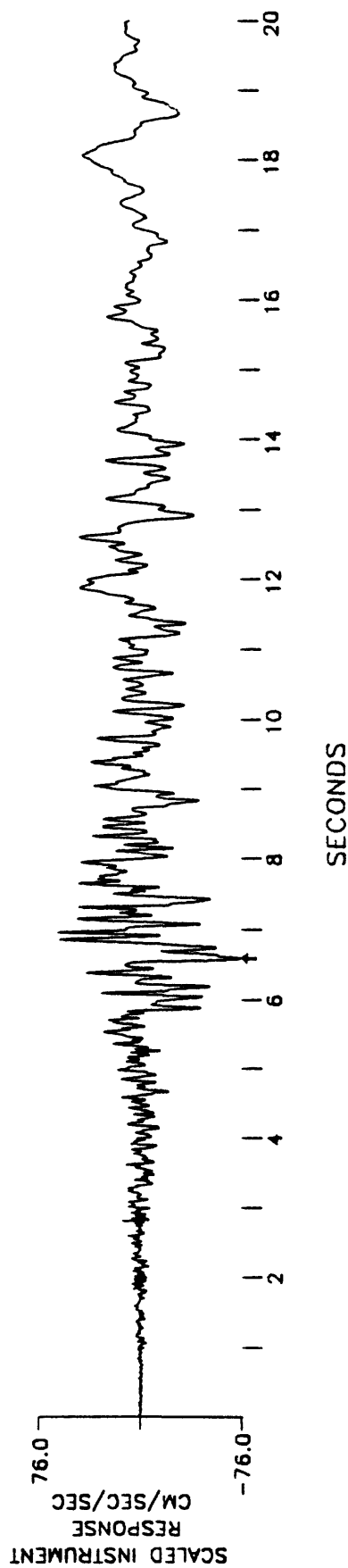
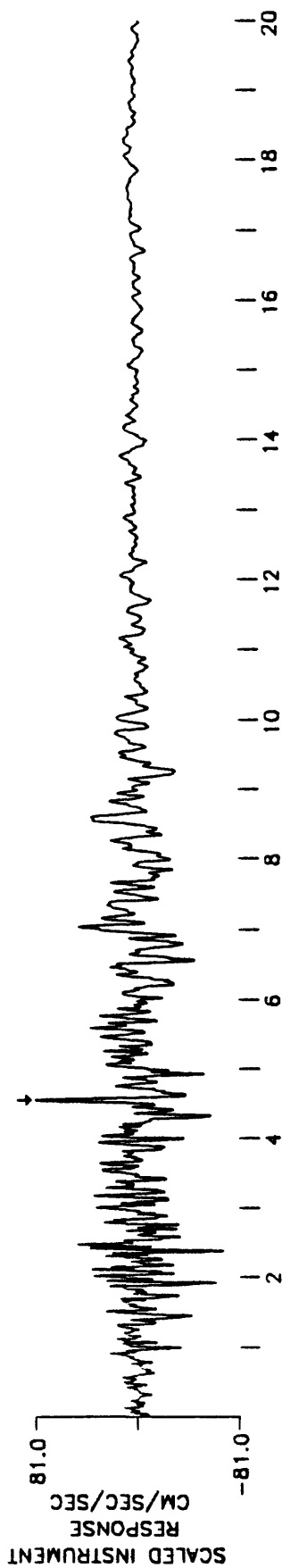
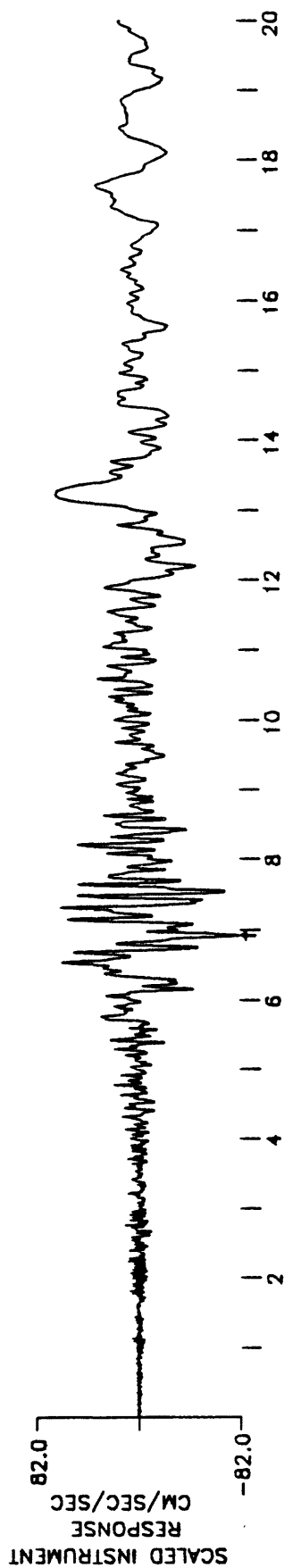
SECONDS

UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 PEAK VALUES(CM/SEC/SEC): -132.14 -189.79 129.31

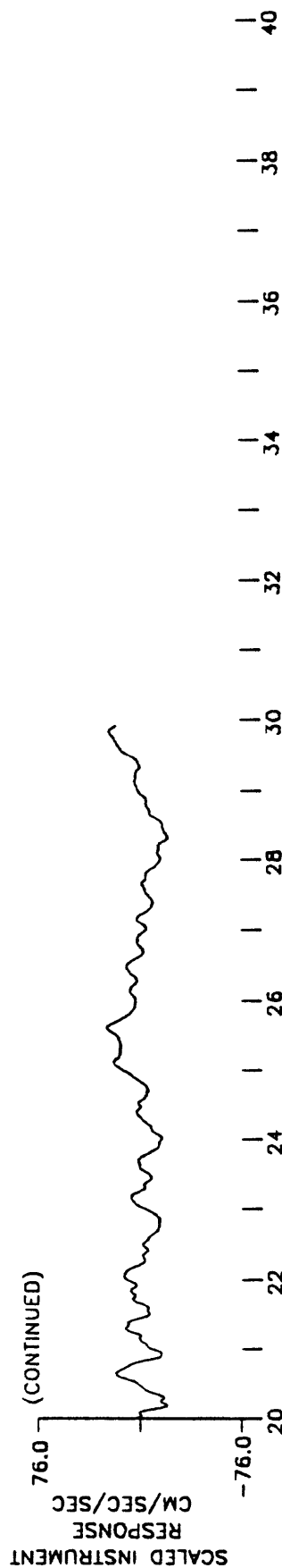
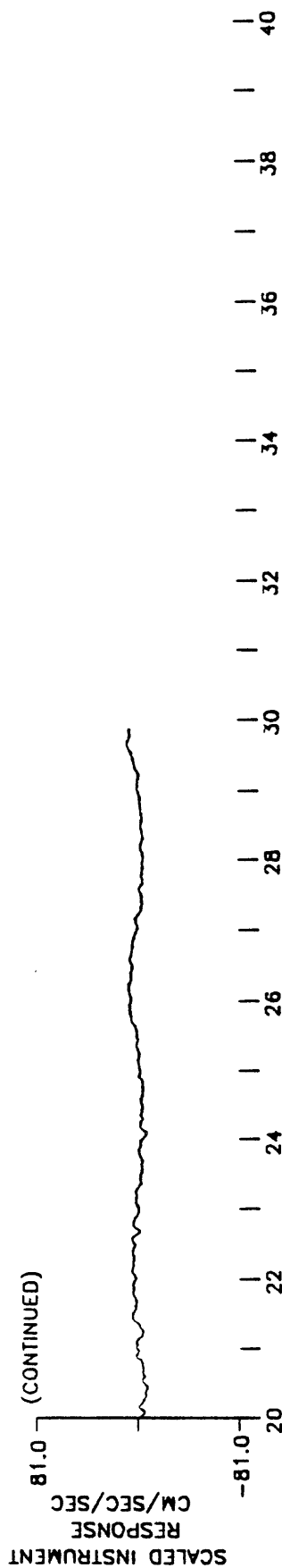
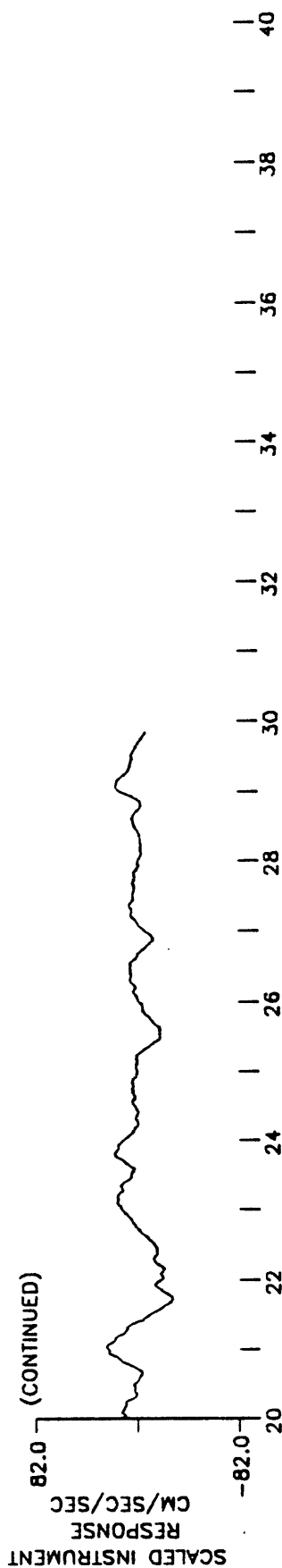


SECONDS

UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 PEAK VALUES(CM/SEC/SEC): -81.77 80.69 -75.51

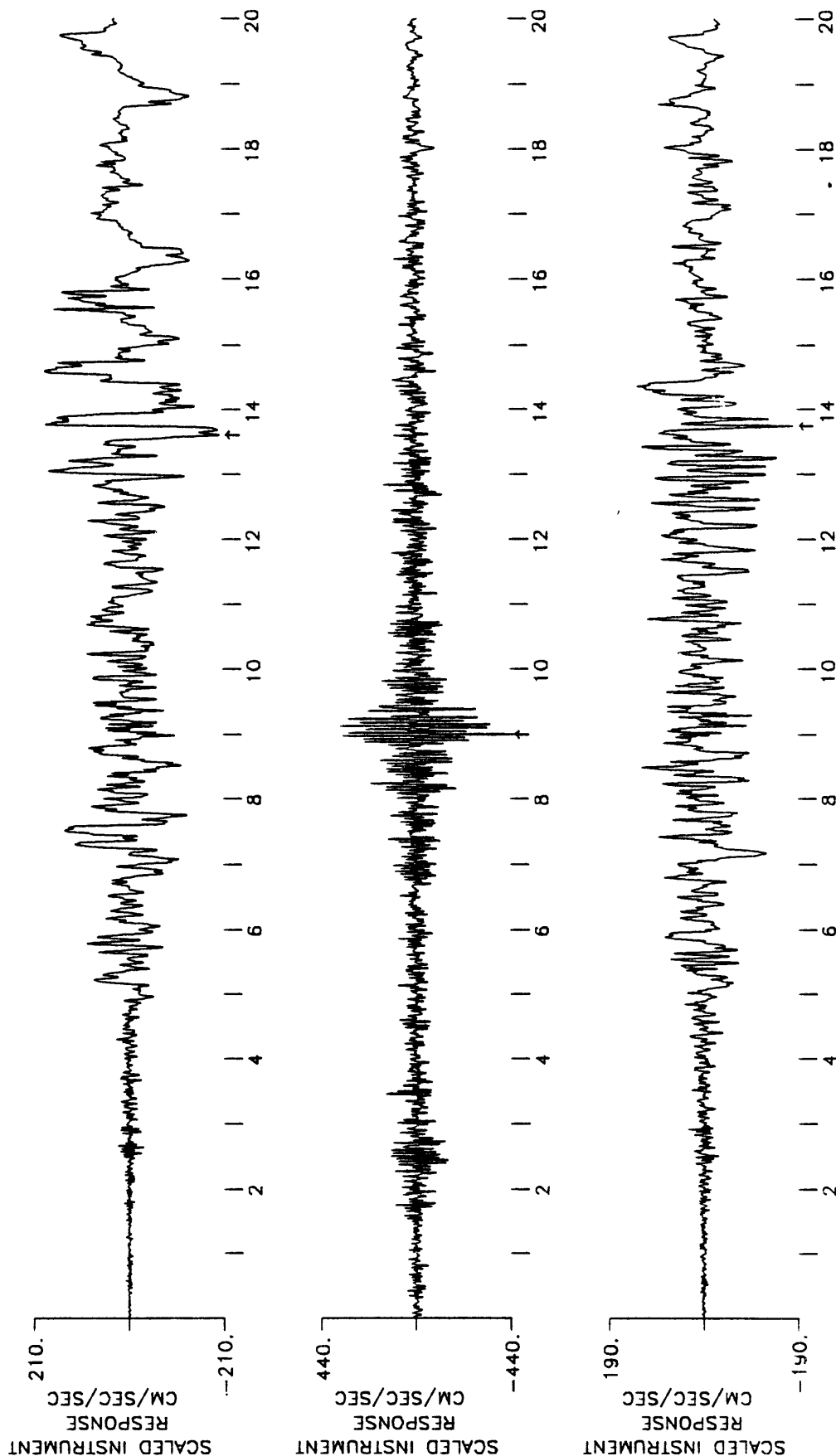


UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 PEAK VALUES(CM/SEC/SEC): -81.77 80.69 -75.51



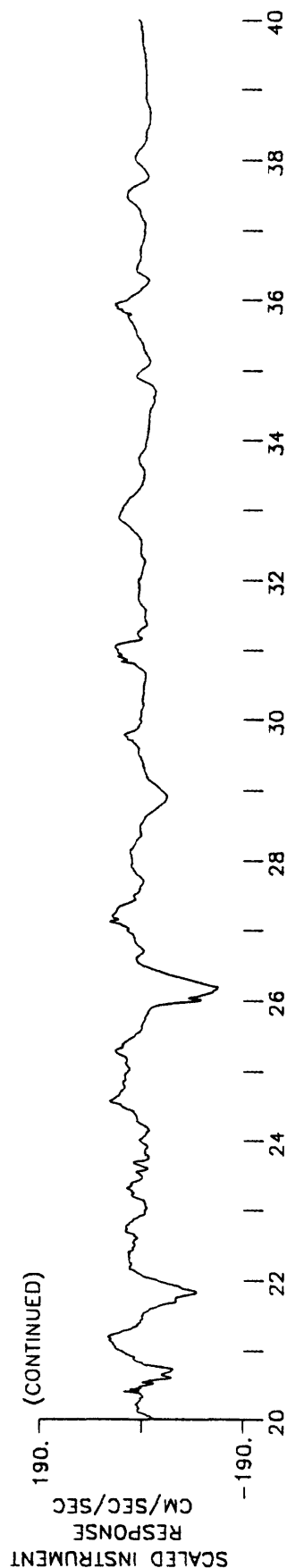
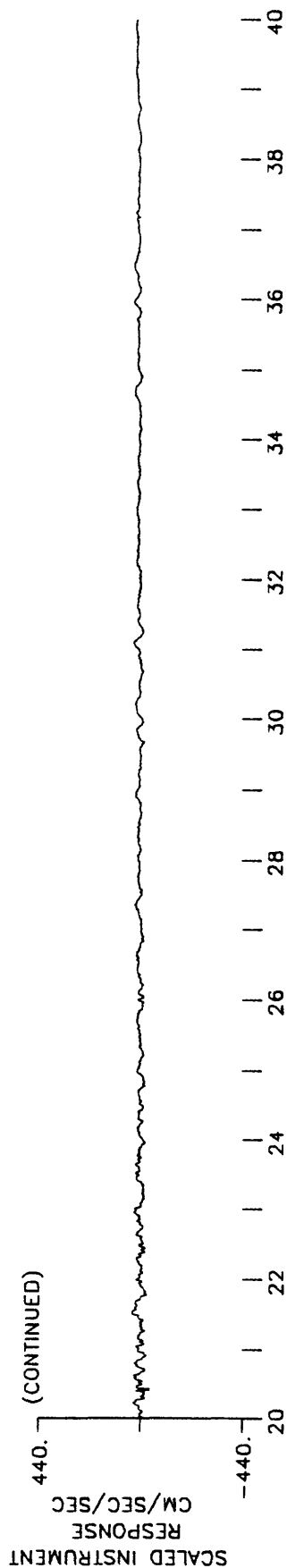
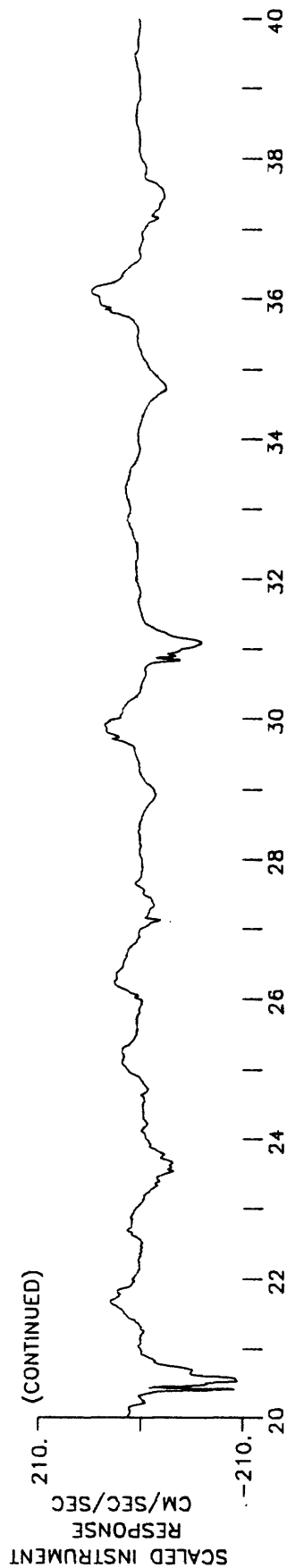
SECONDS

UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -205.81 -436.55 -184.06

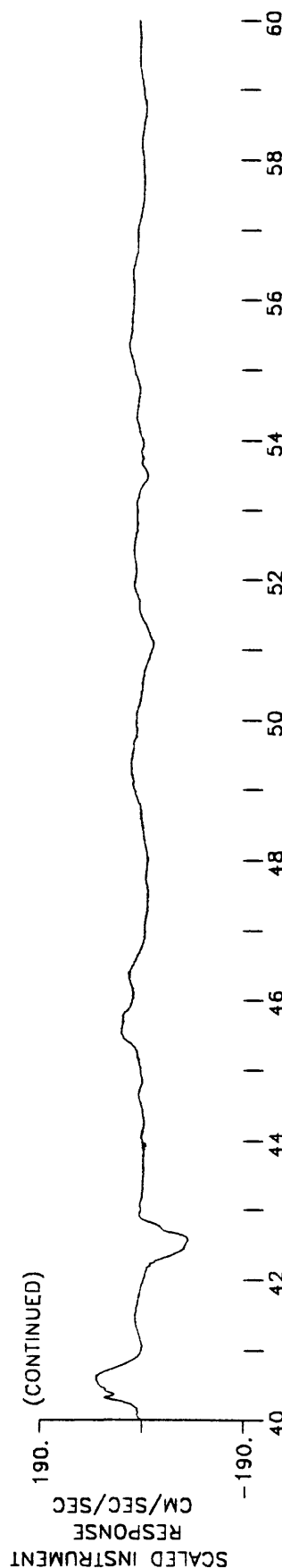
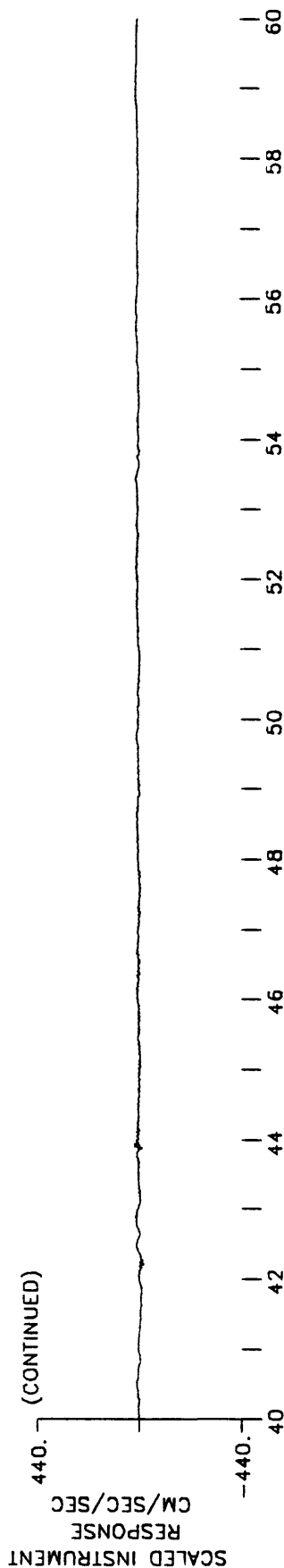
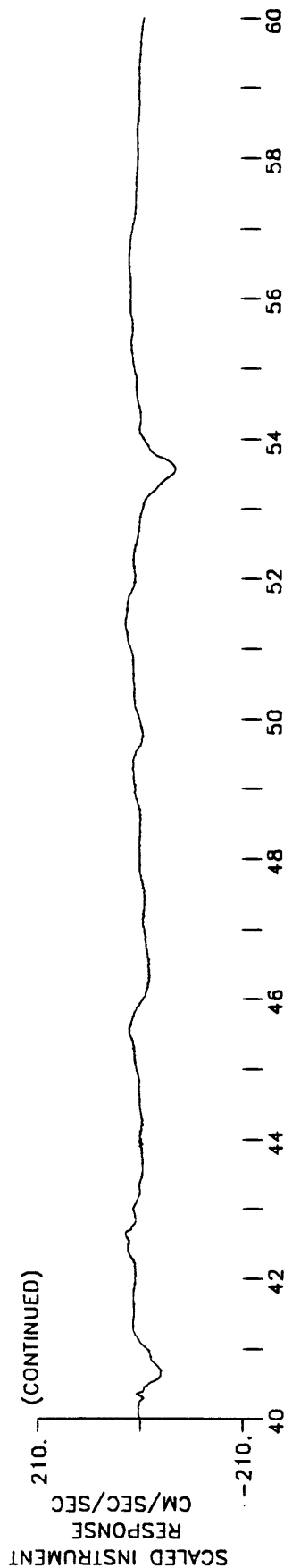


SECONDS

UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -205.81 -436.55 -184.06

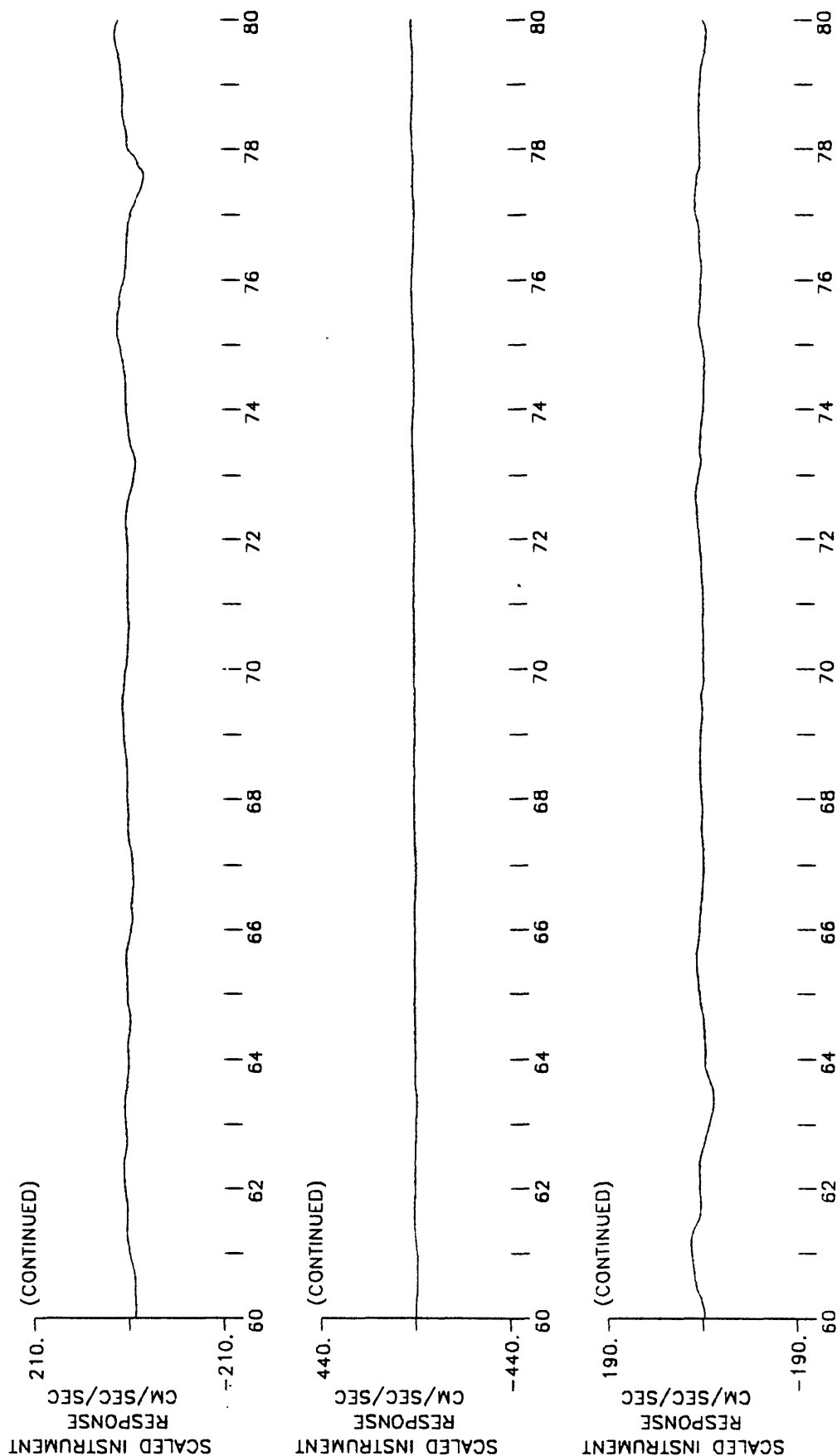


UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -205.81 -436.55 -184.06

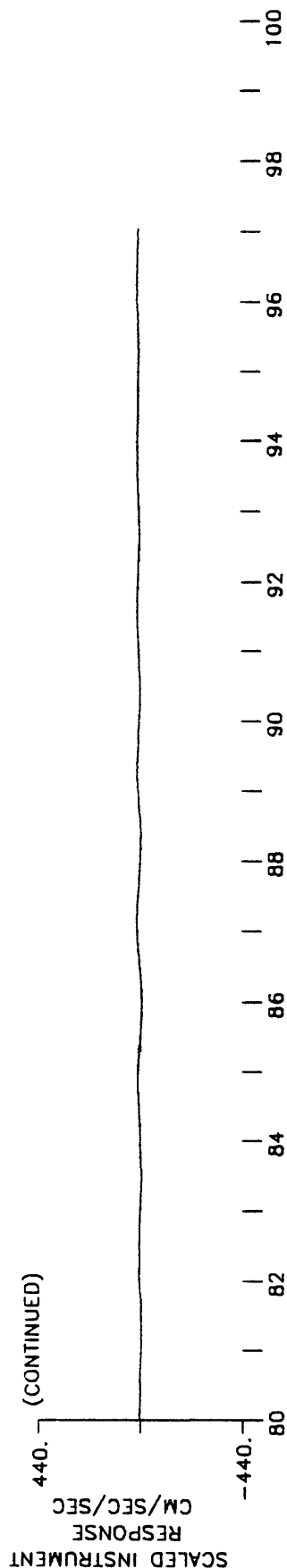
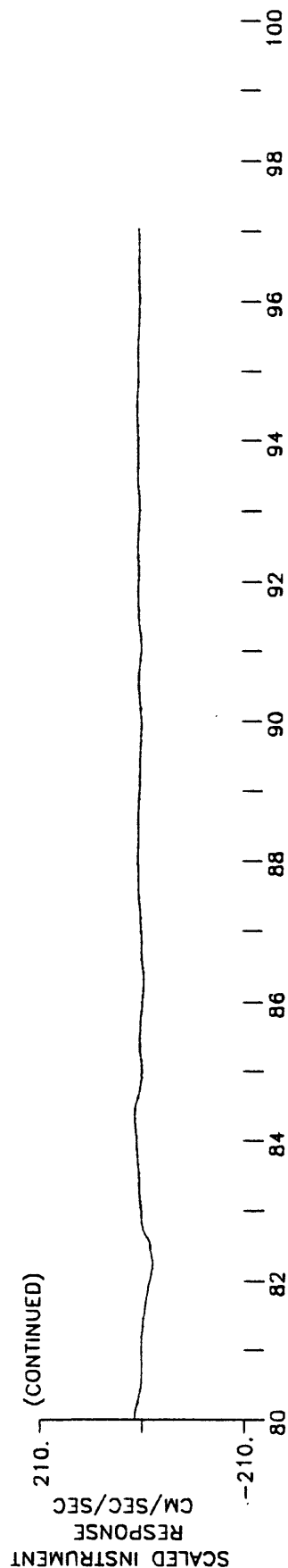


SECONDS

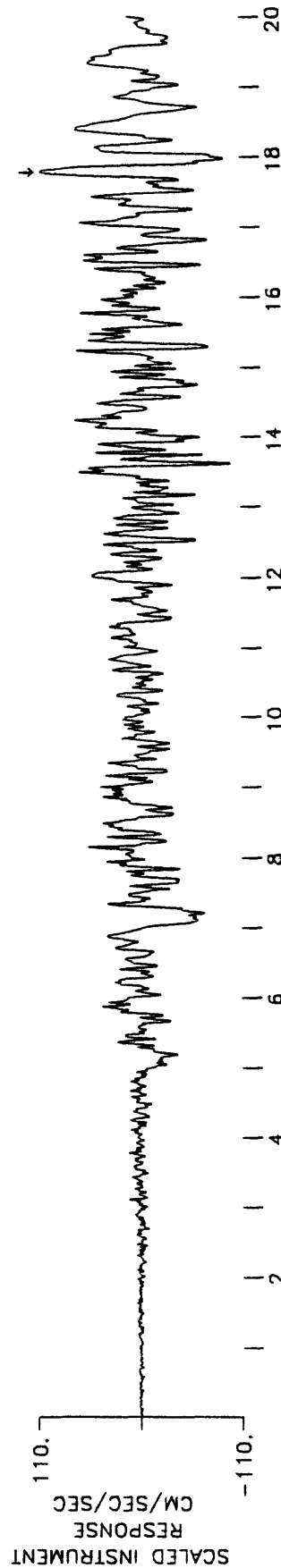
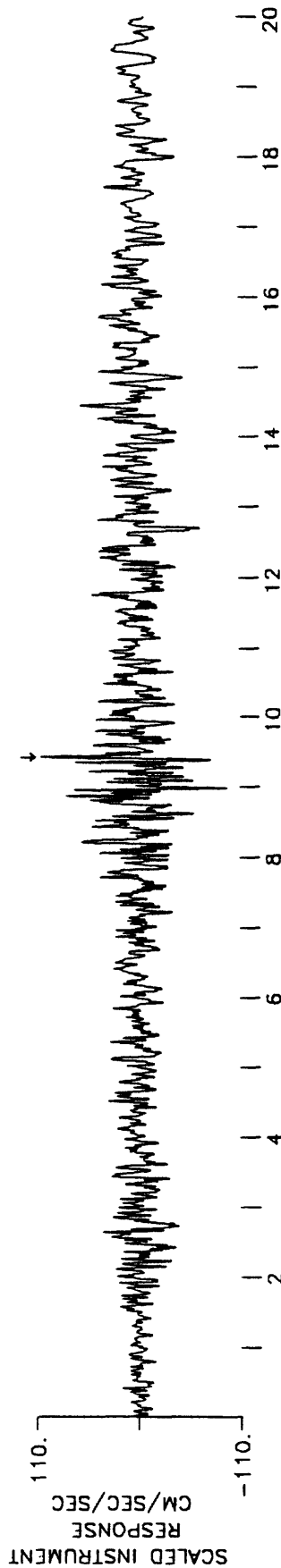
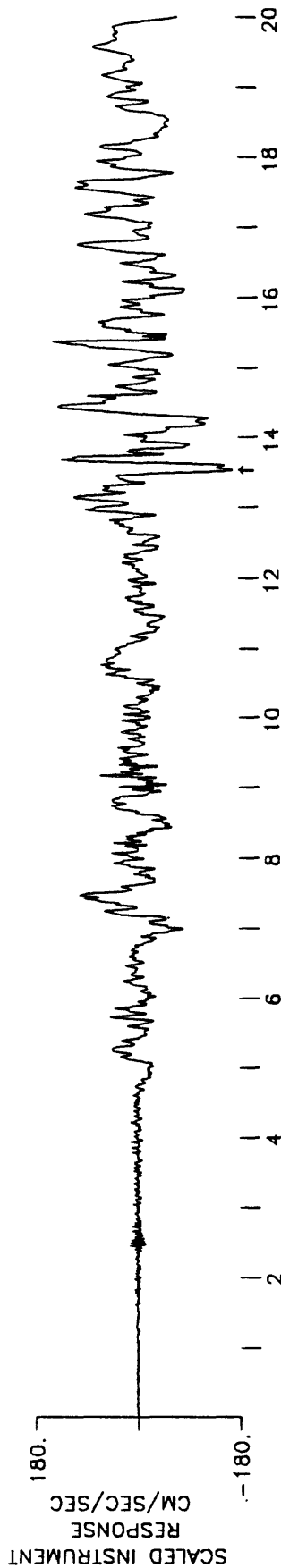
UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -205.81 -436.55 -184.06



UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES, UP, 090 DEGREES
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -205.81 -436.55 -184.06

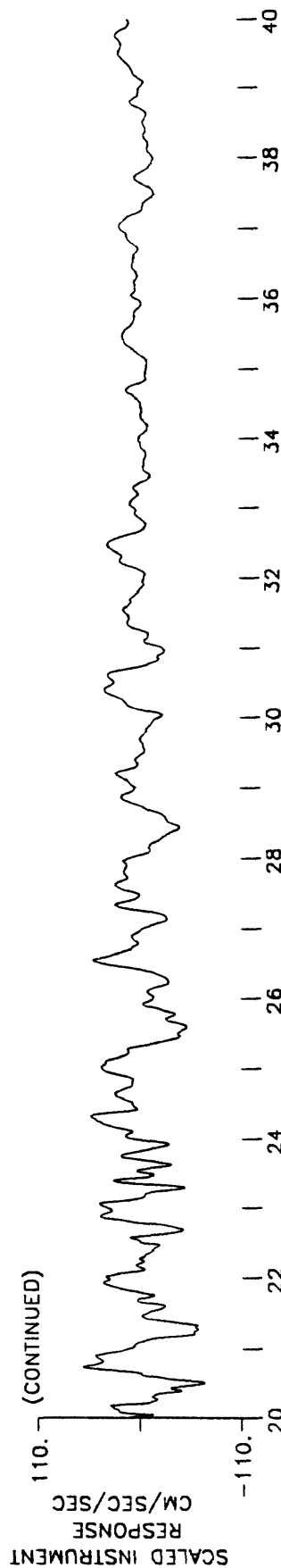
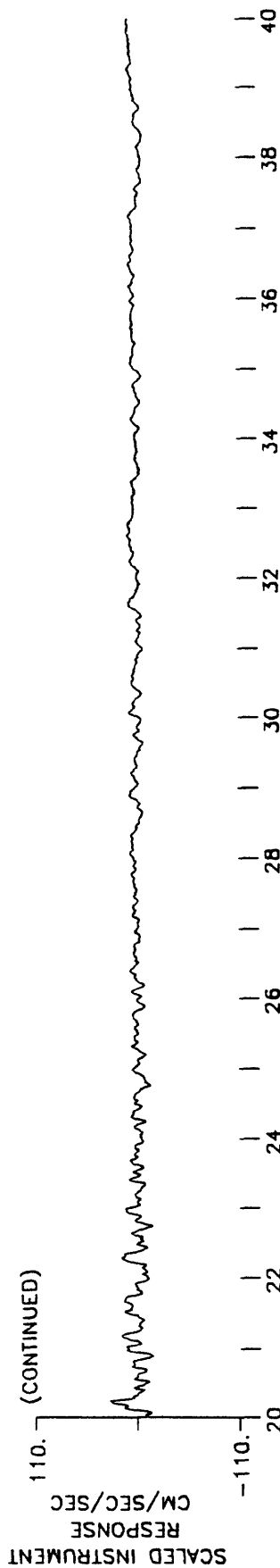
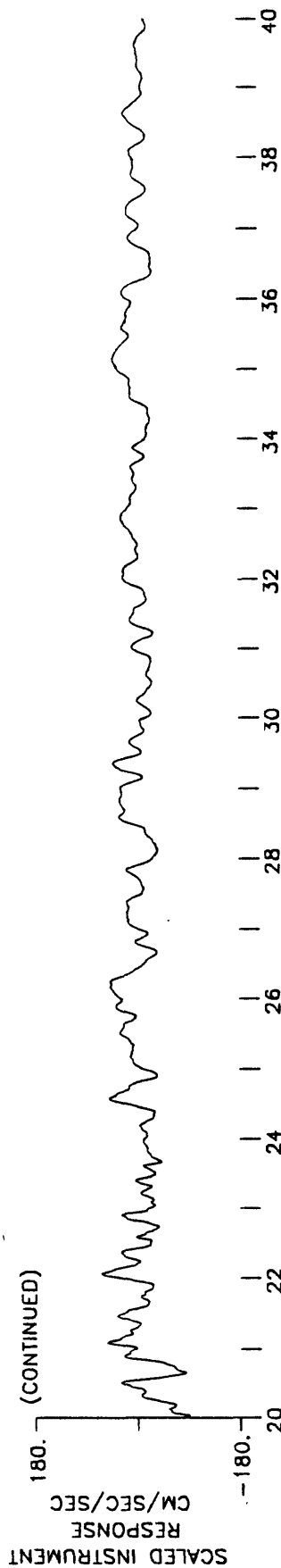


UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -171.52 103.32 104.62

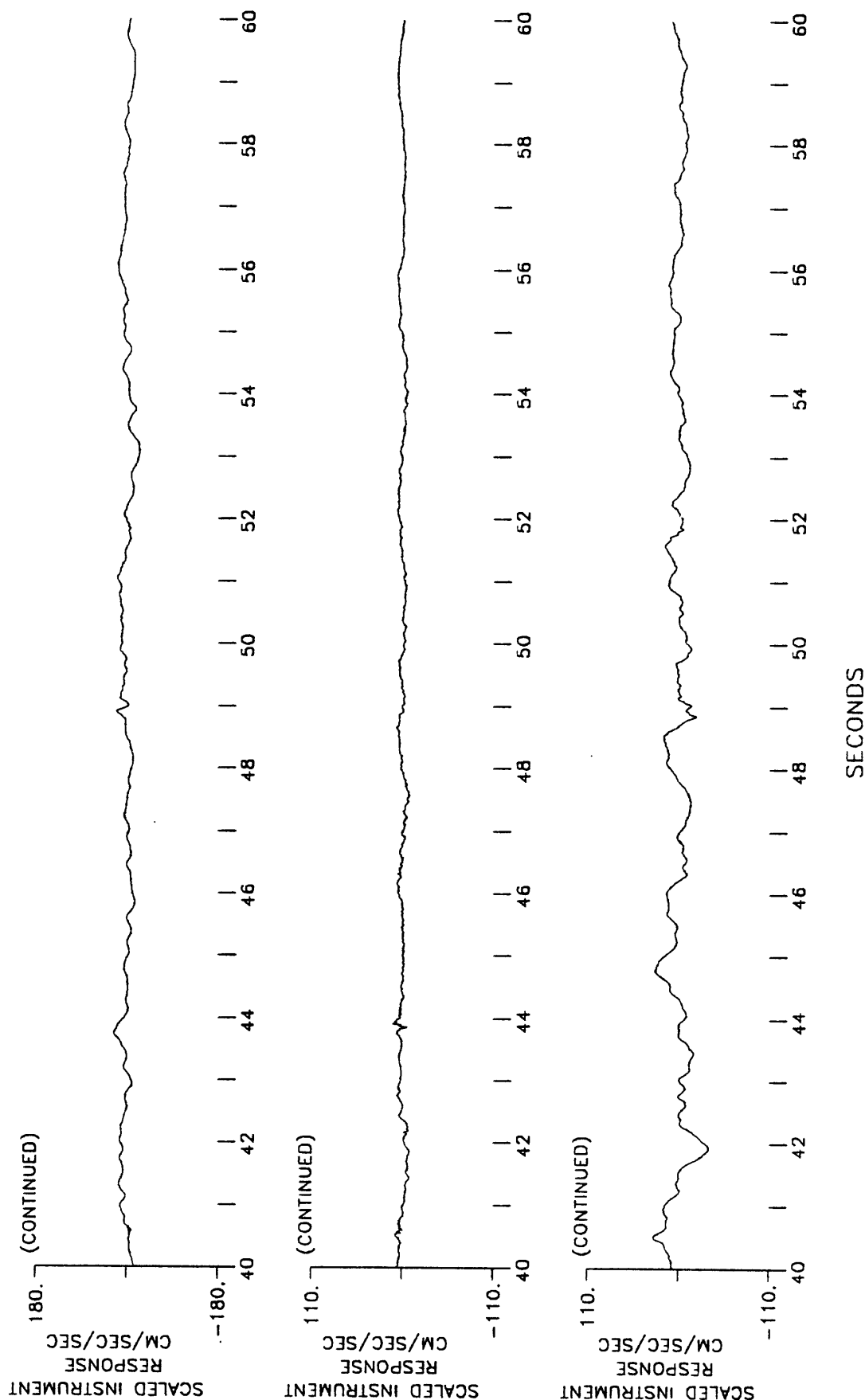


SECONDS

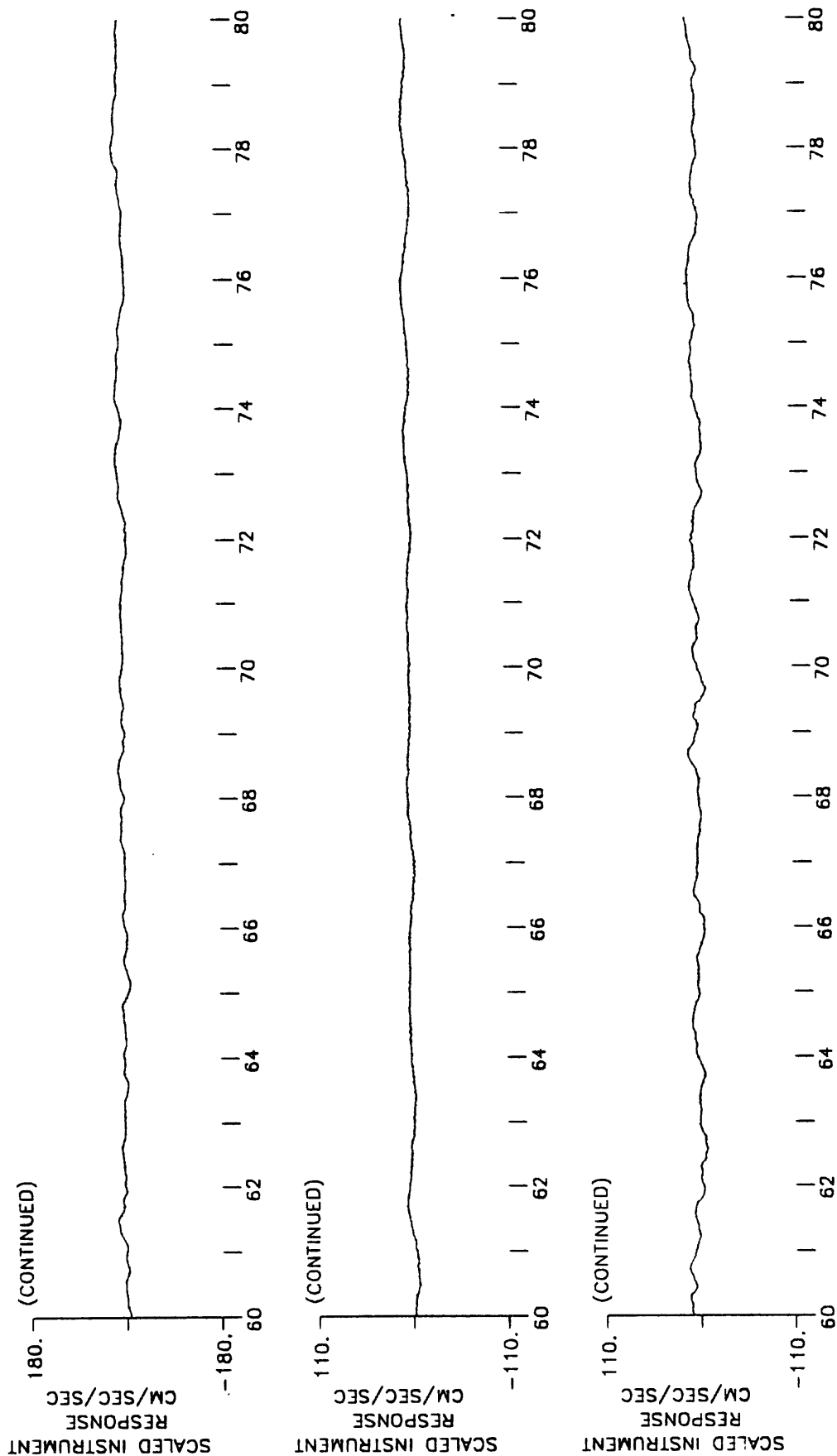
UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -171.52 103.32 104.62



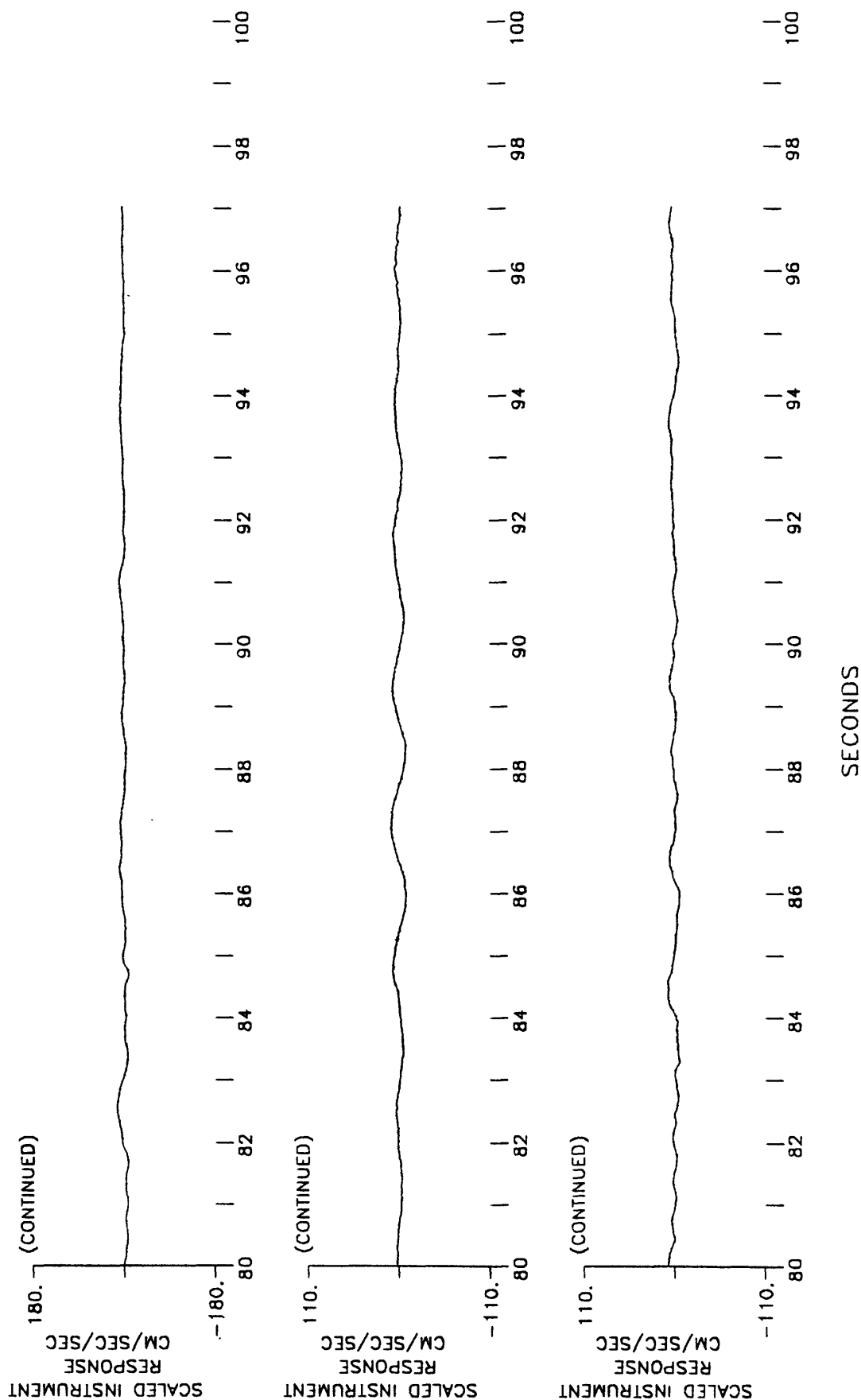
UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -171.52 103.32 104.62



UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -171.52 103.32 104.62



UNCORRECTED ACCELEROGRAM
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE
 360 DEGREES, UP, 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 PEAK VALUES(CM/SEC/SEC): -171.52 103.32 104.62



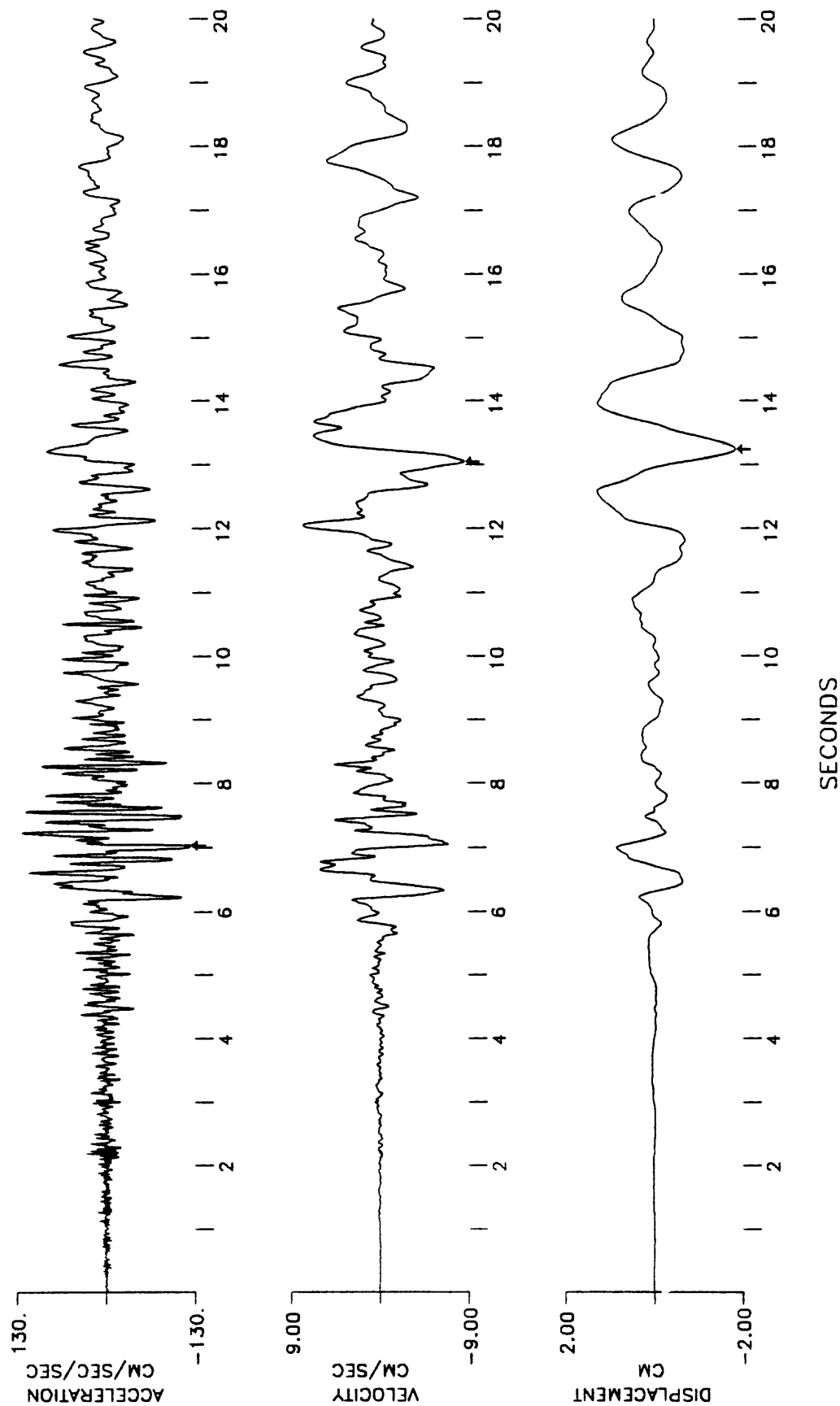
APPENDIX 2

CORRECTED ACCELERATION, VELOCITY AND DISPLACEMENT

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

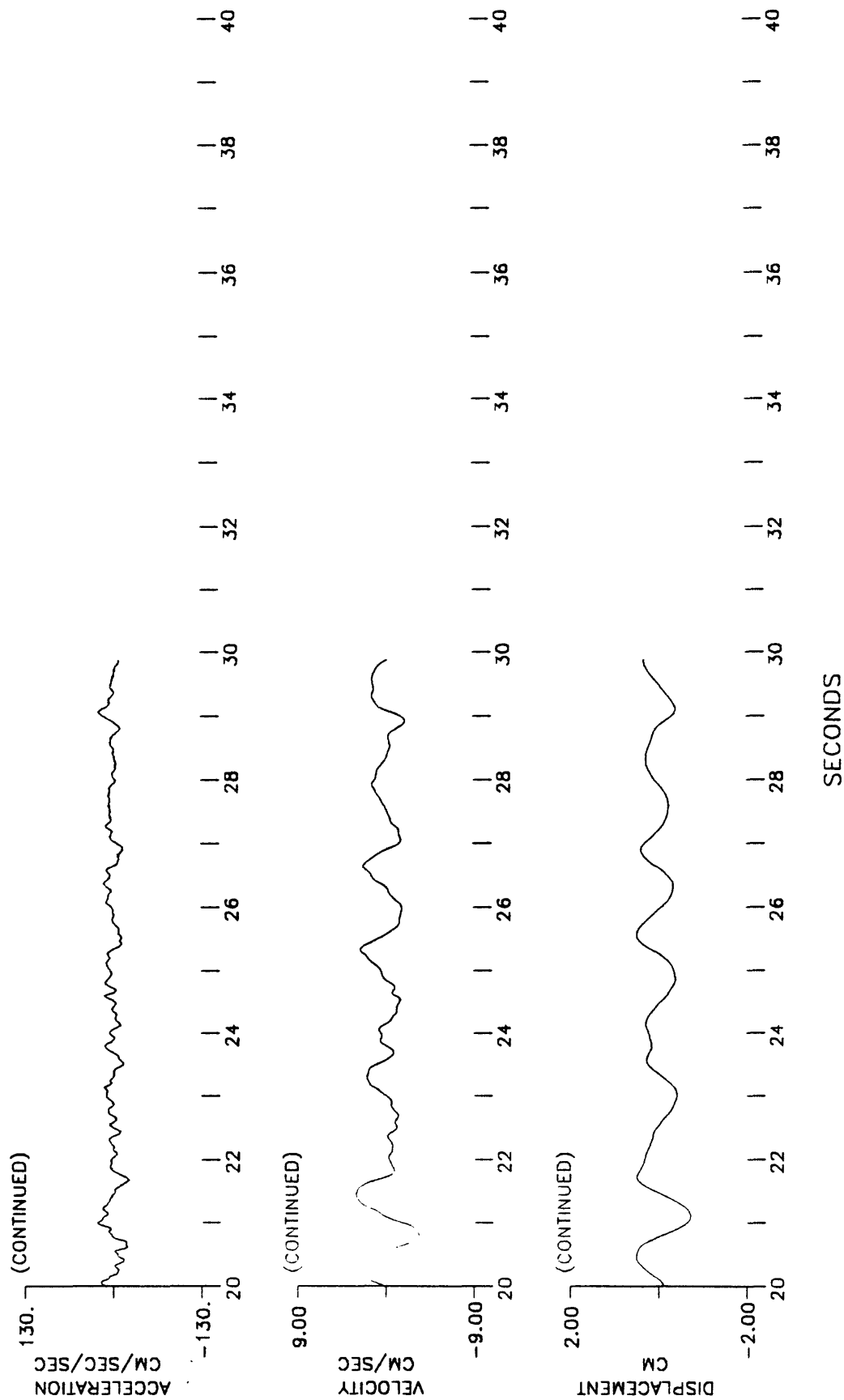
PEAK VALUES: ACCEL=-125.16 CM/SEC/SEC, VELOCITY=-8.90 CM/SEC, DISPL=-1.91 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

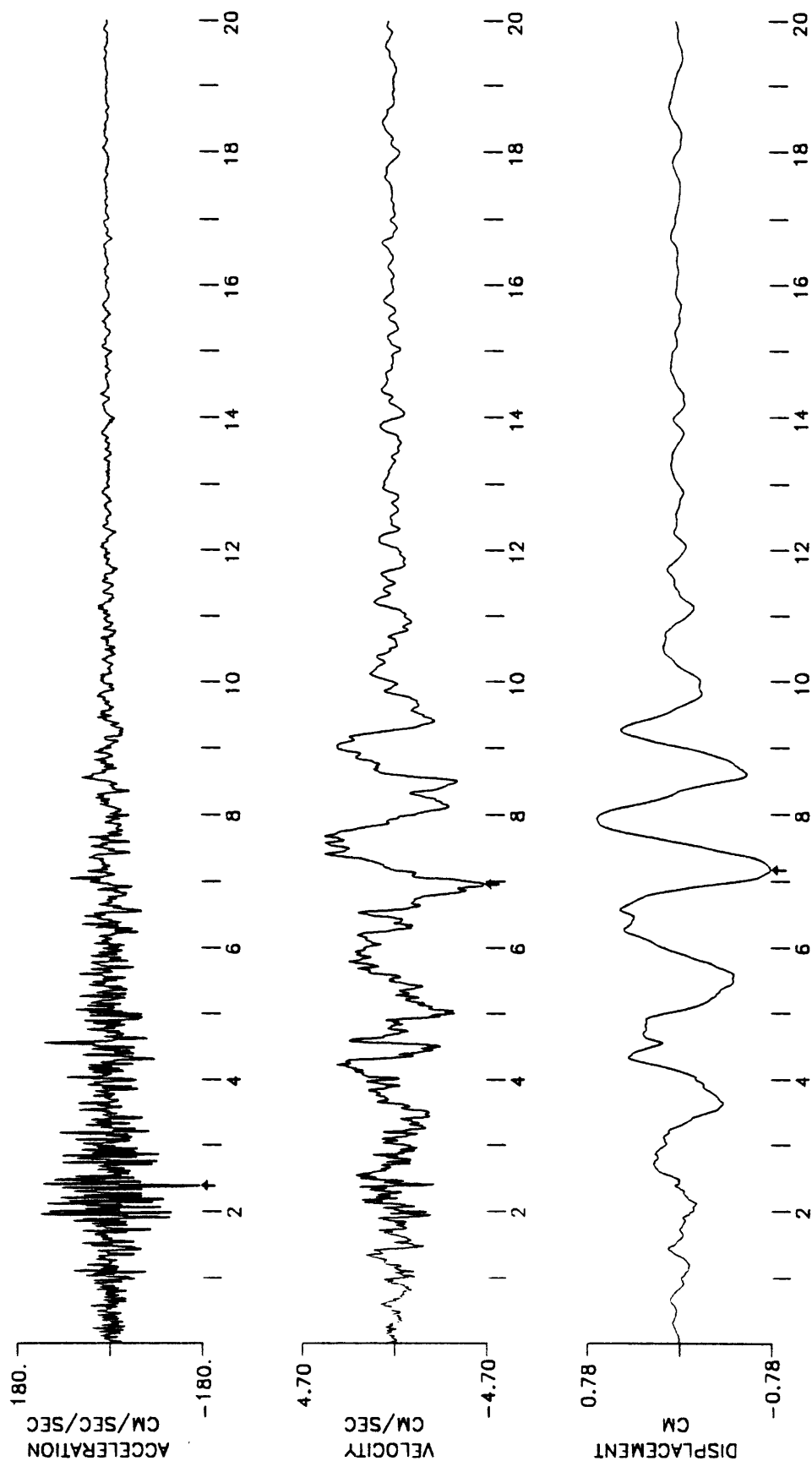
PEAK VALUES: ACCEL=-125.16 CM/SEC/SEC, VELOCITY=-8.90 CM/SEC, DISPL=-1.91 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
UP

EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL=-176.21 CM/SEC/SEC, VELOCITY=-4.61 CM/SEC, DISPL=-0.78 CM

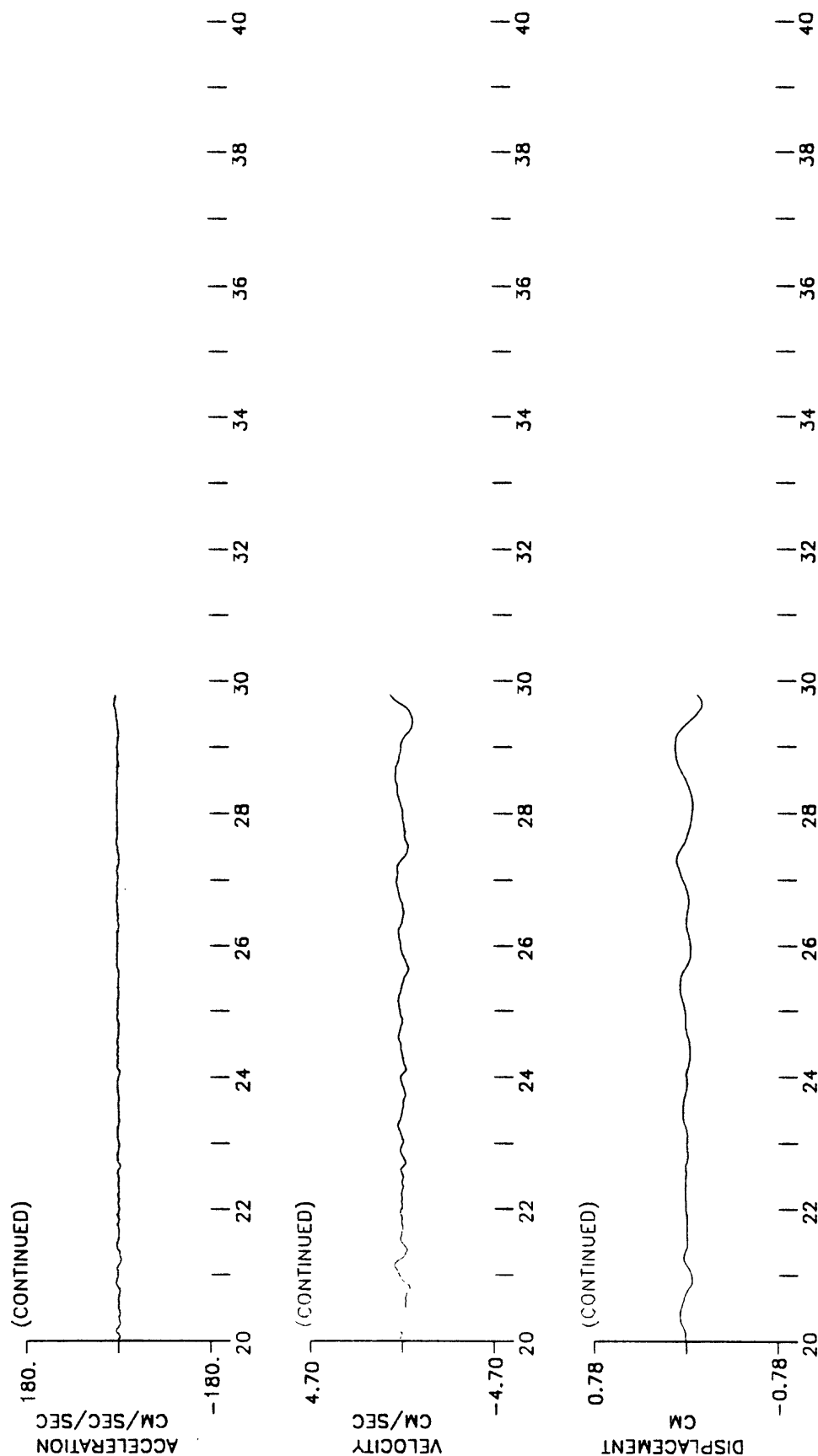


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
UP

EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL=-176.21 CM/SEC/SEC, VELOCITY=-4.61 CM/SEC, DISPL=-0.78 CM



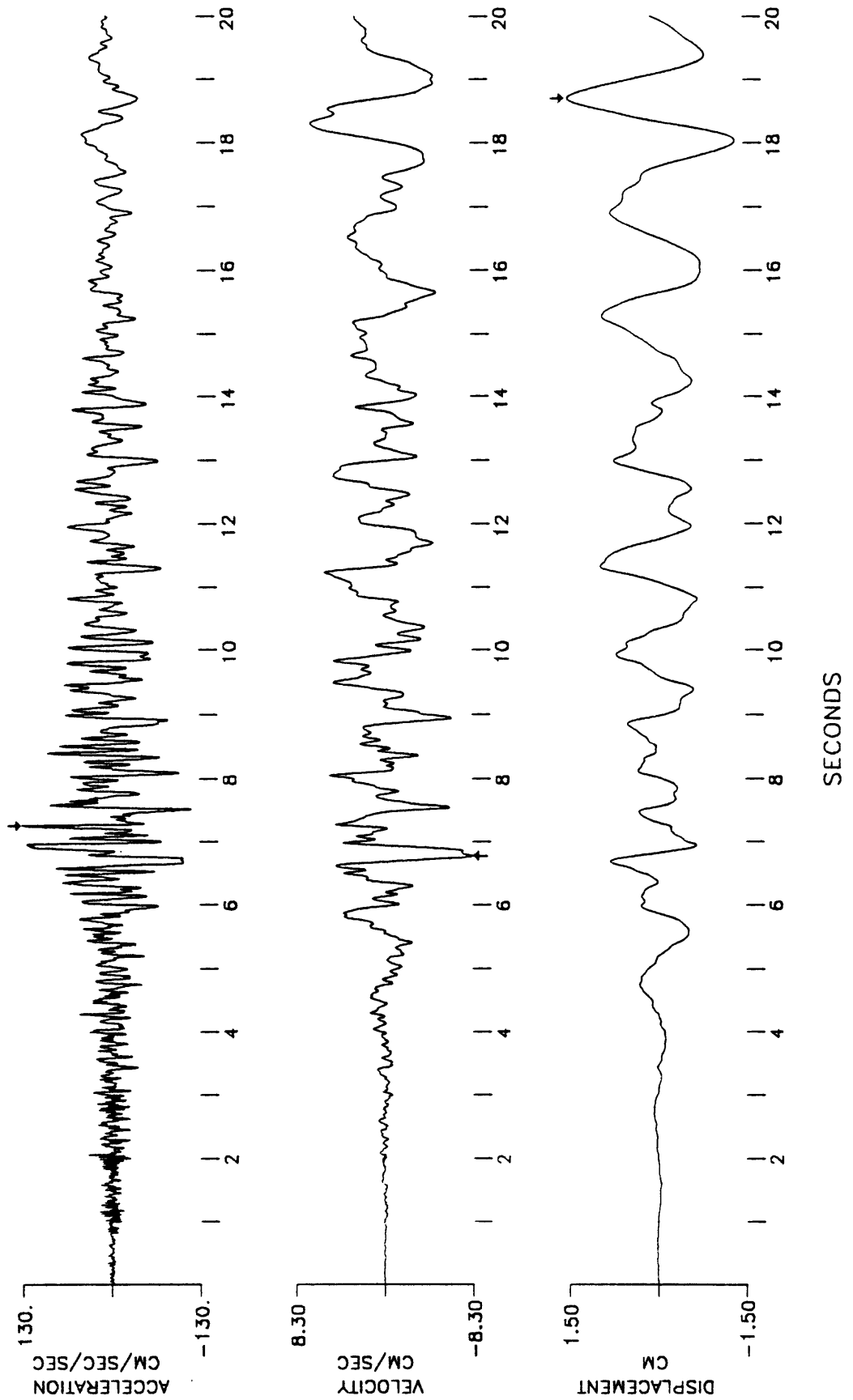
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT

BUTTERWORTH AT .5 HZ, ORDER 4

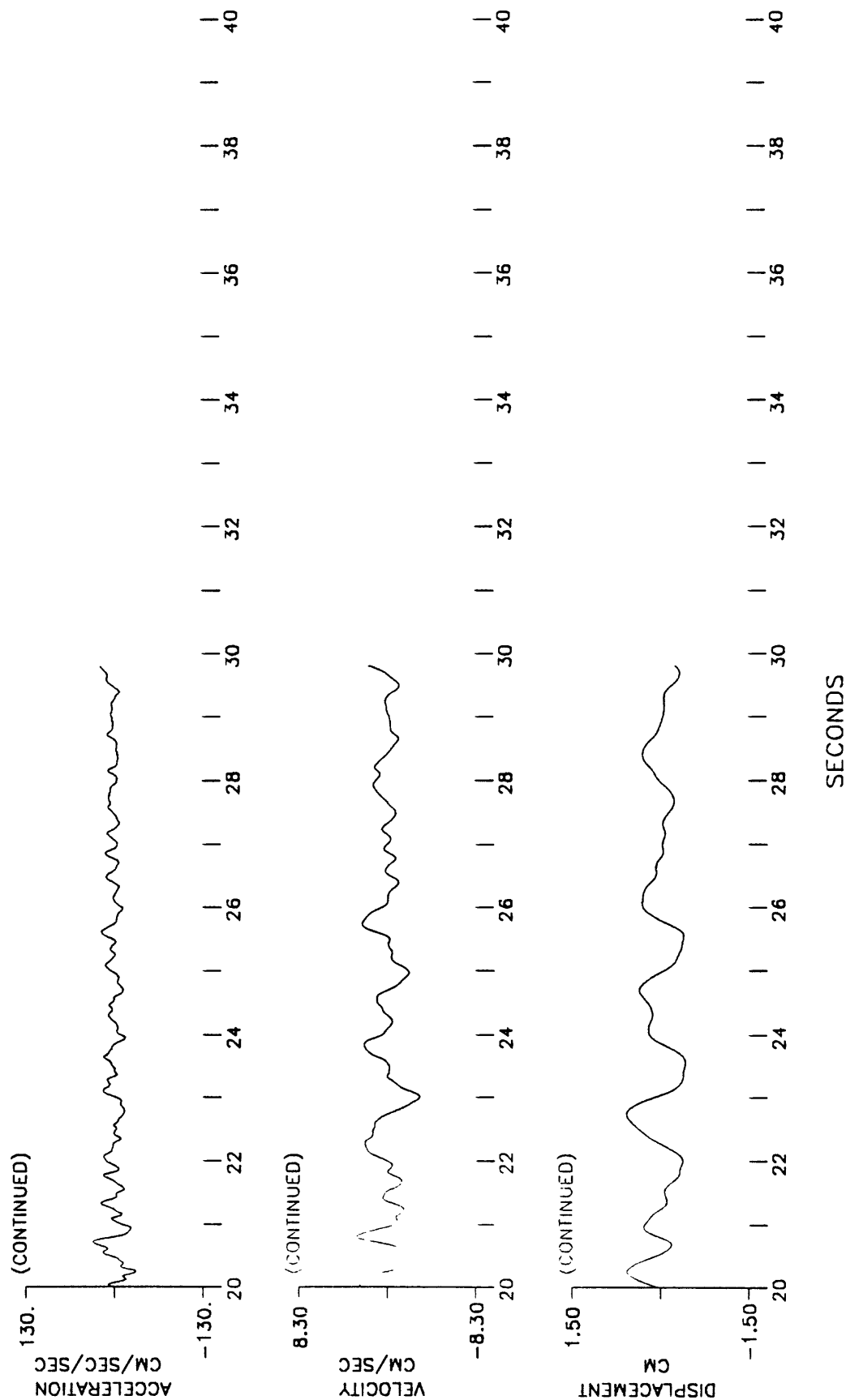
PEAK VALUES: ACCEL=125.99 CM/SEC/SEC, VELOCITY=-8.29 CM/SEC, DISPL=1.47 CM.



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES
EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

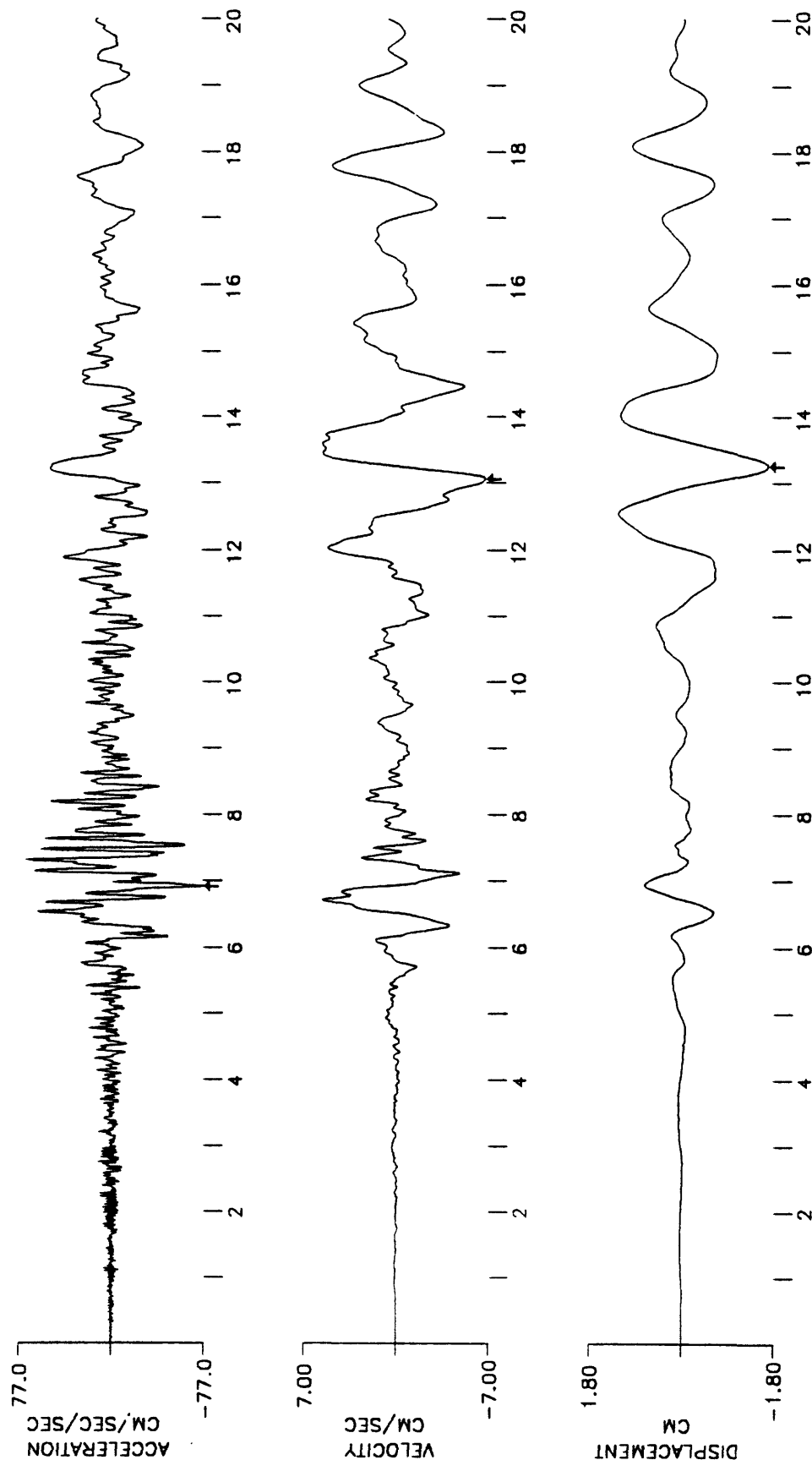
PEAK VALUES: ACCEL=125.99 CM/SEC/SEC, VELOCITY=-8.29 CM/SEC, DISPL=1.47 CM .



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
 360 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL = -76.81 CM/SEC/SEC, VELOCITY = -6.94 CM/SEC, DISPL = -1.74 CM



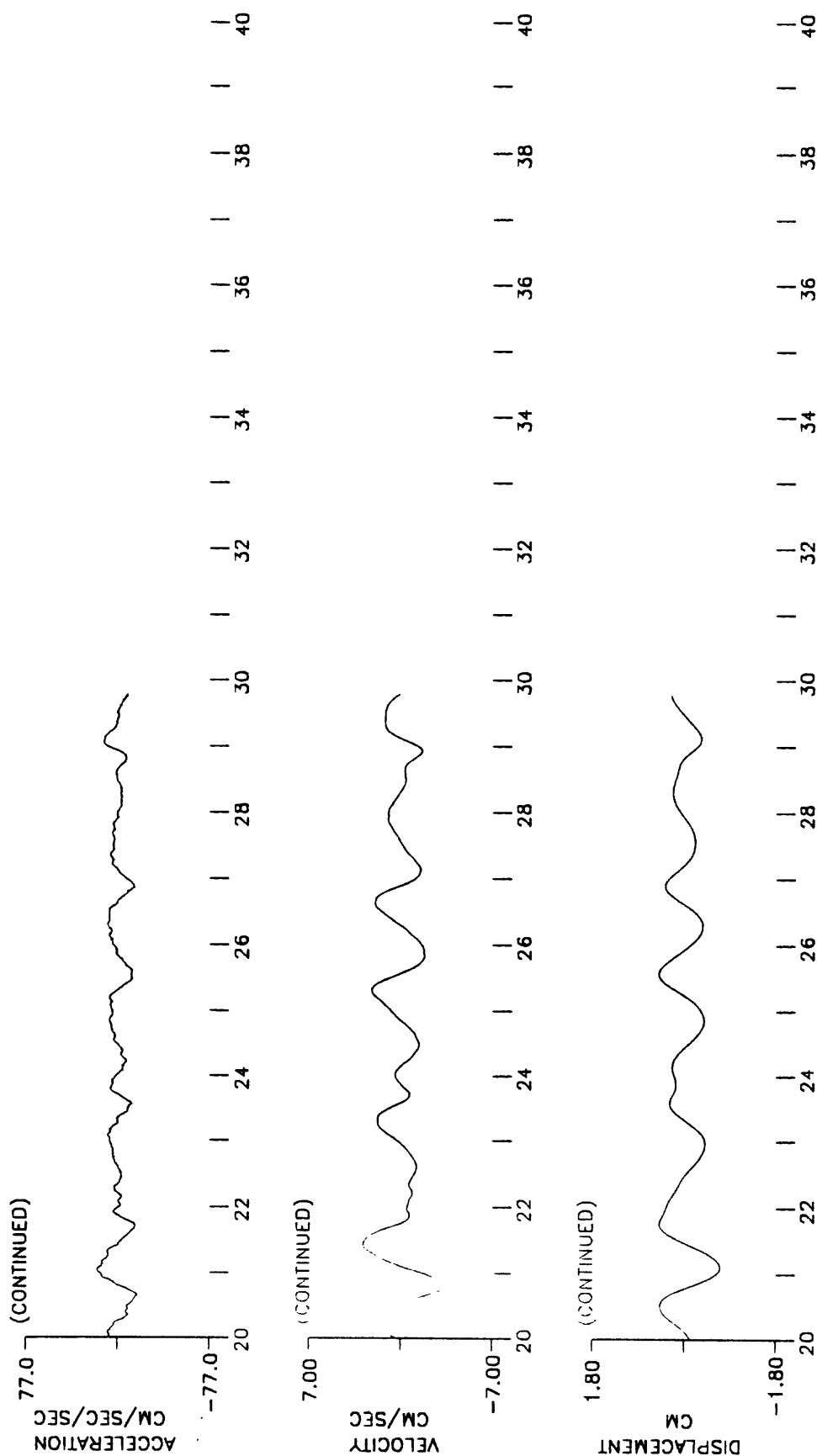
SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

360 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL=-76.81 CM/SEC/SEC, VELOCITY=-6.94 CM/SEC, DISPL=-1.74 CM

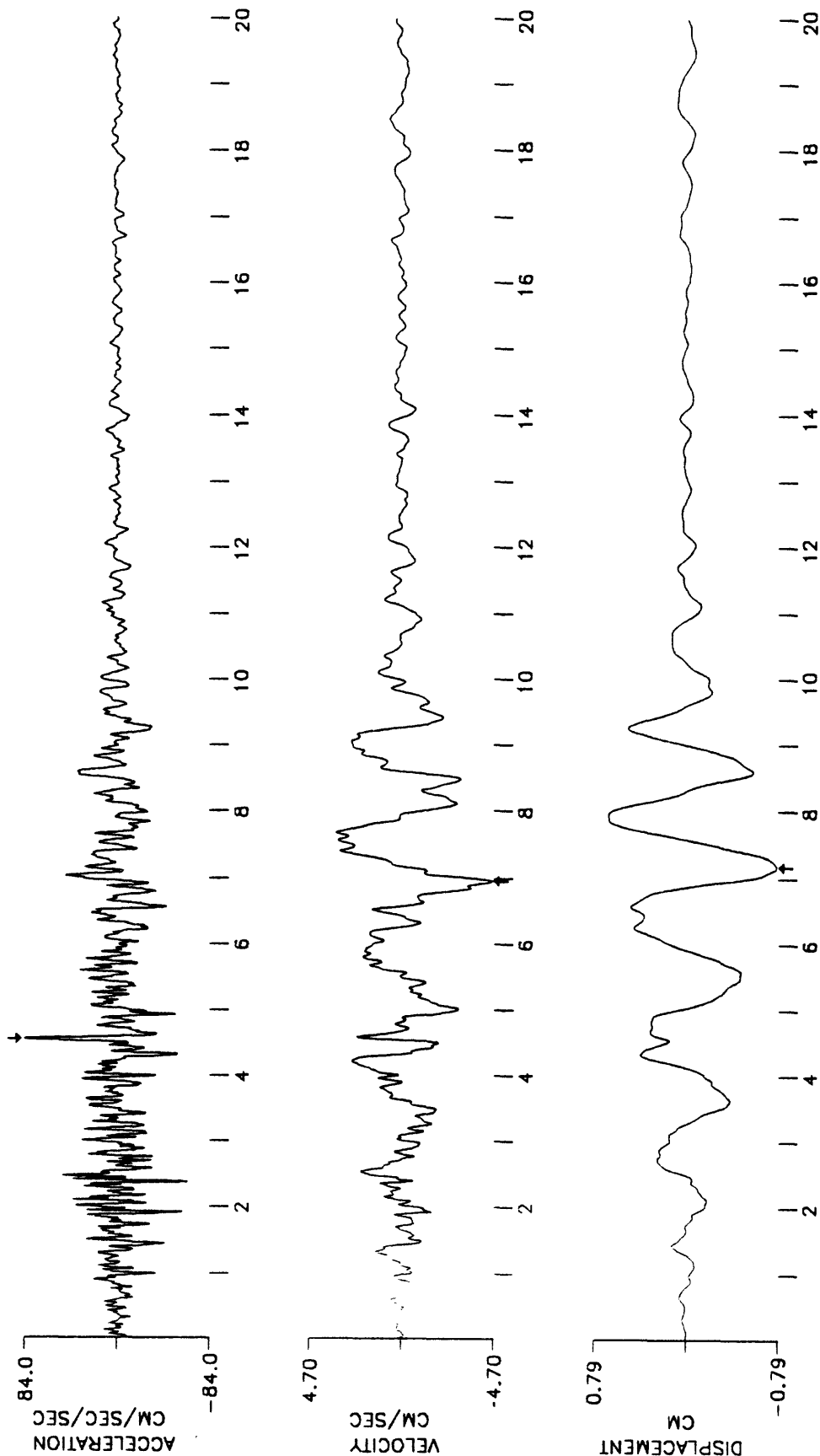


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
UP

EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL=83.22 CM/SEC/SEC, VELOCITY=-4.64 CM/SEC, DISPL=-0.78 CM.



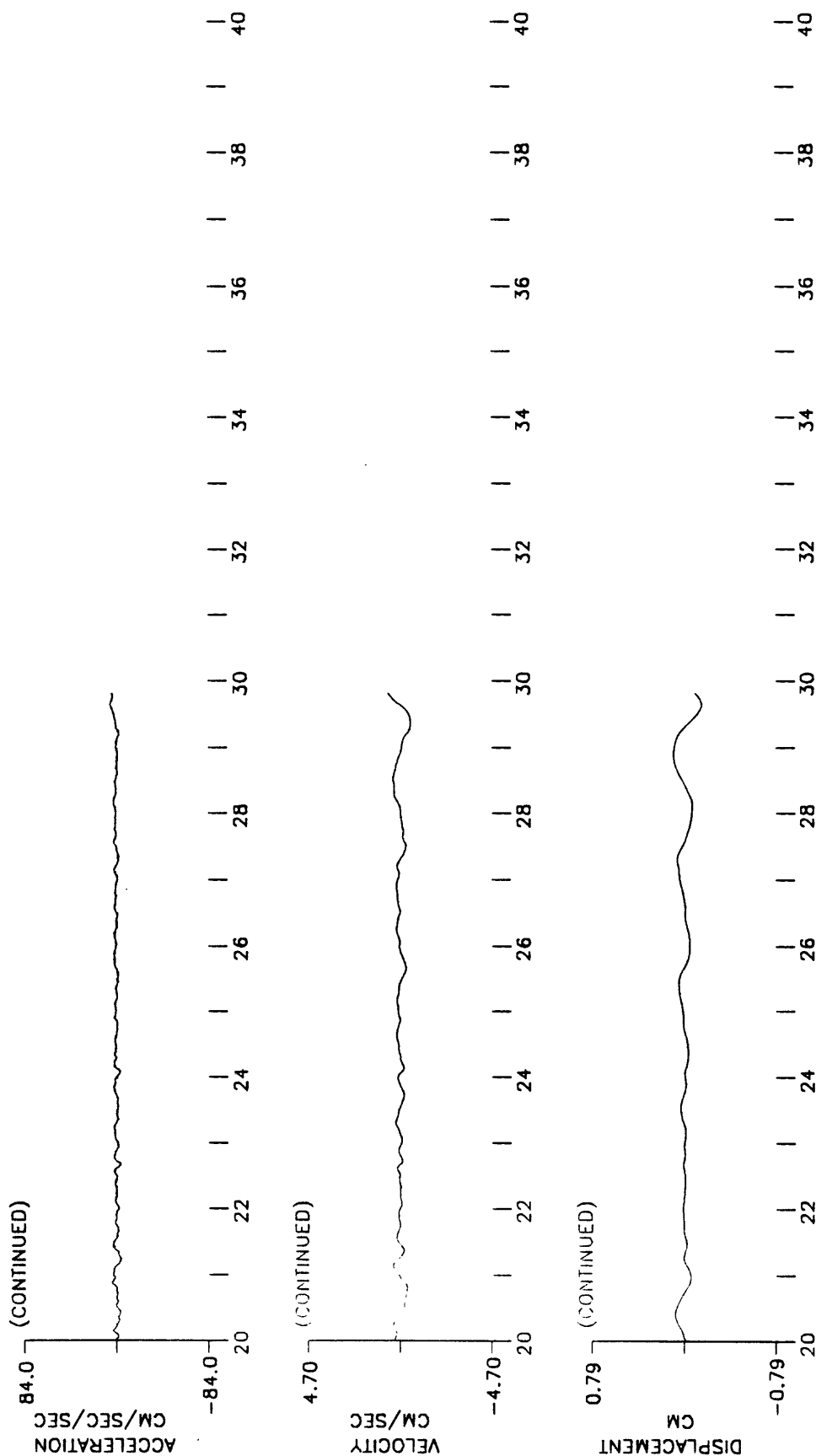
SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

UP

EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL=83.22 CM/SEC/SEC, VELOCITY=-4.64 CM/SEC, DISPL=-0.78 CM.

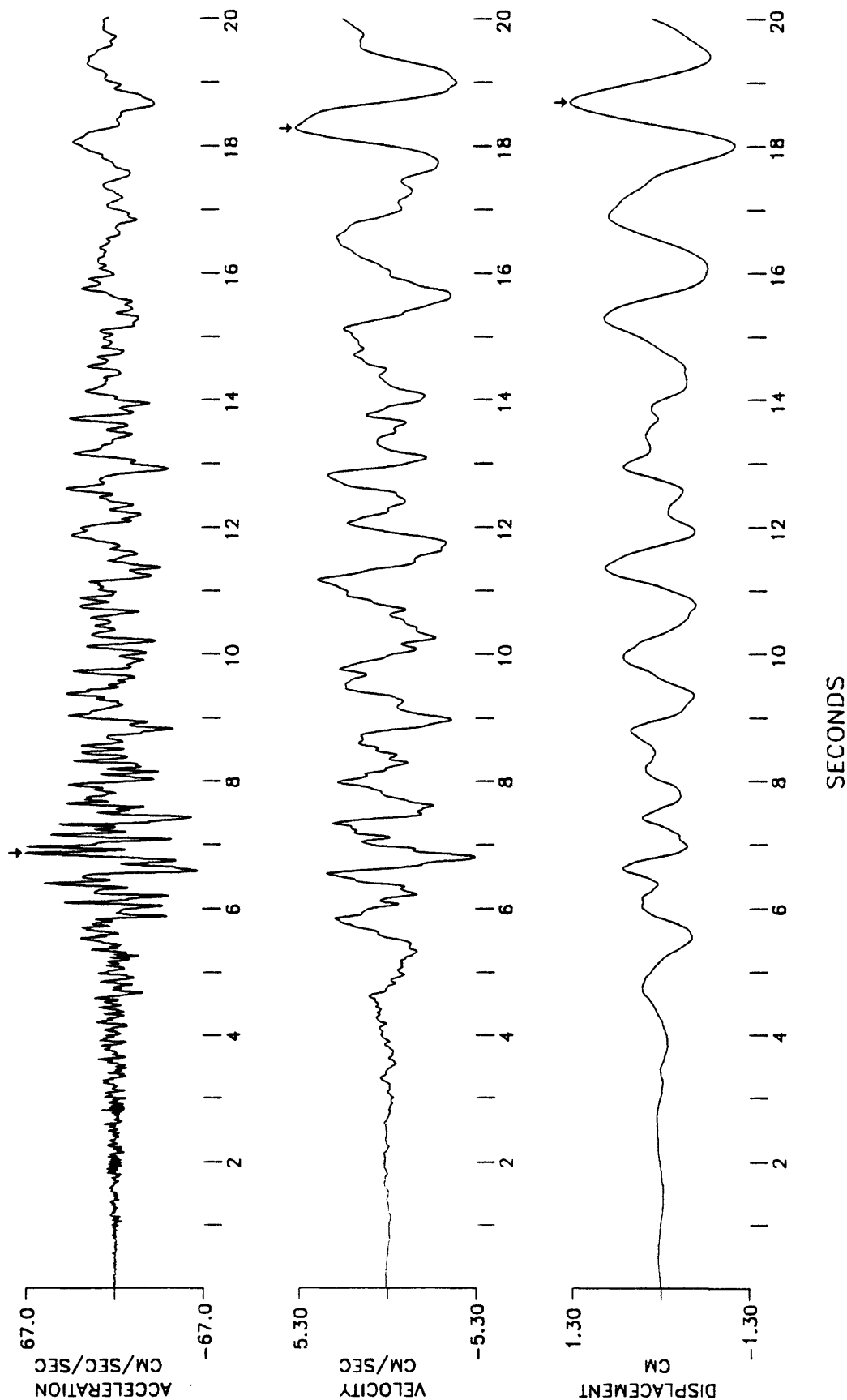


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
090 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
BUTTERWORTH AT .5 HZ, ORDER 4

PEAK VALUES: ACCEL=66.33 CM/SEC/SEC, VELOCITY=5.30 CM/SEC, DISPL=1.28 CM



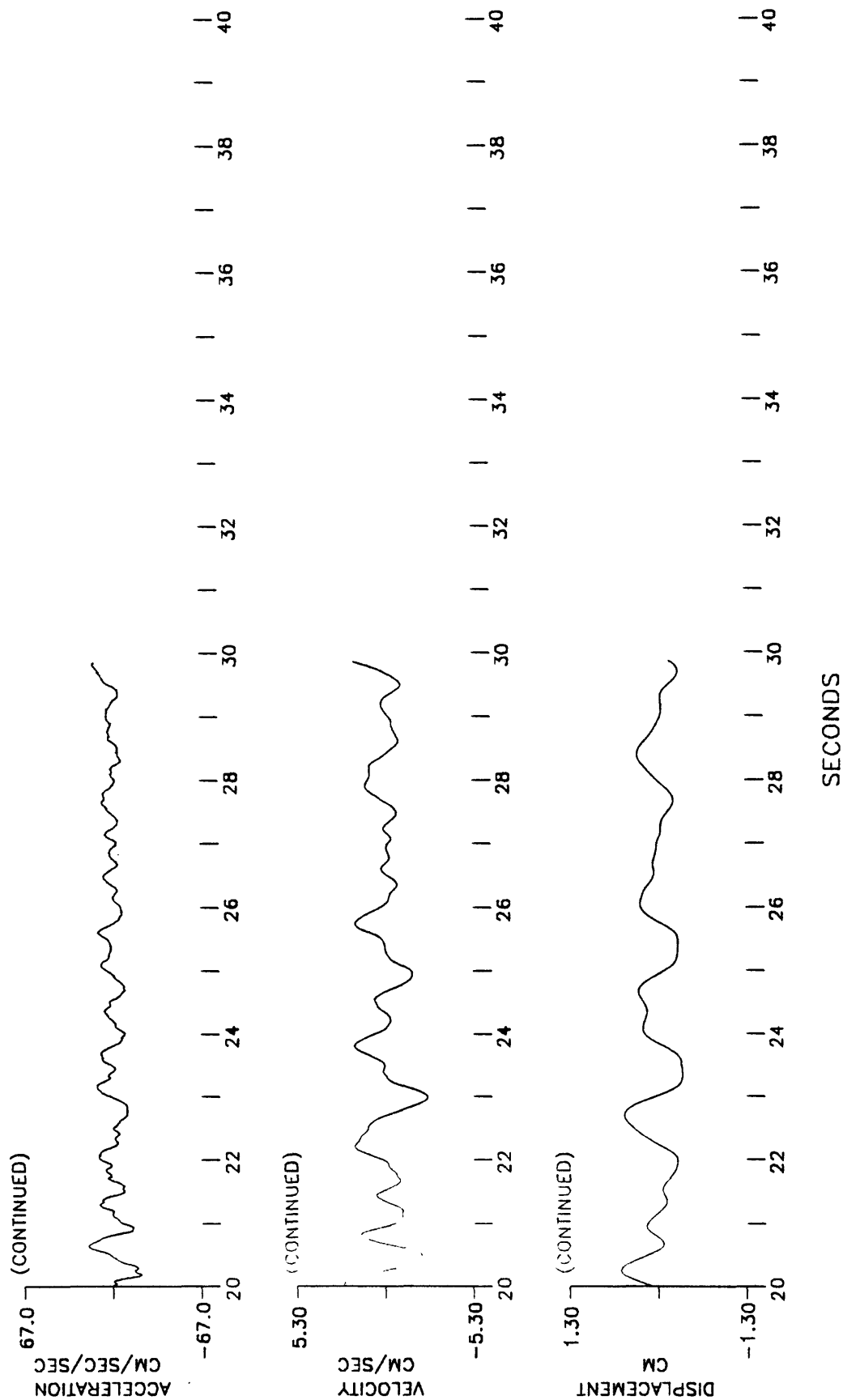
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

090 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT

BUTTERWORTH AT .5 HZ, ORDER 4

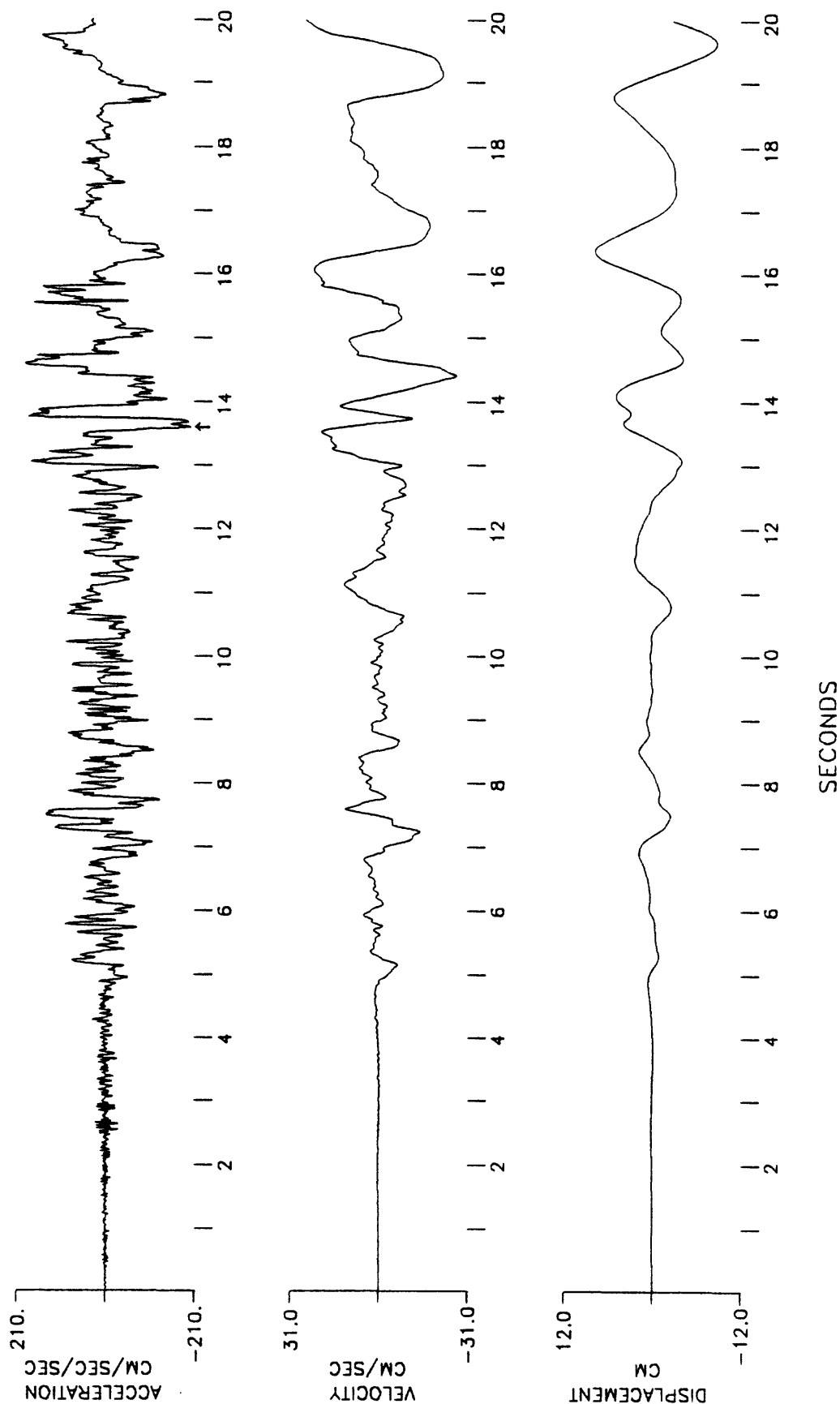
PEAK VALUES: ACCEL=66.33 CM/SEC/SEC, VELOCITY=5.30 CM/SEC, DISPL=1.28 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-201.15 CM/SEC/SEC, VELOCITY=30.49 CM/SEC, DISPL=11.74 CM

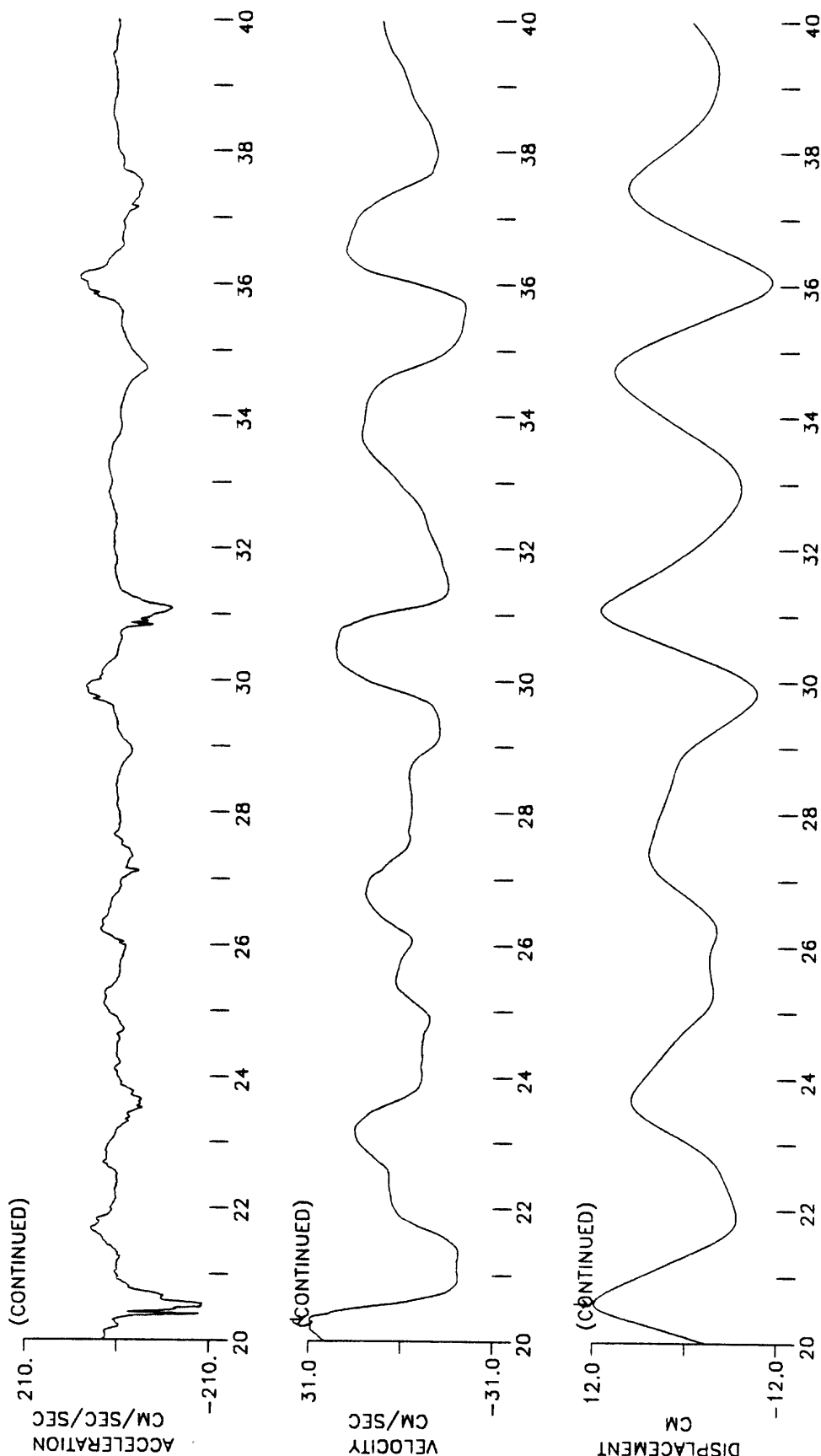


CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-201.15 CM/SEC/SEC, VELOCITY=30.49 CM/SEC, DISPL=11.74 CM



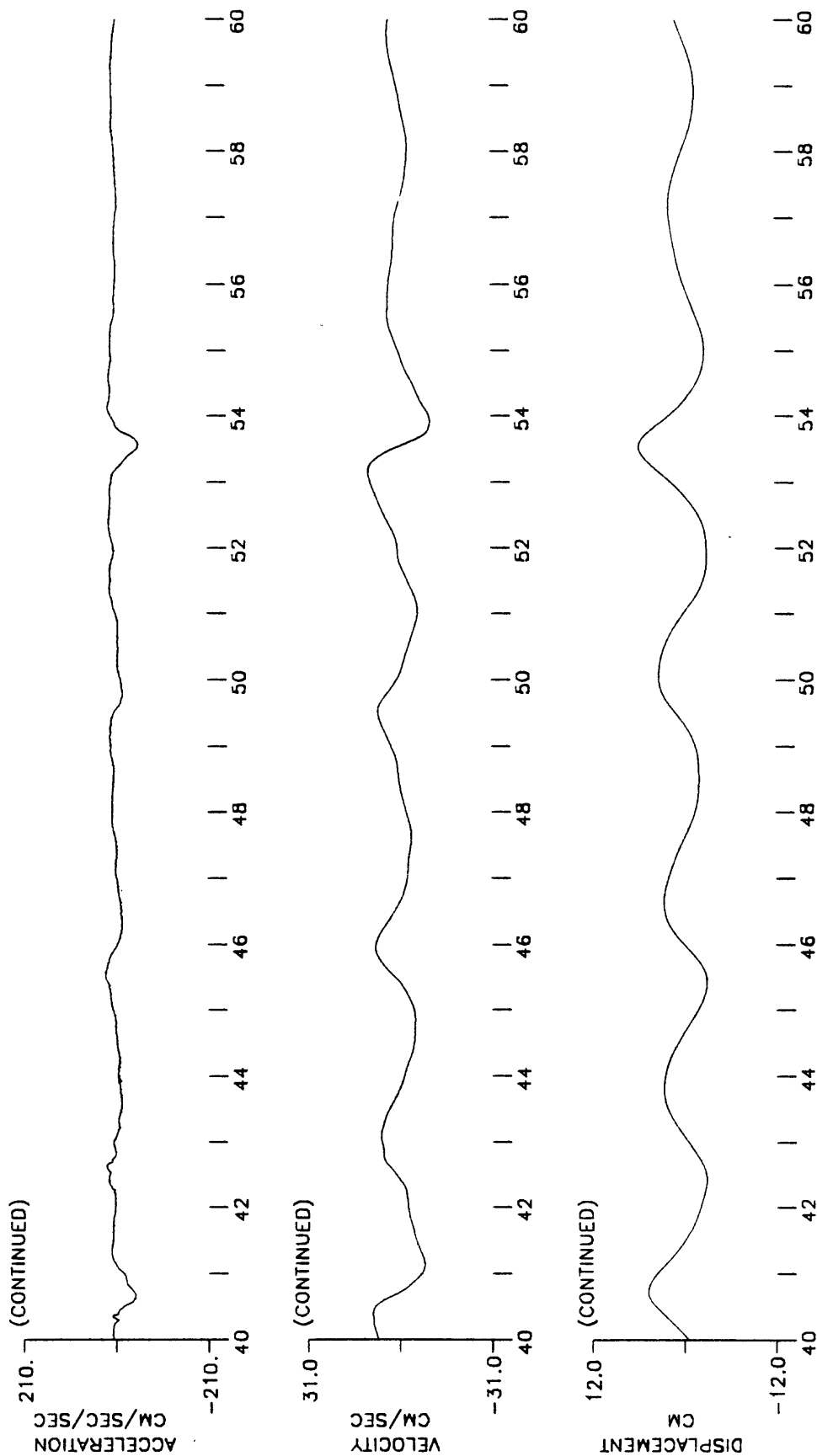
SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-201.15 CM/SEC/SEC, VELOCITY=30.49 CM/SEC, DISPL=11.74 CM



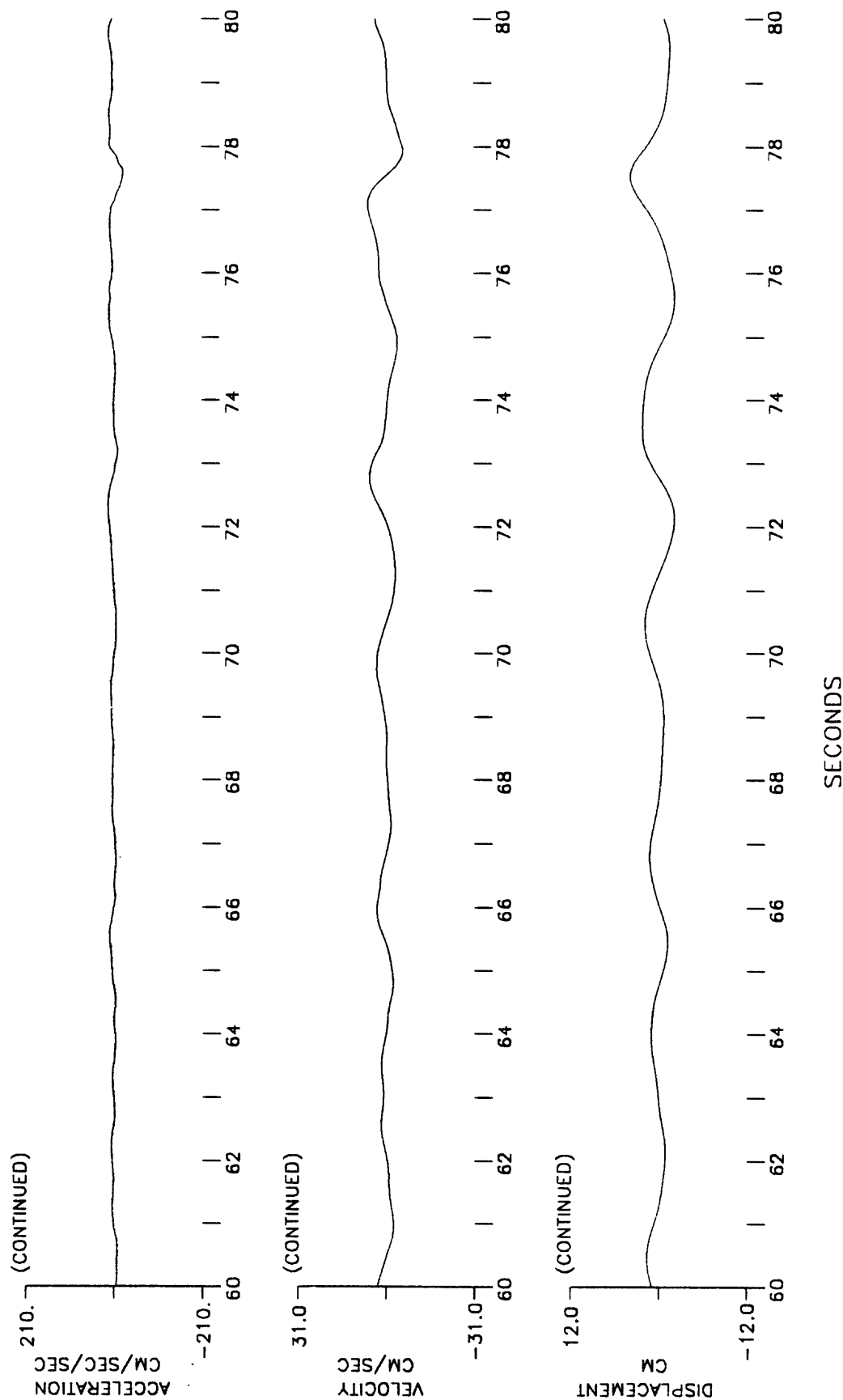
SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-201.15 CM/SEC/SEC, VELOCITY=30.49 CM/SEC, DISPL=11.74 CM

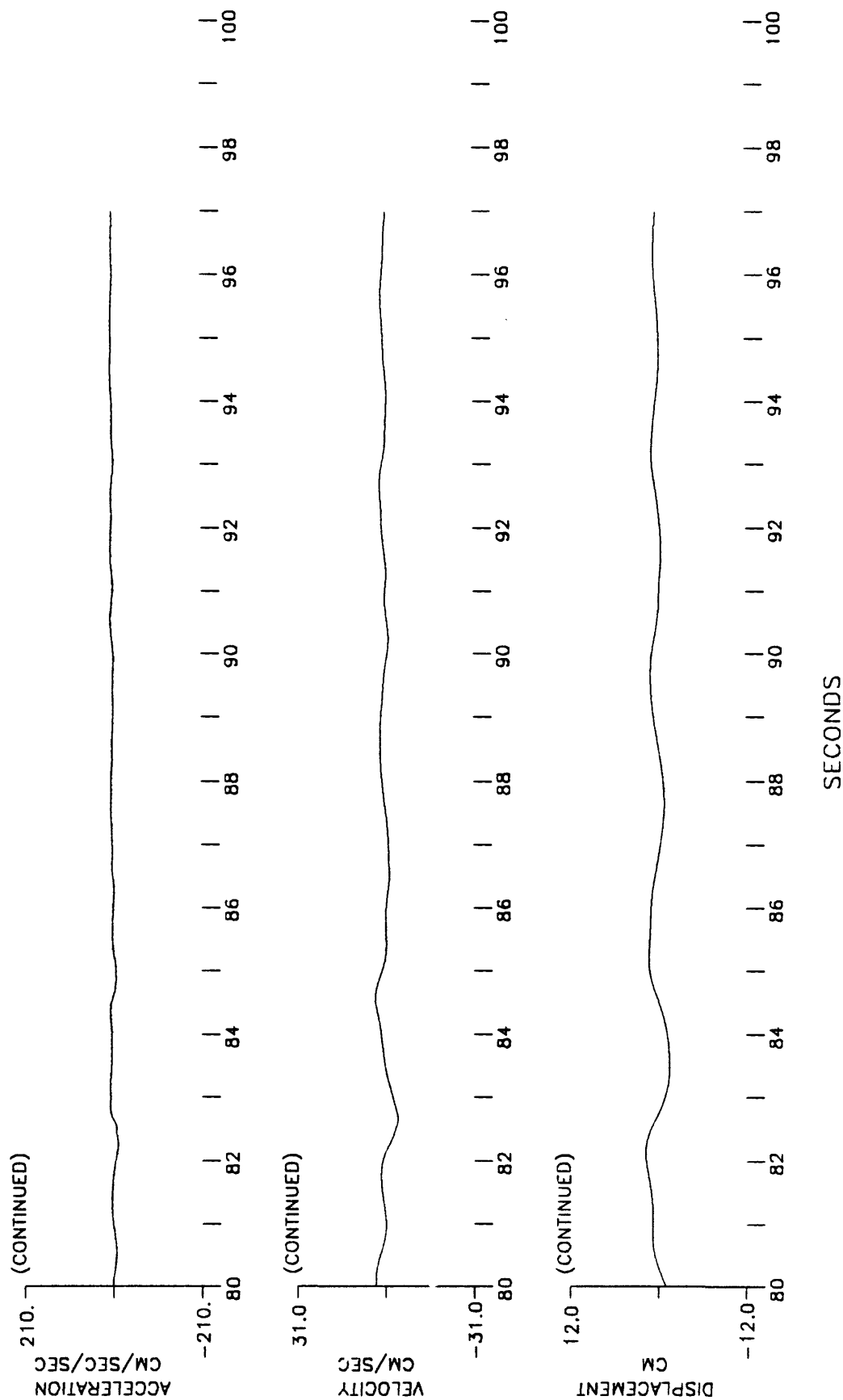


CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

360 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

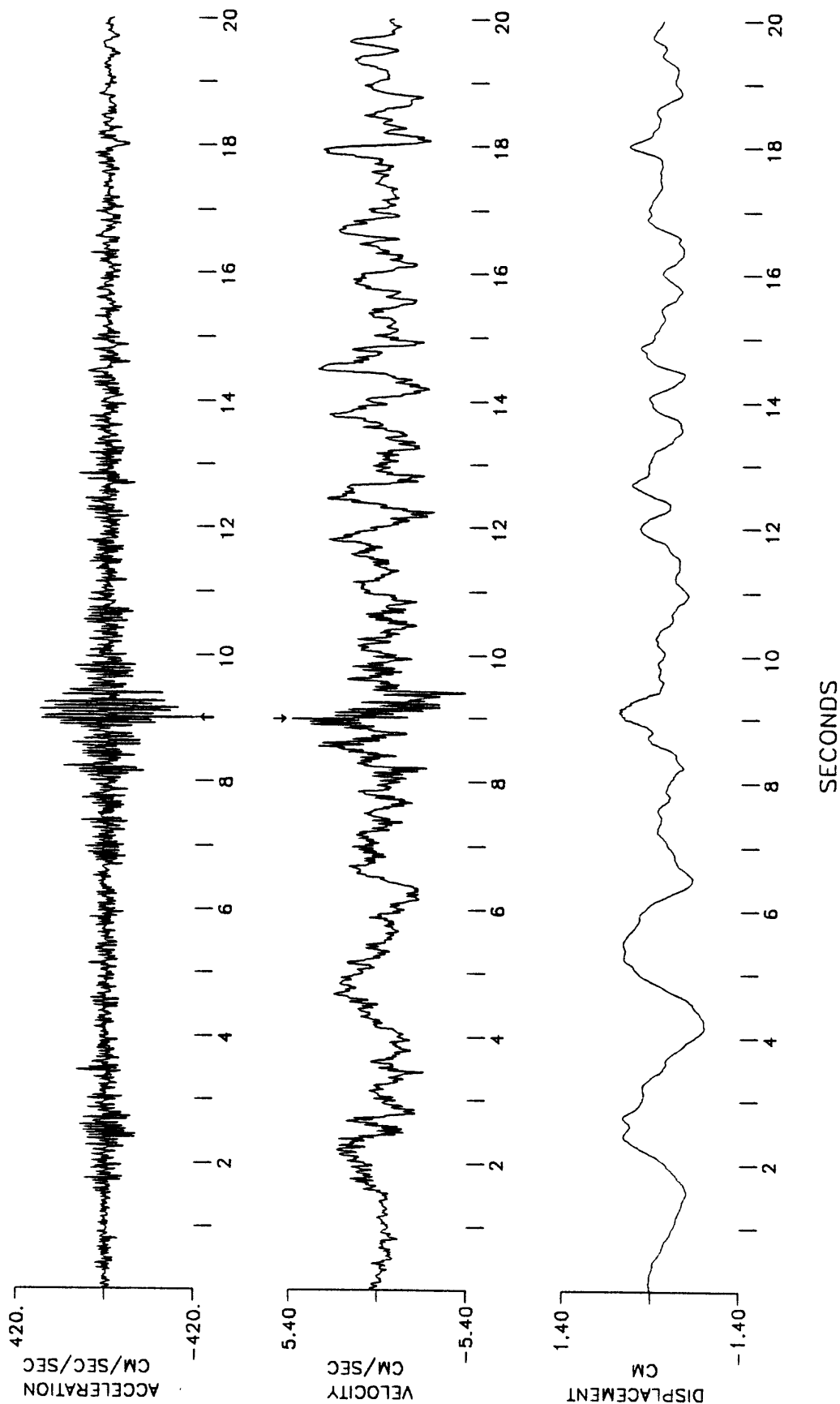
PEAK VALUES: ACCEL=-201.15 CM/SEC/SEC, VELOCITY=30.49 CM/SEC, DISPL=11.74 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
UP

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-414.81 CM/SEC/SEC, VELOCITY=5.34 CM/SEC, DISPL=-1.40 CM

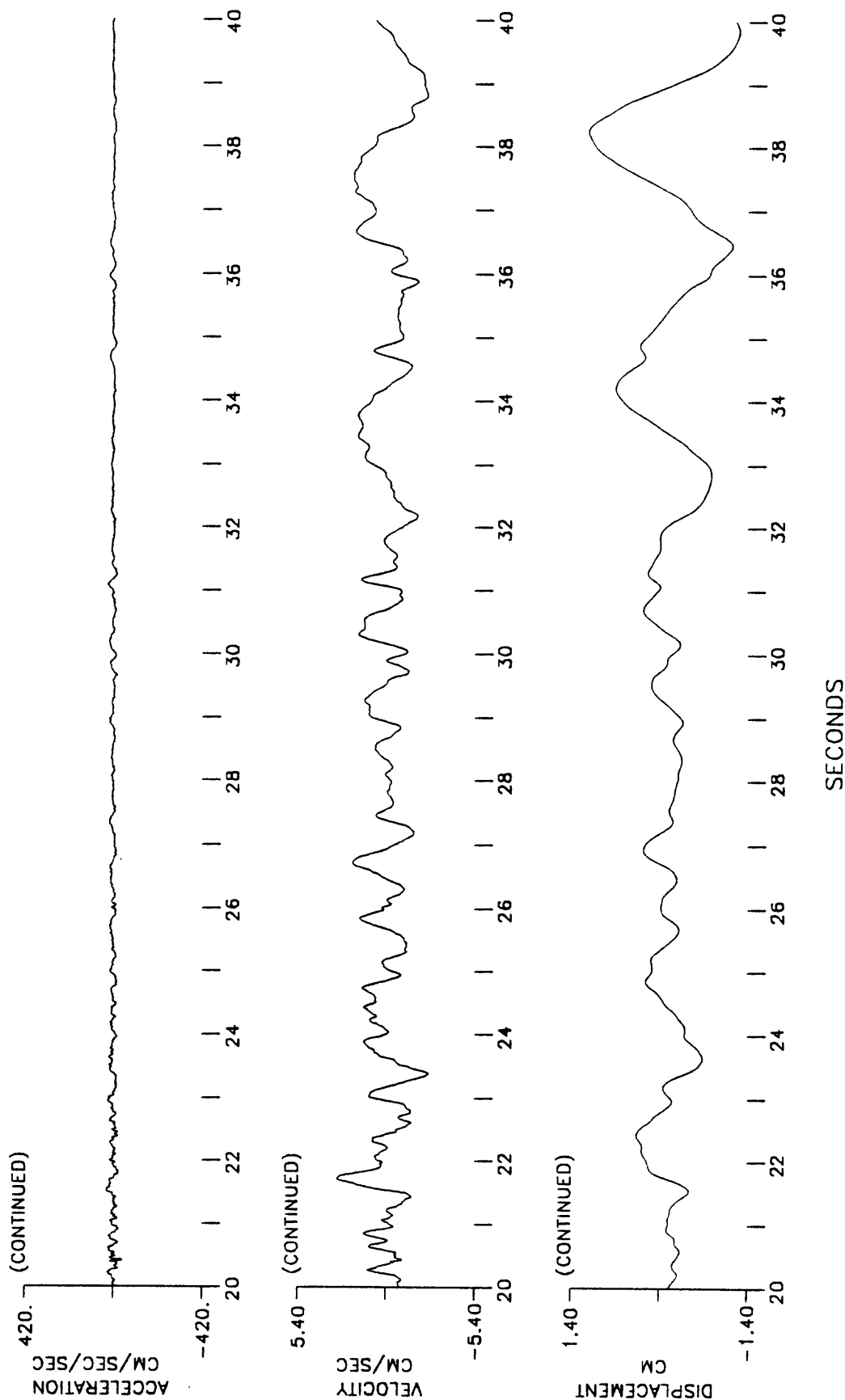


CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

UP

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

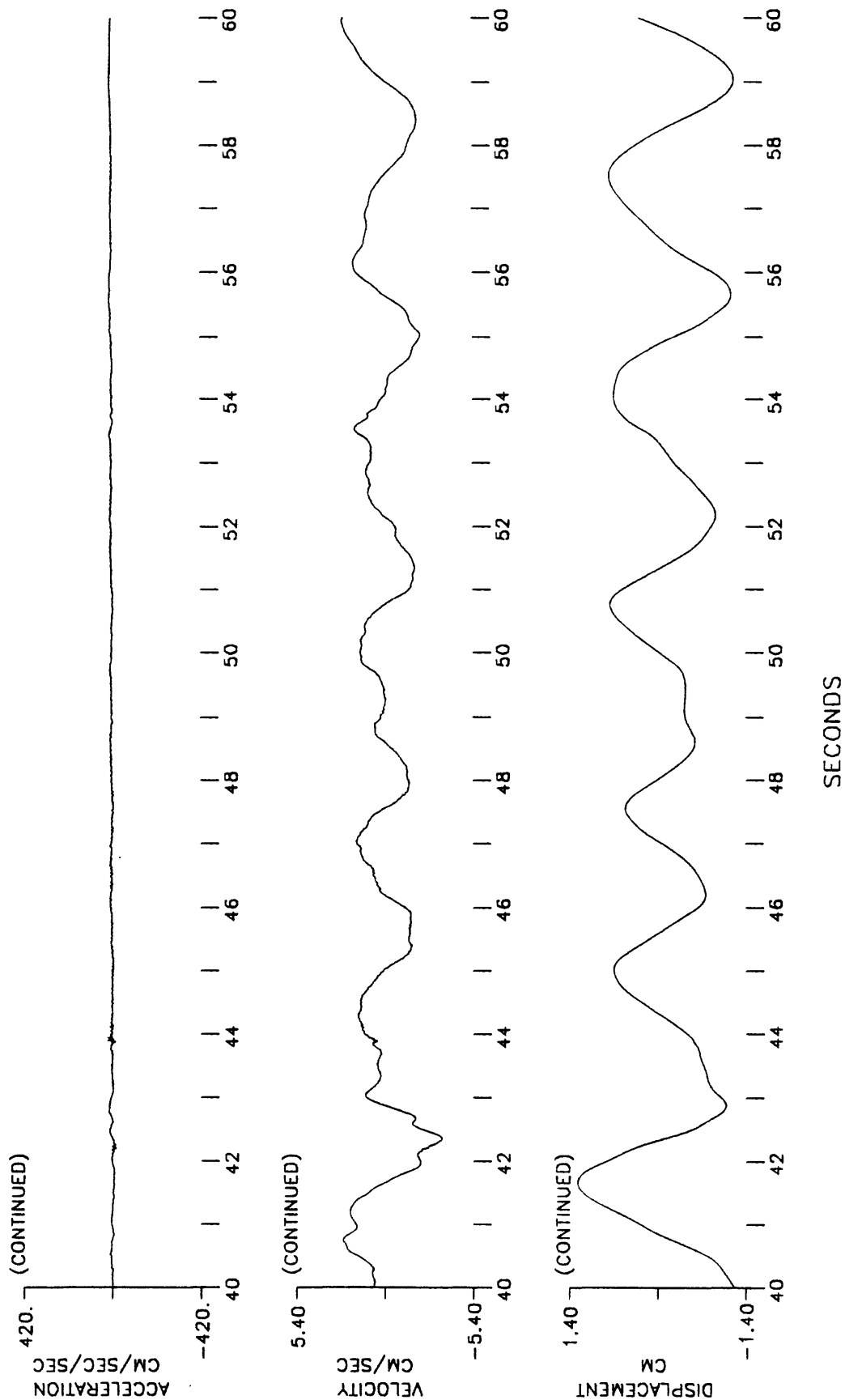
PEAK VALUES: ACCEL=-414.81 CM/SEC/SEC, VELOCITY=5.34 CM/SEC, DISPL=-1.40 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE^{UP}

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

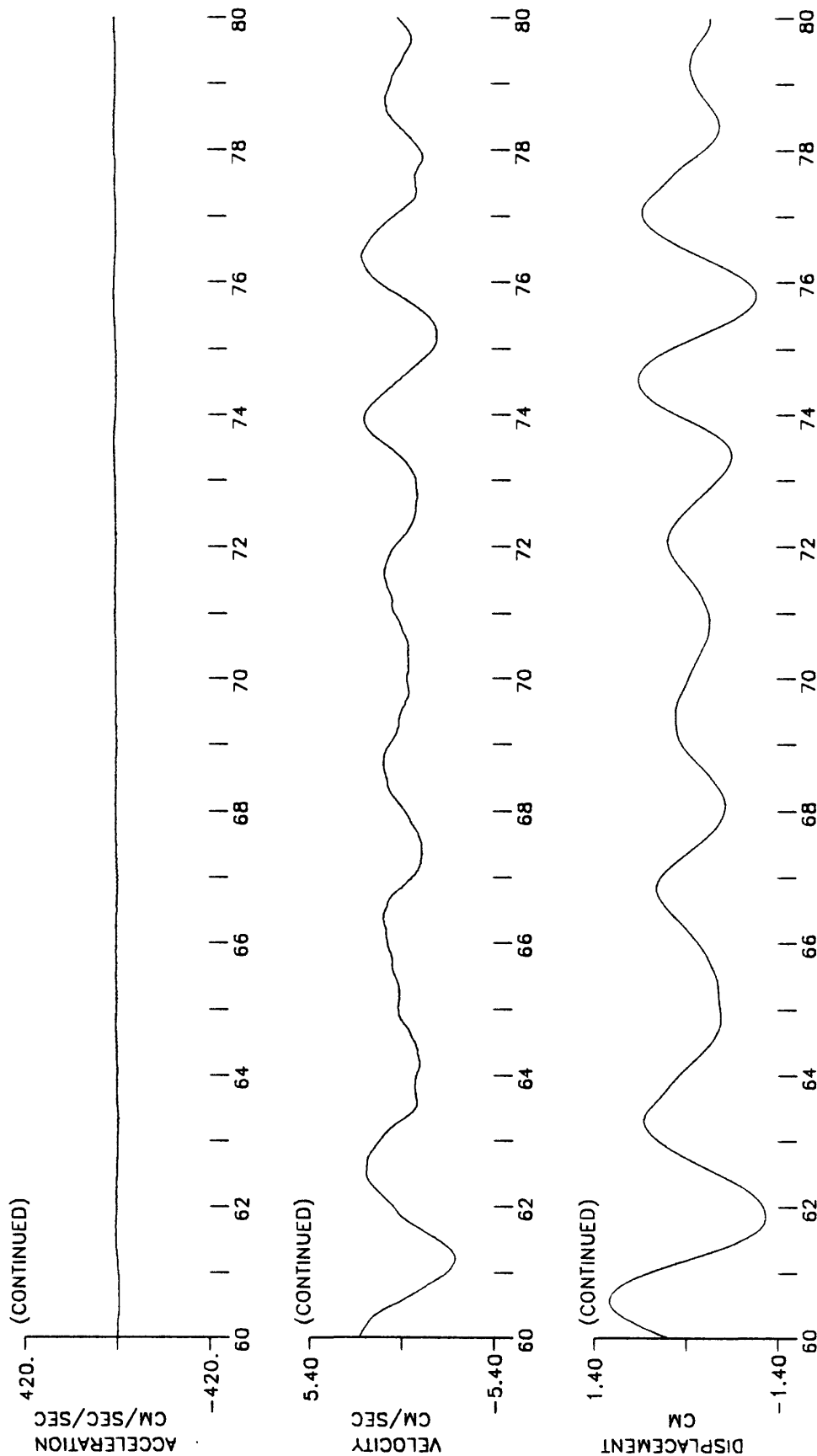
PEAK VALUES: ACCEL=-414.81 CM/SEC/SEC, VELOCITY=5.34 CM/SEC, DISPL=-1.40 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
UP

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-414.81 CM/SEC/SEC, VELOCITY=5.34 CM/SEC, DISPL=-1.40 CM

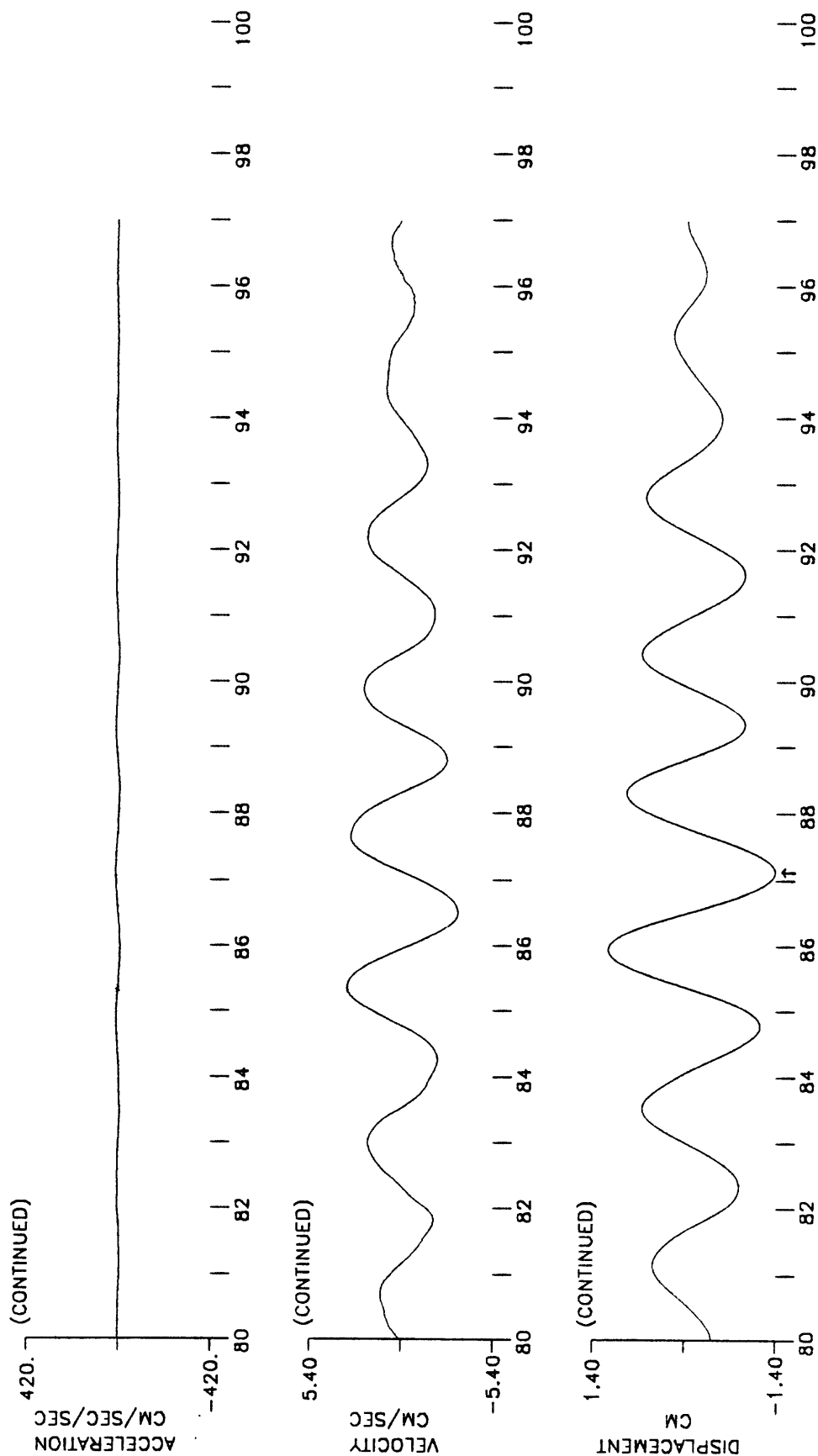


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE
UP

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-414.81 CM/SEC/SEC, VELOCITY=5.34 CM/SEC, DISPL=-1.40 CM



SECONDS

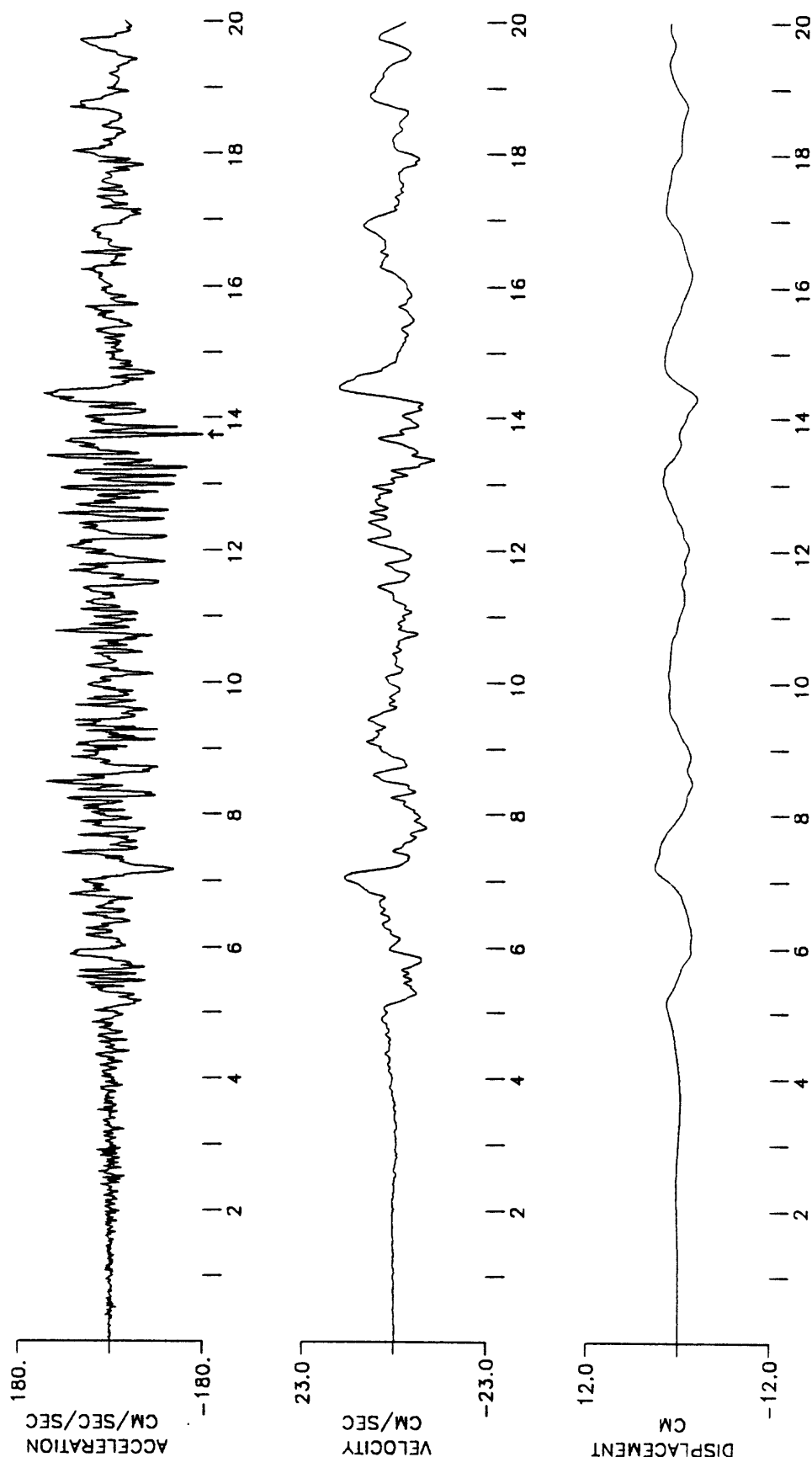
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-179.52 CM/SEC/SEC, VELOCITY=-22.93 CM/SEC, DISPL=11.32 CM



SECONDS

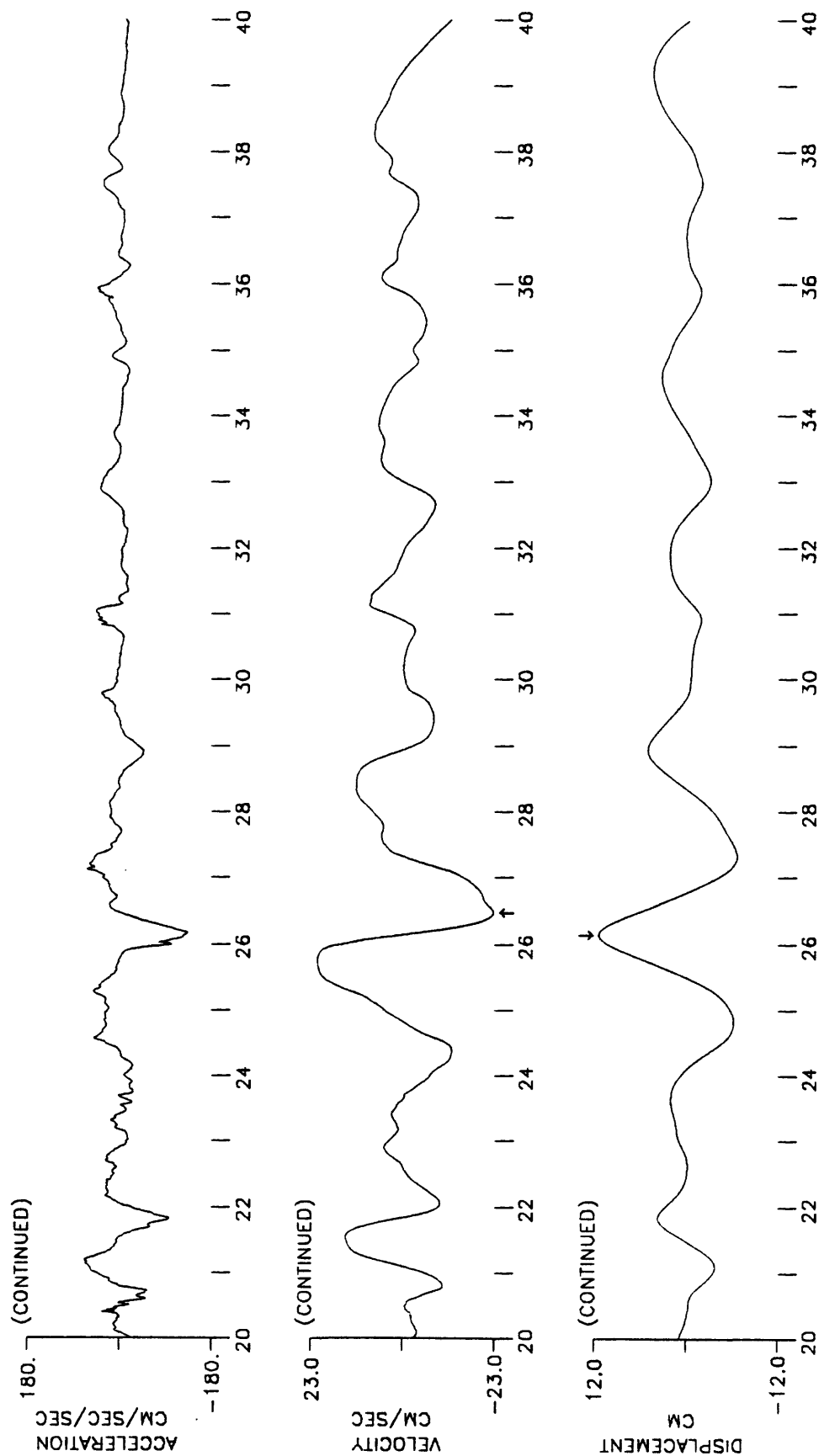
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-179.52 CM/SEC/SEC, VELOCITY=-22.93 CM/SEC, DISPL=11.32 CM



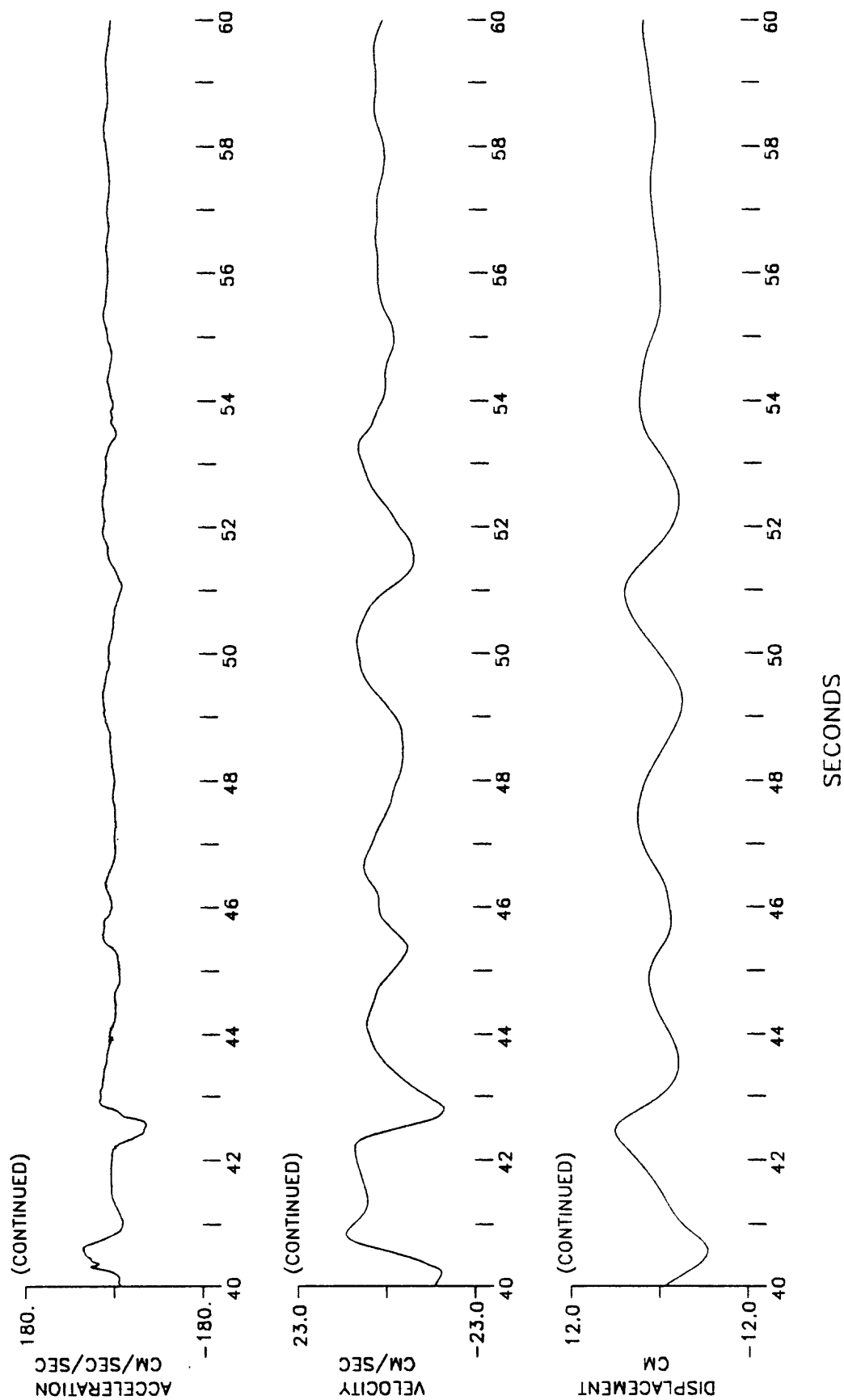
SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-179.52 CM/SEC/SEC, VELOCITY=-22.93 CM/SEC, DISPL=11.32 CM

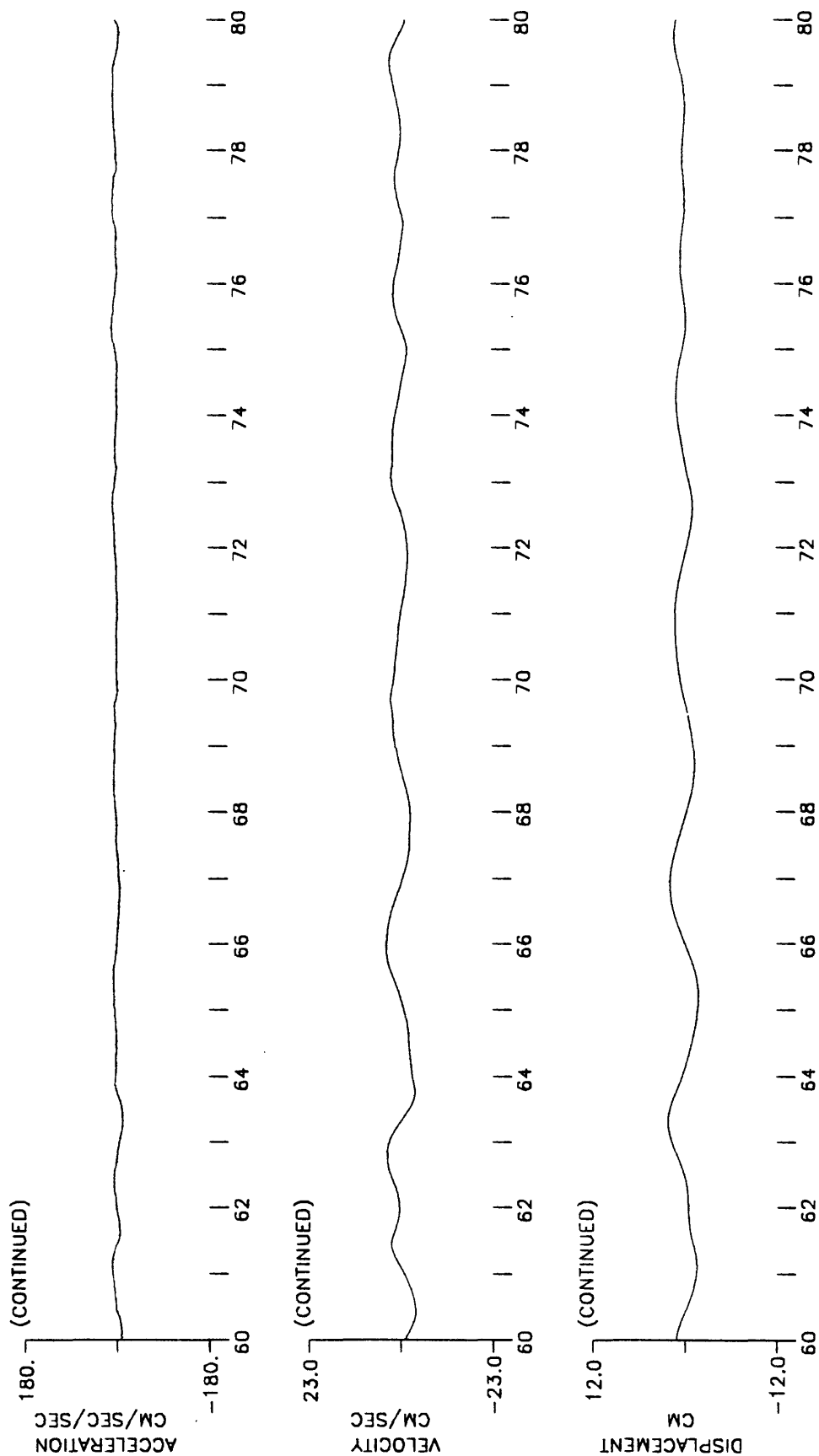


CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-179.52 CM/SEC/SEC, VELOCITY=-22.93 CM/SEC, DISPL=11.32 CM



SECONDS

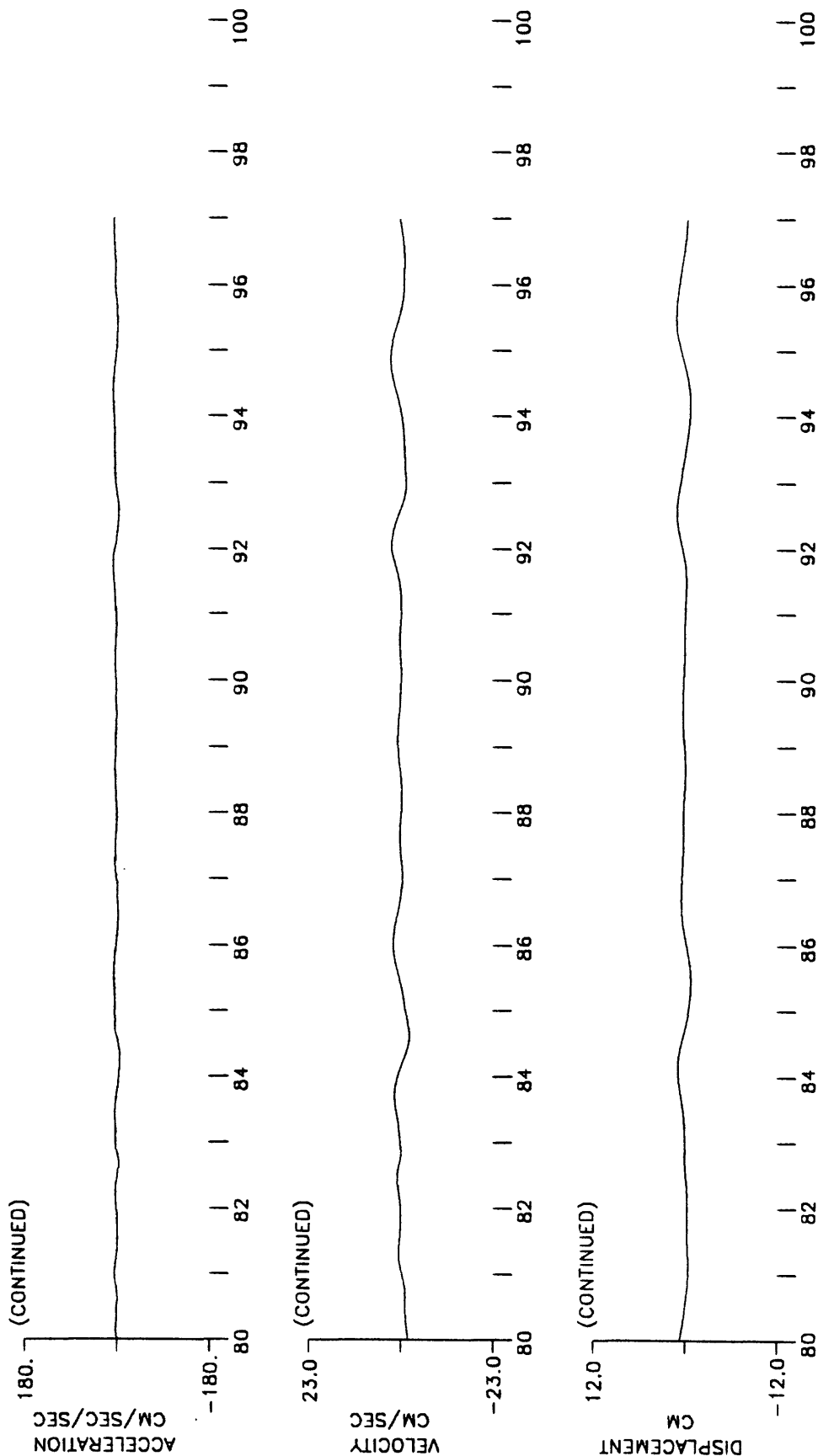
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, SURFACE

090 DEGREES

EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-179.52 CM/SEC/SEC, VELOCITY=-22.93 CM/SEC, DISPL=11.32 CM.



SECONDS

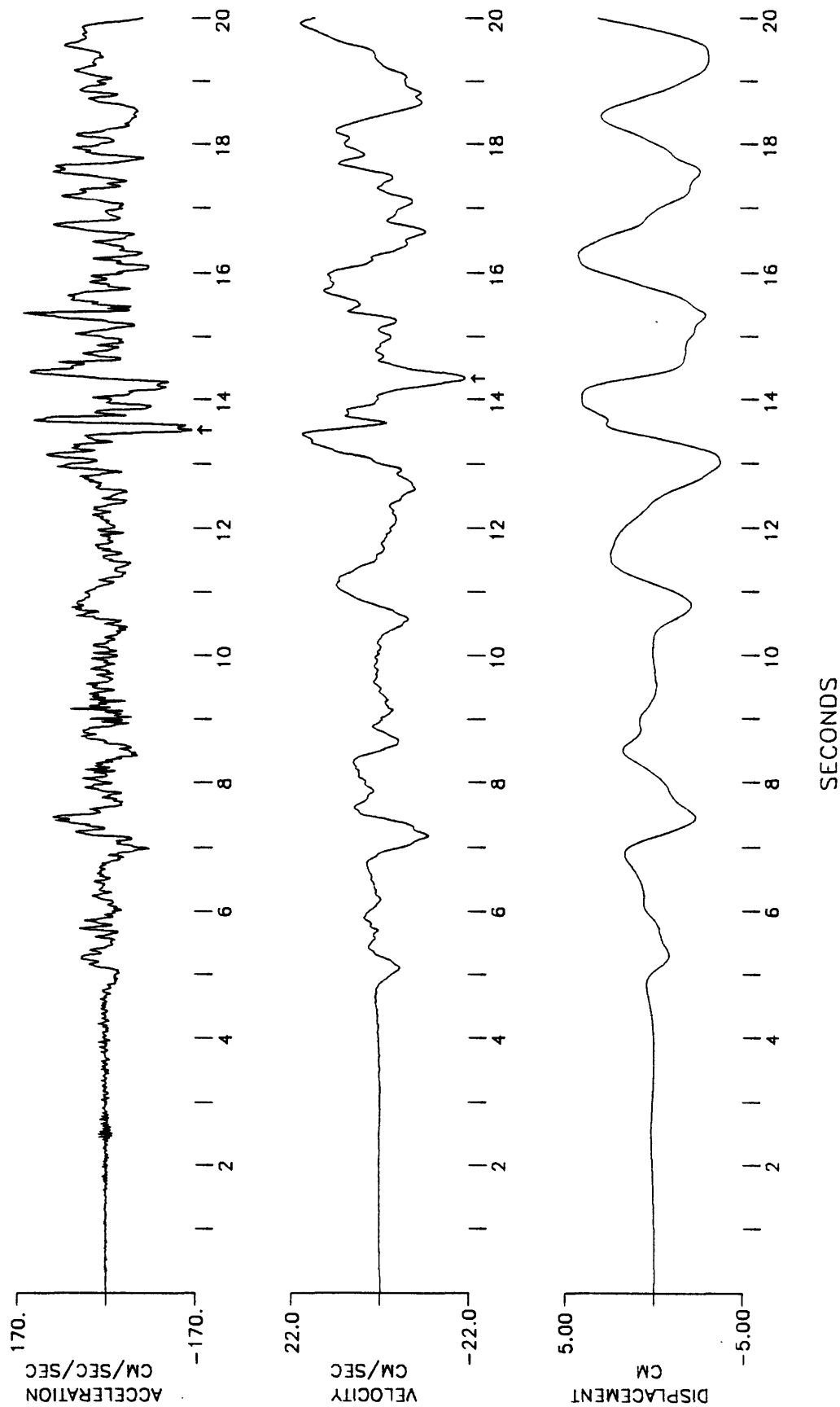
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

360 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

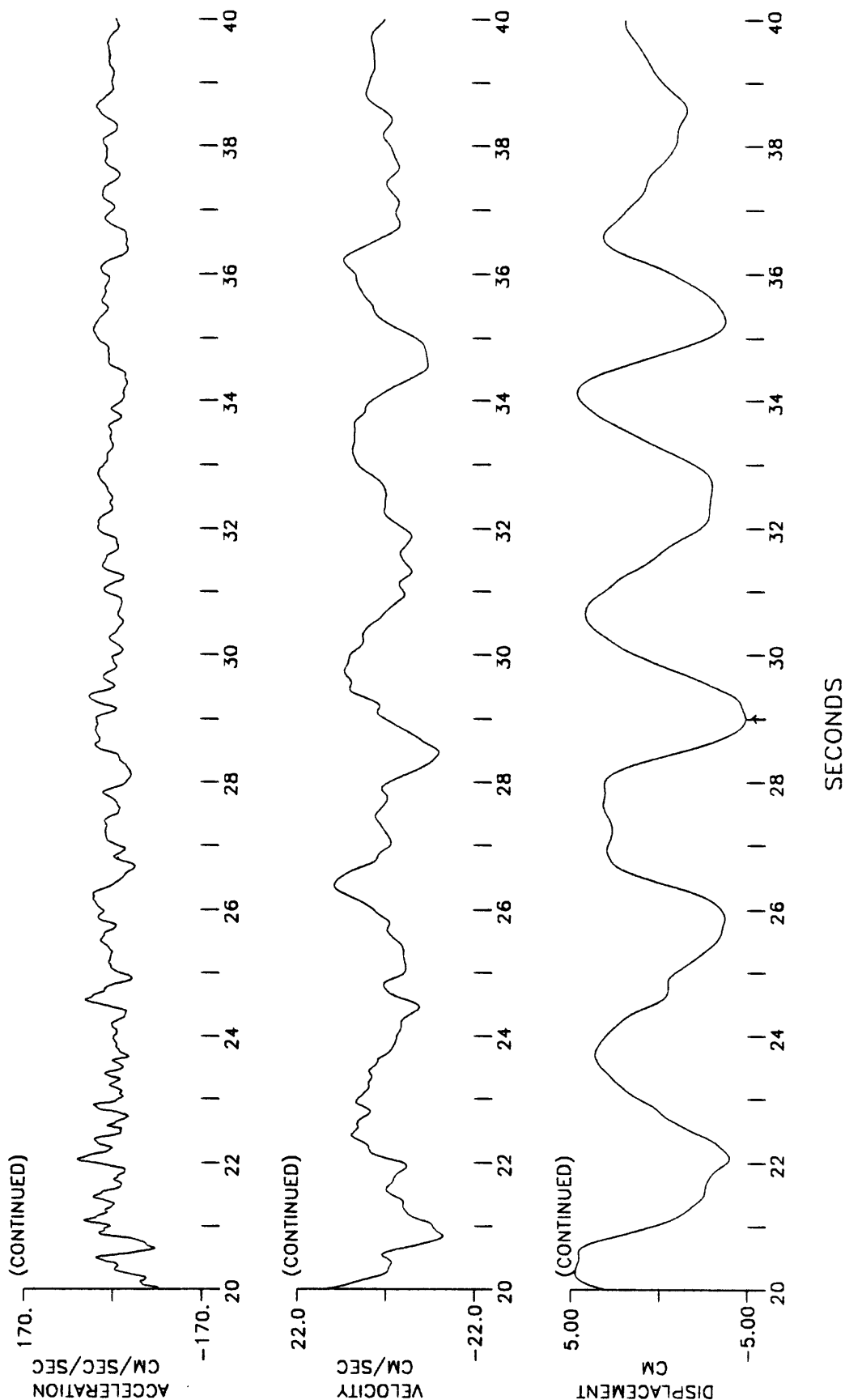
PEAK VALUES: ACCEL=-168.63 CM/SEC/SEC, VELOCITY=-21.78 CM/SEC, DISPL=-5.00 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
360 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

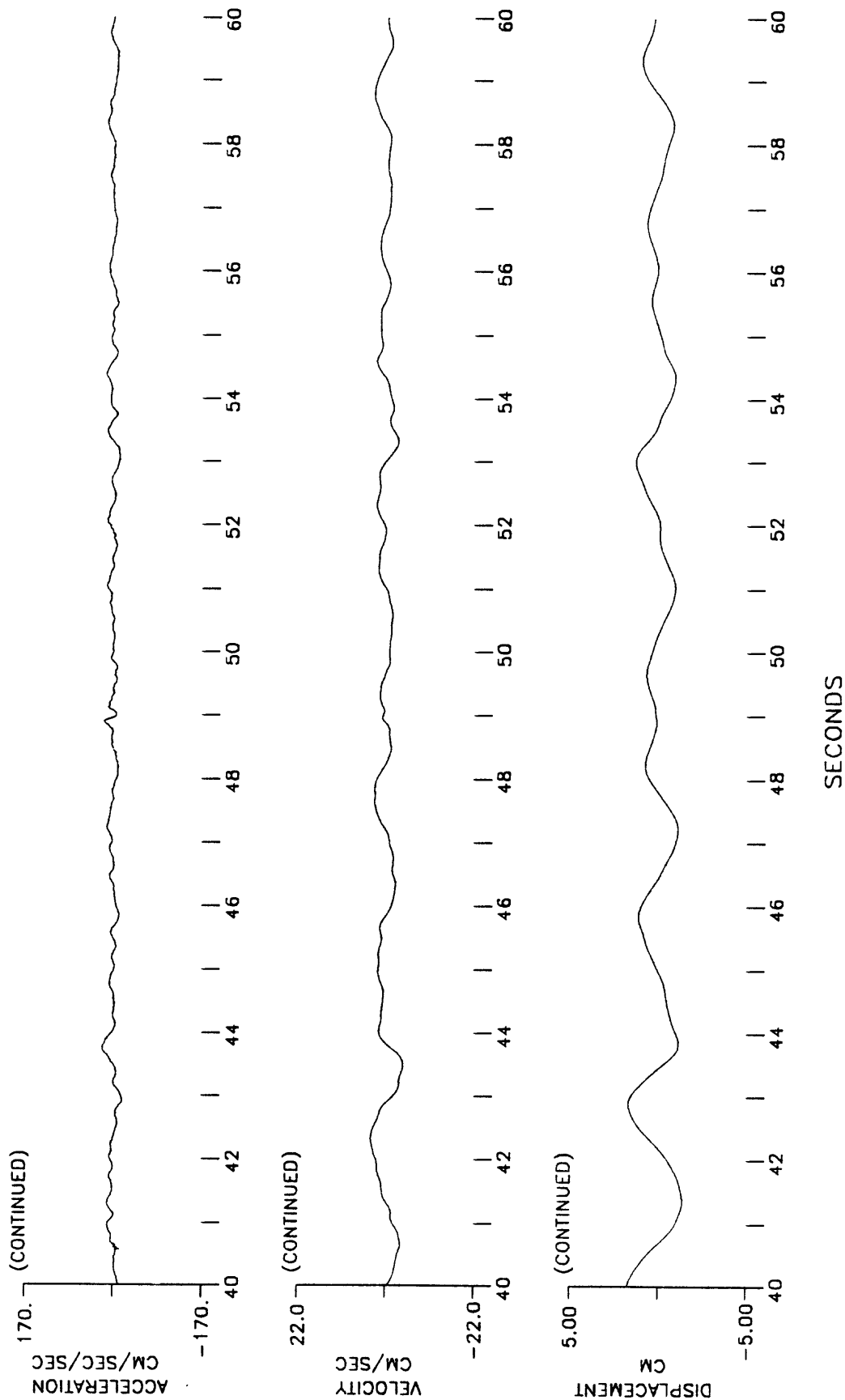
PEAK VALUES: ACCEL=-168.63 CM/SEC/SEC, VELOCITY=-21.78 CM/SEC, DISPL=-5.00 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

360 DEGREES, APPROX.
EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-168.63 CM/SEC/SEC, VELOCITY=-21.78 CM/SEC, DISPL=-5.00 CM

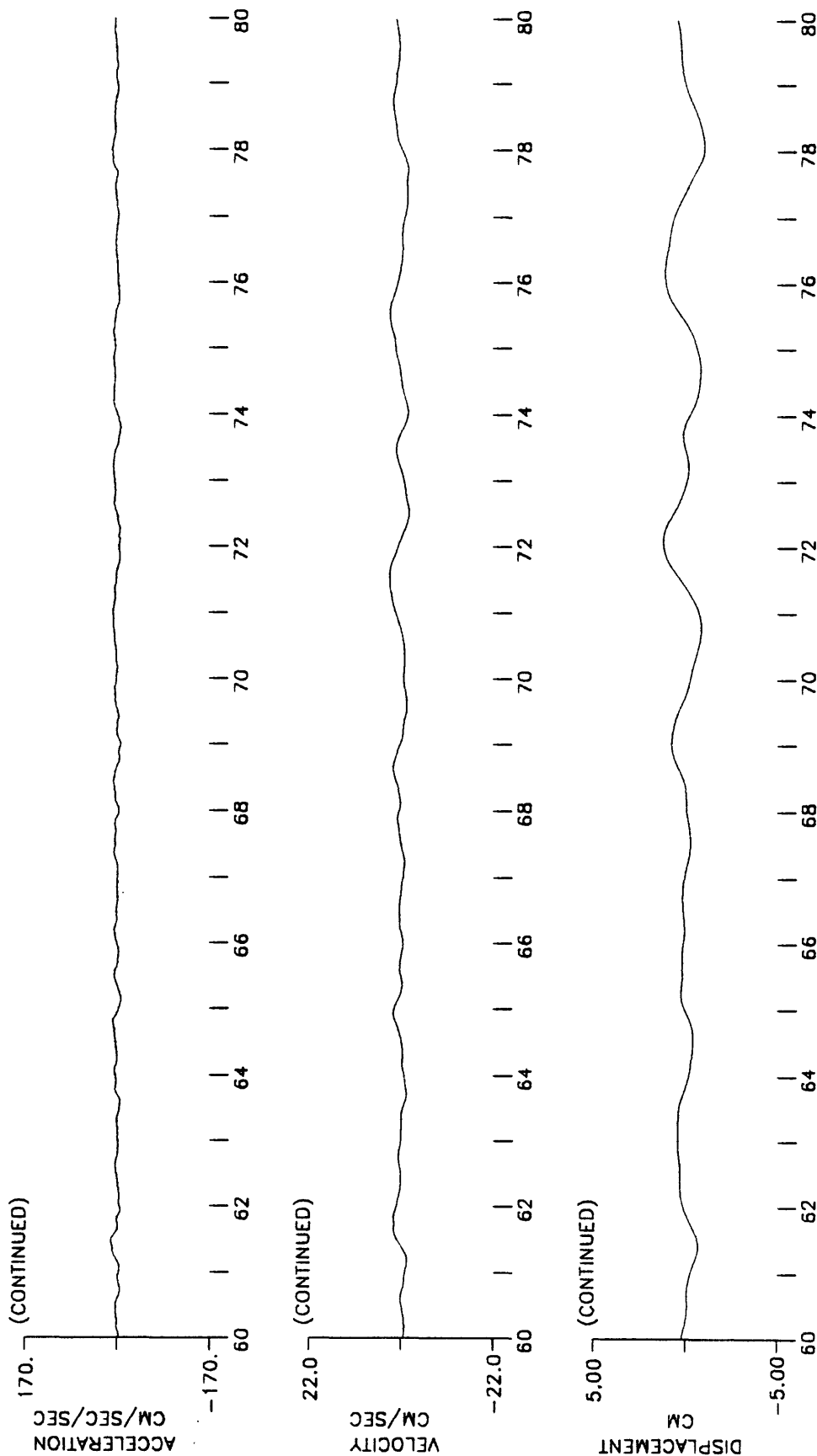


CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

360 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=-168.63 CM/SEC/SEC, VELOCITY=-21.78 CM/SEC, DISPL=-5.00 CM

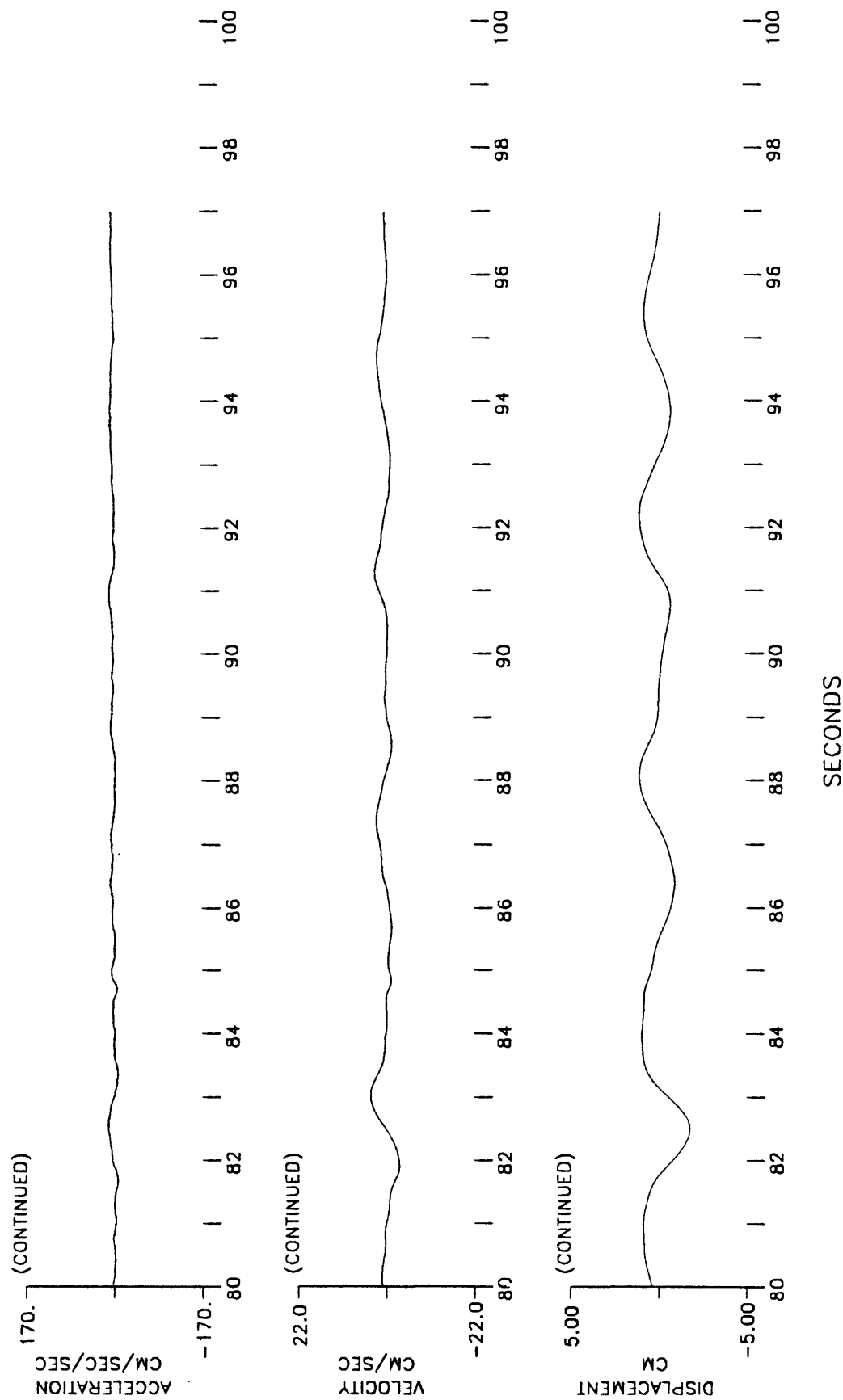


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

360 DEGREES, APPROX.
EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

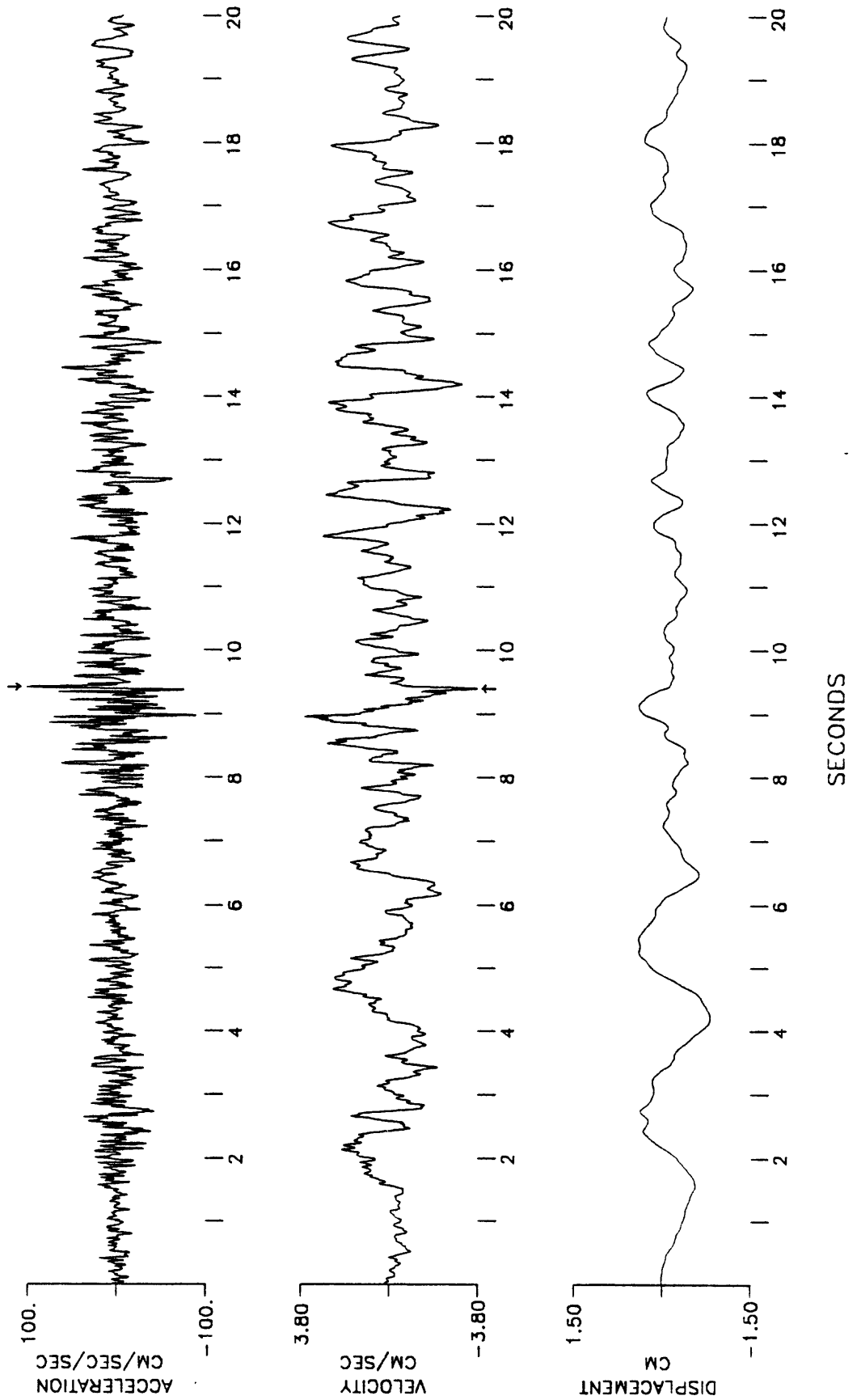
PEAK VALUES: ACCEL=-168.63 CM/SEC/SEC, VELOCITY=-21.78 CM/SEC, DISPL=-5.00 CM



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
UP

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

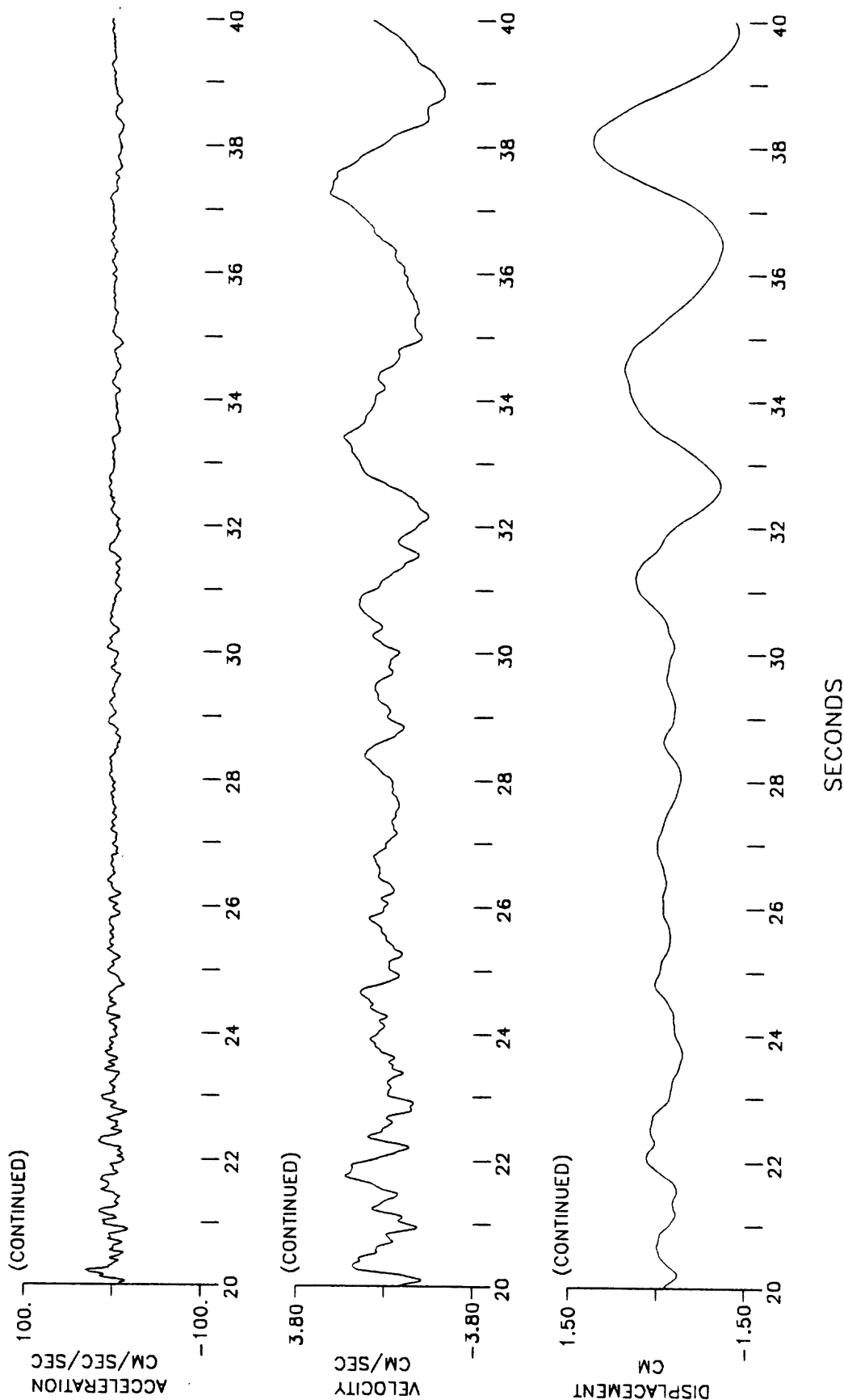
PEAK VALUES: ACCEL=99.67 CM/SEC/SEC, VELOCITY=-3.80 CM/SEC, DISPL=-1.41 CM.



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
UP

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

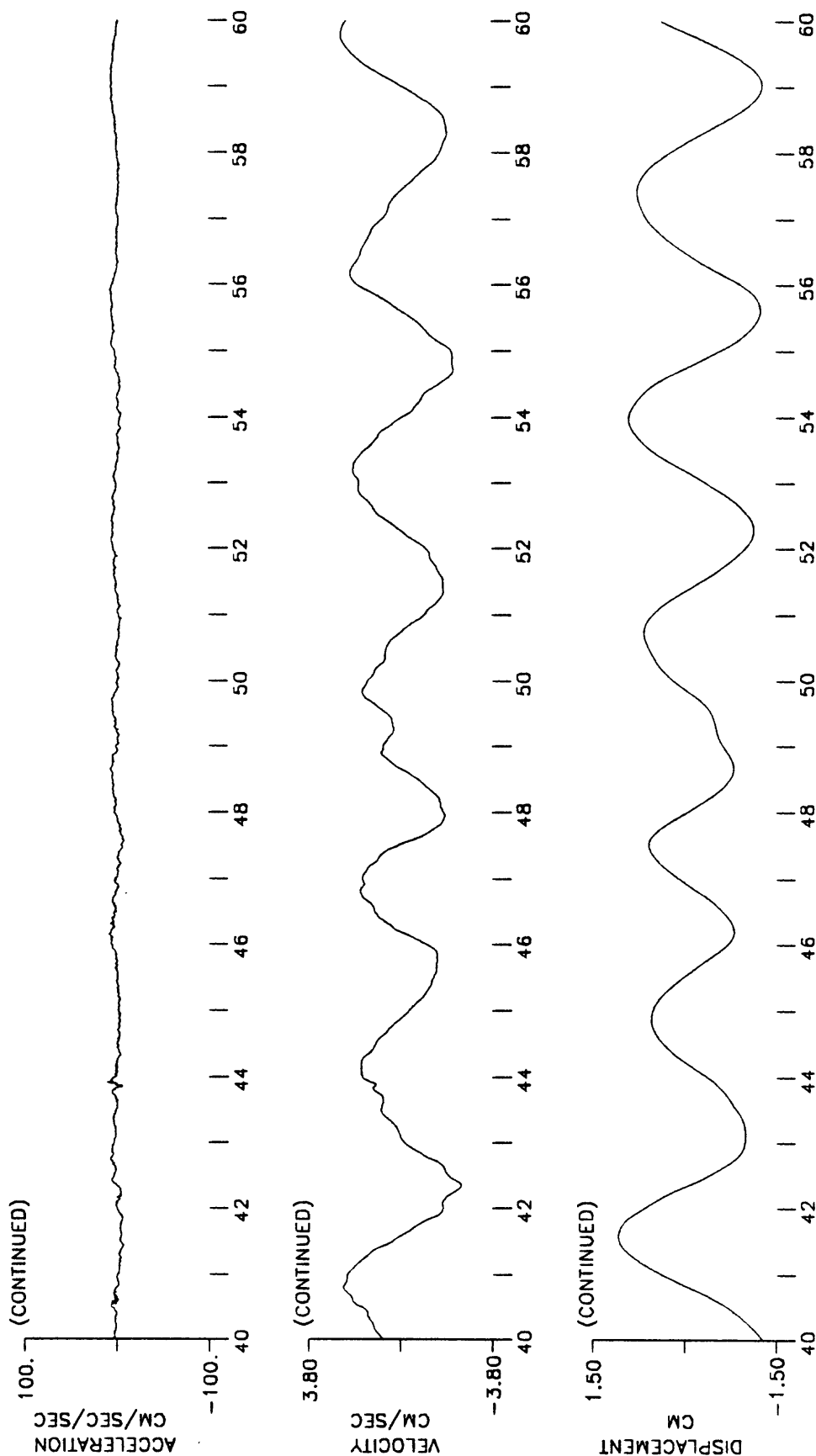
PEAK VALUES: ACCEL=99.67 CM/SEC/SEC, VELOCITY=-3.80 CM/SEC, DISPL=-1.41 CM.



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
UP

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=99.67 CM/SEC/SEC, VELOCITY=-3.80 CM/SEC, DISPL=-1.41 CM.

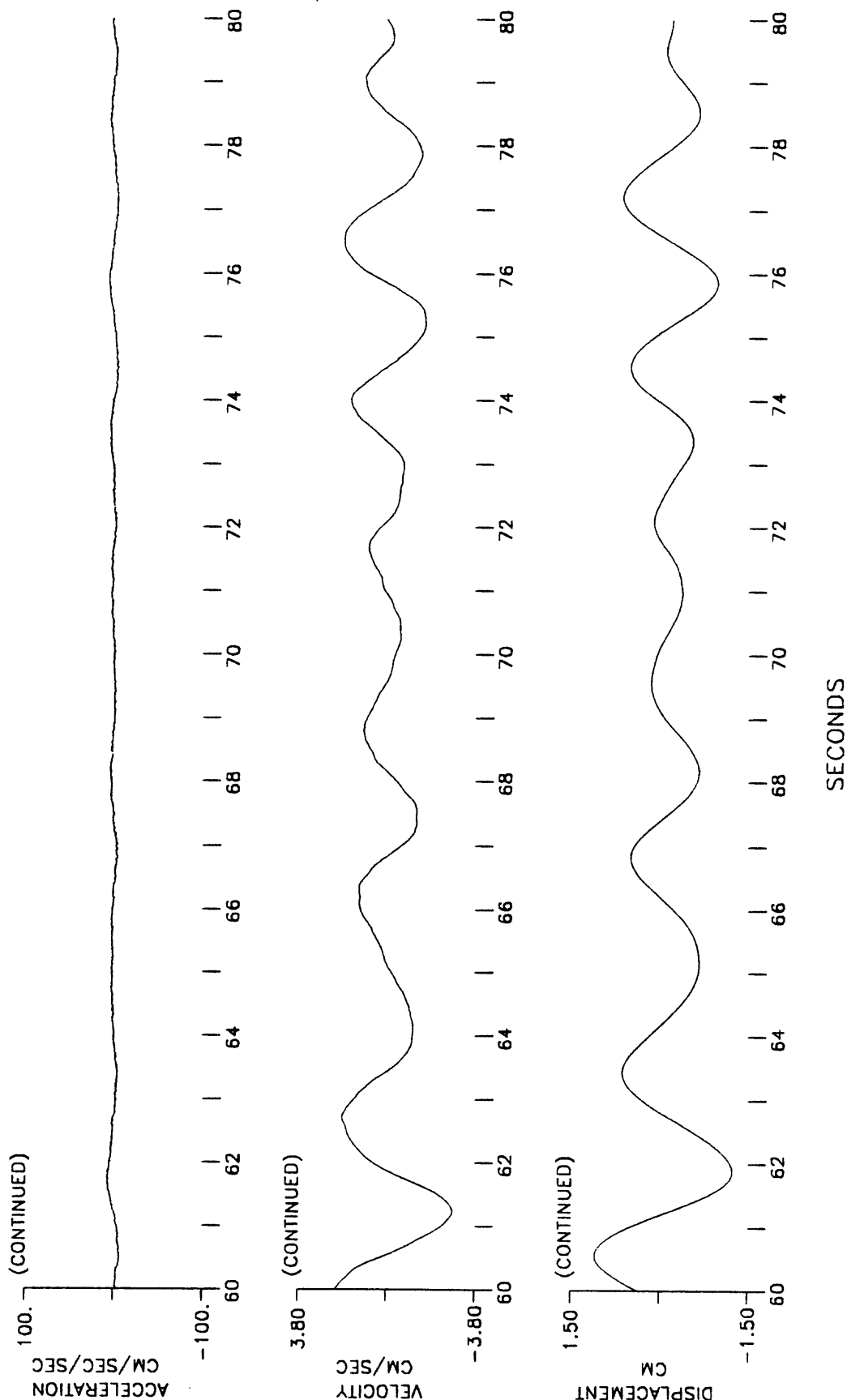


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
UP

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=99.67 CM/SEC/SEC, VELOCITY=-3.80 CM/SEC, DISPL=-1.41 CM.

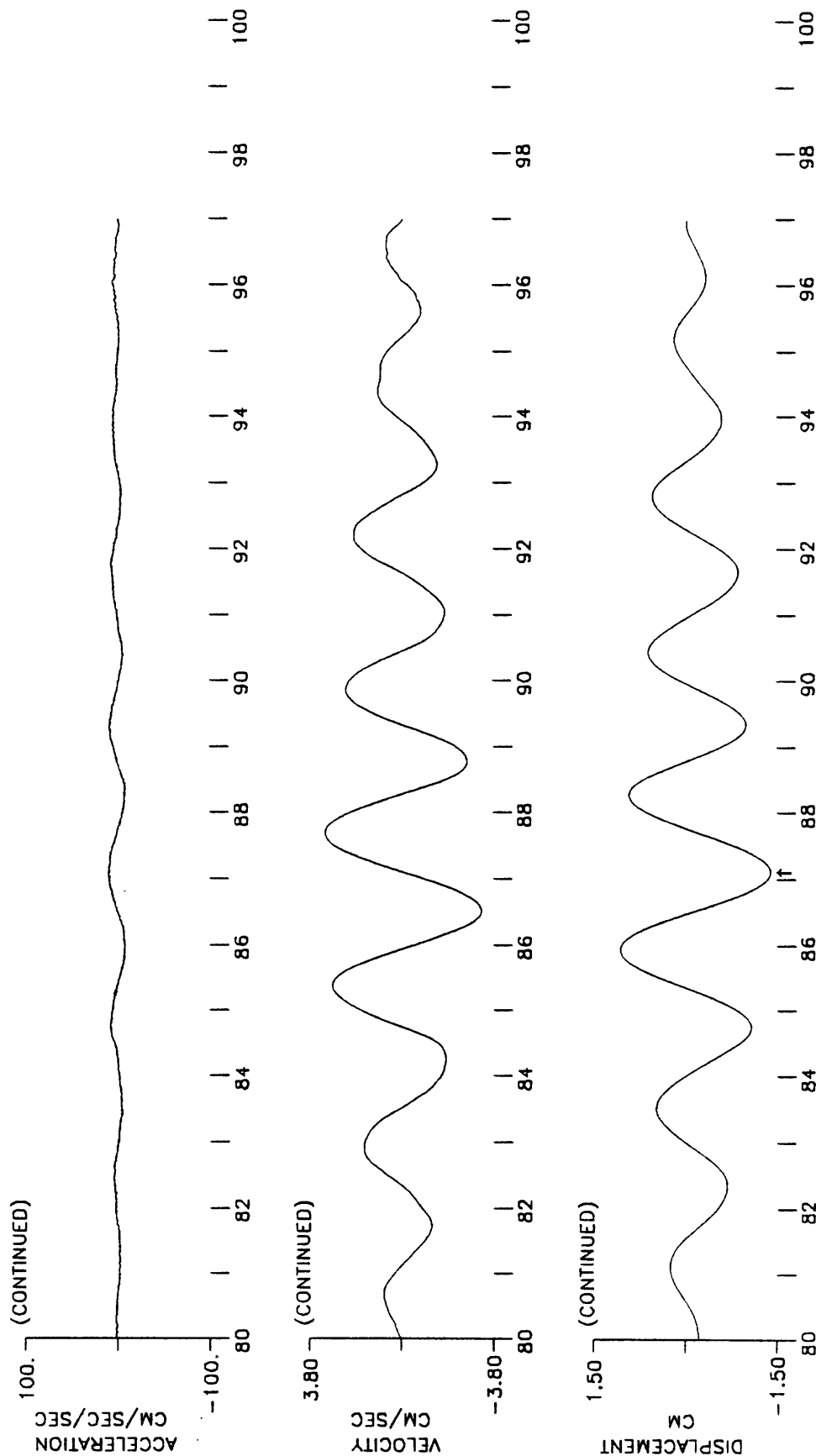


CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

UP

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=99.67 CM/SEC/SEC, VELOCITY=-3.80 CM/SEC, DISPL=-1.41 CM.



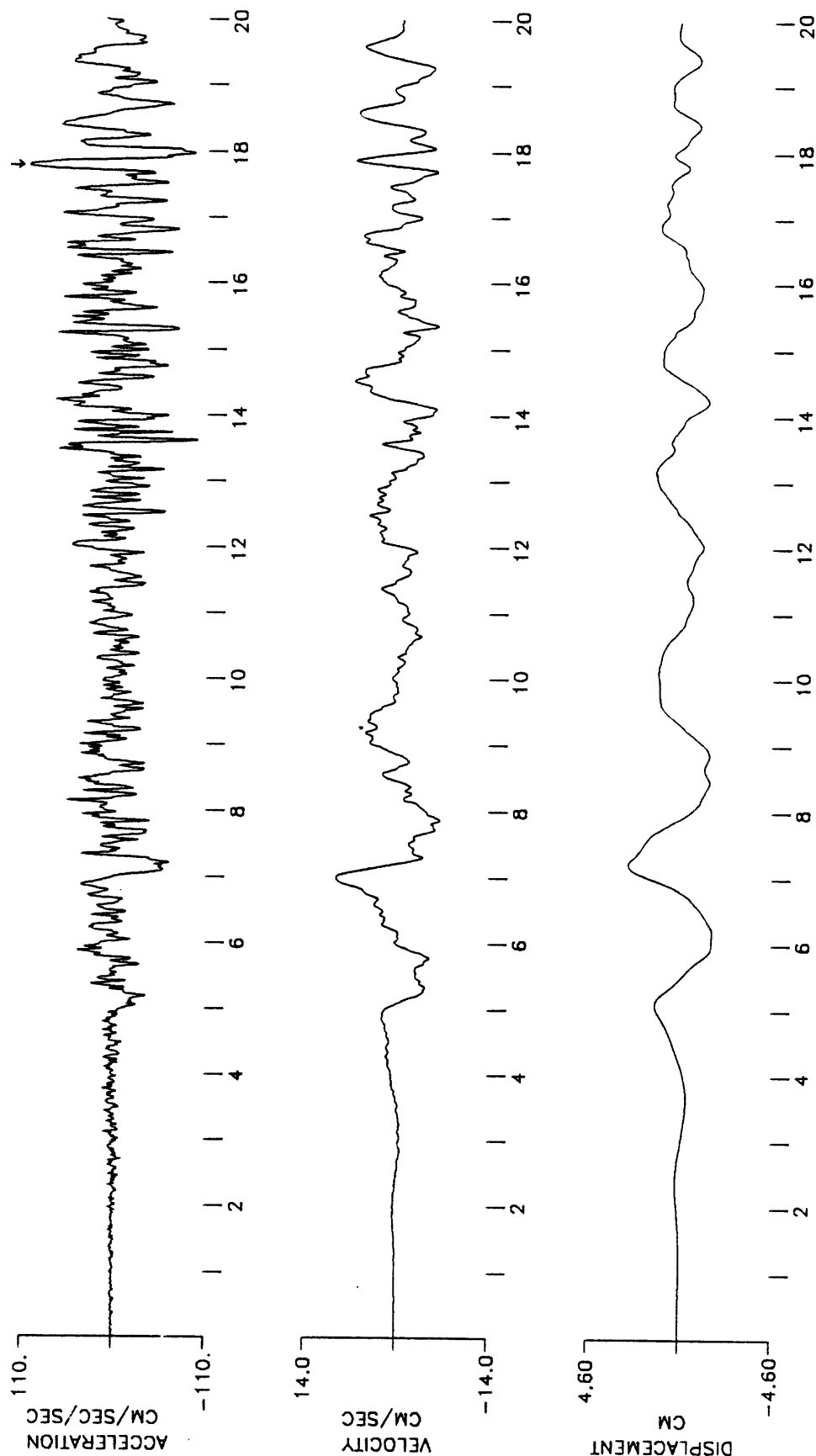
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

090 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

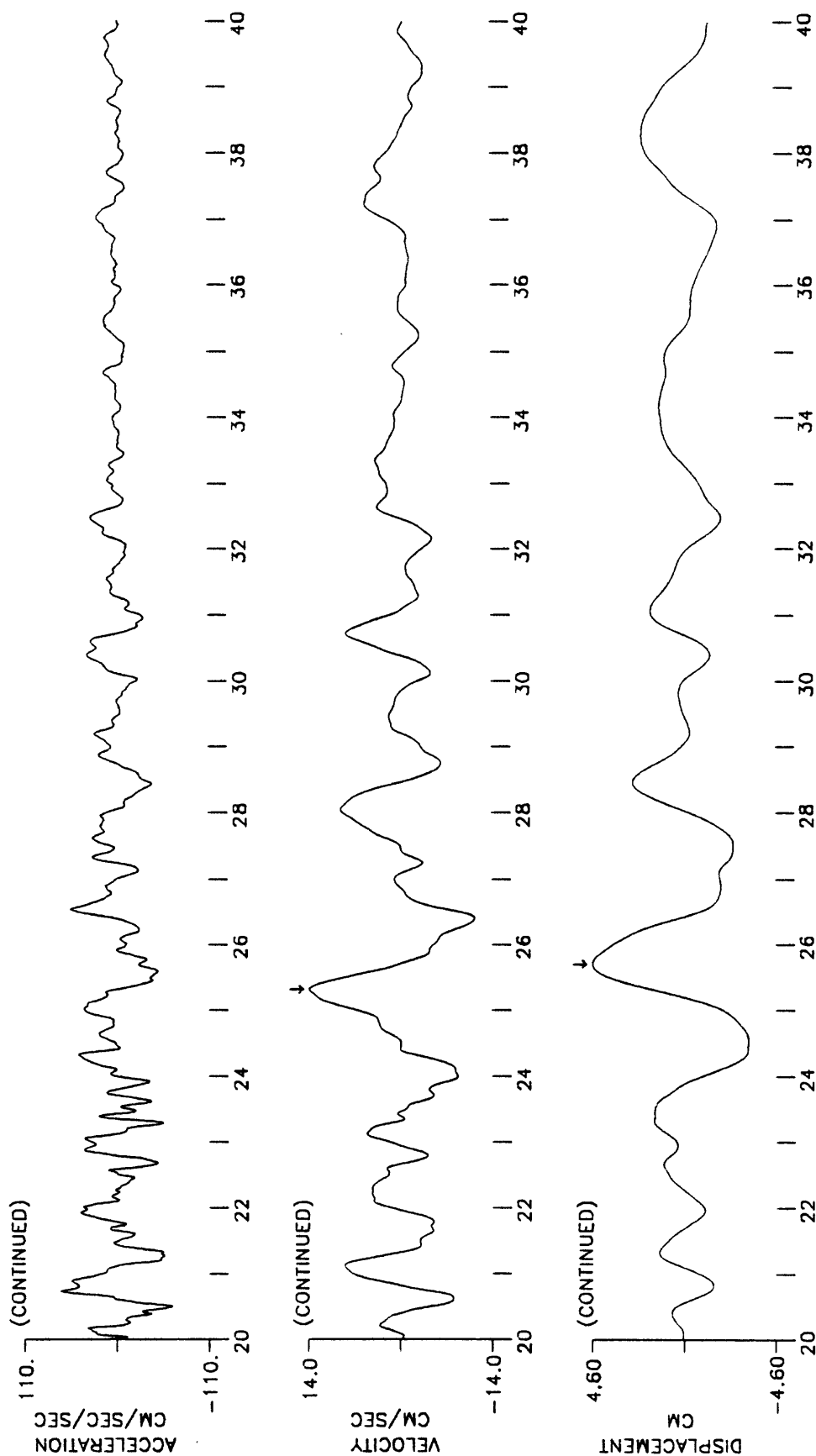
PEAK VALUES: ACCEL=103.29 CM/SEC/SEC, VELOCITY=13.76 CM/SEC, DISPL=4.54 CM.



CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
090 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=103.29 CM/SEC/SEC, VELOCITY=13.76 CM/SEC, DISPL=4.54 CM.

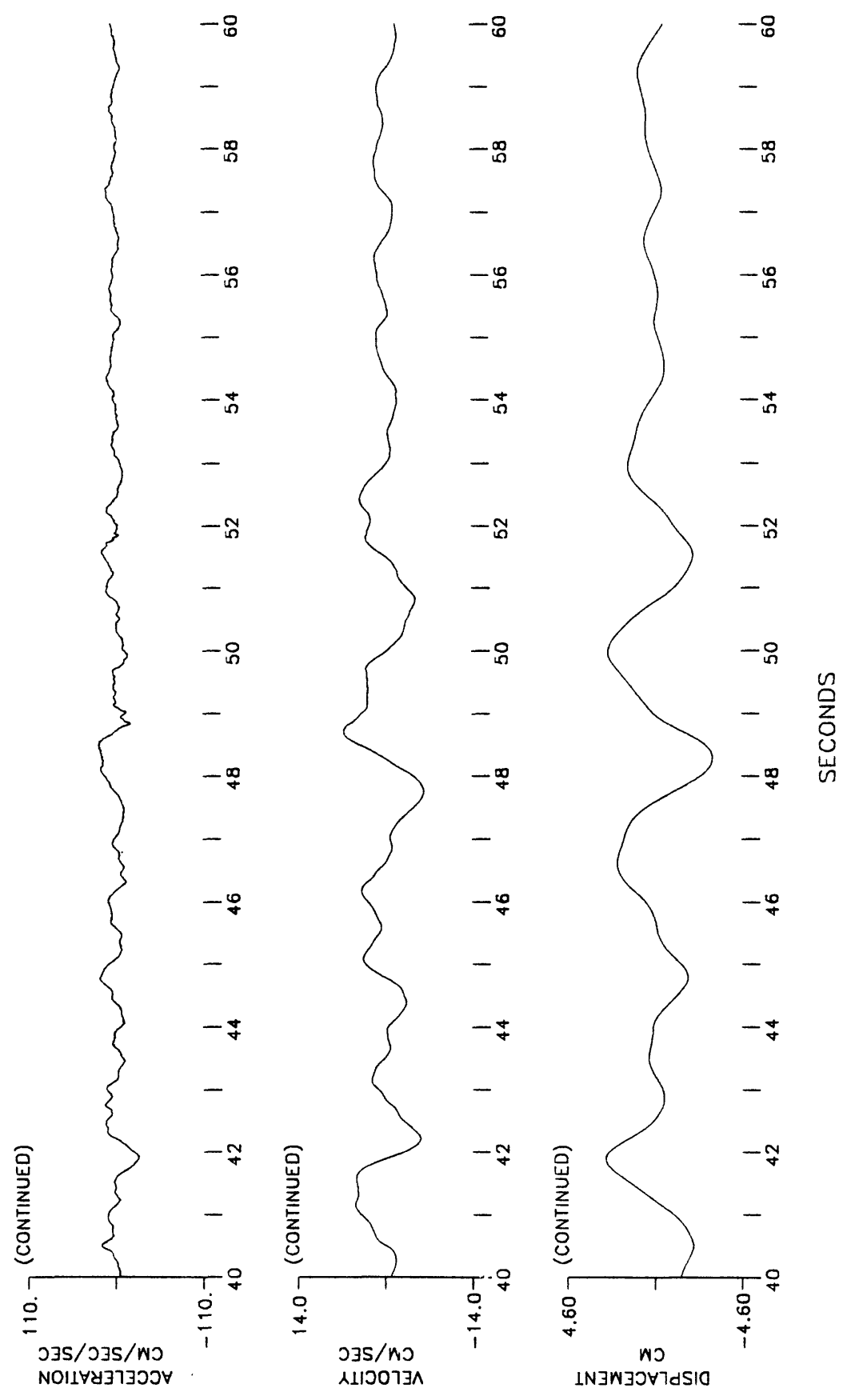


SECONDS

CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

090 DEGREES, APPROX.
EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=103.29 CM/SEC/SEC, VELOCITY=13.76 CM/SEC, DISPL=4.54 CM.



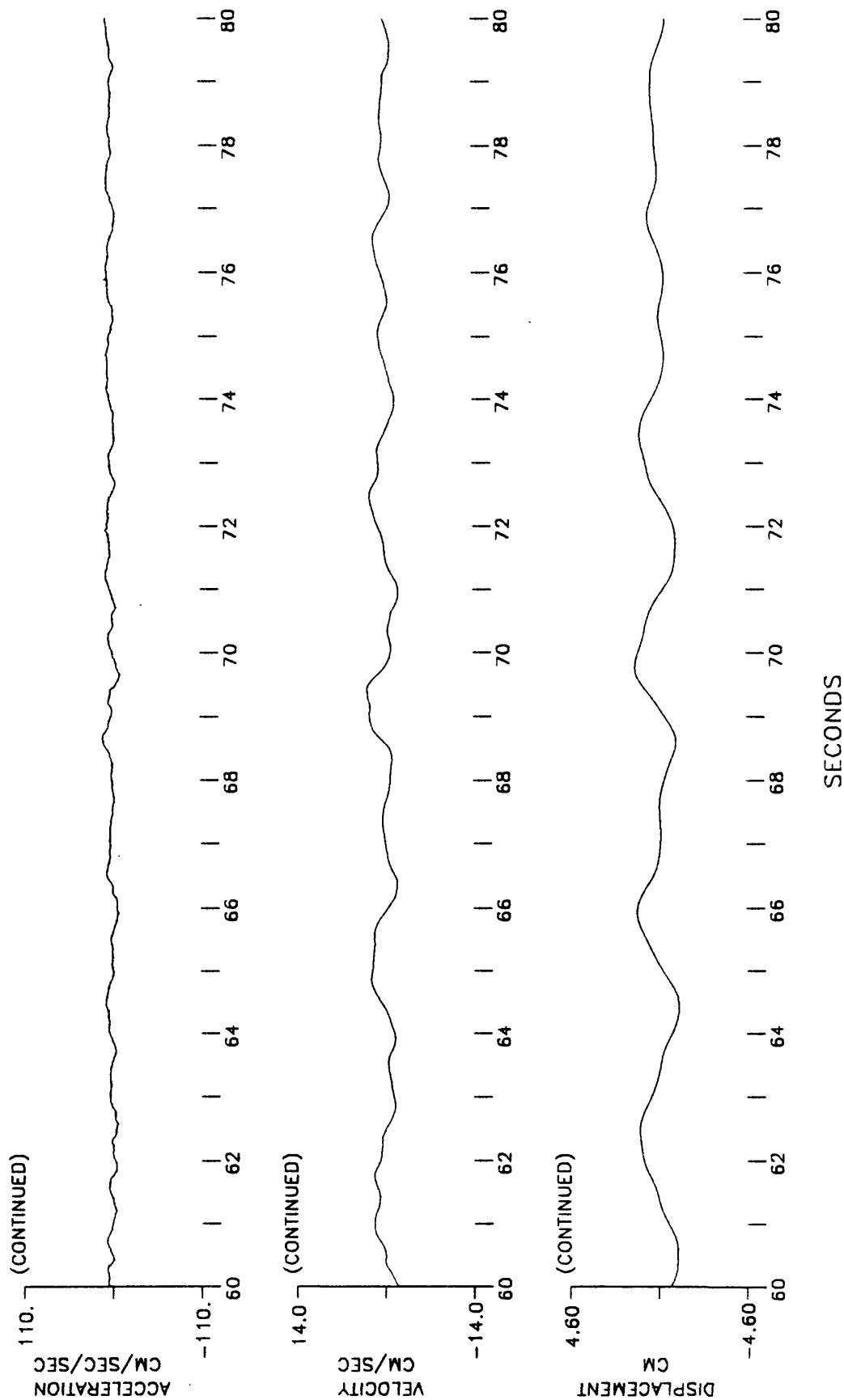
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

090 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

PEAK VALUES: ACCEL=103.29 CM/SEC/SEC, VELOCITY=13.76 CM/SEC, DISPL=4.54 CM.



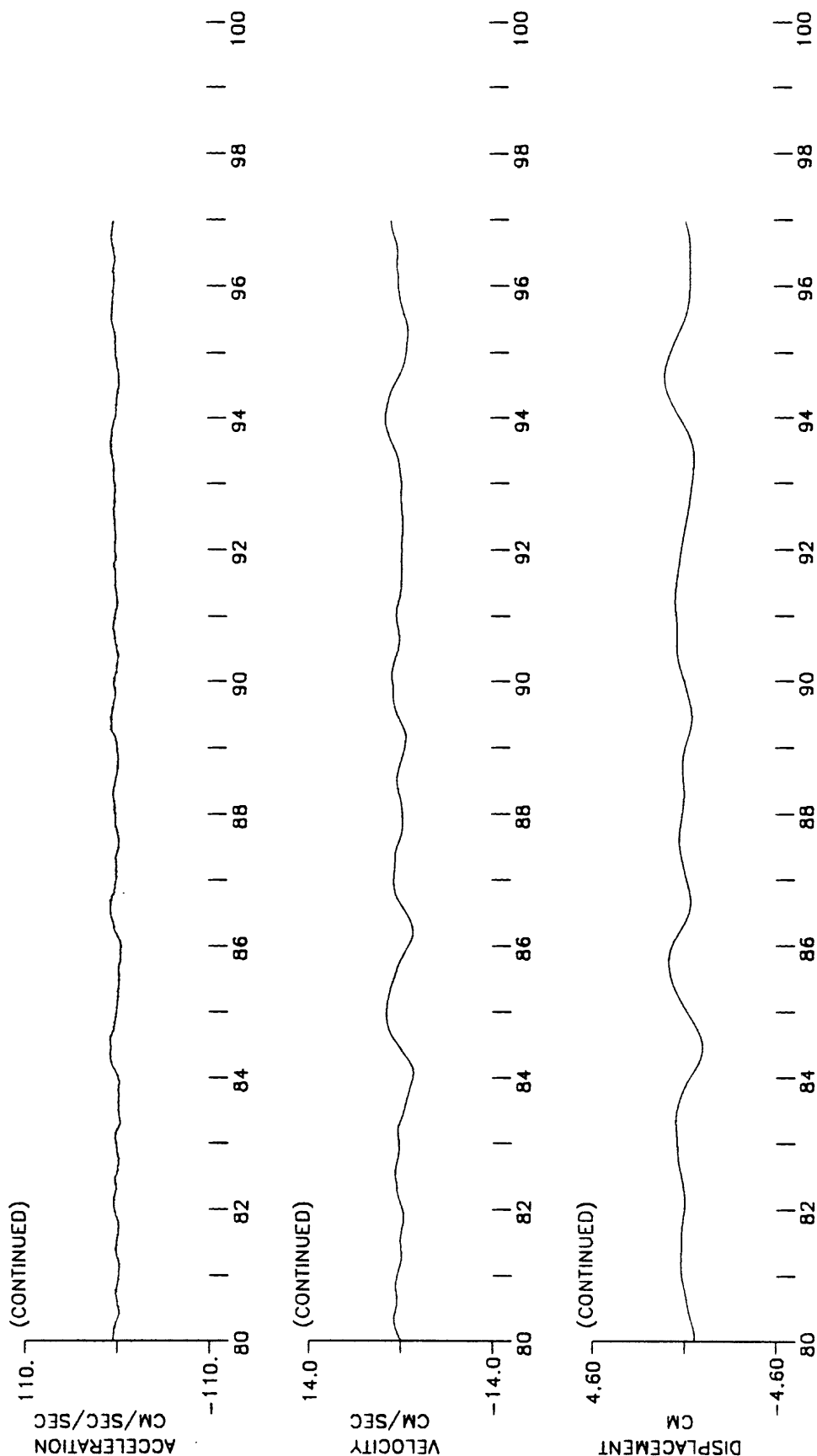
CORRECTED ACCELERATION, VELOCITY, AND DISPLACEMENT 200.00 SPS
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

090 DEGREES, APPROX.

EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT

BUTTERWORTH AT .25 HZ, ORDER 4

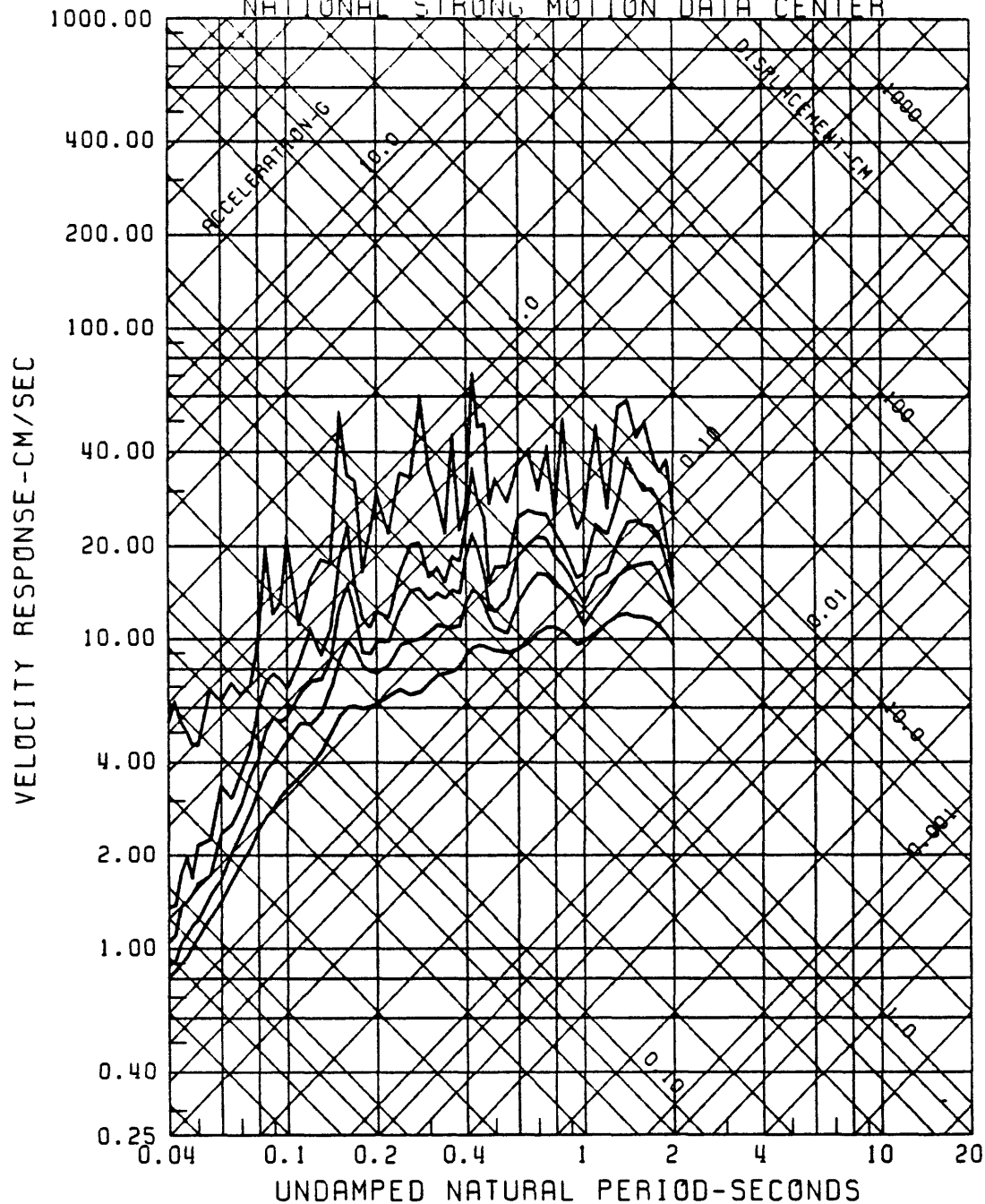
PEAK VALUES: ACCEL=103.29 CM/SEC/SEC, VELOCITY=13.76 CM/SEC, DISPL=4.54 CM.



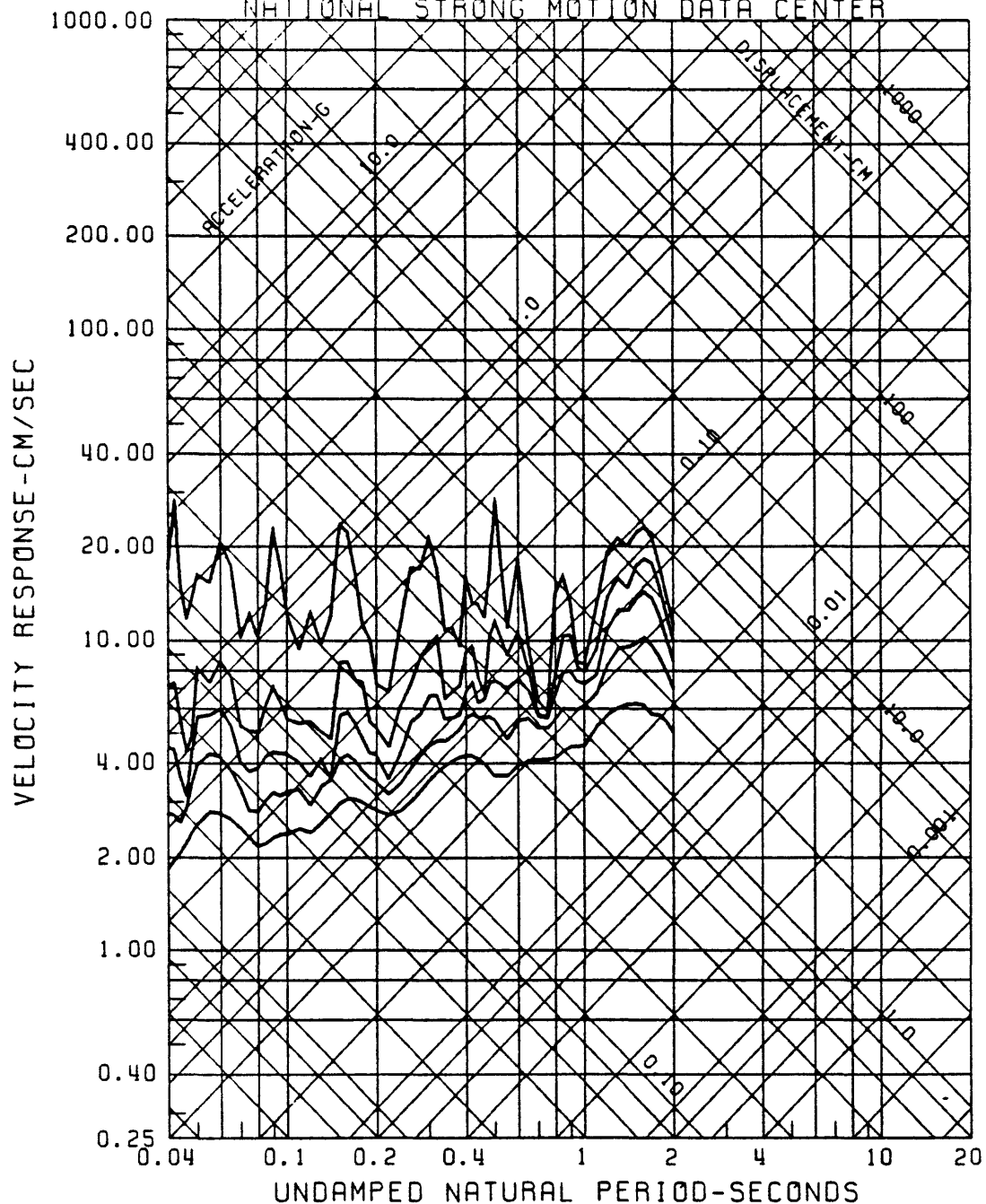
SECONDS

APPENDIX 3
RESPONSE SPECTRUM; TRIPARTITE PLOT

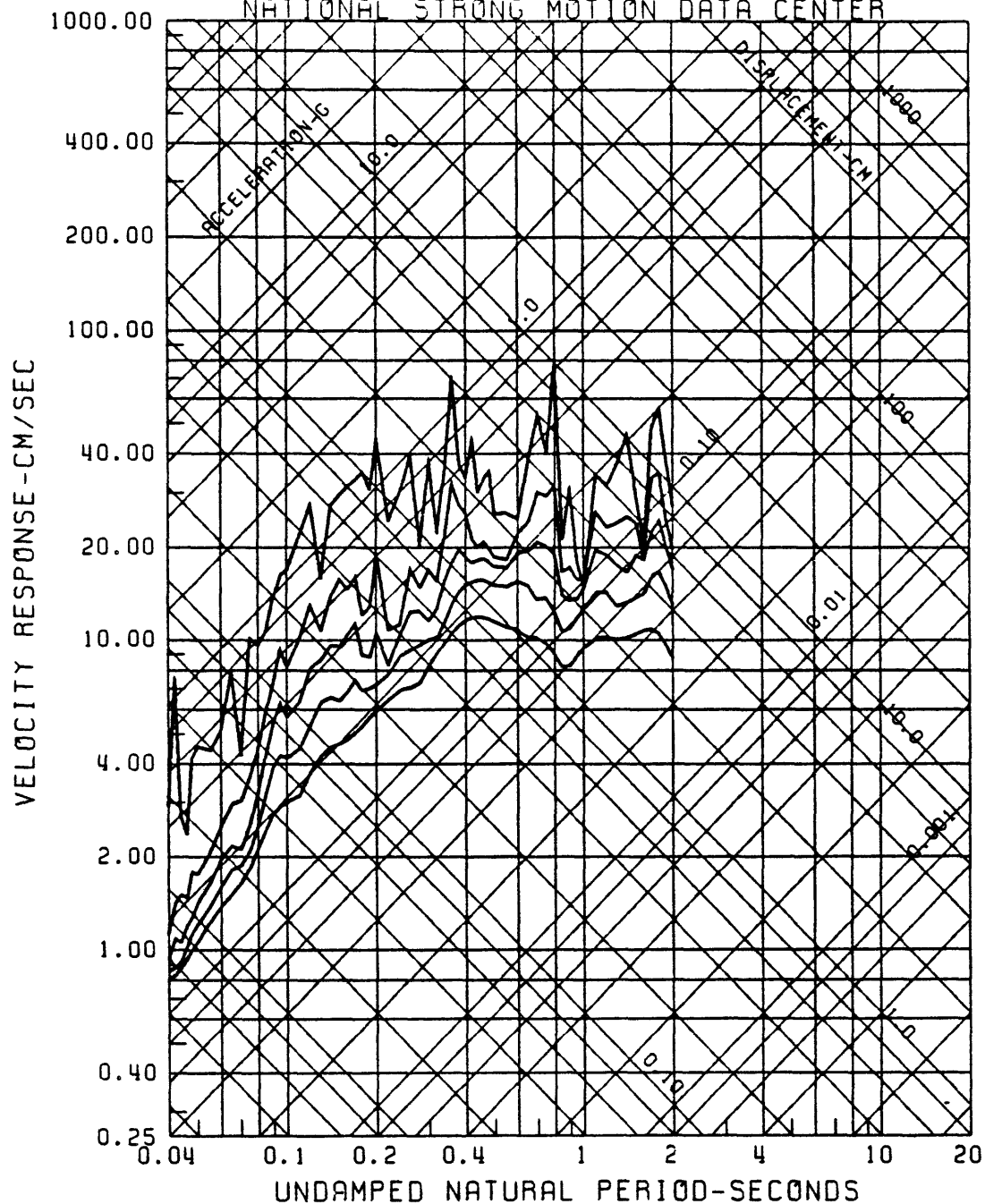
RESPONSE SPECTRA 11/24/87. 0154UTC
 WILDLIFE LIQUEFACTION ARRAY, SURFACE, 360 DEGREES
 0.2, 5, 10, 20 PERCENT CRITICAL DAMPING
 FILTERS: BUTTERWORTH, ORDER 4, 0.500 HZ; ANTIALIAS 50 - 100 HZ
 NATIONAL STRONG MOTION DATA CENTER



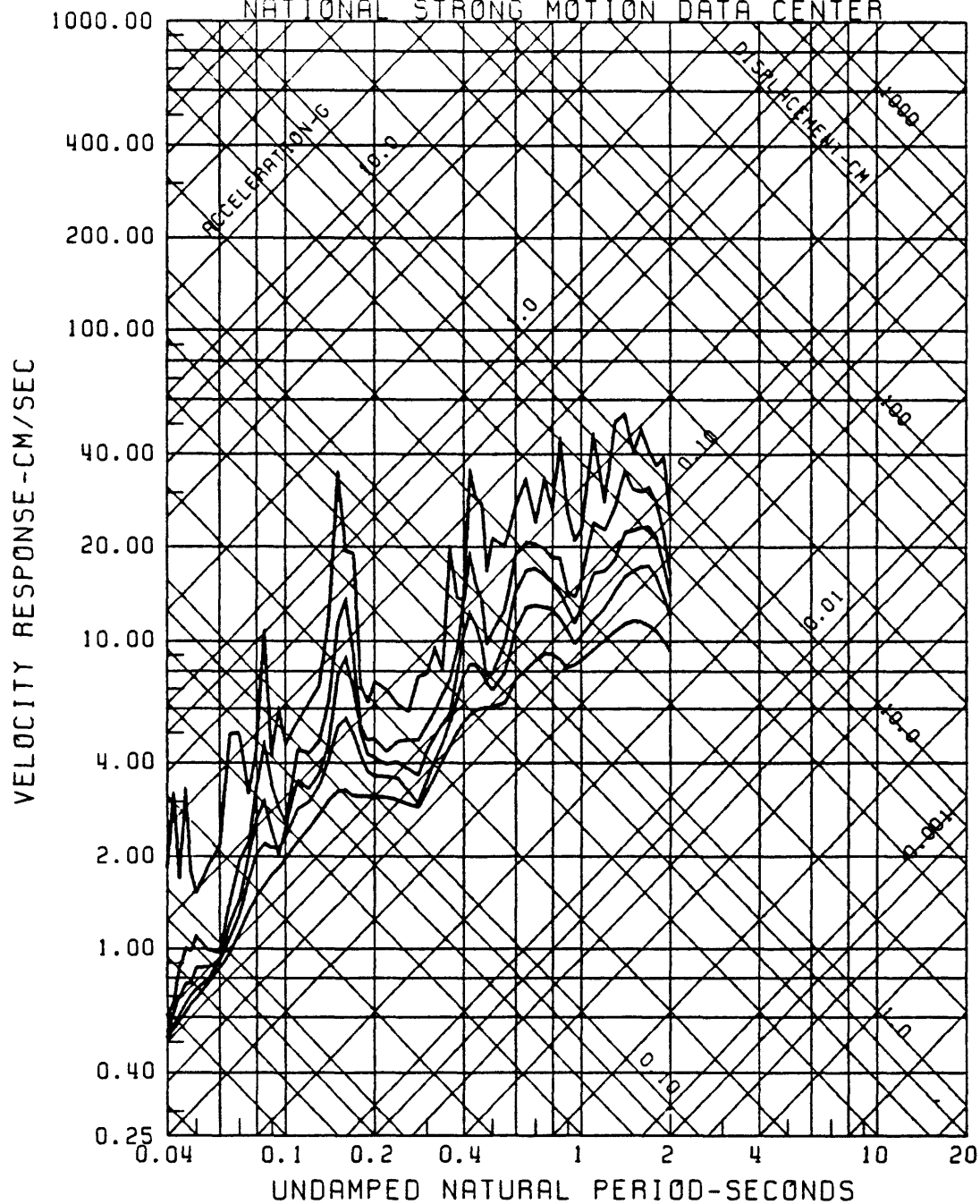
RESPONSE SPECTRA 11/24/87. 0154UTC
 WILDLIFE LIQUEFACTION ARRAY, SURFACE, UP
 0.2, 5, 10, 20 PERCENT CRITICAL DAMPING
 FILTERS: BUTTERWORTH, ORDER 4, 0.500 HZ; ANTIALIAS 50 - 100 HZ
 NATIONAL STRONG MOTION DATA CENTER



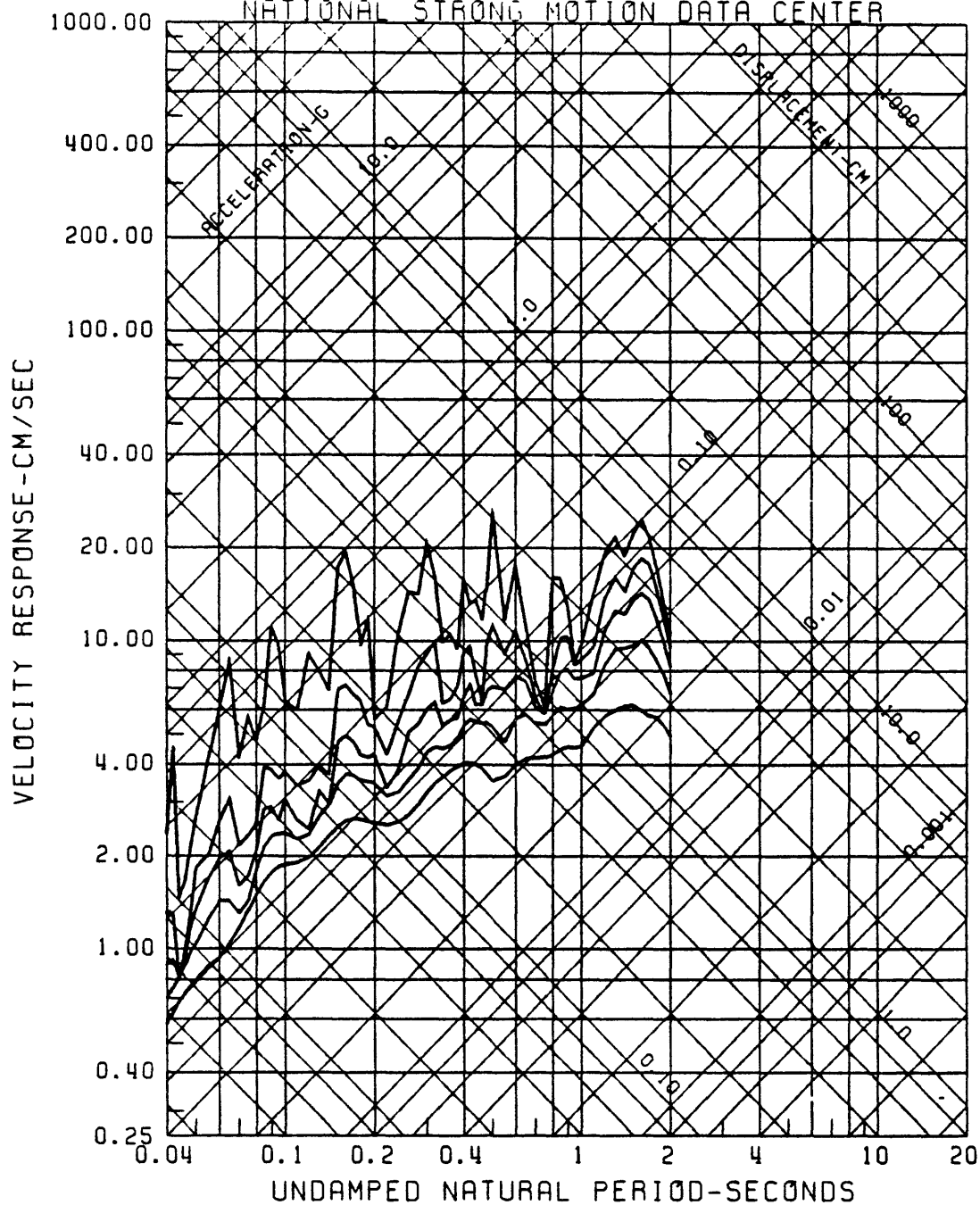
RESPONSE SPECTRA 11/24/87. 0154UTC
 WILDLIFE LIQUEFACTION ARRAY, SURFACE, 90 DEGREES
 0.2,5,10,20 PERCENT CRITICAL DAMPING
 FILTERS: BUTTERWORTH, ORDER 4, 0.500 HZ; ANTIALIAS 50 - 100 HZ
 NATIONAL STRONG MOTION DATA CENTER



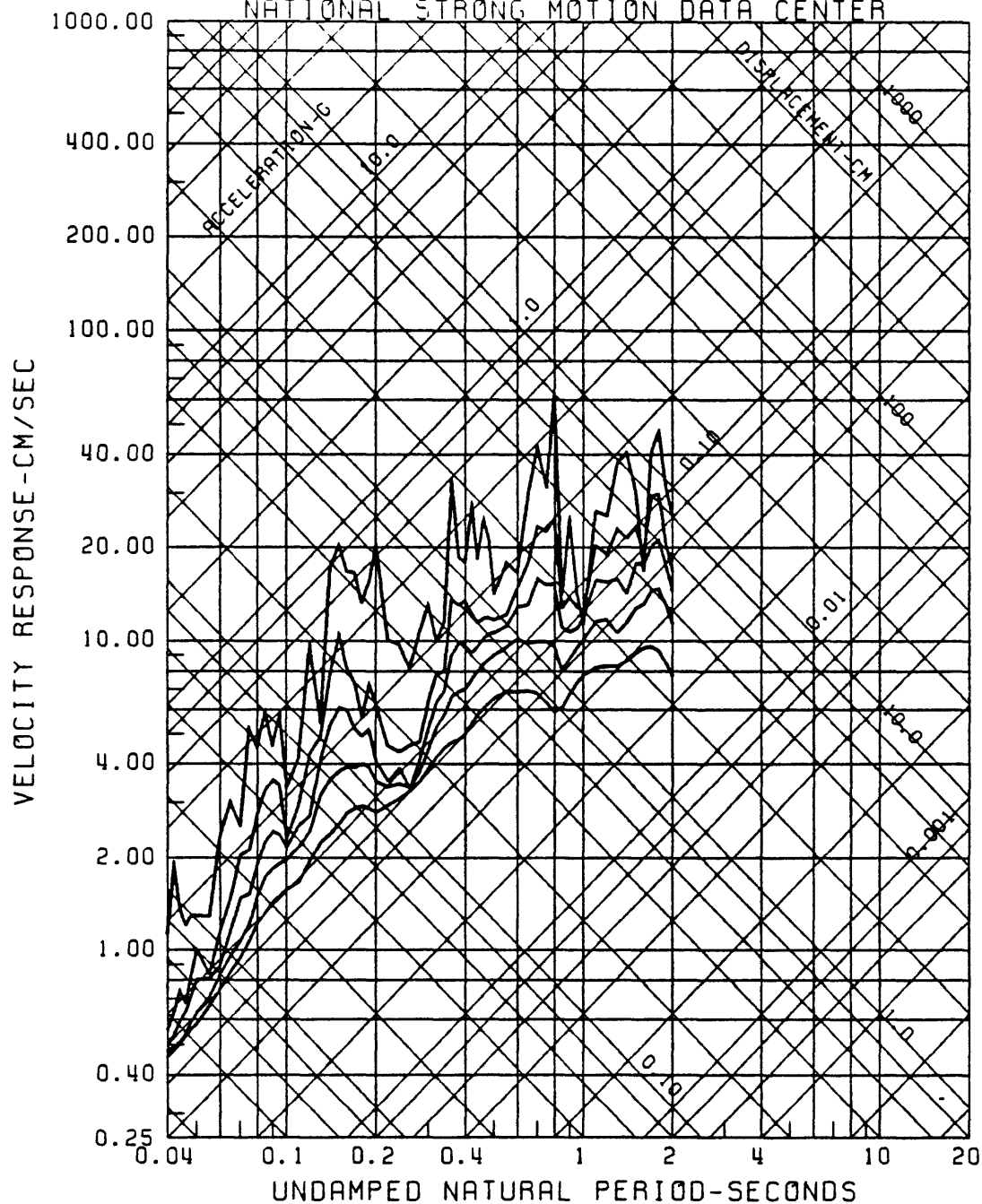
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE, 11/24/87, 0154UTC 360
0, 2.5, 10, 20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.500 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



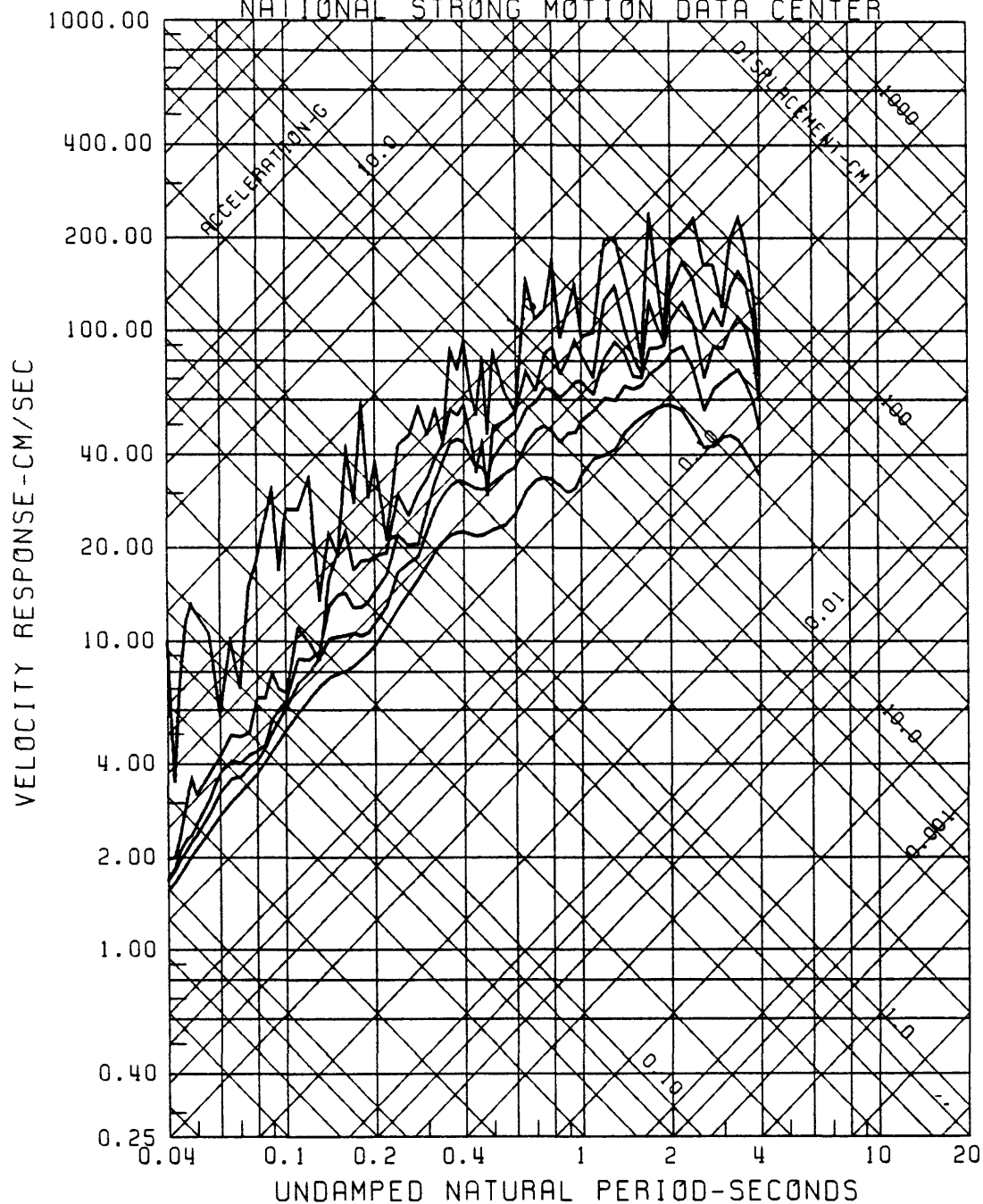
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION AREA, DOWNHOLE, 11/24/87, 0154UTC UP
0.2, 5, 10, 20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.500 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



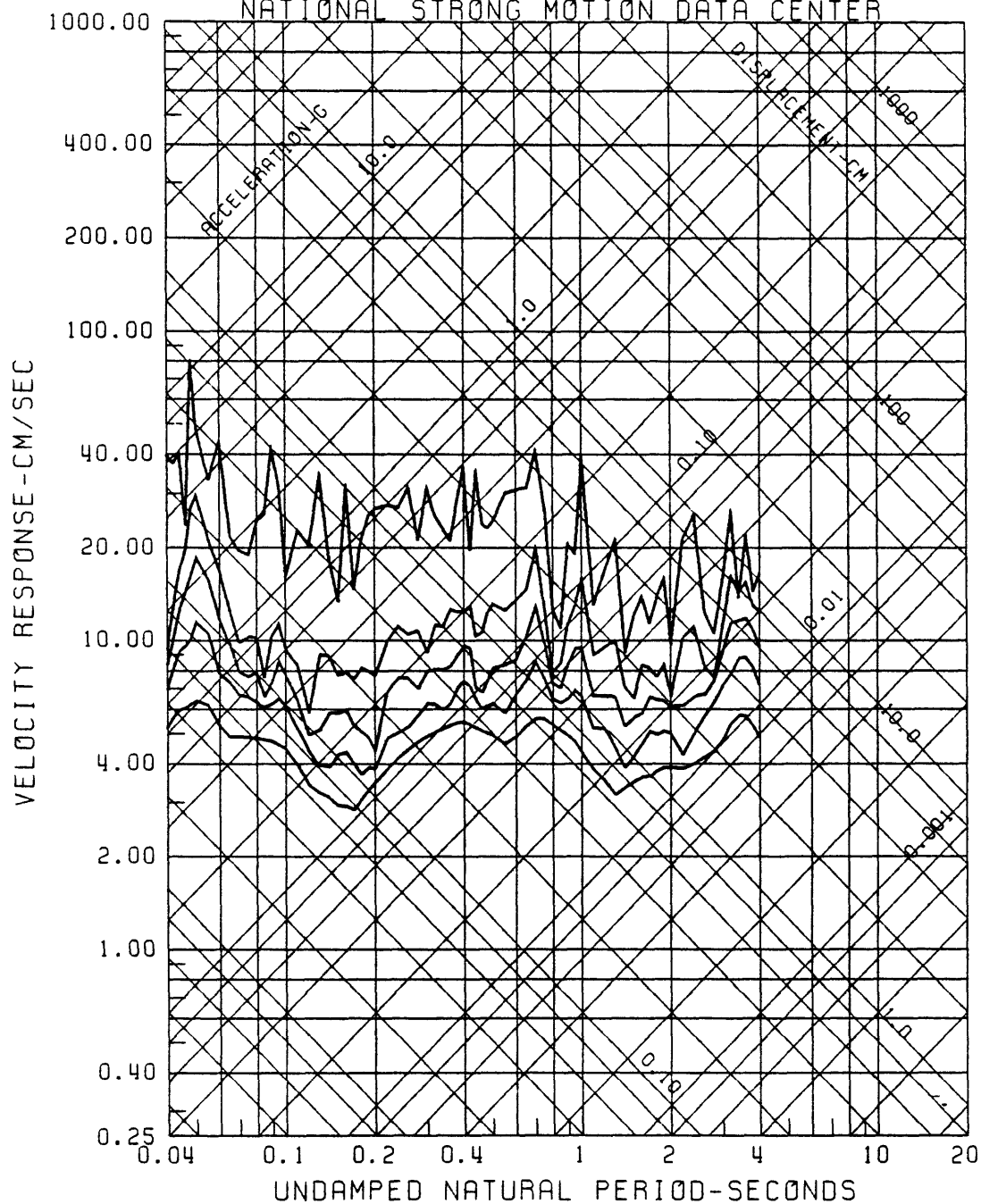
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE, 11/24/87, 0154UTC 90
0.2, 5, 10, 20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.500 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



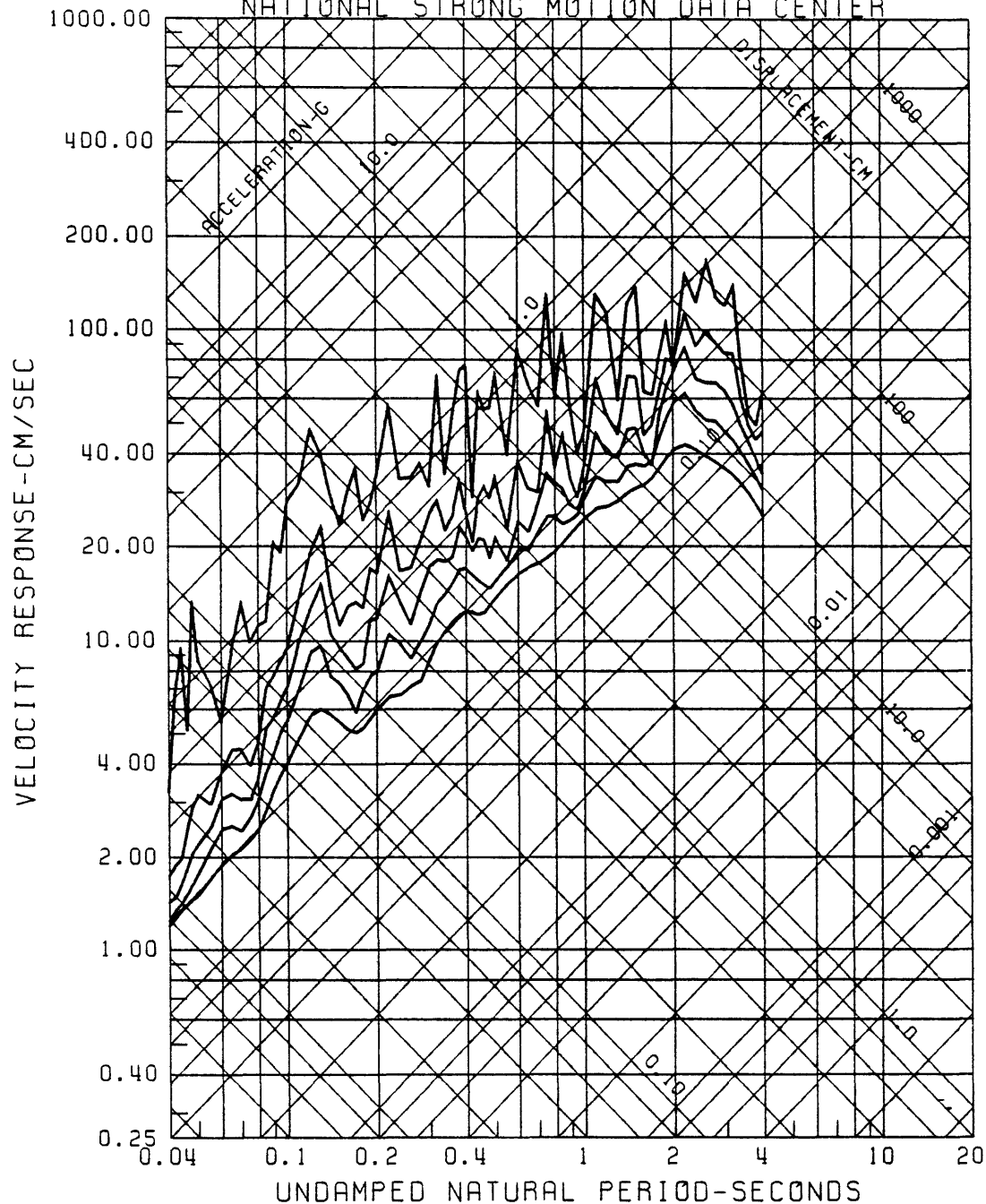
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, SURFACE, 11/24/87, 1315GMT 360 DEG
0.2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.250 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



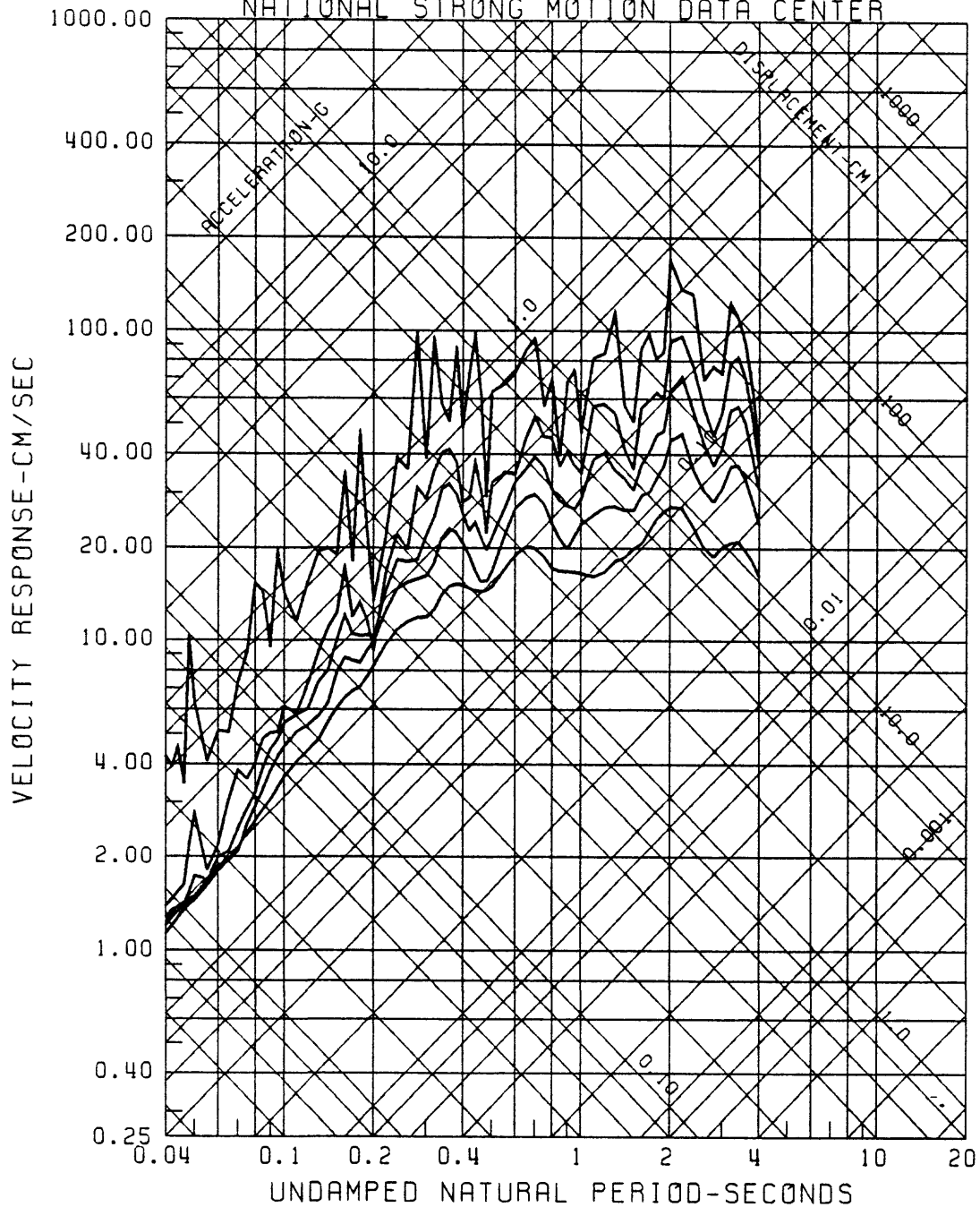
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, SURFACE, 11/24/87, 1315GMT UP
0.2, 5, 10, 20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.250 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



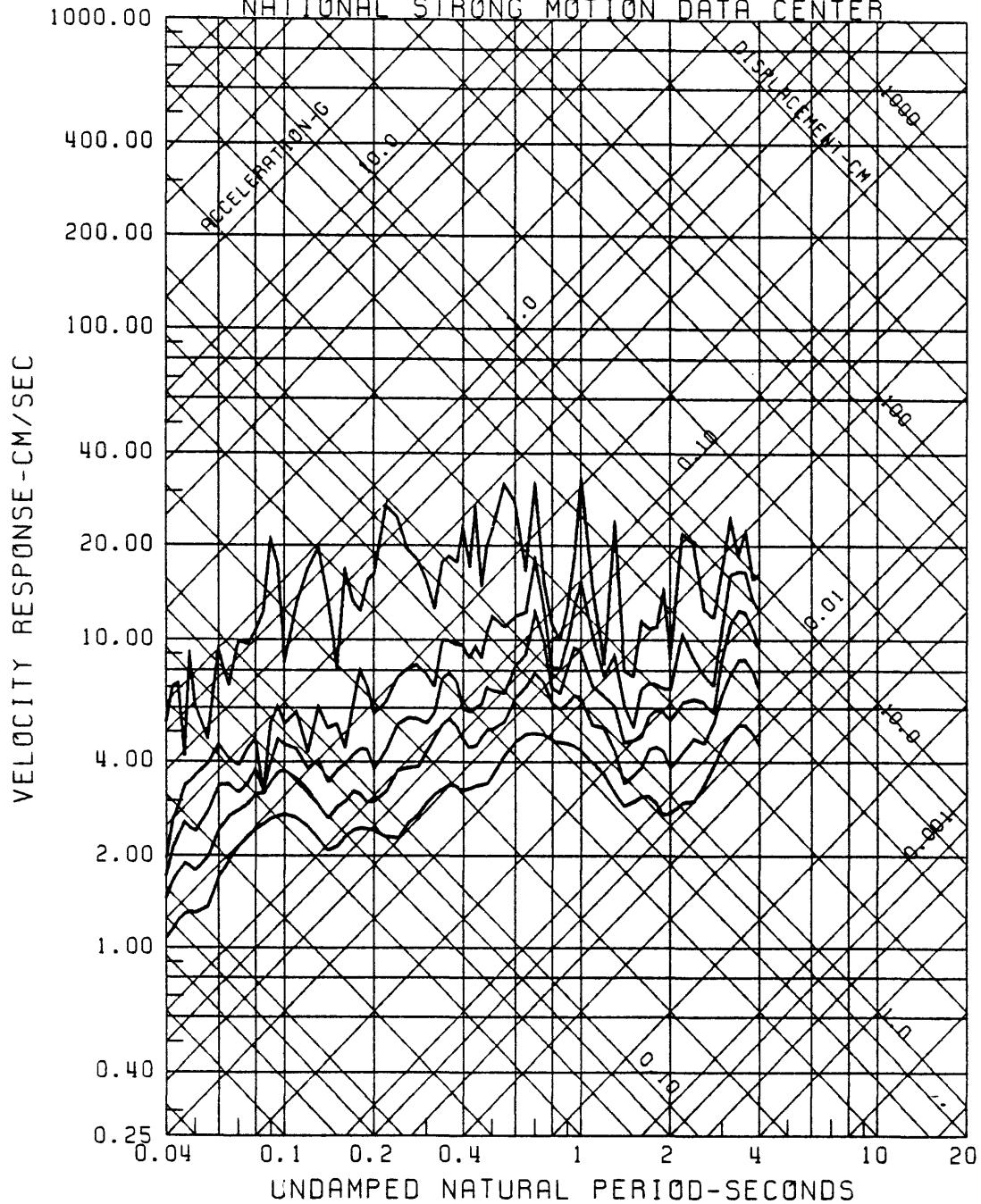
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, SURFACE, 11/24/87, 1315GMT 90 DEG
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.250 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



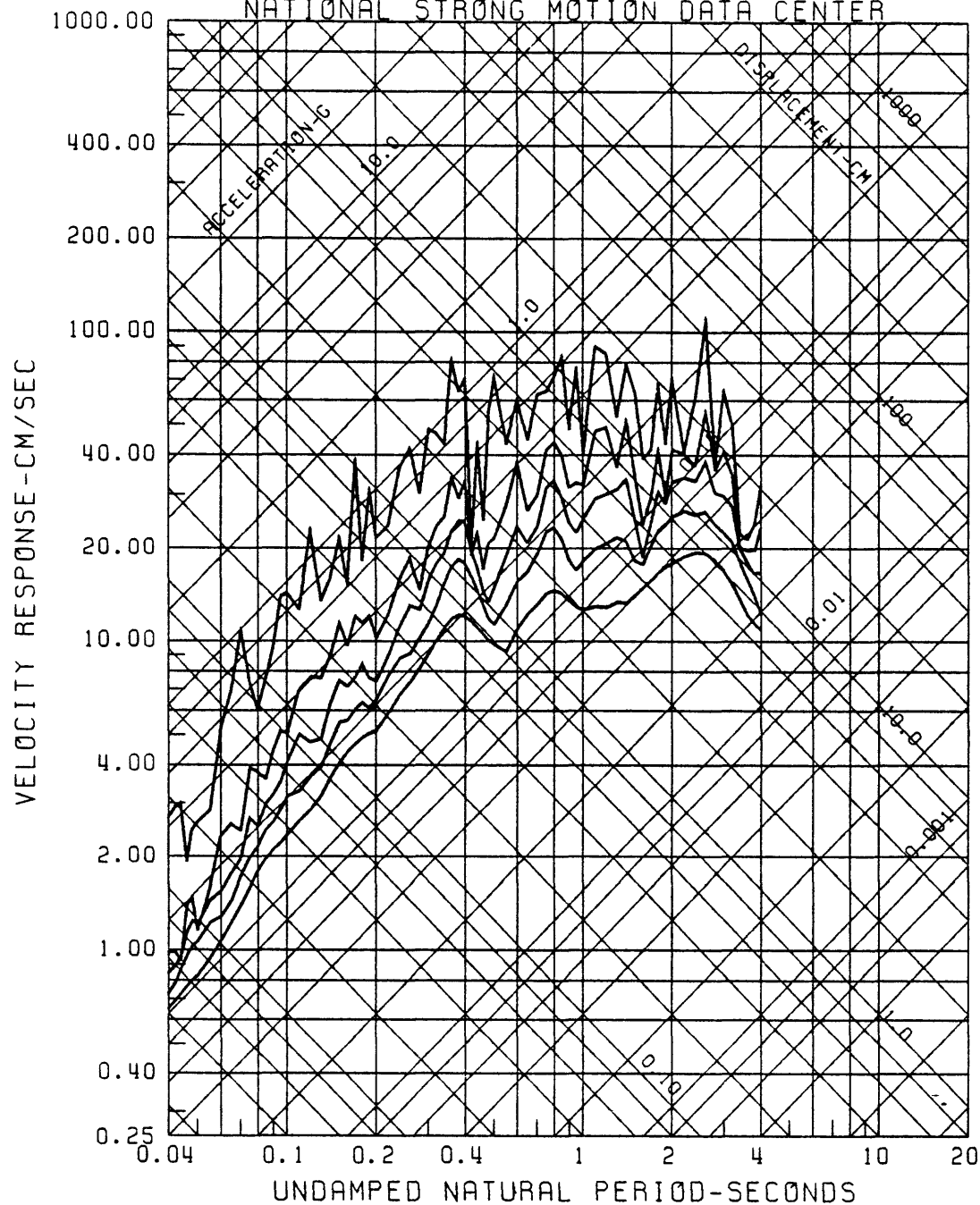
RESPONSE SPECTRA
 WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE, 11/24/87, 1315GMT 360 DEG
 0,2,5,10,20 PERCENT CRITICAL DAMPING
 FILTERS: BUTTERWORTH, ORDER 4, 0.250 HZ; ANTIALIAS 50 - 100 HZ
 NATIONAL STRONG MOTION DATA CENTER



RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE, 11/24/87, 1315GMT UP
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.250 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



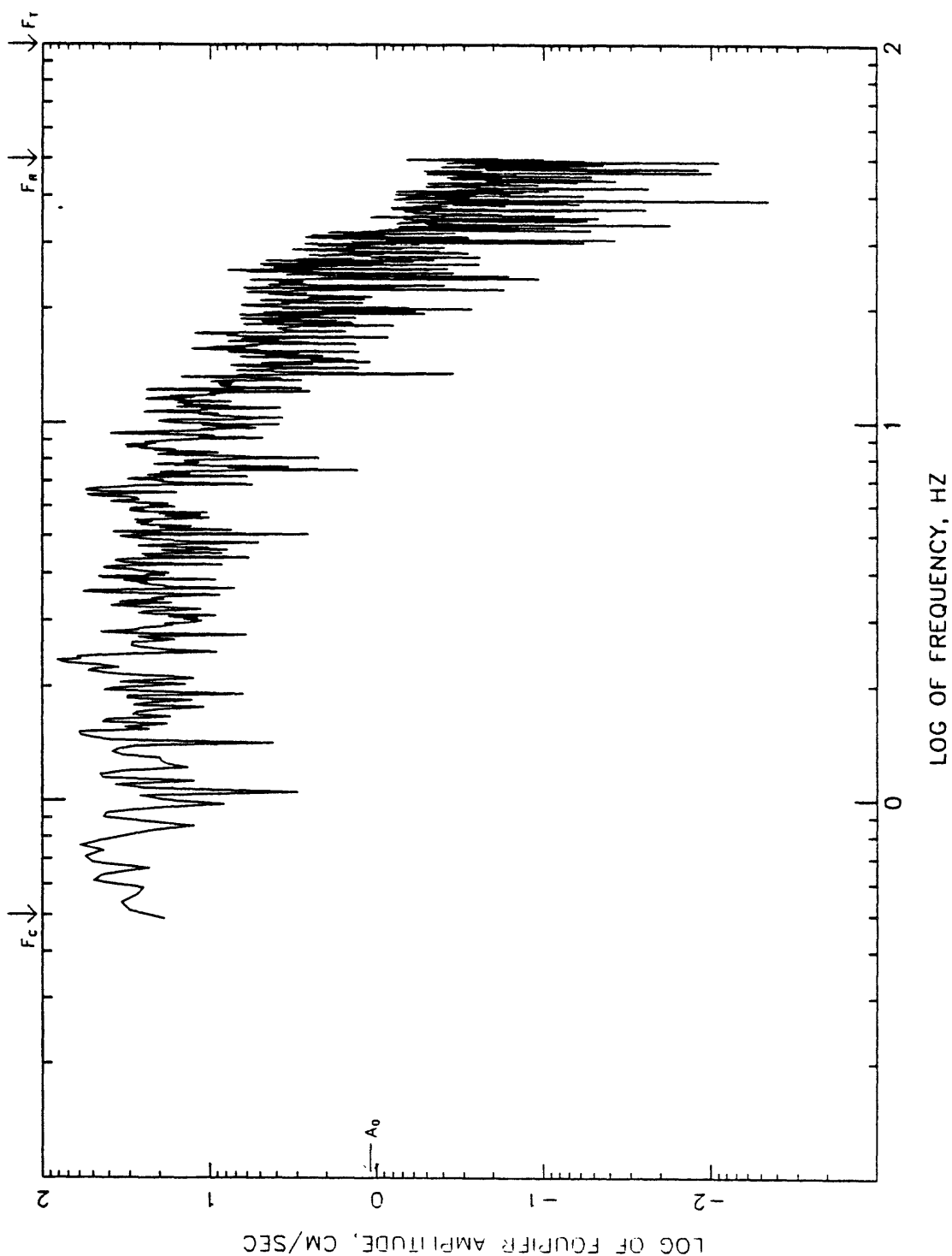
RESPONSE SPECTRA
WILDLIFE LIQUEFACTION ARRAY, DOWNHOLE, 11/24/87, 1315GMT 090 DEG
0,2,5,10,20 PERCENT CRITICAL DAMPING
FILTERS: BUTTERWORTH, ORDER 4, 0.250 HZ; ANTIALIAS 50 - 100 HZ
NATIONAL STRONG MOTION DATA CENTER



APPENDIX 4

FOURIER AMPLITUDE SPECTRUM; LOG-LOG PLOT

FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES
 EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
 BUTTERWORTH AT .5 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS, NONNOISE



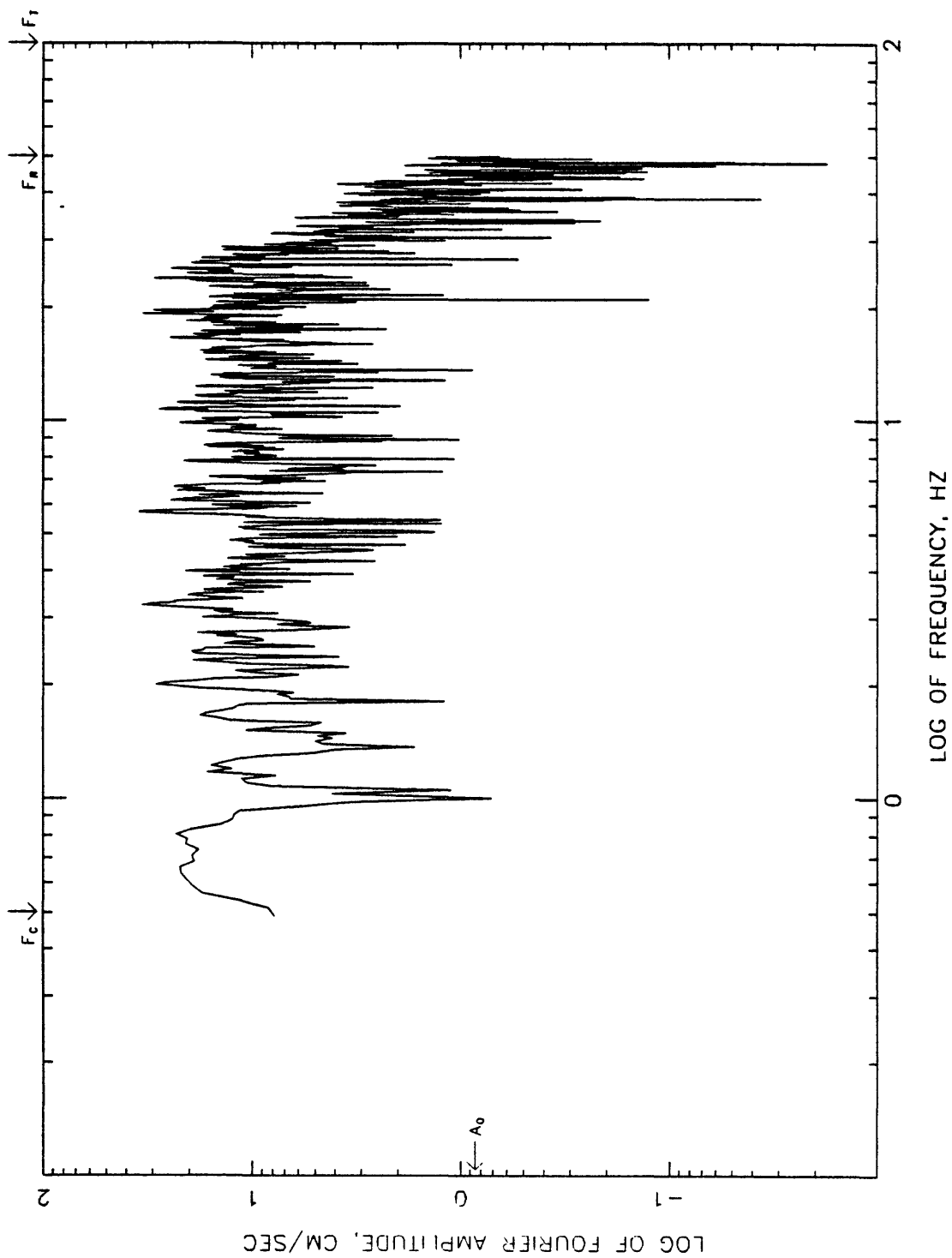
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WILDLIFE LIQUEFACTION ARRAY, SURFACE

UP

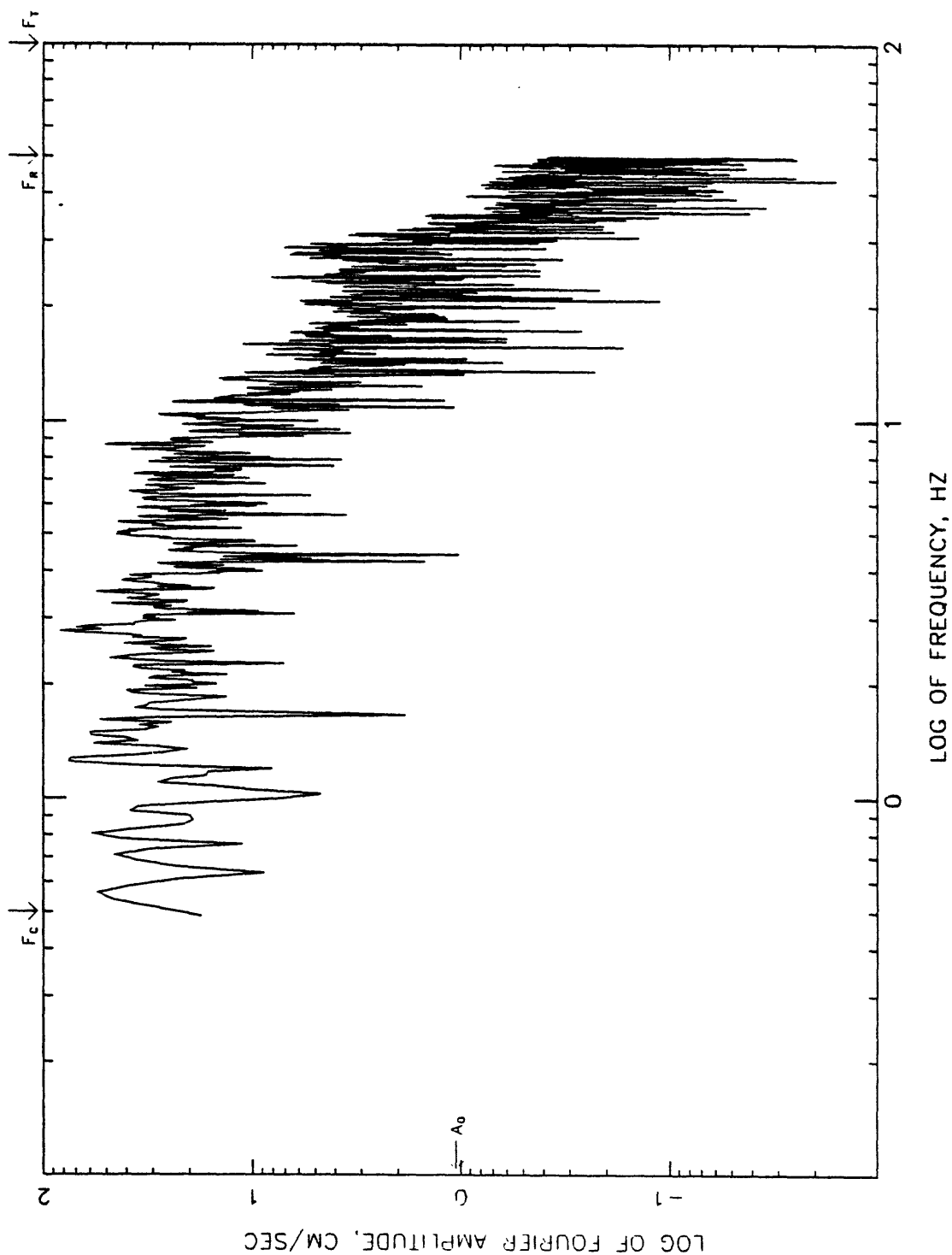
EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT

BUTTERWORTH AT .5 HZ, ORDER 4

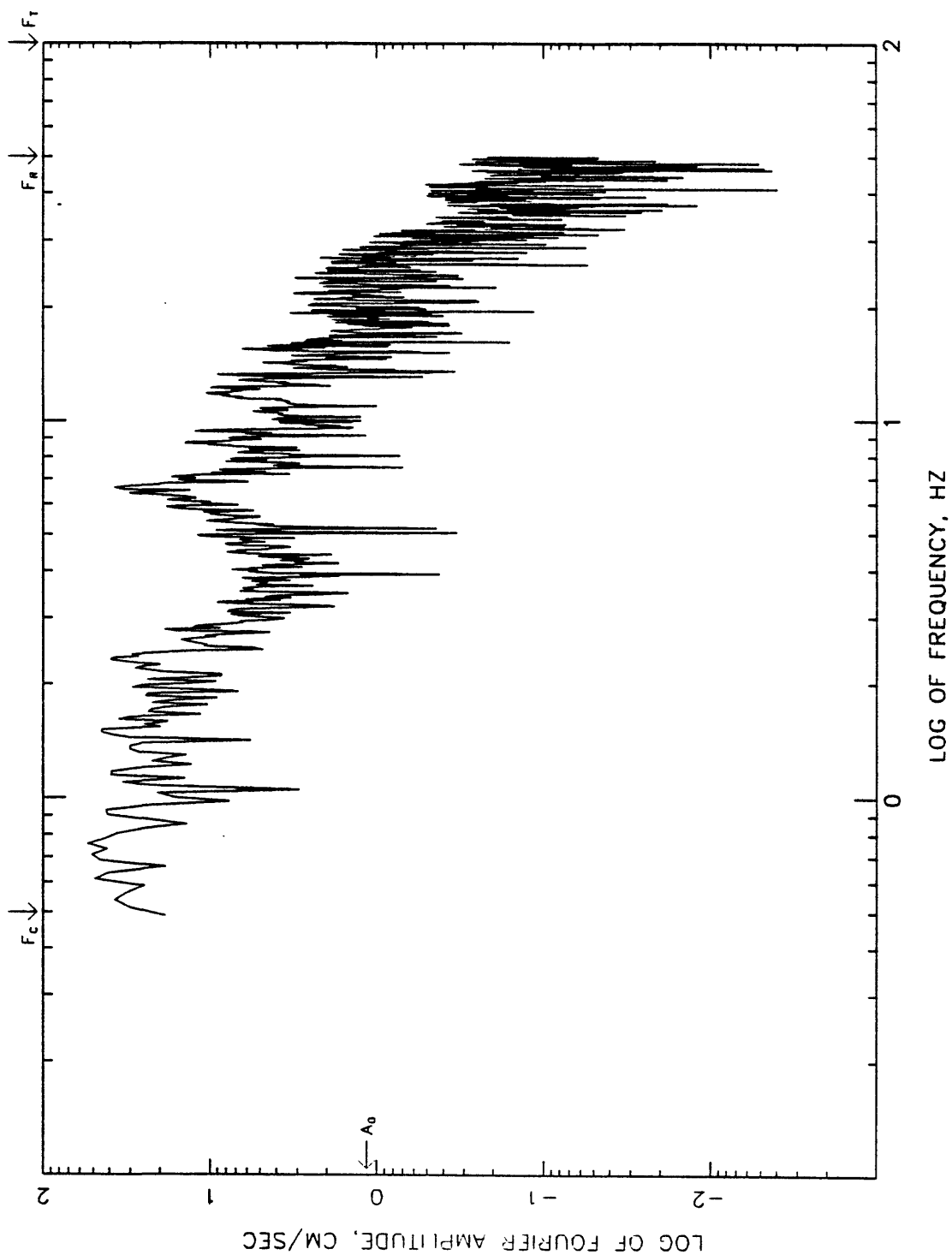
COMPUTING OPTIONS= ZCROSS,NONNOISE



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 090 DEGREES
 EARTHQUAKE OF 24 NOVEMBER, 1987 0154 GMT
 BUTTERWORTH AT .5 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
 360 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 BUTTERWORTH AT .5 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



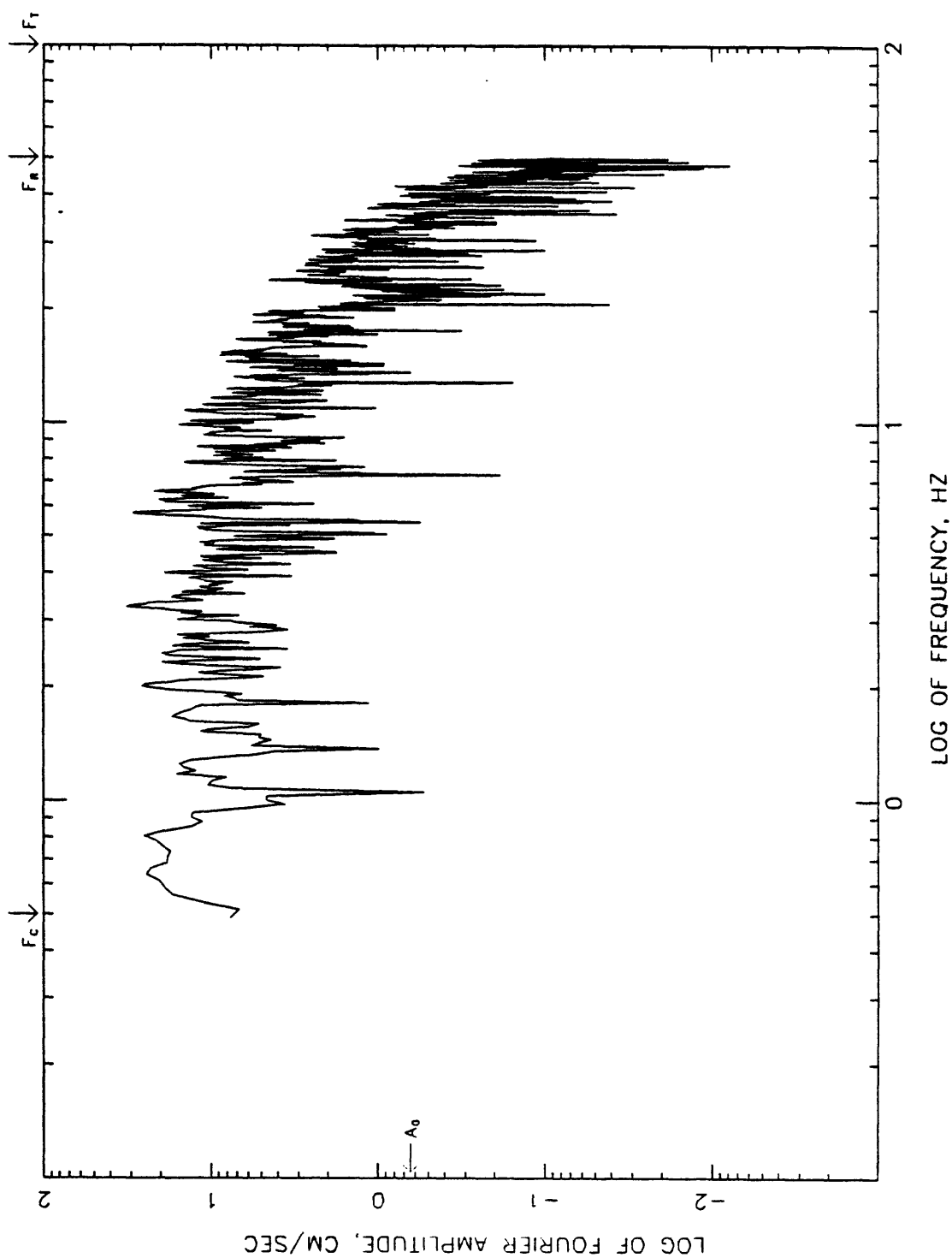
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE

UP

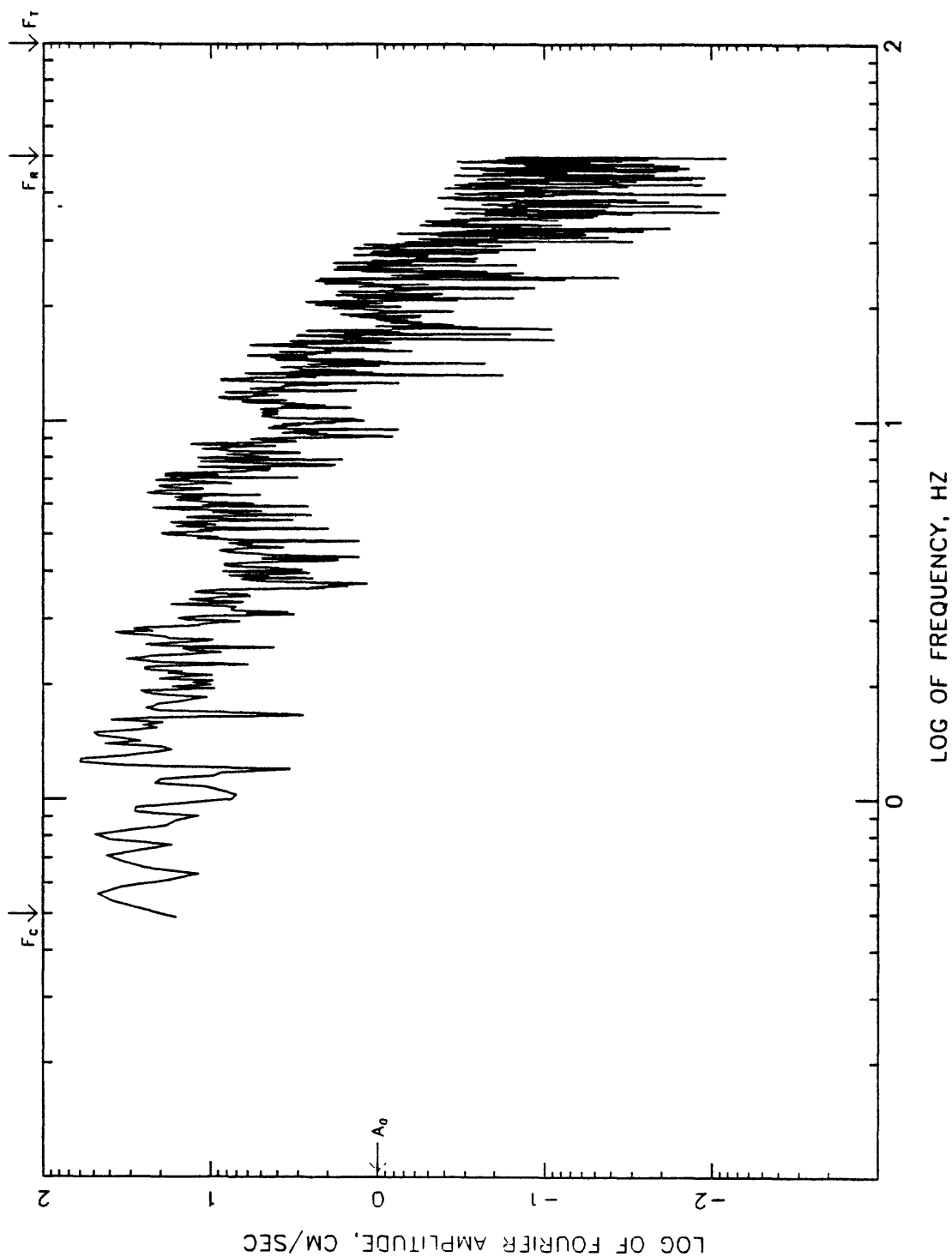
EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT

BUTTERWORTH AT .5 HZ, ORDER 4

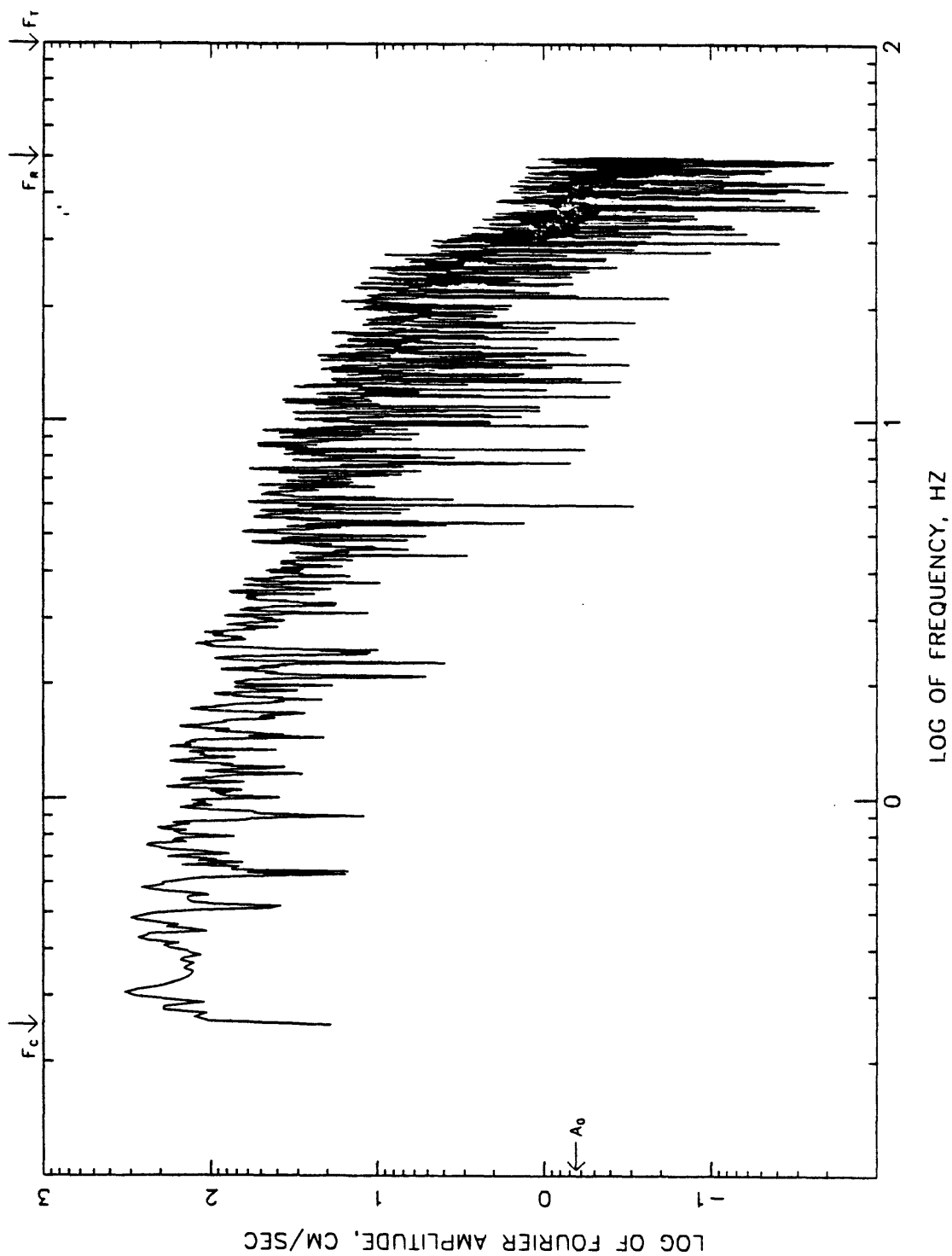
COMPUTING OPTIONS= ZCROSS,NONNOISE



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 0154 GMT
 BUTTERWORTH AT .5 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



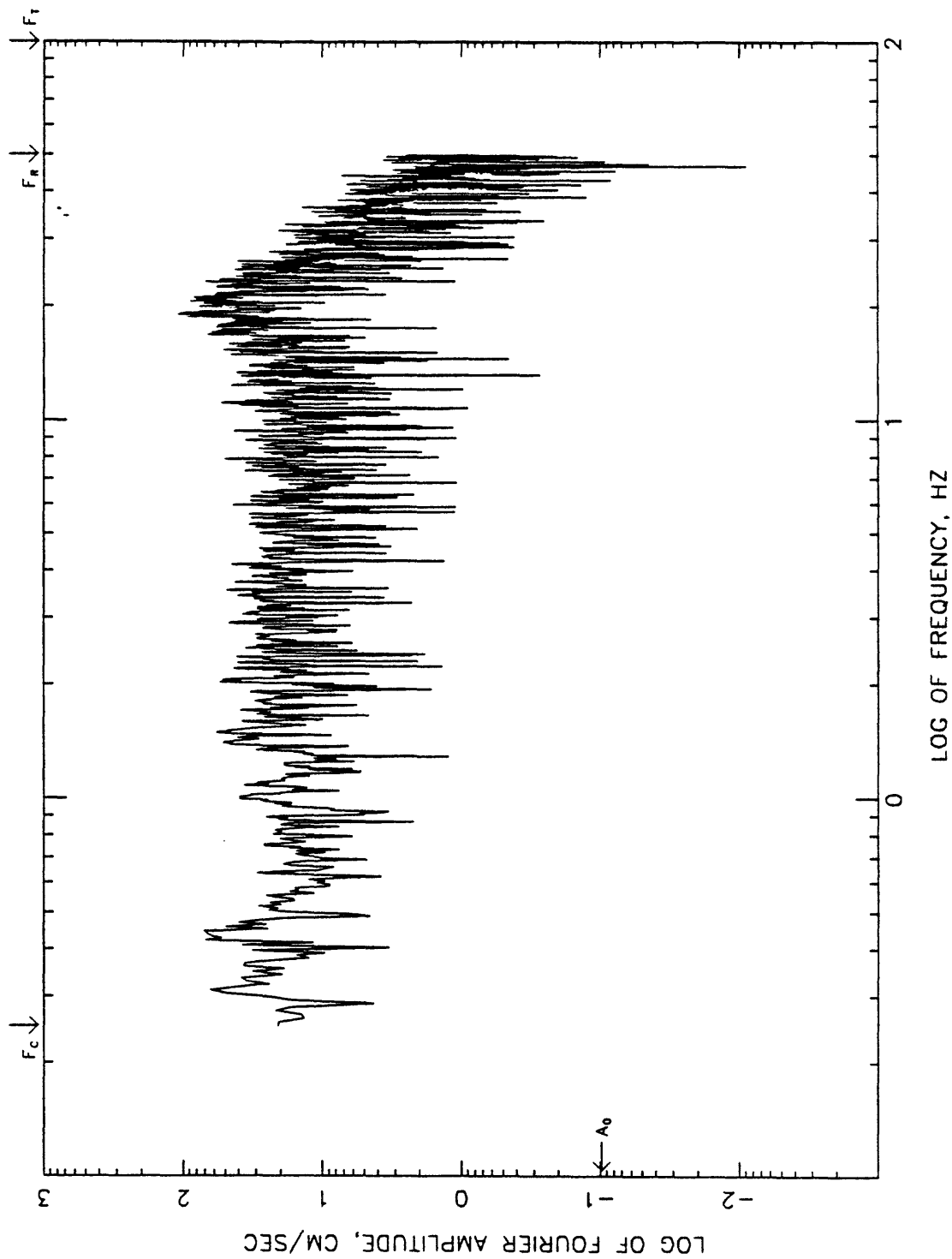
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 360 DEGREES
 EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
 BUTTERWORTH AT .25 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



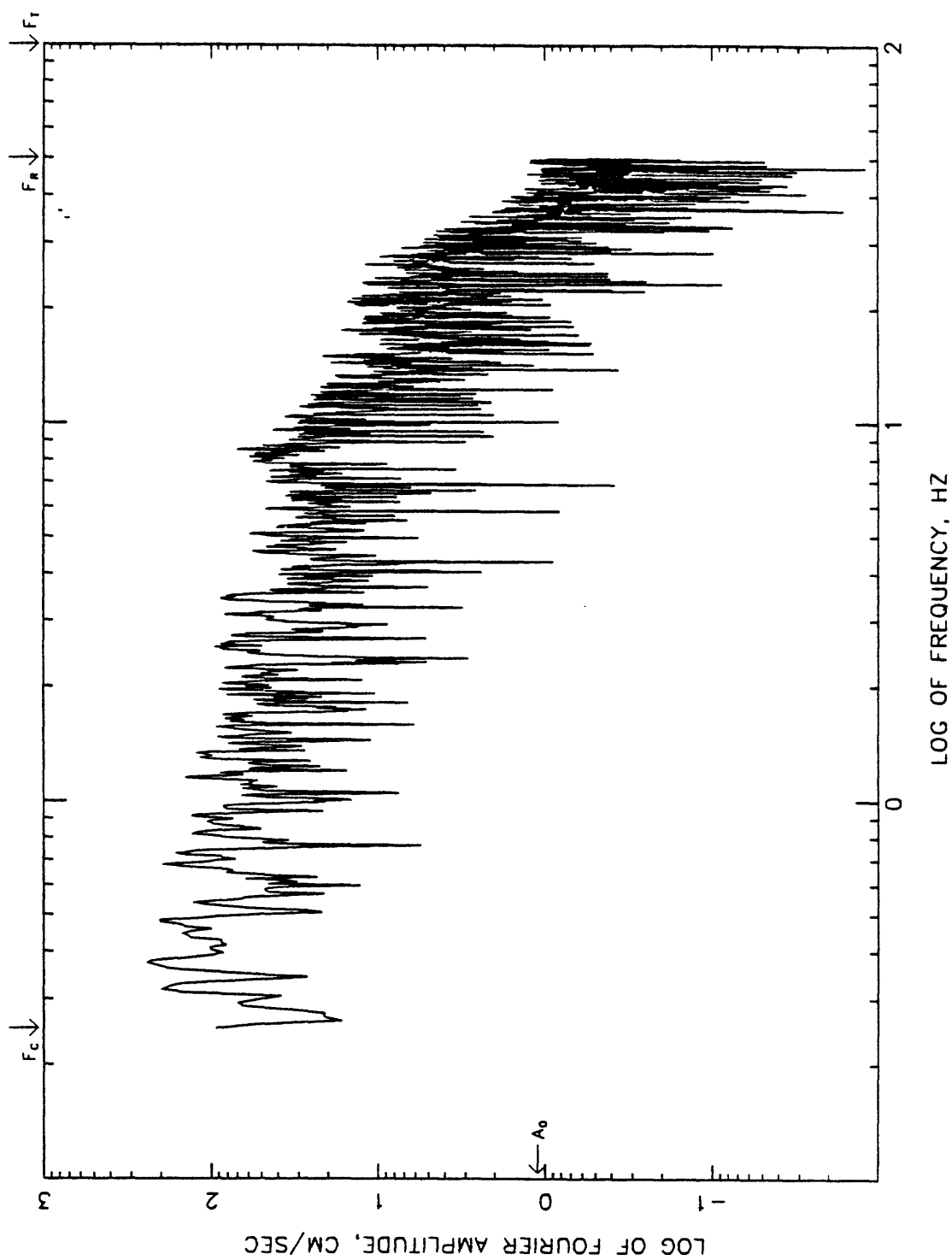
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
WILDLIFE LIQUEFACTION ARRAY, SURFACE

UP

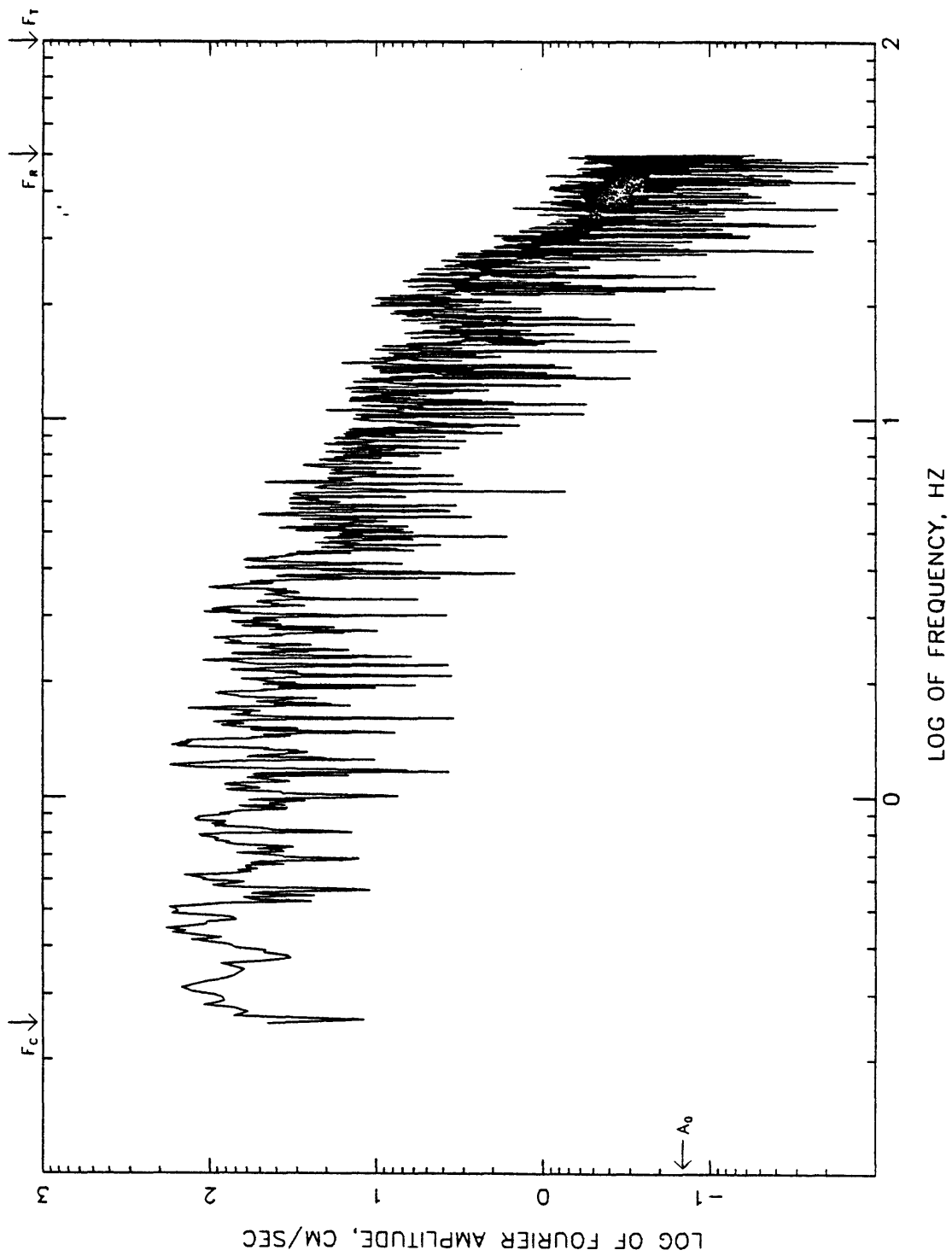
EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
BUTTERWORTH AT .25 HZ, ORDER 4
COMPUTING OPTIONS= ZCROSS,NONNOISE



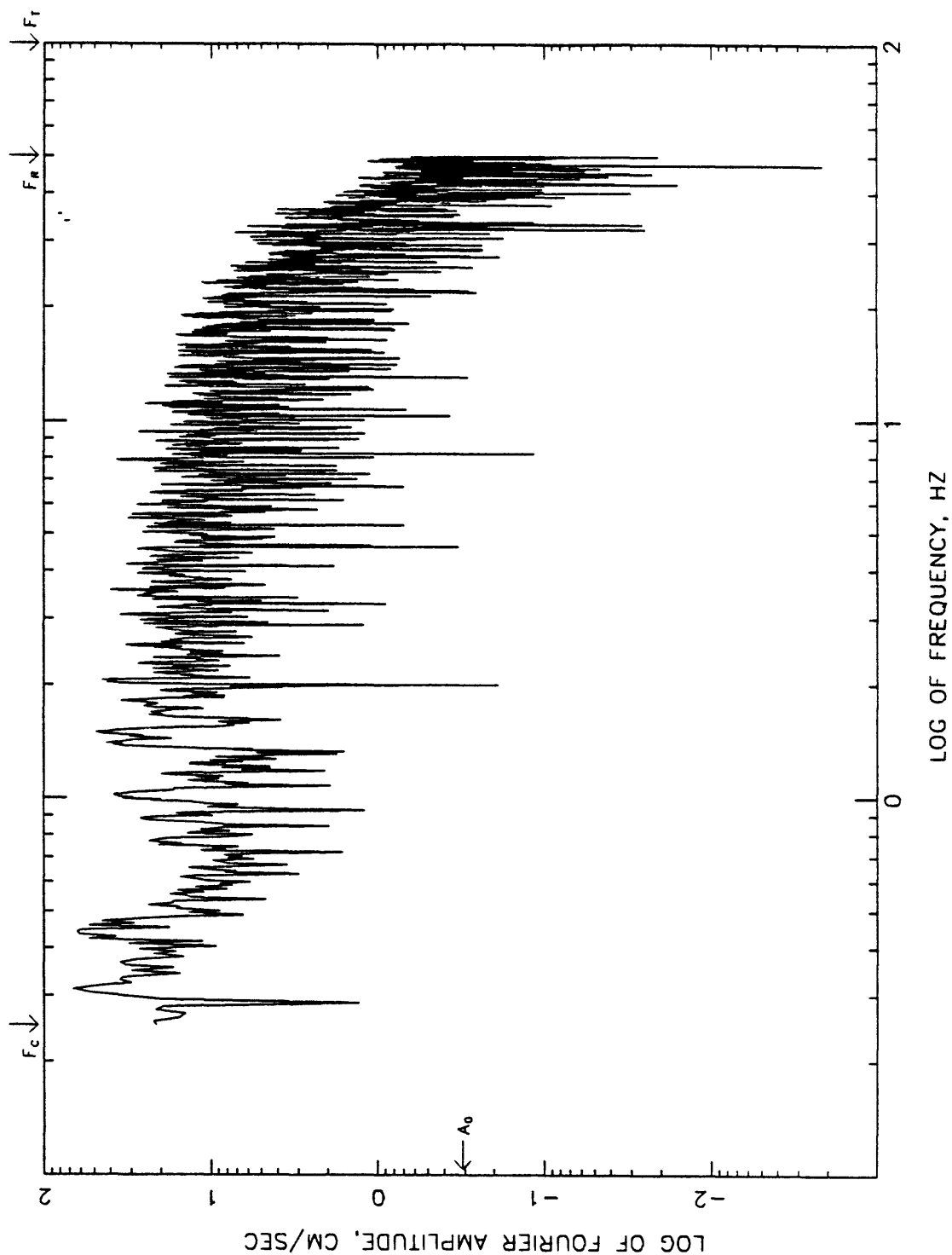
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, SURFACE
 090 DEGREES
 EARTHQUAKE OF 24 NOVEMBER, 1987 1315 GMT
 BUTTERWORTH AT .25 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



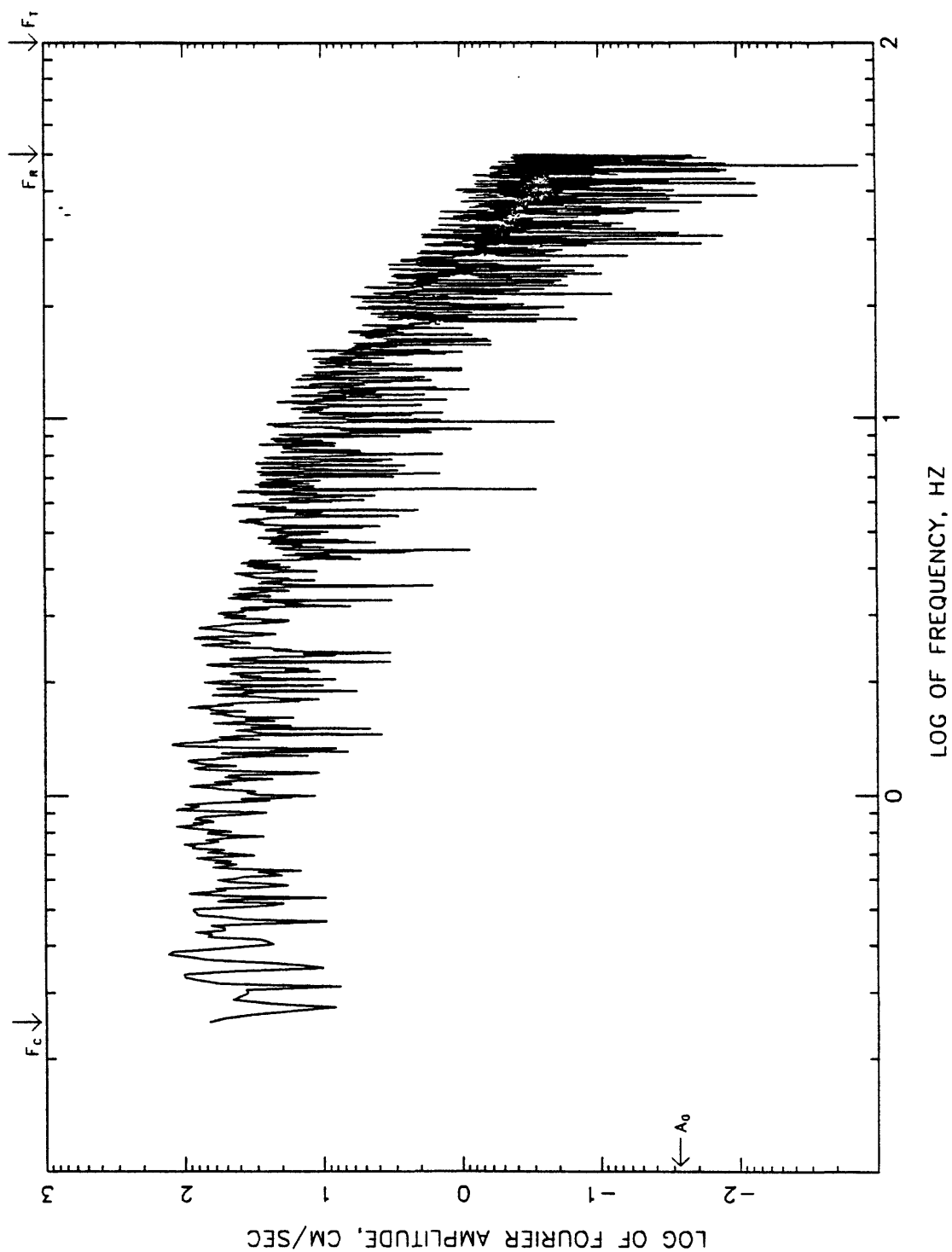
FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
 360 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 BUTTERWORTH AT .25 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
 UP
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 BUTTERWORTH AT .25 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



FOURIER AMPLITUDE SPECTRUM OF ACCELERATION
 WILDLIFE LIQUEFACTION ARRAY, 7.5 M DOWNHOLE
 090 DEGREES, APPROX.
 EARTHQUAKE OF NOVEMBER 24, 1987 1315 GMT
 BUTTERWORTH AT .25 HZ, ORDER 4
 COMPUTING OPTIONS= ZCROSS,NONNOISE



APPENDIX 5
CURRENT LIST OF PROCESSED RECORDS

CURRENT LIST OF PROCESSED RECORDS

USGS processing of records from the National Strong-Motion Instrumentation Network (NSMIN) of strong-motion accelerographs and associated networks.

Strong motion data from earthquakes 1978* and later.

TABLE 1. Chronological list of events and associated reports which describe the existence, processing, analysis of records and the availability of digital data on tape. Contact the USGS for reports; NGDC for tapes (see Preface).

Date & Time (Gmt)	Earthquake	Reference (see attached list)
January 1, 1975; 0355	Southern Alaska	OFR 86-191 (Silverstein, Brady, Mork, 1986b)
March 25, 1978	Coyote Dam, California	OFR 83-166 (Brady & Perez, 1983)
August 27, 1978 and two later shocks	Monticello Dam, Jenkinsville, South Carolina	OFR 81-0448 (Brady & others, 1981)
August 6, 1979	Coyote Lake, California	OFR 81-42 (Brady & others, 1980)
October 15, 1979	Imperial Valley, California	OFR 80-703 (Brady, Perez & Mork, 1980)
October 15, 1979	Imperial Valley, California	OFR 82-183 (Perez, 1982)
October 15, 1979; 2317:41, 2318:20, 2318:40	Imperial Valley California aftershock	OFR 86-441 (Brady, Mork, Silverstein)
October 16, 1979, 0706	Monticello Dam, Jenkinsville, South Carolina	OFR 81-1241 (Mork & Brady, 1981)
December 13, 1981 and March 18, 1983	Solomon Islands	OFR 86-264 (Silverstein, Brady, Mork, 1986a)
February 13, 14, and 23, 1983	Monasavu Dam, Fiji	OFR 85-375 (Silverstein, 1985a)
May 2 and May 9, 1983	Coalinga, California	OFR 84-626 (Maley & others, 1984)
July 9, 1983; 0740	Coalinga, California	OFR 85-584 (Silverstein, 1985b)

*With inclusion of isolated earlier events recently processed.

TABLE 1. Chronological list of events and associated reports (continued)

Date & Time (Gmt)	Earthquake	Reference (see attached list)
July 22, 1983; 0239	Coalinga, California	OFR 85-250 (Silverstein and Brady, 1985)
April 24, 1984	Morgan Hill, California	OFR 84-498, Vol I and II (Compiled by Seena Hoose)
December 23, 1985; 0516 Nov. 9, Dec. 23, Dec 25	Nahanni, Northwest Territories, Canada	Geol. Survey of Canada Open File Report 86-1-PGC, (Weichert and others, 1986)
January 26, 1986; 1920	Hollister, California	OFR 86-156, (Brady and others, 1986)
October 1, 1987; 1442	Whittier Narrows, California	OFR 88-354, (Brady and others, 1988) In press, (Brady and others, 1989a)
November 24, 1987; 0154 and 1315	Superstition Hills, California; MS 6.2 and MS 6.6	OFR 89-87, (Brady and others, 1989b)

TABLE 2. Processed records in each report

January 1, 1975; 0355; southern Alaska; OFR 86-191.
Records (4): Anchorage, 500 W. Third St., Basement
Anchorage, Alaskan Methodist University
Anchorage, Government Hospital
Talkeetna, FAA-VOR Building

March 25, 1978; Coyote Dam, California; OFR 83-166.
Records (3): Coyote Dam, Ukiah, California: abutment, toe, crest

August 27, 1978, 1023 and 2 later shocks; Monticello Dam, South Carolina,
OFR 81-0448.
Records (3): Jenkinsville, Monticello Dam
Shared abutment (center crest)

August 6, 1979, Coyote Lake, California; OFR 81-42.
Records (6): Coyote Creek, San Martin, California
Gilroy Array: Station 6, San Ysidro
Gilroy Array: Station 4, San Ysidro School
Gilroy Array: Station 3, Sewage Treatment Plant
Gilroy Array: Station 2, Mission Trails Motel
Gilroy Array: Station 1, Gavilan College

October 15, 1979, 2317; The Imperial Valley Earthquake; OFR 80-703.
Records (22): El Centro Array 7, Imperial Valley College
El Centro Array 6, Huston Road
El Centro, Bonds Corner, Hiways 98 & 115
El Centro Array 8, Cruickshank Road
El Centro Array 5, James Road
El Centro Differential Array
El Centro Array 4, Anderson Road
Brawley, Brawley Municipal Airport
Holtville, California, Holtville Post Office
El Centro Array 10, El Centro Hospital
Calexico, California, Calalexico Fire Station
El Centro Array 11, McCabe School
El Centro Array 3, Pine Union School
Parachute Test Facility
El Centro Array 2, Keystone Road
El Centro Array 12, Brockman Road
Calipatria, California, Calipatria Fire Station
El Centro Array 13, Strobel Residence
El Centro Array 1, Borchard Ranch
Superstition Mountain, California
Plaster City, California, Storehouse
Coachella Canal Number 4, California

October 15, 1979, 2317:41; Imperial Valley Aftershocks; OFR 86-441
Records (6) El Centro Array 5, James Road
El Centro Array 6, Huston Road
El Centro Array 7, Imperial Valley College
El Centro Array 8, Cruickshank Road
El Centro Array 9, Commercial Ave.
El Centro Differential Array

TABLE 2. Processed records in each report (continued)

October 15, 1979, 2318:21; Imperial Valley Aftershocks; OFR 86-441
Records (6) El Centro Array 5, James Road
El Centro Array 6, Huston Road
El Centro Array 7, Imperial Valley College
El Centro Array 8, Cruickshank Road
El Centro Array 9, Commercial Ave.
El Centro Differential Array

October 15, 1979, 2318:42; Imperial Valley Aftershock; OFR 86-441
Records (7) El Centro Array 6, Huston Road
El Centro Array 7, Imperial Valley College
El Centro Array 8, Cruickshank Road
El Centro Array 9, Commercial Ave.
El Centro Differential Array
Bonds Corner, Highways 115 & 98
Holtville Post Office

October 15, 1979; The Imperial Valley, California; OFR 82-183;
Records (22): This report contains the time-dependent response spectrum plots
for the same records in OFR 80-703, above.

October 16, 1979, 0706 Gmt, Monticello Dam, South Carolina, OFR 81-1214.
Records (1): Jenkinsville, South Carolina, Monticello Dam
shared abutment (center crest)

December 13, 1981 and March 18, 1983; Solomon Islands, OFR 86-264
Records (5): Dec. 13, 1981, 0129 Gmt: 460 Beach, Panguna Mine,
Bougainville Island.
Dec. 13, 1981, 1324 Gmt: "
March 18, 1983: Arawa Town
Bato Bridge
BVE80, Panguna Mine.

February 13, 14, and 23, 1983; Monasavu Dam, Fiji; OFR 85-375
Records (3): Feb 13, 14, 23, 1983: Monasavu Dam.

May 2 and May 9, 1983; Coalinga, California; OFR 84-626.
Records (13): May 2, 1983, 2342 Gmt:
Pleasant Valley Pump Plant: switchyard, basement
(This is a U.S. Bureau of Reclamation station)

May 9, 1983, 0249 Gmt
Anticline Ridge: freefield and pad
Burnett Construction
Oil City
Oil Fields Fire Station
Palmer Avenue
Skunk Hollow
Pleasant Valley Pump Plant: switchyard, basement,
(U.S. BuRec) 1st floor, roof

TABLE 2. Processed records in each report. (continued)

July 9, 1983; 0740; Coalinga, California; OFR 85-584

Records (9): Anticline Ridge: freefield and pad
Burnett Construction
Oil City
Oil Fields Fire Station: freefield and pad
Palmer Avenue
Skunk Hollow
Transmitter Hill

July 22, 1983; 0239; Coalinga, California; OFR 85-250

Records (13): Anticline Ridge: pad site
Burnett Construction
Oil City
Oil Fields Fire Station: freefield and pad
Palmer Avenue
Pleasant Valley Pump Plant: 1st floor, basement, roof,
(U.S. BuRec) switchyard, freefield
Skunk Hollow
Transmitter Hill

April 24, 1984; Morgan Hill, California; OFR 84-498B, Vol. II.

Records (11): Anderson Dam: downstream, crest
Hollister City Hall Annex
Hollister Differential Array
San Justo Damsite: right abutment, left abutment
(This is a U.S. Bureau of Reclamation station)
San Jose 101/280/680 bridge
Hollister Differential Array No. 1, 3, 4, 5

December 23, 1985; with foreshock and aftershocks; Northwest Territories,
Canada; 86-1-PGC.

Records (6): Nov. 9, 1985; 0446 Gmt: Nahanni Site 2
Dec. 23, 1985; 0516 Gmt: Nahanni Sites 1, 2, 3
Dec. 23, 1985; 0548 Gmt: Nahanni Site 1
Dec. 25, 1985; 1543 Gmt: Nahanni Site 3

January 26, 1986; Hollister, California; OFR 86-156

Records (5): Hollister Digital Differential Array, Stations 1, 3, 4, 5, 6

October 1, 1987; Whittier Narrows, California, Volume 1; OFR 88-354

Records (15): Garvey Reservoir Abutment Building
Whittier Narrows Dam: crest, upstream
Alhambra; 900 S. Fremont: Basement, 6, 12
Whittier; 7215 Bright: Basement, 5, 10
Bell; L. A. Bulk Mail Center
Vernon; 4814 Loma Vista Avenue
Norwalk; 12400 Imperial: Basement, 4, Roof, South
ground level

October 1, 1987; Whittier Narrows, California, Volume 2; in press.
 Records (11) Los Angeles; 4407 Jasper Street
 Los Angeles; Griffith Park Observatory
 Orange County Reservoir: abutment
 Brea Dam: crest, left abutment, downstream
 Carbon Canyon Dam: crest, left abutment
 Long Beach; Calif. State Univ. Long Beach
 Santa Ana River Bridge: North abutment (SMA-1)
 North abutment, traces 1-3
 Mid-span, traces 4-6
 Below isolator, traces 7-9
 Above isolator, traces 10-12

November 24, 1987; Superstition Hills, California, OFR 89-87
 0154 and 1315;
 Records (2) Imperial Wildlife Liquefaction Array

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