THE PARKFIELD, CALIFORNIA, EARTHQUAKE
OF
JUNE 27, 1966

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COAST AND GEODETIC SURVEY

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THE PARKFIELD, CALIFORNIA, EARTHQUAKE OF JUNE 27, 1966

PRELIMINARY SEISMOLOGICAL REPORT

By

Samuel T. Harding

and

Wilbur Rinehart

PRELIMINARY ENGINEERING SEISMOLOGICAL REPORT

By

William K. Cloud

Edited by

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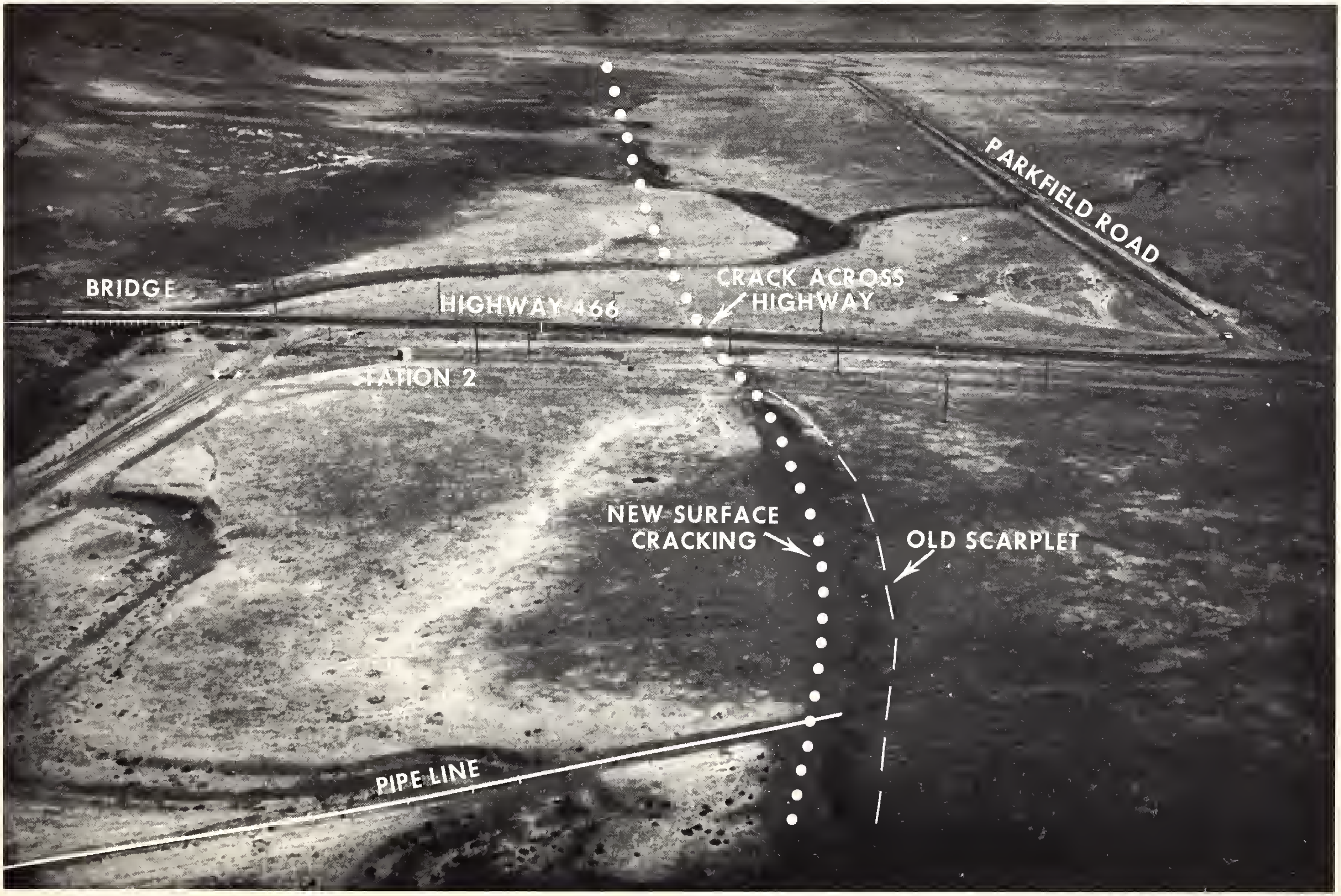

View looking northward along San Andreas fault. (Photo by Lloyd S. Cluff)

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PRELIMINARY SEISMOLOGICAL REPORT

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INTRODUCTION

On June 27, 1966, at 8:26 p.m., Pacific Standard Time, the Parkfield-Cholame, California, region was shaken by a series of earthquakes, similar in many respects to the June 7, 1934, Parkfield series. This report is a preliminary interpretation of the seismological data obtained from permanent seismograph stations throughout the world.

Seismological data available were unusually abundant. This can be attributed to the high density of seismograph stations operated in California by the University of California, California Institute of Technology, and the Coast and Geodetic Survey. Excellent records were written by five strong-motion seismographs, all located within 35 km of the epicenter. A number of seismoscopes were also located in the immediate area.

GEOLOGIC SETTING

The area encompassing the epicentral region of the Parkfield earthquake is structurally and lithologically complex. This area is part of the Southern Coast Ranges. Reed (1933) defines the Southern Coast Ranges as "that part of the Coast Ranges from San Francisco southward to the Transverse Ranges." This portion of the Southern Coast Ranges trends N.35-40°W., is subparallel to the trend of the shore of the Pacific Ocean, and lies between the Great Valley and the coast.

The Southern Coast Ranges are divided longitudinally into three structural subdivisions on the basis of the character of the basement terrain visible beneath unmetamorphosed Cretaceous and Tertiary strata. The basement beneath the middle division, composing the ranges that flank the Salinas River Valley, is coarsely crystalline rock, composed of two intermingled parts—granitic rocks of Late Cretaceous age, and enclosing schists and gneisses, mostly of sedimentary origin (Dickinson, 1966). In the flanking divisions, the basement is a strongly deformed and mildly metamorphosed rock of the Franciscan formation. The Lower Mesozoic Franciscan formation includes igneous, sedimentary, and metamorphic rock of eugeosynclinal assemblage (Reed, 1933). Structurally, the Franciscan complex is an incompetent mass of rocks with a minor proportion of competent beds interspersed through the formation. The incompetence of the Franciscan formation, coupled with a highly resistant superjacent formation, tends to make the structure in the flanking segments complex with many diaper-type folds and faults. The plutonic basement of the middle division is sharply bounded on the east by the active San Andreas fault zone, and on the west by the inactive Sur fault zone. The extension of the Sur fault to the southeast, as the Nacimiento fault, is poorly located because its position in the basement is masked by overlying strata.

The region east of the San Andreas fault zone is a group of *en échelon* anticlinal and hogback ranges, known collectively as the Diablo Range. The Diablo Range is considered a geologic unit because all of its ridges and valleys were formed by erosion of the members of a system of *en échelon* faulted folds, each trending N.45-75°W. at an acute angle to the San Andreas fault zone. Each major fold, or system of folds, is terminated against the fault zone on the northwest and plunges southeastward into the Great Valley. Eardley (1962) points out, "that the most perplexing problem about the San Andreas fault in the Southern Coast Ranges is its setting in a typical compressional structure running parallel, or at an acute angle, to the fault zone. The great fault seems to be at odds with the geomorphic provinces."

Paleocene, Eocene, Oligocene, and Early Miocene times were generally characterized by subsidence of the San Joaquin basin. The Tertiary strata of this region reflect times of mild, recurrent deformation throughout the Tertiary age. The deformation of poorly dated, Pliocene and Pleistocene gravel sequences probably records further evolution of the fold system during the Quaternary period.

SEISMICITY

The Parkfield-Cholame region is part of the active zone of seismicity extending from north of San Francisco to the Murray fracture zone, part of which can be directly, or indirectly, attributed to the active San Andreas fault. The epicenter of the June 27, 1966, Parkfield earthquake falls in the San Andreas fault zone between the epicenters of the two largest earthquakes ever reported in California—the southern California earthquake in 1857, and the 1906 San Francisco earthquake. The Parkfield earthquake epicenter lies southeast of the 1906 earthquake location, and probably not far from the northern limit of faulting during the 1857 earthquake. Richter (1958) points out that there is a comparative lack of minor shocks along sectors of the San Andreas fault which were displaced by the earthquakes of 1857 and 1906. This may be an indication of why the seismicity of the immediate region is slightly higher than the portions northwest and southeast, along the San Andreas fault.

Eppley (1966) lists 399 earthquakes in California from 1769 through 1963 with intensity V or greater. The earthquakes are distributed in intensity as follows: Intensity XI, 4; intensity X, 6; intensity IX, 13; intensity VIII, 32; intensity VII, 87; intensity VI, 145; intensity V, 36; and 76 additional shocks believed to have been intensity V or greater.

Historically, the Parkfield-Cholame area has been subjected to frequent earthquakes of moderate intensity. Table 1 lists the earthquakes with Modified Mercalli intensity of V or greater since 1769. Figure 1 shows the locations, where possible, of the earthquakes listed in table 1. The largest earthquake in this region occurred on March 10, 1922. Its epicenter was located 18 miles southeast of the 1966 earthquake, near the town of Cholame. The Modified Mercalli intensity was IX, according to Eppley (1966), and it was felt over 100,000 square miles. Pipelines crossing the Cholame Valley were ruptured by this shock, and considerable damage was done to existing structures in the Valley.

The March 2, 1901, earthquake was assigned a maximum intensity of VII–

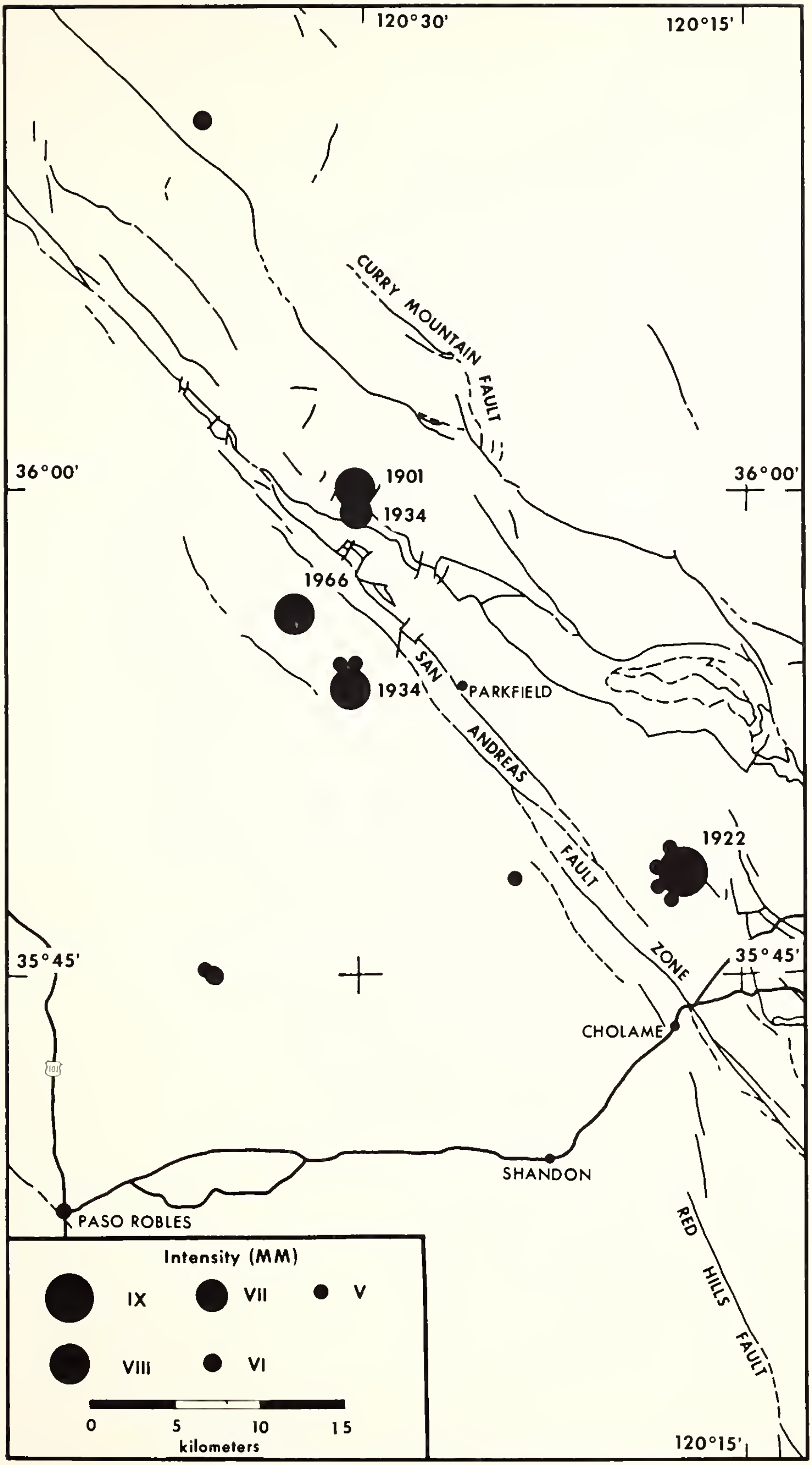

FIGURE 1.—*Earthquakes (intensity V or greater) in the Cholame-Parkfield, California area.*

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TABLE 1.—*Earthquakes in the Parkfield area, 1769–June 1966*

Year	Date	Origin time P.S.T.	N. lat.	W. long.	Depth	Felt area	Intensity M.M.	Magnitude	Authority**
		h m s	*deg*	*deg*	*km*	*sq. mi.*			
1901	Mar. 2	23 45	36.0	120.5		40,000	VII–VIII		1
1922	Mar. 10	*03 21 20.0	35.8	120.3		100,000	IX	6.5	1
	Mar. 16	15 10	35.8	120.3			V		2
	Aug. 17	21 12	35.5	120.5		25,000	VI		2
1931	Feb. 23	02 01	35.8	120.6		5,000	V		3
	Feb. 23	02 33	35.8	120.6		5,000	V		3
1934	June 5	13 49	35.8	120.3		11,000	V	5.0	3
	June 7	20 30	36.0	120.5		About 34,000	VI–VII	5.0	3
	June 7	20 48	35.9	120.5		34,000	VIII	6.0	3
	June 7	21 43	35.8	120.3			V	4.5	3
	June 10	00 03	35.8	120.3			V	4.5	3
1939	Dec. 28	*04 16 38.0	35.8	120.3		14,000	V	5.0	3
1947	Feb. 4	*22 14 23.0	36.2	120.6			VI	5.0	3
1956	Nov. 15	*19 23 09.0	35.9	120.5		8,000	VI	5.0	3
1958	Oct. 10	*05 05 16.0	35.9	120.5		3,500	V	4.5	3
1961	July 30	*16 07 07.0	35.7	120.4		5,000	V	4.5	3
1966	June 27	*20 08 57.0	35.54	120.54			(V)	5.0	4
	June 27	*20 26 14.4	35.54	120.54	5	20,000	VII	5.3	4

( )-Estimated intensity of V or greater.
*-Instrumental epicenter.
**-Authorities are as follows:
1. Eppley, R. A., *Earthquake History of the United States, Part II, Stronger Earthquakes of California and Western Nevada*, Environmental Science Services Administration, Coast and Geodetic Survey, 1966.
2. Townley, S. D. and Allen, M., "Descriptive Catalog of Earthquakes of the Pacific Coast of the United States, 1769–1928," *Bull. Seis. Soc. Am.*, vol. 29, pp. 21–252, 1939.
3. *United States Earthquakes, 1928–1964*, Environmental Science Services Administration, Coast and Geodetic Survey.
4. "Preliminary Determination of Epicenters, June 1966," cards distributed by the Environmental Science Services Administration, Coast and Geodetic Survey.

VIII, and was felt over an area of 40,000 square miles or more. Surface cracks, 6–12 inches in width, were reported along the trace of the San Andreas fault zone. In some places vertical motion of 12 inches was reported (Townley and Allen, 1939).

The epicenter of the June 7, 1934, earthquake lies within a few kilometers of the 1966 shock. (The seismological aspects of the 1934 earthquake are discussed by Wilson, 1936.) It was preceded by three foreshocks, and was followed by a series of aftershocks. The first foreshock had a maximum intensity of V and was felt over about 11,000 square miles. The largest foreshock, which preceded the main shock by 18 minutes, had a maximum intensity of VI–VII and was felt over an area of about 34,000 square miles. The main shock was felt over an area of 34,000 square miles and was assigned an intensity of VIII. The damage caused by this earthquake was moderate to existing structures, and surface cracking was reported in the Middle Mountain area northwest of Parkfield (Byerly and Wilson, 1935). There were two zones of cracks which were close to the surface trace of two faults of the San Andreas fault zone. The zones of cracks were about 25 feet wide and arranged *en échelon*. The largest single crack was about 55 feet long, 9 inches wide, and 18 inches deep.

The sparsity of population in this portion of California prior to 1901 may be a contributing factor to the lack of reported seismic activity in the Cholame-Parkfield region. This is evidenced by the following population figures for Monterey County: 1850, 1,872; 1900, 19,380; and 1966, 224,316. This factor has also been documented for the Alaska region in "The Prince William Sound, Alaska, Earthquake of 1964 and Aftershocks," Department of Commerce, Coast and Geodetic Survey Publication 10–3, vol. 1, p. 21, 1966.

HYPOCENTERS, ORIGIN TIMES, AND MAGNITUDES OF FORESHOCKS, MAIN SHOCK, AND AFTERSHOCKS

It has been pointed out by Eaton (1963), McEvilly (1966), Healy (1963), and Hamilton, et al. (1964) that the crustal velocity on the west side of the San Andreas fault is approximately 0.6 km/sec higher than the 5.6 km/sec velocity reported for the east side of the fault by Byerly (1938) and Byerly and Wilson (1935), and confirmed by Eaton (1963). This is probably, as pointed out by Eaton (1963), the effect of the large strike-slip movement which has occurred in Cenozoic time. A terrain with granitic basement rock on the west has been brought in contact with terrain with a Franciscan basement on the east, producing different basement conditions in the areas on opposite sides of the fault.

The hypocenter and origin time of the main earthquake, the foreshocks, and series of aftershocks were computed using two methods, both taking into consideration the effects of local geology. A digital computer program, described by Rinehart (in press) using local travel-time curves obtained from seismic refraction work and station corrections to compensate for the geologic effect on the velocities between the refraction line and the station, processed the arrival-time data reported by 27 local and regional stations. The digital computer program, described by Engdahl and Gunst (1966), which is used regularly by the Coast and Geodetic Survey for epicenter computation, processed the arrival-time data reported by 54 stations located at distances greater than 25°. This program uses Jeffreys-Bullen travel-time curves.

The epicenter computed using the stations less than 400 km distant is considered to be closest to the actual epicenter, since the velocity data used were from local seismic refraction studies. In the case of Healy's work, the explosive source was located at Camp Roberts, about 30 km to the southwest of the epicenter of the Parkfield earthquake, and would be representative of the velocities for seismic waves leaving the focus of the Parkfield earthquake traveling to stations on the west side of the San Andreas fault. The travel-time curve used for stations east of the San Andreas fault (Eaton, 1963) was derived from an explosive source in the San Francisco area. This confirmed the travel-time curves which Byerly and Wilson (1935) used for this area for locating the 1934 Parkfield earthquake.

Figures 3 and 4 are time difference hyperbola plots of the arrival times for the first nine-station pairs reporting the main shock and a major aftershock. The origin of the coordinates of the plot is 36° N., 120° W. The scale is in kilometers and the plus signs are the intersections of the geographic meridians and parallels. The plots were made on the cathode ray oscilloscope plotter attached to the IBM 7030 computer during the preliminary data pass. The main event, figure 3, clearly shows intersection of numerous hyperbola at about x = −40

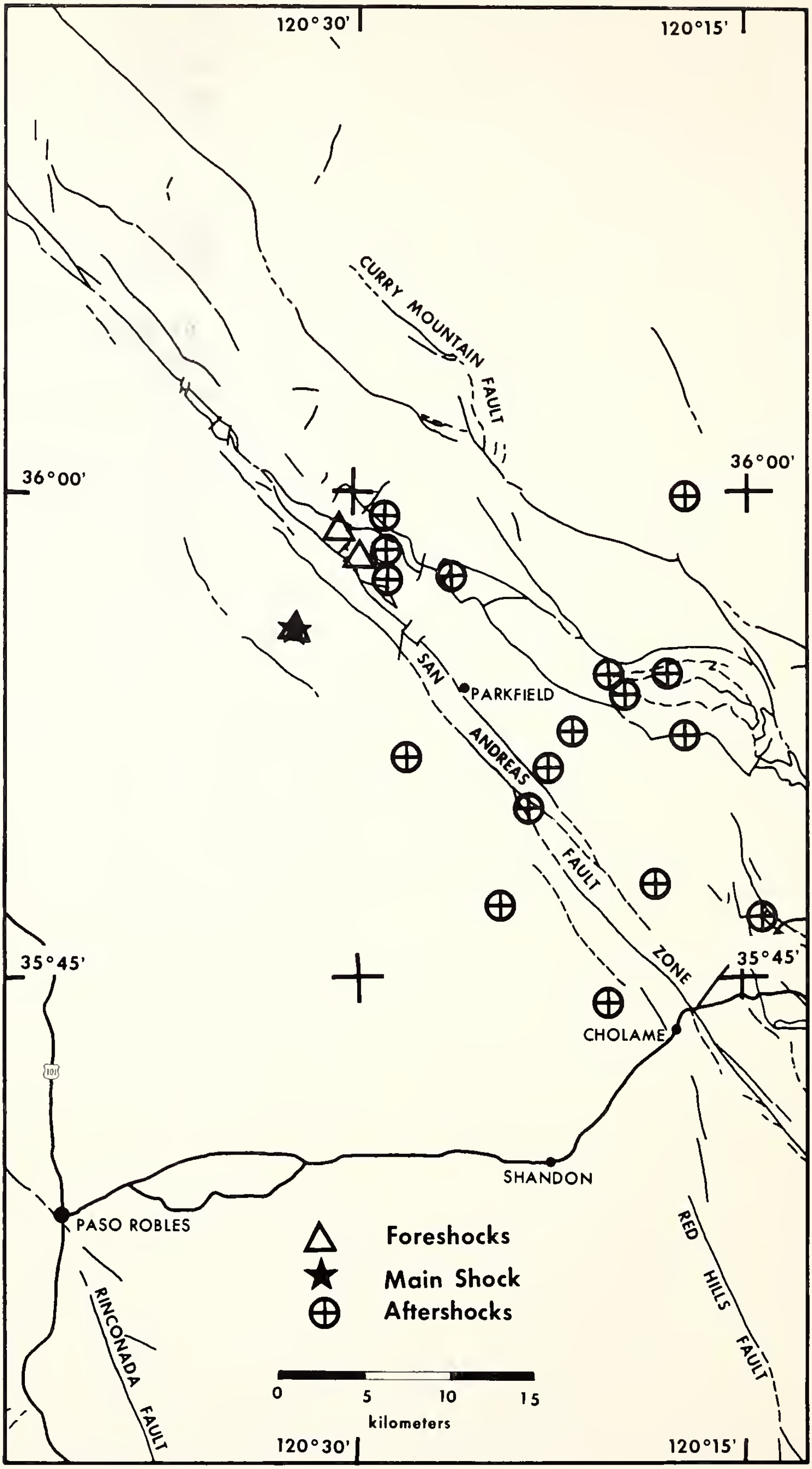

FIGURE 2.—*Location of epicenter of June 28, 1966 (G.M.T.) earthquake, foreshocks, and aftershocks.*

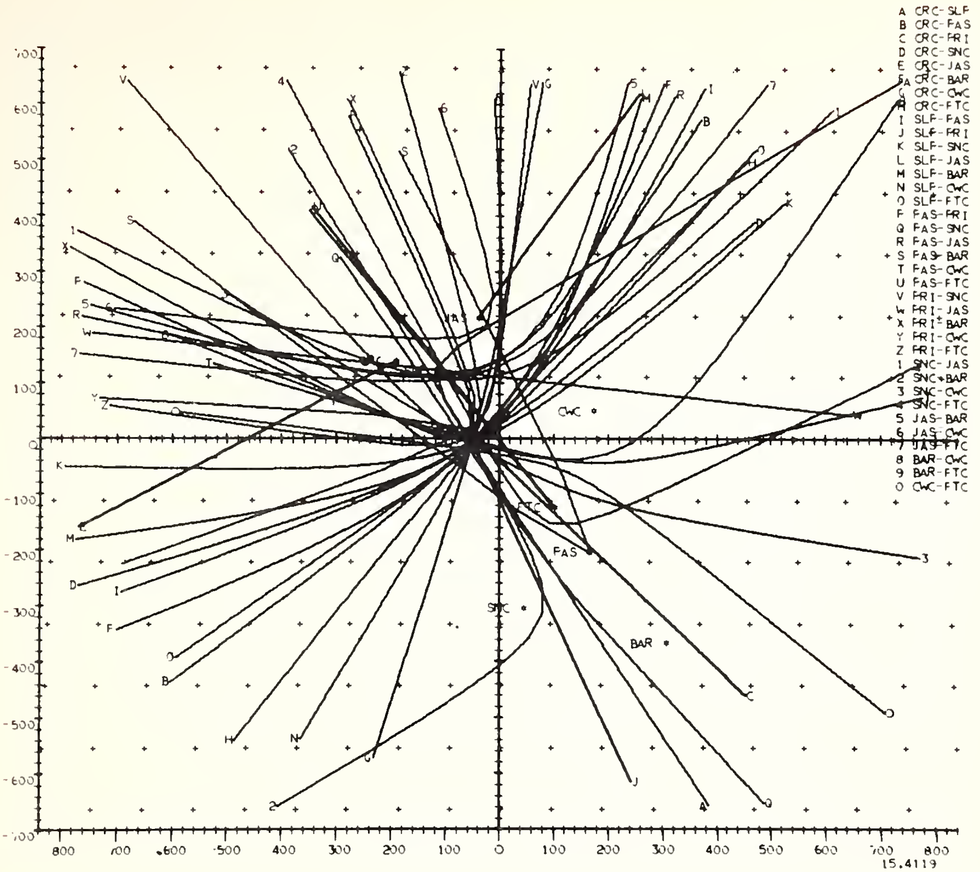

FIGURE 3.—*Time difference hyperbola plot of main earthquake occurring at 04:26:14.4 G.M.T., June 28, 1966.*

and y=−10 (approximately 35.9° N., 120.5° W.). It also shows that the arrival time at station JAS (Jamestown) associated with hyperbola E, L, R, W, 1, 5, 6, and 7 does not fit the solution. This station's data were removed from the hypocenter computation during the final data pass. The plot of the June 28 aftershock (04:39:08.9 G.M.T.) shows the intersection of all hyperbola at about x=−40, y=−10 (approximately 35.9° N., 120.5° W.). There are no apparent errors in the input data. Time difference hyperbola plots were made for each event to assist in the removal of arrival times which were in error and to suggest a first approximation of epicenter location to the least-squares iterative solution used to determine the epicenter and origin time. Table 2 is a list of these earthquakes, three of which are considered foreshocks, and twenty-two are aftershocks. These earthquakes are plotted in figure 2, with the exceptions of one aftershock on June 28 and three aftershocks on July 2, which fall outside the coordinates of the map.

The epicenter, using stations greater than 25° distant, is listed in table 3. The focal depth was constrained to 5 km since there is practically no focal-depth resolution possible when all data are in this distance range. This solution is considered less reliable than the previously discussed solution since most of the readings used were of emergent na-

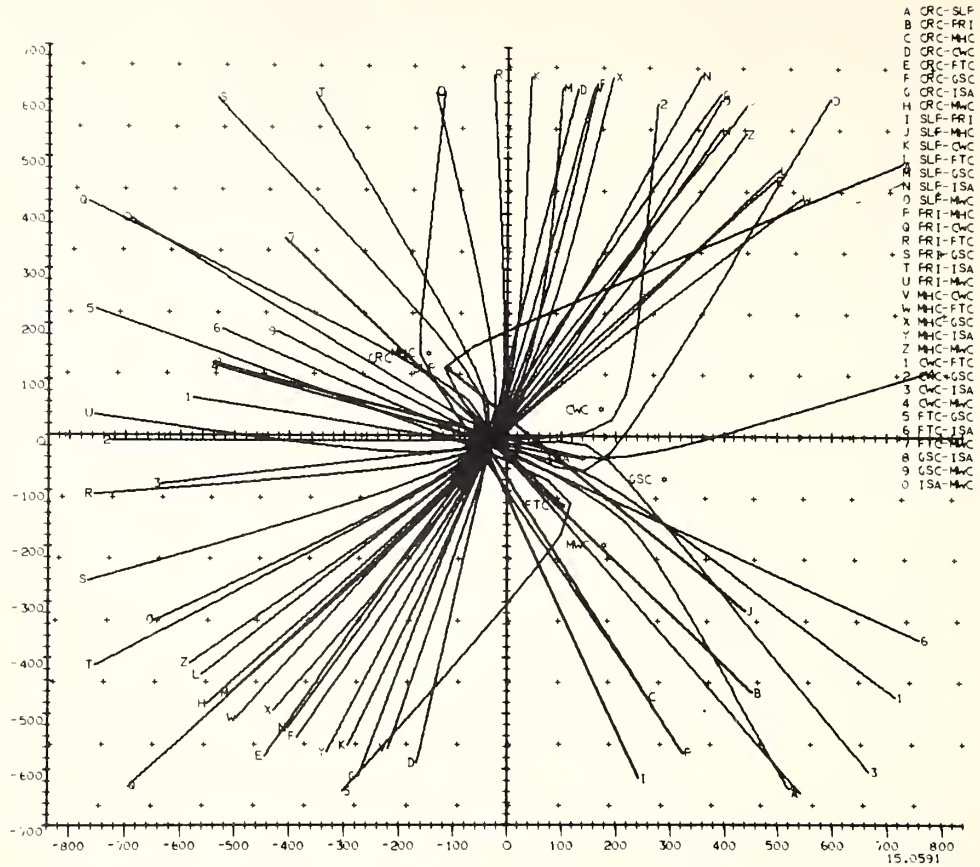

FIGURE 4.—*Time difference hyperbola plot of major aftershock occurring at 04:39:08.9 G.M.T., June 28, 1966.*

ture, and there is some question as to what portion of the wave train was read for the *P* arrival.

The depths assigned to these earthquakes are placed somewhere between 5 and 10 km. In computing the depths, the closest station to the epicenter was Priest (25 km distant). This should give a good depth determination if the velocity model used is correct. But if an increasing with depth velocity is the case, such as proposed by Udias (1965) or McEvilly (1966), the *P* waves arriving at Priest would be leaving the source at close to 80° from the vertical, allowing little or no depth resolution.

The magnitude of the main shock has been reported to be 5.3 by the Coast and Geodetic Survey; 5.8, by Pasadena; 5.5, by Berkeley; and 6½, by Palisades. The surface wave magnitude of 6.2 was computed from the horizontal component seismographs using the method of Gutenberg (1945). The amplitudes were read at approximately the same time, within the same cycle on each of the horizontal components, and the vector sum was used in the computations. In all cases, records were used where it was possible to read amplitudes for periods between 17 and 23 seconds (Bath, 1956). For the seven stations reported here, the periods of the surface waves used ranged from 19 to 22 seconds. The results of these computations are shown in table 4.

TABLE 2.—*Chronological listings of foreshock and aftershock epicenters, June 28–July 2, 1966*

Date 1966	Origin time G.M.T.	N. lat.	W. long.	Magnitude	
				Brk	Pas
	h m s	*deg*	*deg*		
June 28	01 00 33.2	35.97	120.49	3.0	3.5
	04 08 57.0	35.94	120.54	5.3	4.8
	04 18 35.8	35.98	120.51	2.5	3.2
	04 26 14.4	35.94	120.54	5.5	5.8
	*04 31 59.3	35.81	120.13	---	3.5
	04 32 51.6	34.74	120.34	3.5	4.0
	04 35 02.3	35.84	120.39	3.5	3.1
	04 39 08.9	35.91	120.34	3.0	3.5
	04 46 23.0	35.90	120.33	2.5	3.0
	05 01 02.9	35.96	120.48	3.0	3.6
	05 46 02.2	35.86	120.38	3.0–3.5	3.7
	06 32 18.9	35.97	120.48	3.5	3.9
	07 45 50.8	36.00	120.29	2.5–3.0	3.0
	11 51 13.3	35.79	120.41	---	---
	13 48 21.1	35.78	120.24	3.0	3.3
	20 46 58.9	35.91	120.30	3.0	3.4
	23 57 24.2	35.88	120.29	3.0	3.
June 29	02 19 41.1	35.96	120.48	3.5–4.0	4.1
	08 55 55.9	35.87	120.47	3.0	3.2
	13 12 00.7	35.80	120.31	3.0–3.5	3.8
	19 53 26.8	35.99	120.48	5.0	4.8
June 30	01 17 36.9	35.88	120.36	4.0–4.5	4.3
July 1	09 41 23.1	35.96	120.44	3.0	3.6
July 2	*12 08 35.8	36.02	120.06	3.0–3.5	3.9
	*12 16 23.8	35.72	119.60	3.0	3.4
	*12 25 24.3	36.08	120.08	2.5	3.1

NOTE: Depths are assumed to be between 5–10 km. The asterisk (*) indicates those epicenters not plotted in figure 2.

TABLE 3.—*List of hypocenter computations for the main shock at 04:26:14.4 G.M.T.*

Hypocenter computation no.	Origin time G.M.T.	N. lat.	W. long.	Depth	No. of stations used	Comments
	h m s	*deg*	*deg*	*km*		
1	04 26 12.4	35.9	120.5	4	48	C&GS Preliminary Determination of Epicenter Card No. 45–66.
2	04 26 15.8	35.99	120.36	*5	54	Station data $\triangle > 25°$ only.
3	04 26 14.4	35.94	120.54	5	27	Station data $\triangle < 5°$ only.

*Depth constrained.

TABLE 4.—*Magnitude calculations*

Station	Distance	M_s
	deg	
Bogota	52. 9	6. 4
Bermuda	45. 9	6. 3
Caracas	54. 6	6. 4
Copenhagen	80. 4	6. 1
Istanbul	98. 5	6. 0
Quito	53. 1	6. 1

FOCAL MECHANISM STUDIES

A nodal plane solution was made using Byerly's (1938) extended distance technique for the main shock. Tables developed by Hodgson and Storey (1953), based on the Jeffreys-Bullen (1940) travel-time curves, were used to compute the extended distance in the distance range of approximately 12° and greater. For the distance range in which *Pn* is the first arrival, a crustal velocity of 5.6 km/sec and an upper mantle velocity of 7.9 km/sec (Eaton, 1963) were used to determine the critical circle (Romney, 1957). A velocity distribution based on the refraction data of Eaton, 1963, and Healy, 1963, was tried with little or no change in the nodal plane orientation. Stations at which *Pg* is the first arrival were omitted from the plot because the extended distance technique is sensitive to the depth of the earthquake at short epicentral distances, thus requiring assumptions which the available data do not warrant.

For the solution of the main earthquake, 38 first motions were used (see table 5). The seismograms from 14 of these stations were read by the authors, and the remaining 24 readings were obtained from stations that report directions of first motions routinely. Two of the 38 first motions were found to be inconsistent with the solution, amounting to about 5 percent error.

Figure 5 is an extended distance plot in stereographic projection of the direction of first motions of the 38 stations used in the solution. The circles represent the A and B planes found for this earthquake. The smaller circle in figure 5 represents the A plane and the larger circle, the B plane. The A plane has a strike of N.62°E. and dips 60°W. The B plane, restrained by the orthogonality criterion, strikes N.25°W. and dips 86° E. The strike of the San Andreas fault in this region is N.44°W. The B plane is oriented N.25°W., which is 19° east of the strike of the San Andreas fault. This nodal plane indicates right-lateral motion. The A plane is nearly transverse to the regional structure, figure 7. No attempt is made in this discussion to differentiate between the fault plane and the auxiliary plane, since this would imply that the earthquake is classified as a single couple. This cannot be determined by the method used. Work is progressing on an *S*-wave solution which should enable the authors to better evaluate the nature of the focal mechanism.

TABLE 5.—*Character of first motion for main shock at 04:26:14.0 G.M.T.*

Station	First motion	Station	First motion
*Albuquerque	C	Mould Bay	D
Arcata	C	Mt. Hamilton	C
Barrett	C	Mineral	D
Byerly	C	Mount Wilson	C
*Blacksburg	C	*Oroville	D
*Bozeman	C	Pasadena	C
*Cedar Springs	C	Palomar	C
China Lake	C	Priest	C
Cottonwood	C	Riverside	C
Edmonton	D	Santa Barbara	D
*Eureka	C	*State College	C
*Flaming Gorge	C	*Salt Lake City	C
Fort Tejon	C	*San Luis Dam	D
*Glen Canyon	C	San Nicolas	D
Goldstone	C	Tinemaha	C
*Hungry Horse	D	*Tucson	D
Isabella	C	Tulsa	C
Jamestown	D	Ukiah	D
*Junction City	C	Woody	C

C-Compressional.
D-Dilatational.
*-Stations read by authors.

CONCLUSIONS

The Cholame-Parkfield area is part of an active zone of seismicity which is associated with the San Andreas fault zone. Table 1 leads one to believe that the seismic activity in this region has greatly increased since 1901, but as explained on pages 4–5, the sparse population previous to 1901 may account for the lack of reported earthquakes.

The most severe earthquake in the Parkfield area occurred on June 7, 1934, within a few kilometers of the 1966 location. Surface cracks and the fore- and aftershock activity associated with this earthquake have a strong resemblance to the June 27 earthquake effects. One very interesting similarity is that, in both instances, the largest foreshock preceded the main shock by 18 minutes (see table 1).

The B nodal plane of the focal mechanism study is oriented 20° east of the strike of the San Andreas fault.

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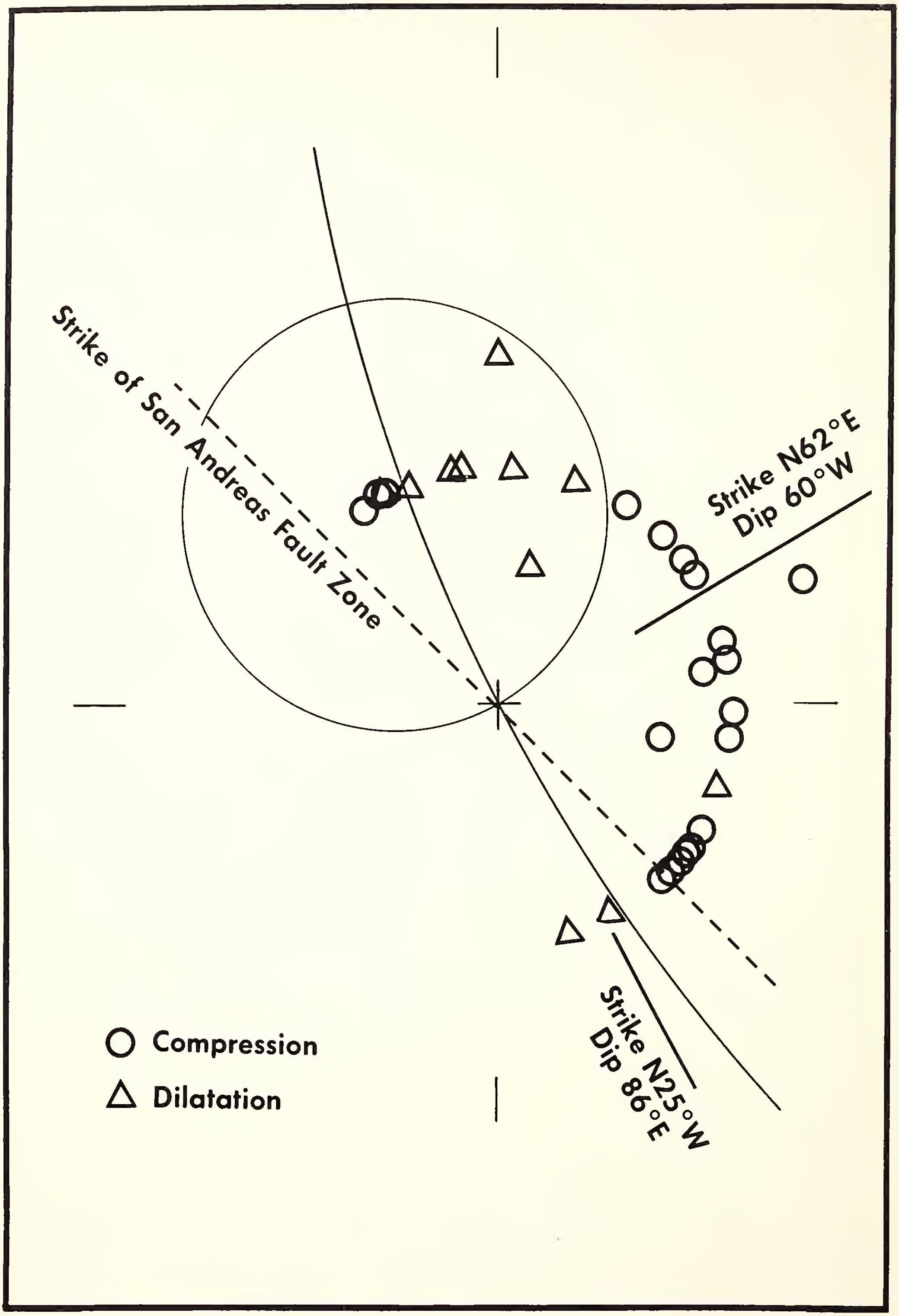

FIGURE 5.—*Stereographic projection showing the first motion and direction of nodal planes.*

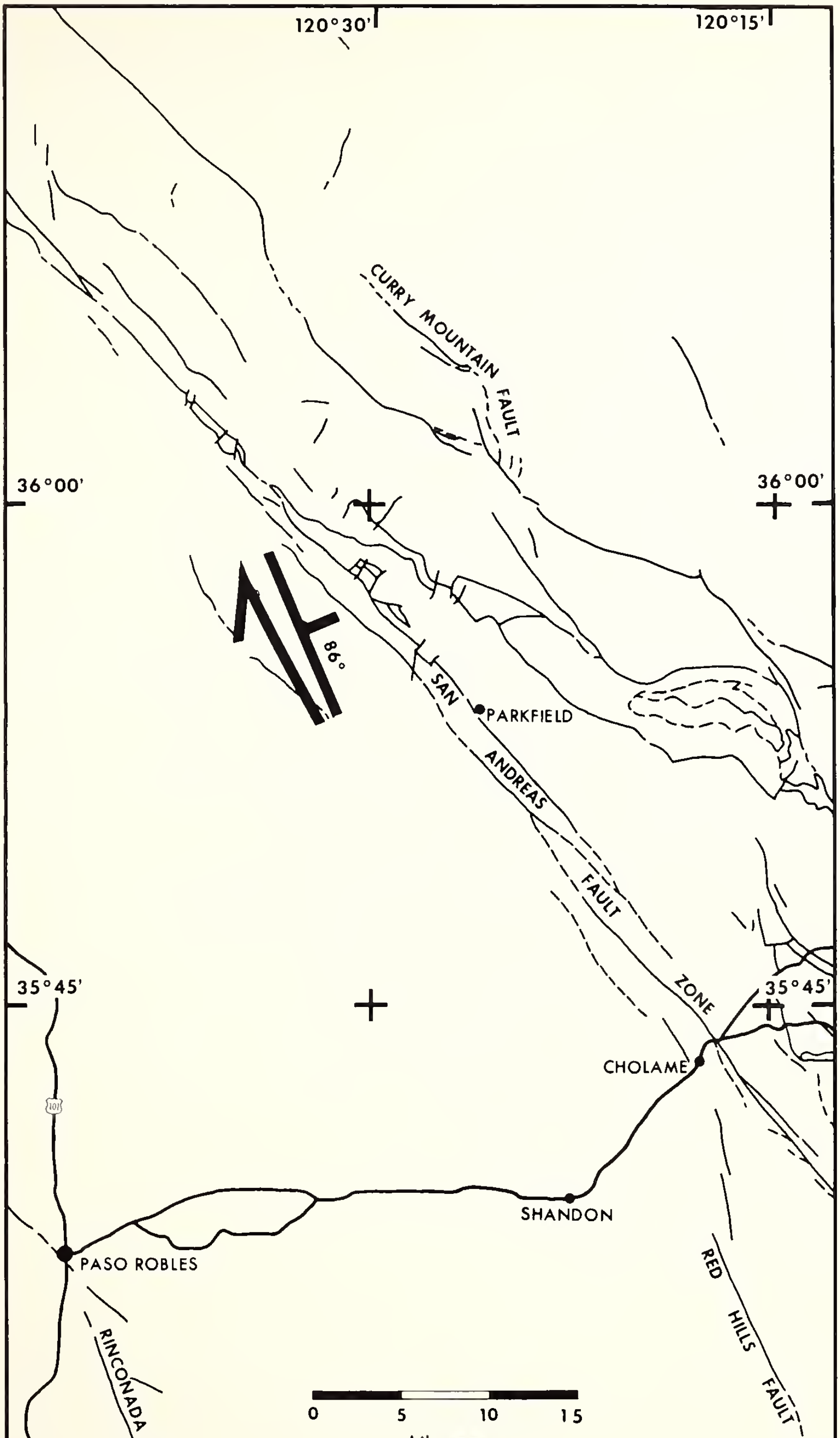

FIGURE 6.—*Comparison of nodal plane solutions of June 28, 1966 (G.M.T.) earthquake to regional faulting B plane.*

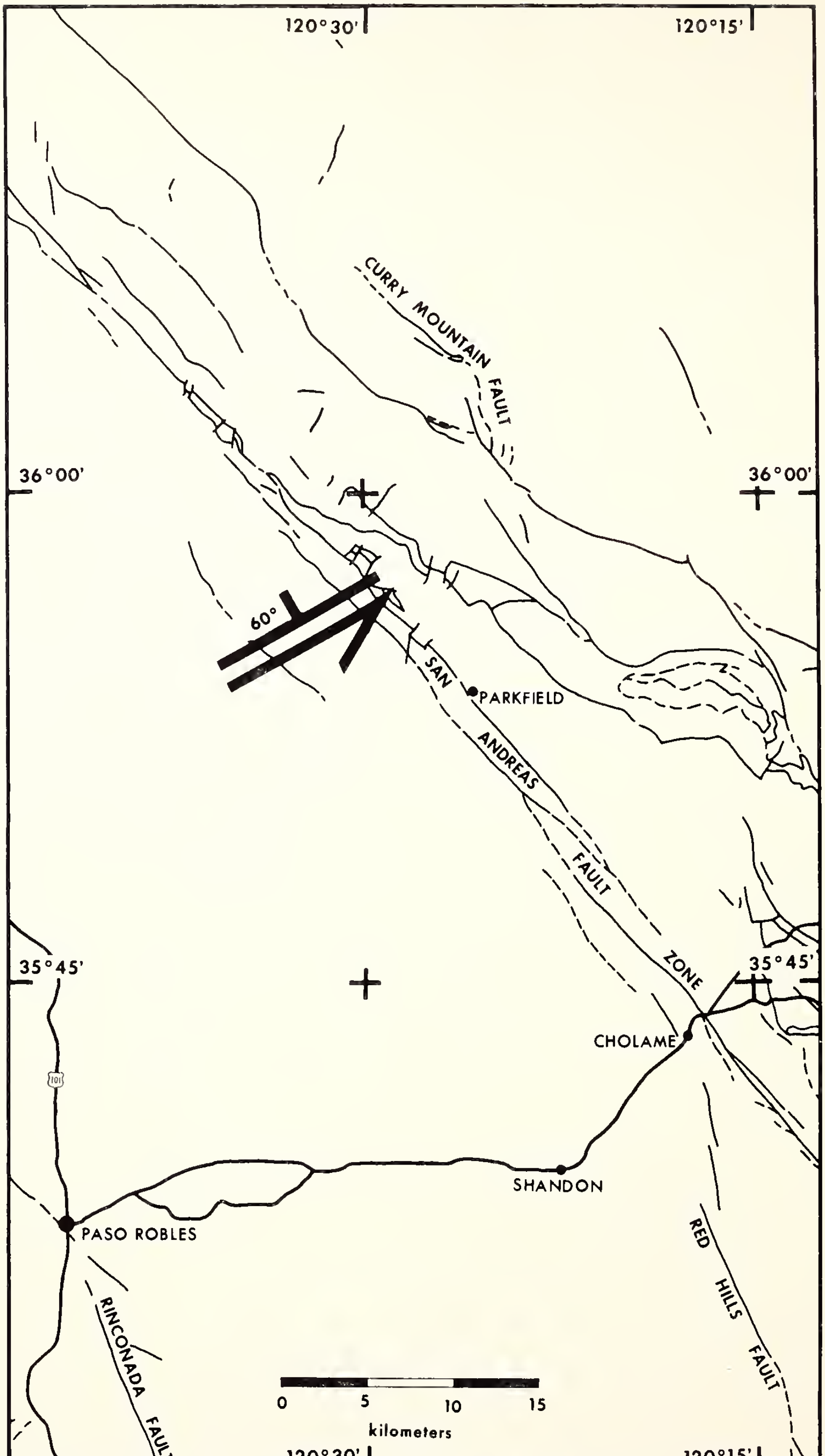

FIGURE 7.—*Comparison of nodal plane solutions of June 28, 1966 (G.M.T.) earthquake to regional faulting A plane.*

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PRELIMINARY ENGINEERING SEISMOLOGICAL REPORT

by
William K. Cloud

INTRODUCTION

In an effort to gain knowledge on earthquake motions of engineering interest at and within a few miles of a fault, a strong-motion instrument array was completed in June 1965 across the San Andreas fault zone near Cholame, California. Implementation of the project became possible as the result of a cooperative agreement between the Coast and Geodetic Survey and the State of California Department of Water Resources.

On June 27, 1966, the hopes for obtaining information from the array were fulfilled. The main shock of the Parkfield-Cholame earthquake series, at 20: 26 Pacific Standard Time, activated instruments in the array and yielded some of the most interesting records ever obtained. Richter magnitude of the shock was reported as 5.3 by the Coast and Geodetic Survey, 5.5 by Berkeley, and 5.8 by Pasadena. Epicenter placement was difficult for seismologists due to the scarcity of teleseismic stations east and west of the area. However, field inspection and past history of the region suggested the Middle Mountain area a few miles northwest of Parkfield. From this area, surface evidence of minor faulting was visible southward along the San Andreas fault zone to a few miles beyond Cholame, a distance of approximately 20 miles.

Results from the strong-motion instruments in the array are presented in this preliminary report in context with effects of the earthquake as determined by field investigation and questionnaire card coverage.

INTENSITY [1]

The main shock of the Parkfield, California, earthquake series occurred on June 27 at 20: 26 Pacific Standard Time. It was felt over an area of approximately 20,000 square miles. A map of the felt area showing Modified Mercalli intensities is displayed in figure 8. The map was prepared from 356 earthquake questionnaire card reports, press reports, and from field investigations conducted by the Coast and Geodetic Survey. A maximum intensity of VII has been assigned to a small area in and near the San Andreas fault zone, extending southeasterly from a few miles north of Parkfield to a few miles south of Cholame. This intensity is based primarily on the ground displacement and cracking which occurred in this area. (Figures 9–13 show pavement cracks on Highway 466, and ground surface fractures and displacement of pipeline near Strong-motion No. 2.)

INTENSITY VII:

Cholame and vicinity.—Water heater torn loose in kitchen. Furniture shifted about 1 foot from walls. Lamps overturned; desk drawers were opened; and a large amount of glassware was broken. "It was like riding a bucking bronco." At the Rafter E Ranch, plaster cracked and fell and furniture shifted. Water sloshed from the swimming pool. Damage moderate. At the Standard Oil Service

[1] By Nina H. Scott, Seismological Field Survey, Coast and Geodetic Survey.

Station, one window cracked near anchoring of shelter ceiling beam, and possible slight buckling of metal facia. Coke machine shifted southeast. At the Cholame Cafe and Grocery Store, concrete slab floor of front of building separated from older wood floor on wood piers (fig. 14). Many objects fell from shelves. No apparent damage to wood-frame residences, wood barn, small wood-frame school, and water tanks.

Cholame (about 1 mile northeast of; Strong-motion Station No. 2).—Bridge cracked and pavement buckled (figs. 9 and 15–18). Base-ground separation at power pole (with small

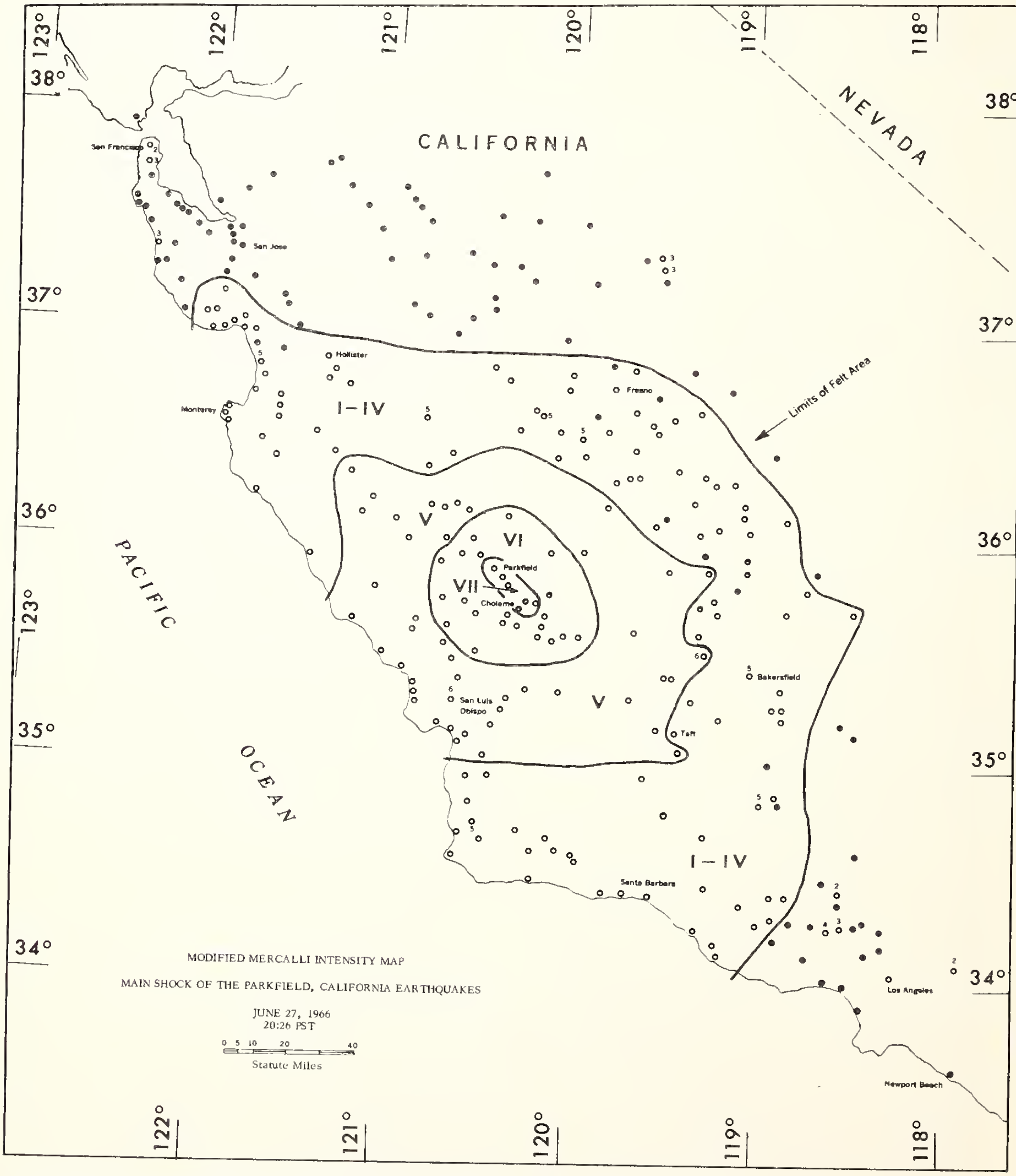

FIGURE 8.—*Map showing Modified Mercalli intensity distribution of the June 27, 1966 (20:26:14.4 P.S.T.), Parkfield earthquake.*

FIGURE 9.—*Crack across pavement of Highway 466 about 270 feet east of Strong-motion Station No. 2. Note right lateral movement indicated by arrow. (Photo by George Murray)*

FIGURE 10.—*En échelon cracks across road about ½ mile south of Strong-motion Station No. 2. View looking south. (Photo by Ed Etheredge)*

FIGURE 11.—*Ground surface fractures about 270 feet east of Strong-motion Station No. 2. View looking southeast. (Photo by Ed Etheredge)*

FIGURE 12.—*Displacement of pipeline located about 200 yards southeast of Strong-motion Station No. 2. Bent grass indicates original location of pipeline. View looking northeast. (Photo by B. J. Morrill)*

FIGURE 13.—*Ground surface fractures about 2 miles northwest of Strong-motion Station No. 2. View looking northwest. (Photo by Ed Etheredge)*

transformer) just east of the station indicated considerable shaking. Quart jar of water overturned at Strong-motion Station No. 2.

Cholame (north of; Jack Ranch, 6.5 miles north of Highway 466, on the Cholame-Parkfield Road).—Water pipes to stock tank, and irrigation pipe broke. Chimney on bunkhouse broke and slipped ¾ inch, but did not fall. About 1 mile west of Jack Ranch, dead trees were knocked over (fig. 19).

Cholame (6–7 miles east of; on U.S. Highway 466).—Observer reported old, poorly built house "tore apart in two places," but also reported damage was slight. Volume of spring water increased. "Our tank is now running over. Before the shock, we had hardly any water in the tank."

Cholame (3.2 miles southeast of Strong-motion Station No. 2; William Alley Ranch).—(VI) Stock water tank (not very full) showed indication of slight motion. Domestic water tank (volume about 4,960 gal and kept rather full) showed evidence of oscillation of not over 1 mm about one edge of base, direction about south-southeast. Some plaster cracked; objects knocked from shelves. Observer standing in yard sat down on ground in fear of being knocked down.

Cholame (Everett Hatch Ranch on Ming Road, about 7 miles east-southeast of Strong-motion Station No. 2).—Tank tower moved about 3 inches off base. Kitchen cabinet doors opened and some dishes, glasses, etc., fell out; jars and canned goods knocked off shelves. The only furniture movement was a table, which slid 10 inches in a westward direction. Doors were difficult to close after the shock. Electricity and phone service disrupted.

Cholame (about 8 miles southeast of).—(VI) Back porch slipped down about 6 inches from rest of house. Few dishes broke. Phone out for about 36 hours.

Cholame (about 3 miles southwest of).—(VI) "The light went out so I couldn't see what was going on. I just sat there in the dark and listened to things crashing down inside the house and trees swishing outside. Texture paint shaken off one wall. No damage to brick chimney."

Cholame (10 miles east of; on U.S. Highway 466).—(VI) Water increased in two springs. "The house seemed to roll from east-west; then at the last very severe shudder the dishes and supplies fell from shelves."

Cholame (10 miles northeast of; on Highway 41).—(VI) Plaster cracked. Water tank swayed. Small objects shifted, overturned, and fell.

Cholame (about 6 miles south of).—(VI) Extensive minor plaster cracks. Power and phones out.

Cholame (12 miles southeast of).—(V) Felt by all. Motion seemed like riding on small waves. No perceptible damage.

Cholame (Bitterwater Road; close to Choice Valley School).—(V) Felt by all. Old crack in cement enlarged.

Cholame (Bitterwater Road).—(V) Small objects overturned; picture fell from shelf. "Six small shocks and one large shock felt on June 27th."

Parkfield and vicinity.—(Press) Water pipes and windows broke at the Parkfield Episcopal Church. Light fixtures broke at the Parkfield School. Floor dropped out of a trailer house. Heavy damage to merchandise at the Parkfield Store. There were numerous reports of minor damage to homes in the rest of the little Cholame Valley, and in Bear Valley which runs just to the west of Parkfield. A 12,000-volt, PG&E power line was torn loose and fell across the phone line serving the forestry station. Fifteen of the 70 telephones in Parkfield were out of service. The forestry service also reported live oak trees were toppled, pulling down wires. The forestry station was slightly damaged by fire touched off by a "hot" wire. It was also reported that several tombstones were overturned in the Parkfield cemeteries (figs. 20–22). At the Parkfield Meeting Hall, a chimney was damaged (figs. 23 and 24), and the west wall was cracked at the fire station (figs. 25 and 26). About five miles south of Parkfield, the X-bracing of a bridge buckled as shown in figures 27–29.

Parkfield (report from Herbert H. Durham; Weather Bureau Observer).—Some landslides. Several large limbs broken off trees. Walls cracked some; plaster cracked, broke, and fell. Furniture shifted. Much glassware breakage. "All my clocks broke."

Parkfield (report from Mrs. John O. Bunch).—Water muddy. Piano shifted 2 feet. Dishes and radio broke.

Parkfield (report from D. M. Garrett).—Water source murky for several days; several water wells showed signs of disturbance. Chimneys fell; windows cracked; plaster cracked, broke, and fell. Furniture shifted, overturned, and broke.

Parkfield (about 1 mile south of; Raymond Miller residence).—Brick chimney fell. Dishes broke; other minor damage.

Parkfield (1 mile south of; Robert H. Durham residence).—Chimneys cracked; plaster cracked; one window cracked. Damage moderate to new log house. Furniture shifted. Much china broken. Tombstones cracked. "For two nights we have had shocks all night long."

Parkfield (2.3 miles south of; Henry Miller place on Parkfield to Cholame Road; report from Henry Miller).—Very violent shock. Ground crack, about 1.3 cm wide, was observed about 30 feet behind the house, running parallel with the house (N.25°W.) and through the swimming pool. Damage to the pool was estimated at about $1,000. Water sloshed from pool. Two water tanks, part of the filter system and about the size of a standard home hot water heater, were shifted about 18 cm in a northeast direction, toward the crack. The tanks are set on a concrete pad about 5 feet south of the crack (fig. 30). Several landslides occurred along a stream behind and to the southeast of the house. Kitchen cabinet doors, facing N.15°E., opened and all dishes fell out, with about 80 percent breakage. No cracked windows or plaster, and no damage to large stone fireplace.

Parkfield (about 5.8 miles south of; Art Wilson residence on Parkfield to Cholame Road).—This house sustained the most damage. A brick chimney fell through the kitchen roof.

Parkfield (1 mile north of; report from Mrs. William Thomason).—Two brick chimneys damaged; windows broke. Heavy upright deepfreeze (full of meat) overturned. Considerable glassware breakage. Electricity disrupted. "The breaking of glass and buckling of walls blotted out any earth noises."

Parkfield (2.8 miles north of).—Old wooden bridge, concrete abutments, with additional steel-supporting framework of I-beams. Roadbed separations indicated longitudinal shaking of possibly several centimeters. Diagonal cracks in south abutment were perhaps due to the earthquake. Longitudinal and lateral movements at wood and steel contacts.

Parkfield (3.3 miles north of).—Roadbed cracks.

Parkfield (4.1 miles north of).—Wooden bridge. Roadbed separations.

Parkfield (abut 4.5 miles north of; Clyde F. Taylor Ranch).—Chimney snapped off at roof line; foundation cracked; water pipes broke; plaster cracked. Much dish breakage. Furniture shifted. Water disturbed.

Parkfield (5 miles north of, on Coalinga Road; report from Zena Varian).—(VI) Ground cracked. Water disturbed. Hanging objects swung violently. Small objects shifted, overturned, and fell; furniture shifted. No plaster or windows cracked; no damage reported.

INTENSITY VI:

Annette (about 10 miles southeast of Cholame, and about 1 mile from San Andreas Fault; Old Annette School).—"I was walking down the hall and was pushed back and forth against the walls." Hanging objects swung violently north-south. Two bottles rolled from shelf.

Annette Lookout.—(V) Water splashed from elevated water tank. Power cut off. No visible damage.

Avenal (about 23 miles northeast of Cholame).—Small objects and furniture shifted. Hanging objects swung violently. Damage slight (no details). No plaster or windows cracked.

Bitterwater Pumping Station (about 18 miles southeast of Cholame).—Small objects shifted. Hanging objects swung violently west-east. Water disturbed. No damage.

Bitterwater Valley (in area to east of Bitterwater Pumping Station).—Exterior hairline house cracks. Two small objects shifted.

Bitterwater Valley (20 miles east of Shandon).—(V) Water disturbed. "Earth noises sounded like rocks grinding together."

Coalinga (about 15 miles from San Andreas fault).—Plaster cracked. Merchandise fell from grocery store shelves. Water in swimming pool disturbed.

Coalinga (about 16 miles west of; Los Gatos Canyon, 36°14′ north, 120°34′ west; Weather Bureau Observer).—(V) "There are some large cracks in our jeep road which we cannot remember seeing before. The soil is dry bog-type."

Creston.—House swayed from side to side. Small objects shifted.

Paso Robles.—Police Department reported they had received no reports of damage in the city. Few cans, bottles, etc., knocked from shelves in some stores. At cafe, few new cracks were observed in plaster ceiling. At fire station (second floor), coarse concrete spalled off along a previous crack near the ceiling along edge of an I-beam. Water sloshed from swimming pool at motel. Police officer reported telephone poles swayed.

Paso Robles (Kiler Canyon).—(V) "We easily observed bushes shake and the wooden arbor shake."

Paso Robles (12 miles northeast of).—Water tower rocked violently; water disturbed. Small objects shifted. Pendulum clock on north-south wall stopped, but clock on east-west wall did not.

FIGURE *14.—Crack between concrete slab front of Cholame Cafe and older wood floor on wood pier section of cafe. (Photo by George Murray)*

FIGURE *15.—Bridge on Highway 466 about 200 feet west of Strong-motion Station No. 2. (Photo by B. J. Morrill)*

FIGURE *16.—Crack in east abutment of bridge shown in figure 15. (Photo by George Murray)*

FIGURE *17.—Crack in concrete pier of bridge shown in figure 15. (Photo by B. J. Morrill)*

FIGURE *18.—Indication of motion at bottom of bridge pier shown in figure 17. (Photo by B. J. Morrill)*

FIGURE *19.—Dead trees knocked down by earthquake, about 1 mile west of Jack Ranch. (Photo by Ed Etheredge)*

San Luis Obispo.—Press reported plaster cracked at the police station.

San Miguel (west side of town, next to freeway).—Few dishes broke. Lamps and stands almost toppled. House has 12-foot ceiling. Walls seemed to twist.

Shafter.—Minor plaster cracks. Lighting fixtures moved rather violently. Small objects shifted, overturned, and fell.

Shandon and vicinity.—Plaster cracked. "Shock at 20:26 was much heavier than the one at 20:09."

Shandon (O. V. Monett home; owner of Cholame Cafe and Grocery).—Cement-block house, slab floor. Little damage. Some cracks enlarged. Few dishes off shelves. Cabinet doors opened. Phone line to restaurant at Cholame was out.

Shandon (Standard Oil Pumping Station on Highway 466, 1½ miles east of Shandon; report from Mrs. O. W. Lund).—Hanging objects swung violently. Forty-pound mirror fell off wall; kitchen cupboard doors popped open and items "flew" out; objects fell from window sills and off tables; pictures fell from walls; pepper shaker on stove turned completely upside down. Attic dust fell on beds from ceiling movement.

Shandon (northeast of; Strong-motion Station No. 5, Cochrum Garage).—No damage. Several cylinders in the garage fell northeast; tank in the garage shifted northeast. Tall cylinders in an outside shed (raised off the ground on skids and alined approximately parallel to the fault) fell to the southwest (fig. 31). Many tires were thrown southeast out of an overhead rack in the garage. Ground contact to the concrete slab floor of the garage was generally broken. Two soda-water fire extinguishers hanging on wall were set off, but did not fall. Steel-frame building.

Shandon (about midway between Shandon and Cholame; Strong-motion Station No. 6, Shandon Pumping Station).—Slight shifting of storage tank ladders on back fill. Evidence of shaking at base of small water tank (about 1,000 bbl) on a low mound as shown in figures 32 and 33.

Shandon (northeast of; Strong-motion Station No. 8, Shandon Pumping Station).—Only damage was shifting of one of the eight boilers (fig. 34). The two southwest boilers were filled with water; the end boiler shifted southwest, probably ½ cm, forcing out caulking around the southwest boiler front. Water in each boiler was roughly estimated to be 350 bbl or about 11,000 gal. Mr. D. R. Imhoof reported one window broke and one cracked on south side of his wood-frame house. A mirror, 24 by 30 inches, on dressing table fell to floor without disturbing small perfume bottles on dressing table.

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Shandon (southwest of; Strong-motion Station No. 12; report from Wilbur Thompson).—Strong rolling motion. Kitchen cabinet doors opened and a few items spilled onto floor. No other damage reported. No damage to irrigation pipes.

Slack Canyon (about 12 miles north by west of Parkfield; report from James B. Harrison).—Ground cracks, landslides, water disturbances. Nothing shifted, overturned, or fell; no damage.

Valleton (Indian Valley; report from Mrs. John Curtis).—Damage slight. Cracks around windows and in west walls of cinderblock house. Furniture shifted; small objects fell. Knocked needle off chart of Weather Bureau rain gage and bent the arm.

Walti Ranch (about 10 miles northwest of Parkfield).—Very little damage (no details; no windows or plaster cracked). Hanging objects swung violently. Small objects shifted.

Work Ranch (about 8 miles northwest of Shandon; Hog Canyon Road, near Ellis School).—Adobe house. Damage moderate in east portion; severe in west wing. Plaster cracked, broke, and fell. Furniture shifted slightly. Small objects shifted, overturned, and fell.

INTENSITY V:

Adelaida area (west of Paso Robles), Alpaugh, Arroyo Grande, Atascadero, Avila Beach, Bakersfield (one observer reported plaster cracked around bathtub, but other reports indicated only moderate intensity), Baywood Park, Bryson, Burrel, Buttonwillow and 1 mile west of, Earlimart, Fellows, Frazier Park and Cuddy Valley area west of Frazier Park, Greenfield, Harmony, Indian Valley (20 miles north of San Miguel), Kettleman City, King City, La Panza, Lost Hills, Maricopa, Mee Ranch (corner Highway 198 and Highway 25), Morro Bay, Moss Landing, Musick (about 15 miles southeast of San Luis Obispo), Nipomo, Oceano, Panoche (report indicated the shock was only moderately felt, but observer stated one irrigation pipe was broken), Pine Canyon (lower Burns Road), Pozo Guard Station (about 10 miles west of La Panza), Priest Valley (report indicated the shock was moderately felt; however, on August 7, observer reported: "We believe the June 27–28 earthquakes made us loose our well. One of the streams has disappeared."), San Ardo, San Joaquin, San Lucas, San Simeon, Simmler (about 12 miles southeast of La Panza, Carrisa Plains), Stratford, Templeton, and Vandenberg Air Force Base.

MODIFIED MERCALLI INTENSITY SCALE OF 1931

All intensities used by the Coast and Geodetic Survey refer to the Modified Mercalli Intensity Scale of 1931 (Wood and Neumann, 1931). The abridged version of this scale is given here with equivalent intensities according to the Rossi-Forel scale.

(ABRIDGED)

I. Not felt except by a very few under specially favorable circumstances. (I Rossi-Forel scale.)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel scale.)

III. Felt quite noticeably indoors, especially on upper floors of building, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel scale.)

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale.)

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage **slight.** (VI to VII Rossi-Forel scale.)

VII. Everybody runs outdoors. Damage **negligible** in buildings of good design and construction; **slight** to **moderate** in well-built ordinary structures; **considerable** in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel scale.)

VIII. Damage **slight** in specially designed structures; **considerable** in ordinary substantial buildings with partial collapse; **great** in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX− Rossi-Forel scale.)

IX. Damage **considerable** in specially designed structures; well-designed frame structures thrown out of plumb; **great,** in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale.)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel scale.)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

FIGURE *20.—Tombstone at Parkfield, Todd Cemetery. Direction of fall, northwest. (Photo by Frank McClure)*

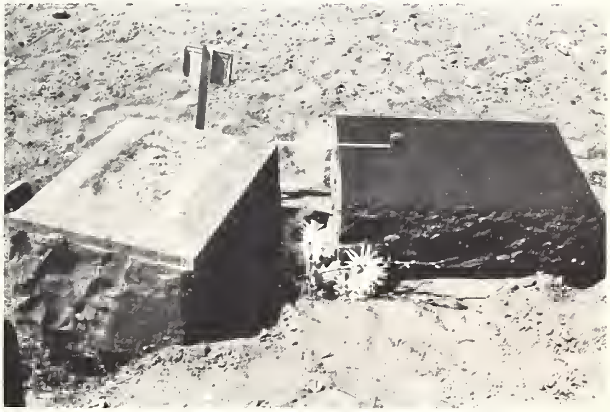

FIGURE *21.—Same as figure 20.*

FIGURE *22.—Same as figure 20.*

FIGURE 23.—*Parkfield Meeting Hall. (Photo by Frank McClure)*

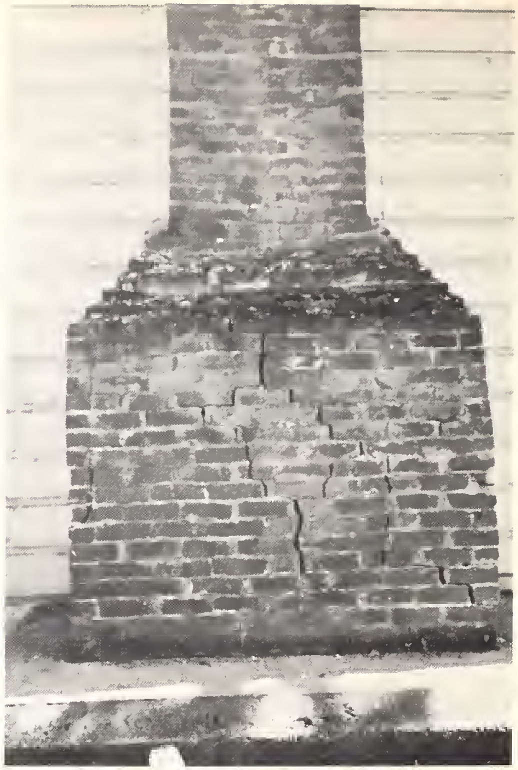

FIGURE 24.—*Close-up of chimney damage shown in figure 23.*

FIGURE 25.—*Parkfield Fire Station. (Photo by George Murray)*

FIGURE *26.—Interior view of cracked west wall of Parkfield Fire Station. (Photo by George Murray)*

FIGURE *27.—Bridge about 5 miles south of Parkfield. Orientation N.3°E. (Photo by Frank McClure)*

FIGURE *28.—Buckled X-bracing of bridge shown in figure 27. (Photo by Frank McClure)*

FIGURE *29.—Same as figure 28.*

FIGURE 30.—*Cracked swimming pool about 2.3 miles south of Parkfield. Adjacent home was undamaged. (Photo by Frank McClure)*

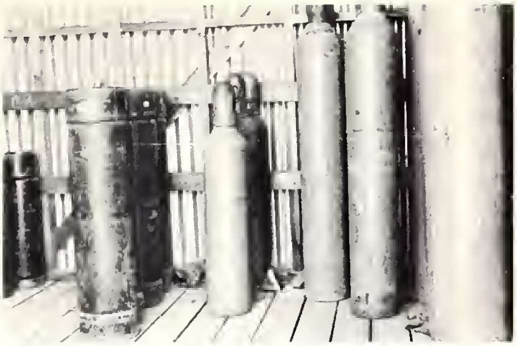

FIGURE 31.—*Acetylene and oxygen cylinders in Cochrum Garage storage shed reported to have been knocked over by carthquake. (Photo by George Murray)*

FIGURE 32.—*Union Oil Co., Shandon Pumping Station. Strong-motion Station No. 6 is adjacent to pumping station. Note undamaged stack at right side of photo. (Photo by George Murray)*

FIGURE 33.—*Indication of earthquake-caused motion at base of tank in foreground of figure 32. (Photo by George Murray)*

FIGURE 34.—*Standard Pipeline Co., Shandon Pumping Station. Only damage reported was slight shifting toward southwest of one of the eight boilers. Note tall stack, at center of photo, that is still intact. Strong-motion Station No. 8 is adjacent to the pumping station. (Photo by George Murray)*

AREA OF MAJOR INTEREST

The area of major interest from an engineering viewpoint was roughly from Parkfield to Cholame (fig. 35) and in the vicinity of the strong-motion instrument array (fig. 36). Effects of the main shock within this area were described in the preceding section under intensity VII. Additional details on the relatively moderate damage in the area are shown by the photographs (figs. 9–34).

ARRAY INSTRUMENTATION

The 16 strong-motion recording stations, located relative to the fault as shown in figures 35 and 36, were instrumented with Coast and Geodetic Survey seismoscopes (Cloud and Hudson, 1961). In addition, for control, Stations 12, 8, 5, 2, and Temblor were instrumented with Model AR-240 accelerographs (Halverson, 1964).

Each accelerograph in the array, after being triggered into operation by the main shock through a pendulum starter switch, recorded the relative motion of three, mutually perpendicular pendulums (vertical, longitudinal, and transverse) against time. Period and damping of the pendulum were such that recorded amplitudes could be assumed reasonable approximations of ground acceleration in the period range $t_e > t_0$. Shaking table tests of a single production model pendulum made prior to the earthquake indicate the probable degree of approximation to be expected (see table 7).

Each seismoscope in the array consisted of a magnetically damped, unifilar suspended, free, conical pendulum which could move in any horizontal direction, angular deflection being recorded by a scriber on a smoked spherical watch glass. The purpose of the seismoscopes was to measure one point on the 10 percent-damped velocity response spectrum and to provide information on the sequence of motion during the shock. Complete spectra (not included in this report) result from analysis of accelerograph records.

Pictures of an AR-240 accelerograph and a seismoscope appear in a later section of this report (figs. 37 and 45).

INSTRUMENTAL RESULTS

The five AR–240 accelerographs in the array, of the type shown in figure 37, recorded the accelerograms shown in figures 38–41. Since the figures are precision photocopies of the original records they are suitable for analysis, provided the ratio of the measured diameter of the circle that appears on each record to 5 cm is used as a scale factor for adjusting sensitivity.

To supplement the records, some of the more noticeable accelerations and the roughly estimated ground periods at which they occurred are given in table 6. To further supplement the records, resultant horizontal acceleration trajectories are shown in figures 42, 43, and 44.

The fifteen C&GS seismoscopes in the array, plus the one at the Avenal Gap Station, all of the type shown in figure 45, produced the records shown in figures 46–61. Each figure is a precision photocopy of the original 6.35-cm-diameter smoked watch glass record, and thus suitable for analysis.

The maximum response of each seismoscope, scaled from what was judged by eye to be the neutral or rest point of the scriber needle on the record, is given in table 8.

SUMMARY

The relatively shallow-focus, small-magnitude (5.3–5.8) main shock of the Parkfield-Cholame earthquake series produced new and provocative engineering seismological data that will require

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time, analysis, and thought to fully explain.

First, there was surface evidence of faulting for approximately 20 miles along the San Andreas fault zone, with rupture approximately proceeding southeasterly from the epicentral region. Second, maximum, short-duration, transient accelerations at several array stations were the highest ever recorded, the extreme maximum being 0.5 gravity. (The highest acceleration previously recorded was 0.3 gravity during the El Centro, California, earthquake of May 18, 1940.) Third, the recorded high acceleration caused only relatively minor damage to existing structures in the area. Fourth, the maximum response of seismoscopes near the fault was at approximately right angles to the strike of the fault.

CONCLUSIONS

Since strong motions at and adjacent to faulting have never before been instrumentally measured, there is no way of actually knowing if data recorded during the main shock of the Parkfield-Cholame series are unusual or commonplace. However, the explosionlike high accelerations, the directions of seismoscope maximum response, and the direction of tombstone fall suggest very local phenomena, such as progressive rupture along the fault, as the cause. If this is true, then high transient accelerations might be expected near any point where faulting reaches the surface regardless of earthquake magnitude. Damage potential of the high accelerations would depend on duration, and on period and damping of existing structures.

ACKNOWLEDGMENTS

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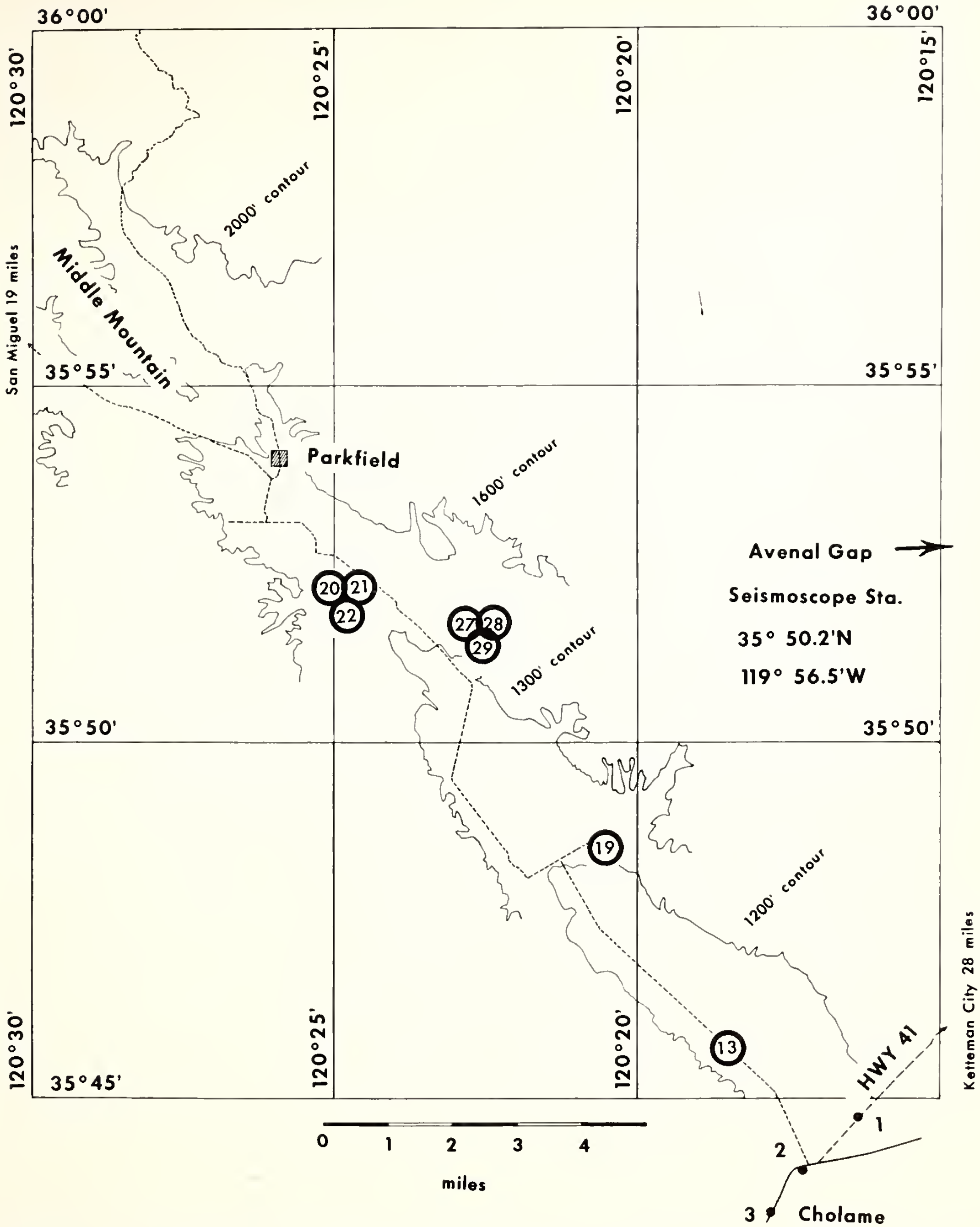

FIGURE 35.—*Parkfield-Cholame section of epicentral region. Locations where photographs were taken south of Parkfield are noted by circled figure numbers.*

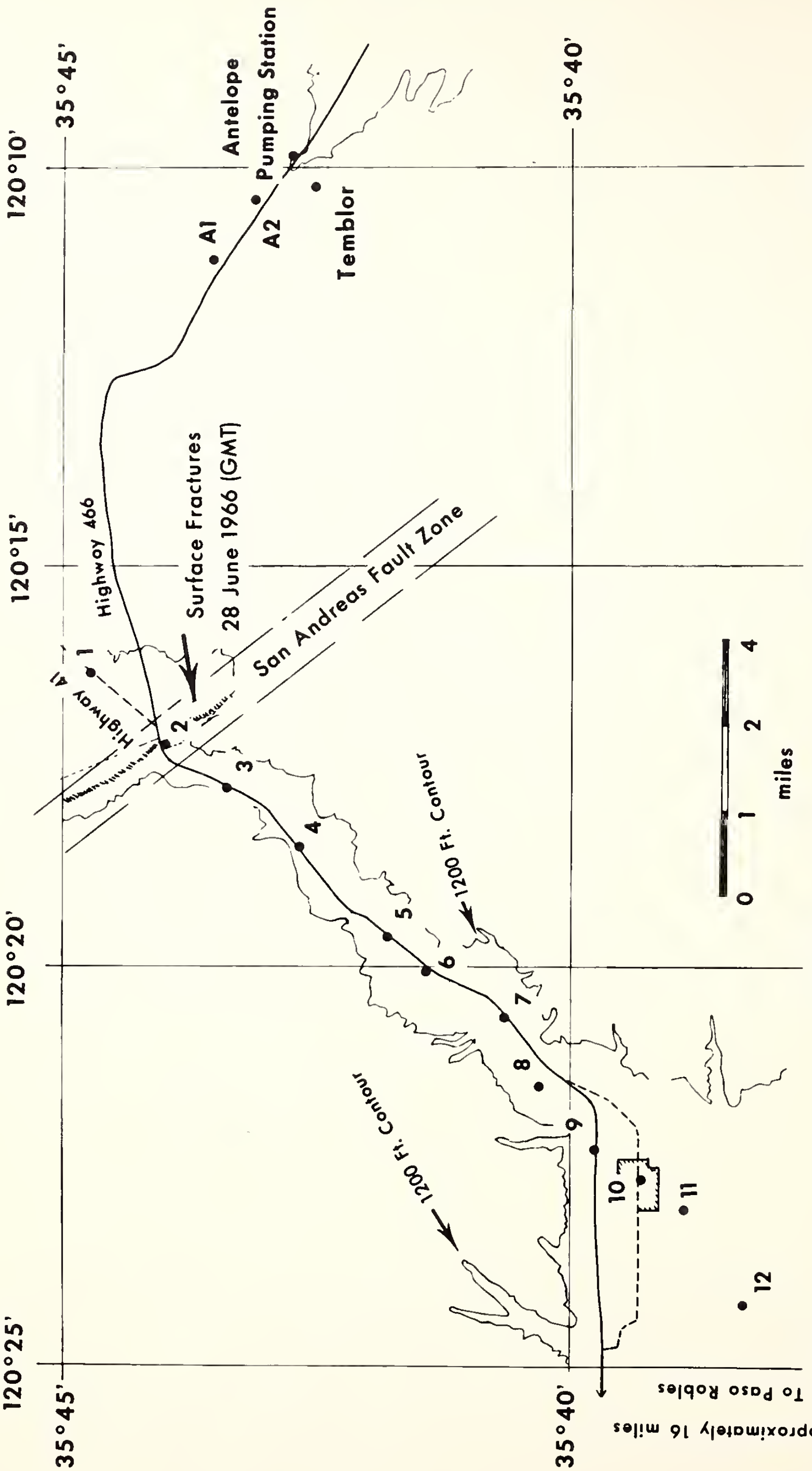

FIGURE 36.—*Location of the Cholame-Shandon strong-motion instrument array.*

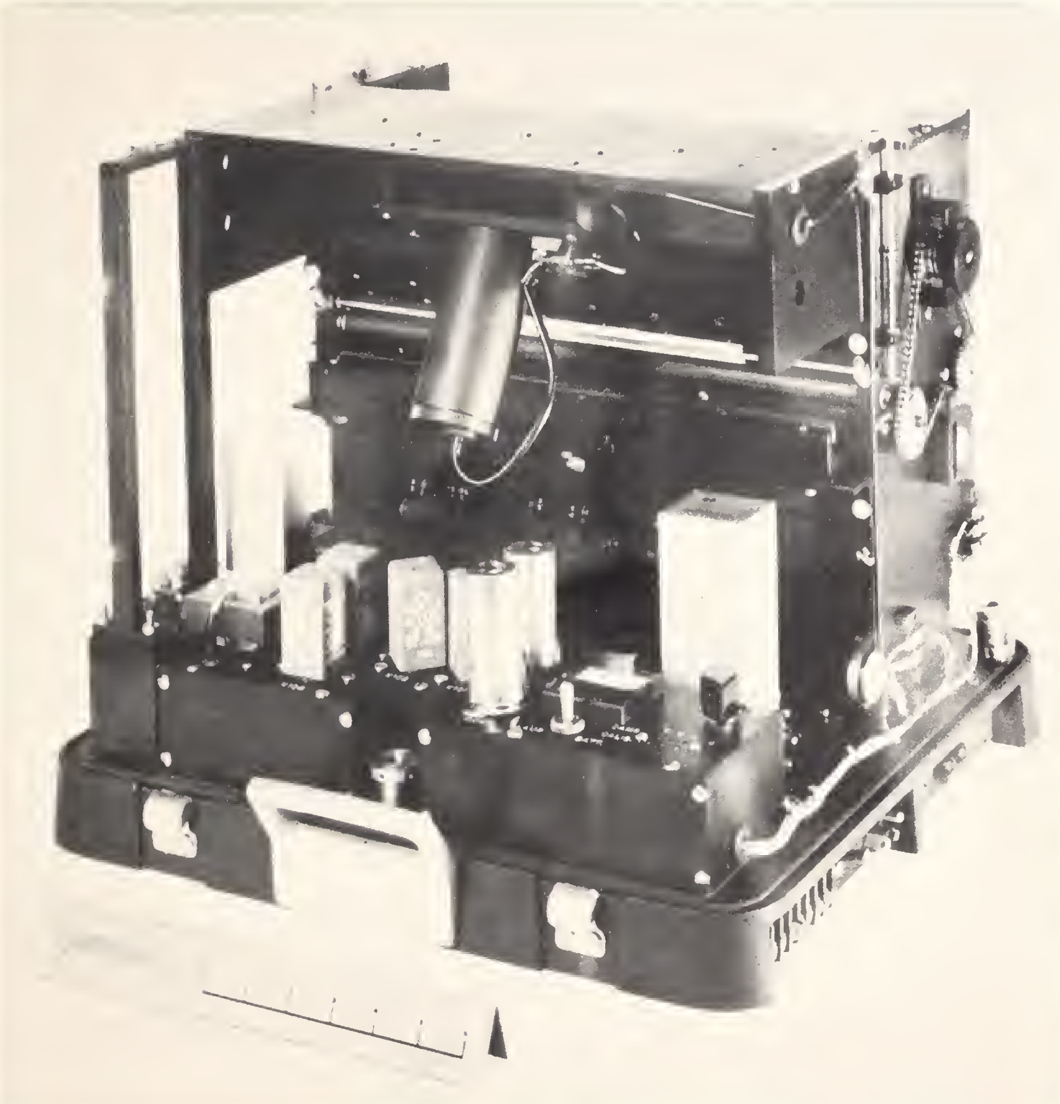

FIGURE 37.—*AR–240 strong-motion accelerograph.*

TABLE 6.—*Accelerations recorded by AR-240 accelerographs*

(See notes at end of table)

Component		Component		Component	
Accelerograph (*g*)	Period (*sec*)	Accelerograph (*g*)	Period (*sec*)	Accelerograph (*g*)	Period (*sec*)
Station 12–9.3 miles; 1,120 feet, elevation; alluvium					
N50°E		*Down*		*N40°W*	
0.06	0.3	0.05	0.1	0.03	0.3
.05	.1	.01	1.3	.06	.2
.01	1.3	.01	2.5	.03	.1
				.02	1.8
Station 8–5.9 miles; 1,060 feet, elevation; alluvium					
N50°E		*Down*		*N40°W*	
0.07	0.4	0.14	0.1	0.11	0.2
.27	.1	.03	1.0	.17	.3
.13	.2			.28	.2
.09	.5			.05	.6
Station 5–3.4 miles; 1,100 feet, elevation; alluvium					
N85°E		*Down*		*N5°W*	
0.18	0.2	0.18	0.1	0.10	0.1
.46	.3	.01	.8	.17	.5
.08	.8			.40	.3
.03	1.3			.02	.9
Station 2–0.05 mile; 1,140 feet, elevation; alluvium					
N65°E		*Down*		*N25°W*	
0.10	0.1	0.35	0.1	Not in operating condition at time of earthquake.	
.11	1.0	.09	.8		
.50	.6	.02	1.4		
.44	.4				
.45	.8				
Station Temblor–6.7 miles; 1,480 feet, elevation; rock					
N65°W		*Down*		*S25°W*	
0.29	0.3	0.16	0.2	0.40	0.2
.12	.2	.04	.3	.15	.4
.03	.6	.09	.1	.24	.5

NOTES: Component direction given is pendulum motion for trace up on the record. Distance given is from station to crack across Highway 466 near Strong-motion Station 2. Period given is merely a crude timeguide based on half-cycle estimates. Photocopy of Station 12 accelerogram was not available in time to be included in this report, but may be obtained upon request to the Coast and Geodetic Survey.

TABLE 7.—*Comparison of shaking table accelerations recorded by an AR-240 accelerometer and a Statham accelerometer*

Statham accelerometer [1] (*Fraction of gravity*)	AR-240 accelerometer [2] (*Fraction of gravity*)	Shaking table period (*sec*)
0.157	0.161	0.515
.655	.645	.350
.445	.457	.270
.562	.550	.220
.515	.500	.183
.632	.632	.158
.925	.890	.133
1.29	1.25	.117
.511	.518	.100
.410	.438	.088
.374	.390	.078
.340	.352	.073
.328	.344	.067
.318	.312	.059
.292	.274	.054
.281	.250	.050

[1] Statham Model A45-2-350, ±2g–natural period 0.01 sec.
[2] AR-240 accelerometer #333–natural period 0.051 sec.

TABLE 8.—*Maximum velocity response of seismoscopes relative to the ground during main shock of Parkfield earthquake series*

Station	T Period (*sec*)	h [1] Damping (*percent critical*)	S Sensitivity (*in/radian*)	A Max. trace amplitude (*inches*)	R=A/S (*radius*)	S_v [2] Velocity response (*ft/sec*)	Distance [3] (*miles*)
12	0.78	20	2.39	0.08	0.033	0.186	9.3
11	.78	18	2.36	.12	.055	.295	8.0
10	.78	10	2.29	.19	.083	.332	7.5
9	.77	7.5	2.18	.36	.165	.564	6.8
8	.78	11	2.32	.28	.121	.507	5.9
7	.78	9.5	2.46	.39	.159	.616	5.0
6	.78	10	2.50	.34	.136	.544	4.0
5	.78	9	2.36	.48	.203	.770	3.4
4	.78	10	2.29	.51	.227	.907	2.0
3	.78	9	2.44	.92	.377	1.278	.9
2	.78	8.5	2.32	>1.4	>.603	>2.2	.05
1	.78	9	2.52	>1.4	>.556	>2.1	1.2
A1	.75	9	2.17	.41	.189	.727	5.6
A2	.75	10	2.17	.29	.134	.515	6.5
Antelope	.75	10	2.17	.38	.175	.638	7.1
Avenal Gap	.78	10	2.44	.17	.070	.319	19.4

[1] From damping curve for trace amplitude "A".
[2] $S_v = \frac{RgT}{2\pi}\sqrt{\frac{h}{10}}$
[3] Distance from station to crack across Highway 466 near Strong-motion Station 2.

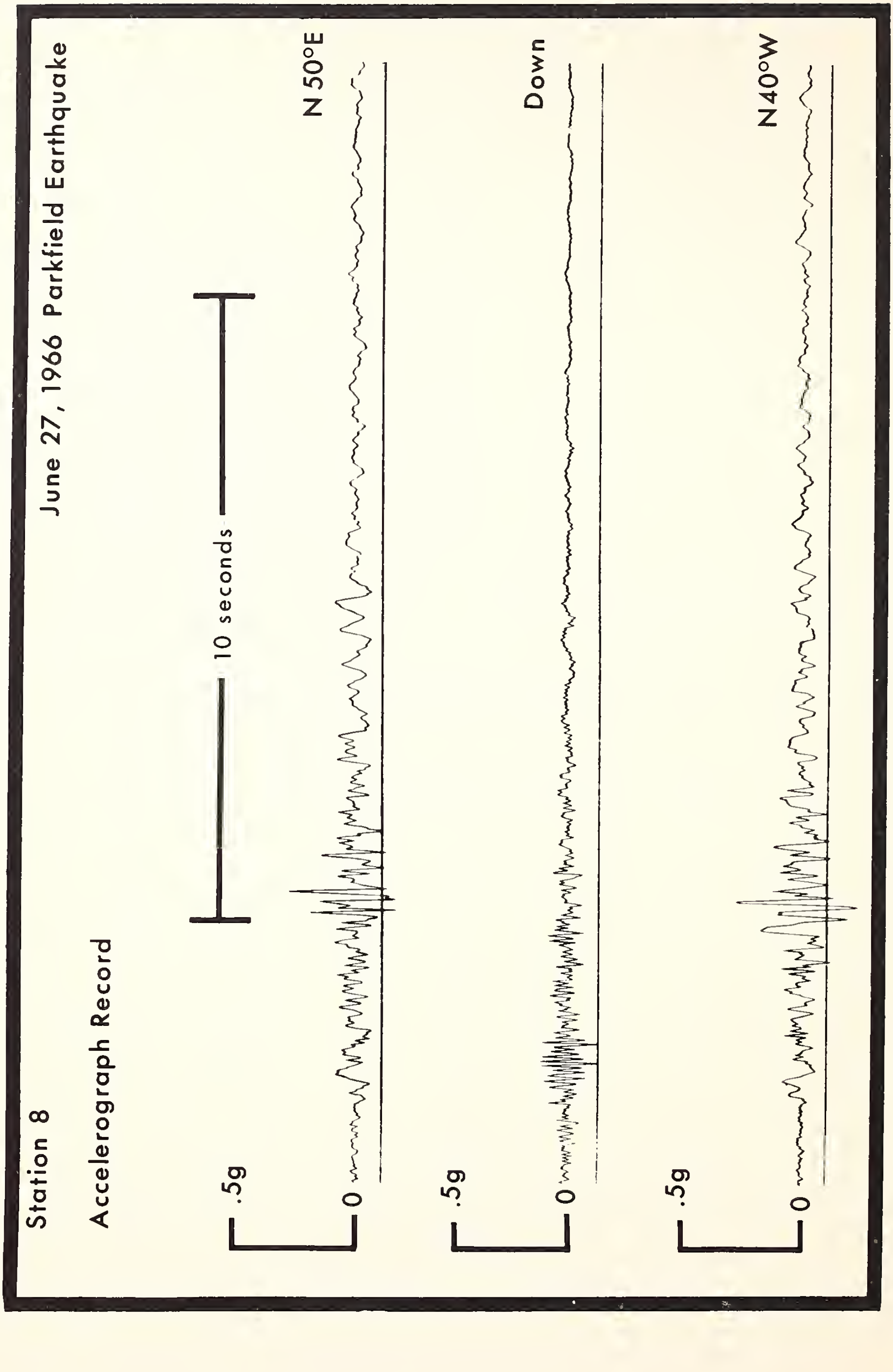

FIGURE 38.—*Photocopy of Station 8 accelerogram.*

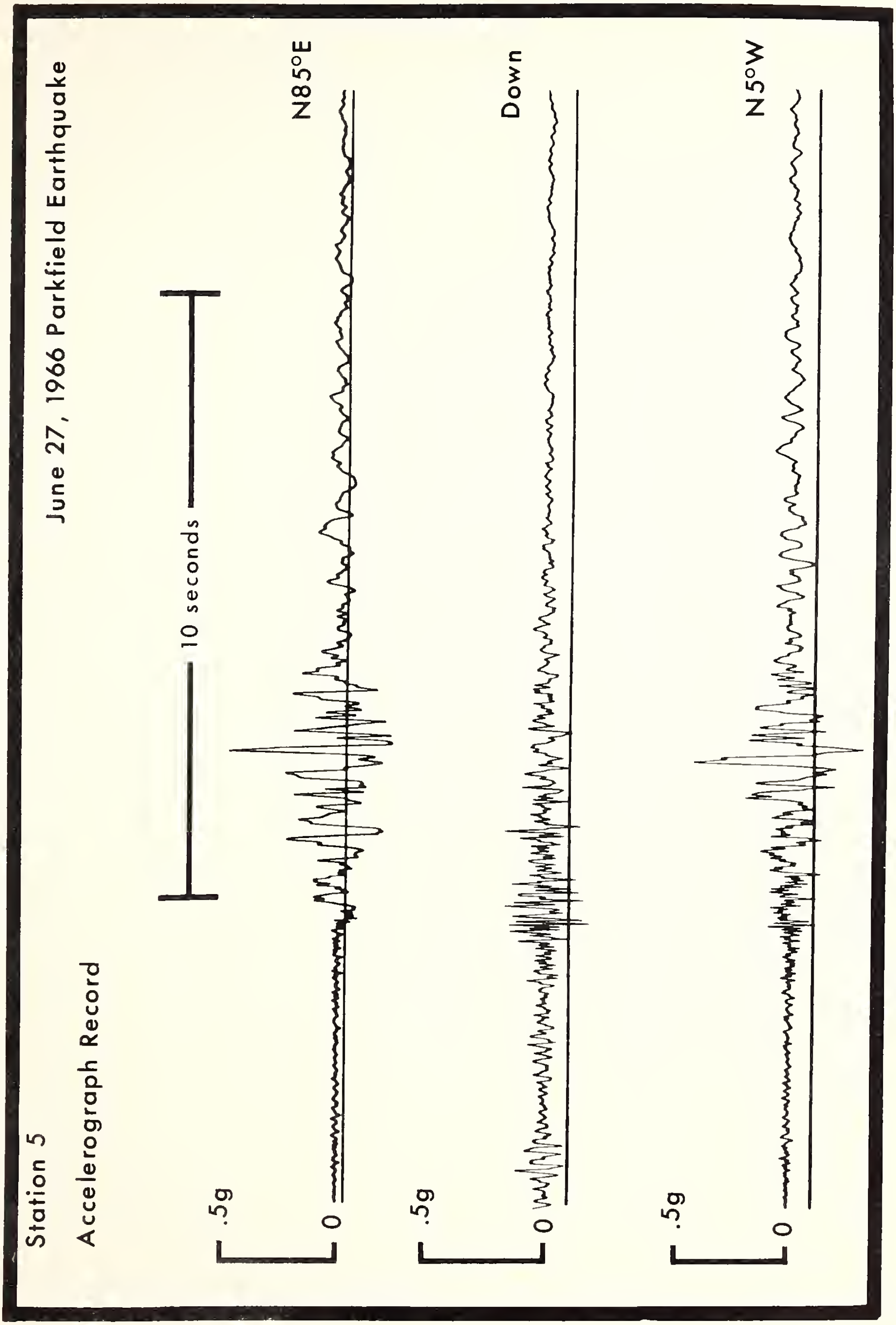

FIGURE 39.—*Photocopy of Station 5 accelerogram.*

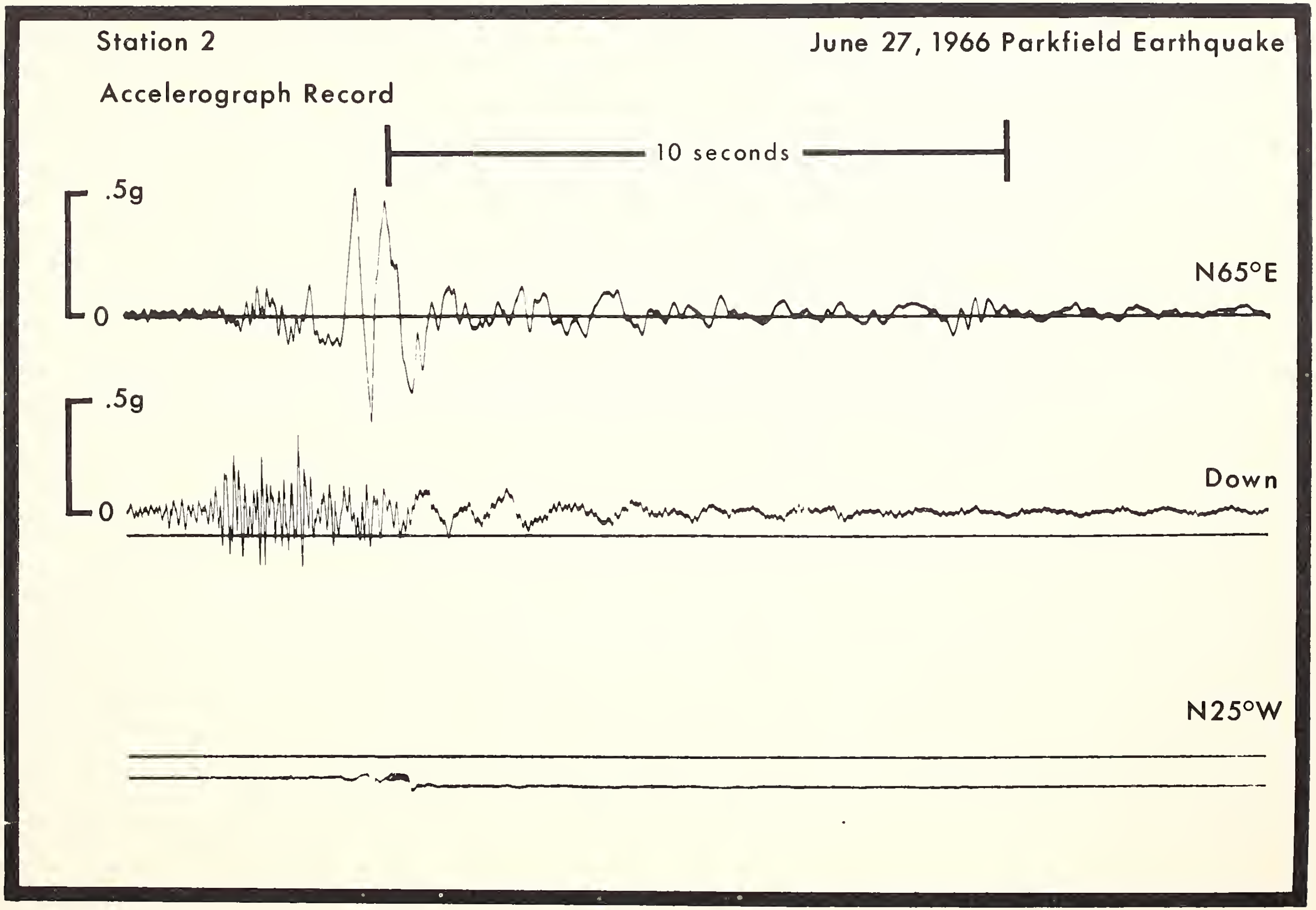

FIGURE *40.—Photocopy of Station 2 accelerogram. Pendulum recording lower N.25°W. Trace was not in operating condition during the earthquake.*

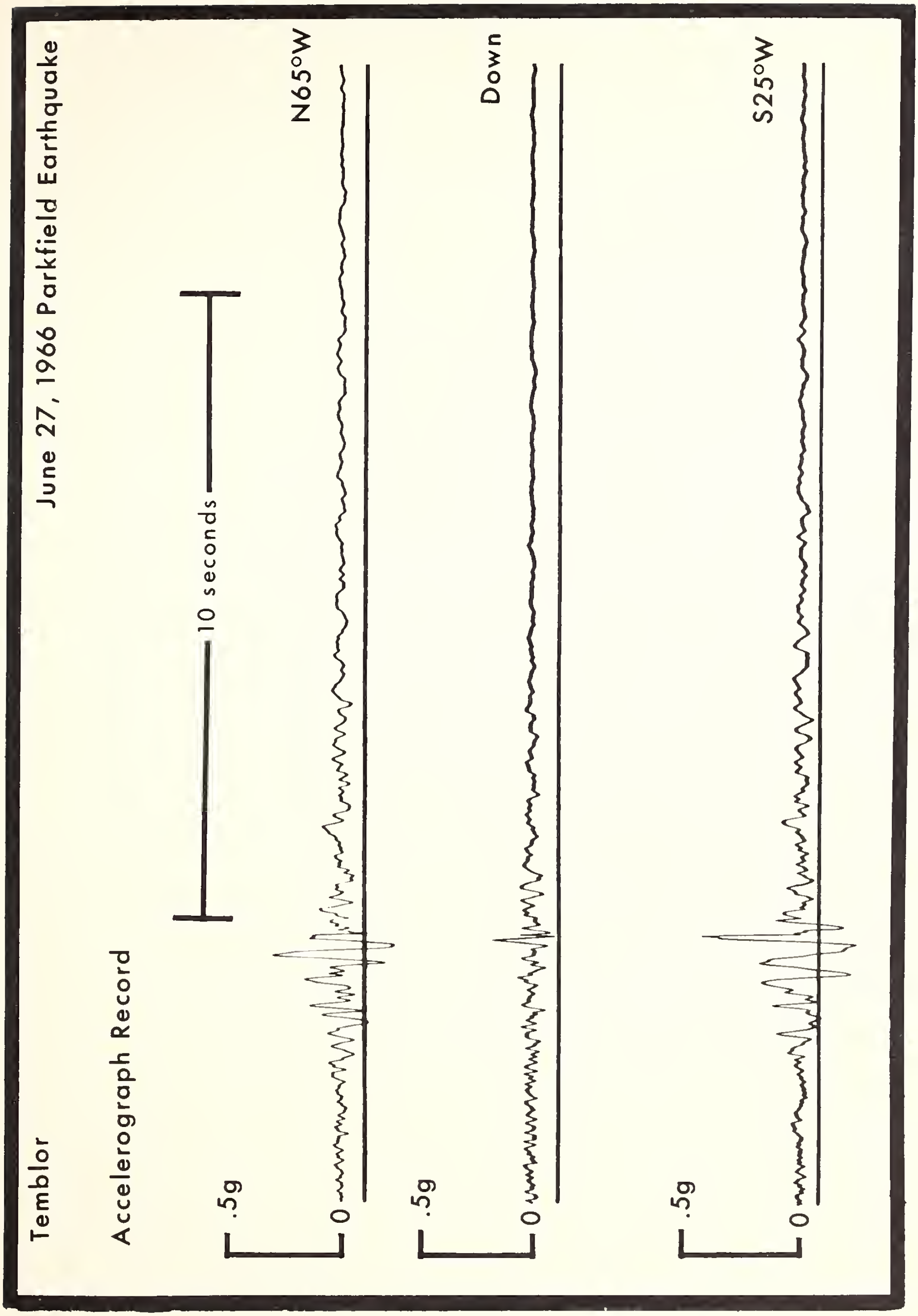

FIGURE 41.—*Photocopy of Station Temblor accelerogram.*

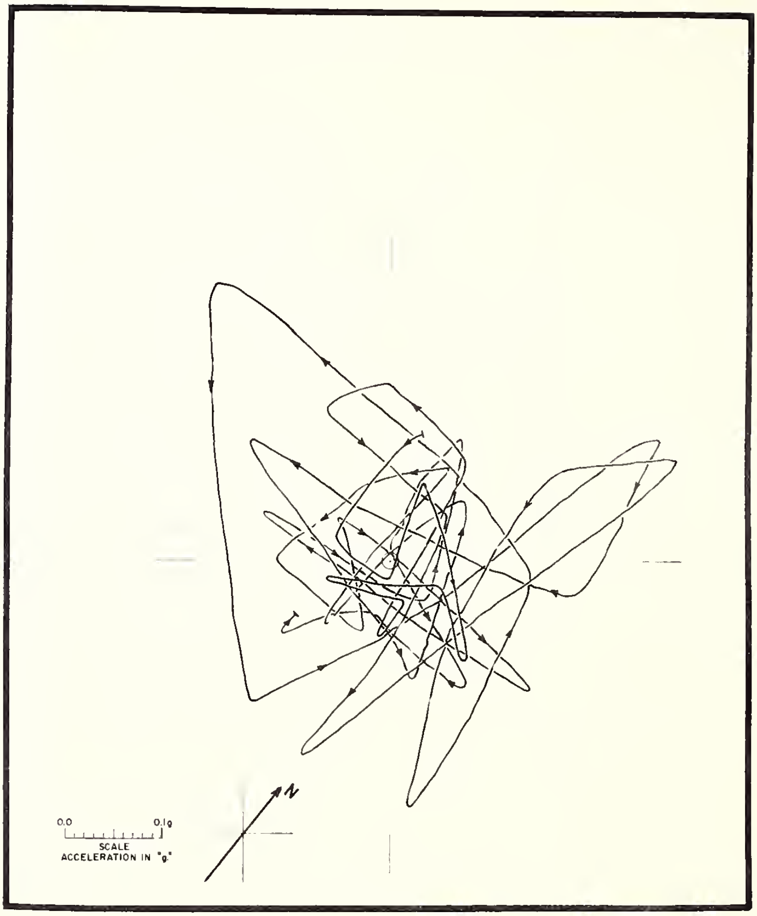

Figure 42.—*Station 8. Resultant horizontal accelerations from 3.5 to 5.5 seconds after start of record.*

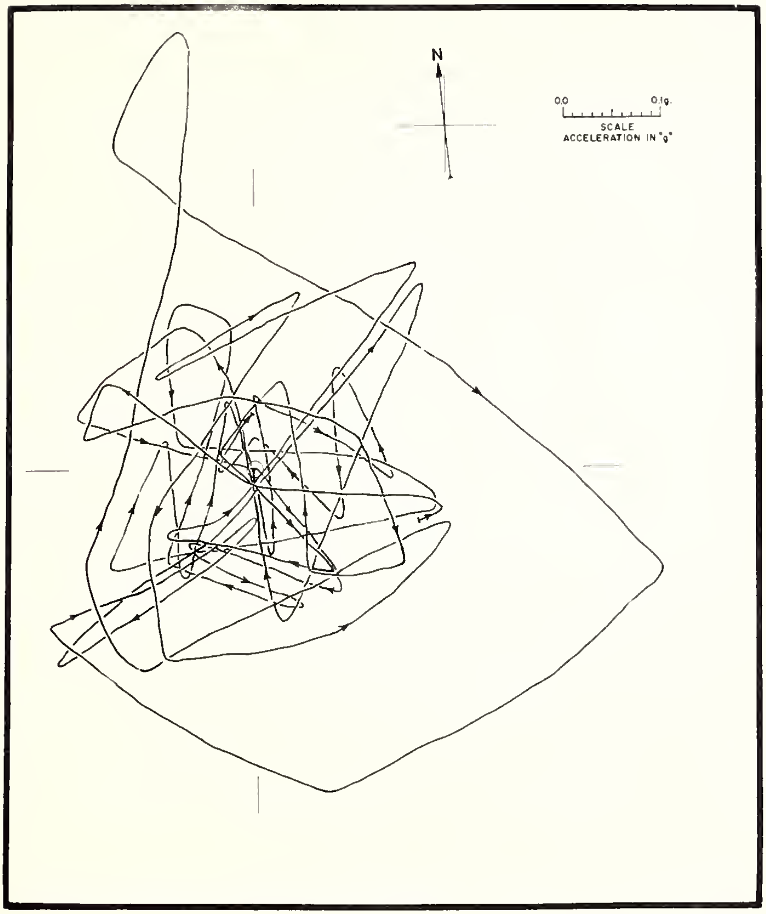

FIGURE *43.—Station 5. Resultant horizontal accelerations from 6.0 to 9.0 seconds after start of record.*

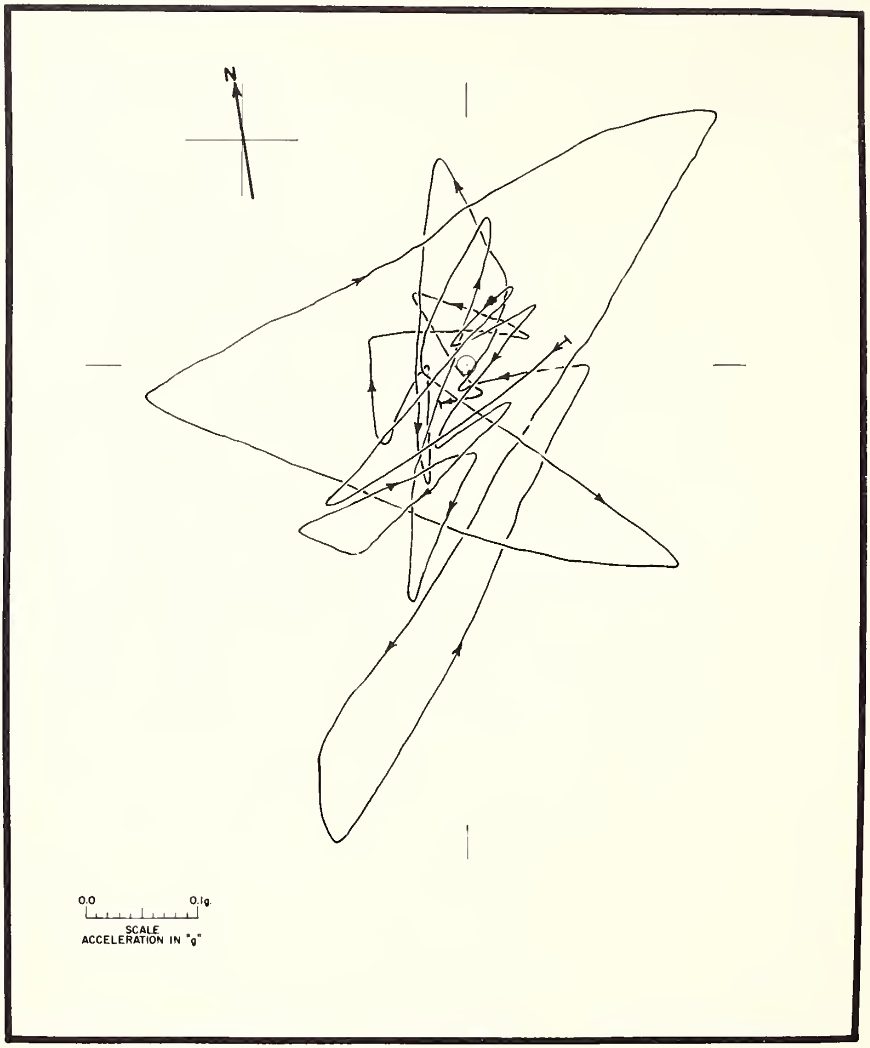

FIGURE 44.—*Temblor Station. Resultant horizontal accelerations from 3.0 to 5.0 seconds after start of record.*

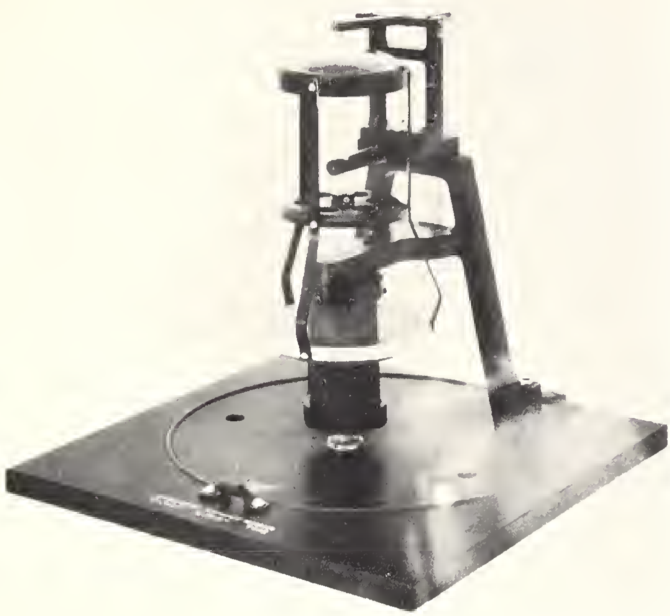

FIGURE 45.—*Coast and Geodetic Survey seismoscope.*

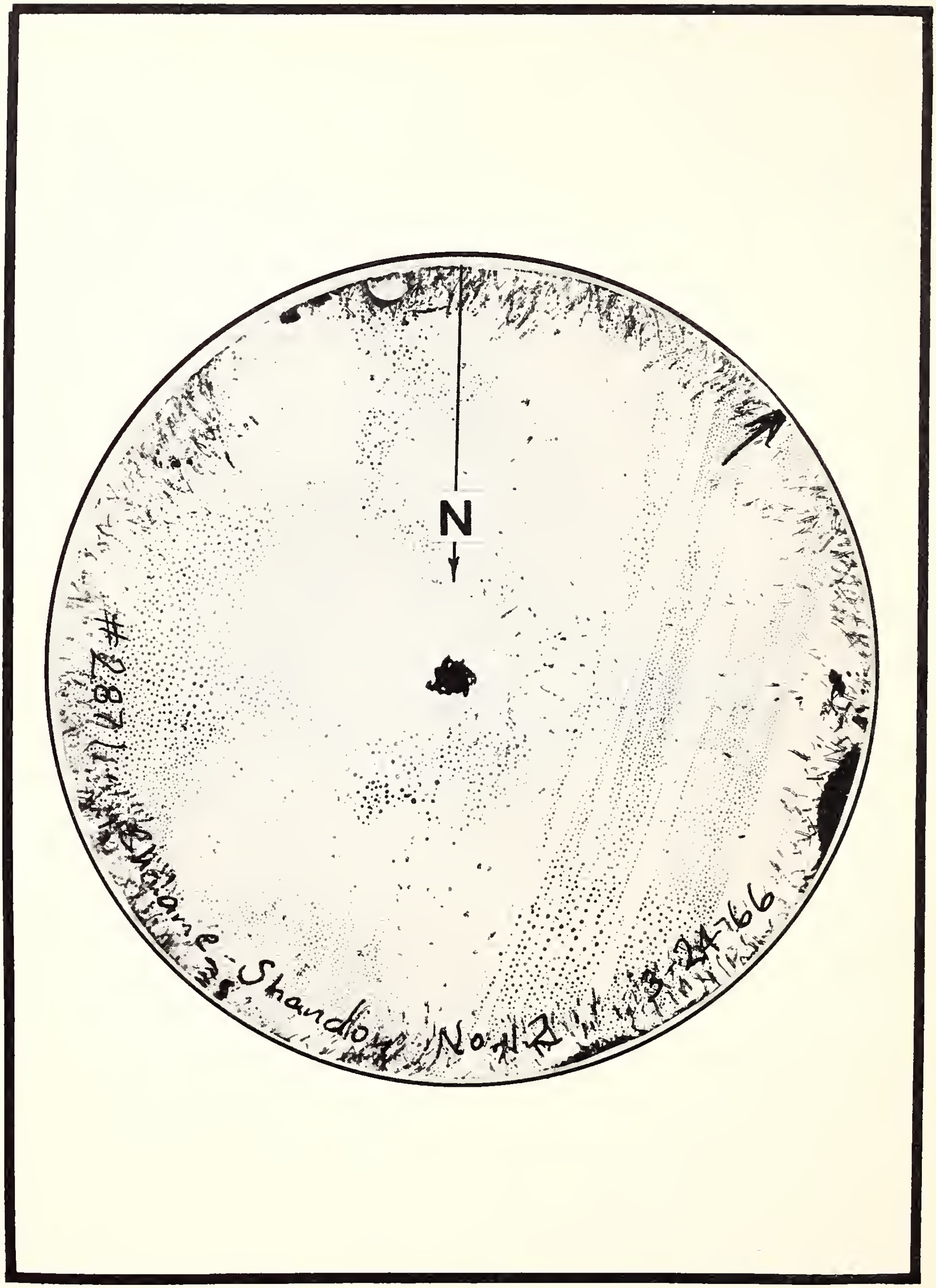

FIGURE 46.—*Seismoscope record - Station 12.*

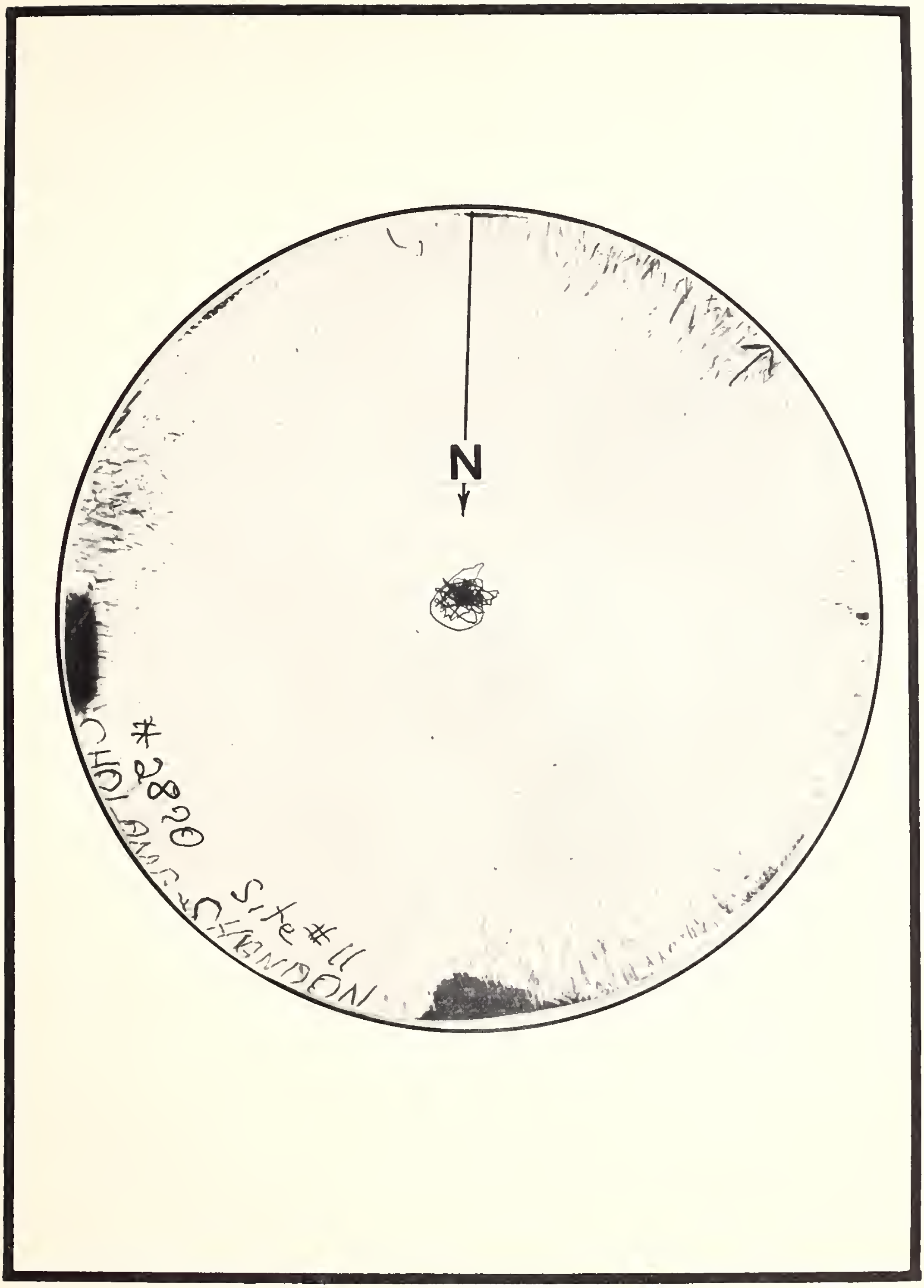

FIGURE *47.—Seismoscope record - Station 11.*

FIGURE 48.—*Seismoscope record - Station 10.*

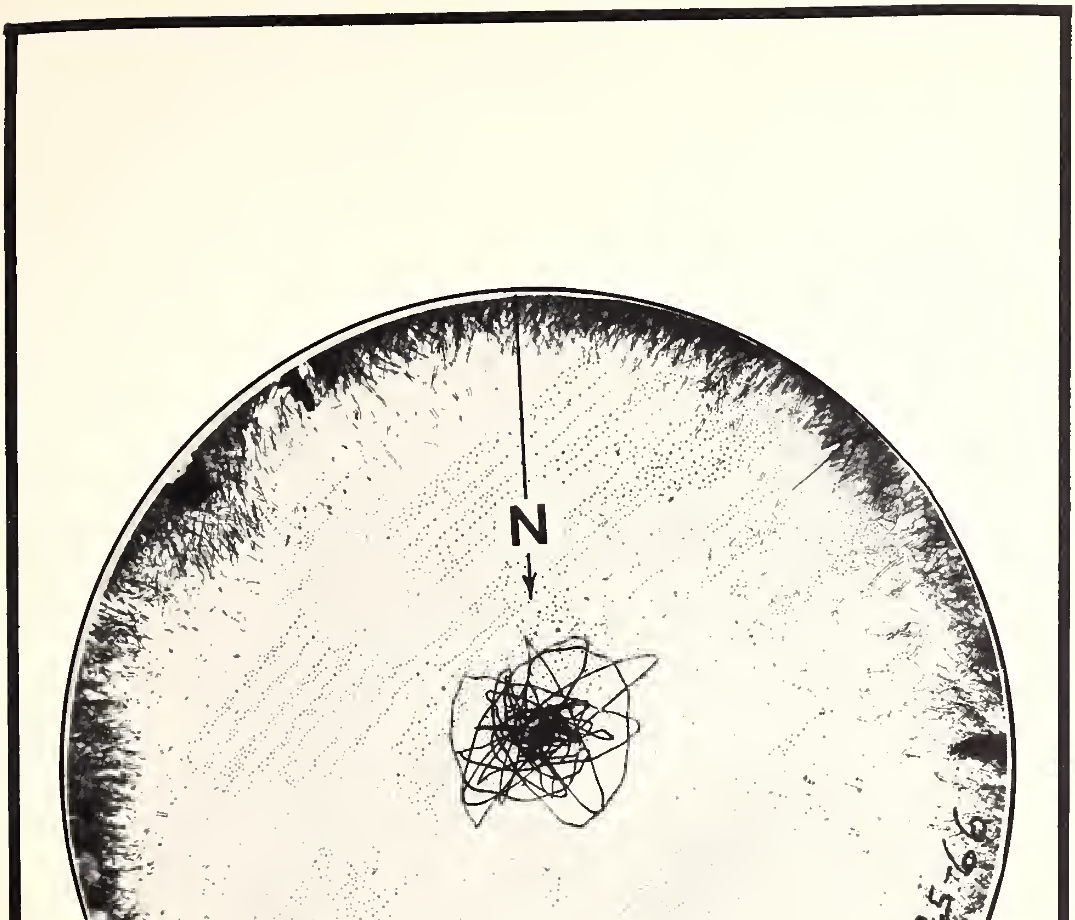

FIGURE 49.—*Seismoscope record - Station 9*

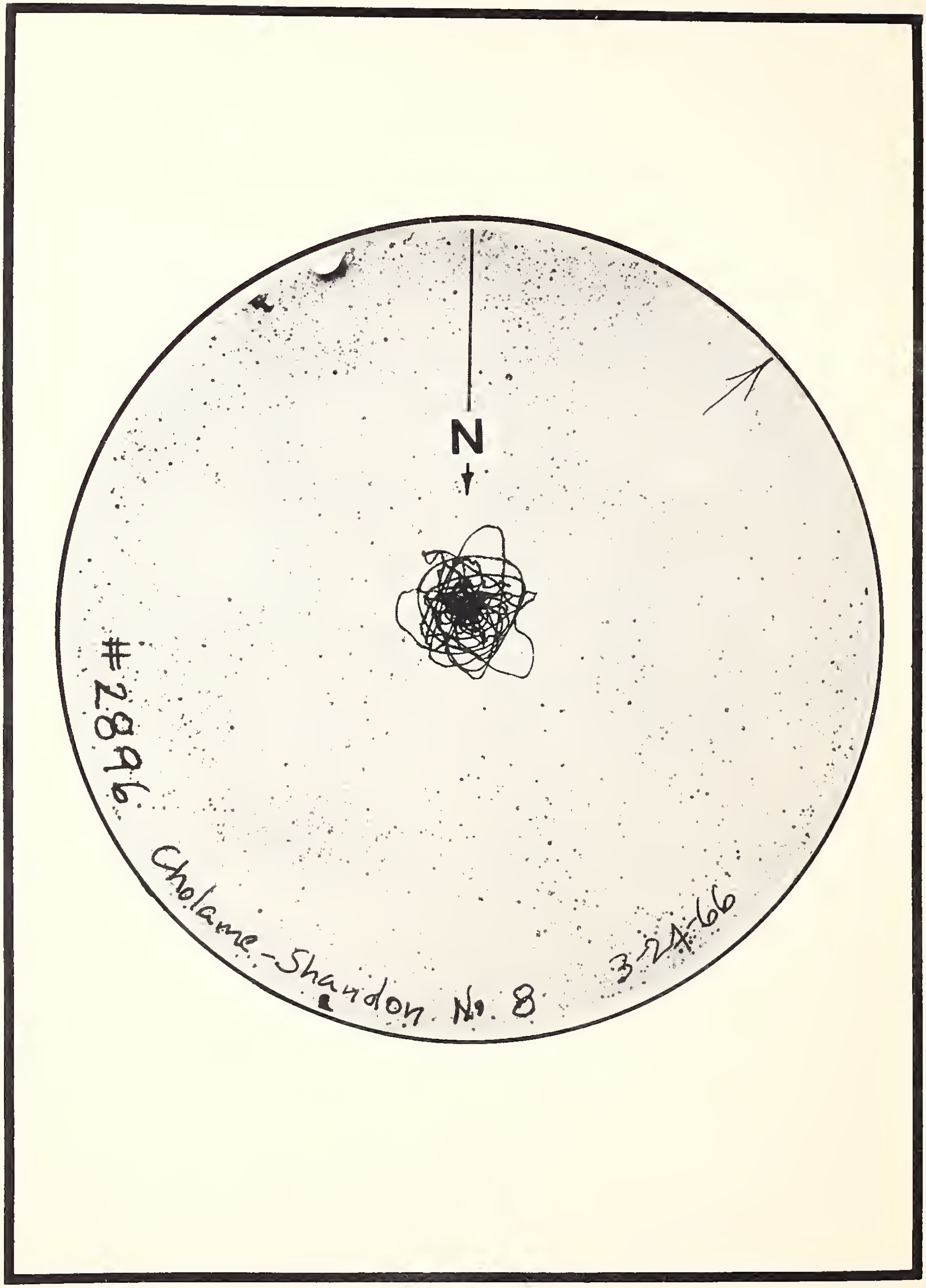

FIGURE 50.—*Seismoscope record - Station 8.*

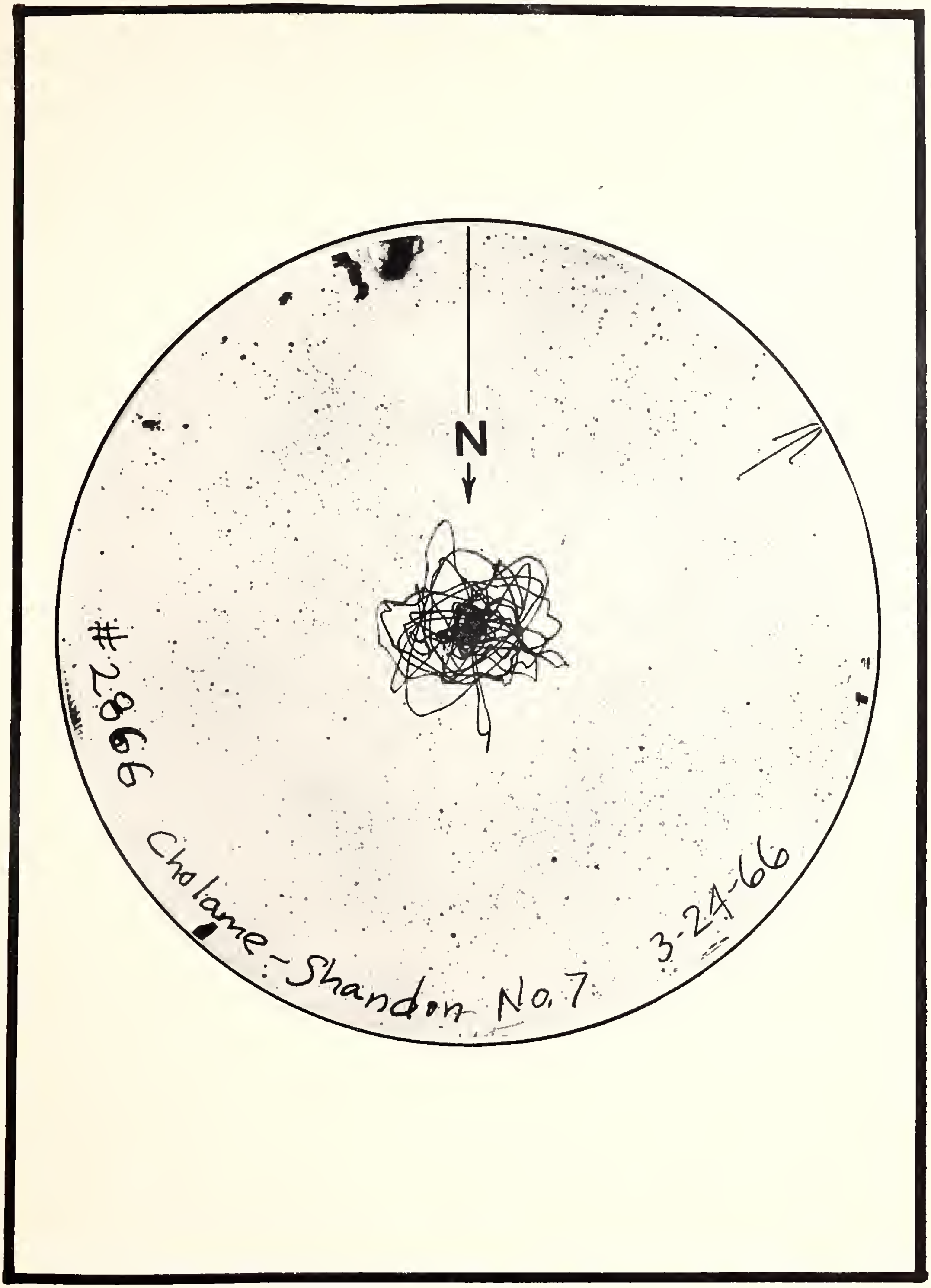

FIGURE 51.—*Seismoscope record - Station 7.*

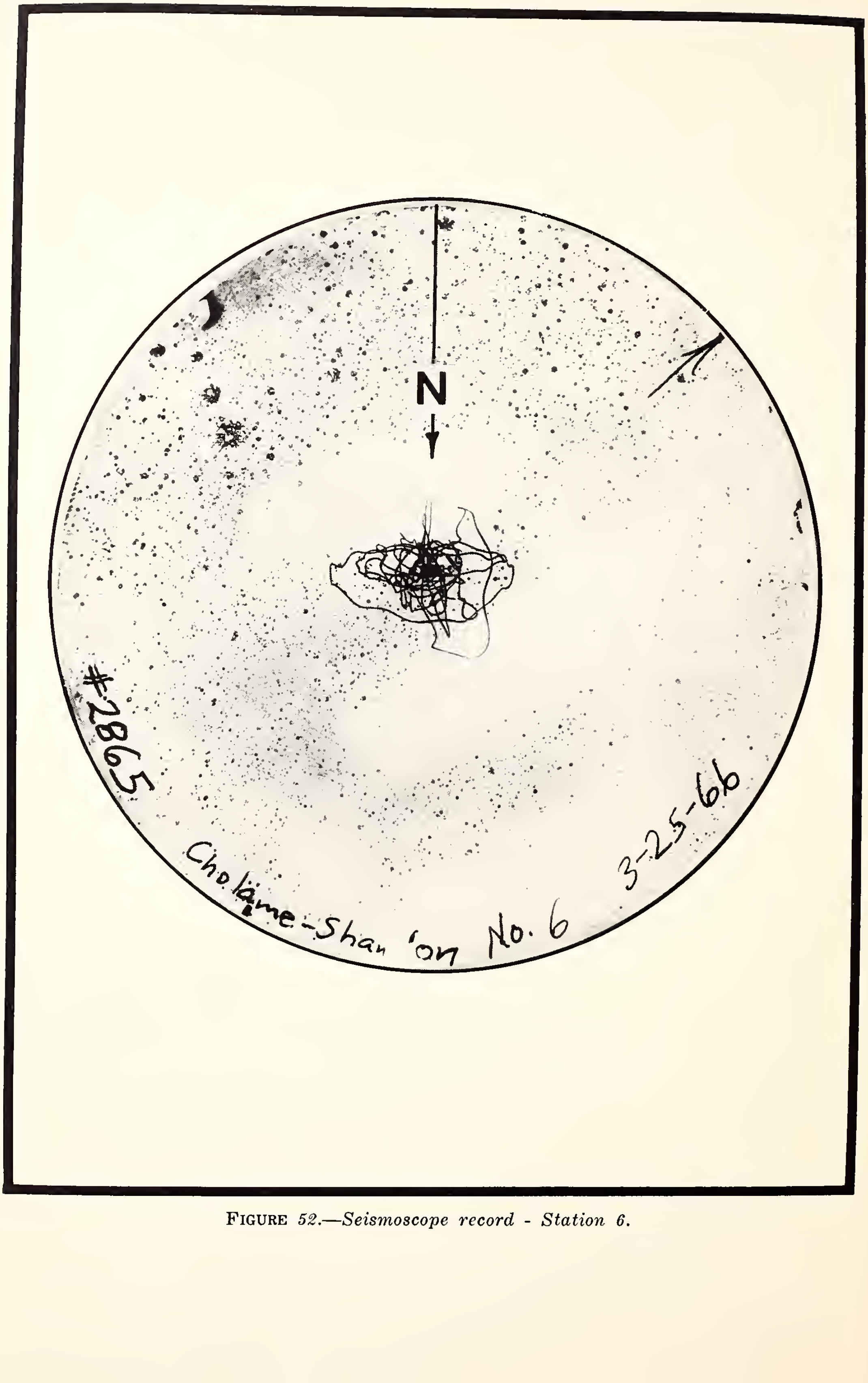

FIGURE 52.—*Seismoscope record - Station 6.*

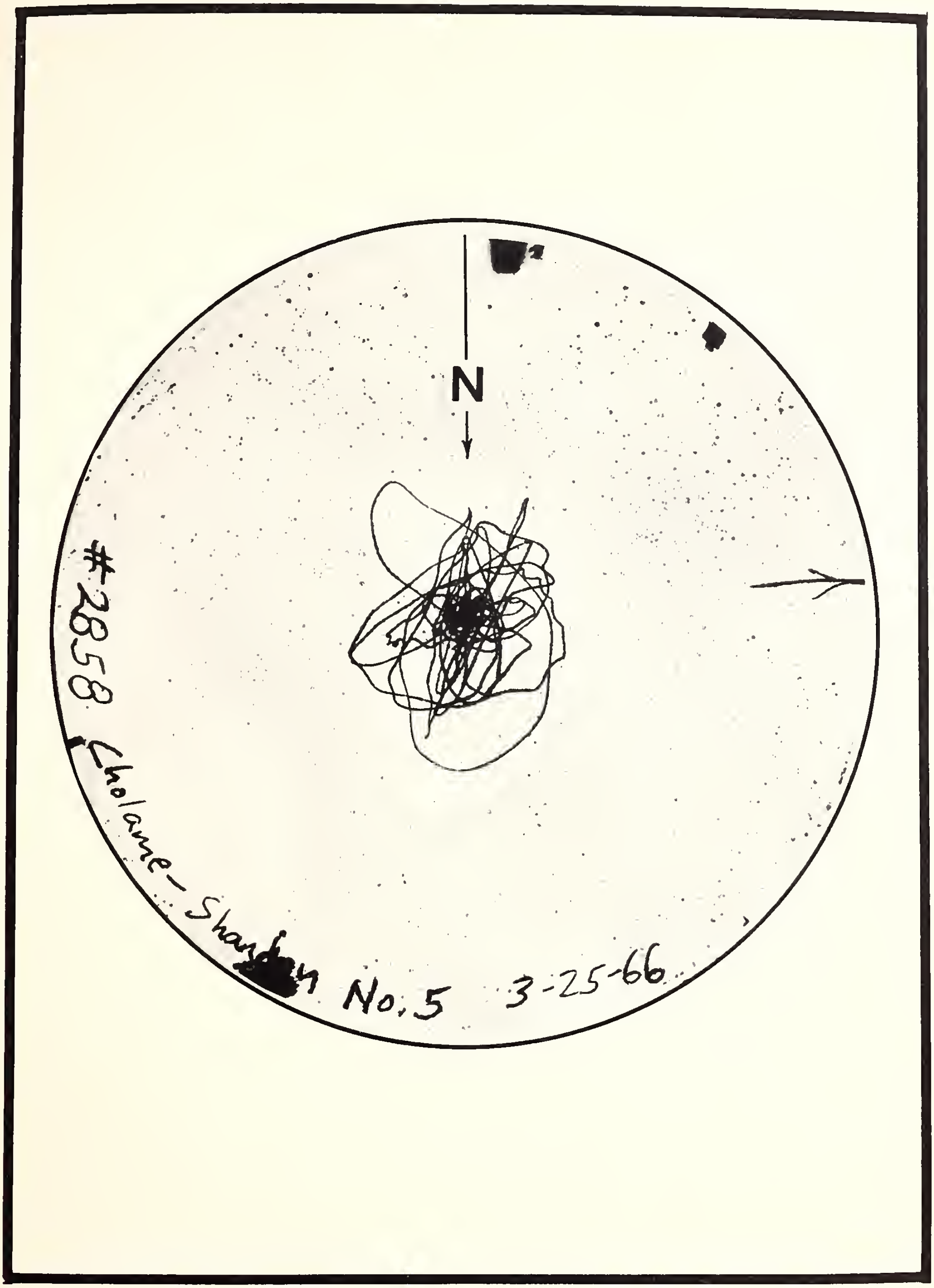

FIGURE 53.—*Seismoscope record - Station 5.*

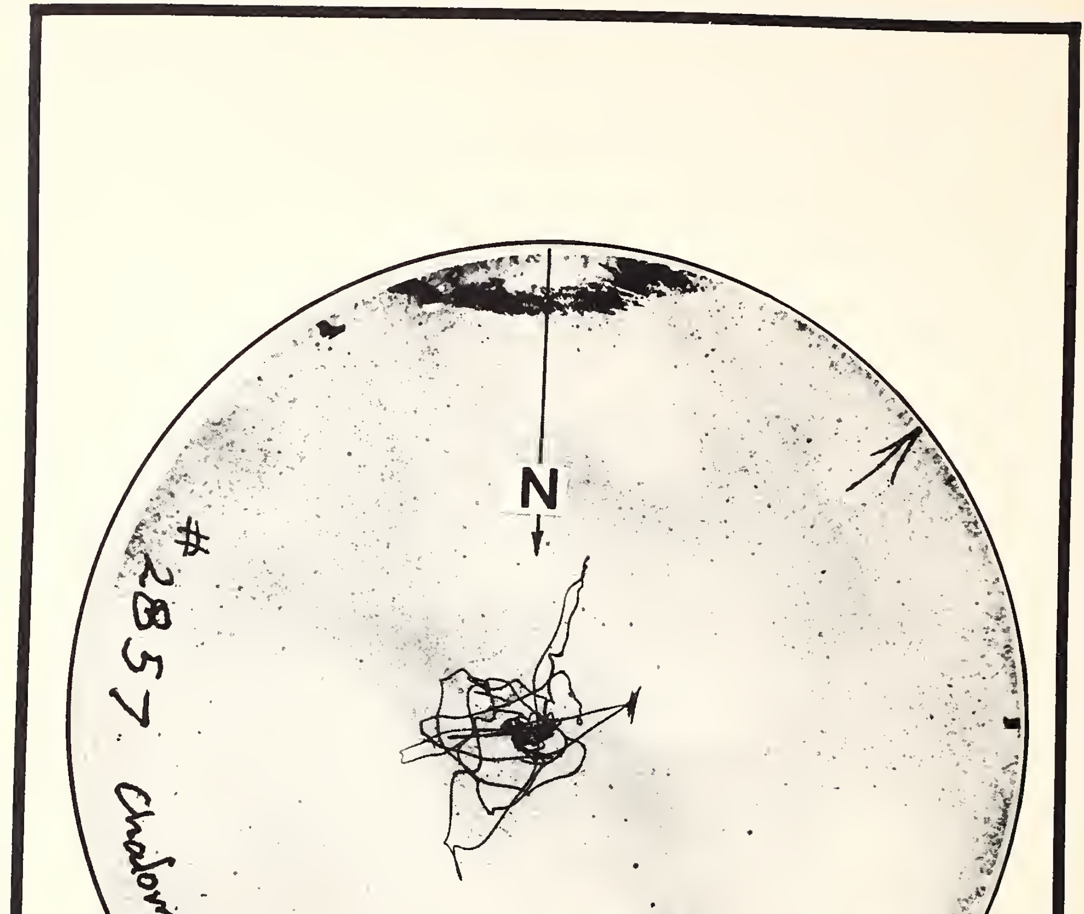

FIGURE 54.—*Seismoscope record - Station 4.*

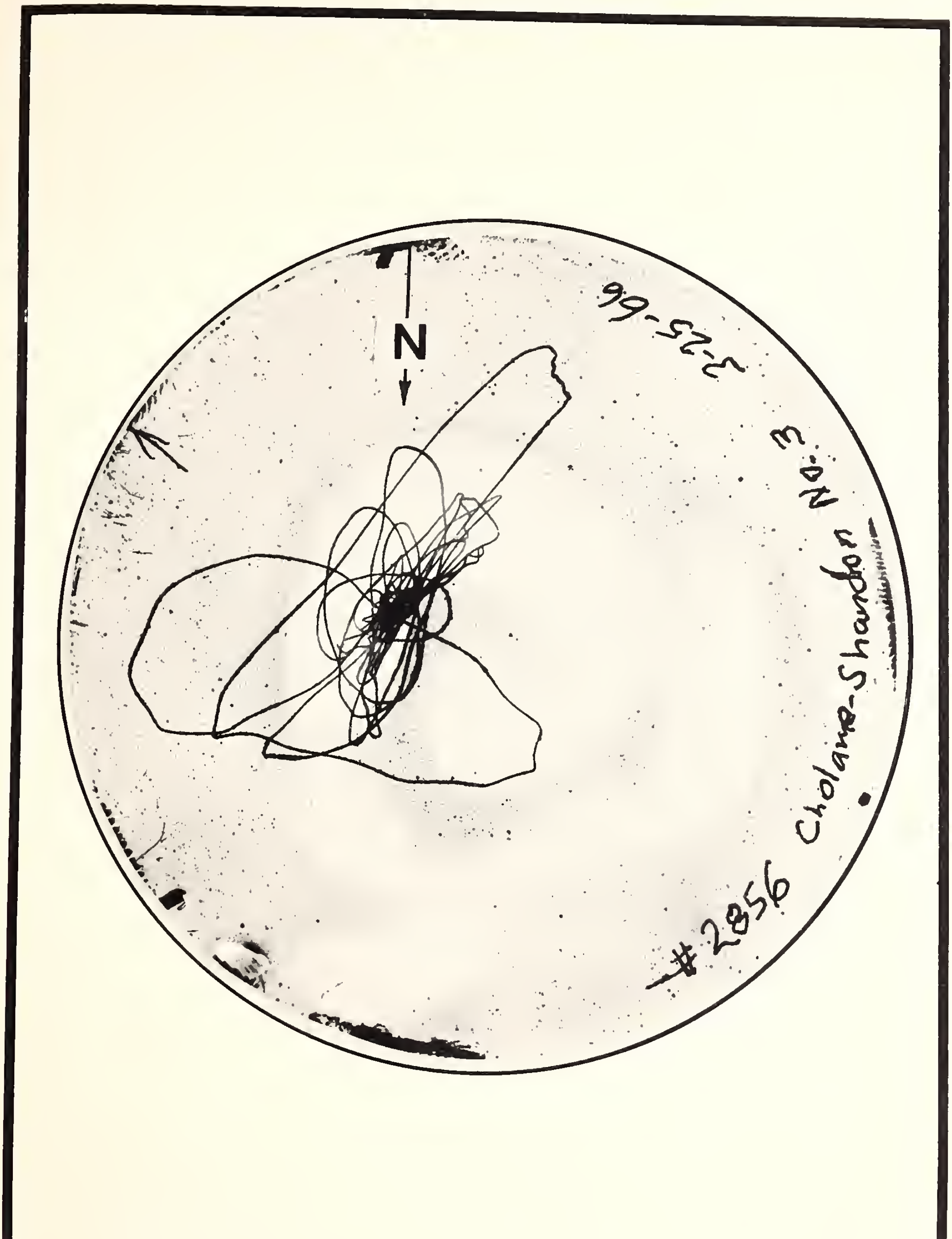

FIGURE 55.—*Seismoscope record - Station 3.*

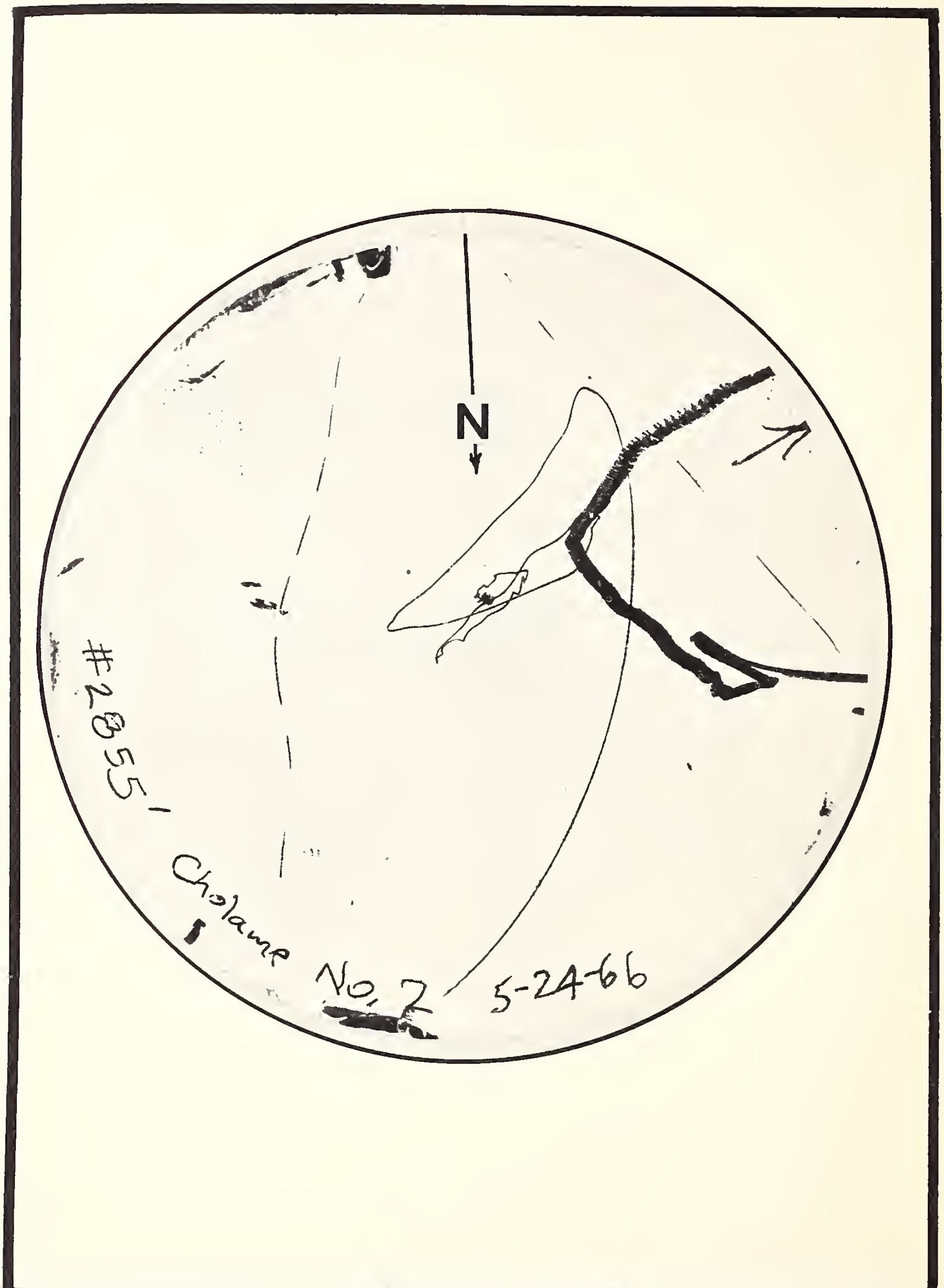

FIGURE 56.—*Seismoscope record - Station 2. Glass record plate fell off instrument during main shock.*

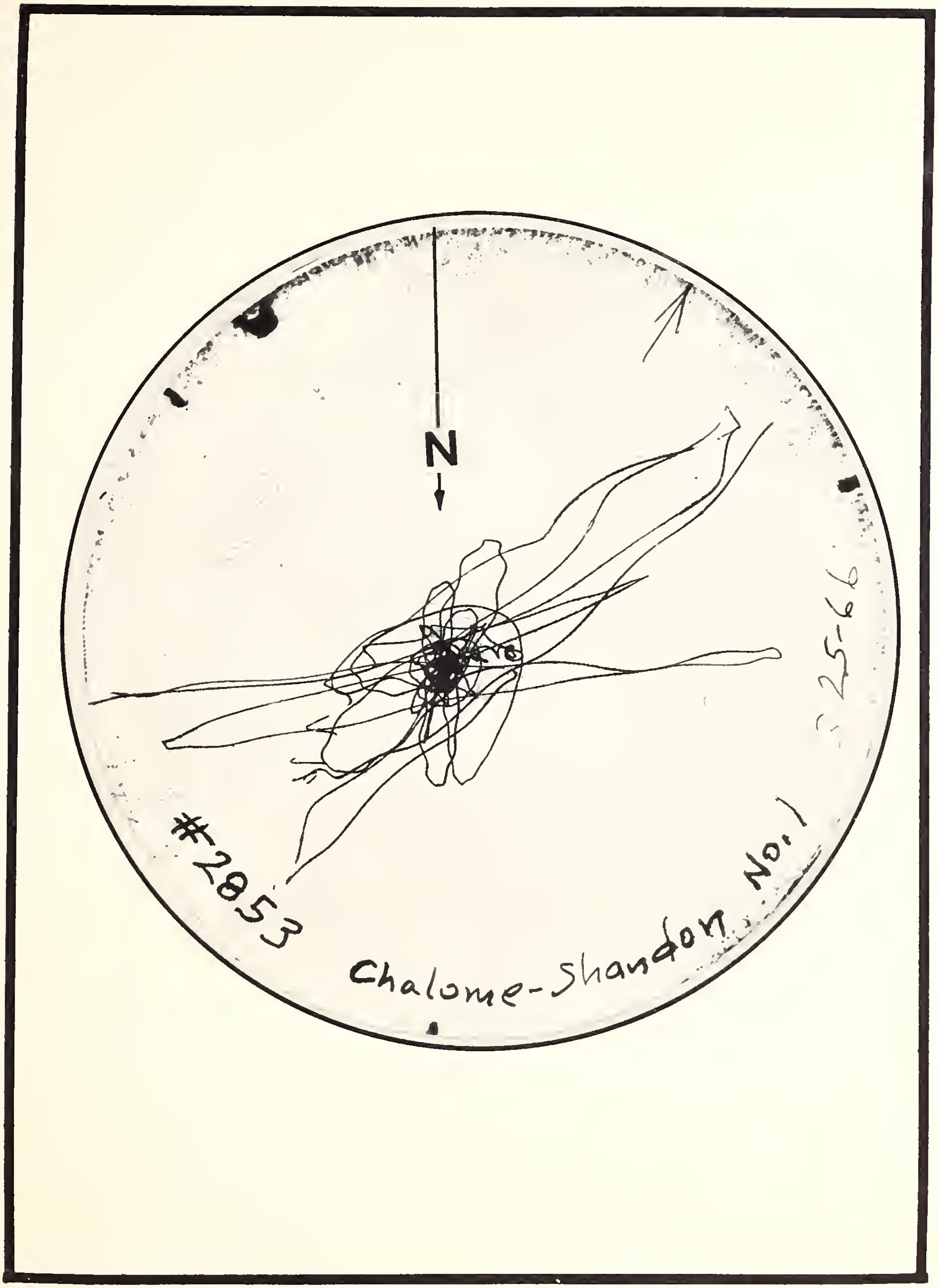

FIGURE 57.—*Seismoscope record - Station 1.*

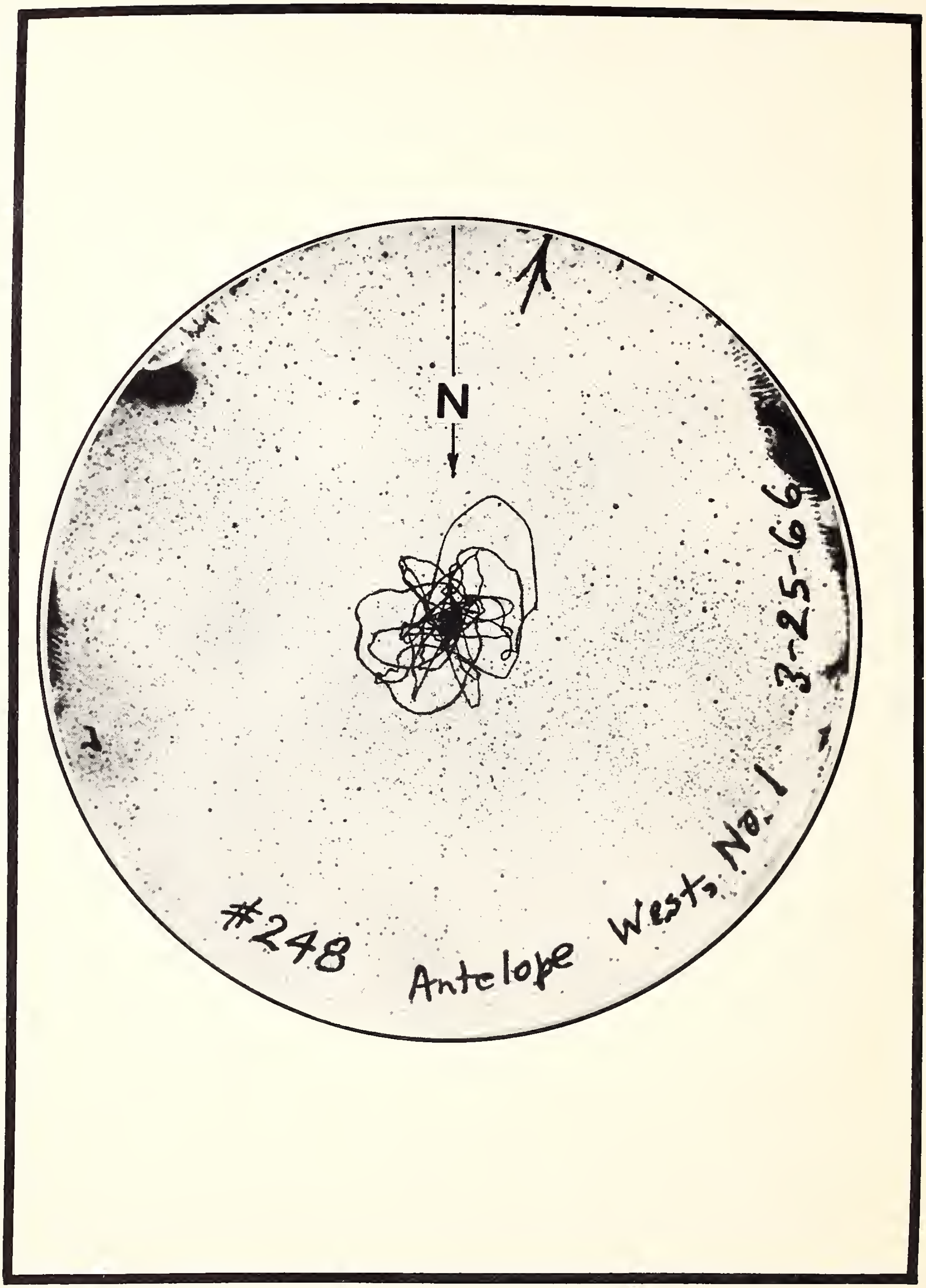

FIGURE 58.—*Seismoscope record - Station A-1.*

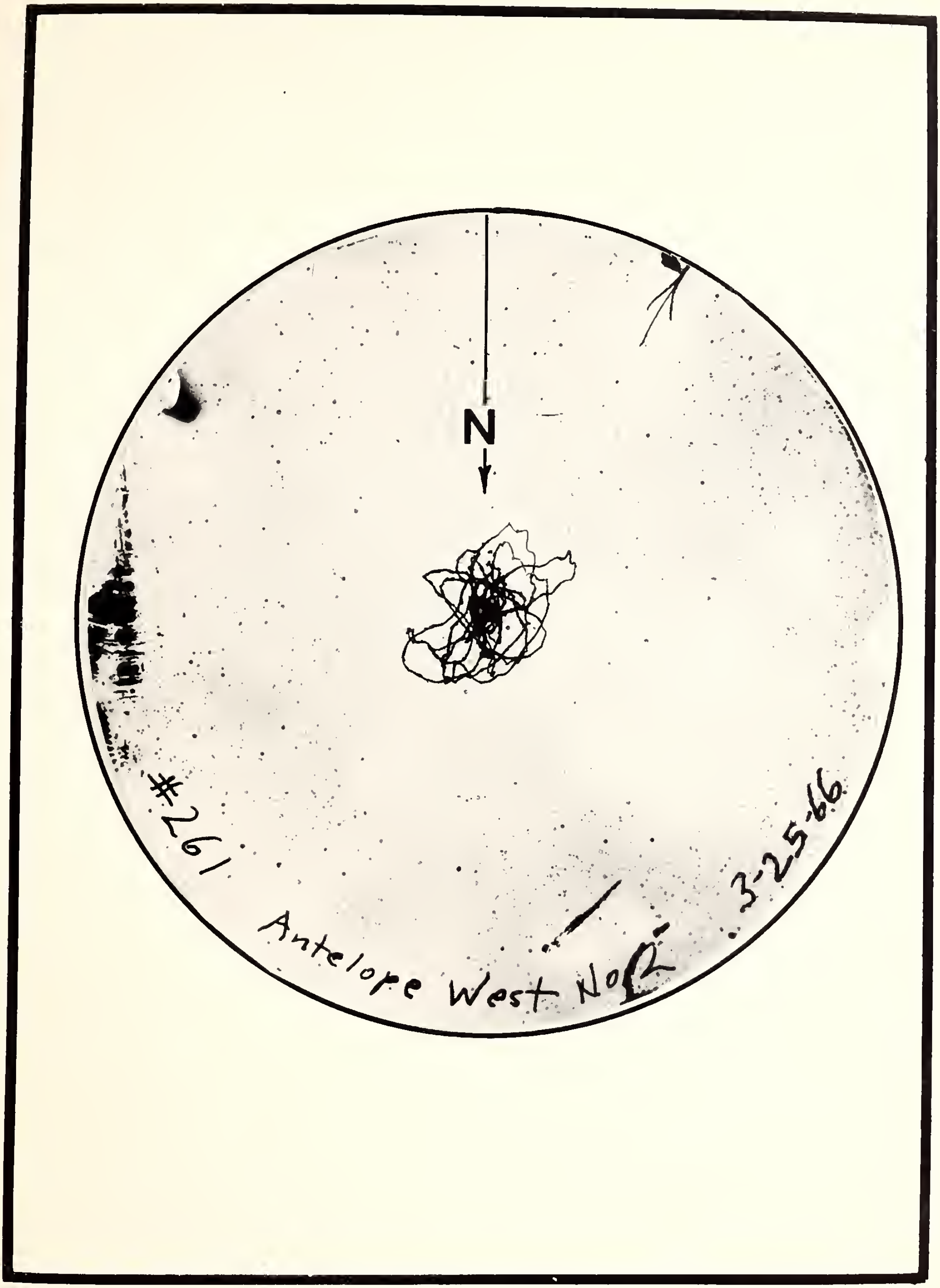

FIGURE 59.—*Seismoscope record - Station A-2.*

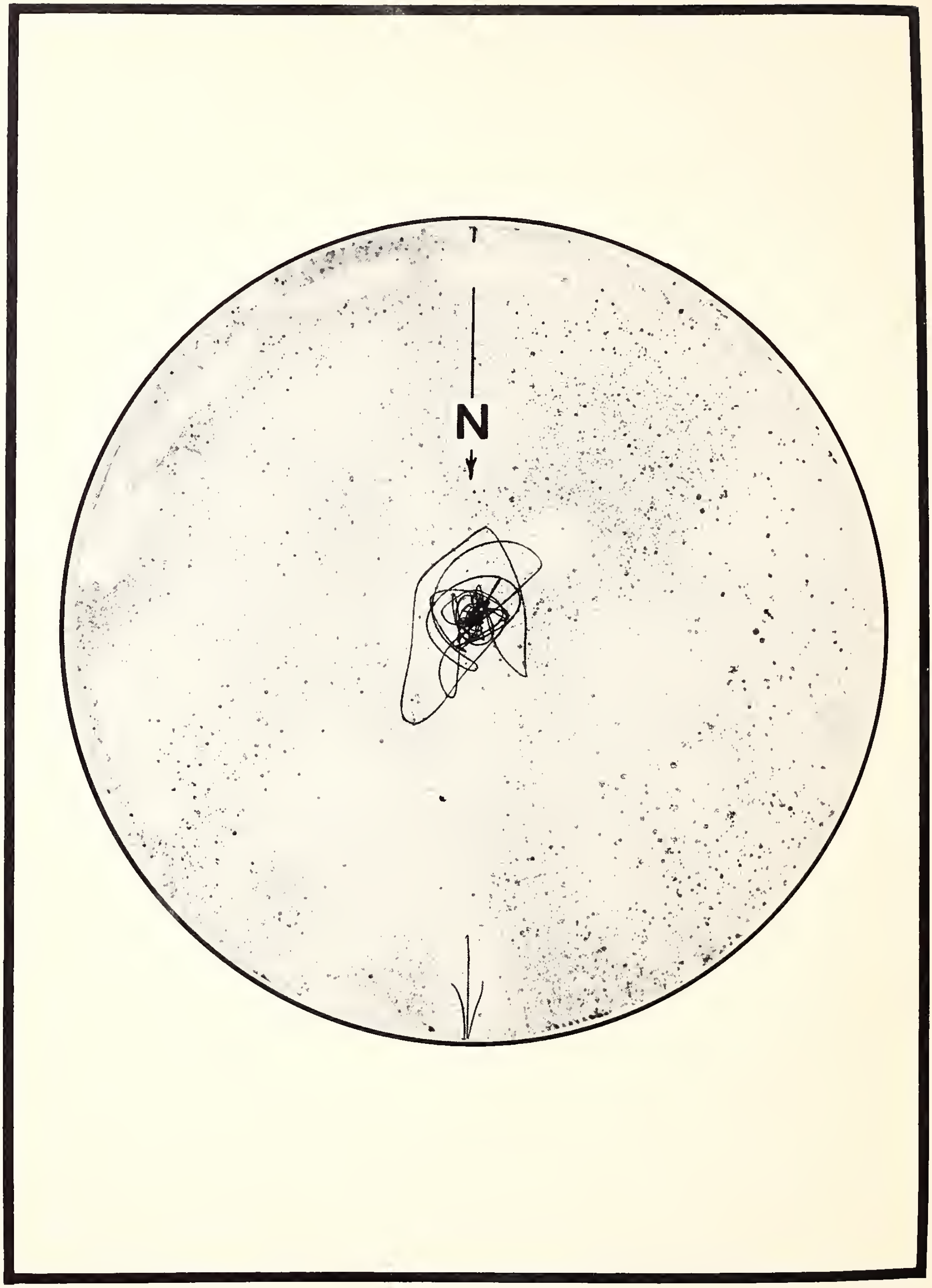

FIGURE 60.—*Seismoscope record - Antelope Pumping Station.*

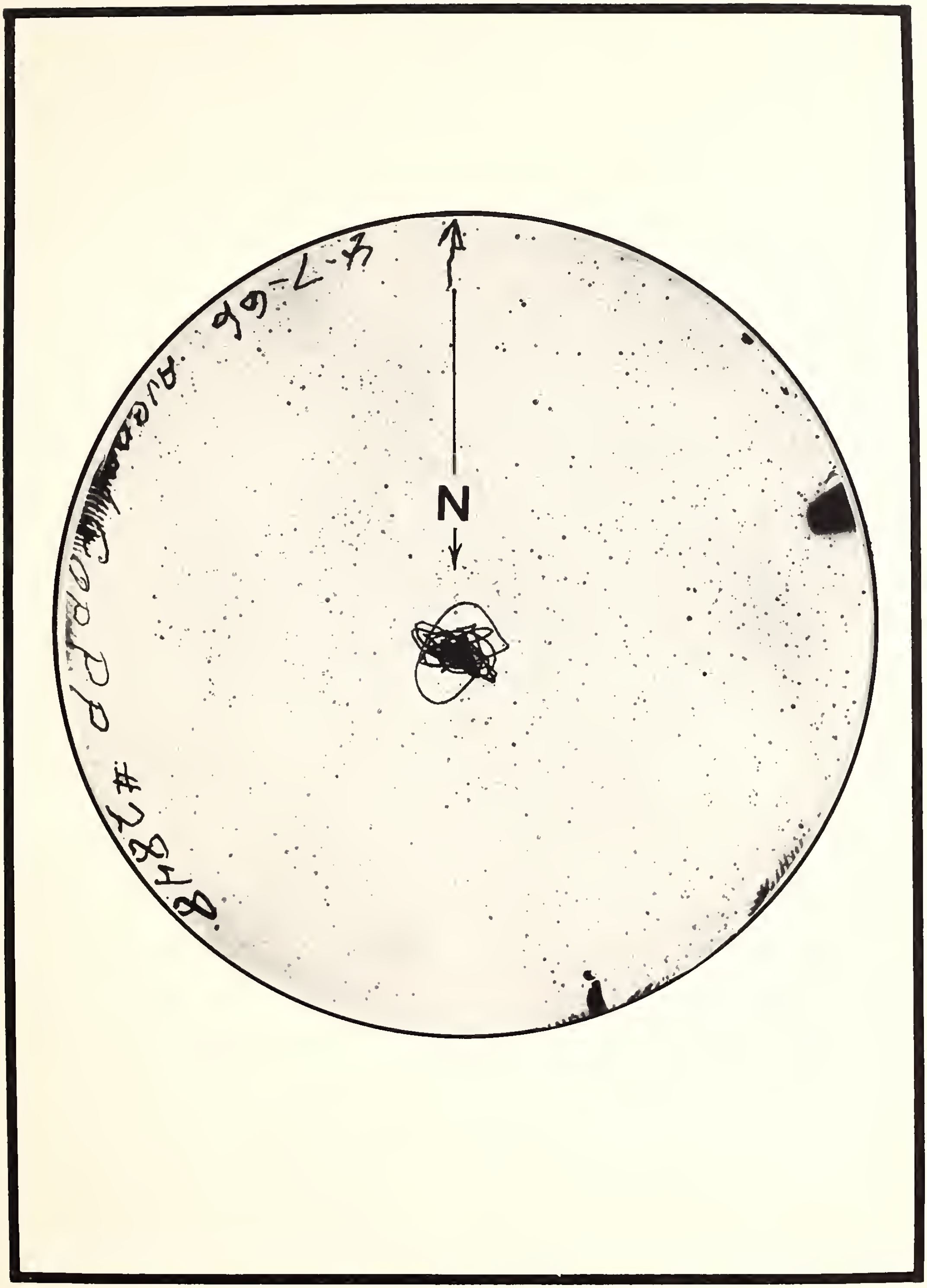

FIGURE *61.—Seismoscope record - Avenal Gap Station.*

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