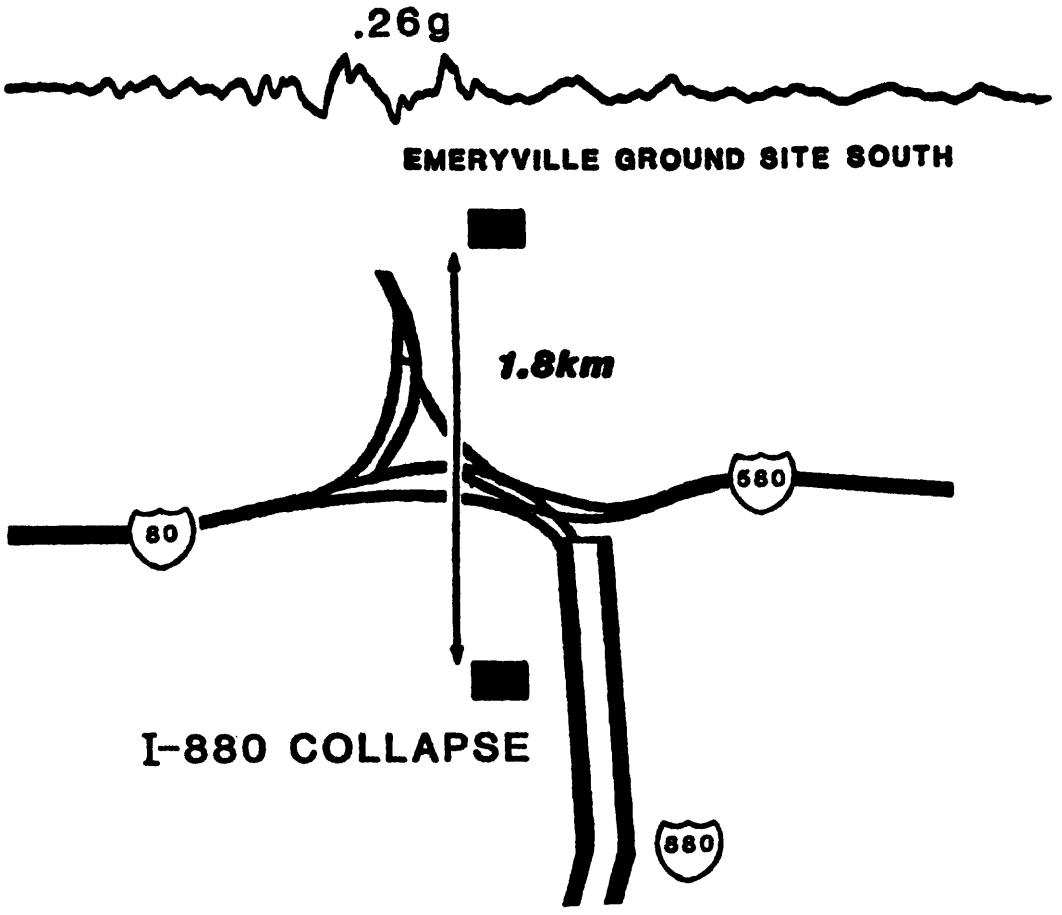
DEPARTMENT OF THE INTERIOR

U.S. Geological Survey

U.S. GEOLOGICAL SURVEY STRONG-MOTION RECORDS FROM THE NORTHERN CALIFORNIA (LOMA PRIETA) EARTHQUAKE OF OCTOBER 17, 1989



OPEN-FILE REPORT 89-568

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U.S. GEOLOGICAL SURVEY STRONG-MOTION RECORDS FROM THE NORTHERN CALIFORNIA (LOMA PRIETA) EARTHQUAKE OF OCTOBER 17, 1989

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1/ Menlo Park,CA

2/ Lawndale, CA

3/ Seattle, WA

4/ Las Vegas, NV

October 1989

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INTRODUCTION

The strong-motion network operated by the U.S. Geological Survey (USGS) contains approximately 1000 stations in 41 states and Puerto Rico. Instrumentation is owned by both private industry and numerous Federal, State, and local agencies and organizations. The primary objectives of the program are to record strong ground motions and the response of representative engineered structures during strong, local earthquakes, and to disseminate the resultant information and data to the international earthquake engineering research and design community. The purpose of this report is to present both information about the October 17, 1989 main shock and the USGS stations that recorded the event, as well as ground motion and structure response data from all stations including copies of the accelerograms. An additional significant collection of strong-motion data from this earthquake is available from the California Division of Mines and Geology, Office of Strong-Motion Studies, Sacramento, Ca 95814-0189.

The Ms=7.1 northern California earthquake, which occurred at 1704:15.24 Pacific Daylight Time on October 17, 1989, was centered approx. 16 km northeast of Santa Cruz, Calif. at an hypocentral depth of about 18.5 km, deeper than most events on the San Andreas fault zone in this region (U.S. Geological Survey, Oct. 22, 1989). It was reported felt as far away as Reno and Las Vegas, Nevada and Los Angeles, California, and was the largest magnitude earthquake centered in northern California since 1906. It also has been reported to have caused at least 62 deaths, more than 3000 injuries, and up to $10 billion in damages in the greater San Francisco Bay region. (San Francisco Chronicle, Oct. 23, 1989).

STRONG-MOTION DATA

Strong-motion accelerographs at 38 USGS stations located at epicentral distances in the range 27 to 115 km were triggered during the Ms=7.1 main shock, which was centered approx. 16 km northeast of Santa Cruz, Calif., at 37.037° N. lat. and 121.883° W. long. (see fig. 1 and table 1). These 38 stations consist of 21 ground stations, 13 large buildings including 5 hospitals, 2 dams, and 2 bridge abutments.

Figure 2 contains copies of the accelerograms and includes structure instrumentation drawings for extensively instrumented structures. For a description of these structures see the next section. Table 2 contains peak acceleration data for all sensors, at both ground level and in structures.

The closest USGS accelerograph station was located at Anderson Dam, east of Morgan Hill at an epicentral distance of 27 km (see next section for description). Peak accelerations at the abutment, toe, and downstream stations were 0.08, 0.23, and 0.26 g, respectively. Peak horizontal motions were 0.39 and 0.38 g, at the center and right crest stations and 0.14 g at the mid-dam level (center and right).

The second closest USGS station was the San Jose freeway interchange at the junction of U.S. 101 and Interstates 280 and 680, at an epicentral distance of 34 km. A single triaxial accelerograph located in the abutment recorded a peak horizontal motion of 0.18 g. No other USGS stations were located within 40 km (25 miles) of the epicenter.

In Hollister, approx. 45 km southeast of the epicenter, two triaxial accelerographs recorded relatively high amplitude (0.23 and 0.29 g) peak horizontal motions. These stations were in the reported direction of the main-shock rupture propagation and are located about 10 km northeast of the fault zone, at Hollister Airport and City Hall.

The Palo Alto Veterans Administration Hospital (Bldg. 1) is a 6-story building with triaxial accelerographs located in the basement and on the roof (7th level). The two accelerograms are somewhat similar, with the roof level motions amplified by a factor of 2 to 3, and some prominent high-amplitude, long-period motion presumed to be first mode response. Peak horizontal accelerations were 0.38 g in the basement and 1.09 g on the roof.

Another notable comparison is the records from APEEL No. 2 (Redwood City) and Foster City. Both instruments are located on engineered fill above bay mud in developed areas east of the Bayshore freeway (U.S. 101), approximately 65 km northwest of the epicenter. Although both accelerograms contain long-period horizontal motions, the Foster City record has peak motions in the 0.08-0.12 g range at about 2 Hz while the Redwood City (Redwood Shores) record has peak accelerations in the range 0.20-0.28 g at about 1 Hz.

The Bear Valley Array south of Hollister produced 5 records; 2 stations are west of the San Andreas fault zone and 3 are east of the zone. Most are located on or near hard rock and recorded small ground accelerations at distances in the range 50-90 km. One exception was Bear Valley No. 12 with several cycles of 0.5 s motion in the 0.12-0.17 g range at a distance of 70 km.

The Transamerica Building on Montgomery Street in San Francisco produced 22 channels of acceleration data from sensors located at the foundation, basement, ground, 5th, 21st, 29th, and 49th levels (see structure drawing, next section). Peak horizontal accelerations were 0.10 at the foundation and 0.31 g at the 49th floor.

Another extensively instrumented building is a 30-story structure on Christie Avenue in Emeryville, nearly 100 km north of the epicenter and less than 2 km north of the collapsed I-880 freeway in Oakland. Twenty-seven

acceleration channels recorded peak accelerations of 0.26, 0.32, 0.24, and 0.39 g at the ground, 13th, 21st, and 31st (roof) levels. There are 6 horizontal ground level sensors -- 2 on the ground floor, 2 at ground level 40 meters north of the building, and 2 at ground level approx. 100 m south of the building. Only the latter two sensors recorded any obvious long-period motion late in the record.

A 12-story structure of rather unique design on Shattuck Avenue in Berkeley has been instrumented with 18 data channels (see next section); 6 are at basement level, 5 are at the 4th level, and 7 are at the 13th (roof) level. Peak recorded accelerations at these 3 levels were 0.11, 0.23, and 0.23 g, respectively.

The south (San Francisco) abutment of the Golden Gate Bridge contains a triaxial accelerograph mounted in an office building just beneath the toll plaza. This site is 100 km northwest of the epicenter and recorded significant horizontal accelerations, 0.12 g in the north-south and 0.24 g in the east-west directions.

EXTENSIVELY INSTRUMENTED STRUCTURES

An extensively instrumented structure is defined as one in which sensors are located on or within the structure at a sufficient number of locations to provide significant dynamic response data for a rigorous analysis of the structures performance during strong earthquake motion. Records from six such structures, five buildings and one dam, are included in this report. The following information briefly describes the design characteristics of each structure. Drawings of the instrumentation schemes are included in figure 2 with copies of the accelerograms.,

Emeryville, 6363 Christie Avenue.

The 6363 Christie Avenue building is a 30-story symmetrical three-winged Y-shaped structure built in 1983. The tower is supported by 900 14 inch x 14 inch concrete piles driven in rows along both longitudinal and transverse column lines. The base of the building rests on a 5 foot thick mat. Twenty-one acceleration sensors are distributed over the three wings and central core on the 31st level (roof), 21st and 13th floors, and at the ground level. Free-field accelerometers are located north and south of the building.

Hayward City Hall.

The Hayward City Hall, constructed in 1968-69, is a rectangular 11-story building with the first floor partially below grade. It has a light-weight reinforced concrete space frame and a pan-joist floor system. A masonry-block wall in the longitudinal direction extends from the 3rd level to the roof; the Council Chamber is below the wall on the 2nd and 3rd levels. The structure is supported by 25-foot deep reinforced concrete belled piers. Fourteen acceleration sensors are located in the building, on the 12th level (roof), 7th and 3rd floors, and at the ground level. Free-field accelerographs are located both north and south of the building.

Berkeley, 2168 Shattuck Avenue.

The 13-story 2168 Shattuck office building is a rectangular structure constructed in downtown Berkeley in 1968. The primary load-supporting structural members, not apparent from the exterior of the building, are twin reinforced concrete cores, each 20 by 36 ft in plan and 88 ft apart. At the top of these cores, a steel-framed grid supports a total of 16 vertical hanging straps from which all floors above the third are suspended. Each

floor is a horizontal structural steel frame with a steel-decked concrete slab. Floors 1 through 3 are supported on columns from ground level. Eighteen acceleration sensors are located in the building, at both cores and at the southwest side of the building on the 13th and 4th floors and at the ground level.

San Francisco, Transamerica Building.

The pyramid-shaped Transamerica Building, completed in 1972, has 48 floors with an additional 204 ft of tower (49th-60th floors) and is of steel-frame construction erected on a 9-ft-thick base mat. The 853 foot high building has a square plan 174 feet by 174 feet and consists of a two-story high ground floor, a triangularly shaped tubular space truss around the perimeter between and 2nd and 5th floor levels, and above the 5th level, a moment resistant frame with the exterior walls sloping inward at an approxmiate ratio of 1 to 11. The unoccupied upper 10 stories consist of an open-framed pyramid shaped structure. The building contains elevators on the east side and a stairwell and duct shaft on the west side. Twenty-two acceleration sensors are distributed throughout the structure on the 49th, 24th, 21st, and 5th floors and at several locations on the foundation.

San Francisco, 575 Market Street.

The 575 Market Street building, constructed in 1974, is a 41-story rectangular moment-resisting steel frame structure. Typical floors are 82 ft x 155 ft consisting of cellular metal decking with concrete fill. Exterior wall panels are precast concrete. The structure is supported by precast piles 20 to 30 feet in length. Fourteen acceleration sensors are located in the structure; at the 42nd level (penthouse), 34th, 25th, and ground floors and in

the sub-basement.

Anderson Dam.

The Santa Clara Valley Water District's Anderson Dam constructed east of Morgan Hill in 1950 is an earth and rockfill structure 210 ft high with a 1385 ft crest length and a clay core cutoff wall. Its maximum capacity is 91,000 acre-feet, impounding runoff from the Diablo Range. Acceleration sensors are located at the center and right sections of the crest and mid-level of the dam, and at the toe. Free-field accelerographs are located on the left abutment and downstream.

ACKNOWLEDGEMENTS

The National Cooperative Strong-Motion Network operated by the U.S. Geological Survey includes instrumentation owned by both private industry as well as Federal, State, and local agencies and organizations. The Veterans Administration, the California Dept. of Water Resources, Stanford University, and the University of California at Berkeley contributed accelerographs that triggered during the main shock. We especially thank the many government agencies, private companies, and individuals that have permitted the U.S Geological Survey to operate instrumentation on their property.

Table 1.- Index of strong-motion stations shown in figure 1

Map Index No.	Station Name	Peak Horizontal Ground Accel.	Record Page No.
1.	Anderson Dam	0.26g	17
2.	San Jose Interchange	0.18g	23
3.	Cherry Flat Reservoir	0.09g	24
4.	Sunnyvale	0.22g	25
5.	Hollister Airport	0.29g	26
6.	Palo Alto VA	0.38g	27
7.	Hollister City Hall	0.25g	29
8.	Calaveras Reservoir	0.13g	30
9.	Hollister, SAGO	0.06g	31
10.	Stanford, SLAC	0.29g	32
11.	Menlo Park VA	0.27g	33
12.	Fremont	0.20g	34
13.	Crystal Springs Reservoir	0.12g	35
14.	Sunol	0.10g	36
15	Redwood City	0.28g	37
16.	Foster City	0.12g	38
17.	Del Valle Dam	0.06g	39
18.	Livermore VA	0.06g	41
19.	Bear Valley No. 12	0.17g	43
20.	APEEL 2E, Hayward	0.16g	44
21.	Bear Valley No. 5	0.07g	45
22.	Hayward City Hall	0.10g	46
23.	Dublin	0.09g	52
24.	Bear Valley No. 10	0.13g	53
25.	Bear Valley No. 7	0.06g	54
26.	S.F., 1295 Shafter	0.11g	55
27.	S.F. State University	0.14g	56
28	S.F., 575 Market	0.13g	57
29.	S.F., 600 Montgomery	0.18g	61
30.	Emeryville	0.26g	67
31.	Berkeley, Strawberry Canyon	0.08g	73
32.	Berkeley, Haviland Hall	0.06g	74
33.	Berkeley, 2168 Shattuck	0.11g	75
34.	San Francisco VA	0.16g	80
35.	S.F., Golden Gate Bridge	0.24g	82
36.	Richmond	0.11g	83
37.	Martinez VA	0.07g	84
38.	Larkspur	0.14g	85

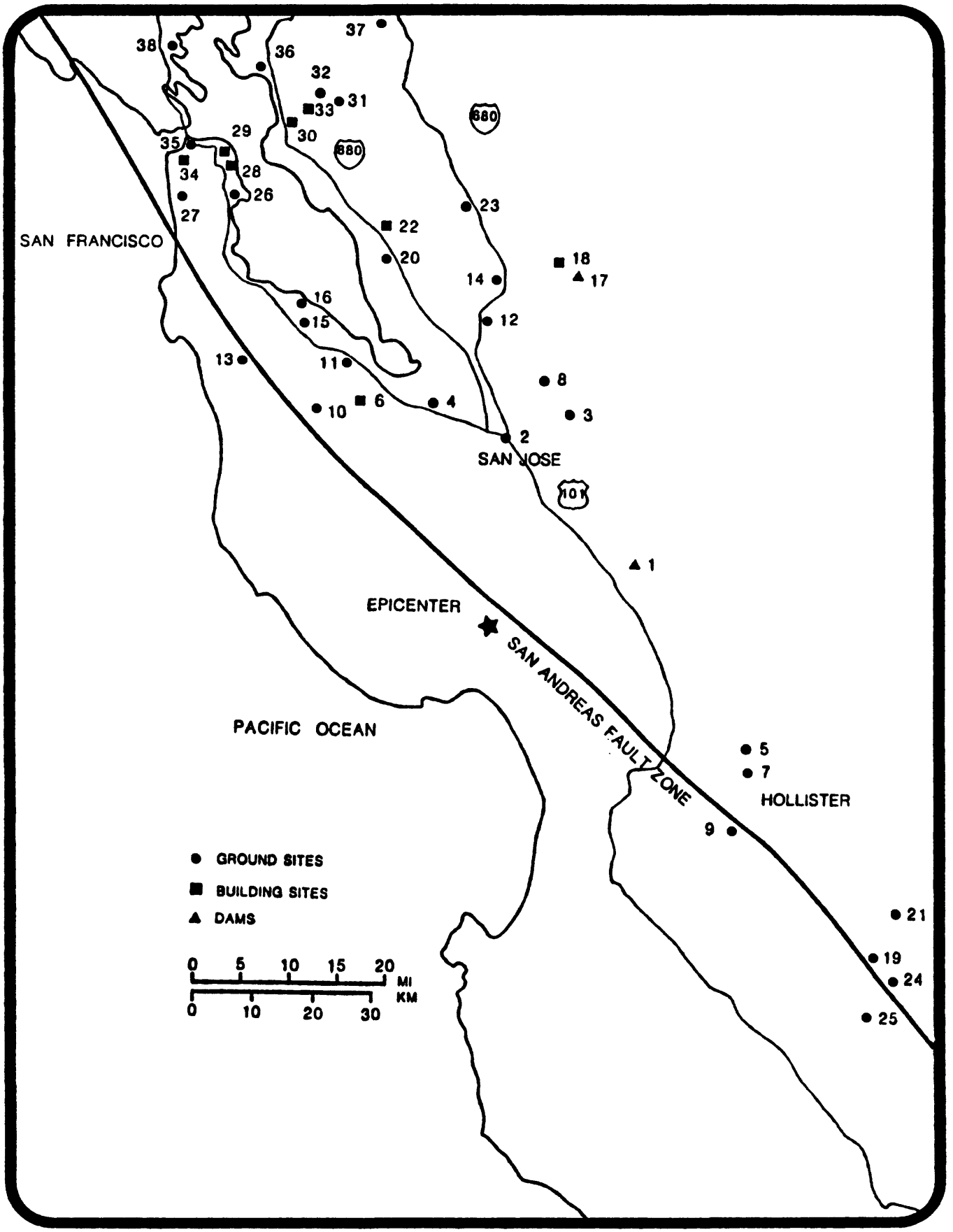


Figure 1. Map of USGS stations triggered during the October 17 main shock.

Table 2. Strong-motion data from the main shock

Station Identification				Epicentral	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)	Distance (km)	Direction (degrees)	Maximum (g)
1.	1652	Anderson Dam	37.166 121.628	27		
		Crest			340	0.26
					Up	.19
					250	.39
		Downstream			340	.25
					Up	.17
					250	.26
		Left Abutment			340	.08
					Up	.05
					250	.07
		Structure Array:				
		Ch. 1- Toe			160	.18
		Ch. 2- Toe			Up	.16
		Ch. 3- Toe			250	.23
		Ch. 4- Mid-dam, Center			160	.11
		Ch. 5- Mid-dam, Center			250	.14
		Ch. 6- Mid-dam, Right			070	.14
		Ch. 7- Center Crest			160	.32
		Ch. 8- Center Crest			Up	.16
		Ch. 9- Center Crest			250	.43
		Ch. 10- Right Crest			160	.32
		Ch. 11- Right Crest			Up	.23
		Ch. 12- Right Crest			250	.38
2.	1571	San Jose Interchange, 101/280/680 Abutment	37.340 121.851	34	322 Up 232	.18 .08 .13
3.	1696	Calaveras Array Cherry Flat Reservoir	37.396 121.756	42	360 Up 270	.09 .06 .07
4.	1695	Sunnyvale Colton Avenue	37.402 122.024	43	360 Up 270	.22 .10 .19
5.	1656	Hollister Airport Differential Array	36.888 121.413	45	255 Up 165	.29 .16 .27

Table 2. Strong-motion data from the main shock

Station Identification				Epicentral Distance (km)	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)		Direction (degrees)	Maximum (g)
6.	1227	Palo Alto VA Hospital, Bldg. 1	37.40 122.14	47		
		Basement			302	0.34
					Up	.20
					212	.38
		Roof (7th level)			302	1.09
					Up	.64
					212	.79
7.	1575	Hollister City Hall Basement	36.851 121.402	47	180	.23
					Up	.22
					090	.25
8.	1687	Calaveras Array Calaveras Reservoir S.	37.452 121.807	47	180	.13
					Up	.07
					090	.08
9.	1032	Hollister SAGO Vault	36.765 121.446	49	360	.06
					Up	.05
					270	.04
10.	1601	Stanford University SLAC Test Lab.	37.419 122.205	51	360	.29
					Up	.10
					270	.19
11.	1230	Menlo Park VA Hospital, Bldg. 37	37.468 122.157	54	110	.12
					Up	.11
					020	.27
12.	1686	Fremont Emerson Court	37.535 121.929	56	180	.15
					Up	.07
					090	.20
13.	1161	APEEL Array Station 9 Crystal Springs Res.	37.47 122.32	62	227	.11
					Up	.06
					137	.12
14.	1688	Calaveras Array Sunol Fire Station	37.597 121.880	63	180	.07
					Up	.03
					090	.10
15.	1002	APEEL Array Station 2 Redwood City	37.52 122.25	63	133	.23
					Up	.08
					043	.28

Table 2. Strong-motion data from the main shock

Station Identification				Epicentral Distance (km)	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)		Direction (degrees)	Maximum (g)
16.	1515	Foster City Menhaden Court	37.555 122.248	66	360 Up 270	.12 .09 .11
17.	1265	Del Valle Dam	37.615 121.745	66		
		Crest			065 Up 335	0.08 .07 .08
		Toe			065 Up 335	.06 .03 .04
18.	1226	Livermore VA Hospital, Bldg. 62	37.625 121.762	67		
		Basement			125 Up 035	.06 .03 .05
		Roof (7th)			125 Up 035	.08 .03 .15
19.	1481	Bear Valley Station 12 Williams Ranch	36.658 121.249	70	310 Up 220	.17 .10 .16
20.	1121	APEEL Array Station 2E Hayward, Muir School	37.66 122.08	72	054 Up 324	.13 .06 .16
21.	1474	Bear Valley Station 5 Callens Ranch	36.673 121.195	73	310 Up 220	.07 .04 .07
22.	1129	Hayward City Hall	37.679 122.082	74		
		Ground Floor			064 Up 334	.05 .03 .06
		Ground Site North			064 Up 334	.06 .02 .06

Table 2. Strong-motion data from the main shock

Station Identification				Epicentral Distance (km)	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)		Direction (degrees)	Maximum (g)
		Hayward City Hall - continued				
		Ground Site South			064	.09
					Up	.03
					334	.10
		Structure Array:				
		Ch. 1- 12th Floor, West			334	0.10
		Ch. 2- 12th Floor, Center			334	.10
		Ch. 3- 12th Floor, Center			064	.13
		Ch. 4- 7th Floor, West			334	.09
		Ch. 5- 7th Floor, Center			334	.08
		Ch. 6- 7th Floor, Center			064	.09
		Ch. 7- 3rd Floor, West			334	Inoperative
		Ch. 8- 3rd Floor, Center			334	.07
		Ch. 9- 3rd Floor, Center			064	.08
		Ch. 10- 3rd Floor, Southwest			Up	.05
		Ch. 11- 3rd Floor, Southwest			Up	.04
		Ch. 12- Ground Floor, West			334	.07
23.	1689	Calaveras Array	37.709	75	360	.08
		Dublin Fire Station	121.932		Up	.03
					270	.09
24.	1479	Bear Valley Station 10	36.532	86	310	.10
		Webb Residence	121.143		Up	.05
					220	.13
25.	1476	Bear Valley Station 7	36.483	88	310	.04
		Pinnacles Nat'l Mon.	121.180		Up	.03
					220	.06
26.	1675	San Francisco	37.728	89	360	.11
		1295 Shafter St.	122.385		Up	.05
					270	.07
27.	1116	San Francisco State U.	37.724	93	270	.14
		Thornton Hall	122.475		Up	.04
					180	.11
28.	1446	San Francisco	37.79	96		
		575 Market St.	122.40			
		Basement			135	.08
					Up	.06
					045	.11

Table 2. Strong-motion data from the main shock

Station Identification				Epicentral	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)	Distance (km)	Direction (degrees)	Maximum (g)
		San Francisco, 575 Market St. - continued				
		Structure Array:				
		Ch. 1- 42nd Level, Northwest			045	0.22
		Ch. 2- 42nd Level, Center			225	.19
		Ch. 3- 42nd Level, Center			135	.14
		Ch. 4- 34th Level, Northwest			045	.15
		Ch. 5- 34th Level, Center			225	.16
		Ch. 6- 34th Level, Center			135	.19
		Ch. 7- 25th Level, Northwest			045	.19
		Ch. 8- 25th Level, Center			225	.23
		Ch. 9- 25th Level, Center			135	.16
		Ch. 10- Ground Level			045	.12
		Ch. 11- Ground Level			315	.13
29.	1239	San Francisco 600 Montgomery St.	37.80 122.40	97		
		Basement			261	.12
					Up	.05
					171	.11
		29th Floor			261	.15
					Up	.11
					171	.17
		49th Floor			261	.31
					Up	.14
					171	.29
		Structure Array:				
		Ch. 1- 21st Floor West Central			351	.20
		Ch. 2- 21st Floor South Central			351	.17
		Ch. 3- 21st Floor South Central			081	.22
		Ch. 4- 5th Floor West Central			351	.27
		Ch. 5- 5th Floor South Central			351	.28
		Ch. 6- 5th Floor South Central			081	.24
		Ch. 7- SE Corner Foundation			Up	.07
		Ch. 8- Ground Level West Central			351	.17
		Ch. 9- Ground Level Center			351	.15
		Ch. 10- Ground Level Center			351	.18
		Ch. 11- NW Corner Foundation			351	.10
		Ch. 12- West Side Foundation			351	.09
		Ch. 13- SW Corner Foundation			Up	.05

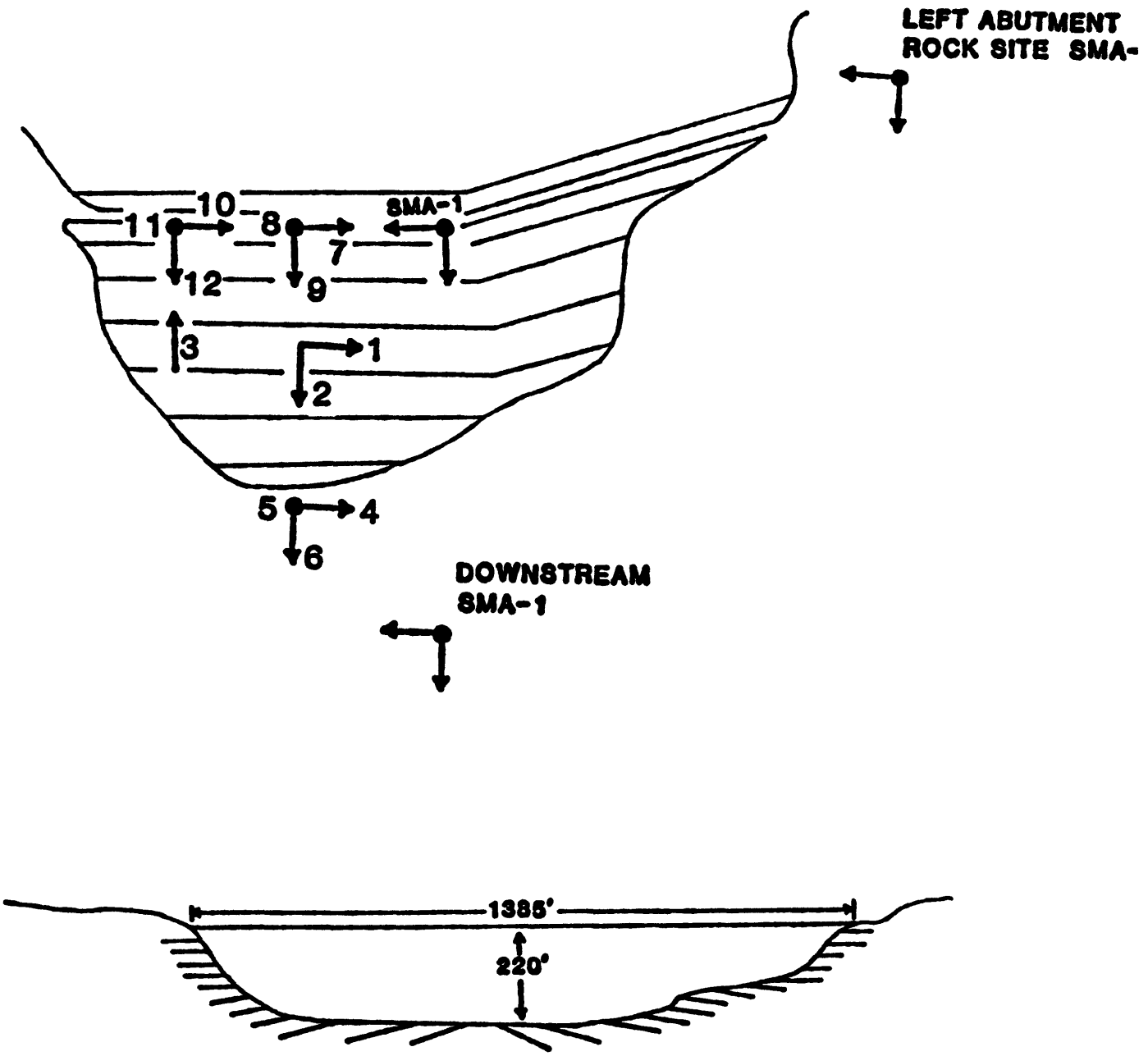
Table 2. Strong-motion data from the main shock

Station Identification				Epicentral Distance (km)	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)		Direction (degrees)	Maximum (g)
30.	1662	Emeryville 6363 Christie Ave.	37.844 122.295	97		
		Ground Site South			350	0.22
					Up	.06
					260	.26
		Structure Array 1:				
		Ch. 1- Roof (31st), West Wing			350	.27
		Ch. 2- Roof (31st), South Wing			050	.31
		Ch. 3- Roof (31st), North Wing			290	.39
		Ch. 4- Roof (31st), Central Core			260	.25
		Ch. 5- Roof (31st), Central Core			350	.38
		Ch. 6- 21st Floor Central Core			260	.20
		Ch. 7- 21st Floor West Wing			350	.19
		Ch. 8- 21st Floor South Wing			050	.18
		Ch. 9- 21st Floor North Wing			290	.24
		Ch. 10- 13th Floor Central Core			260	.27
		Ch. 11- 13th Floor Central Core			350	.26
		Ch. 12- 21st Floor Central Core			350	.23
		Structure Array 2:				
		Ch. 1- 13th Floor West Wing			350	.22
		Ch. 2- 13th Floor South Wing			050	.23
		Ch. 3- 13th Floor North Wing			290	.32
		Ch. 4- Ground Floor, West Wing			Up	.06
		Ch. 5- Ground Floor, South Wing			Up	.06
		Ch. 6- Ground Floor, Central Core			Up	.05
		Ch. 7- Ground Floor, North Wing			260	.22
		Ch. 8- Ground Floor, North Wing			Up	.05
		Ch. 9- Ground Floor, North Wing			350	.17
		Ch. 10- Ground Site North			350	.20
		Ch. 11- Ground Site North			Up	.09
		Ch. 12- Ground Site North			260	.22
31.	1005	Berkeley, U.C. Strawberry Cyn.	37.87 122.24	98	135 Up 045	.04 .02 .08
32.	1006	Berkeley, U.C. Haviland Hall Basement	37.87 122.26	99	135 Up 045	.03 .02 .06
33.	1103	Berkeley 2168 Shattuck Ave.	37.87 122.27	99		
		Basement, East			261	.09
					Up	.02
					171	.11

Table 2. Strong-motion data from the main shock

Station Identification				Epicentral Distance (km)	Acceleration	
Map Index Number	USGS Number	Name	Coordinates (Lat. °N, Long. °W)		Direction (degrees)	Maximum (g)
		Berkeley, 2168 Shattuck - continued				
		Basement, West			261	0.10
					Up	.03
					171	.09
		Structure Array:				
		Ch. 1- 13th Floor, East Core			171	.13
		Ch. 2- 13th Floor, East Core			261	.23
		Ch. 3- 13th Floor, Center			171	.13
		Ch. 4- 13th Floor, Roof West Core			171	.19
		Ch. 5- 13th Floor, Roof West Core			081	.21
		Ch. 6- 13th Floor, Southwest			081	.23
		Ch. 7- 13th Floor, Southwest			171	.16
		Ch. 8- 4th Floor, Southwest			171	.23
		Ch. 9- 4th Floor, Southwest			081	.11
		Ch. 10- 4th Floor, West Core			081	.08
		Ch. 11- 4th Floor, West Core			171	.11
		Ch. 12- 4th Floor, East Core			171	.08
34.	1225	San Francisco VA Hospital	37.783 122.504	100		
		Basement			185	.08
					Up	.05
					095	.16
		7th Floor			185	.34
					Up	.08
					095	.22
35.	1678	San Francisco Golden Gate Bridge	37.806 122.472	100	360	.12
					Up	.06
					270	.24
36.	1439	Richmond Bulk Mail 2501 Rydin Road	37.884 122.302	101	057	.08
					Up	.04
					327	.11
37.	1448	Martinez VA Hospital Basement	37.993 122.115	109	020	.07
					Up	.03
					290	.05
38.	1590	Larkspur Ferry Terminal	37.946 122.508	115	360	.10
					Up	.06
					270	.14

ANDERSON DAM STRUCTURE ARRAY



DAM TYPE

ROLLED EARTH AND ROCKFILL STRUCTURE WITH CLAY CORE

Figure 2. Copies of accelerograms and selected structure drawings.

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1652 37.166N, 121.628W	340°	Sens. = 2.02 cm/g Freq. = 25.0 Hz	0.26g
Anderson Dam - Crest		Damp. = 0.6 crit	
SMA-1 No. 4324 (USGS)	Up	Sens. = 1.73 cm/g Freq. = 26.3 Hz	0.19g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	250°	Sens. = 1.75 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.39g

Film speed = 1 cm/sec

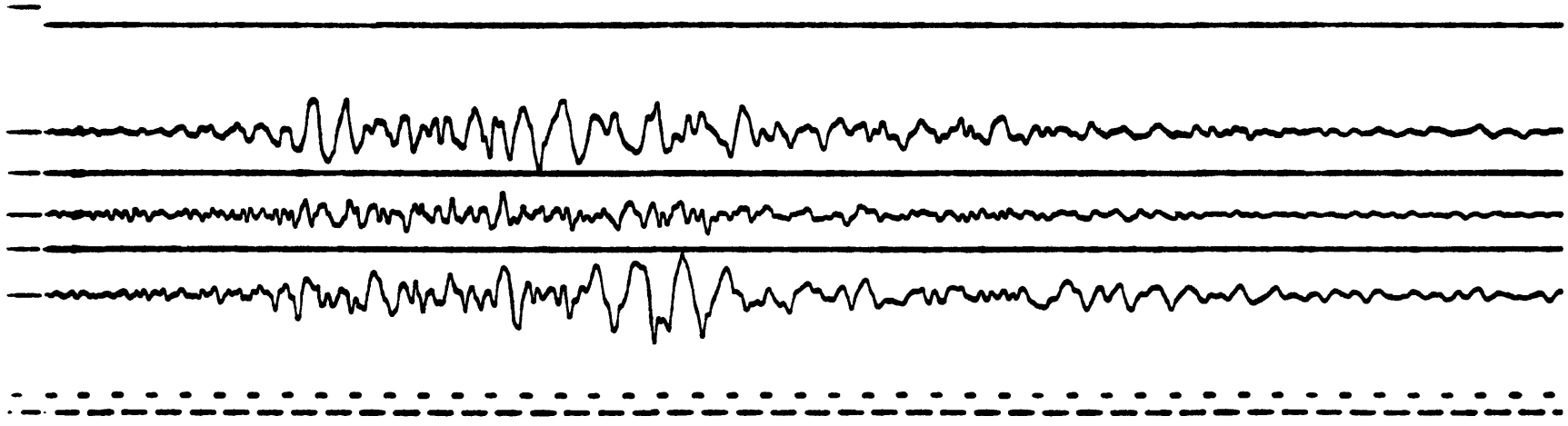


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1652 37.165N, 121.631W	340°	Sens. = 1.73 cm/g Freq. = 27.0 Hz	0.25g
Anderson Dam - Downstream		Damp. = 0.6 crit	
SMA-1 No. 2803 (USGS)	Up	Sens. = 1.69 cm/g Freq. = 27.0 Hz	0.17g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	250°	Sens. = 1.71 cm/g Freq. = 27.0 Hz Damp. = 0.6 crit	0.26g
		Film speed = 1 cm/sec	

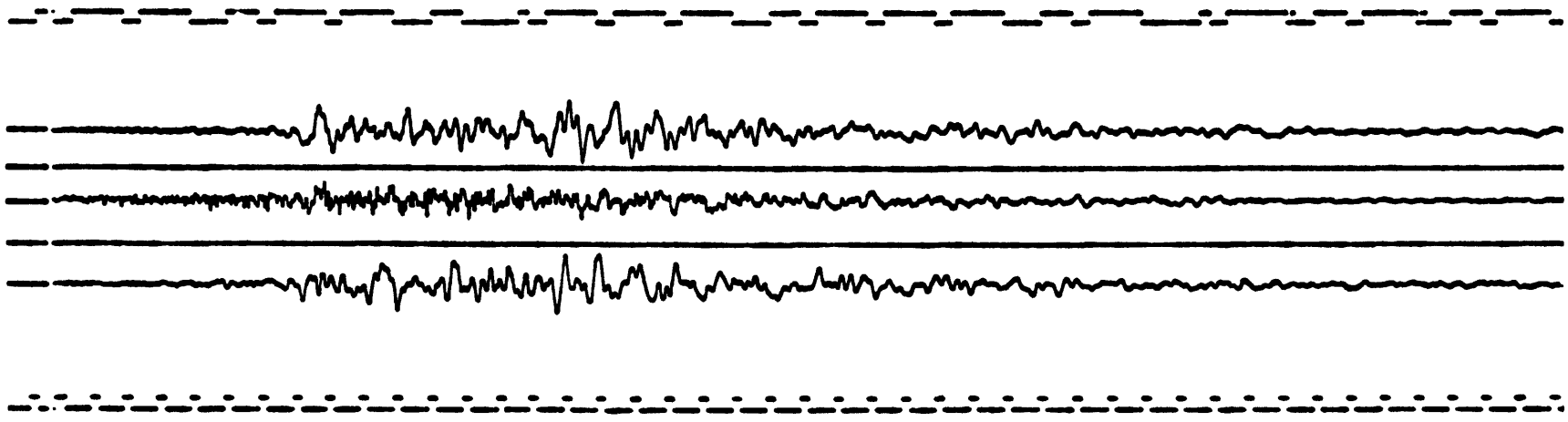


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1652 37.166N, 121.628W	340°	Sens. = 1.84 cm/g Freq. = 25.6 Hz	0.08g
Anderson Dam - L. Abutment		Damp. = 0.55 crit	
SMA-1 No. 468 (USGS)	Up	Sens. = 1.74 cm/g Freq. = 25.6 Hz	0.05g
EARTHQUAKE OF		Damp. = 0.57 crit	
18 October 1989 - 0004 G.m.t.	250°	Sens. = 1.82 cm/g Freq. = 25.6 Hz Damp. = 0.55 crit	0.07g
		Film speed = 1 cm/sec	

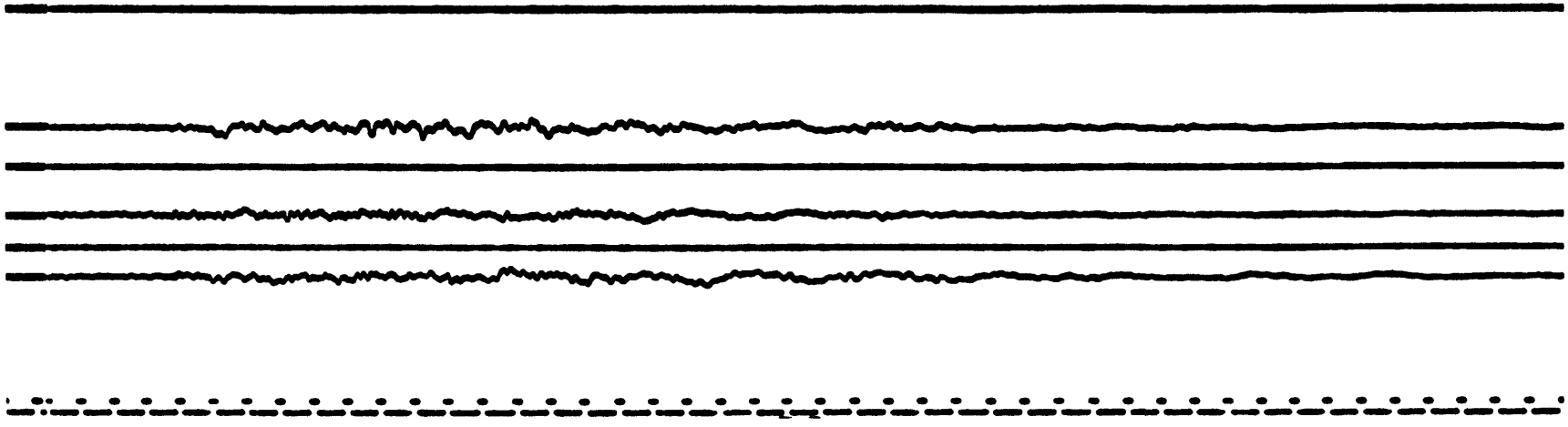


Figure 2. Continued

U.S. STRONG-MOTION NETWORK
Station No. 1652 37.166N, 121.628W

Anderson Dam

CRA-1 No. 252

EARTHQUAKE OF

18 October 1989 - 0004 G.m.t.

Film speed - 1 cm/sec

CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
1	160°	Mid-dam, Center	1.75 cm/g	0.11g
2	250°	Mid-dam, Center	1.85 cm/g	0.14g
3	070°	Mid-dam, Right	1.78 cm/g	0.14g
4	160°	Toe	1.91 cm/g	0.18g
5	Up	Toe	1.84 cm/g	0.16g
6	250°	Toe	1.84 cm/g	0.23g
7	160°	Center Crest	1.81 cm/g	0.32g
8	Up	Center Crest	1.77 cm/g	0.16g
9	250°	Center Crest	1.87 cm/g	0.43g
10	160°	Right Crest	1.78 cm/g	0.32g
11	Up	Right Crest	1.54 cm/g	0.23g
12	250°	Right Crest	1.75 cm/g	0.38g

(See Accelerogram on next page)

Figure 2. Continued

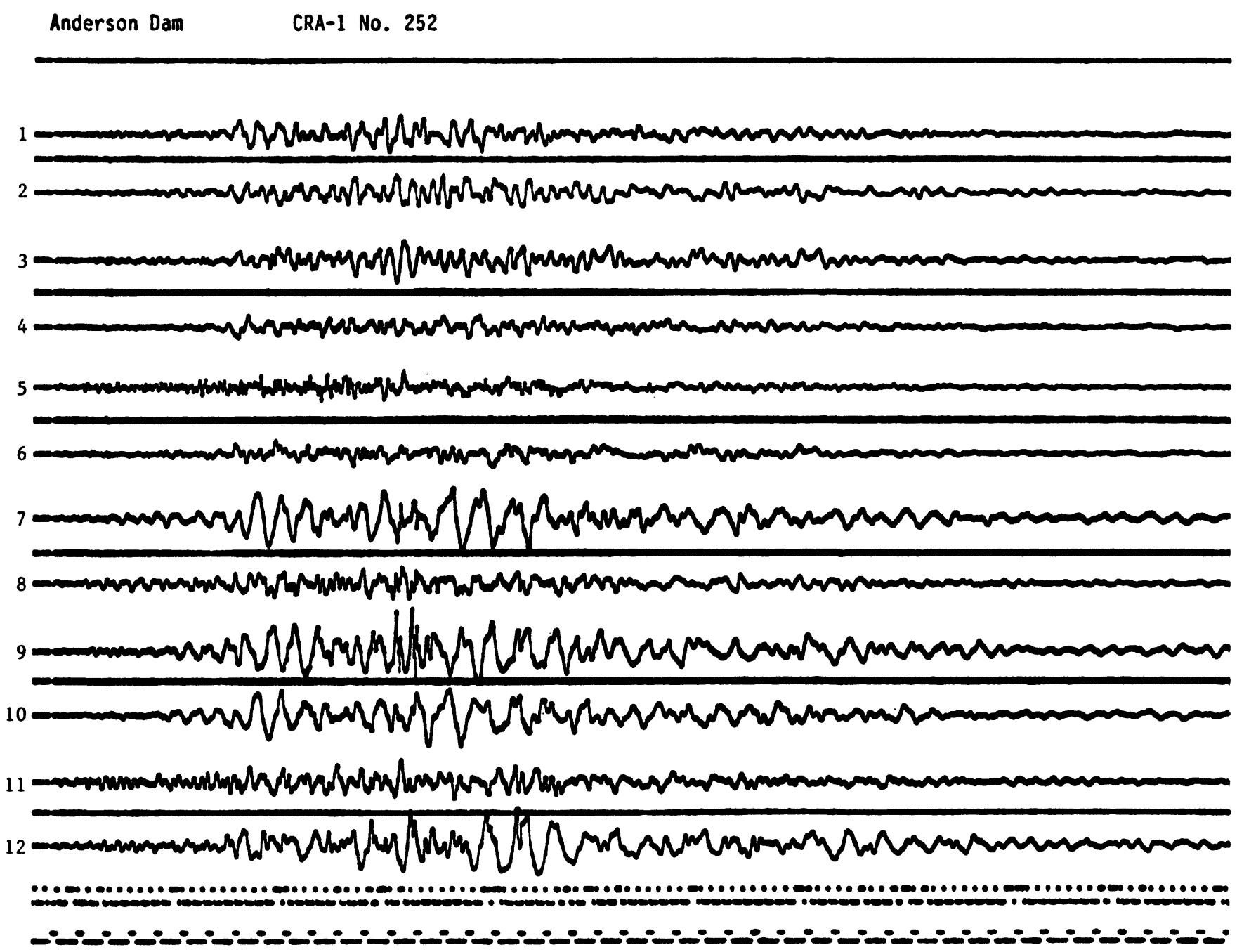


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1571 37.340N, 121.851W	322°	Sens. = 1.63 cm/g Freq. = 26.3 Hz	0.18g
San Jose 101/280/680 Fwy Interchange		Damp. = 0.6 crit	
SMA-1 No. 288 USGS/CDOT (Bridge)	Up	Sens. = 1.84 cm/g Freq. = 26.3 Hz	0.08g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	232°	Sens. = 1.81 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.13g
		Film speed = 1 cm/sec	

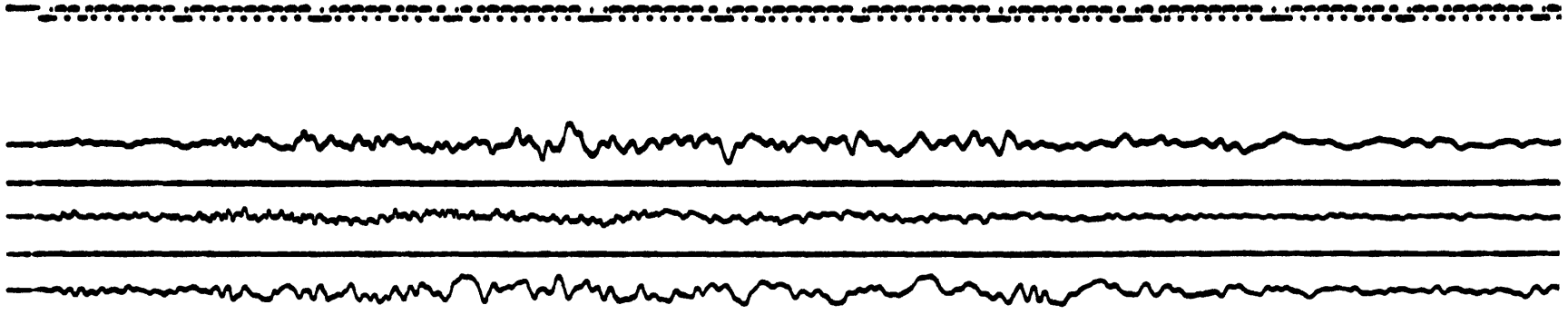


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1696 37.396N, 121.756W	360°	Sens. = 2.00 cm/g Freq. = 24.7 Hz Damp. = 0.62 crit	0.09g
Calaveras Array - Cherry Flat Reservoir			
SMA-1 No. 600 (USGS) L. abutment	Up	Sens. = 1.70 cm/g Freq. = 25.8 Hz Damp. = 0.59 crit	0.06g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.75 cm/g Freq. = 25.0 Hz Damp. = 0.59 crit	0.07g
		Film speed = 1 cm/sec	

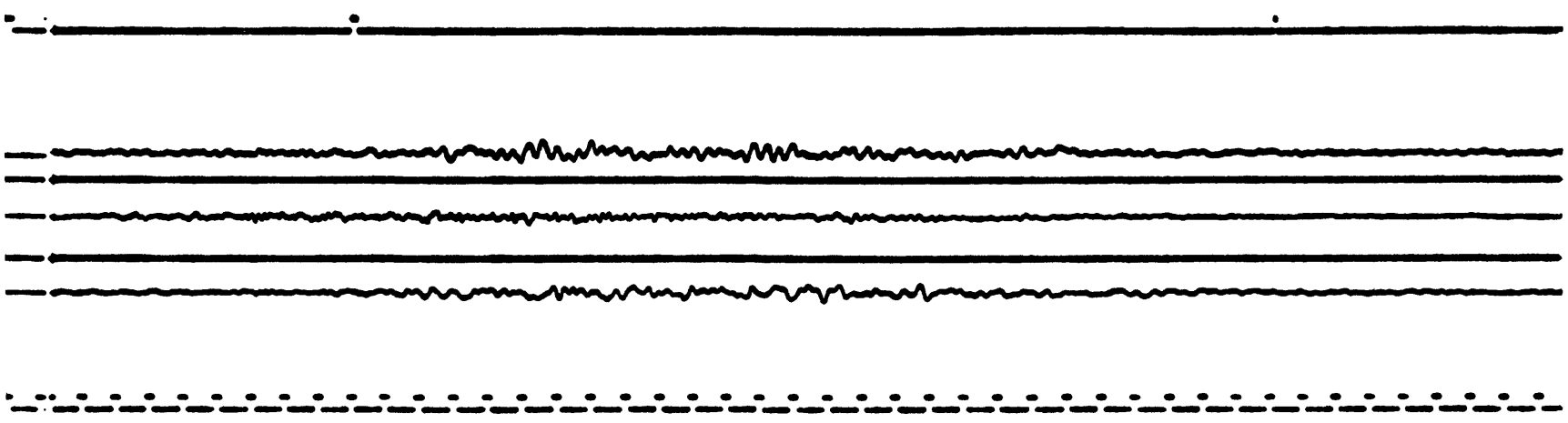


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1695 37.402N, 122.024W	360°	Sens. = 1.88 cm/g Freq. = 25.5 Hz Damp. = 0.6 crit	0.22g
Sunnyvale - Colton Avenue			
SMA-1 No. 4053 (USGS) Ground	Up	Sens. = 1.95 cm/g Freq. = 24.9 Hz Damp. = 0.6 crit	0.10g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.71 cm/g Freq. = 26.1 Hz Damp. = 0.6 crit	0.19g
		Film speed = 1 cm/sec	

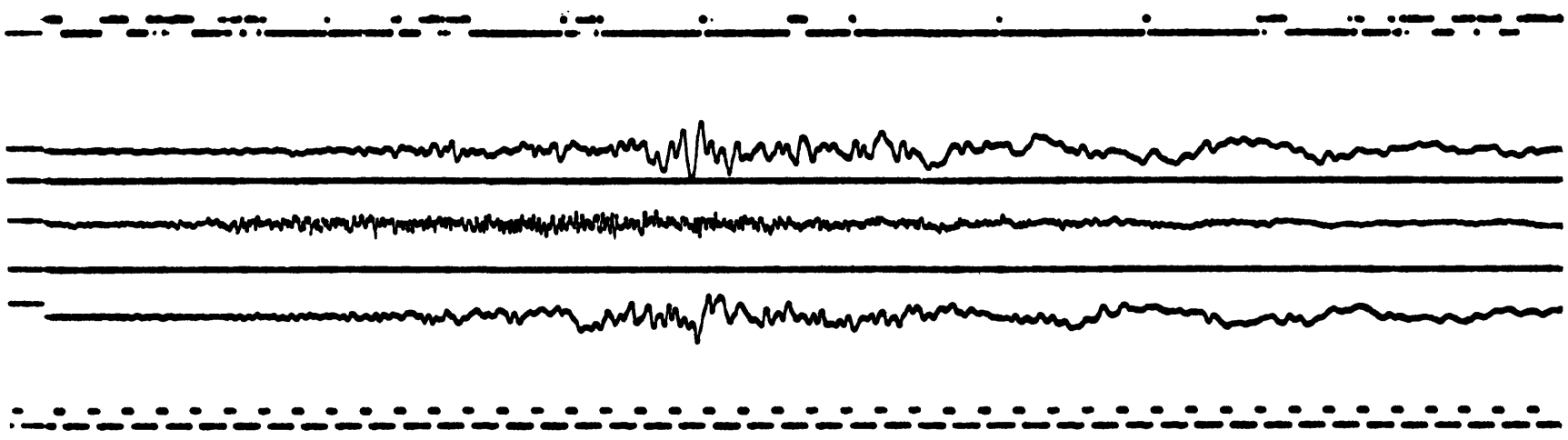


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1656 36.888N, 121.413W	255°	Sens. = 1.80 cm/g Freq. = 26.2 Hz	0.29g
Hollister Airport		Damp. = 0.6 crit	
SMA-1 No. 3928 (USGS) Ground	Up	Sens. = 1.83 cm/g Freq. = 25.7 Hz	0.16g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	165°	Sens. = 1.91 cm/g Freq. = 25.5 Hz Damp. = 0.6 crit	0.27g

Film speed = 1 cm/sec

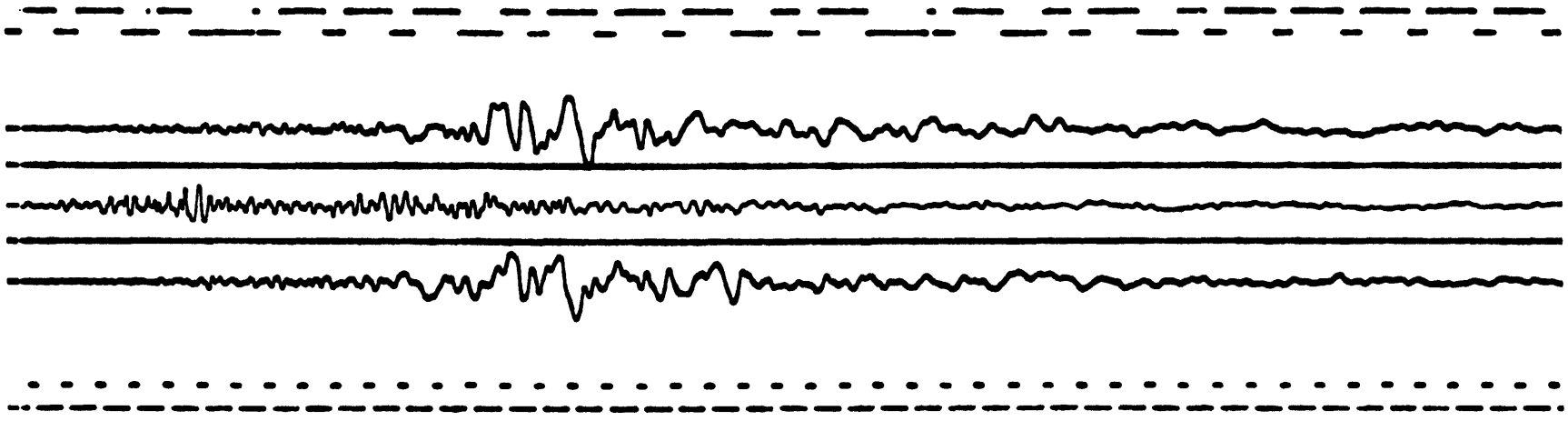


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1227 37.40N, 122.14W	302°	Sens. = 1.78 cm/g Freq. = 28.6 Hz	0.34g
Palo Alto VA Hospital - Bldg. 1		Damp. = 0.57 crit	
SMA-1 No. 605 (VA) Basement	Up	Sens. = 1.64 cm/g Freq. = 28.6 Hz	0.20g
EARTHQUAKE OF		Damp. = 0.57 crit	
18 October 1989 - 0004 G.m.t.	212°	Sens. = 1.78 cm/g Freq. = 27.8 Hz Damp. = 0.57 crit	0.38g
		Film speed = 1 cm/sec	

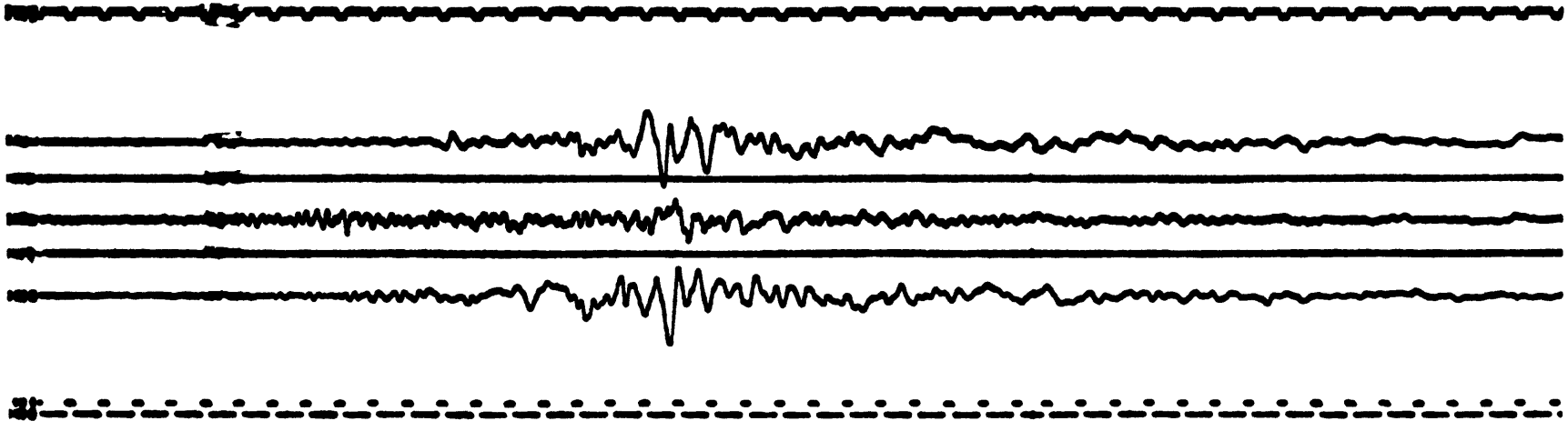


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1227 37.40N, 122.14W	302°	Sens. = 1.79 cm/g Freq. = 26.3 Hz Damp. = 0.57 crit	1.09g
Palo Alto VA Hospital - Bldg. 1			
SMA-1 No. 853 (VA) Roof (7th level)	Up	Sens. = 1.74 cm/g Freq. = 25.6 Hz Damp. = 0.57 crit	0.64g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	212°	Sens. = 1.90 cm/g Freq. = 27.0 Hz Damp. = 0.57 crit	0.79g
		Film speed = 1 cm/sec	

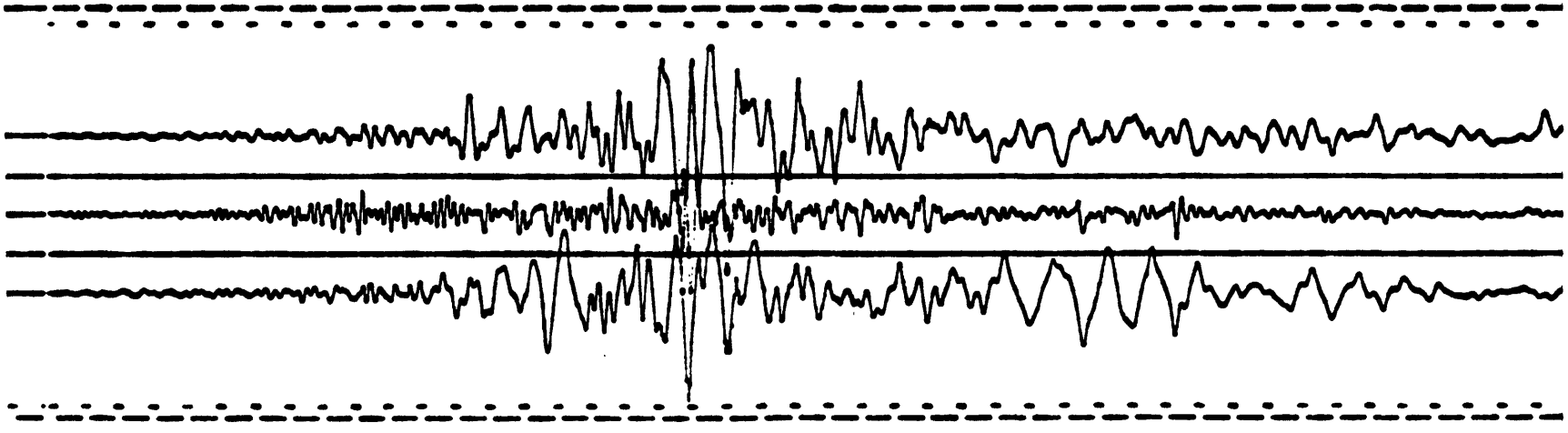


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1575 36.851N, 121.402W	180°	Sens. = 1.79 cm/g Freq. = 25.8 Hz	0.23g
Hollister City Hall Annex - Basement		Damp. = 0.58 crit	
SMA-1 No. 2504 (USGS)	Up	Sens. = 1.67 cm/g Freq. = 26.7 Hz	0.22g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	090°	Sens. = 1.69 cm/g Freq. = 27.2 Hz Damp. = 0.59 crit	0.25g
		Film speed = 1 cm/sec	

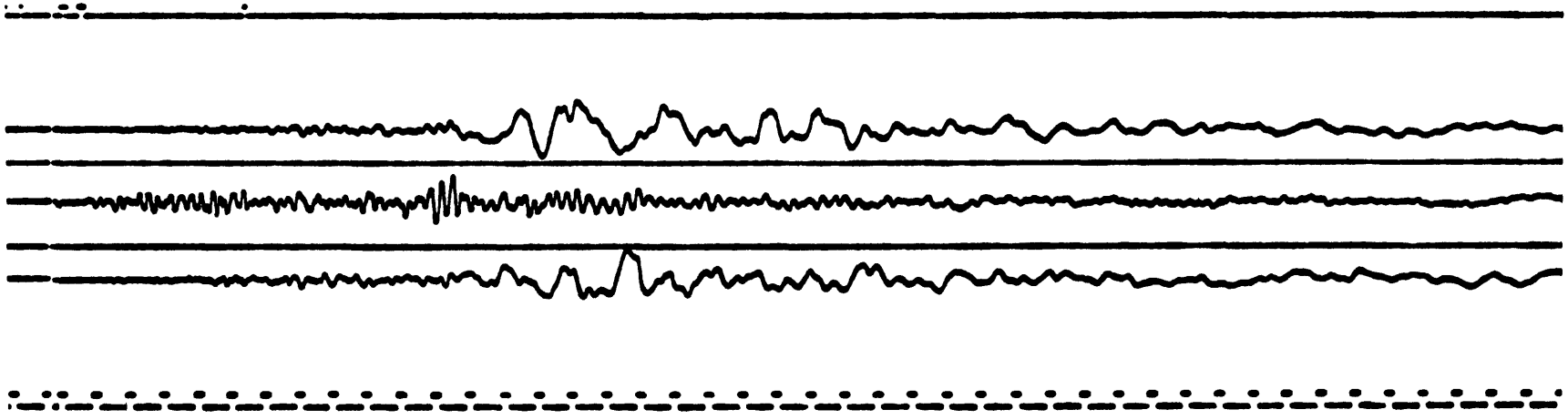


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1687 37.452N, 121.807W	180°	Sens. = 1.81 cm/g Freq. = 25.7 Hz Damp. = 0.60 crit	0.13g
Calaveras Array - Calaveras Reservoir South SMA-1 No. 2257 (USGS) Ground	Up	Sens. = 1.76 cm/g Freq. = 26.3 Hz Damp. = 0.56 crit	0.07g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	090°	Sens. = 1.71 cm/g Freq. = 26.2 Hz Damp. = 0.58 crit	0.08g
		Film speed = 1 cm/sec	

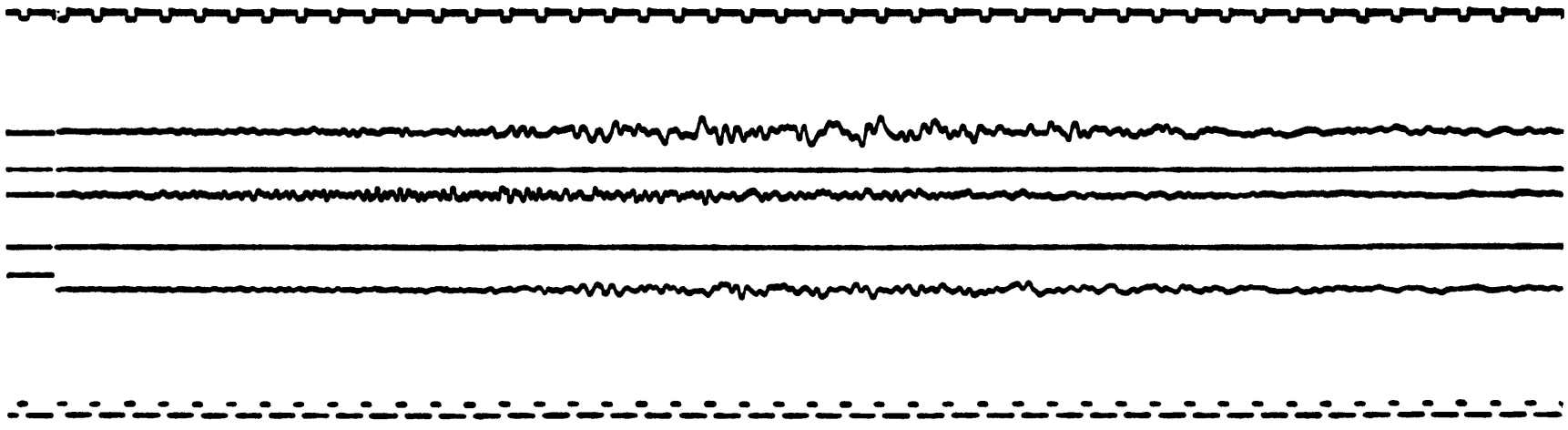


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1032 36.765N, 121.446W	360°	Sens. = 1.94 cm/g Freq. = 25.3 Hz	0.06g
Hollister, SAGO Vault		Damp. = 0.6 crit	
SMA-1 No. 832 (UCB) Ground	Up	Sens. = 1.85 cm/g Freq. = 25.5 Hz	0.05g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.81 cm/g Freq. = 26.1 Hz Damp. = 0.6 crit	0.04g

Film speed = 1 cm/sec

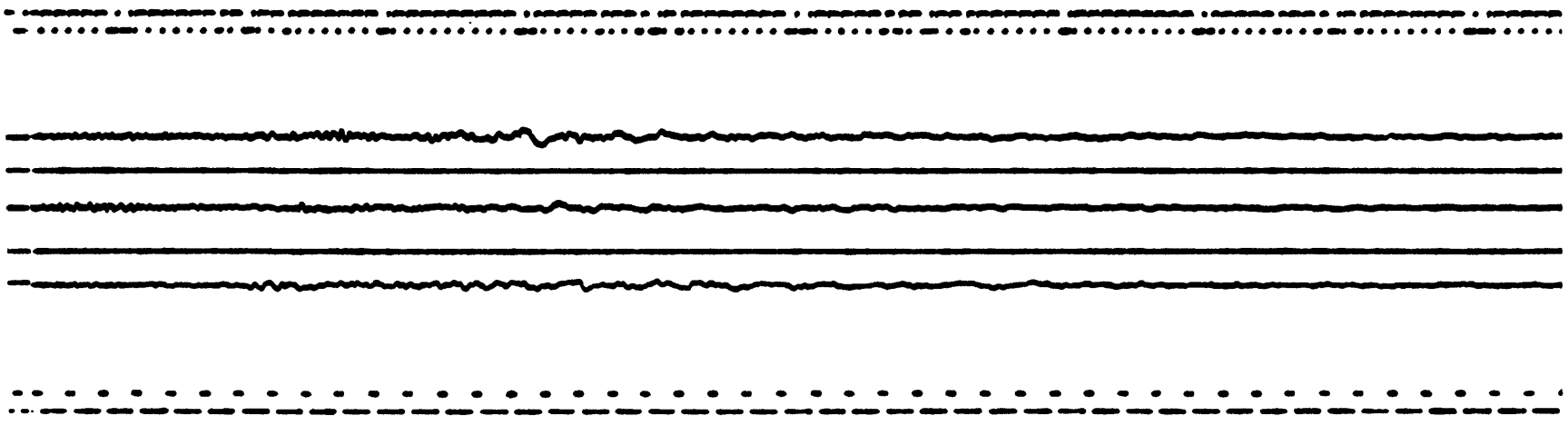


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1601 37.419N, 122.205W	360°	Sens. = 1.96 cm/g Freq. = 25.5 Hz Damp. = 0.6 crit	0.29g
Stanford University - SLAC Test Lab.			
SMA-1 No. 4766 (USGS) Ground	Up	Sens. = 1.80 cm/g Freq. = 26.1 Hz Damp. = 0.6 crit	0.10g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.88 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.19g
		Film speed = 1 cm/sec	

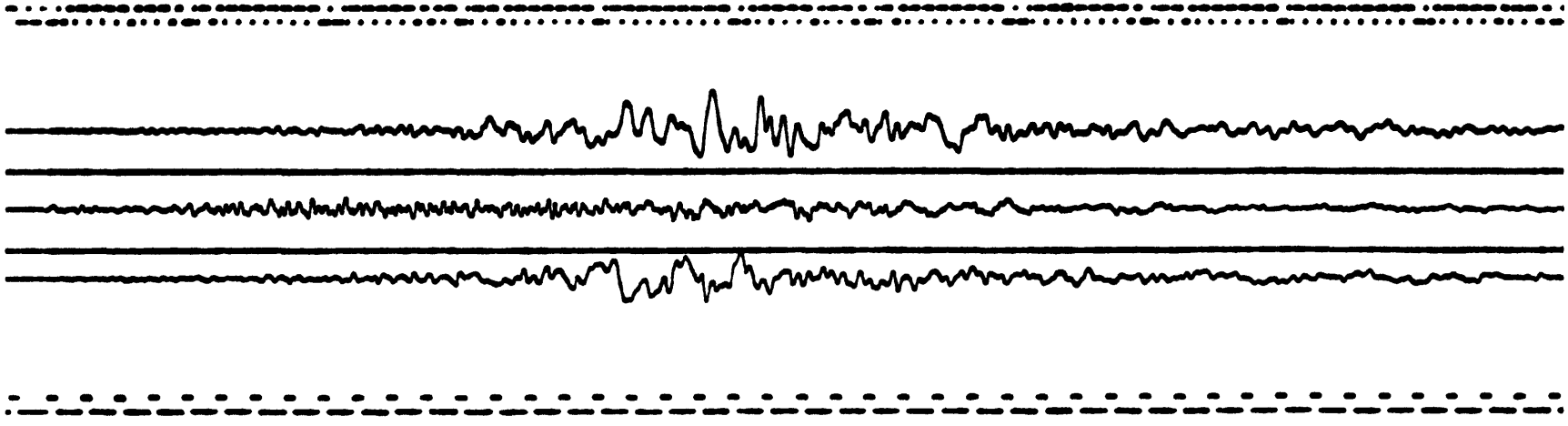


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1230 37.468N, 122.157W	110°	Sens. = 1.80 cm/g Freq. = 25.4 Hz	0.12g
Menlo Park VA Hospital - Bldg. 137		Damp. = 0.6 crit	
SMA-1 No. 752 (VA) Ground level	Up	Sens. = 1.93 cm/g Freq. = 24.6 Hz	0.11g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	020°	Sens. = 1.90 cm/g Freq. = 25.7 Hz Damp. = 0.6 crit	0.27g

Film speed = 1 cm/sec

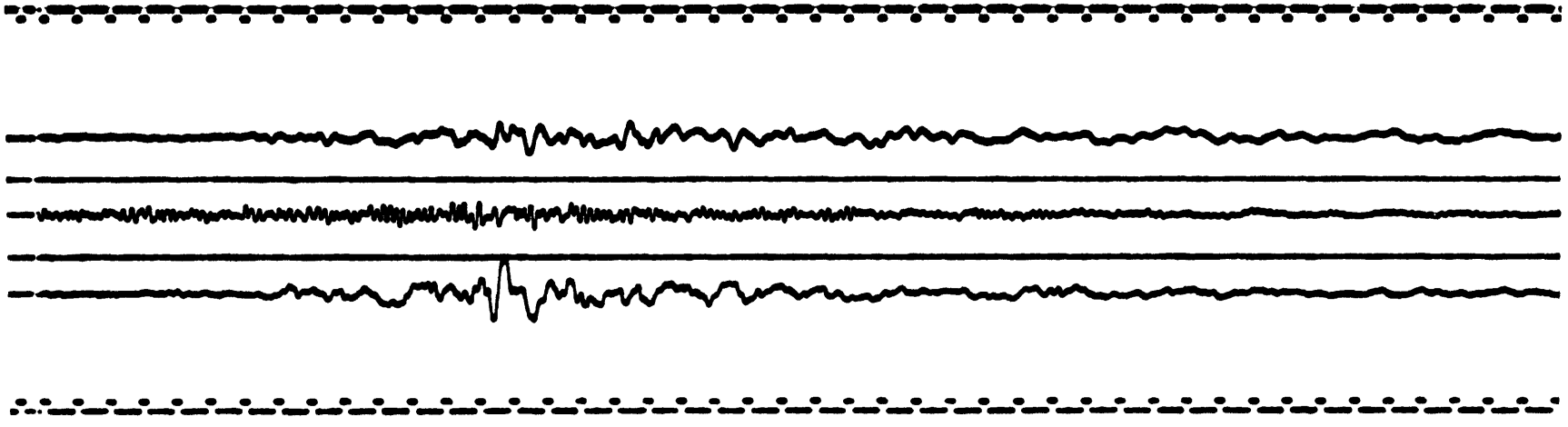


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1686 37.535N, 121.929W	180°	Sens. = 1.85 cm/g Freq. = 25.2 Hz Damp. = 0.61 crit	0.15g
Calaveras Array - Fremont, Emerson Ct.			
SMA-1 No. 2261 (USGS) Ground	Up	Sens. = 1.75 cm/g Freq. = 26.1 Hz Damp. = 0.59 crit	0.07g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	090°	Sens. = 1.87 cm/g Freq. = 25.4 Hz Damp. = 0.6 crit	0.20g
		Film speed = 1 cm/sec	

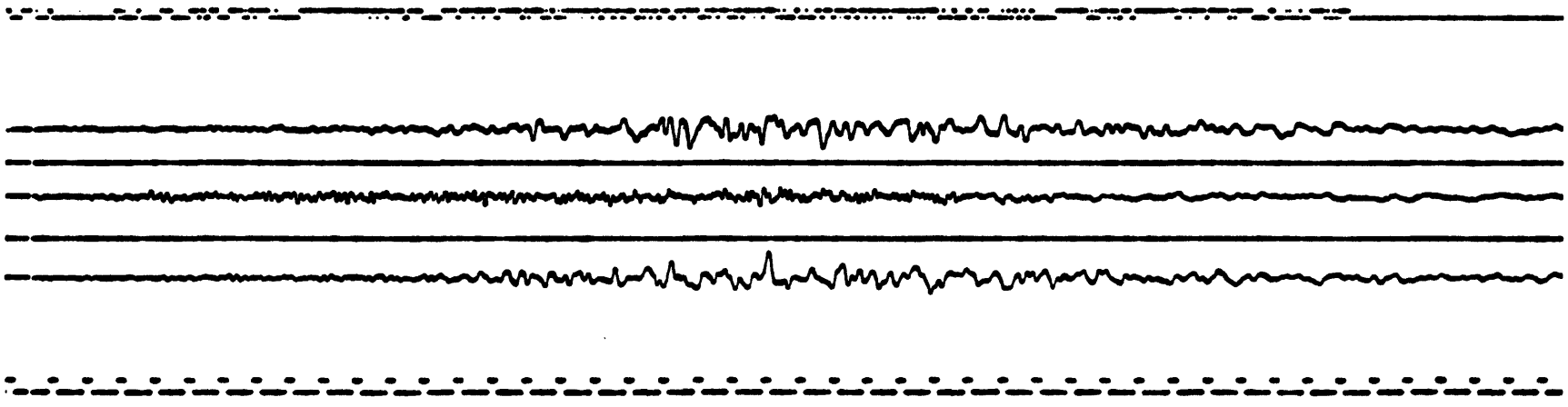


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1161 37.47N, 122.32W	227°	Sens. = 1.78 cm/g Freq. = 26.8 Hz	0.11g
APEEL Array Station #9		Damp. = 0.6 crit	
SMA-1 No. 590 (USGS) Ground	Up	Sens. = 1.79 cm/g Freq. = 26.3 Hz	0.06g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	137°	Sens. = 1.82 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.12g
		Film speed = 1 cm/sec	

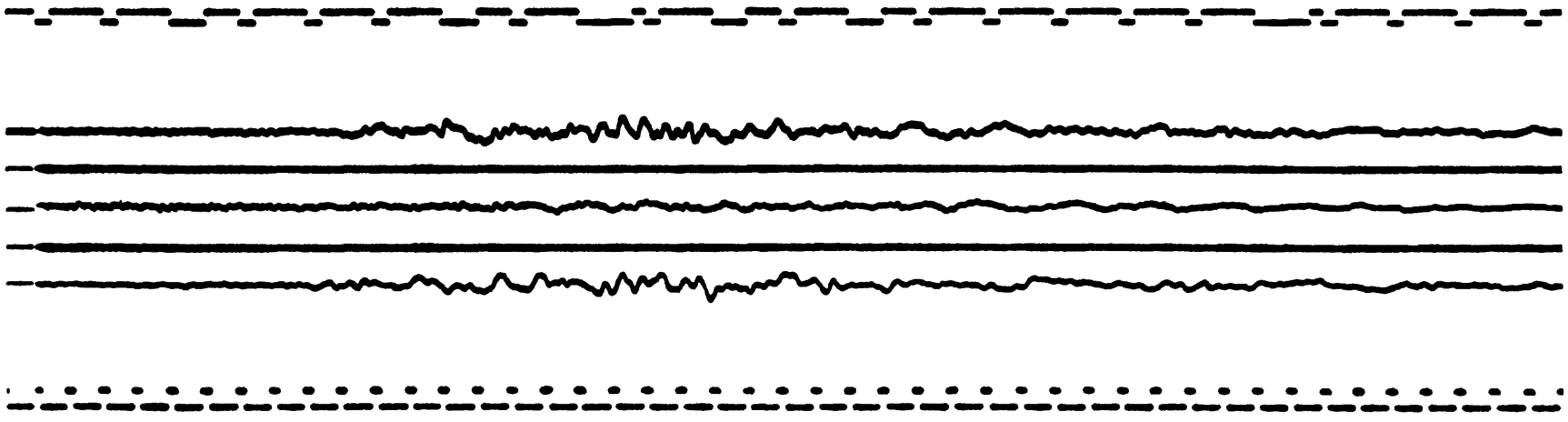


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1688 37.597N, 121.880W	180°	Sens. = 1.91 cm/g Freq. = 25.3 Hz Damp. = 0.6 crit	0.07g
Calaveras Array - Sunol Fire Station			
SMA-1 No. 4703 (USGS) Ground	Up	Sens. = 1.91 cm/g Freq. = 24.9 Hz Damp. = 0.6 crit	0.03g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	090°	Sens. = 1.89 cm/g Freq. = 25.5 Hz Damp. = 0.6 crit	0.10g
		Film speed = 1 cm/sec	

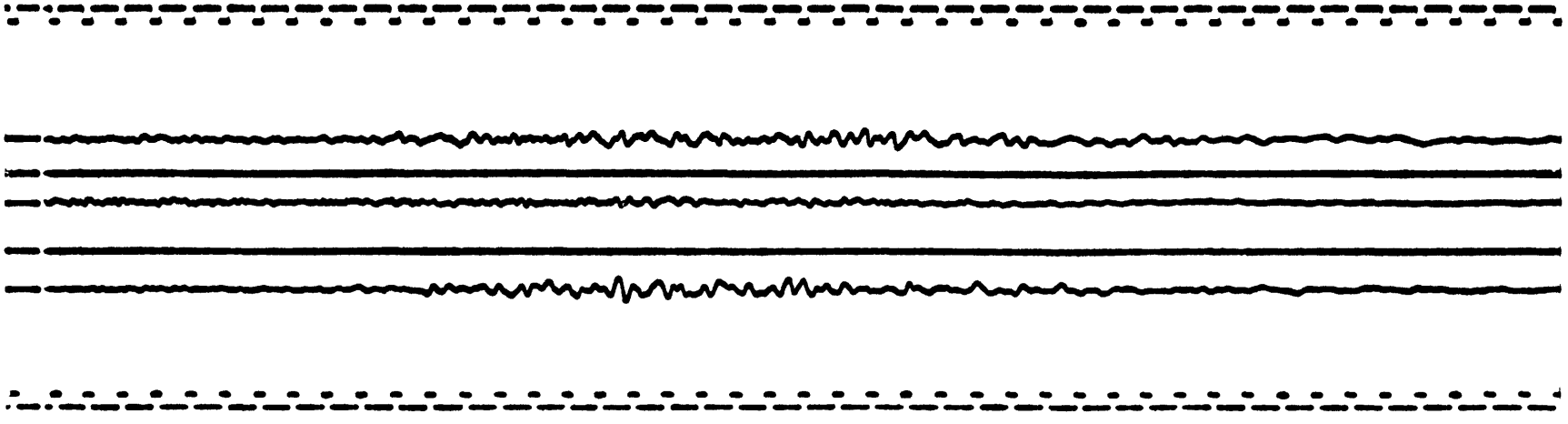


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1002 37.52N, 122.25W	133°	Sens. = 2.06 cm/g Freq. = 24.2 Hz Damp. = 0.6 crit	0.23g
APEEL Array #2, Redwood City			
SMA-1 No. 4225 (USGS) Ground	Up	Sens. = 2.04 cm/g Freq. = 24.8 Hz Damp. = 0.6 crit	0.08g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	043°	Sens. = 1.83 cm/g Freq. = 25.7 Hz Damp. = 0.6 crit	0.28g
		Film speed = 1 cm/sec	

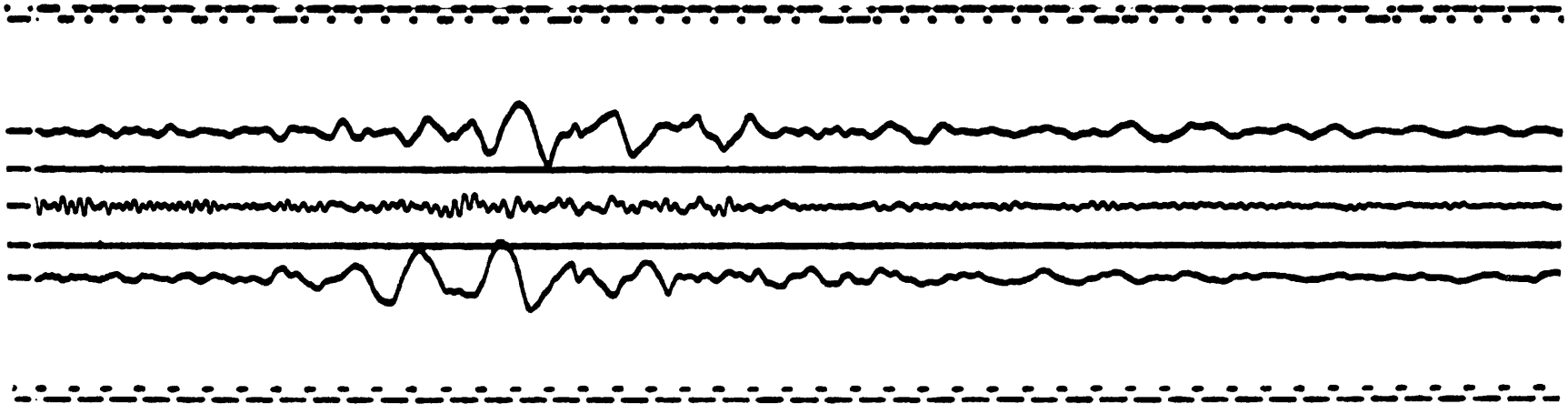


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1515 37.555N, 122.248W	360°	Sens. = 2.03 cm/g Freq. = 24.8 Hz	0.12g
Foster City, 355 Menhaden Ct.		Damp. = 0.6 crit	
SMA-1 No. 3034 (USGS) Ground	Up	Sens. = 1.88 cm/g Freq. = 26.0 Hz	0.09g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.85 cm/g Freq. = 25.8 Hz Damp. = 0.6 crit	0.11g
		Film speed = 1 cm/sec	

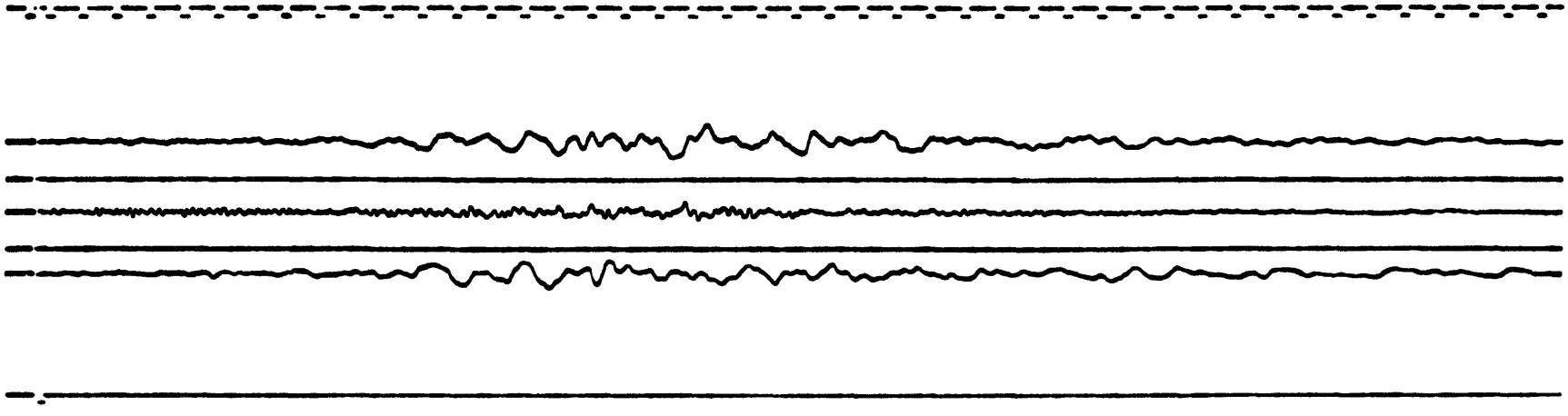


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1265 37.615N, 121.745W	065°	Sens. = 1.90 cm/g Freq. = 25.4 Hz	0.08g
Del Valle Dam - Crest		Damp. = 0.6 crit	
SMA-1 No. 444 (CDWR)	Up	Sens. = 1.75 cm/g Freq. = 26.5 Hz	0.07g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	335°	Sens. = 1.70 cm/g Freq. = 26.5 Hz Damp. = 0.6 crit	0.08g
		Film speed = 1 cm/sec	

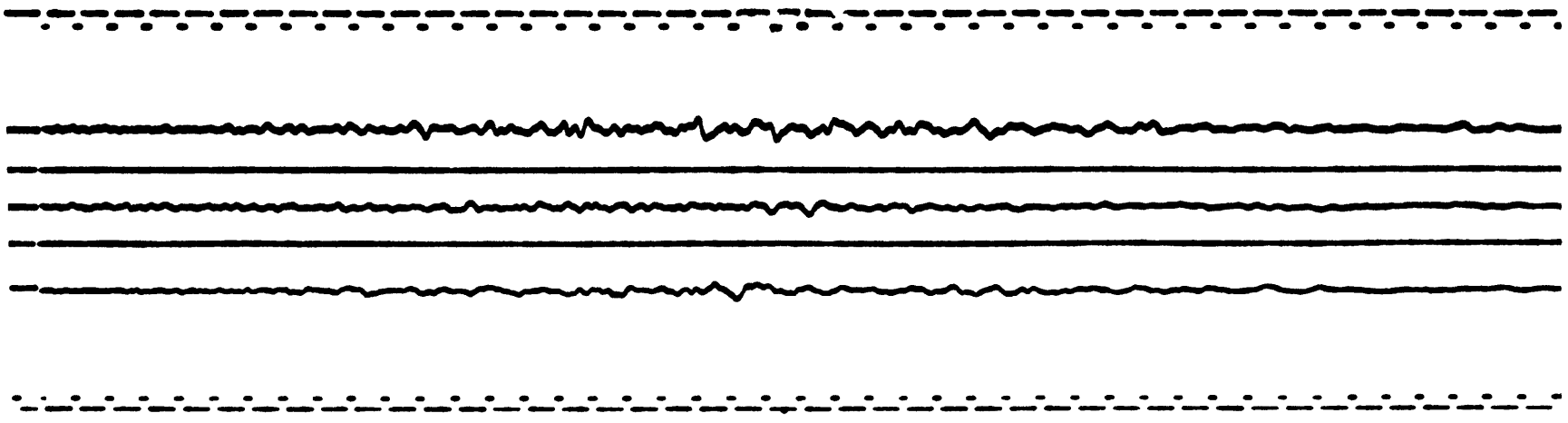


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1265 37.615N, 121.745W	065°	Sens. = 2.00 cm/g Freq. = 25.4 Hz	0.06g
Del Valle Dam - Toe		Damp. = 0.6 crit	
SMA-1 No. 451 (CDWR)	Up	Sens. = 1.80 cm/g Freq. = 25.6 Hz	0.03g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	335°	Sens. = 1.80 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.04g

Film speed = 1 cm/sec

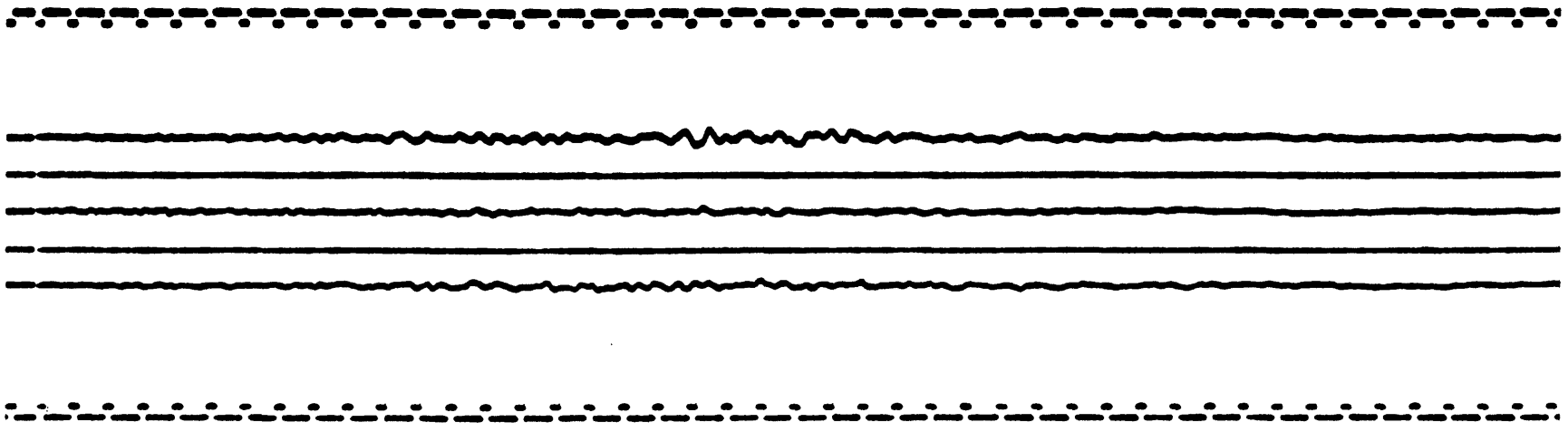


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1226 37.625N, 121.762W	125°	Sens. = 1.86 cm/g Freq. = 25.4 Hz	0.06g
Livermore VA Hospital - Bldg. 62		Damp. = 0.6 crit	
SMA-1 No. 602 (VA) Basement	Up	Sens. = 1.79 cm/g Freq. = 25.8 Hz	0.03g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	035°	Sens. = 1.95 cm/g Freq. = 25.8 Hz Damp. = 0.6 crit	0.05g
		Film speed = 1 cm/sec	

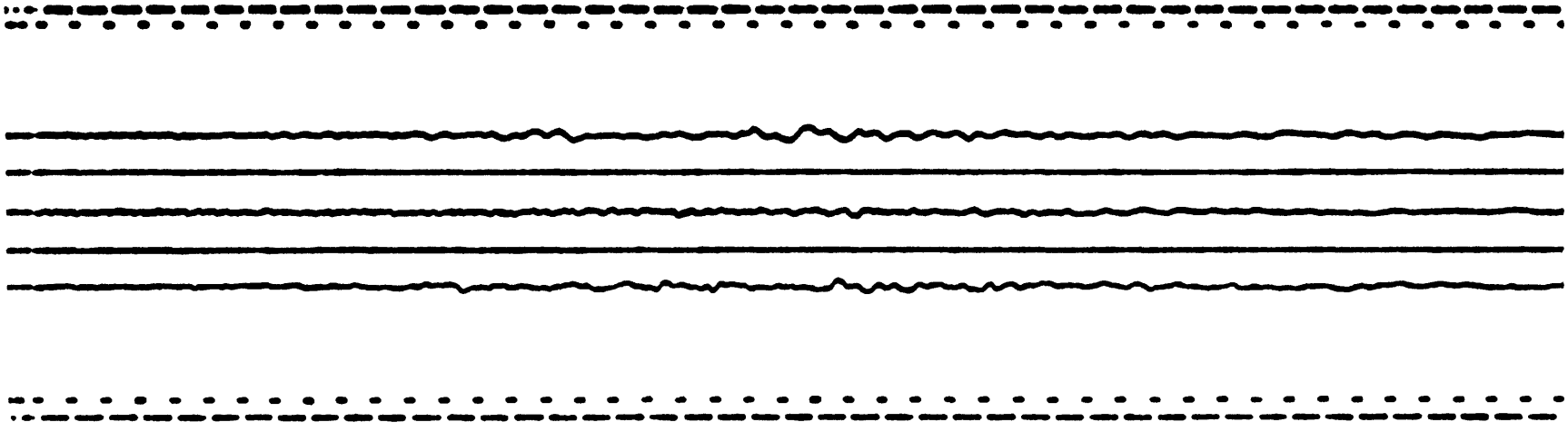


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1226 37.625N, 121.762W	125°	Sens. = 1.80 cm/g Freq. = 25.8 Hz	0.08g
Livermore VA Hospital - Bldg. 62		Damp. = 0.6 crit	
SMA-1 No. 854 (VA) Roof (7th)	Up	Sens. = 1.80 cm/g Freq. = 25.8 Hz	0.03g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	035°	Sens. = 1.90 cm/g Freq. = 25.3 Hz Damp. = 0.6 crit	0.15g

Film speed = 1 cm/sec

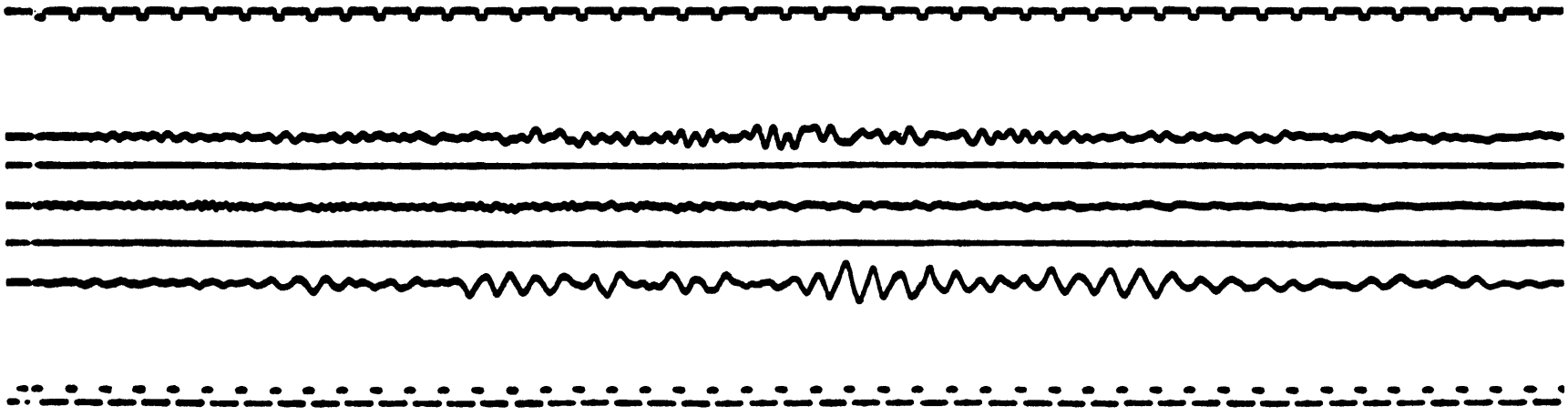


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1481 36.658N, 121.249W	310°	Sens. = 1.90 cm/g Freq. = 25.6 Hz	0.17g
Bear Valley Station 12 - Williams Ranch		Damp. = 0.6 crit	
SMA-1 No. 1490 (USGS) Ground	Up	Sens. = 1.79 cm/g Freq. = 26.2 Hz	0.10g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	220°	Sens. = 1.81 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.16g

Film speed = 1 cm/sec

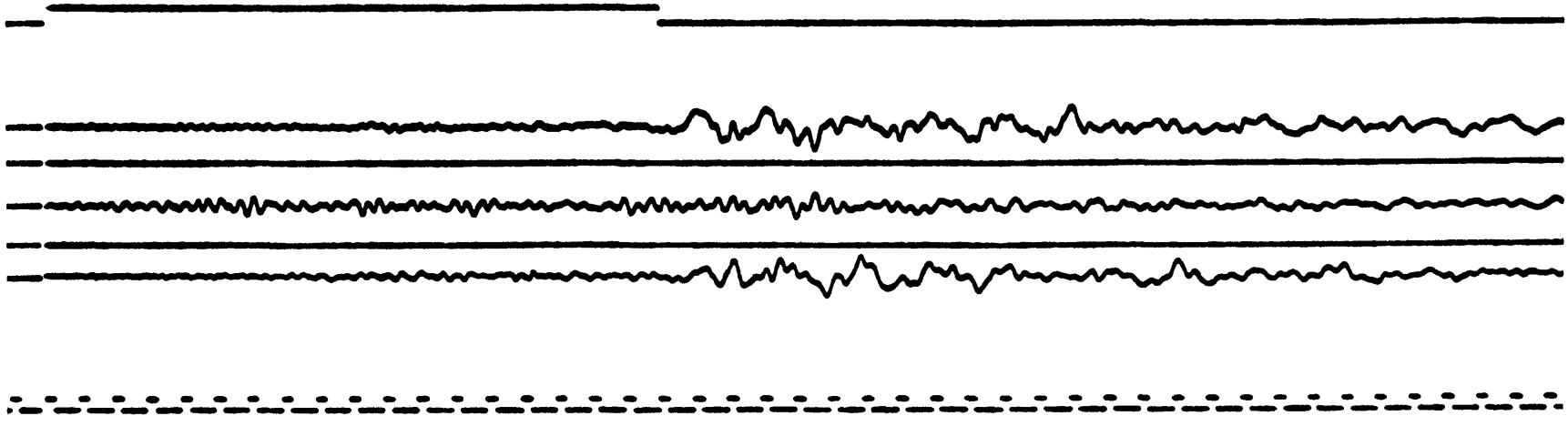


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1121 37.66N, 122.08W	054°	Sens. = 2.50 cm/g Freq. = 50.1 Hz Damp. = 0.64 crit	0.13g
APEEL Array Station 2E - Hayward John Muir School DSA-1 No. 137 (USGS) Ground	Up	Sens. = 2.50 cm/g Freq. = 51.3 Hz Damp. = 0.66 crit	0.06g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	324°	Sens. = 2.50 cm/g Freq. = 51.9 Hz Damp. = 0.66 crit	0.16g

Paper speed = 2.5 cm/sec

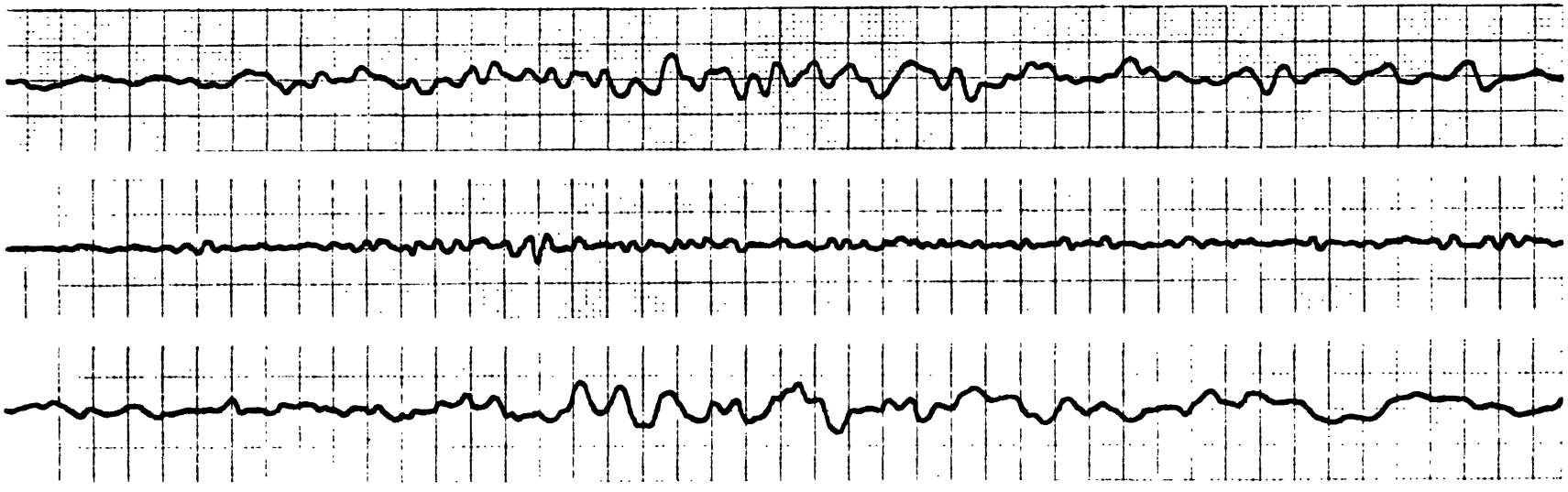


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1474 36.673N, 121.195W	310°	Sens. = 1.98 cm/g Freq. = 25.0 Hz	0.07g
Bear Valley Station 5 - Callens Ranch		Damp. = 0.6 crit	
SMA-1 No. 1481 (USGS) Ground	Up	Sens. = 1.81 cm/g Freq. = 25.8 Hz	0.04g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	220°	Sens. = 1.91 cm/g Freq. = 24.9 Hz	0.07g
		Damp. = 0.6 crit	
		Film speed = 1 cm/sec	

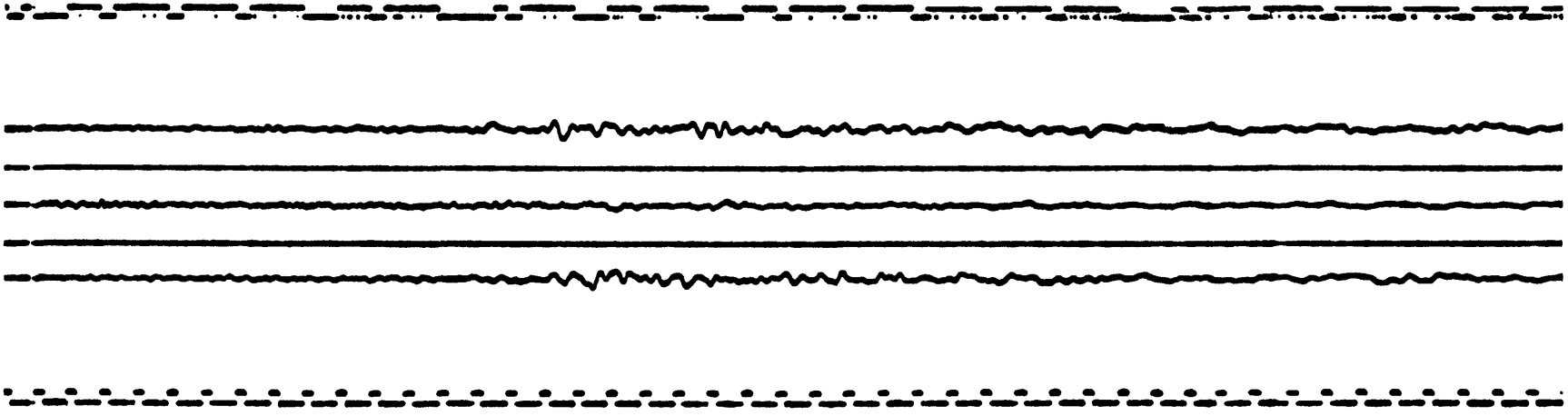


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1129 37.679N, 122.082W	064°	Sens. = 1.85 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.05g
Hayward City Hall, Ground floor			
SMA-1 No. 431 (USGS)	Up	Sens. = 1.82 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.03g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	334°	Sens. = 1.90 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.06g

Film speed = 1 cm/sec

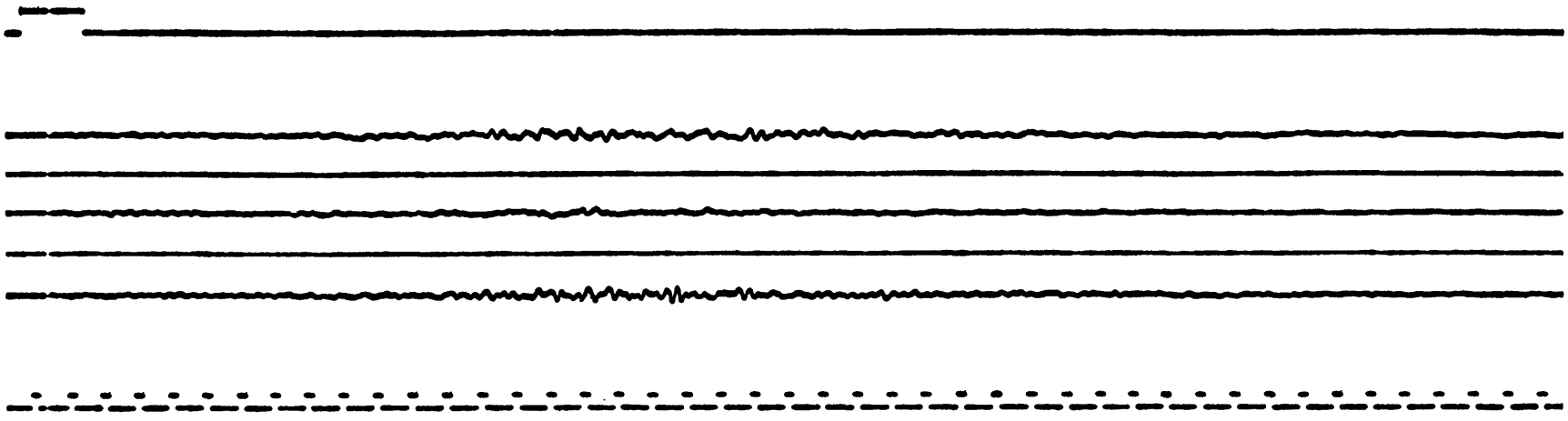


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1129 37.68N, 122.08W	064°	Sens. = 1.80 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.06g
Hayward City Hall, Ground Site North			
SMA-1 No. 430 (USGS)	Up	Sens. = 1.90 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.02g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	334°	Sens. = 1.75 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.06g

Film speed = 1 cm/sec

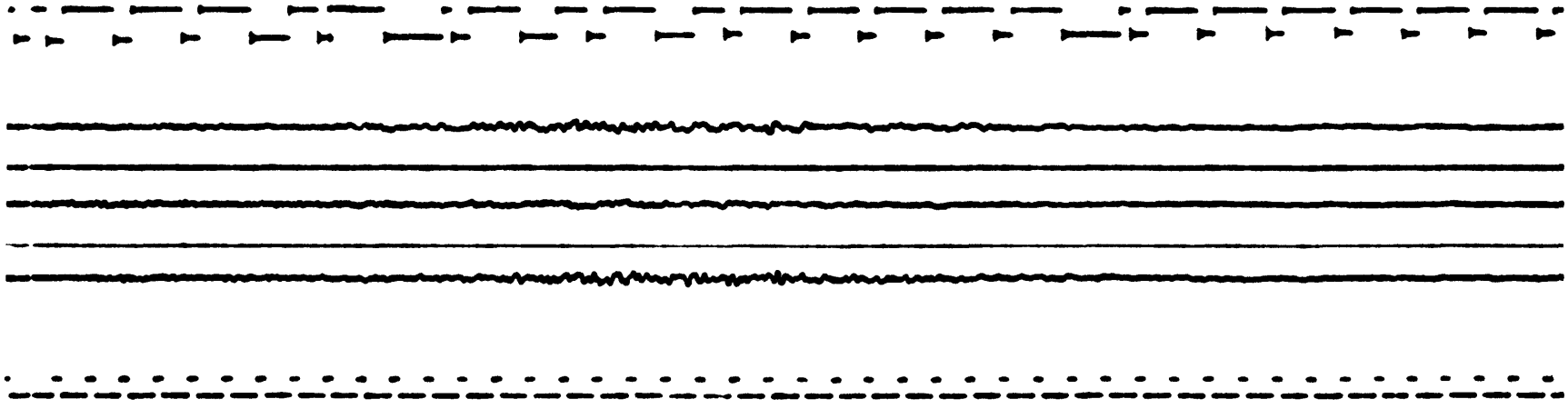


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1129 37.68N, 122.08W	064°	Sens. = 1.90 cm/g Freq. = 25.0 Hz Damp. = 0.6 crit	0.09g
Hayward City Hall, Ground Site South			
SMA-1 No. 429 (USGS)	Up	Sens. = 1.77 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.03g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	334°	Sens. = 1.85 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.10g

Film speed = 1 cm/sec

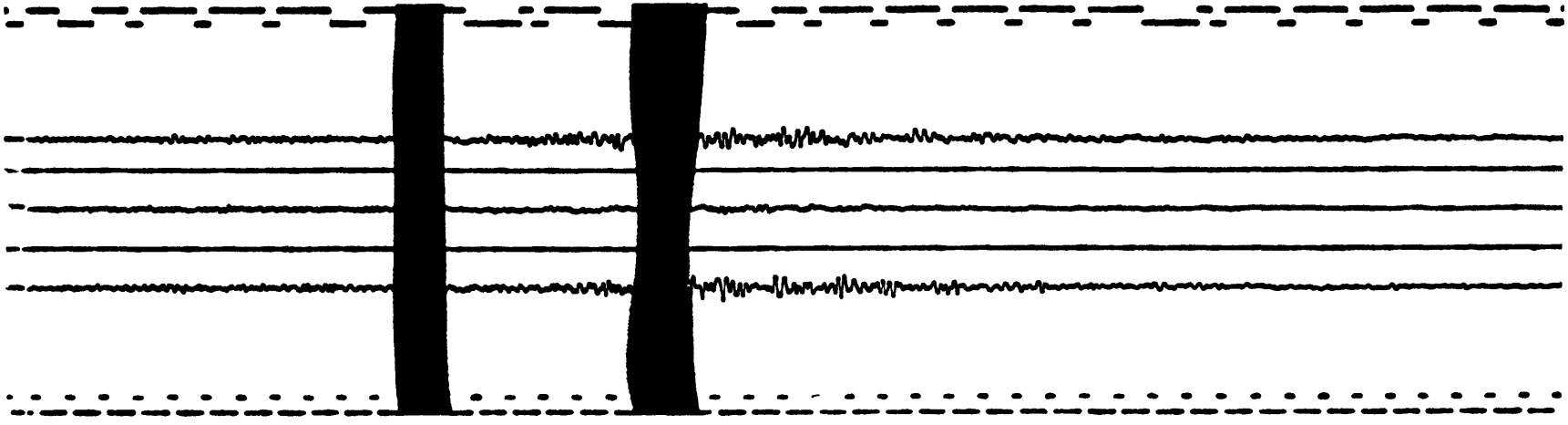
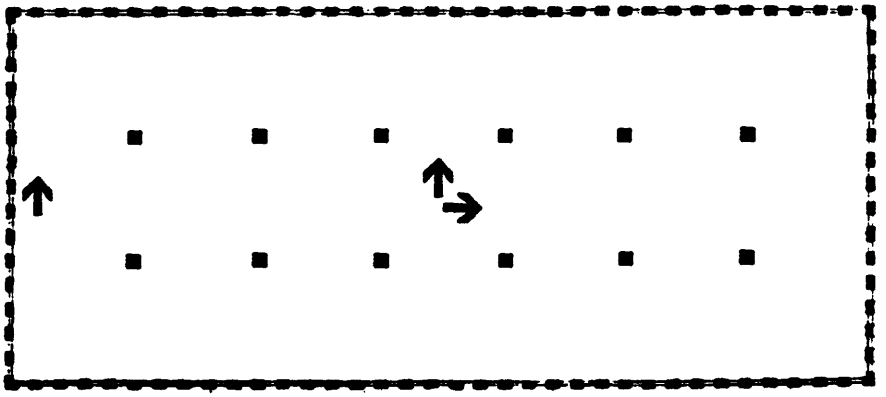
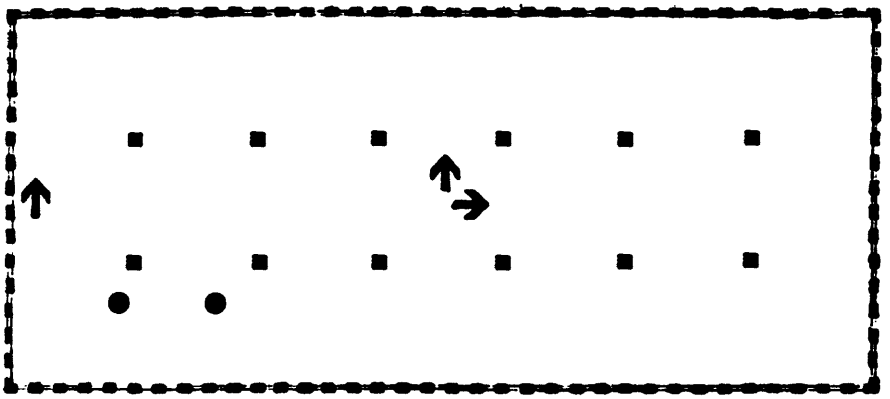


Figure 2. Continued

HAYWARD CITY HALL INSTRUMENTATION



12TH & 7TH FLOORS

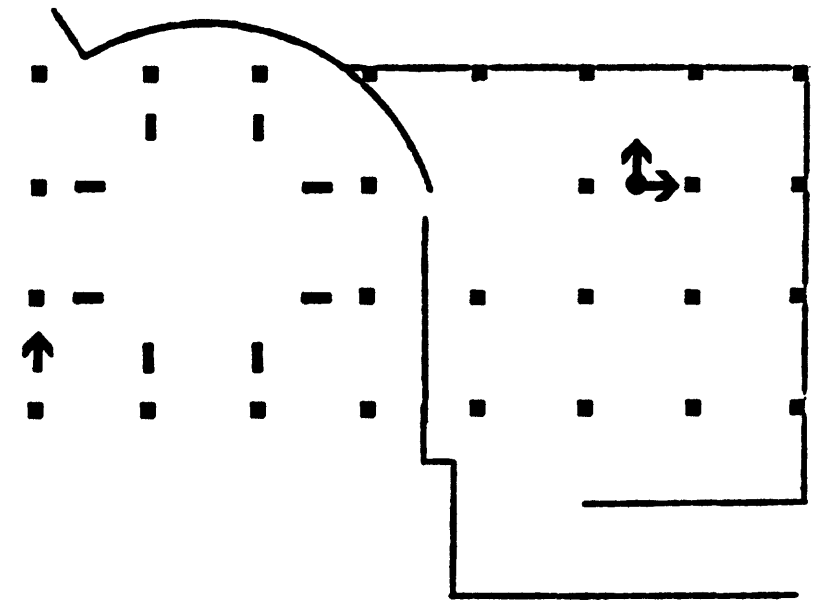


3RD FLOOR

SENSORS

● VERTICAL

→ HORIZONTAL



GROUND FLOOR (PARTIALLY BELOW GRADE)

Figure 2 Continued

U.S. STRONG-MOTION NETWORK

Station No. 1129 37.679N, 122.082W

Hayward City Hall

CRA-1 No. 271

EARTHQUAKE OF

18 October 1989 - 0004 G.m.t.

Film speed = 1 cm/sec

CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
1	334°	12th Floor, West	1.70 cm/g	0.10g
2	334°	12th Floor, Center	1.75 cm/g	0.10g
3	064°	12th Floor, Center	1.74 cm/g	0.13g
4	334°	7th Floor, West	1.82 cm/g	0.09g
5	334°	7th Floor, Center	2.45 cm/g	0.08g
6	064°	7th Floor, Center	1.82 cm/g	0.09g
7	334°	3rd Floor, West	1.82 cm/g	Inoperative
8	334°	3rd Floor, Center	1.82 cm/g	0.07g
9	064°	3rd Floor, Center	1.77 cm/g	0.08g
10	Up	3rd Floor, Southwest	1.80 cm/g	0.05g
11	Up	3rd Floor, Southwest	1.85 cm/g	0.04g
12	334°	Ground Floor, West	1.77 cm/g	0.07g

(See accelerogram on next page)

Figure 2. Continued

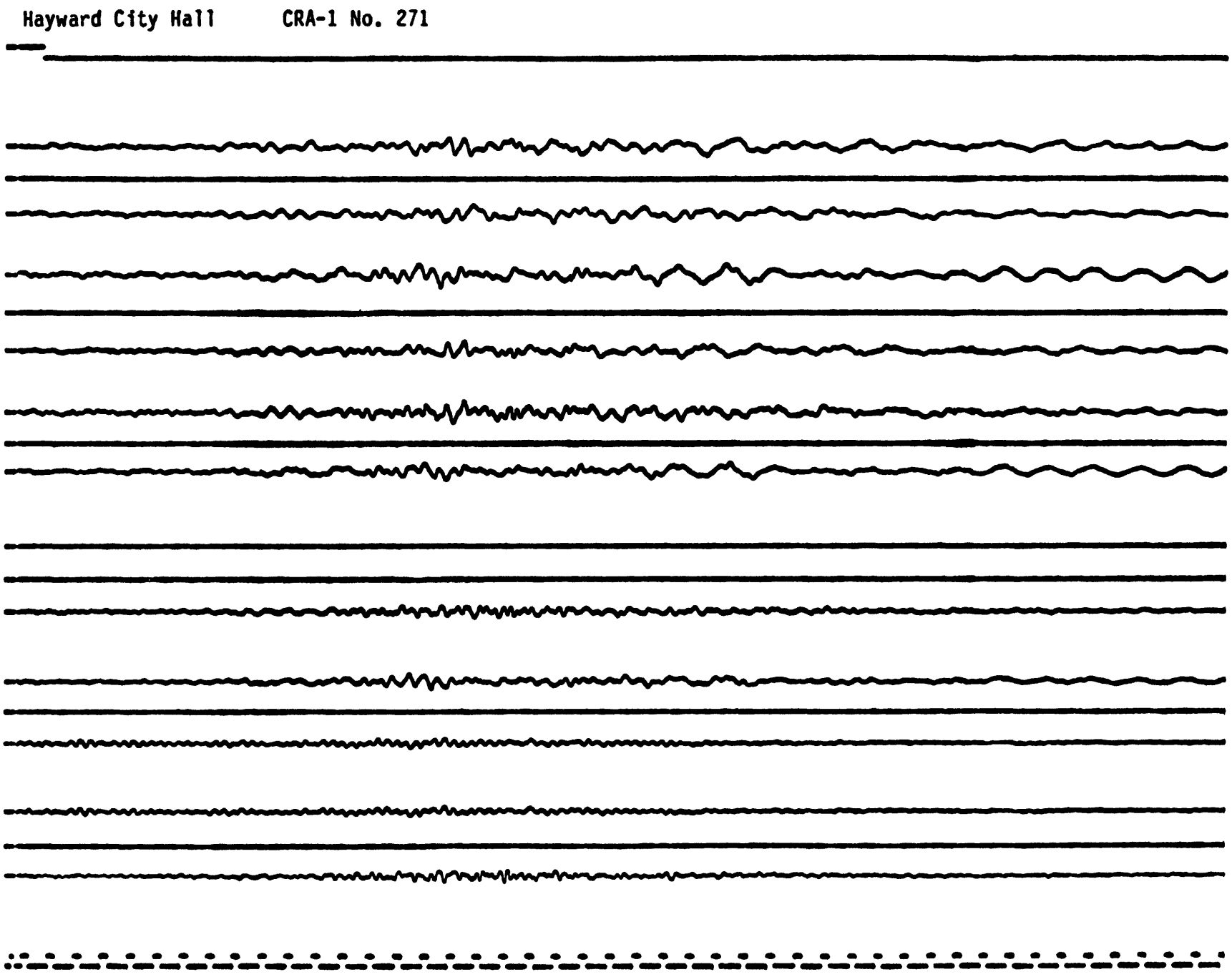


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1689 37.709N, 121.932W	360°	Sens. = 2.00 cm/g Freq. = 25.2 Hz Damp. = 0.6 crit	0.08g
Calaveras Array - Dublin Fire Station			
SMA-1 No. 493 (USGS) Ground level	Up	Sens. = 1.80 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.03g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.80 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.09g
		Film speed = 1 cm/sec	

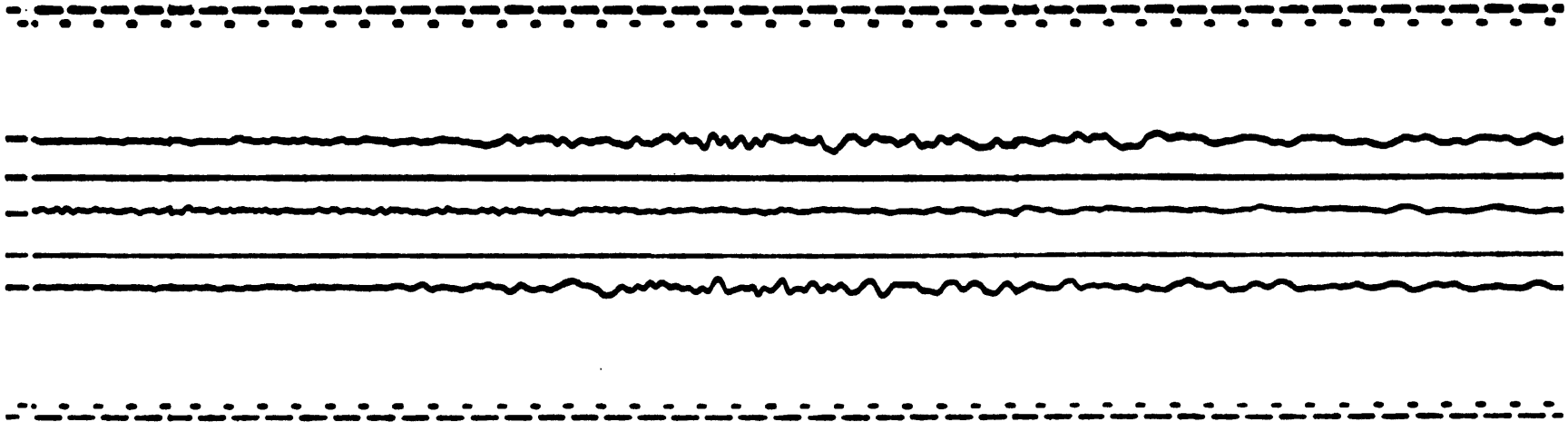


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1479 36.532N, 121.143W	310°	Sens. = 1.83 cm/g Freq. = 26.0 Hz Damp. = 0.6 crit	0.10g
Bear Valley Array Station 10 Webb Residence SMA-1 No. 1498 (USGS) Ground	Up	Sens. = 1.80 cm/g Freq. = 25.7 Hz Damp. = 0.6 crit	0.05g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	220°	Sens. = 1.80 cm/g Freq. = 26.1 Hz Damp. = 0.6 crit	0.13g
		Film speed = 1 cm/sec	

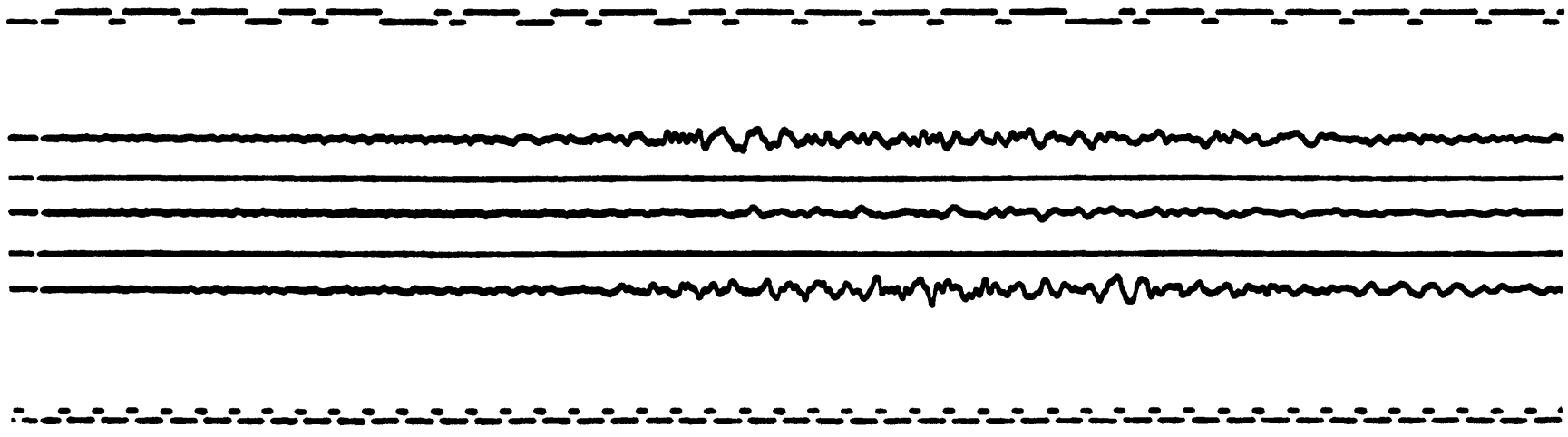


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1476 36.483N, 121.180W	310°	Sens. = 1.84 cm/g Freq. = 25.8 Hz	0.04g
Bear Valley Station 7 Pinnacles National Monument SMA-1 No. 1478 (USGS) Ground	Up	Damp. = 0.6 crit Sens. = 1.84 cm/g Freq. = 26.0 Hz	0.03g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 0004 G.m.t.	220°	Sens. = 1.80 cm/g Freq. = 26.2 Hz Damp. = 0.6 crit	0.06g

Film speed = 1 cm/sec

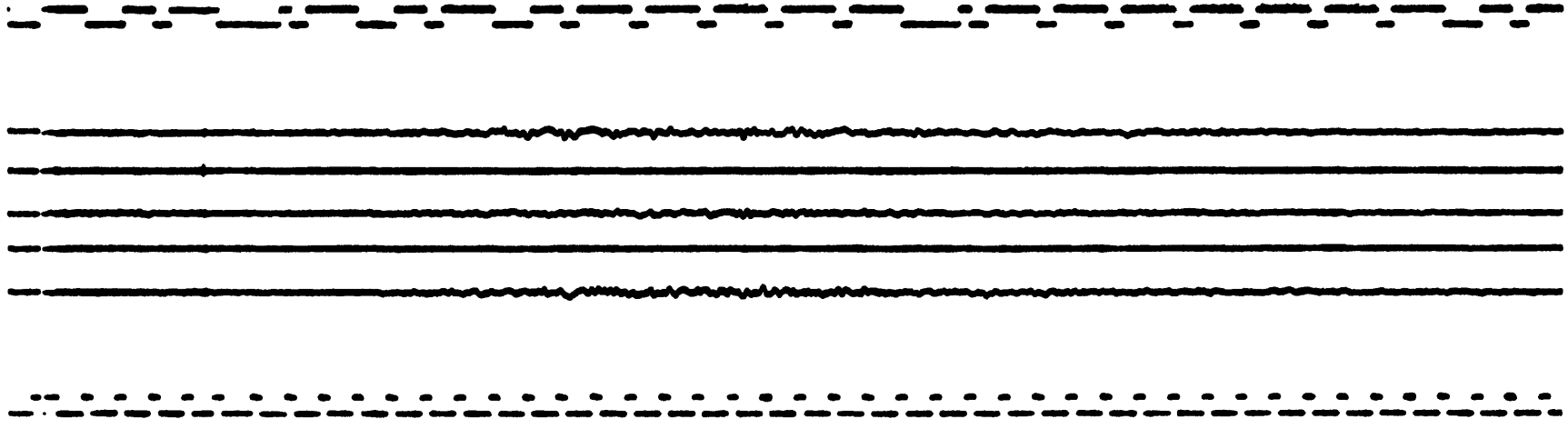


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1675 37.728N, 122.385W	360°	Sens. = 1.90 cm/g Freq. = 25.5 Hz Damp. = 0.6 crit	0.11g
San Francisco, 1295 Shafter Fire Stn #17 SMA-1 No. 111 (USGS) Ground	Up	Sens. = 1.85 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.05g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.90 cm/g Freq. = 26.0 Hz Damp. = 0.6 crit	0.07g
		Film speed = 1 cm/sec	

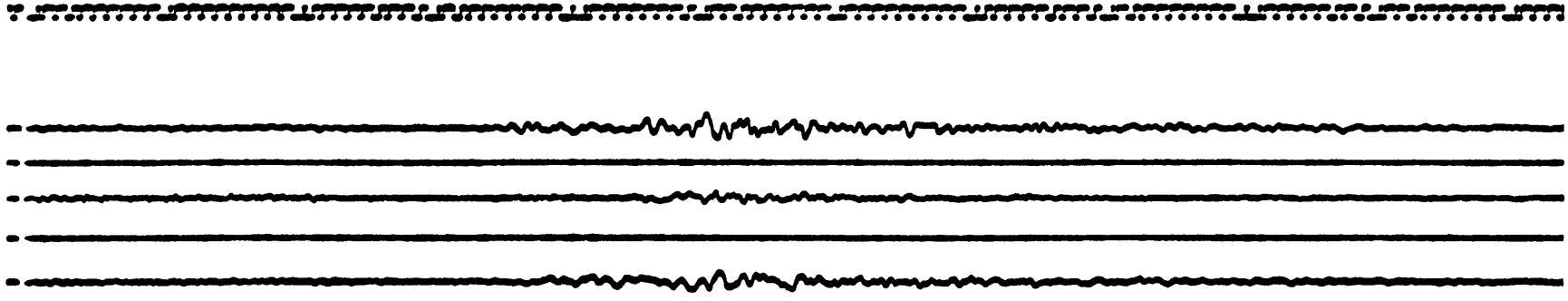


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1664 37.724N, 122.475W	270°	Sens. = 1.86 cm/g Freq. = 26.2 Hz	0.14g
San Francisco State U. - Thornton Hall		Damp. = 0.6 crit	
SMA-1 No. 1116 (USGS) Ground level	Up	Sens. = 1.85 cm/g Freq. = 25.7 Hz	0.04g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	180°	Sens. = 1.80 cm/g Freq. = 26.2 Hz Damp. = 0.6 crit	0.11g
		Film speed = 1 cm/sec	

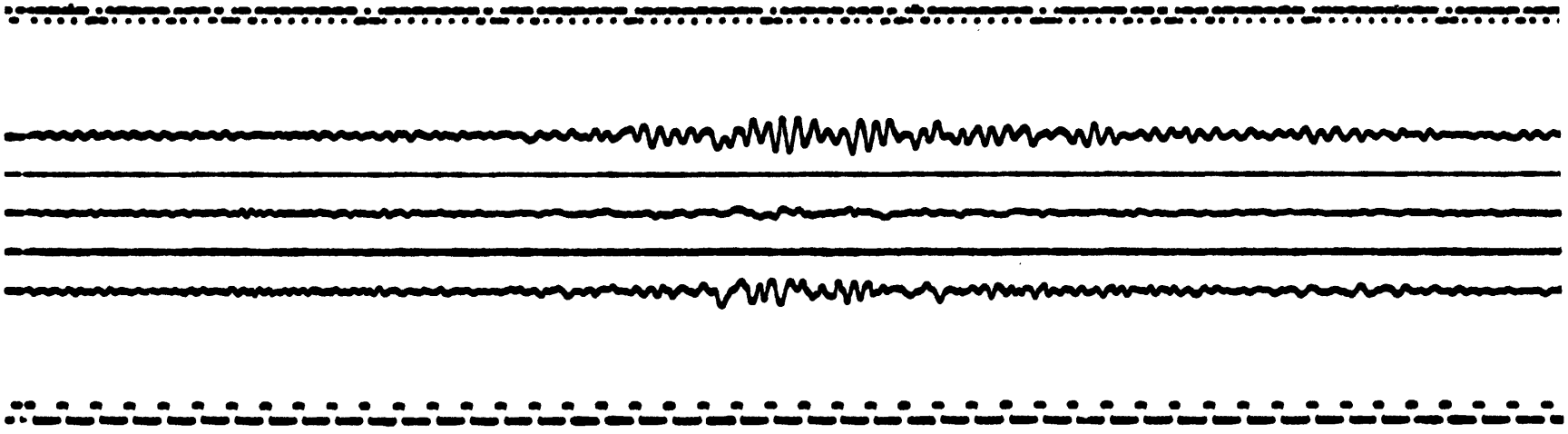


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1446 37.79N, 122.40W	135°	Sens. = 1.75 cm/g Freq. = 25.4 Hz Damp. = 0.6 crit	0.08g
San Francisco, 575 Market Street Chevron Building SMA-1 No. 1221 (USGS) Basement	Up	Sens. = 1.88 cm/g Freq. = 25.7 Hz Damp. = 0.6 crit	0.06g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	045°	Sens. = 1.78 cm/g Freq. = 26.0 Hz Damp. = 0.6 crit	0.11g
		Film speed = 1 cm/sec	

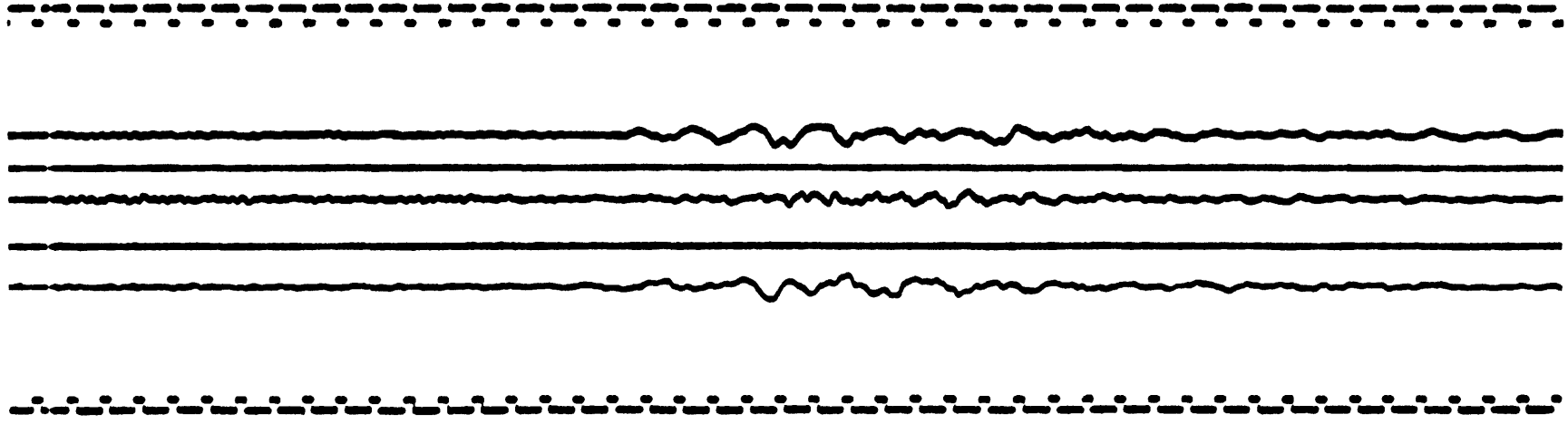


Figure 2. Continued

SAN FRANCISCO, 575 MARKET INSTRUMENTATION

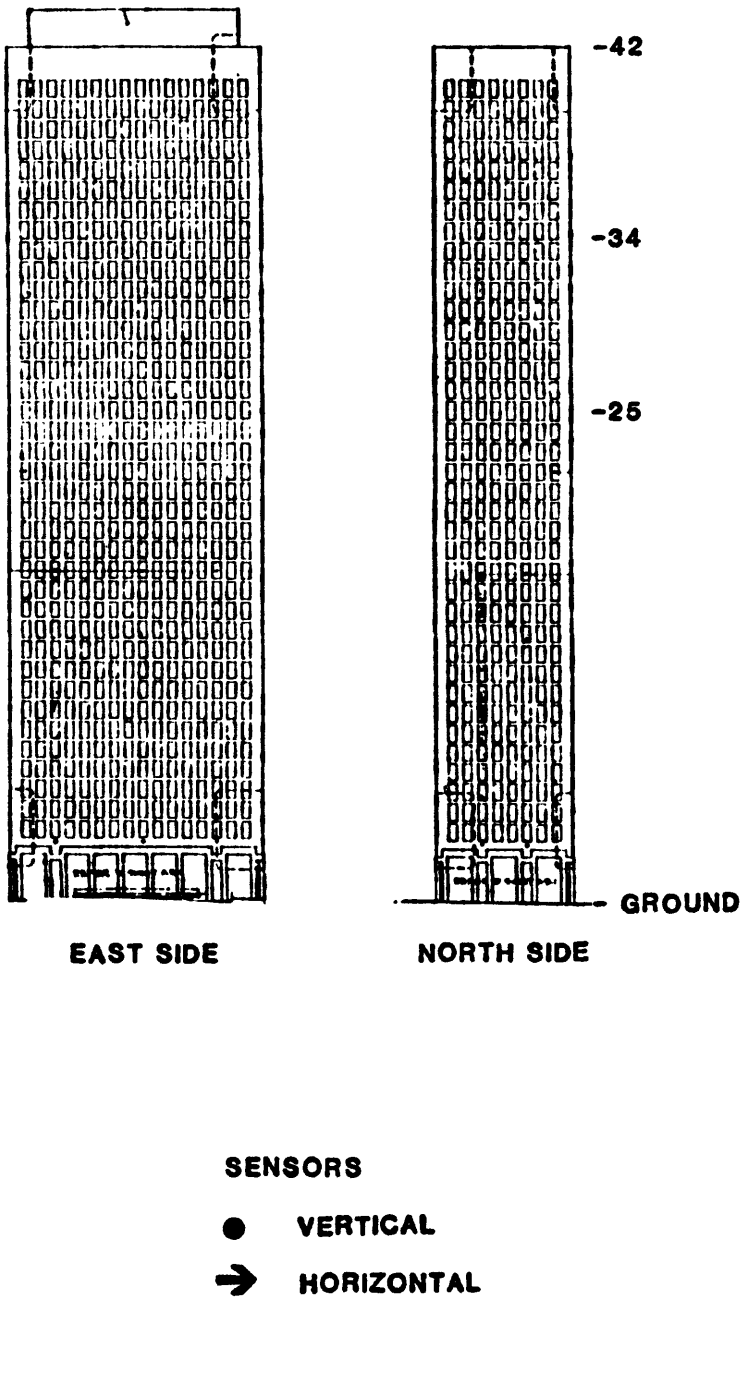


Figure 2. Continued

U.S. STRONG-MOTION NETWORK Station No. 1446 37.79N, 122.40W	CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
San Francisco, 575 Market Street	1	045°	42nd Floor, Northwest	1.8 cm/g	0.22g
	2	225°	42nd Floor, Center	1.8 cm/g	0.19g
CRA-1 No. 210	3	135°	42nd Floor, Center	1.8 cm/g	0.14g
	4	045°	34th Floor, Northwest	1.8 cm/g	0.15g
EARTHQUAKE OF	5	225°	34th Floor, Center	1.8 cm/g	0.16g
18 October 1989 - 0004 G.m.t.	6	135°	34th Floor, Center	1.8 cm/g	0.19g
	7	045°	25th Floor, Northwest	1.8 cm/g	0.19g
Film speed = 1 cm/sec	8	225°	25th Floor, Center	1.8 cm/g	0.23g
	9	135°	25th Floor, Center	1.8 cm/g	0.16g
	10	045°	Ground Floor	1.8 cm/g	0.12g
	11	315°	Ground Floor	1.8 cm/g	0.13g

(See accelerogram on next page)

Figure 2. Continued

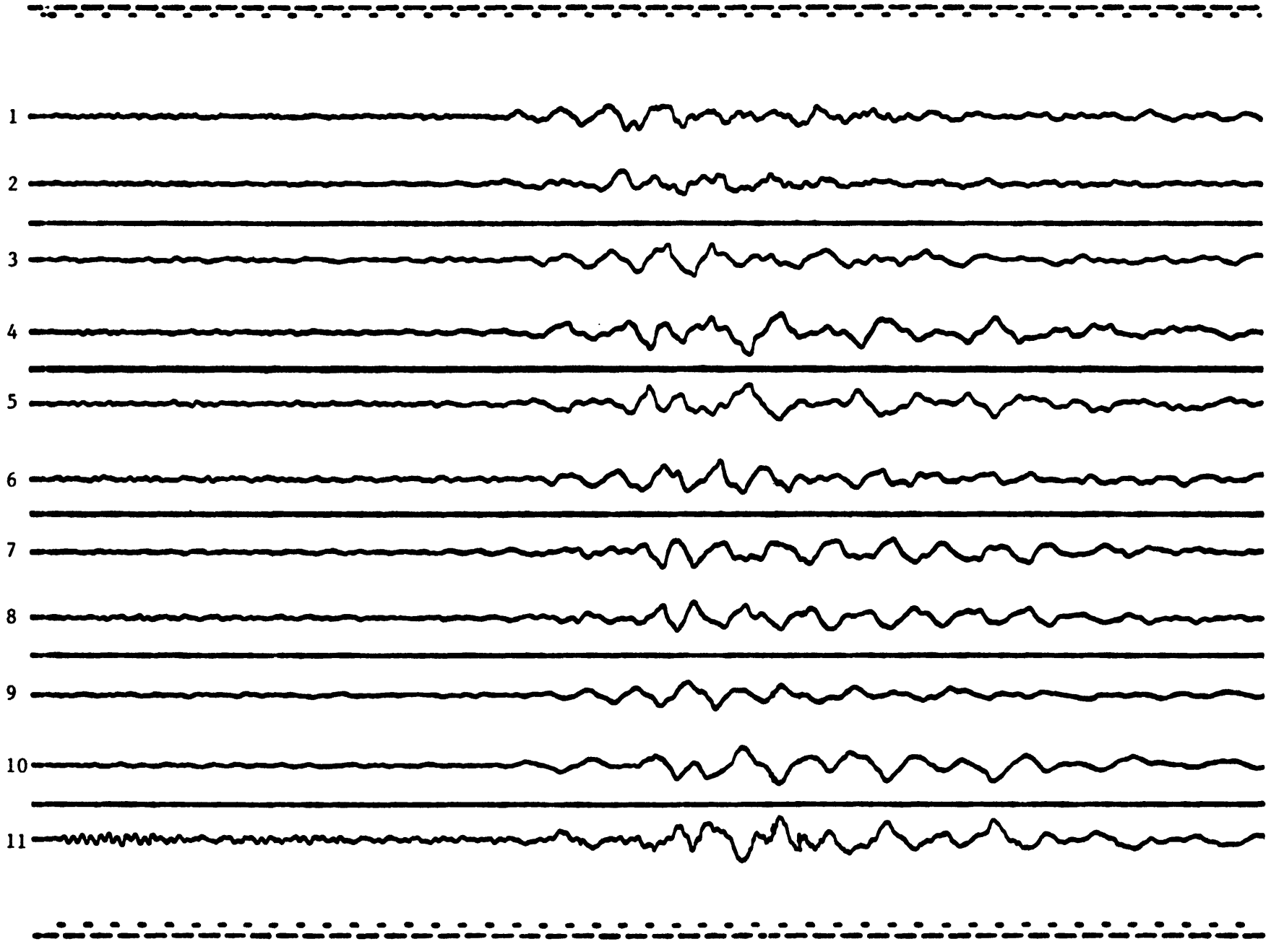


Figure 2. Continued

TRANSAMERICA BUILDING INSTRUMENTATION

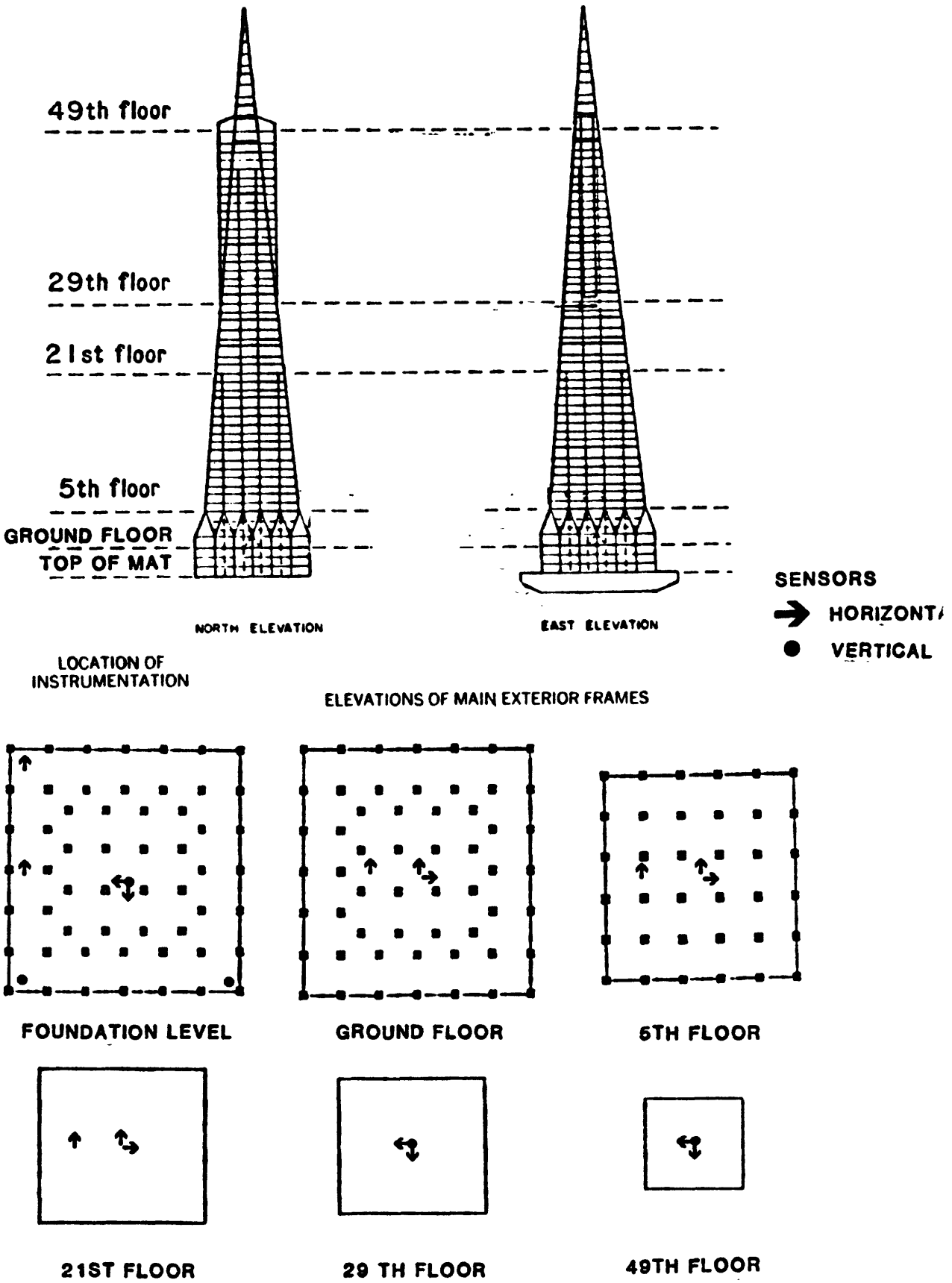


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1239 37.80N, 122.40W	261°	Sens. = 1.84 cm/g Freq. = 26.0 Hz Damp. = 0.6 crit	0.12g
San Francisco, 600 Montgomery Transamerica Building SMA-1 No. 526 (USGS) Basement	Up	Sens. = 1.90 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.05g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	171°	Sens. = 1.87 cm/g Freq. = 25.7 Hz Damp. = 0.6 crit	0.11g
		Film speed = 1 cm/sec	

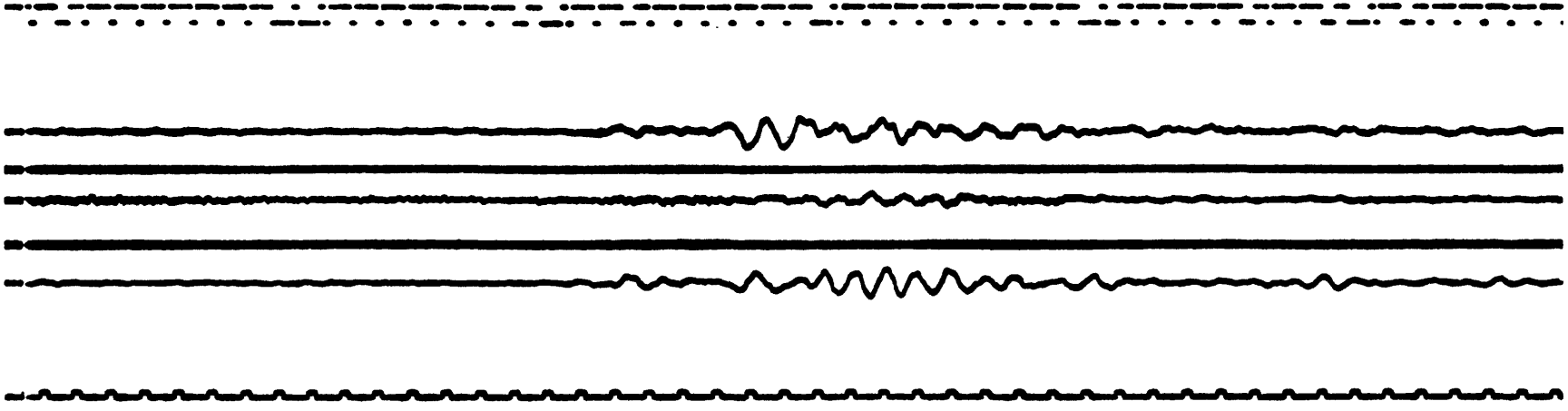


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1239 37.80N, 122.40W	261°	Sens. = 1.90 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.15g
San Francisco. 600 Montgomery Transamerica Building SMA-1 No. 527 (USGS) 29th floor	Up	Sens. = 1.87 cm/g Freq. = 26.5 Hz Damp. = 0.6 crit	0.11g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	171°	Sens. = 1.80 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.17g
		Film speed = 1 cm/sec	

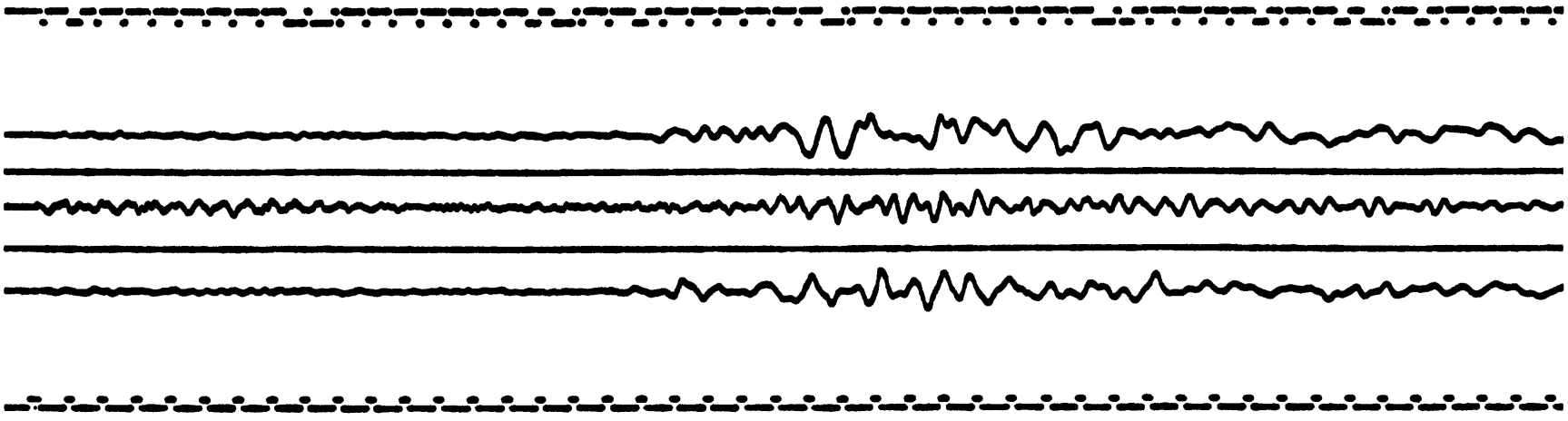


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1239 37.80N, 122.40W	261°	Sens. = 1.90 cm/g Freq. = 26.2 Hz Damp. = 0.6 crit	0.31g
San Francisco, 600 Montgomery Transamerica Building SMA-1 No. 529 (USGS) 49th floor	Up	Sens. = 1.82 cm/g Freq. = 26.1 Hz Damp. = 0.6 crit	0.14g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	171°	Sens. = 1.86 cm/g Freq. = 25.7 Hz Damp. = 0.6 crit	0.29g

Film speed = 1 cm/sec

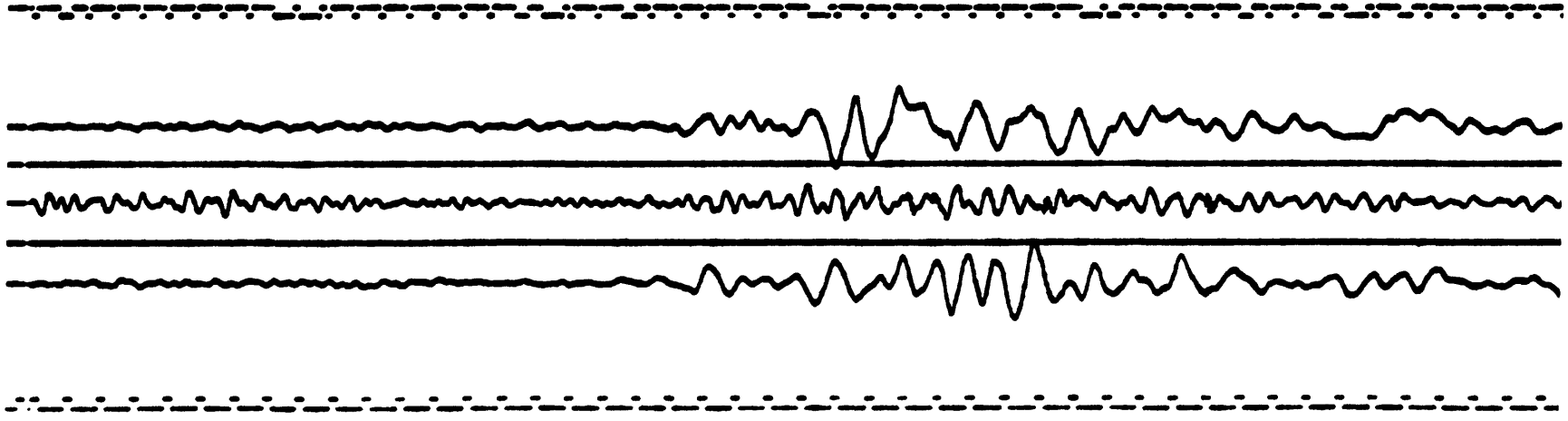


Figure 2. Continued

U.S. STRONG-MOTION NETWORK
Station No. 1239 37.80N, 122.40W

San Francisco - Transamerica Bldg.
600 Montgomery

CRA-1 No. 292

EARTHQUAKE OF

18 October 1989 - 0004 G.m.t.

Film speed = 1 cm/sec

CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
1	351°	21st Floor West Central	1.70 cm/g	0.20g
2	351°	21st Floor South Central	1.66 cm/g	0.17g
3	081°	21st Floor South Central	1.71 cm/g	0.22g
4	351°	5th Floor West Central	1.74 cm/g	0.27g
5	351°	5th Floor South Central	1.72 cm/g	0.28g
6	081°	5th Floor South Central	1.74 cm/g	0.24g
7	Up	SE Corner Foundation	1.66 cm/g	0.07g
8	351°	Ground Floor West Central	1.66 cm/g	0.17g
9	351°	Ground Floor Center	1.71 cm/g	0.15g
10	081°	Ground Floor Center	1.87 cm/g	0.18g
11	351°	NW Corner Foundation	1.73 cm/g	0.10g
12	351°	West Side Foundation	1.71 cm/g	0.09g
13	Up	SW Corner Foundation	1.68 cm/g	0.05g

(See Accelerogram on next page)

Figure 2. Continued

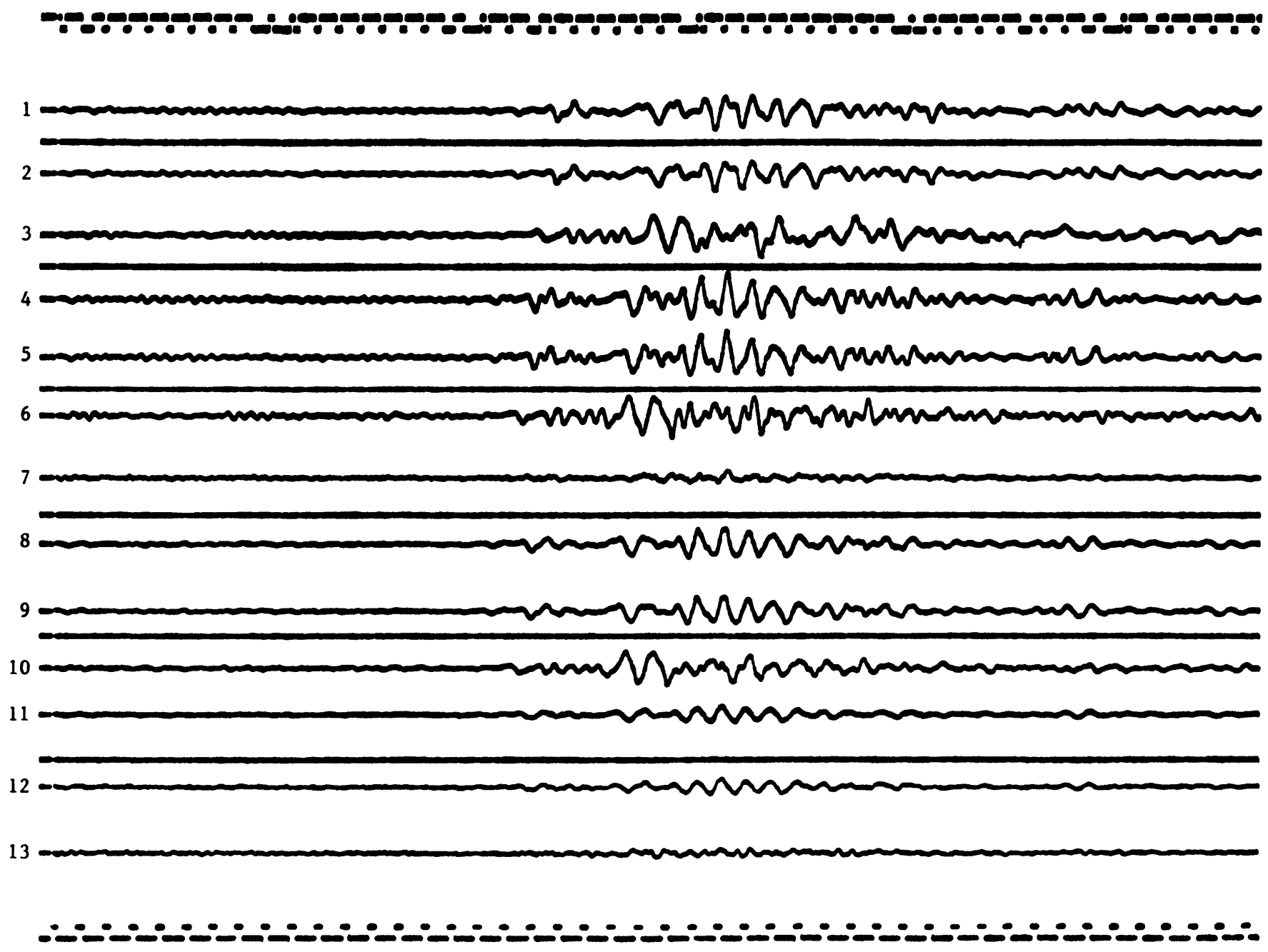


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1662 37.844N, 122.295W	350°	Sens. = 1.71 cm/g Freq. = 28.0 Hz	0.22g
Emeryville - 6363 Christie Ave.		Damp. = 0.55 crit	
SMA-1 No. 2895 (USGS) Ground Site South	Up	Sens. = 1.77 cm/g Freq. = 27.0 Hz	0.06g
EARTHQUAKE OF		Damp. = 0.57 crit	
18 October 1989 - 0004 G.m.t.	260°	Sens. = 1.78 cm/g Freq. = 26.0 Hz Damp. = 0.53 crit	0.26g

Film speed = 1 cm/sec

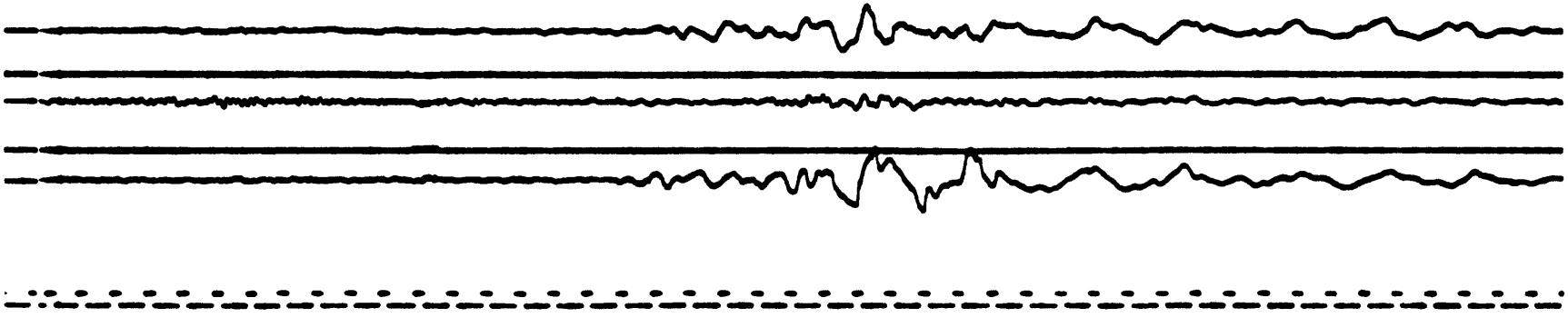
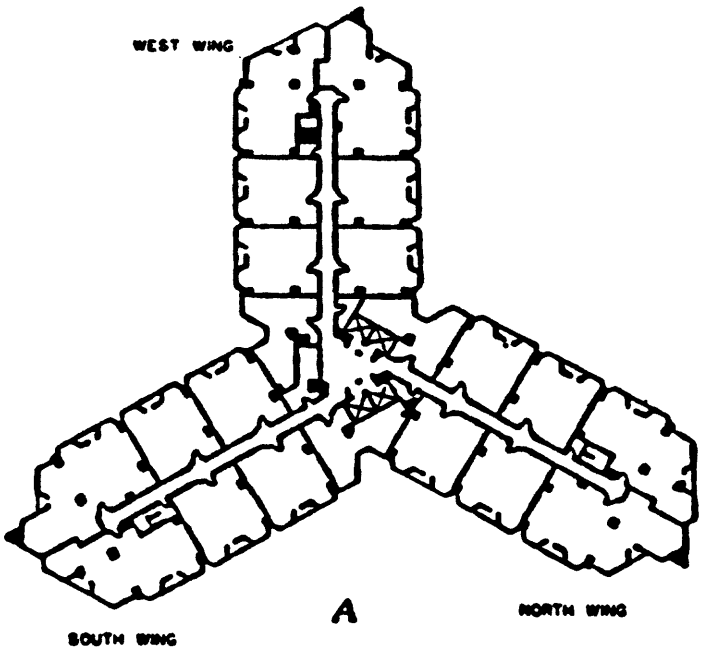
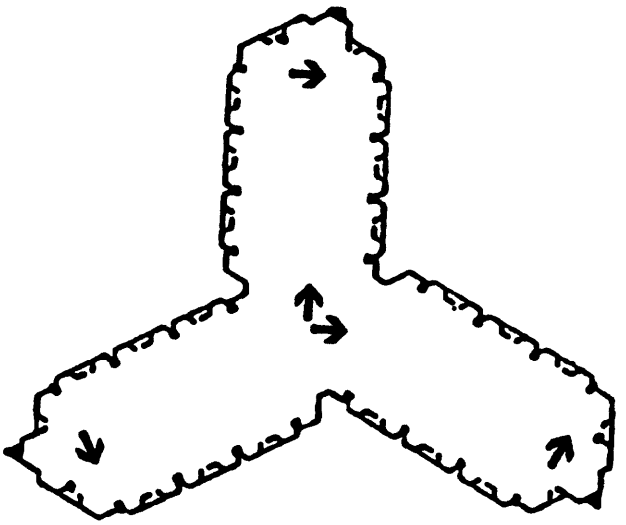


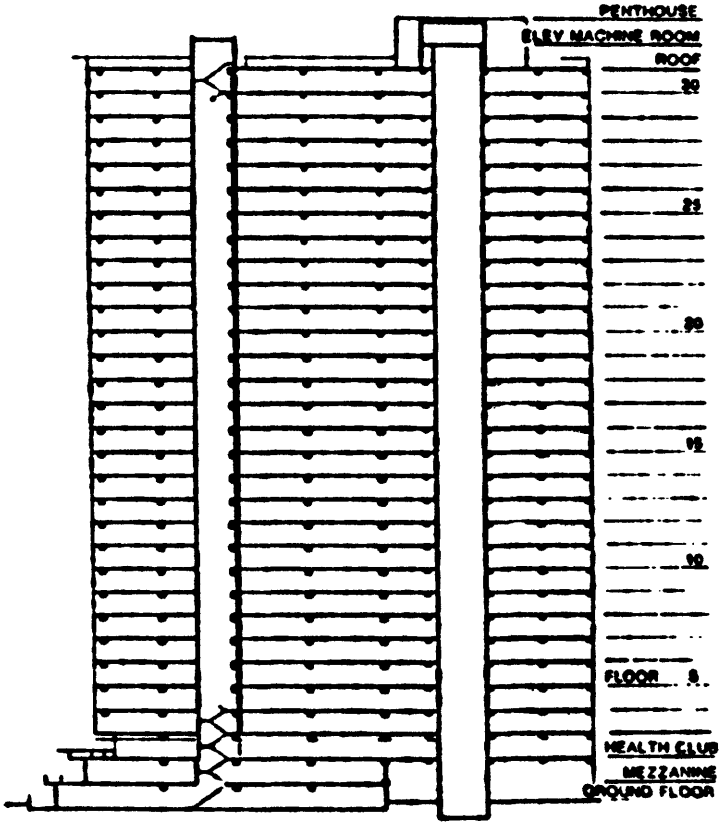
Figure 2. Continued

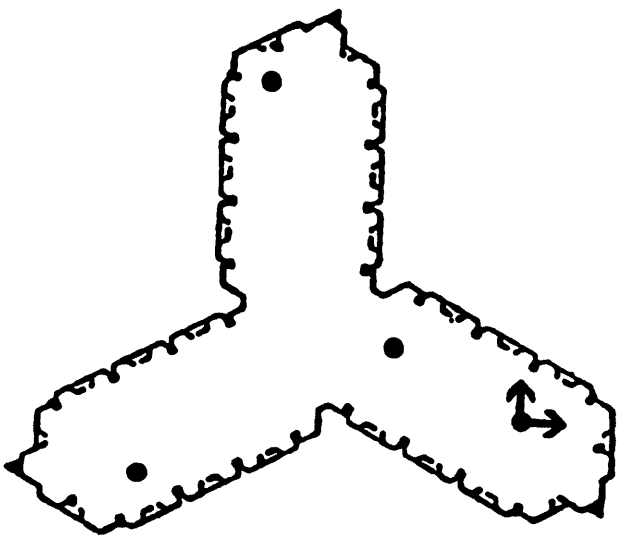
EMERYVILLE BUILDING INSTRUMENTATION





31ST (ROOF) , 21ST , & 13TH FLOORS





GROUND FLOOR

SENSORS

→ HORIZONTAL

● VERTICAL

Figure 2. Continued

U.S. STRONG-MOTION NETWORK Station No. 1662 37.844N, 122.295W	CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
Emeryville - 6363 Christie Ave.	1	350°	Roof (31st), West Wing	2.00 cm/g	0.27g
Structure Array #1	2	050°	Roof (31st), South Wing	1.75 cm/g	0.31g
CRA-1 No. 253	3	290°	Roof (31st), North Wing	1.88 cm/g	0.39g
	4	260°	Roof (31st), Central Core	1.86 cm/g	0.25g
EARTHQUAKE OF	5	350°	Roof (31st), Central Core	1.89 cm/g	0.38g
18 October 1989 - 0004 G.m.t.	6	260°	21st Floor Central Core	1.85 cm/g	0.20g
	7	350°	21st Floor West Wing	1.84 cm/g	0.19g
Film speed = 1 cm/sec	8	050°	21st Floor South Wing	1.88 cm/g	0.18g
	9	290°	21st Floor North Wing	1.80 cm/g	0.24g
	10	260°	13th Floor Central Core	1.83 cm/g	0.27g
	11	350°	13th Floor Central Core	1.82 cm/g	0.26g
	12	350°	21st Floor Central Core	1.86 cm/g	0.23g

(See accelerogram on next page)

Figure 2. Continued

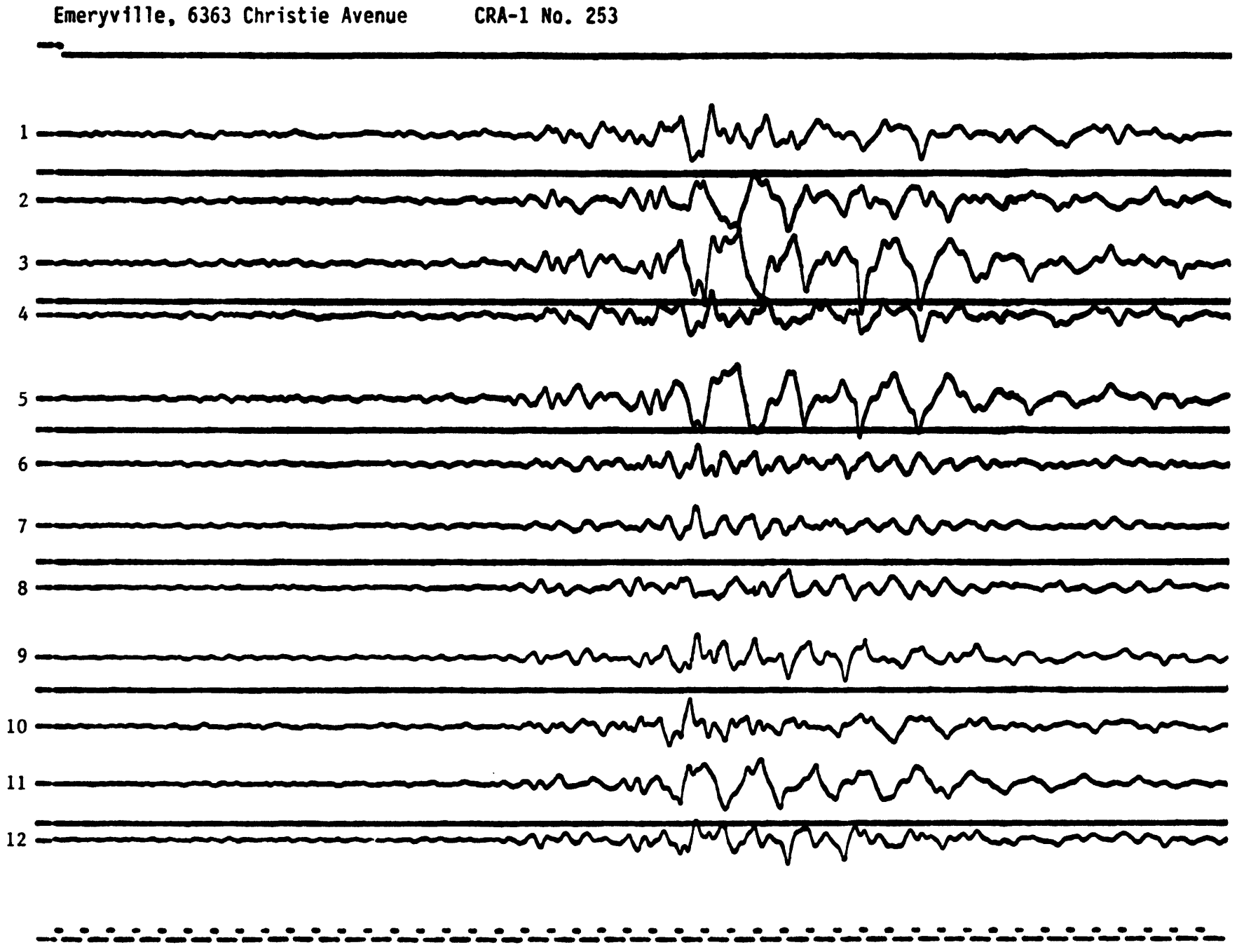


Figure 2. Continued

U.S. STRONG-MOTION NETWORK Station No. 1662 37.844N, 122.295W	CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
Emeryville - 6363 Christie Ave.	1	350°	13th Floor West Wing	1.90 cm/g	0.22g
Structure Array #2	2	050°	13th Floor South Wing	1.89 cm/g	0.23g
CRA-1 No. 254	3	290°	13th Floor North Wing	1.90 cm/g	0.32g
	4	Up	Ground Floor, West Wing	1.87 cm/g	0.06g
EARTHQUAKE OF	5	Up	Ground Floor, South Wing	1.90 cm/g	0.06g
18 October 1989 - 0004 G.m.t.	6	Up	Ground Floor, Central Core	1.89 cm/g	0.05g
Film speed = 1 cm/sec	7	260°	Ground Floor, North Wing	1.93 cm/g	0.22g
	8	Up	Ground Floor, North Wing	1.90 cm/g	0.05g
	9	350°	Ground Floor, North Wing	1.90 cm/g	0.17g
	10	350°	Ground Site North	1.86 cm/g	0.20g
	11	Up	Ground Site North	1.88 cm/g	0.09g
	12	260°	Ground Site North	1.90 cm/g	0.22g

(See accelerogram on next page)

Figure 2. Continued

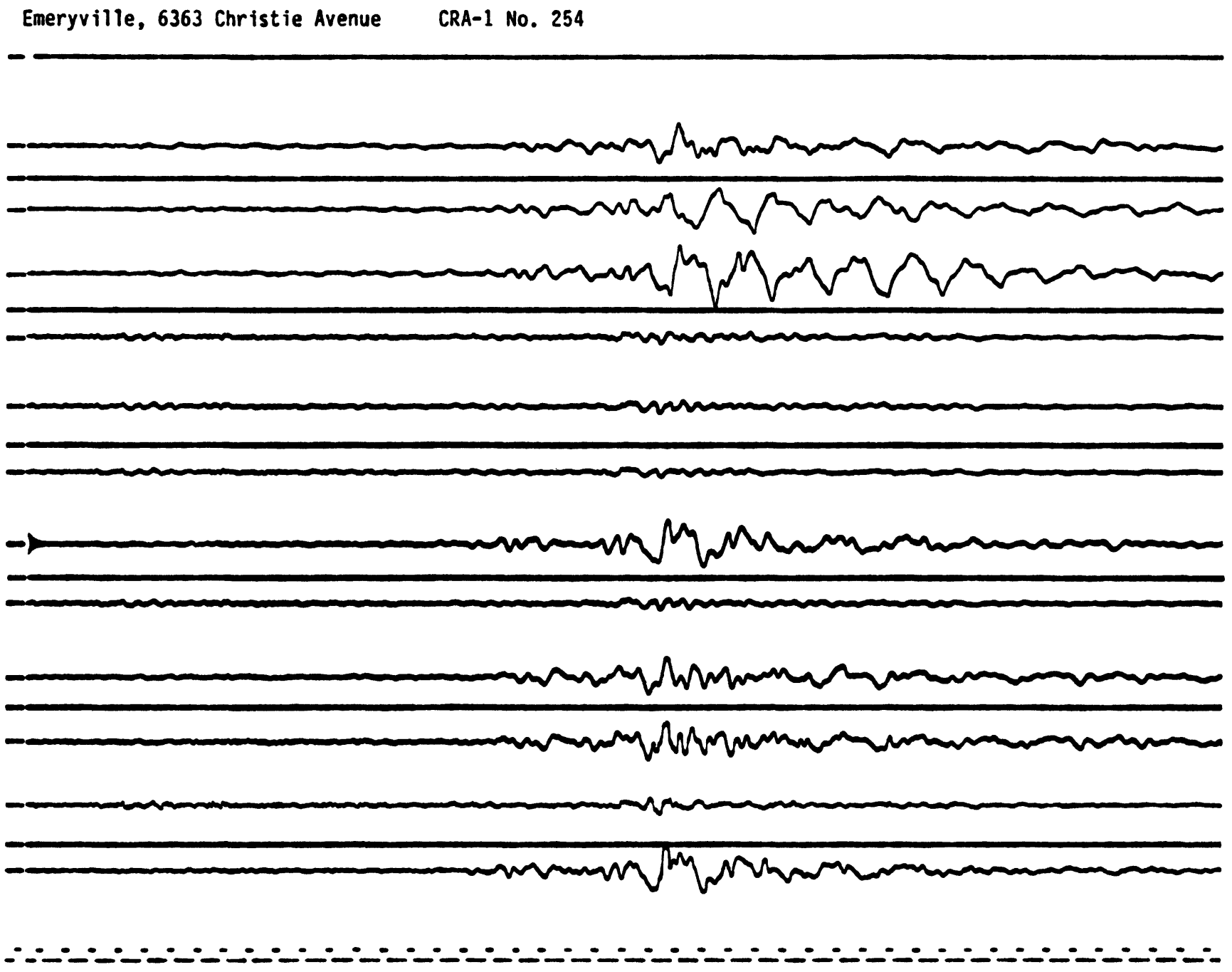


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1005 37.87N, 122.24W	135°	Sens. = 1.79 cm/g Freq. = 26.3 Hz	0.04g
U.C. Berkeley, Strawberry Canyon		Damp. = 0.6 crit	
SMAT No. 2503 (UCB)	Up	Sens. = 1.79 cm/g Freq. = 25.6 Hz	0.02g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	045°	Sens. = 1.73 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.08g

Film speed = 1 cm/sec

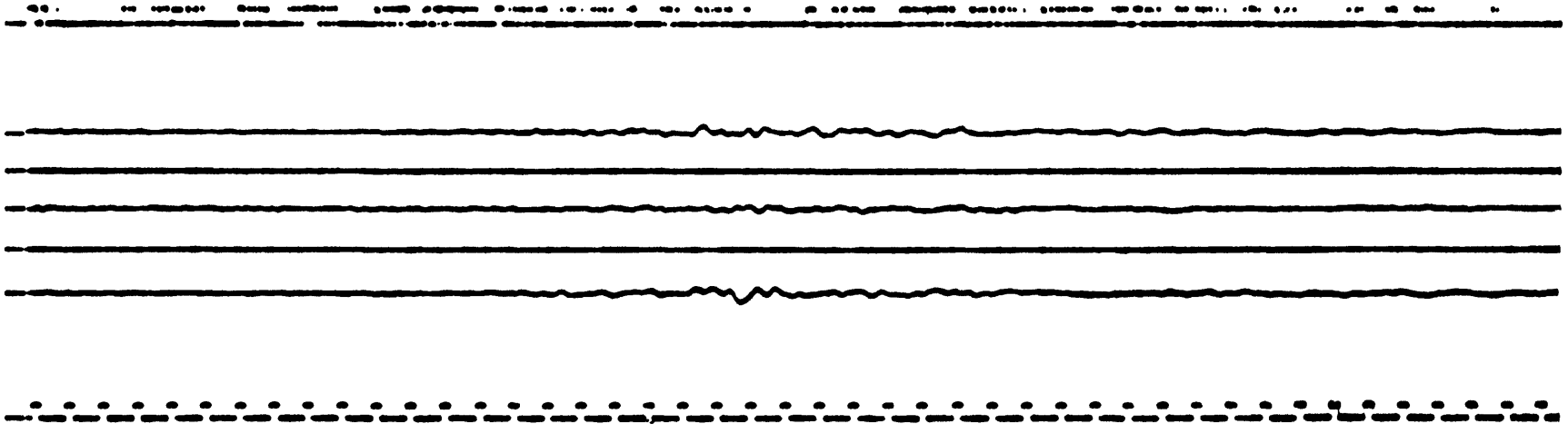


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1006 37.87N, 122.26W	135°	Sens. = 1.74 cm/g Freq. = 26.2 Hz	0.03g
U.C. Berkeley - Haviland Hall		Damp. = 0.58 crit	
SMA-1 No. 2500 (UCB) Basement	Up	Sens. = 1.70 cm/g Freq. = 26.1 Hz	0.02g
EARTHQUAKE OF		Damp. = 0.58 crit	
18 October 1989 - 0004 G.m.t.	045°	Sens. = 1.71 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.06g

Film speed = 1 cm/sec

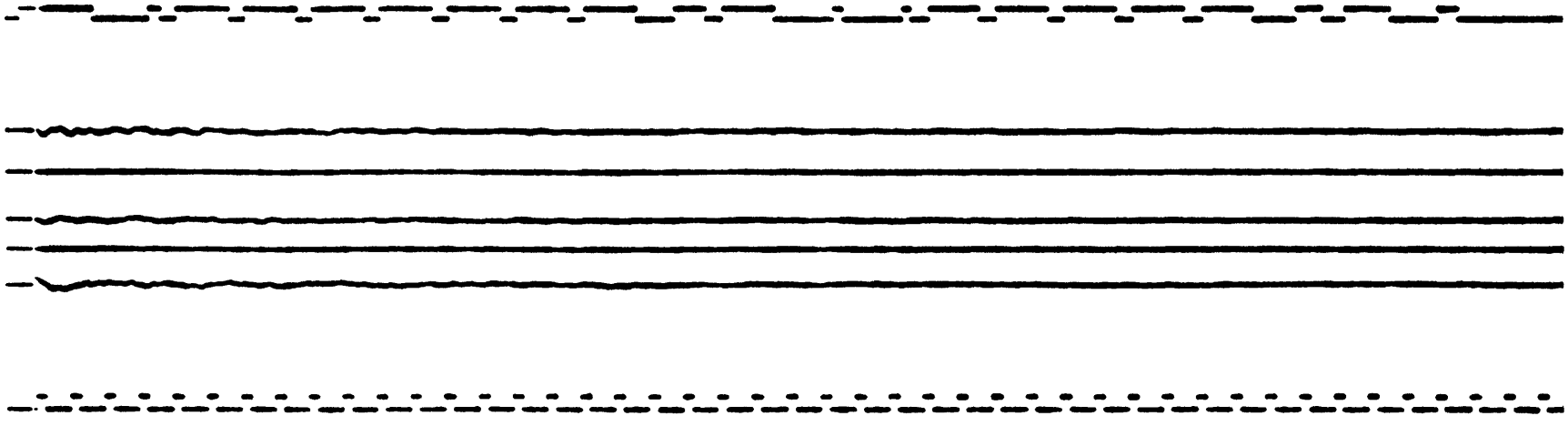
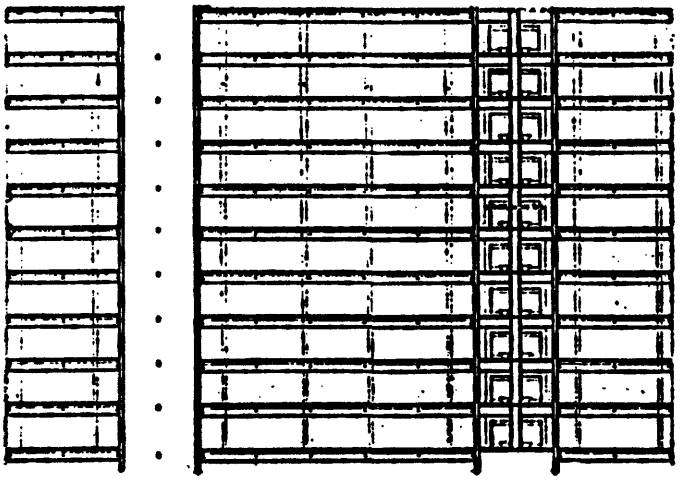


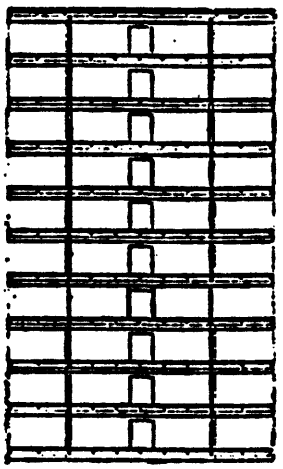
Figure 2. Continued

BERKELEY BUILDING INSTRUMENTATION

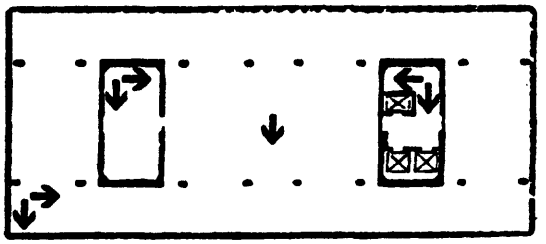


WEST CORE EAST CORE

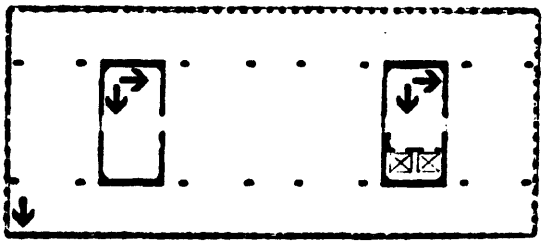
LONGITUDINAL SECTION SUSPENDED FLOORS



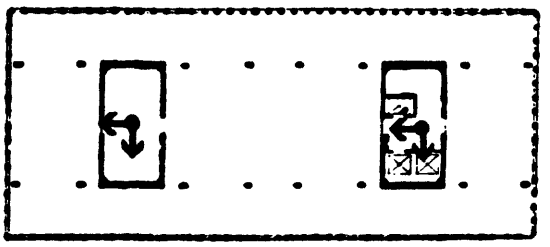
TRANSVERSE SECTION SUSPENDED FLOORS



ROOF (13)



4TH FLOOR



GROUND FLOOR

SENSORS

HORIZONTAL

VERTICAL

Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1103 37.87N, 122.27W	261°	Sens. = 1.95 cm/g Freq. = 25.1 Hz Damp. = 0.6 crit	0.09g
Berkeley, 2168 Shattuck Ave. Great Western Bank SMA-1 No. 144 (USGS) Basement, East	Up	Sens. = 1.90 cm/g Freq. = 25.8 Hz Damp. = 0.6 crit	0.02g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	171°	Sens. = 1.80 cm/g Freq. = 25.2 Hz Damp. = 0.6 crit	0.11g
		Film speed = 1 cm/sec	

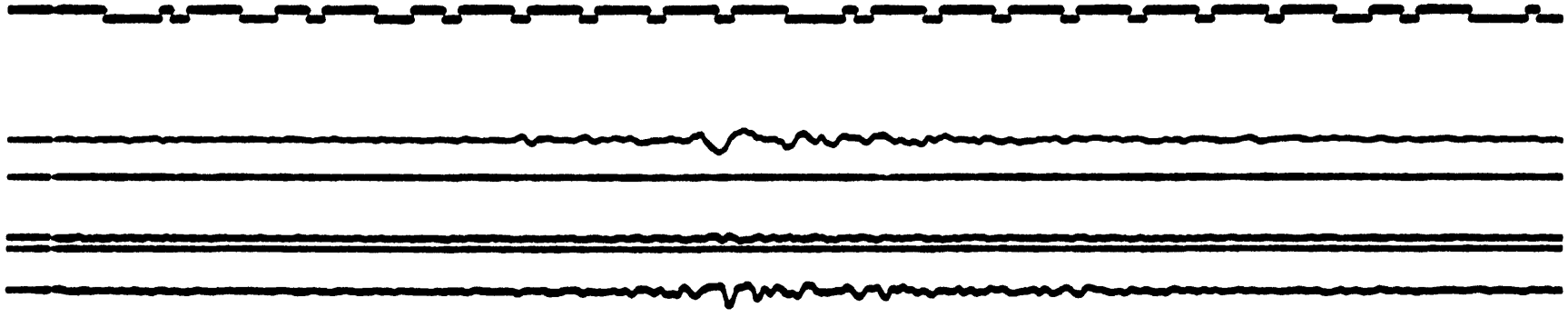


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1103 37.87N, 122.27W	261°	Sens. = 1.80 cm/g Freq. = 26.7 Hz Damp. = 0.6 crit	0.10g
Berkeley, 2168 Shattuck Ave. Great Western Bank SMA-1 No. 142 (USGS) Basement, West	Up	Sens. = 1.90 cm/g Freq. = 25.2 Hz Damp. = 0.6 crit	0.03g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	171°	Sens. = 1.95 cm/g Freq. = 24.1 Hz Damp. = 0.6 crit	0.09g
		Film speed = 1 cm/sec	

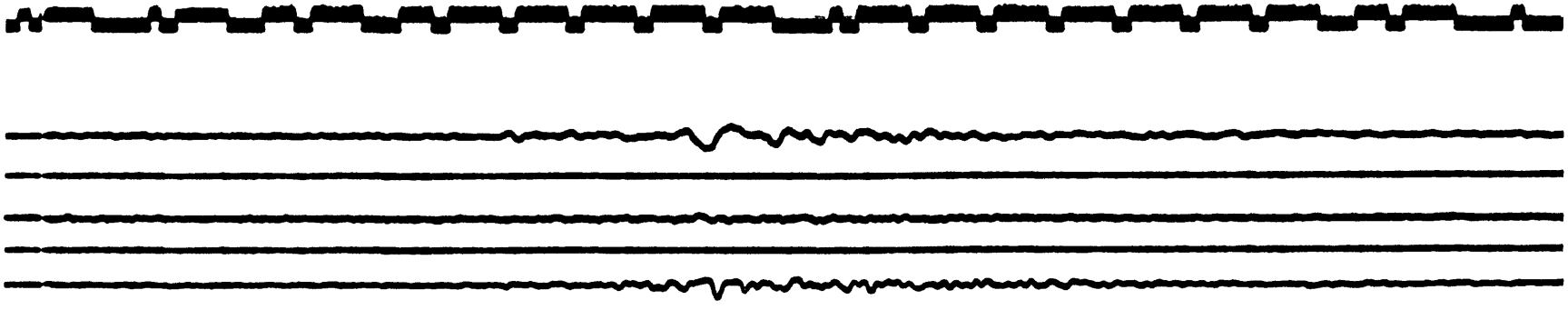


Figure 2. Continued

U.S. STRONG-MOTION NETWORK

Station No. 1103 37.87N, 122.27W

Berkeley - 2168 Shattuck Ave.
Great Western Bank

CRA-1 No. 293

EARTHQUAKE OF

18 October 1989 - 0004 G.m.t.

Film speed = 1 cm/sec

CHANNEL	DIRECTION	LOCATION	SENSITIVITY	MAX. ACCELERATION
1	171°	13th Floor, East Core	1.75 cm/g	0.13g
2	261°	13th Floor, East Core	1.77 cm/g	0.23g
3	171°	13th Floor, Center	1.75 cm/g	0.13g
4	171°	13th Floor, Roof West Core	1.81 cm/g	0.19g
5	081°	13th Floor, Roof West Core	1.78 cm/g	0.21g
6	081°	13th floor, Southwest	1.79 cm/g	0.23g
7	171°	13th Floor, Southwest	1.71 cm/g	0.16g
8	171°	4th Floor, Southwest	1.89 cm/g	0.23g
9	081°	4th Floor, Southwest	1.80 cm/g	0.11g
10	081°	4th Floor, West Core	1.75 cm/g	0.08g
11	171°	4th Floor, West Core	1.93 cm/g	0.11g
12	171°	4th Floor, East Core	1.80 cm/g	0.08g

(See accelerogram on next page)

Figure 2. Continued

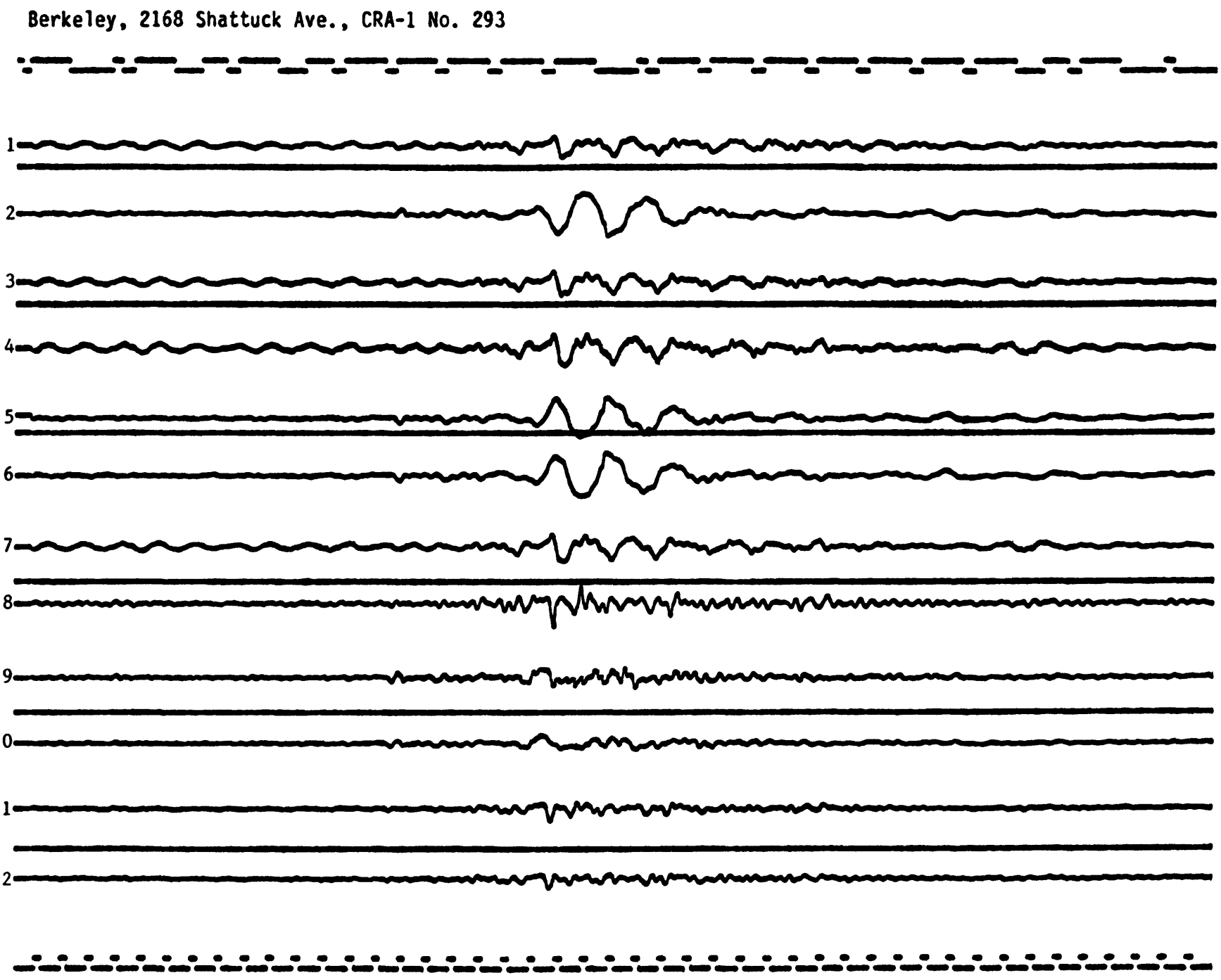


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1225 37.783N, 122.504W	185°	Sens. = 1.95 cm/g Freq. = 25.1 Hz Damp. = 0.6 crit	0.08g
San Francisco Veterans Hospital			
SMA-1 No. 604 (VA) Basement	Up	Sens. = 1.79 cm/g Freq. = 25.9 Hz Damp. = 0.6 crit	0.05g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	095°	Sens. = 1.90 cm/g Freq. = 24.5 Hz Damp. = 0.6 crit	0.16g

Film speed = 1 cm/sec

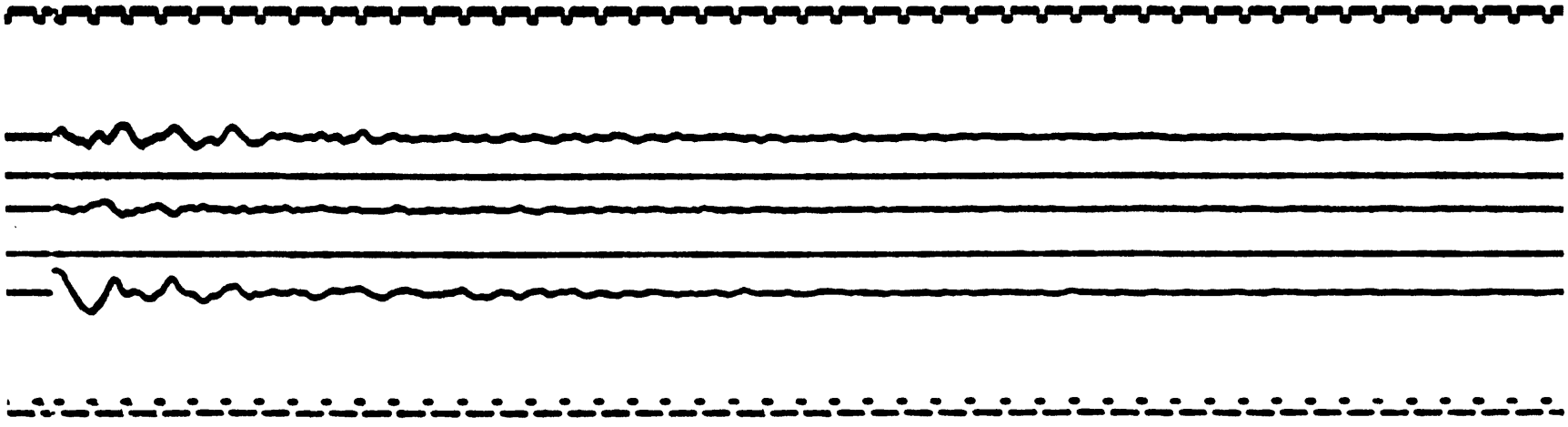


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1225 37.783N, 122.504W	185°	Sens. = 1.90 cm/g Freq. = 26.0 Hz	0.34g
San Francisco Veterans Hospital		Damp. = 0.6 crit	
SMA-1 No. 767 (VA) 7th Floor	Up	Sens. = 1.99 cm/g Freq. = 24.8 Hz	0.08g
EARTHQUAKE OF		Damp. = 0.6 crit	
18 October 1989 - 0004 G.m.t.	095°	Sens. = 1.85 cm/g Freq. = 25.3 Hz Damp. = 0.6 crit	0.22g
		Film speed = 1 cm/sec	

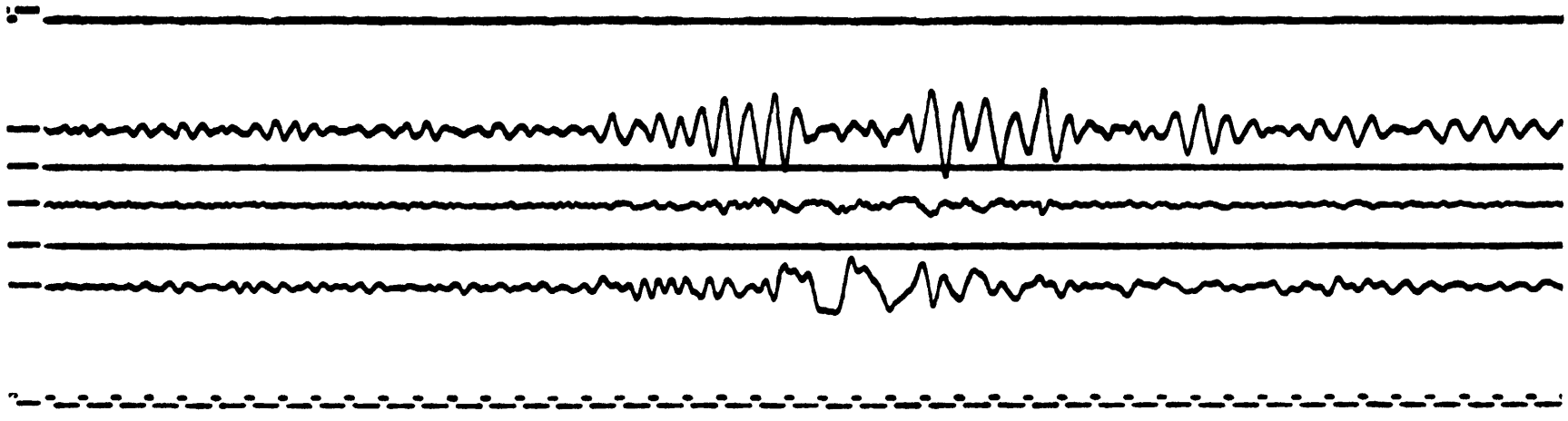


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1678 37.806N, 122.472W	360°	Sens. = 1.95 cm/g Freq. = 25.4 Hz Damp. = 0.6 crit	0.12g
San Francisco - Golden Gate Bridge			
SMA-1 No. 298 (USGS) Abutment Bldg.	Up	Sens. = 1.80 cm/g Freq. = 26.7 Hz Damp. = 0.6 crit	0.06g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.95 cm/g Freq. = 25.5 Hz Damp. = 0.6 crit	0.24g
		Film speed = 1 cm/sec	

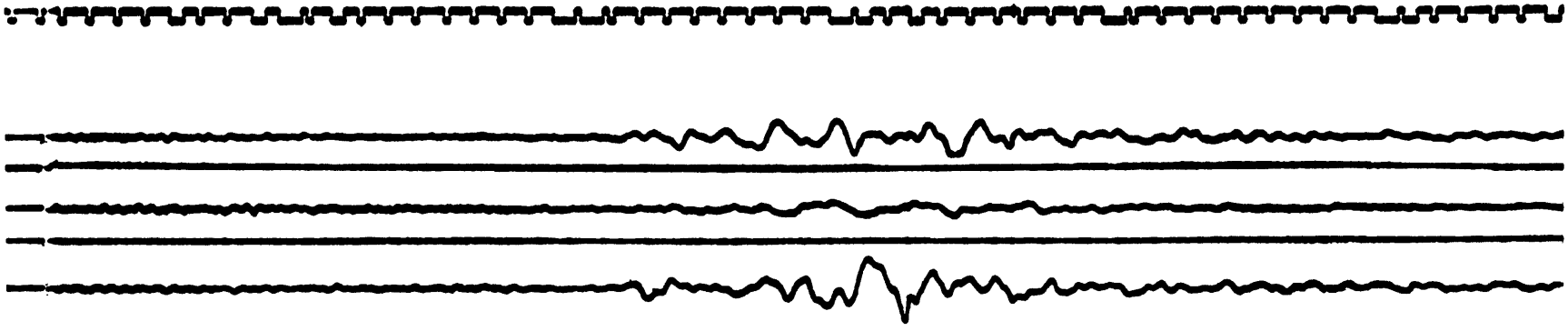


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1439 37.884N, 122.302W	057°	Sens. = 1.75 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.08g
Richmond, 2501 Rydin Rd. Bulk Mail Center SMA-1 No. 178 (USGS) Ground	Up	Sens. = 1.77 cm/g Freq. = 25.6 Hz Damp. = 0.6 crit	0.04g
EARTHQUAKE OF 18 October 1989 - 0004 G.m.t.	327°	Sens. = 1.77 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.11g

Film speed = 1 cm/sec

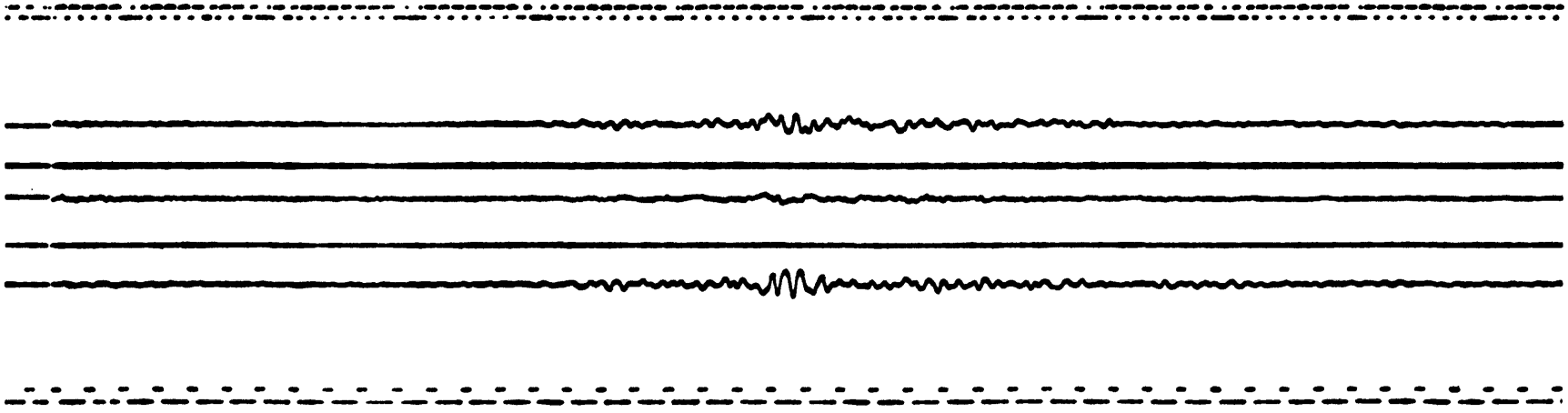


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1448 37.993N, 122.115W	020°	Sens. = 2.00 cm/g Freq. = 23.8 Hz Damp. = 0.6 crit	0.07g
Martinez VA Hospital			
SMA-1 No. 112 (VA) Basement	Up	Sens. = 1.90 cm/g Freq. = 27.2 Hz Damp. = 0.6 crit	0.03g
EARTHQUAKE OF			
18 October 1989 - 0004 G.m.t.	290°	Sens. = 1.95 cm/g Freq. = 26.3 Hz Damp. = 0.6 crit	0.05g

Film speed = 1 cm/sec

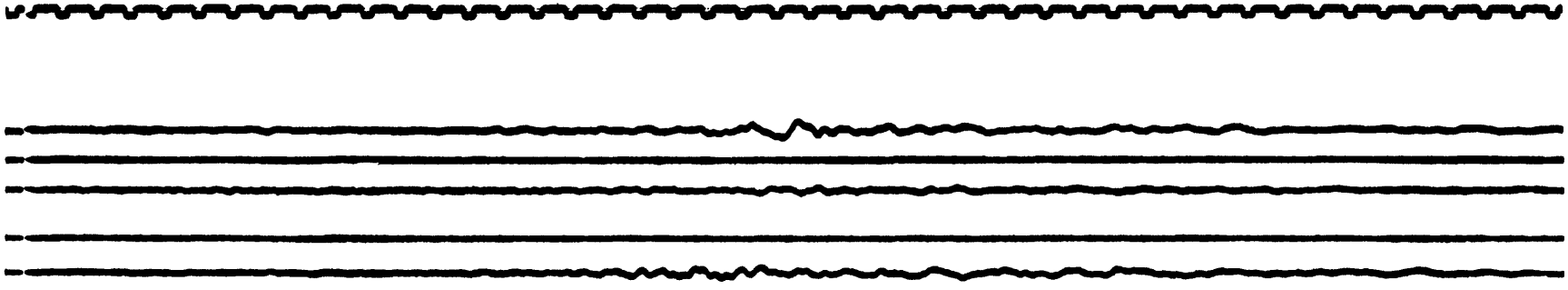


Figure 2. Continued

U.S. STRONG-MOTION NETWORK	DIRECTION	CONSTANTS	MAX. ACCELERATION
Station No. 1590 37.946N, 122.508W	360°	Sens. = 1.81 cm/g Freq. = 26.3 Hz	0.10g
Larkspur Ferry Terminal		Damp. = 0.57 crit	
SMA-1 No. 5155 (USGS) Ground	Up	Sens. = 1.66 cm/g Freq. = 27.0 Hz	0.06g
EARTHQUAKE OF		Damp. = 0.55 crit	
18 October 1989 - 0004 G.m.t.	270°	Sens. = 1.44 cm/g Freq. = 28.6 Hz Damp. = 0.57 crit	0.14g
		Film speed = 1 cm/sec	

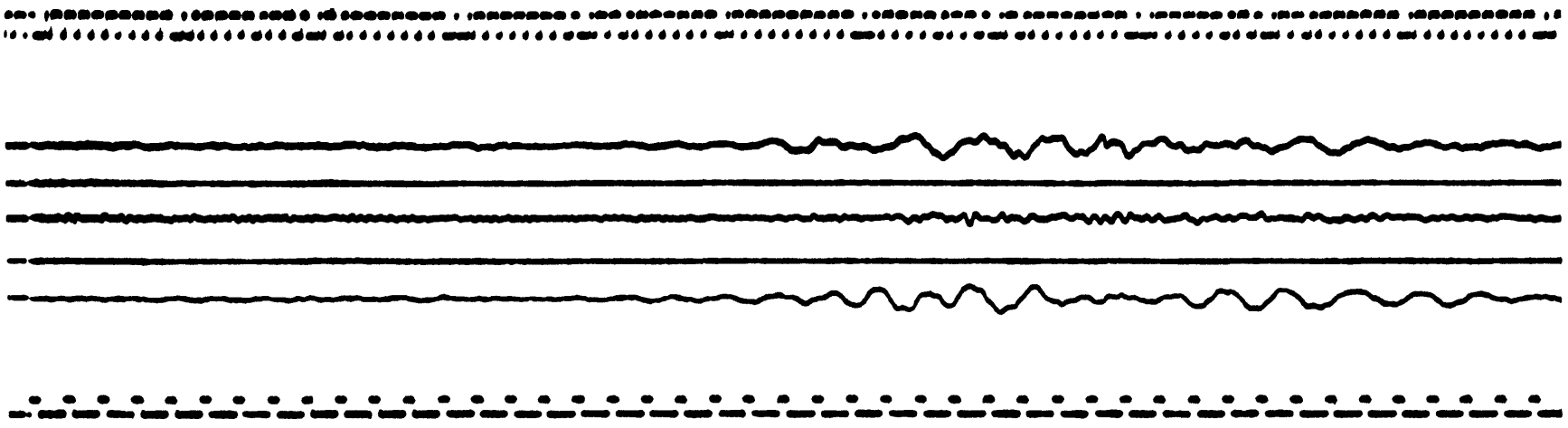


Figure 2. Continued