DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

United States Earthquakes, 1968

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Introduction

United States Earthquakes, the annual report of the National Earthquake Information Center, was first issued in 1928 and has been published each year since that time. Although its principal objective is to describe briefly, earthquakes in the United States for the calendar year, the report also summarizes shocks occurring in or near the Panama Canal Zone, Puerto Rico, and the Virgin Islands. Additionally, it contains a list and short description of principal earthquakes of the world for the year.

The sources of noninstrumental information used in the compilation include the U.S. Weather Bureau, whose observers prepare periodic reports on local seismic activity; telegraphic information collected by Science Service, Washington, D.C.; bulletins of the Seismological Society of America; special reports of various institutions; newspaper clippings; and reports from interested individuals.

Instrumental data utilized in the location of earthquakes are obtained from the seismological observatories listed on page 69, and from cooperating seismograph stations throughout the world. Instrumental locations are issued in the *Preliminary Determination of Epicenters* report (see Teleseismic Results, page 3). Refined epicenters are later published in the monthly *Seismological Bulletin.*

The Coast and Geodetic Survey endeavors to coordinate efforts in collecting all types of earthquake information, with the special objective of correlating instrumental earthquake locations with noninstrumental reports received from the epicentral and surrounding areas. This is achieved through intensive regional investigations in various states by local organizations and the Coast and Geodetic Survey. This information is used to map the seismic areas of the country (see Seismic Risk Map, page 9), thereby promoting public safety through a better understanding of earthquake phenomena. Since the success of the general information service depends largely on the cooperation of local officials and citizens, all who receive earthquake questionnaire forms requesting information on specific shocks are urged to complete and return the forms to the office indicated.

EARTHQUAKE INFORMATION SERVICES

In August 1966, the National Earthquake Information Center (NEIC) was established at the Coast and Geodetic Survey Headquarters, Rockville, Md. This Center is a focal point for the dissemination of seismic information, both immediate and historical, for technical and public users.

The first new service from the Center was an expanded earthquake reporting system that provides accurate and rapid hypocenter locations and magnitude values to the press and other interested parties. These results are available within 2 to 3 hours for earthquakes of magnitude 6½ or larger, with smaller events treated on request or on receipt of a press report.

The global facilities of the Coast and Geodetic Survey, its seismograph stations, and cooperating observatories, are used to

provide the information for the earthquake reporting system. When a large earthquake occurs, the participating observatories telephone or telegraph their observations to the National Meteorological Center at Suitland, Md. This information is relayed to a duty seismologist at the NEIC who locates the epicenter graphically on a large world globe and scales the magnitude. This information, together with background and explanatory comments for nonseismologists, is released via Weather Bureau circuits and directly to news media.

The Center serves as a focal point for numerous additional seismological services provided by the Coast and Geodetic Survey, including preparation of seismic histories for engineers, actuaries, and scientists, and answering direct inquiries from various groups and individuals desiring earthquake information.

This Center also publishes a bimonthly *Earthquake Information Bulletin* to inform the public of past and continuing studies in this field, and of techniques used in the investigation and description of earthquakes and related phenomena. Through this *Bulletin* the Center attempts to bridge the long-existing gap between the technical report of the seismologist and the need of the layman for earth science information he can understand and use. Although back issues of this magazine are not available, the January-February 1970 and subsequent issues may be ordered on a subscription basis from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 ($1.50 per year), or they may be purchased at 30 cents a copy.

The Coast and Geodetic Survey maintains the Seismological Field Survey in San Francisco, where earthquake information is collected by field investigation and questionnaire canvass for the Pacific Coast and Western Mountain States. Details concerning general effects, damage, and felt area are enumerated in the quarterly *Abstracts of Earthquake Reports for the United States.* Active cooperation in this work is received from the University of California Seismographic Station at Berkeley, the Seismological Laboratory at Pasadena, and from state collaborators in seismology. The following collaborators served as agents of the Coast and Geodetic Survey in their respective states during 1968:

Arizona.—Dr. Richard T. Moore, University of Arizona, Tucson.

Colorado.—Prof. W. Warren Longley, University of Colorado, Boulder.

Montana.—Prof. Stephen W. Nile, Montana School of Mines, Butte.

Nevada.—Dr. David B. Slemmons, University of Nevada, Reno.

New Mexico.—Prof. Stuart A. Northrop, University of New Mexico, Albuquerque.

Oregon.—Dr. Peter Dehlinger, Oregon State University, Corvallis.

Utah.—Prof. J. Stewart Williams, Utah State University, Logan.

Washington.—Prof. Howard A. Coombs, University of Washington, Seattle.

Among the commercial agencies on the West Coast rendering valuable services are telephone, power, oil, railroad, and insurance companies. Certain concerns interested in the manufacture of earthquake-resistive building materials are also active, together with various organizations of structural engineers and architects.

Earthquake information was collected in other parts of the country in 1968 as follows:

Northeastern Region.—Rev. Daniel J. Linehan, S.J., Weston College, Weston, Mass.

Eastern Region.—Dr. Gerald R. MacCarthy, University of North Carolina, Chapel Hill (for earthquakes in North Carolina).

Central Region.—Rev. Dr. Victor J. Blum, S.J., St. Louis University, Mo. (for earthquakes in the central Mississippi Valley area); Dr. E. J. Walter, John Carroll Institute, Cleveland, Ohio (for earthquakes in Ohio); and Mr. Berlen C. Moneymaker, Tennessee Valley Authority, Knoxville, (for earthquakes in Tennessee).

EPICENTER MAPS

Figure 1 is designed to show the existence of damaging earthquakes in the United States through 1968. A review of the earthquakes plotted on this map in previous annual reports has revealed two errors. The Charleston, Mo., shock of 1895 and the western Texas earthquake of 1931 were both intensity VIII shocks. Their symbols have been changed to intensity VIII–IX category (instead of IX–X). Also, a thorough review of the damage connected with the Charleston, S. C., shock of 1886 has led to a revision of its intensity from X to IX. It is therefore given on this map in intensity IX–X category (instead of X–XII). Some of the most prominent historical earthquakes displayed in figure 1 are listed on page 5.

Figure 3 shows earthquake distribution in the United States during 1968. In a few instances where instrumental control is not satisfactory, or where results of investigations are inadequate, the plotted epicenters show the existence of the earthquakes, rather than the precise locations. Earthquakes in the California area are plotted when felt reports are received from several towns. Feeble earthquakes, and minor aftershocks of large earthquakes, are usually not shown on this map. A numeral associated with a dot indicates the number of shocks which occurred at the specified location. Bulletins of the University of California Seismographic Station and the Seismological Laboratory should be consulted for further details regarding epicenters, and for data on other California shocks.

The selection of isoseismal or "felt area" maps (figs. 4–10) is governed largely by the size of the area affected, the minimum radius generally being about 50 miles. This means that sharp, localized shocks of intensity VI (mostly in California) may not be shown on such maps, whereas others of intensity IV and V (largely in the Eastern and Central States) will often be shown. Felt and nonfelt reports from towns are designated on isoseismal maps by open and solid circles, respectively. Intensities higher, or lower, than those in the specific isoseismal zones are frequently noted and are indicated by small numerals beside the open circles.

TELESEISMIC RESULTS

The seismological observatories for which the National Earthquake Information Center publishes results are listed on page 69, and their locations are shown in figure 14. During the year, the locations of 5,695 epicenters were announced in the *Preliminary Determination of Epicenters* (PDE) list. To provide rapid service, these epicenters are released as soon as sufficient information has accumulated to ensure a reasonable degree of accuracy. As the title indicates, the results are preliminary, and do not always agree exactly with later determinations where more extensive network data or new information from critical azimuths and distances is used. For special studies, an inquiry should be made to this office for possible recomputation of epicenters of interest, using more complete instrumental data. The biweekly PDE service is available without charge to scientific organizations, and the monthly PDE reports, previously available to educational institutions and the public, may soon be obtained on a subscription basis.

All seismogram interpretations for 1968 are published in the monthly *Seismological*

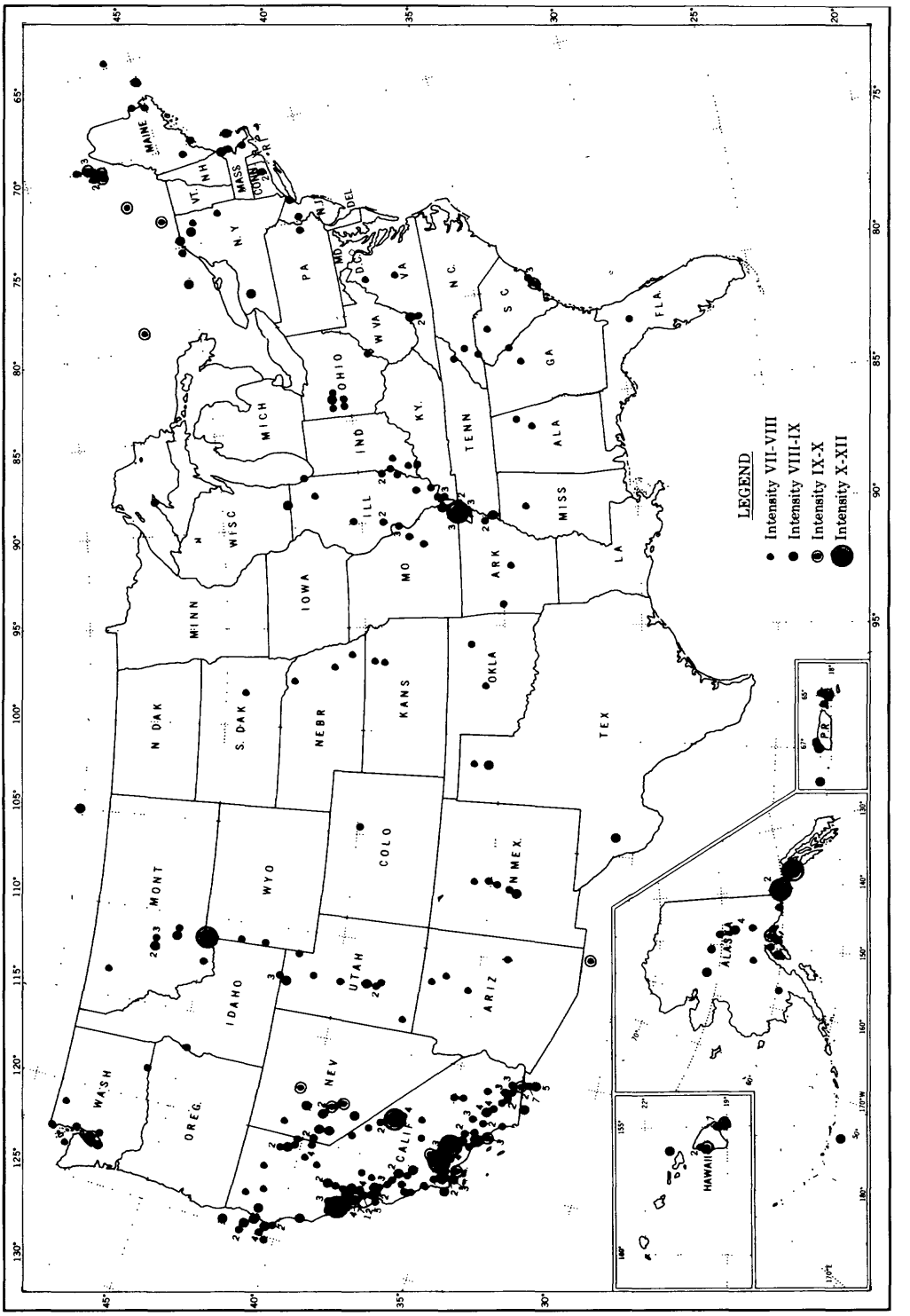

FIGURE 1.—Damaging earthquakes in the United States through 1968.

List of Prominent Earthquakes of the United States (see fig. 1)

Date	Locality	N. Lat.	W. Long.	Area	Intensity
		deg	*deg*	*sq. mi.*	
1663 Feb. 5	St. Lawrence River region	47.6	70.1	750,000	X
1755 Nov. 18	East of Cape Ann, Mass	42.5	70.0	300,000	VIII
1811 Dec. 16	Near New Madrid, Mo	36.6	89.6	2,000,000	XII
1812 Jan. 23					
1812 Feb. 7					
1812 Dec. 21	Off coast of southern California	34	120		X
1836 June 10	San Francisco Bay	38	122		IX–X
1838 June	San Francisco region	37½	122½		X
1852 Nov. 9	Near Fort Yuma, Ariz	33	114½		VIII–IX
1857 Jan. 9	Near Fort Tejon, Calif	35	119		X–XI
1865 Oct. 1	Fort Humboldt and Eureka, Calif	41	124½		VIII–IX
1865 Oct. 8	Santa Cruz Mts., Calif	37	122		VIII–IX
1868 Apr. 2	Near south coast of Hawaii	19	155½		X
1868 Oct. 21	Hayward, Calif	37½	122		IX–X
1872 Mar. 26	Owens Valley, Calif	36½	118	125,000	X–XI
1886 Aug. 31	Northwest of Charleston, S.C	32.9	80.0	2,000,000	IX
1892 Feb. 23	Northern Baja California	31½	116½		VIII–IX (U.S.)
1892 Apr. 19	Vacaville, Calif	38½	122½		IX
1892 Apr. 21	Winters, Calif	38½	122		IX
1893 Apr. 4	Northwest of Los Angeles	34½	118½		VIII–IX
1895 Oct. 31	Charleston, Mo	37.0	89.4	1,000,000	VIII
1898 Apr. 14	Mendocino County, Calif	39	124		VIII–IX
1899 Sept. 3	Yukutat Bay, Alaska	60	142		XI
1899 Sept. 10	do	60	140		XI
1899 Dec. 25	San Jacinto and Hemet, Calif	33½	116½	100,000	IX
1906 Apr. 18	Northwest of San Francisco, Calif	38	123	375,000	XI
1915 Oct. 2	Pleasant Valley, Nev	40½	117½	500,000	X
1918 Apr. 21	Riverside County, Calif	33¾	117	150,000	IX
1921 Sept. 29	Elsinore, Utah	38.8	112.2		VIII
1921 Oct. 1					
1922 Mar. 10	Cholame Valley, Calif	35¾	120¼	100,000	IX
1925 Feb. 28	St. Lawrence River region	47.6	70.1	2,000,000	VIII
1925 June 27	Helena, Mont	46.0	111.2	310,000	VIII
1925 June 29	Santa Barbara, Calif	34.3	119.8		VIII–IX
1927 Nov. 4	West of Point Arguello	34½	121½		IX–X
1931 Aug. 16	Western Texas	30.6	104.1	450,000	VIII
1932 Dec. 20	Western Nevada	38.7	117.8	500,000	X
1933 Mar. 10	Long Beach, Calif	33.6	118.0	100,000	IX
1934 Jan. 30	Southeast of Hawthorne, Nev	38.3	118.4	110,000	VIII–IX
1934 Mar. 12	Near Kosmo, Utah	41.7	112.8	170,000	VIII
1935 Oct. 18	Northeast of Helena, Mont	46.6	112.0	230,000	VIII
1935 Oct. 31	do	46.6	112.0	140,000	VIII
1940 May 18	Southeast of El Centro, Calif	32.7	115.5	60,000	X
1949 Apr. 13	Western Washington	47.1	122.7	150,000	VIII
1952 July 21	Kern County, Calif	35.0	119.0	160,000	XI
1954 July 6	East of Fallon, Nev	39.4	118.5	130,000	IX
1954 Aug. 23	do	39.6	118.5	150,000	IX
1954 Dec. 16	Dixie Valley, Nev	39.3	118.2	200,000	X
1958 July 9	Southeastern Alaska	58.6	137.1	100,000	XI
1959 Aug. 17	Near Hebgen Lake, Mont	44.8	111.1	600,000	X
1964 Mar. 27	Southern Alaska	61.0	147.8	700,000	IX–X
1965 Apr. 29	Northwestern Washington	47.4	122.3	130,000	VIII

Bulletin, MSI-325 through MSI-336. A list of epicenters, in chronological order and with some recomputations and additions, is also included in this report.

These publications may be obtained on request to the National Earthquake Information Center.

STRONG-MOTION SEISMOGRAPH NETWORK

The maintenance of a network of strong-motion seismographs and the analysis of the records of destructive earthquake motions thus obtained are functions of the Coast and Geodetic Survey in connection with a broad, cooperative research program being conducted on the Pacific Coast with several local organizations and institutions interested in the engineering aspects of the earthquake problem. More details concerning this subject may be found on page 83, Strong-Motion Seismograph Results. Locations of the strong-motion stations operated by the Seismological Field Survey are shown in figure 15, including eight stations in Central and South America and one in Connecticut.

The preliminary analyses of strong-motion records are published in the *Quarterly Engineering Seismology Bulletin.* Revised analyses are presented in tables 4 and 5.

MAGNITUDE AND INTENSITY RATINGS

Magnitude, stated according to the Gutenberg-Richter scale, is a measure of the energy release at the focus of an earthquake as determined by the amplitudes produced on a seismogram. Although the magnitude scale has no "top" nor "bottom" values, the highest ever recorded was magnitude 8.9 and the lowest about −3. On this logarithmic scale, a magnitude 8 earthquake represents recorded amplitudes ten times larger than those for a magnitude 7 earthquake, 100 times larger than a shock of magnitude 6, etc. (see *Bulletin of the Seismological Society of America,* vol. 32, No. 3, 1942).

Intensity rating, expressed on the Modified Mercalli Intensity Scale of 1931 (see next section) is a measure of the effects of an earthquake on people and objects, as determined by experienced observers. It is a result of many factors, including magnitude of the earthquake, distance from its epicenter, local geological conditions, and structural properties of buildings. An earthquake in a populated area will have several intensities, depending on the local factors mentioned previously, but only one magnitude (although it may vary slightly at different observatories due to variations in equipment and methods of estimating).

MODIFIED MERCALLI INTENSITY SCALE OF 1931

All intensities used by the Coast and Geodetic Survey refer to the Modified Mercalli Intensity Scale of 1931.[1] The abridged version of this scale is given here with equivalent intensities according to the Rossi-Forel Scale.

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 buildings, 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)

[1] Harry O. Wood and Frank Neumann, in *Bulletin of the Seismological Society of America,* vol. 21, No. 4, December 1931.

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 their foundations; ground badly cracked. Rails bent. Landslides considerable from river banks 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.

EARTHQUAKE HISTORY

A history of the more important earthquakes of the country appears in Publication No. 41-1, *Earthquake History of the United States*. Part I, revised 1963 edition, includes stronger earthquakes of the United States, exclusive of California and western Nevada; Part II, revised 1963 edition, covers the stronger earthquakes of California and western Nevada. These reports are presently being revised and will be issued under one cover in late 1971.

A history of minor activity is covered largely in a series of references listed in Publication No. 41-1, in recent reports of the Coast and Geodetic Survey, and in the *Bulletin of the Seismological Society of America*, vol. 29, No. 1, January 1939. The latter reference gives detailed information for California and other Pacific Coast earthquakes, and contains all information

appearing in early catalogs published by the Smithsonian Institution.

C&GS Special Publication 282, *Earthquake Investigation in the United States,* revised 1969 edition, explains the more important facts about earthquakes and outlines the role played by the Federal Government and private seismological organizations in dealing with the earthquake problem. It discusses briefly, all major earthquakes in the United States, Puerto Rico, and Panama Canal Zone, and shows in tabular form, dollar damage and lives lost as a result of strong U.S. shocks.

SEISMIC RISK MAP[1]

A seismic probability map of the United States was prepared in 1948 by F. P. Ulrick of the Coast and Geodetic Survey. In 1949, the map was revised such that the Charleston, S.C., area was changed from Zone 3 (major damage) to Zone 2 (moderate damage), and the Puget Sound, Wash., region was moved from Zone 2 to Zone 3. The revised map was adopted by the Pacific Coast Building Officials Conference for inclusion in the 1952 edition of the *Uniform Building Code.* Subsequent editions of this report have included the probability map with no changes, but the Coast and Geodetic Survey withdrew the map from circulation in 1952 because it was subject to misinterpretation and too general to satisfy the requirements of many users.

The seismic risk map in figure 2 is a revision of that originally prepared by the Coast Survey in 1948. It is only an interim map and does not represent the final form of a risk map for the United States. Figure 2 is based on:

1. The distribution of Modified Mercalli intensities associated with known seismic history of the United States;

2. Strain release in the United States since 1900; and

3. The association of strain release patterns with large-scale geologic features believed to be related to Recent seismic activity.

Where seismic activity has occurred intermittently along a recognizable geologic trend, it has generally been assumed that earthquakes could occur with equal likelihood anywhere along that structure. In areas where the relations between seismicity and geologic structure are not clear, or where only limited geologic information is available, the risk zones are based on the distribution of Modified Mercalli intensities and strain release. In all cases, the size and shape of the zones have been heavily influenced by the historical distribution of intensities. Although it would be desirable to relate risk to a measurable quantity less subjective than intensity, the available strong-motion and other data appear to be insufficient to attempt this at present. No special corrections are presented for types of surficial geology and soils that may increase or decrease the intensity of shaking. It should be remarked, however, that the intensities reported for an earthquake are usually the maximum effects observed on the worst ground.

The risk zones in the northeast portion of the United States are not greatly changed from the original risk map. The St. Lawrence Valley continues to be Zone 3 because of strong earthquakes in 1663 and 1925 and the Attica and Massena, N.Y., shocks in 1929 and 1944. The Boston, Mass., area was zoned 3 as result of the earthquake east of Cape Ann in 1755 and many other lesser shocks in the area.

In the Eastern United States, Zone 2 has been extended to include the main structures of the Appalachian area, from Pennsylvania to Alabama, which are associated with numerous moderate earthquakes.

In the Central United States, Zones 2

[1] S. T. Algermissen, *Seismic Risk Studies in the United States,* Presented to the Fourth World Conference on Earthquake Engineering, January 14, 1969, Santiago, Chile.

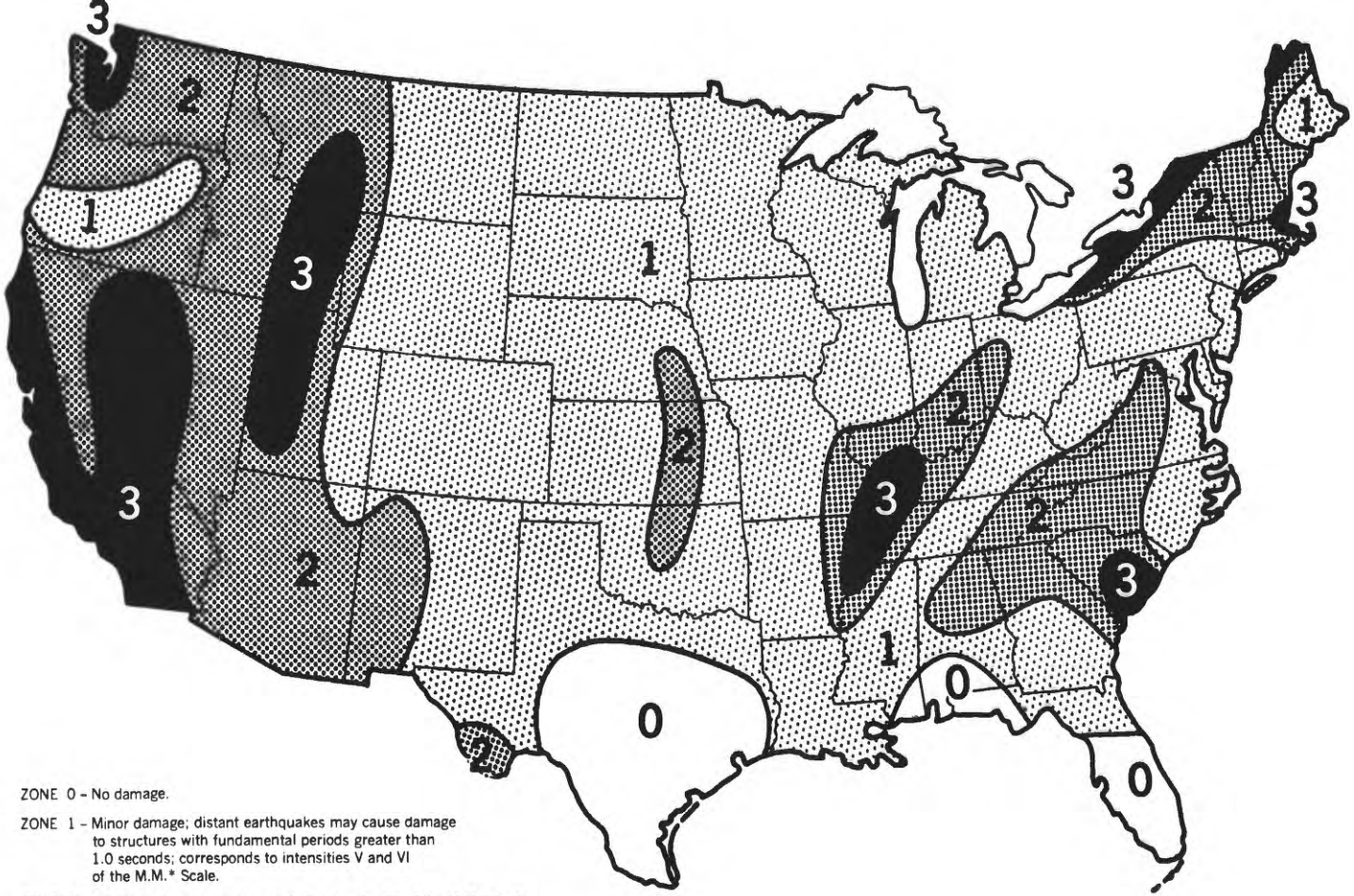

FIGURE 2.—Seismic risk map for conterminous United States. Zones are defined in text. M.M.* refers to the Modified Mercalli Intensity Scale on p. 6.

and 3 have been enlarged in the Mississippi Valley. The new zone more nearly reflects the probable distribution of intensities in any repetition of the 1811–12 series near New Madrid, Mo. Also, Zone 2 has been extended northeast across a zone of relatively minor seismicity in Indiana to southwestern Ohio. Although earthquakes with maximum intensities of VII are known in western Ohio, connection of Zone 2 in Ohio with the Zone 2 surrounding the New Madrid, Mo., area is a matter of interpretation. A Zone 2 area has been drawn along the Nemaha Ridge structure, in Nebraska, Kansas, and Oklahoma, which includes the 1952 earthquake near El Reno, Okla., and numerous additional shocks along the Nemaha Ridge.

The North Central Plains States have generally been rated in Zone 1 because of the lack of data relating seismicity with geologic structure, and because of the rather widespread and erratic distribution of moderate earthquake activity. The Zone 3 area, restricted to southeastern Montana on the old map, has been extended southward through Idaho and Utah. The large earthquake near Hebgen Lake, Mont., in 1959, the Kosmo, Utah, shock of 1934, the series in Elsinore, Utah, in 1920 and 1921, and the related north-south trending faults amply justify the zoning.

Only minor changes have been made from the original risk map in the states bordering the Pacific. The original Zone 1 area in Oregon has been slightly changed. Other minor alterations have been made in the shape of the Zone 3 area in Washington and at the south end of Zone 2 in the Great Valley of California.

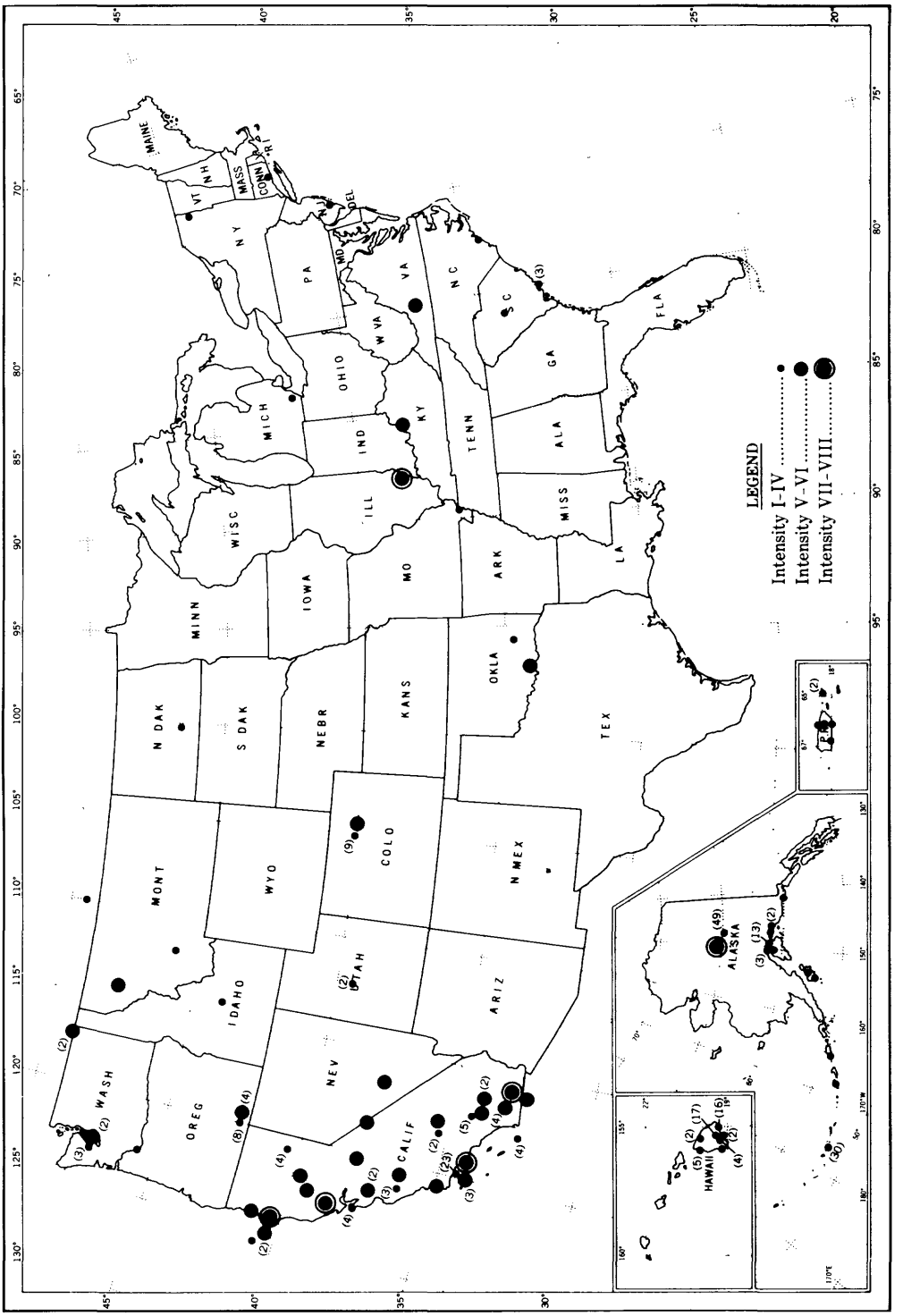

FIGURE 3.—United States earthquake epicenters for 1968.

Summary of Earthquake Reports

The following symbols are used to indicate authority for times or epicenters in the regions which follow: P, reported by the Seismological Laboratory, California Institute of Technology, Pasadena; B, reported by the Seismographic Station, University of California, Berkeley; NESA, reported by the Northeastern Seismological Association, Weston, Mass.; JSA, reported by the Jesuit Seismological Association, St. Louis, Mo.; and W, reported by the Rockville office of the Coast and Geodetic Survey.

Two magnitudes may now be determined by the Coast and Geodetic Survey: Surface wave magnitude (M_S) and body wave magnitude (m_B). Each represents an average of individual station magnitudes which are determined from reported periods and amplitudes of representative waves. Body wave magnitude is computed from *P* phases only, in the manner defined by Gutenberg and Richter[1]. Surface wave magnitude is determined using a formula recommended by the International Committee on Magnitudes. Magnitudes reported by other organizations are identified by the symbols given in the preceding paragraph.

An asterisk (*) indicates instrumental origin time of the earthquake when coordinates of the epicenter are given. Otherwise, instrumental times shown with asterisks indicate the arrival time at a nearby station.

When more than one degree of intensity is reported from a town, the town is listed under the highest reported. More details will be found in the quarterly *Abstracts of Earthquake Reports for the United States,* MSA series, issued on mailing list CGS-3.

[1] Gutenberg, B. and C. F. Richter, "Magnitude and Energy of Earthquakes," *Annali di Geofisica,* vol. 9, pp. 1–15, 1956.

EARTHQUAKE ACTIVITY IN THE VARIOUS STATES

This section summarizes the earthquake data in the regions which follow. Intensities of earthquakes for which no intensity ratings are given range from I to IV.

Alaska: (Intensity V and above). Oct. 29, VII–VIII; Dec. 17, VI.

Arizona: Felt California earthquake of Apr. 8, VI.

California: (Intensity VI and above). Feb. 5, VI; Apr. 8, VII; 8, VI; 25, VII; felt Oregon earthquake of June 3, VI. June 25, VII; July 4, VI.

Colorado: Jan. 13; 18; Feb. 24; Apr. 13; July 15, V; 27; Aug. 13; Sept. 24, IV; Nov. 2, IV; 28.

Connecticut: Nov. 3, V.

Delaware: Felt New Jersey earthquake of Dec. 10, II.

Hawaii: Several were felt. None had intensity designations (see page 59).

Idaho: July 20, IV; Aug. 12; 13; 14; Nov. 29.

Illinois: Nov. 9, VII (felt in 23 states and Canada).

Indiana: Felt Kentucky shock of Dec. 11.

Kentucky: Dec. 11, V.

Michigan: Oct. 31.

Missouri: Feb. 9.

Montana: Mar. 26, V; July 17, IV; Nov. 19.

Nevada: Jan. 30, V; felt California shock of Feb. 5, V. Feb. 21, V; felt California earthquake of Apr. 8, IV. May 22; July 6, V.

New Jersey: Dec. 10, V.

New York: Felt Canadian shock of Oct. 19, V.

North Carolina: Felt Virginia shock of Mar. 8, IV. Nov. 25, IV.

North Dakota: July 8, IV.

Oklahoma: Jan. 4, IV; Oct. 10; 11; 14, VI.

Oregon: Jan. 27, IV; May 26; 29, IV; 29, V; June 3, V; 3, VI; 3 (2); 25; 26.

Pennsylvania: Felt New Jersey earthquake of Dec. 10, V.

South Carolina: July 9; 10; 11, IV; Sept. 22, IV.

Utah: Jan. 16; Aug. 3.

Virginia: Mar. 8, IV.

Washington: Mar. 6; June 18, IV; Sept. 6, V; 25, IV; Nov. 30, V.

West Virginia: Felt Virginia earthquake of Mar. 8.

EARTHQUAKE ACTIVITY OUTSIDE THE UNITED STATES

Panama Canal Zone: Dec. 15.

Puerto Rico: Apr. 12, IV; May 2; Sept. 3; Oct. 15.

Virgin Islands: Mar. 29, IV; Apr. 14.

NORTHEASTERN REGION

[75th Meridian or Eastern Standard Time]

October 19: 05:37:17.4*. Epicenter 45.4° north, 74.0° west, southern Ontario, Canada, W. V. Felt by, awakened, and frightened all 3 miles east of Chazy, N.Y. Trees and bushes shook. Loud earth noises were heard. A rumble was reported at Ellenburg Depot, N.Y.

November 3: 03:33:52.5*. Southern Connecticut. V. Felt at several towns along a 30-mile stretch of the Connecticut River, from Lyme in the south to Glastonbury in the north. Plaster cracked at Madison. Furniture shifted at Chester. Questionnaire canvass conducted by Weston Observatory, Weston, Mass.

INTENSITY V:

Chester.—Felt by and awakened many in community; few frightened. Furniture shifted. Small objects fell. Breakage was reported but not described. Loud earth noises.

Deep River.—Felt by, awakened, and frightened many in community. Windows, doors, and dishes rattled. Earth noises, like a loud blast, were heard.

Essex.—Felt by and awakened many in community. Windows rattled. Explosion-like sounds heard.

Madison.—Felt by several; few awakened in home. Plaster cracked. Small objects fell. Faint earth noises.

INTENSITY IV:

East Haddam and Westbrook.

INTENSITY I–III:

Durham, Glastonbury, Lyme, and Old Saybrook (press).

EASTERN REGION

[75th Meridian or Eastern Standard Time]

March 8: 00:38:15.1*. Epicenter 37.0° north, 80.5° west, Virginia, W. Magnitude 3.9. IV. Felt over approximately 3,200 square miles of the New River Valley in Virginia and West Virginia. A paper by G. A. Bollinger[1] states: "The writer and Dr. C. E. Sears visited the Narrows area the same morning of the earthquake occurrence. Discussions with the residents there and in the surrounding communities revealed that no damage had been done. . . In the town of Narrows, a relay controlling the street lights on several blocks was apparently thrown by the earthquake vibrations, causing them to go out, but no damage was done to the lighting system. . .

[1] Bollinger, G. A., "The Narrows, Virginia Earthquake of March 8, 1968," *Earthquake Notes*, vol. 39, Sept.–Dec. 1968.

Unconfirmed damage reports consisted of a broken sewer line at a home in Bluefield, Va., and cracks in a cement flower box attached to a house in Pembroke, Va." Intensity IV effects were also noted at Blacksburg, Narrows, Pearisburg, Pulaski, and Radford, Va., and Boone, N.C.; intensity I–III at Allisonia, Bland, Christiansburg, Dublin, Hillsville, and Wytheville, Va., and Alderson, Mullens, and Peterstown, W. Va.

July 9: 23:24. July 10: 05:46. July 11: 20:12. Press reports indicated the first two earthquakes were felt by a resident who called the University of South Carolina to inquire about the shocks. The July 11 earthquake was felt by two persons west of Ashley who reported their house shook (IV).

September 22: 16:41:18.5*. Epicenter 34.0° north, 81.5° west, South Carolina, W. Magnitude 3.7. IV. Felt over approximately 400 square miles of Richland and Lexington Counties. Intensity IV effects occurred at Ballentine, Blythewood, Cayce, and Columbia; intensity I–III at Gilbert, Irmo, and Lexington.

November 25: About 20:00. Southwestern North Carolina. IV. Press reported dishes rattled and earth noises were heard at Wrightsville Beach, Greenville Sound, Masonboro Sound, and Carolina Beach.

December 10: 04:12:44.9*. Epicenter 39.7° north, 74.6° west, New Jersey, W. Magnitude 2.5. V. Press reported some broken windows. Intensity V effects were noted at Camden, Moorestown, Palmyra, Riverside, and Willingboro, N.J., and Darby and Philadelphia, Pa. Intensity IV at Stratford, N.J., and Sharon Hill, Pa. Intensity II was reported at Wilmington, Dela. Press reported toll booths on the Benjamin Franklin and Walt Whitman Bridges in Philadelphia trembled during the shock, and that a picture fell from a wall in the Colwyn section of this city.

December 11: 10:00. Press reports indicated that portions of the Ohio River Valley experienced a slight earthquake at 10:00. Dishes were knocked from a cupboard at Louisville, Ky., and residents hurried into the streets (V). Also felt at New Albany and Jeffersonville, Ind.

CENTRAL REGION

[90th Meridian or Central Standard Time]

January 4: 16:30. Haileyville-Hartshorne-Gowen, Okla., area. IV. Felt by several. Windows and doors rattled loudly. "Many in town (Hartshorne) did not feel it. Others did in an area from Haileyville to Gowen, a distance of 9–10 miles." A U.S. Navy Ammunition Depot is located about 15 miles west of Hartshorne, but the observer reported there were no explosions at the time of the earthquake.

February 9: 19:34:32.1*. Epicenter 36.5° north, 89.9° west, New Madrid, Mo., region, W. Magnitude 3.8. Felt at Malden.

July 8: 10:50:12*. Epicenter 46.5° north, 100.6° west, North Dakota, W. Magnitude 4.4. IV. Felt over approximately 3,000 square miles of south-central North Dakota. This was the first earthquake to be instrumentally located in the State historically, and one of the few ever felt. The shock centered near Huff, where a television set shifted and sounds like thunder were heard. Intensity IV effects were also noted at Bismarck, Fort Rice, Huff, Linton, Mandan, Menoken, and Moffit; intensity I-III at Almont, Flasher, Halliday, and St. Anthony.

October 14: 08:43:00*. Durant, Okla. VI. Felt by all. Walls cracked; some cracks enlarged. Glass in two structures broke. Trees and bushes swayed visibly. Press reported a 5-foot-tall advertising stand fell over, and canned goods fell from rack in supermarket. It was also reported that foreshocks were felt at Durant on the night of the 10th, and at 03:00 on the 11th. Intensity IV effects from the Oc-

tober 14 earthquake were noted at Caddo, about 12 miles northeast of Durant.

October 31: Afternoon. Port Huron-Flint, Mich. Press reported a tremor was felt in Port Huron, Flint, and other towns within a 60-mile area of Port Huron.

November 9: 11:01:41.1*. Epicenter 38.0° north, 88.5° west, south-central Illinois, W. Magnitude 5.3. VII. Felt over approximately 580,000 square miles of the central United States, including all or portions of 23 states[1] (see figs. 4 and 5). It was the strongest shock in this region since 1895. The earthquake caused minor damage in the nearest metropolitan centers—Evansville, 50 miles east; Chicago, over 270 miles north; and St. Louis, about 110 miles to the northwest. Considerable masonry damage was sustained at the City Building at Henderson, Ky., 50 miles east-southeast

[1] Gordon, David W., et al., "The South-central Illinois Earthquake of November 9, 1968: Macroseismic Studies," to be published in the *Bulletin of the Seismological Society of America.*

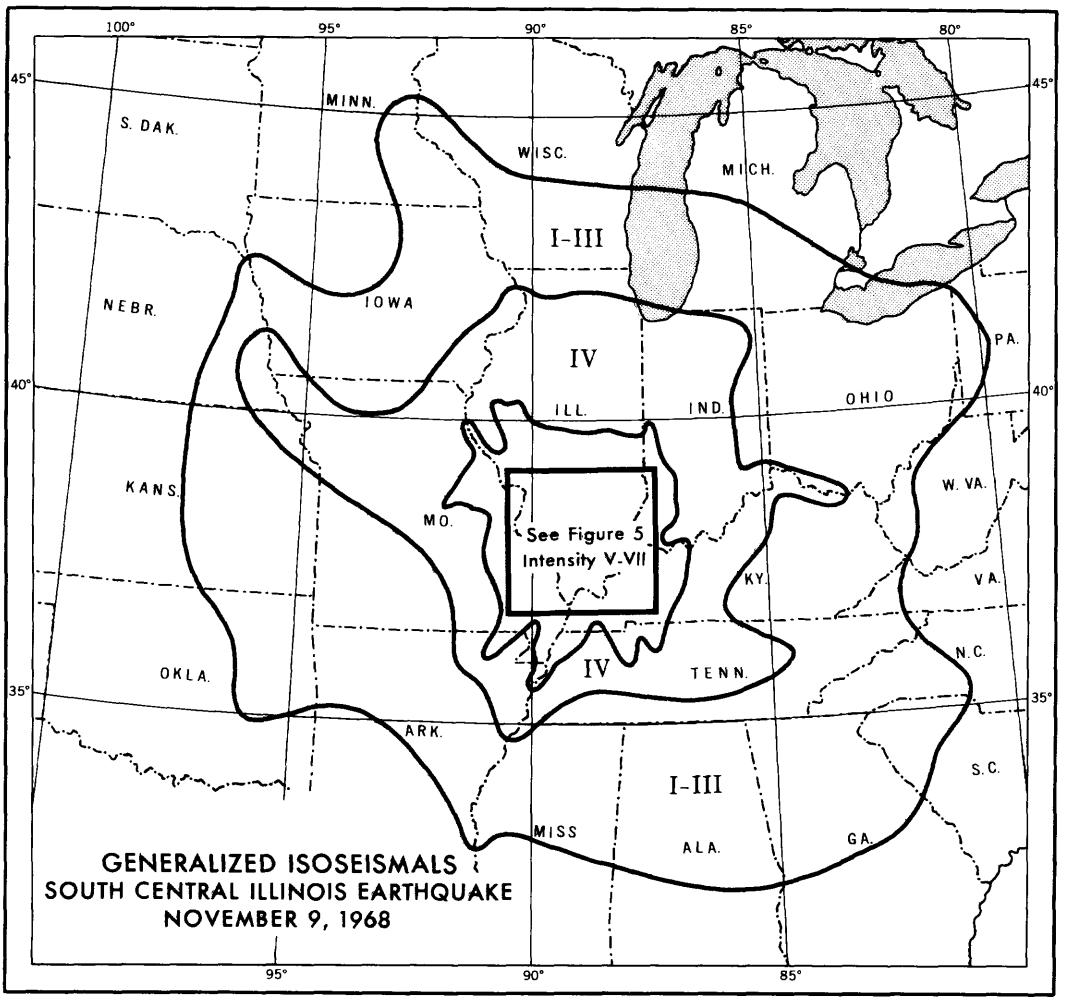

FIGURE 4.—Area affected by Illinois earthquake of November 9.

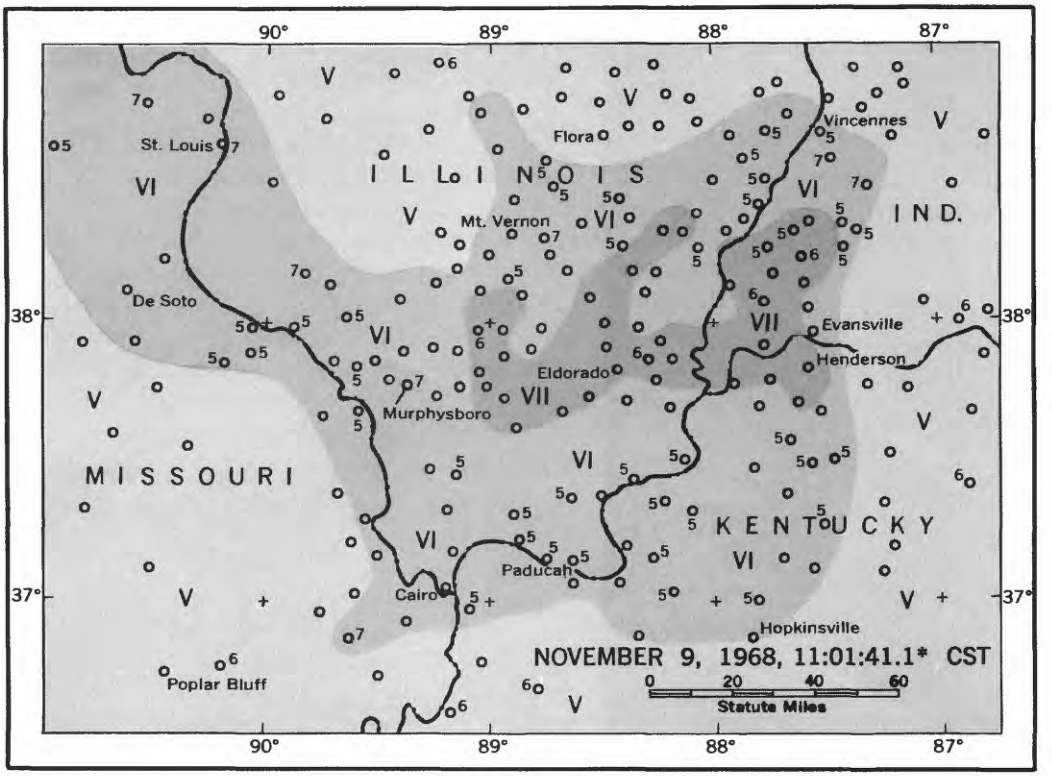

FIGURE 5.—Epicentral area of Illinois earthquake of November 9.

of the epicenter. There were isolated felt reports from people in tall buildings at more distant localities, such as Boston, Mobile, and southern Ontario. Earthquake damage in south-central Illinois consisted primarily of bricks thrown from chimneys, broken windows, toppled television antennae, and cracked plaster. In the epicentral area, intensity VII was characterized by downed chimneys, foundation cracks, and scattered instances of collapsed parapets and overturned tombstones. In every observed instance of chimney damage, the building affected appeared to be from 30 to more than 50 years old. A survey of cemeteries revealed that many tombstones had been rotated slightly, and a few had been thrown down. All of the overturned tombstones were found west of the epicenter at cemeteries on terraces overlooking Hogg Creek, Rector Creek, and the Middle Fork of the Saline River.

INTENSITY VII IN ILLINOIS:

Albion.—Felt by all and frightened many. Few chimneys toppled. Plaster cracked. Small objects overturned and fell. Damage slight.

Baldwin.—Felt by all and frightened few. Two chimneys knocked down. Plaster and windows cracked. Small objects fell. Moderate earth noises. Damage slight. "This shock was the most severe ever felt here, but there was not much damage. Several chimneys were downed, some plaster cracked, and some cracks in concrete buildings were widened."

Benton (near business district).—Felt by and frightened all. Chimneys cracked. Window and plaster cracked. Small objects overturned. Trees and bushes shook. "I was sitting in auto. It seemed as if someone were jumping up and down on bumper. Ground seemed to wave." Loud earth noises. Damage slight. Press reported chim-

ney collapsed at County jail. A wall fell at beauty shop on Main Street. Several small fires were reported throughout the city.

Bluford.—Felt by all and frightened several. Foundations cracked. Plaster, dishes, and one or two picture windows cracked. Furniture shifted. Small objects overturned and fell. Trees and bushes shook; vehicles rocked. Damage slight.

Broughton.—Felt by and frightened all in community. At the post office, marks in the asphalt flooring indicated a steel desk rotated about 1 degree counterclockwise. About 40 percent of the chimneys in town were damaged. Diagonal tension cracks were observed in exterior east and west walls of a 1-story brick building. Plaster fell. Small objects shifted and fell. Trees and bushes shook. Loud earth noises. Damage slight. "I ran outside and saw others that had run out of their homes too. Another slight tremor was felt about 10 minutes later. Church bells rang here. One of them had not rung for years, having been lodged in the belfry." At the Mt. Oval Cemetery, 5½ miles east of Broughton, tombstones were disturbed.

Dale.—Felt by all and frightened many. Chimneys cracked and twisted. Hamilton County Courthouse and library were damaged. At the service station, X-cracking occurred in south and east walls. In east side of station, a vertical crack about ½ inch wide formed between the office section and a later addition. Windows cracked; plaster cracked and fell. Trees and bushes shook. Big, booming earth noises. At the Texaco Flood Station, a two-story sheet-steel and reinforced concrete structure, abrasions on freshly-painted 2½-inch pipes gave an estimate of the relative movement between individual elements of the building. A scar 5 centimeters long was formed by a wall bracket rubbing against a horizontal pipe. In the northwest corner of the building, the action of a bracket 6½ feet above ground level formed a scar 9 centimeters long on a vertical pipe. On the second floor, a wooden desk was translated 1½ centimeters and rotated clockwise. During the shock, a reinforced concrete ground-level tank opened along preexisting hairline cracks, sending a jet of water 50 feet into the adjacent parking area. The cylinder, which had walls 1 foot thick and 12 inches high, and an outside diameter of 52 feet, was bound with five ¾-inch bands that probably prevented complete failure. When examined 1 week later, the tank had been repaired by caulking 1-centimeter vertical cracks in the south and west walls.

A large two-story brick house, 3½ miles west of Dale, sustained several thousand dollars in damage. Cracks occurred along the seams of all interior walls, and plaster fell where chimneys passed through the ceilings. Two large chimneys were broken and leaning, and the front porch pulled several inches away from the house. In the basement, a trace of powdered cement and chipped paint, 4½ feet above the concrete floor, marked the junction between the foundation and upper walls of the structure.

At Tuckers Corners, 6 miles west of Dale, merchant reported violent shaking tumbled one-third of his merchandise off shelves. Two fluorescent lights, which had hung from the ceiling by a hook and eyelet device, were found hanging by one hook and electric wiring. Shear cracks occurred in southwest corner of the store, and bricks in the chimney were loosened above the roofline. A concrete and brick cistern collapsed at a residence ½ mile north of Tuckers Corners.

At Braden, 7 miles west of Dale, a television antenna toppled from the roof of a house. Plaster cracked, and extensive china and glassware breakage occurred. An older home nearby lost its chimney. During the shock, waves with crests moving east to west were observed on Lake Jay, an artificial lake ¼ mile wide and adjacent to Braden.

At Little Springs Cemetery, 8½ miles west of Dale, tombstone was thrown to west from its pedestal.

Eldorado.—Felt by all and frightened many. Many chimneys fell. Plaster cracked. Furniture shifted. Heavy, thunderous earth sounds. Quake loosened parapet wall in front of two-story bank; in rear, window broke and diagonal X-crack appeared. Bricks loosened above entrance to Education Center. Debris dislodged from upper portion of twin, 150-foot-high, brick chimneys at abandoned mine, 2 miles southwest of Eldorado. Several monuments were thrown down, several rotated in cemetery.

Frankfort Heights.—Felt by all and frightened many. Chimneys cracked and overturned. Plaster cracked. Furniture shifted. Small objects fell. Trees and bushes shook; vehicles rocked. Safe moved in post office. Loud earth noises. Damage slight to moderate. "We felt three distinct quakes, noise with first two."

Galatia.—Felt by and frightened all. Chimneys torn down. Plaster cracked and fell. Windows broke. Dishes fell from cabinets. Cracked chimneys rotated counterclockwise. "At the time of the quake I was in the city cemetery 1 mile east of town. The earth trembled and tombstones shook." Loud earth noises.

Goldengate.—Felt by and frightened all. Chimneys fell. Windows cracked. Small objects shifted and overturned. Ground rolled. Trees and bushes shook; vehicles rocked. Rumbling earth noises. Damage slight.

Goreville.—Felt by and alarmed nearly all. Some old chimneys fell. Plaster cracked and fell. Some new walls and windows cracked. Trees and bushes shook; vehicles rocked. Damage slight.

Harrisburg.—Felt by and frightened many. Chimneys were wrecked. Walls, windows, and plaster cracked. Furniture shifted. Loose objects fell. Bricks fell from exterior wall of automobile agency. Damage moderate. "I could hardly stand on my feet it was so strong."

Herald.—Felt by and frightened all. Chimneys moved; some torn down. Plaster fell. Furniture shifted. Thirty percent of merchandise overturned and fell in store. Trees and electric lines moved. Damage slight.

Herrin.—Felt by and frightened all. Chimneys overturned. Windows broke. Small objects shifted. Trees and bushes shook. Moderate earth noises. Slight damage.

Marion.—Felt by and frightened many. Much chimney damage; some all the way to ground. Windows cracked. Small objects fell. Entrance to Baptist Church damaged. Trees and bushes shook. Loud earth noises. Damage moderate.

McLeansboro.—Felt by all and frightened many. Plaster cracked on second and third floors of Hamilton County Courthouse. Spalling scar 2 inches deep, 8 inches long, on reinforced concrete beam of courthouse. At Methodist Church, masonry fell from tower and top of rear wall. Diagonal X-cracks in rear wall of church. Ornate chimney damaged beyond repair at Memorial Library. Nineteen windows broke at high school gym. Chimneys and tombstones, cracked, twisted, and overturned. Some sidewalks cracked. Furniture shifted. Trees and bushes shook; vehicles rocked. Damage slight.

McLeansboro (7 miles south of).—Felt by and frightened all in home. Chimneys and elevated gas tanks badly cracked and broken. Windows pulled away from casing. Plaster broke and fell. Furniture shifted. Small objects overturned and fell. Hanging objects swung violently. Loud earth noises. Damage moderate to great.

Mill Shoals.—Felt by all and frightened few. Some chimneys broke. Plaster cracked and fell. Small objects overturned and fell. Bushes shook. Concrete block building cracked. Faint earth noises. Damage slight.

Murphysboro.—Felt by all and fright-

ened many. A few old chimneys partially collapsed. Water was disturbed. Plaster cracked. Small objects shifted and fell. Trees and bushes shook; vehicles rocked. Loud earth noises. Damage slight.

New Haven.—Felt by all and frightened many. Ground, sidewalks, and chimneys cracked; chimneys overturned. Windows cracked. Small objects fell. Trees and bushes shook. Loud earth noises. Damage slight.

Ridgway.—Felt by and frightened all. Bricks thrown from 35-foot section of parapet over 1½-story, W. M. Speckt Building. Tall chimney cracked above roofline on church. Knickknacks overturned. "I ran into next room of trailer and our tropical goldfish aquariums were rocking, and water was sloshing all over the floor." Windows cracked. Plaster cracked and fell. Furniture shifted somewhat. Trees and bushes shook. Loud earth noises. Damage slight.

Royalton.—Felt by many. General panic. A few chimneys knocked down. Block foundation slightly damaged. One block on northeast corner and one on northwest corner of foundation were moved outward approximately 1 inch. One block near center on south side moved outward. Furniture shifted. Stock fell from shelves. Rumbling earth noises. Damage slight.

INTENSITY VII IN INDIANA:

Cynthiana.—Felt by and frightened many. Chimneys cracked, twisted, and overturned. Objects fell to the floor. Trees and bushes shook. Loud earth noises.

Fort Branch.—Felt by community. Some chimneys fell. Plaster cracked. Pictures on wall shifted. Groceries fell from shelves in stores. Trees and bushes shook. "Metal springs on garage doors vibrated for more than 5 minutes." Roaring earth noises. Observer reported "no damage."

Mount Vernon.—Felt by and frightened all. Chimneys overturned; bricks fell from chimneys. Plaster cracked, broke, and fell. Furniture shifted. Small objects fell. Trees and bushes shook. Loud earth noises. Damage slight.

New Harmony.—Felt by all and frightened many. Chimneys fell. Cracks appeared in windows, basements, and walls. Plaster fell. Furniture shifted. Loud earth noises.

Petersburg.—Press stated that chimneys fell or partially collapsed.

Princeton.—Felt by all and frightened many. Ground cracked. Chimneys damaged. Plaster cracked. Furniture shifted. Small objects overturned. Trees and bushes shook. Rumbling earth noises. Damage slight.

Stewartsville.—Felt by and frightened all. Chimneys knocked off a few buildings. Plaster cracked and fell. Small objects fell. Trees and bushes shook. Moderate earth noises. Damage slight.

INTENSITY VII IN KENTUCKY:

Henderson.—Felt by and frightened all. Four or five chimneys toppled on old houses. Two old buildings cracked. Considerable masonry damage at the City Building. Plaster fell. Door came open. Pictures fell. Trees and bushes shook. Moderate earth noises. Damage very slight.

Poole.—Felt by and frightened all. Chimneys cracked; some fell. Trees and bushes shook; vehicles rocked. Loud rumbling earth noises. Observer also reported "no damage."

Smith Mills.—Felt by and frightened all. A few chimneys toppled. Plaster cracked. Furniture shifted. Small objects fell. Trees and bushes shook. "People who were moving in cars felt it only slightly, but drivers of large trucks felt it with such severity that they had to pull off to side of road." Moderate earth noises. Damage slight.

Uniontown.—Felt by all and frightened few. Chimneys fell or bricks broke off. Some objects shifted. Vehicles shook. Moderate earth noises. Damage slight.

INTENSITY VII IN MISSOURI:

Hermann.—Felt by many in community. Some chimneys fell on old buildings. Plaster cracked. Furniture and small ob-

jects shifted. Vehicles rocked. Damage slight.

St. Charles.—Felt by and frightened all. Chimneys knocked down. Overhang above service counter in post office knocked loose; one light fixture loose. Moderate earth noises.

Sikeston.—Felt by many and frightened few. One or two chimneys fell. Small objects shifted. Trees and bushes shook; vehicles rocked. "Shock was very brief."

St. Louis.—Press reported: Several injured by falling debris. Walls cracked, chimneys fell, and windows broke. A 15-by 20-foot section of southwest wall at Mid-American Metal Company collapsed. Civil War Museum at Jefferson Barracks closed due to a large crack opening in museum wall, causing bricks and plaster to fall. Many objects crashed to floors.

INTENSITY VI IN ILLINOIS:

Akin.—Felt by all and frightened many. Chimneys cracked. Dishes broke. Plaster cracked. Small objects fell. Trees and bushes shook. Hanging objects swung violently. Damage slight.

Albion (2 miles north of).—Felt by all and frightened few. Chimneys cracked. Plaster fell from ceiling on second floor. Damage slight. "Sounded like boiler system was getting ready to explode."

Anna.—Press reported part of roof caved in at State Hospital.

Arcola.—Felt by all and frightened few. Plaster cracked and fell. Grocery stores reported canned goods fell from shelves. Small objects shifted and overturned. Trees and bushes shook. Loud earth noises. Damage slight, if any.

Ava.—Felt by all and frightened few. Damaged chimneys reported. Plaster cracked and fell. Furniture shifted. Small objects fell. Hanging objects swung violently. Trees and bushes shook. Loud earth noises. Damage slight.

Avon.—Felt by all and frightened few. Ground around house cracked. Brick formations separated in chimneys. Plaster cracked around windows. Everything shook. Small objects and furniture shifted. Loud earth noises. Damage slight.

Belle Rive.—Chimneys cracked. Plaster cracked, broke, and fell. Furniture shifted. Small objects fell. Trees and bushes shook; vehicles rocked. Loud earth noises. Damage slight.

Belleville.—Felt by many. Chimneys overturned. Ceiling lights moved. Building rumbled. Loud earth noises. Damage slight.

Bellmont.—Felt by all and frightened few. Very few bricks loosened on chimneys. Small objects danced violently. Hanging objects swung violently. Moderate earth noises.

Browns.—Felt by and frightened all. Small objects shifted. Windows, doors, dishes, etc., rattled. Loud earth noises.

Buckner.—Felt by all. Brick building and chimneys cracked. Awnings loosened. Doors not in alinement with locks. Trees shook; wires set in motion. Loud rumbling. Damage very slight.

Cairo.—Felt by all and frightened many. Chimneys damaged. Some plaster and windows cracked. Stock fell from shelves in market. Damage slight.

Cambria.—Felt by all and frightened few. Some chimney damage and cracked foundations. Plaster broke in few cases. Powerlines and telephone wires swayed. Small objects dislodged. Observer also reported "no damage."

Carbondale.—Felt by all and frightened many. Putty cracked around picture windows of trailer. North-south crack in cement walk. Some oil tanks overturned, all oriented with long axis north-south. Small objects fell to the west. Television shifted slightly. Water in fish tank was splashed out on the west side. Trailer's blocks sank into mud on the northwest corner and had to be releveled after quake. Walking was difficult. Damage slight.

Carriers Mills.—Felt by and frightened all. Chimneys slightly damaged. Small objects overturned and fell. Trees and bushes

shook; vehicles rocked. Moderate earth noises. "I was looking at the ground and observed what appeared to be ripples in the earth. My home is a new frame structure. No damage, nothing broken. Others nearby reported dishes and other articles fell from shelves. Few loose bricks fell from chimneys."

Carterville.—Felt by and frightened many. Some chimneys damaged. Small objects overturned and fell. Wall fixtures fell. Trees and bushes shook. Faint earth noises. Damage slight.

Charleston (2 miles east of).—Felt by nearly all and frightened few. Shock caused leak in roof near chimney. Furniture shifted. Dishes fell from table. Trees and bushes shook. Noises like continuous, distant thunder. Damage slight. Press reported a 12-inch water main snapped at Charleston.

Chicago.—Felt by several; frightened all in home. Chimney crown partly off. Plaster cracked and fell. South wall cracked. Damage moderate.

Colp.—Felt by all and frightened many. Chimneys and foundation blocks cracked. Table moved 3 inches to north. Water spilled from container. Small objects shifted and fell. Damage moderate to brick flue. Loud earth noises.

Crossville.—Felt by all and frightened many. Little chimney damage. Plaster cracked in few places. Canned goods fell from shelves. Moderate earth noises. Very little damage.

Dahlgren.—Felt by all and frightened many. Chimneys damaged. Windows cracked. Plaster cracked in many homes. Small articles overturned. Furniture shifted. Trees and bushes shook. Moderate earth noises. Damage slight.

Dongola.—Felt by all and frightened many. Chimneys damaged. Small objects shifted. Hanging objects swung. Faint earth noises.

Dowell.—Felt by and frightened all. Bricks fell from chimneys. Plaster fell from walls. Dishes fell from shelves. Cars rocked. Loud earth noises. Slight damage.

Ellery.—Felt by all and frightened few. Chimneys cracked. Small objects shifted. Trees and bushes shook. Loud earth noises.

Emma.—Felt by and frightened all. Several chimneys damaged. Plaster cracked and fell. Small objects fell. Light poles swayed. Loud earth noises. Damage slight.

Enfield.—Felt by several and frightened few. Stones loosened in facade of post office. Windows cracked. Putty around windows cracked. Moderate earth noises.

Ewing.—Felt by and frightened all. Several chimneys cracked. Bricks fell. Plaster cracked and fell. Small objects overturned and fell. Trees and bushes shook. Loud earth noises. Damage slight.

Fairfield.—Felt by several in community. Chimneys damaged. Small objects shifted. Trees and bushes shook; vehicles rocked. Observer reported "no damage."

Golconda.—Felt by all. Some falling of brick and debris. Plaster fell. Small objects overturned and fell. Trees and bushes shook. Severe trembling and shaking.

Hidalgo.—Felt by all and frightened many. Some reported brick garages cracked. Furniture shifted. Vehicles rocked. Damage slight.

Junction.—Felt by community. Plaster and windows cracked. Furniture overturned. Small objects fell. Hanging objects swung violently. Trees and bushes shook. Loud earth noises. Damage slight.

Lawrenceville.—Felt by all and frightened many. Bricks fell. Plaster cracked on east and south wall. Very noticeable, constant noise for several seconds.

Logan.—Felt by several and frightened few. Bricks fell from chimney. Plaster cracked. Two windows broke, one cracked. Small objects overturned. Loud earth noises. Damage moderate.

Mattoon.—Felt by and frightened all. Chimneys damaged. Small objects shifted. Trees and bushes shook. Moderate earth noises. Damage moderate.

Mound City.—Press reported a house was shaken off its foundation.

Mount Erie.—Felt by and frightened all. Bricks fell from chimney tops. Plaster cracked. Foundations cracked in some buildings. Furniture shifted. Small objects fell. Powerlines shook. Rumbling earth noises. Damage slight.

Mount Vernon.—Felt by all and frightened many. Light fixtures suspended from ceiling at store plunged toward floor and were caught by safety chains. Chimneys cracked. Plaster cracked. Merchandise fell from shelves. Slight plaster cracks. Heavy rumble. Damage slight.

Mount Zion.—Felt by all and frightened few. Glass jars broke when knocked from shelves. Hanging objects swung moderately.

Mulberry Grove.—Felt by all and frightened few. Plaster and chimneys cracked. Furniture shifted. Moderate earth noises. Damage slight.

Norris City.—Felt by all and frightened many. Chimneys, walls, windows, and plaster cracked. Lots of glass breakage. Bricks dislodged from parapet wall above two-story building. Trees and bushes shook. Very loud earth noises.

Omaha.—Felt by and frightened all. Chimneys and plaster cracked. Furniture shifted. Small objects overturned. Hanging objects swung violently. Loud earth noises. Damage slight.

Orchardville.—Felt by and frightened all. Plaster and windows cracked. Furniture shifted. Cans fell from shelves. Trees and bushes shook. Moderate earth noises. Damage slight.

Ozark.—Felt by all and frightened few. Chimneys cracked. Plaster cracked. Small objects fell. Loud earth noises. Damage slight.

Pinckneyville.—Felt by many and frightened few. Bricks fell from chimneys and old buildings. Vehicles rocked. Moderate earth noises. "No noticeable damage in this community."

Rockwood.—Felt by all. Chimneys twisted. Small objects shifted. Damage slight.

Salem.—Felt by all and frightened few. Chimneys damaged. Few plaster cracks. Loud earth noises. Damage slight.

Sesser.—Felt by all and frightened few. Chimneys cracked. Hairline cracks in walls and foundation. Plaster cracked. Loud rumble. Damage slight.

Sesser (2 miles west of).—Felt by and frightened all. Plaster cracked and fell. Heavy mirror fell to floor. Dishes broke. Small objects shifted and fell. Loud earth noises. Damage slight.

Shawneetown.—Felt by all and frightened many. Chimneys cracked; one moved 2 inches. Plaster cracked, broke, and fell. Furniture shifted. Glasses in cabinet turned over. Knickknacks fell from shelves. Television antenna shook. Loud earth noises. Damage slight.

Sparta.—Felt by all and frightened few. Chimneys cracked. Plaster cracked. Furniture shifted. Small objects fell. Trees and bushes shook. Faint earth noises.

Staunton.—Felt by all and frightened many. Some panic. Some buildings and plaster cracked. Furniture shifted. Small objects overturned. Trees and bushes shook. Faint earth noises. Damage slight.

Sumner.—Felt by all and frightened few. Water was disturbed. Plaster cracked. Furniture shifted. Felt while driving car. Animals were disturbed. Damage very slight.

Tamaroa.—Felt by all and frightened many. Chimneys cracked. Plaster broke. Furniture shifted. Small objects overturned. Trees and bushes shook. Loud earth noises. Damage moderate.

Texico.—Felt by community. Few chimneys damaged. Plaster and windows cracked. Furniture shifted. Trees and bushes shook. Faint earth noises. Damage slight. "I was in a pickup truck. It shook the truck with great force."

Thompsonville.—Felt by all. General panic. Chimneys damaged. Plaster cracked

and fell. Windows cracked. Small objects fell. Trees and bushes shook. Loud earth noises. Damage moderate.

Vernon.—Felt by all and frightened few. Chimneys and plaster cracked. Small objects shifted. Loud earth noises, then rumbling sound.

Waltonville.—Felt by community; few frightened. Chimneys, walls, ceilings, and plaster cracked. Furniture shifted. Small objects fell. Water disturbed. Hanging objected swung violently. Trees and bushes shook. Moderate earth noises. Damage moderate.

Wayne City.—Felt by many and frightened few. Some bricks toppled from chimneys. Plaster broke and fell. Furniture shifted. Hanging objects swung moderately. Trees and bushes shook. Moderate earth noises. Damage slight to moderate.

West Frankfort.—Felt by all and frightened few. A few chimneys cracked. Some school buildings were slightly damaged. Plaster cracked. Small objects fell. Trees and bushes shook. Loud earth noises. Damage slight.

Zeigler.—Felt by and frightened many. Chimneys cracked. Waterline broke. Small objects shifted and fell. Loud earth noises.

INTENSITY VI IN INDIANA:

Evansville (Federal Building).—Felt by all. Two ornament columns on building dislodged. About 4 square feet of plaster fell from third floor ceiling. Small objects fell. Loud earth noises. Damage slight. Press reported a chimney fell on old house, and that plaster cracked and broke throughout the city. Bricks loosened on an old church building, and wall threatened to collapse.

Grandview.—Felt by and frightened all. Plaster cracked and fell. Furniture shifted. Small objects fell. Trees and bushes shook. Faint earth noises. Damage slight.

Griffin.—Felt by all and frightened many. Chimneys and plaster cracked. Small objects fell. Loud earth noises. Damage slight.

Haubstadt.—Felt by and frightened many. Some chimneys cracked. Plaster fell. Small objects shifted. Damage moderate.

Merom.—Felt by all and frightened many. Some chimneys cracked. Plaster cracked. Furniture shifted. Trees and bushes shook. Moderate earth noises. Damage slight.

Monroe City.—Felt by many and frightened few. One old chimney fell. Furniture shifted. Vehicles rocked.

Poseyville.—Felt by and frightened all. Chimneys damaged. Plaster cracked and fell. Furniture shifted. Trees and bushes shook. Moderate earth noises. "Fish jumped out of river, ponds, and lakes."

Shoals.—Plaster knocked from wall at Martin County Jail (press).

Terre Haute.—Felt by all. Some persons evacuated from buildings. Plaster and windows cracked; some cracks in cement structures. One X-crack located in brick building. Dishes broke. Damage slight.

Wadesville.—Felt by all and frightened few. Plaster fell. Furniture shifted. Small objects fell. Trees and bushes shook. Loud earth noises.

INTENSITY VI IN KENTUCKY:

Benton.—Felt by all and frightened many. Plaster cracked. Small objects shifted. Trees and bushes shook; vehicles rocked.

Cadiz.—Felt by and frightened many. Some bricks fell from chimneys. Plaster cracked. Small objects fell. Trees and bushes shook; vehicles rocked. Terrific noises. Damage slight.

Clay.—Felt by all and frightened many. Articles fell from shelves. Pots and pans rattled. Loud earth noises.

Clinton.—Felt by all and frightened many. One chimney fell. Dishes fell from shelves. Plaster and windows cracked. Trees and bushes shook. Faint earth noises. Damage slight.

Corydon.—Felt by and frightened all. Plaster cracked. Small objects shifted. Trees

and bushes shook. Loud earth noises. Damage slight.

Crofton (Post Office Building).—Felt by and frightened many. Some bricks fell from chimney tops. Furniture shifted. Small objects fell. Faint earth noises.

Dawson Springs (near).—Press reported several bricks fell from chimneys and a new school building cracked. Items fell from shelves.

Hampton.—Felt by and frightened all. Some chimneys damaged. Waterlines broke. Small objects shifted. Trees and bushes shook. Loud earth noises.

Hartford.—Felt by all and frightened few. Plaster cracked. Small objects shifted. Trees and bushes shook. Damage moderate.

Hickman.—Bricks fell from courthouse walls (press).

Paducah.—Few bricks fell from chimneys (press).

Sebree.—Bricks fell from chimneys (press).

Smithland.—Felt by and frightened many. Bricks fell from chimney. Small objects shifted. Trees and bushes shook. Loud earth noises.

Sturgis.—Felt by all and frightened many. Few chimneys damaged. Bushes shook. Rumbling sound, explosive at onset.

INTENSITY VI IN MISSOURI:

Bonne Terre.—Felt by all and frightened some. Plaster cracked, broke, and fell. One light was damaged. Moderate earth noises.

Broseley.—Felt by all and frightened many. Plaster cracked and fell. Small objects fell. Damage slight.

Cape Girardeau.—Felt by all in restaurant; few frightened. Chimneys damaged. Few cases of cracked windows, fallen plaster, and fallen objects. Trees and bushes shook. Loud earth noises. Damage slight.

Charleston.—Press reported concrete floor of new brick home was cracked. Numerous foundation cracks in churches. Plaster damaged at one church.

Crosstown.—Press reported chimney lost several bricks, and that plaster cracked throughout Perry County.

De Soto.—Felt by many and frightened few. Plaster cracked and fell. Small objects shifted, overturned, and fell. Trees and bushes shook. Loud earth noises. "Damage slight, if any."

Elsberry.—Felt by many and frightened few. Two chimneys damaged on one home. Plaster cracked. Furniture and small objects shifted. Trees and bushes shook. Roaring earth noises. Press reported several rows of brick and the iron rim of chimney were torn off and scattered on ground. Guy rod bent; chimney twisted.

Festus.—Felt by and frightened all. Furniture and small objects shifted. Trees and bushes shook. Faint earth noises.

Illmo.—Press reported machinery visibly moved, walls cracked, and that the whole community was frightened. Groceries fell from market shelves.

Jamesport.—Press reported furniture moved considerably and desks and chairs swayed. Plaster fell in some places.

Linn.—Felt by several; few frightened. Heavy safe moved. Damage slight. "Thought building would collapse."

Louisiana.—Press reported one chimney collapsed. Few loose bricks fell in scattered portions of city. Several reports of cracked walls in business district. Many swarmed into streets.

Marshall.—Felt by all; few frightened. Small objects shifted and fell. Car rocked rather violently.

Oregon.—Frightened all. Plaster broke. Small objects fell. Furniture shifted. Trees and bushes shook. Damage slight.

Troy.—Felt by all. Stock fell from store shelves. Trees and bushes shook. Damage slight.

Unionville.—Felt by and frightened many. Furniture and small objects shifted. Trees shook.

Weston.—Press reported that plaster fell, desk moved, doors banged, and light fixtures danced. Loud earth noises.

INTENSITY VI IN NEBRASKA:

Nebraska City.—Felt by several; frightened few. Plaster cracked. Gasline broke in old frame house, and fire from pilot light ignited gas. "House extensively damaged."

INTENSITY VI IN TENNESSEE:

Dyersburg.—Felt by many and frightened few. Furniture and small objects shifted. Hanging objects swung moderately.

Erin.—Felt by many. Water muddy after earthquake. Small objects shifted. Hanging objects swung. Moderate earth noises. No damage.

Hartsville.—Felt by many and frightened few. One city water main burst. "Sounds like a loud wind." No observable damage.

Huntingdon.—Felt by many and frightened few. Furniture and small objects shifted. Hanging objects swung. Moderate earth noises. Trees and bushes shook.

INTENSITY VI IN WISCONSIN:

Waukesha.—Felt by few. Water utility reported some breaks in mains that may have been caused by shock.

INTENSITY V IN ALABAMA:

Red Bay (press).

INTENSITY V IN ARKANSAS:

Jonesboro, Osceola, Paragould, Piggott, and Pocahontas.

INTENSITY V IN GEORGIA:

Cleveland.

INTENSITY V IN ILLINOIS:

Allendale, Annapolis, Ashley, Athens, Aviston, Barnhill, Bayle City, Beecher City, Bellwood, Bible Grove, Blue Island, Blue Mound, Bogota, Bone Gap, Bonnie, Bridgeport, Brocton, Brooklyn, Brookport, Brownfield, Carlinville, Carlyle, Cave in Rock, Centralia, Champaign, Clay City, Coffeen, Danville, De Soto, Dennison, Des Plaines, Dubois, Dundas, Edgewood, Edwardsville, Elizabethtown, Elmwood Park, Eureka, Evanston, Flat Rock, Flora, Fults, Galesburg, Geff, Geneseo, Grand Chain, Greenville, Havana, Hazel Dell, Highland, Hinsdale, Hutsonville, Ina, Iola, Iuka, Jacob, Jerseyville, Johnsonville, Jonesboro, Joppa, Karnak, Keensburg, Keyesport, Kinmundy, La Grange, Lake Bluff, Lancaster, Lincoln, Litchfield, Louisville, Macedonia, Markham, Maunie, Metropolis, Montrose, Mount Carmel, Mulkeytown, Neoga, Newton, Noble, Nokomis, Norridge, Oak Lawn, Oak Park, Oblong, Oconee, Olney, Oquawka, Oraville, Palestine, Palmer, Pana, Parkersburg, Patoka, Paxton, Percy, Perry, Petersburg, Pinkstaff, Quincy, Radom, Raymond, Riverdale, Robbs, Robinson, Rosiclare, Rushville, Saint Elmo, Saint Francisville, Shattuc, Shelbyville, Shumway, Sims, Skokie, Springerton, Springfield, Stonefort, Stoy, Streator, Taylorville, Teutopolis, Tunnel Hill, Tuscola, Urbana, Valier, Varna, Villa Park, Virginia, Wakefield, Walsh, Watson, West Liberty, West York, Wheeler, Whittington, Willow Hill, Winchester, Woodlawn, and Xenia. Press reports: Fairfield.

INTENSITY V IN INDIANA:

Attica, Bicknell, Blanford, Bloomfield, Chandler, Clinton, Crawfordsville, Crown Point, Decker, Doans, Edwardsport, Elnora, Emison, English, Evanston, Fairbanks, Fort Wayne, Francisco, Freelandville, Gary, Goshen, Graysville, Greenfield, Hatfield, Hazleton, Huntingburg, Indianapolis, Jasper, Linton, Little York, Lynnville, Medora, New Albany, New Lebanon, Newport, Nineveh, Oakland City, Owensville, Patoka, Portage, Rosedale, Somerville, South Bend, Spurgeon, Sulphur, Velpen, Vincennes, Washington, Westphalia, and Worthington.

INTENSITY V IN IOWA:

Albia, Bloomfield, Burlington, Clinton, Elkader, Muscatine, and Wapello.

INTENSITY V IN KENTUCKY:

Albany, Arlington, Baskett, Beech Grove, Blackford, Bremen, Burna, Calhoun, Cobb, Columbia, Dixon, Earlington, Elkton, Fordsville, Greenville, Hawesville, Hazel, Hebbardsville, Hodgenville, Manitou, Mar-

ion, Morgantown, Murray, Owensboro, Robards, Sheridan, Stephensport, Wheatcroft, and Wickliffe. Press reports: Fulton, Kenton, Kuttawa, Newport, Salem, Shelby, and Simpsonville.

INTENSITY V IN MISSISSIPPI:

Tunica.

INTENSITY V IN MISSOURI:

Albany, Altenburg, Alton, Augusta, Benton, Bowling Green, Centerville, Daisy, East Prairie, Farmington, Florissant, Fredericktown, Grant City, Greenville, Hendrickson, Huntsville, Ironton, Jackson, Lebanon, Maryville, Mexico, Montgomery City, New London, Oran, Painton, Palmyra, Parma, Plattsburg, Poplar Bluff, Portageville, Potosi, Saint Marys, Sainte Genevieve, Sullivan, Van Buren, Vanduser, Washington, Weingarten, and West Plains. Press reports: Cameron, Clarence, Crystal City, Lancaster, and Lawson.

INTENSITY V IN NEBRASKA:

Lincoln.

INTENSITY V IN OHIO:

Chillicothe, Columbus, Eaton, and Paulding.

INTENSITY V IN PENNSYLVANIA:

Lemont.

INTENSITY V IN SOUTH CAROLINA:

Gaffney.

INTENSITY V IN TENNESSEE:

Camden, Centerville, Charlotte, Chattanooga, Clarksville, Clinton, Cookeville, Decaturville, Fayetteville, Franklin, Gadsden, Gainesboro, Obion, Paris, Parsons, Pikeville, Ridgely, Sparta, Springfield, Tiptonville, and Union City.

INTENSITY V IN WISCONSIN:

Jefferson and Kenosha.

INTENSITY I–IV IN ALABAMA:

Anniston, Ashland, Birmingham, Centreville, Cullman, Double Springs, Florence, Fort Payne, Franklin, Gadsden, Greensboro, Greenville, Guntersville, Heflin, Huntsville, Mobile, Oneonta, Pell City, Russellville, Union Springs, and Vernon. Press reports: Littleville, Montgomery, Muscle Shoals, Phil Campbell, Prattville, and Sheffield.

INTENSITY I–IV IN ARKANSAS:

Batesville, Blythesville, Clarendon, Clinton, Dardanelle, De Valls Bluff, Forrest City, Hardy, Harrison, Helena, Lake City, Little Rock, Marked Tree, Melbourne, Mountain Home, and Murfreesboro. Press reports: Egypt, Monette, and West Memphis.

INTENSITY I–IV IN FLORIDA:

Pensacola.

INTENSITY I–IV IN GEORGIA:

Atlanta, Barnesville, Blue Ridge, Calhoun, Carrollton, Dahlonega, Dallas, Dawsonville, Dublin, Fayetteville, Franklin, Gibson, La Fayette, Lawrenceville, Madison, Monticello, Ringgold, Sandersville, Summerville, Toccoa, and Zebulon. Press reports: Augusta, Gainesville, Savannah, Swainsboro, and Thomson.

INTENSITY I–IV IN ILLINOIS:

Addison, Aledo, Arlington Heights, Barrington, Beecher, Bement, Bensenville, Berkeley, Berwyn, Birds, Bloomington, Broadview, Bushnell, Calumet City, Cambridge, Carrollton, Carthage, Caseyville, Chesterfield, Chicago Ridge, Christopher, Cisne, Claremont, Clinton, Crete, Crystal Lake, Decatur, Dieterich, Dix, Dixon, Downers Grove, Effingham, Elgin, Elkville, Elmhurst, Flossmoor, Forest Park, Freeport, Galena, Glencoe, Glen Ellyn, Glenview, Hamletsburg, Hardin, Hartsburg, Hazel Crest, Hebron, Herrick, Highland Park, Hillsboro, Hillside, Homer, Homewood, Indianola, Ingraham, Itasca, Jacksonville, Joliet, Keenes, Kell, Kenney, Lansing, Lerna, Lisle, Lombard, Macomb, Martinsville, Mason, Midlothian, Moline, Monmouth, Monticello, Morrison, Mount Carroll, Mount Prospect, Mount Sterling, Naperville, Nashville, New Lenox, Northbrook, Norwood Park, Oak Forest, Oregon, Ottawa, Park Ridge, Peoria, Peoria Heights, Pittsfield, Pocahontas, Pontiac, Posen, Ransom, River Forest, Riverside, Rockford, Rolling Meadows, Round Lake,

Saint Charles, South Holland, Tilden, Toulon, Venedy, Vergennes, Walnut Hill, Waterloo, Watseka, West Salem, Wheaton, Wheeling, Winnetka, and Yale. Press reports: Alton.

INTENSITY I–IV IN INDIANA:

Anderson, Bedford, Boonville, Brazil, Brownstown, Bruceville, Bryant, Buckskin, Carlisle, Chesterton, Columbia City, Columbus, Connersville, Corydon, Covington, Danville, Delphi, Elberfield, Fowler, Frankfort, Franklin, Goshen, Greencastle, Hammond, Hartford City, Indian Springs, Inglefield, Jeffersonville, Kingman, Knox, Lafayette, Lagrange, La Porte, Lawrenceburg, Liberty, Lincoln City, Logansport, Mackey, Marion, Martinsville, Marysville, Millersburg, Monticello, Mount Pleasant, Muncie, Nashville, Newburgh, New Castle, New Haven, Noblesville, Oaktown, Odon, Orleans, Otwell, Paragon, Paxton, Peru, Portland, Quincy, Ramsey, Rensselaer, Richmond, Rockport, Rushville, Saint Meinrad, Scottsburg, Shelburn, Smithville, Spencer, Stendal, Tell City, Tobinsport, Union City, Unionville, Valparaiso, Vernon, Versailles, Wabash, Whiting, Winamac, Winslow, and Youngs Creek.

INTENSITY I–IV IN IOWA:

Adel, Audubon, Bedford, Centerville, Chariton, Cherokee, Clarinda, Corydon, Davenport, Des Moines, Dubuque, Fairfield, Fort Madison, Indianola, Iowa City, Keosaqua, Manchester, Maquoketa, Marengo, Montezuma, Mount Ayr, Mount Pleasant, Nevada, Osceola, Oskaloosa, Ottumwa, Sidney, Sigourney, Sioux City, Tipton, Toledo, Washington, Waverly, West Union, and Winterset.

INTENSITY I–IV IN KANSAS:

Atchison Baxter Springs, Burlingame, Burlington, Cottonwood Falls, Fort Scott, Garnett, Hiawatha, Humboldt, Lawrence, Leavenworth, Manhattan, Marysville, Mound City, Pittsburg, Troy, Valley Falls, Wamego, Wellington, and Wichita.

INTENSITY I–IV IN KENTUCKY:

Adairville, Alexandria, Barlow, Bedford, Bowling Green, Brandenburg, Brooksville, Brownsville, Burkesville, Burlington, Calvert City, Campbellsville, Carrollton, Covington, Eddyville, Edmonton, Elizabethtown, Falmouth, Frankfort, Franklin, Glasgow, Greensburg, Guston, Hamlin, Hardinsburg, Harrodsburg, Hite, Hopkinsville, Inez, Irvington, Jamestown, La Grange, Lawrenceburg, Leitchfield, Lexington, Liberty, Lola, Louisville, Madisonville, Mayfield, Maysville, McDaniels, Monticello, Mount Sterling, Oak Grove, Owenton, Owinsgville, Pineville, Prestonsburg, Russellville, Saint Charles, Salyersville, Shelbyville, Shepherdsville, Somerset, Spottsville, Springfield, Taylorsville, Tompkinsville, Vanceburg, Warsaw, Welchs Creek, and Windsor.

INTENSITY I–IV IN MASSACHUSETTS:

Boston and Cambridge.

INTENSITY I–IV IN MICHIGAN:

Allegan, Cassopolis, Douglas, Flint, Grand Rapids, Hillsdale, Jackson, Kalamazoo, Muskegon, New Buffalo, Paw Paw, Saint Joseph, Stanton, and Watervliet. Press reports: Ann Arbor, Bath, Battle Creek, Centreville, Dearborn, Detroit, Edwardsburg, Kincheloe Air Force Base (near Sault Sainte Marie), Lansing, Rockford, Southfield, and Warren.

INTENSITY I–IV IN MINNESOTA:

Austin, Glencoe, Mankato, Minneapolis, Rochester, and Saint Paul.

INTENSITY I–IV IN MISSISSIPPI:

Aberdeen, Ashland, Batesville, Booneville, Clarksdale, Cleveland, Coffeeville, Corinth, Greenwood, Hernando, Iuka, Marks, New Albany, Oxford, Port Gibson, Ripley, State College, Tupelo, and University. Press reports: Columbus and Starkfield.

INTENSITY I–IV IN MISSOURI:

Bethany, Bolivar, Brookfield, Brunswick, Butler, California, Carrollton, Caruthersville, Clinton, Edina, Eminence, Fayette, Fulton, Gainesville, Gallatin, Garrison,

Hannibal, Harrisonville, Hornersville, Holland, Houston, Jefferson City, Kahoka, Kelso, Kennett, King City, Kingston, Kirksville, Kirkwood, Lamar, Linneus, Macon, Malden, Marshfield, Maysville, Memphis, Milan, Monticello, Mound City, Odessa, Paris, Platte City, Princeton, Revere, Rockport, Savannah, Sedalia, Shelbyville, Steelville, Stockton, Trenton, Union, University City, Vandalia, Versailles, Waynesville, Willow Springs, and Womack. Press reports: Belton, Bismarck, Bland, Bloomfield, Cabool, Dearborn, Ellington, Keytesville, La Grange, Licking, New Madrid, Norborne, Oak Grove, Owensville, Perryville, Poplar Bluff, Saint Clair, Shelbina, Stanberry, and Thayer.

INTENSITY I–IV IN NEBRASKA:

Auburn, Beatrice, Falls City, Nelson, Nemaha, and Omaha.

INTENSITY I–IV IN NORTH CAROLINA:

Franklin, Hayesville, Jefferson, Robbinsville, Sylva, and Waynesville. Press reports: Asheville.

INTENSITY I–IV IN OHIO:

Akron, Bryan, Celina, Georgetown, Greenville, Hamilton, Hillsboro, Ironton, Jackson, Kenton, Lancaster, Marion, Napoleon, New Lexington, Portsmouth, Toledo, Van Wert, Wapakoneta, Washington, Waverly, West Union, Wilmington, Xenia, Youngstown, and Zanesville. Press reports: Cincinnati, Cleveland, Dayton, Madisonville, Pleasant Ridge, and Springfield.

INTENSITY I–IV IN OKLAHOMA:

Durant, Eufaula, Miami, Oklahoma City, Pryor, and Vinita. Press reports: Tulsa.

INTENSITY I–IV IN PENNSYLVANIA:

Butler, Meadville, and Washington.

INTENSITY I–IV IN SOUTH CAROLINA:

Anderson, Blacksburg, Charleston, Clinton, Greenwood, and Laurens. Press reports: Barnwell and Greenville.

INTENSITY I–IV IN TENNESSEE:

Alcoa, Altamont, Ashland City, Athens, Benton, Byrdstown, Celina, Cleveland, Columbia, Covington, Dayton, Dickson, Dover, Dresden, Dunlap, Gallatin, Greeneville, Henderson, Hohenwald, Jackson, Jasper, Knoxville, Lafayette, Lawrenceburg, Lewisburg, Lexington, Linden, Lynchburg, Manchester, Martin, Maynardville, McKenzie, McMinnville, Memphis, Mount Pleasant, Munford, Nashville, Newport, Oak Ridge, Oneida, Pulaski, Ripley, Savannah, Selmer, Shelbyville, Smithville, Somerville, Spencer, Tracy City, Trenton, Tullahoma, Waverly, Waynesboro, Winchester, and Woodbury.

INTENSITY I–IV IN WEST VIRGINIA:

Hamlin, Huntington, Point Pleasant, Wayne, and Williamson. Press reports: Parkersburg.

INTENSITY I–IV IN WISCONSIN:

Baraboo, La Crosse, Milwaukee, Port Washington, Portage, Prairie Du Chien, and Sheboygan. Press reports: Beloit, Janesville, and Madison.

INTENSITY I–IV OUTSIDE UNITED STATES (CANADA):

Press reported the shock felt at Hamilton, London, Toronto, and Windsor.

WESTERN MOUNTAIN REGION

[105th Meridian or Mountain Standard Time]

January 13: 11:46. Denver, Colo., region. Magnitude 2.3 (Golden). Intensity III in farmland area northeast of Thornton.

January 16: 02:41:46*. Epicenter 39.3° north, 112.1° west, central Utah, W. Slight damage (No location was given.)

January 18: 07:30. Commerce City, Colo. Magnitude 2.4 (Golden). Intensity III at Commerce City and north of, in farmland area.

January 30: 08:20:05.6*. Epicenter 41.0° north, 117.4° west, north-central Nevada, W. Magnitude 4.5. Felt over approximately 3,500 square miles. No damage was reported, but intensity V effects were noted at Golconda and Valmy; intensity IV in Carlin area (Pine Valley), Midas, and

Paradise Valley; intensity I–III at Winnemucca.

February 21: 01:16:18.1*. Epicenter 38.6° north, 116.3° west, central Nevada, W. Magnitude 4.1. V. In Hot Creek Valley (about 30 miles west of Currant), drill rig shook strongly, and men in trailer were reportedly thrown from beds.

February 24: 07:06. Denver, Colo., region. Magnitude 2.2 (Golden). Felt in the farmland area north of Adams City, west of Commerce City, and along and near the Platte River bottom. "Things are moving at my home, Commerce City. Some cracks closing; carport posts loosen at ground level, then become tight; cinder blocks moving out from under shed."

March 26: 11:22:26.8*. Epicenter 47.7° north, 114.4° west, northwestern Montana, W. Magnitude 4.3. V. Felt over a small area of southwest Flathead Lake region. At Big Arm, new block addition to store sustained cracks. Intensity IV at Elmo, Polson, and Proctor.

April 8: 18:28:58.9*. See California and Western Nevada section, p. 31, for this southern California shock felt in Arizona and Nevada.

April 13: 15:47. Commerce City, Colo. Magnitude 2.4 (Golden). House shook a little.

May 22: 06:21:55.7*. Epicenter 38.6° north, 116.2° west, central Nevada, W. Magnitude 5.1. Felt at Eurkea (about 65 miles north of epicenter).

July 6: 07:02:42.0*. Epicenter 41.0° north, 117.4° west, north-central Nevada, W. Magnitude 5.1. Felt over approximately 9,500 square miles, but caused no damage. Intensity V effects were noted at Golconda, Rye Patch Dam (about 10 miles southwest of Imlay), and Winnemucca; intensity IV at Beowawe, Getchell Mine (about 20 miles northeast of Golconda), Imlay, Lovelock, Paradise Valley, and Tuscarora; intensity I–III at Valmy.

July 15: 11:33:12.1*. Epicenter 39.9° north, 104.8° west, Colorado, W. Magnitude 3.4 (Golden). V. Slight damage reported at two places in Commerce City. Small objects overturned at two homes. Strongest at Commerce City, Dupont, Henderson, Irondale, and north of the Rocky Mountain Arsenal. Also felt at Adams City, Denver (Bear Valley area), Brighton, Broomfield, Eastlake, Northglenn, Thornton, and Welby.

July 17: 11:26:42*. Intensity IV at Marysville, Mont.

July 20: 04:36:23.7*. Epicenter 44.0° north, 114.4° west, south-central Idaho, W. Magnitude 3.1. Intensity IV at the Clayton Ranger Station located about 6 miles south of Clayton.

July 27: 12:06. Magnitude 2.3 (Golden). Intensity III at Commerce City, Colo.

August 3: 23:23:36.4*. Epicenter 39.1° north, 111.4° west, Utah, W. Magnitude 4.0. Intensity II at Clawson.

August 12, 13, and 14: No times given. Intensity IV in the Sunbeam Resort area of Idaho (about 10 miles northeast of Stanley).

August 13: 19:03. Magnitude 2.3 (Golden). Intensity III at Commerce City, Colo.

September 24: 07:51. Magnitude 2.4 (Golden). Intensity IV in the Denver, Colo., area.

November 2: 07:28. Magnitude 3.0 (Golden). Intensity IV at Commerce City, Colo. Also felt at Brighton (south of), Denver and east of, Irondale, Northglenn, Rocky Mountain Arsenal and about ½ mile east of, Thornton, Welby, and Westminster.

November 19: 14:01:10*. Intensity III at Great Falls, Mont.

November 28: 21:27. Magnitude 2.3 (Golden). Intensity III at Commerce City, Colo. Also felt north of Commerce City and east and west of the Platte River.

November 29: 10:43. Intensity IV at the Clayton Ranger Station (about 6 miles south of Clayton), Idaho.

CALIFORNIA AND WESTERN NEVADA

[120th Meridian or Pacific Standard Time]

NOTE: All places mentioned are in California unless otherwise stated.

January 9: 23:51:22.3*. Epicenter 37° 46.9′ north, 122°35.3′ west, central California, B. Magnitude 2.5. Intensity III at San Francisco.

January 13: 20:32:52.8*. Epicenter 35° 23.0′ north 117°55.6′ west, central California, P. Magnitude 2¾–3. Intensity IV at Cantil.

January 18: 13:22:31.2*. Epicenter 33° 51.7′ north, 118°28.2′ west, southern California, P. Magnitude 3.2. Intensity II at Manhattan Beach.

January 18: 22:22:53.7*. Epicenter 34° 10.1′ north, 117°16.6′ west, southern California, P. Magnitude 2.6. Felt at San Bernardino.

January 19: 04:08:55.4*. Epicenter 33° 56.8′ north, 118°16.1′ west, southern California, P. Magnitude 3.0. Felt at Inglewood, Torrance, and Venice.

January 19: 19:50:58*. Epicenter 40.2° north, 124.3° west, near coast of northern California, W. Magnitude 3.8, B. Intensity IV at Ferndale; intensity III at Scotia.

January 25: 05:55:00.4*. Epicenter 33° 04.3′ north, 115°45.3′ west, southern California, P. Magnitude 3.1. Felt at Westmorland.

January 30: 03:50:13.9*. Epicenter 33° 52.7′ north, 118°29.0′ west, southern California, P. Magnitude 3.1. Intensity III at Manhattan Beach. Also felt at Commerce and Maywood.

February 5: 16:41:37.2* (main shock), 17:19:14.7*, 19:48:12.0*. Epicenter (1) 38.0° north, 118.4° west; (2) 38.1° north, 118.1° west; (3) 38.0° north, 118.4° west, California-Nevada border region, W. Magnitudes 4.6, 4.0, and 4.4, respectively. VI. Felt over about 8,000 square miles of eastern California and western Nevada. Rocks fell onto the highway 2 miles west of Mount Montgomery Pass Highway Station, Nev. Intensity V at the Highway Station and at Benton and Owens River Gorge, Calif.; intensity IV at Dyer, Gabbs, Gardnerville, Hawthorne, and Mina, Nev., and Deep Springs, Dunlap, June Lake, and Tinemaha, Calif. Intensity I–III in several towns.

February 13: 13:33:38.2*. Epicenter 33° 52.9′ north, 118°16.7′ west, southern California, P. Magnitude 2.3. Felt in southwest Los Angeles area.

February 21: 03:55. Intensity IV at San Gregorio.

February 21: 06:39:48.0*. Epicenter 37° 11.0′ north, 121°33.7′ west, central California, B. Magnitude 3.8. Intensity V at Corralitos, Morgan Hill, San Martin, and Soquel; intensity IV at Aptos (4 miles north of), Aromas, Gilroy, Hollister, and Mountain View; intensity I–III at Aptos, Milpitas, Mission San Jose, Mount Hamilton, and Santa Cruz.

February 25: 04:39:16.0*, 18:51:26.4*. Epicenter (1) 40.4° north, 120.9° west, B; (2) 40.0° north, 121.1° west, northern California, W. Magnitudes 3.1 and 3.7, respectively, B. Intensity IV at Keddie (about 7 miles north of Quincy).

March 3: 04:05:26.3*. Epicenter 33° 56.7′ north, 118°18.9′ west, southern California, P. Magnitude 2.7. Felt at Inglewood.

March 6: 01:15. Press reported a shock at Santa Cruz.

March 7: 21:48:54.6*. Epicenter 34°10.9′ north, 117°03.1′ west, southern California, P. Magnitude 3.4. Felt at San Bernardino.

March 14: 06:05. Intensity IV in Bishop area.

March 21: 13:55:00.3*. Epicenter 37°01.4′ north, 121°44.7′ west, central California, B. Magnitude 4.3. Felt over approximately 3,500 square miles, but caused no damage. Intensity V at Aptos, Corralitos, and Morgan Hill; intensity IV at Alvarado, Alviso, Aptos (4 miles north of), Ben Lomond, Capitola, Coyote, Freedom, Gilroy, Holy City, Jamesburg, Mountain View, New Almaden, Newark, Pinnacles National Monument, Salinas, San Bruno, San Francisco, San Martin, Soquel, and Sunnyvale; intensity I–III at Berkeley, Bolinas, Daly City-Colma, Half Moon Bay, Los Gatos, Milpitas, Moraga, Mount Hamilton, Oakland, Palo Alto, San Jose, Sunol, and Union City.

March 25: 03:32:07.4*. Epicenter 36° 22.1′ north, 120°41.8′ west, central California, B. Magnitude 3.6. Intensity V at Idria; intensity IV at Panoche.

March 25: 08:25:55.4*. Epicenter 36° 37.6′ north, 121°17.1′ west, central California, B. Magnitude 3.5. Intensity IV at Soledad.

March 27: 20:53:27.5*. Epicenter 36° 09.6′ north, 120°08.6′ west, central California, P. Magnitude 3.3. Intensity IV at Avenal and 6 miles northeast of.

March 28: 13:21:33.4*. Epicenter 34° 03.1′ north, 116°07.3′ west, southern California, P. Magnitude 4½. Felt over approximately 4,000 square miles of Riverside and San Bernardino Counties, but no damage was sustained. Intensity V at Cathedral City and White Water; intensity IV at Eagle Mountain, Indio, Mountain Center, North Palm Springs, Palm Springs, Rancho Mirage, Thousand Palms, and Twenty-nine Palms; intensity I–III at Chiriaco Summit, Coachella, La Quinta, Pioneertown, Sky Valley, Thermal, and Twenty-nine Palms (near, at Marine Corps Station).

April 2: 08:15:15*. Epicenter 40.1° north, 120.7° west, northern California, B. Magnitude 3.2. Felt at Keddle, Storrie, and Twain.

April 4: 13:08:58*. Epicenter 40.0° north, 120.8° west, northern California, B. Felt at Quincy.

April 8: 18:27:36.7*. Epicenter 33°10.5′ north, 116°07.3′ west, southern California, P. Magnitude 3.7. (Foreshock of 18:28: 58.7*). Felt at the Ironwoods Motel, about 3 miles west of Ocotillo Wells.

April 8: 18:28:58.9*. Epicenter 33°12.0′ north, 116°06.9′ west, southern California, P. Magnitude 6.5. VII. Felt over approximately 60,000 square miles of southern California, western Arizona, and southern Nevada (see fig. 6). Intensity VII was assigned to a small area in northeastern San Diego County, principally in the Borrego Mountain-Ocotillo Wells area. Minor displacements were observed on the Coyote Creek Fault, and Highway 78 was cracked adjacent to Ocotillo Wells. Large boulders fell at several points in the Anza-Borrego Desert State Park. At Ocotillo Wells, a room separated from rest of house; walls split over doorways and at room corners; 3,600 gallons of water gushed from storage tank. About 3 miles west of Ocotillo Wells, water pipes in a building broke; tile block cracked; water from swimming pool flooded the building. Large transformers were shifted, shearing anchor bolts and breaking X-bracing at a substation about 3.2 miles south-southeast of Ocotillo Wells. About 6 miles west of Imperial, there was a 200-foot-long, 2-inch-wide crack in a road. Minor damage also occurred in the San Diego area, in Los Angeles, and at Yuma, Ariz.

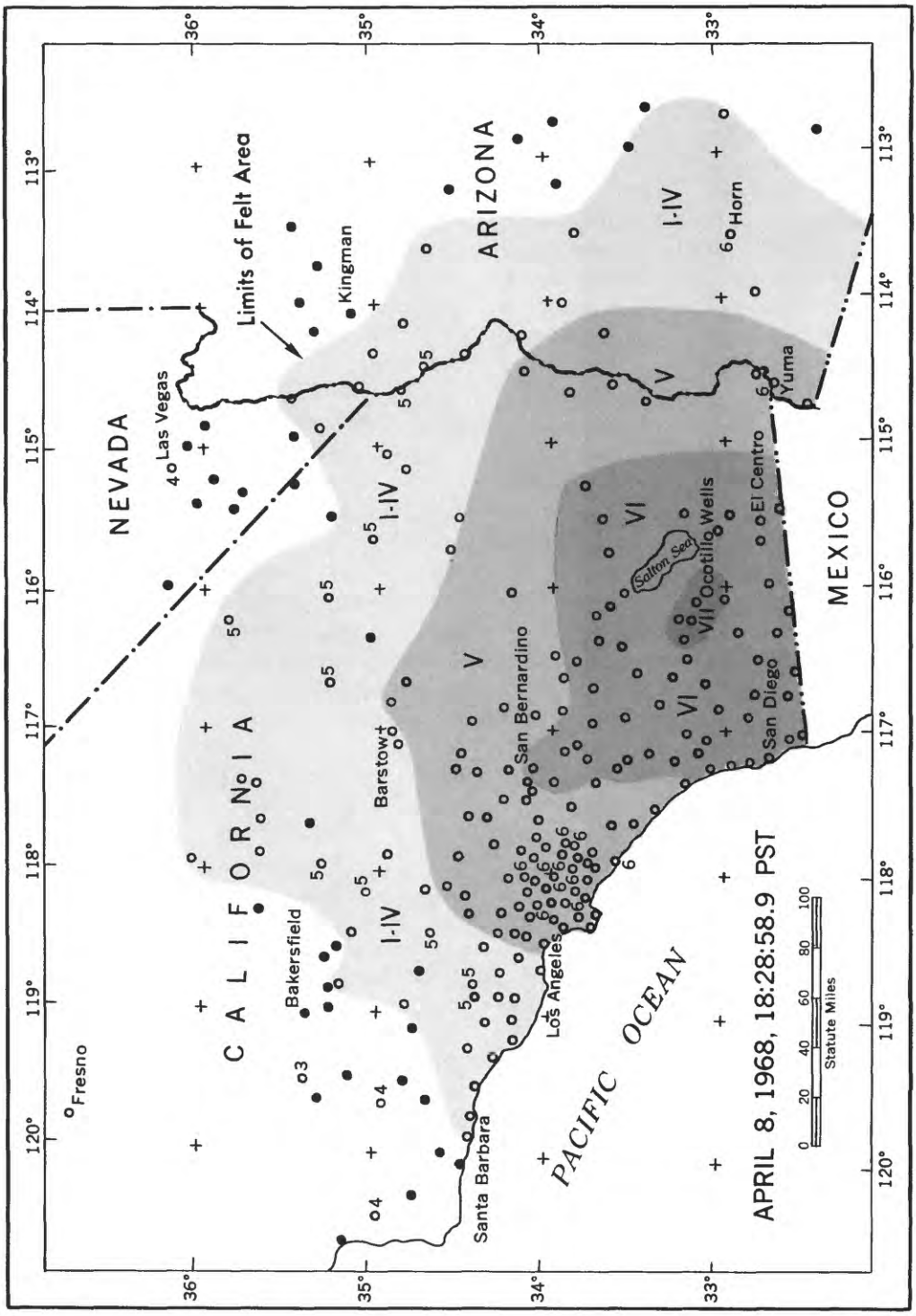

FIGURE 6.—Area affected by southern California earthquake of April 8.

INTENSITY VII:

Anza-Borrego Desert State Park.—Park rangers reported: "Earthquake was very heavy. Rockslides occurred at Font's Point, Palm Canyon, Split Mountain, and in other areas. Font's Point suffered heavy damage from cracking and upheaval." A ranger at Split Canyon reported: "Vehicles of campers in the Split Mountain area were damaged by falling rocks. Dust rose several hundred feet. Much falling of sandstone blocks from sides of canyon; also falling rocks, mostly granite, weighing up to several tons." Huge boulders blocked the Montezuma-Borrego Highway at the head of Culp Canyon, about 3 miles southwest of Borrego Springs.

Coyote Creek Fault.—In a preliminary report[1] C. R. Allen, et al., reported:

"The earthquake was accompanied by right-lateral displacement along a 33-km segment of the Coyote Creek fault—a major branch of the San Jacinto fault zone, which in turn is the most active member of the San Andreas fault system in southern California. Earthquakes of comparable magnitude had occurred earlier along the San Jacinto fault zone just to the north of this area in 1954 and just to the south in 1942, but no known major historic activity had occurred along the exact segment broken on April 9th . . . .

"The fault break consists of two northwest-trending en echelon segments that overlap and are separated by a 2-km-wide zone of highly fractured terrane just southeast of the settlement of Ocotillo Wells. The maximum displacement observed was along the northern segment, 5 km northwest of Ocotillo Wells, where 38 cm of right-lateral slip was indicated by offset channels and vehicle tracks and by displaced slabs of dried mud crust. The maximum horizontal slip observed along the southern segment, 20 cm, was noted 10 km southeast of Ocotillo Wells. Vertical displacements were nil in most areas where the fault cut level ground, but wherever the break lay along a pre-existing fault scarp or bordered hills, vertical displacements of up to 20 cm occurred—almost invariably with the same sense of displacement as that of the earlier movements that produced the fault scarps and hills. Neither side was consistently uplifted with respect to the other.

"In most areas, the fault trace comprised a series of overlapping en echelon cracks. The total width of the fractured zone along the main fault trace varied from less than 1 meter to several hundred meters, but in the wider parts of this zone most of the displacement took place in a narrower zone of fractures that ranged in width from less than 1 to 15 or 20 meters . . . .

"In addition to the primary displacement of the Coyote Creek fault, minor horizontal displacements or creep episodes must have taken place at about the same time on the Superstition Hills fault, Imperial fault, and Banning-Mission Creek (San Andreas) fault . . . Although these fresh breaks were not noticed until a few days after April 9th, no other significant earthquakes have been identified in these areas, and the remarkable freshness of the surficial cracks makes it highly likely that the displacements or creep episodes were triggered by the Borrego Mountain earthquake."

Ocotillo Wells.—Press reported four or five cracks, 3 to 4 inches wide, across Highway 78 about ½ mile from the Ocotillo Wells Inn. Ground cracks were also noted at the airport. One bedroom was completely detached from rest of home; walls split over doorways and at corners of rooms. Thirty-six hundred gallons of water gushed out of the storage tank next to house and spewed out over the porch, the posts of which fell to the ground. The pump in the community well broke, leav-

[1] "The Borrego Mountain, California, Earthquake of 9 April [GMT] 1968: A Preliminary Report," *Bulletin of the Seismological Society of America*, vol. 58, No. 3, June 1968.

ing most without water for some time. Three miles west of Ocotillo Wells, water pipes and sewerage pipes broke at a motel. Water from the swimming pool flooded lower floor. Tile block cracked. At a residence near the motel, pumice block was slightly damaged; well water was muddied; boat fell off blocks. About 10 miles northwest of Ocotillo Wells at a ranch, well water became dark; pipeline sprung leaks; swimming pool lost 1½ feet of water.

INTENSITY VI:

Agua Caliente Springs.—Felt by all and frightened few. Springs opened—more water. Small objects shifted, overturned, and fell. Vehicles rocked.

Aguanga.—Felt by all and frightened few. Coffe slopped out of half-full cups on table. Trees and bushes shook; vehicles rocked.

Alpine.—Felt by all and frightened many. Cracks in yard opened 2 inches. Furniture shifted. Trees and bushes shook; vehicles rocked. Press reported waves in swimming pools.

Anza.—Felt by all and frightened many. Plaster broke. Cracks in concrete slab floor widened. Drawers moved out. Trees and bushes shook; vehicles rocked.

Arcadia.—Felt by all. Water sloshed from swimming pool. Furnishings shifted. Trees and bushes shook strongly.

Barrett Dam.—Felt by and frightened many. Ground cracked. Minor rockslides noted. Trees and bushes shook; power poles swayed.

Beaumont (2.9 miles northeast of).—Felt by all; frightened few. Everything loose rattled. Small objects shifted. Hanging objects swung violently. Trees and bushes shook.

Borrego Springs.—Felt by all and frightened many. Windows and ground cracked. Slight crack in church facade. Furniture shifted. Trees and bushes shook. Damage slight. Slight damage was also sustained 5 miles east of Borrego Springs. Furniture shifted; 7 inches of water sloshed from swimming pool.

Boulevard.—Felt by and frightened all. Chimneys, plaster, and windows cracked. Landslides occurred. Furniture shifted. Trees and bushes shook; vehicles rocked.

Brawley.—Felt by all and frightened many. Hanging objects swung violently. Trees and bushes shook; vehicles rocked. Press reported grocery stores were forced to close due to fallen and broken merchandise. At the Moore Ranch, 7 miles west of Brawley, water sloshed from reservoir. Small objects shifted, overturned, and fell. At the Wieman Ranch, about 3 miles west of Brawley, plaster broke and furniture shifted. Damage slight.

Brea.—Felt by all and frightened few. Much canned goods fell off shelves. People in supermarket fell to floor. Hanging objects swung violently. Trees and bushes shook.

Calexico.—Felt by all and frightened few. Furniture shifted. Small objects fell. Trees and bushes shook; vehicles rocked. Press reported a portion of ceiling fell in a supermarket.

Calipatria.—Felt by all and frightened many. Plaster cracked. Hanging objects swung violently. Trees and bushes shook; vehicles rocked. Press reports indicated electricity was temporarily interrupted in the north section of town.

Campo.—Felt by and frightened all. Plaster cracked, broke, and fell. Small objects overturned and fell. Furniture shifted. Trees and bushes shook; vehicles rocked.

Chiriaco Summit.—Felt by all in community. Hanging objects swung violently. Powerline insulator (hanging in store), 24 inches long and consisting of six glass knobs, swung for about 15 minutes.

Chula Vista.—Felt by all in community. Many grocers had shelves emptied. Motion started gently, but increased to a very noticeable shock. "It surprised me that no more cracking of glass or plaster occurred." Power out in 4 square-mile area.

Coachella.—Felt by and frightened all. Small objects fell. Furniture shifted. Plaster cracked. "A great deal of breakage." Water disturbed. Press reported some utility lines were knocked down.

Colton.—Felt by all. Parked car rocked from side to side. Rocking, rolling motion caused feeling of seasickness. Flag standard in building rolled, and flag waved back and forth.

Coyote Wells (about 3 miles east of Ocotillo.—Building on Highway 80 shook and made loud cracking noise. Small objects shifted, overturned, and fell. Vehicles rocked.

Curtis.—Felt by all in community (located southeast of Aguanga). Trees and bushes shook; vehicles rocked. Moderate earth noises.

Del Mar.—Felt by all in home. Groceries fell at supermarket. Hanging objects swung moderately.

Descanso.—Felt by all and frightened many. Rolling and heaving motion. Everything shook for 3 minutes. Small objects moved 1 to 2 inches. At the Descanso Ranger Station, a chimney cracked and dishes fell. Damage slight.

Desert Center.—Felt by all. Small objects overturned and dishes fell. "Canal water level showed 0.1-foot movement on still well charts."

Dulzura.—Felt by all. Small objects shifted, overturned, and fell. Trees and bushes shook; vehicles rocked. Loud earth noises. Rocks were reported on Highway 94, about 12 miles west of Potrero in Dulzura area.

Eagle Mountain (10 miles east of).—Felt by and frightened many. Swimming pool had waves about 6 inches high, and about 100 gallons of water slopped out on northwest-southeast sides. Hanging objects swung violently.

El Cajon.—Press reported a garage shelf fell on a car.

El Centro.—Felt by all in community; awakened and frightened few. Hanging objects swung violently. Small objects fell. Trees and bushes shook; vehicles rocked. Press reported customers ran from stores when food fell from shelves. Several glassware stores reported minor damage. Manikins toppled. Part of ceiling fell at one store. The Balboa Hotel was damaged. Plaster fell from walls and ceilings on the second floor, foundation shifted some, and screens fell from windows. Manager was injured when a ladder was jolted from under him. Pacific Telephone Headquarters reported power went out for about 4 hours. One cable TV microwave unit was knocked out of commission. Burglar alarms were activated.

Encinitas.—Press reported fire truck rolled 1 foot back and forth. Fireman thought he was going to faint.

Escondido.—Felt by all and frightened few. Small objects shifted and fell. Trees and bushes shook moderately; vehicles rocked. Loud earth noises. Damage slight. Press reported burglar alarms were activated.

Fallbrook (4½ miles south of).—Felt by all; frightened few. Hanging objects swung moderately; two unstable dolls toppled. Powerlines swayed noticeably, and pole guy protectors made noises. At the Rainbow Conservation Camp, about 6 miles northeast of Fallbrook, coffee pot overturned; several pictures shifted. Crack at base of chimney ½ inch wide and 14 inches long.

Gilman Hot Springs.—Felt by all. Small objects shifted. Trees and bushes shook; vehicles rocked. Water splashed. Loud earth noises.

Guatay.—Felt by all and frightened few. Few rocks fell from chimneys. Plaster cracked. Small objects shifted.

Hacienda Heights (2 miles south of Pomona Freeway).—Felt by all. Tall, slender trees swayed slightly. Bookcase on east wall overturned.

Heber.—Felt by all and frightened few. Plaster cracked, broke, and fell. Small ob-

jects shifted, overturned, and fell. Trees and bushes shook; vehicles rocked. Hanging objects swung violently. Water disturbed.

Hemet.—Felt by and frightened all in building. Small objects shifted and fell. Trees and bushes shook. Fairly loud earth noises. Press reported some utility lines were knocked down near Hemet and that power failures and disruptions in telephone service occurred. Five miles east of Hemet, water in swimming pool sloshed over sides for 10 minutes after the shock was apparently over. Movement in trailer was violent. "Impossible to walk in trailer during shock."

Holtville.—Felt by all. Small objects overturned and fell. Trees and bushes shook. Damage slight. Press reported about $250 damage in market due to broken merchandise.

Homeland.—Felt by all. Small objects shifted and fell. Trees and bushes shook. Moderate noises.

Idyllwild.—Felt by all. Small objects shifted and fell. Hanging objects swung violently in all directions. Loud earth noises.

Imperial.—Felt by and frightened all. Plaster and chimneys cracked; some windows broke. Furniture shifted. Trees and bushes shook. Water disturbed. Press reported about 7,500 books at public library were dumped from shelves. Downtown area had a 15-minute power outage. About 6 miles west of Imperial, press noted a crack in road about 200 feet long and 2 inches wide, believed to have been caused by settling of roadbed.

Indio.—Felt by all and frightened many. Plaster and few windows cracked. Small objects shifted and fell. Trees and bushes shook. Water sloshed over sides of swimming pools. Faint earth noises. Damage slight.

Jacumba.—Felt by all and frightened many. Small objects overturned and broke. Trees and bushes shook. Loud earth noises. Landslides were noted on the new freeway in Jacumba area.

Jamul.—Felt by all and frightened few. Ground cracked. Plaster cracked. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. Loud earth noises. Damage slight.

Julian.—Felt by all and frightened many. Furniture and small objects shifted. Trees and bushes shook. Faint earth noises.

Lakeside.—Felt by all. Trees and bushes shook. Press reported heavy damage at pharmacy and liquor store, where large plate glass window broke and much merchandise was damaged.

Lakewood.—Felt by all and frightened many in building. Plaster cracked. Books fell. Small objects shifted. Trees and bushes shook slightly. Loud earth noises. Damage slight.

La Quinta.—Felt by all and frightened many. Plaster cracked. Cement waterlines broke. Furniture shifted. Hanging objects swung violently. Water disturbed in swimming pools. Damage slight.

Leucadia (6 miles south of).—A well-built house on hillside had plaster cracks in several places.

Live Oak Springs.—Felt by and frightened all. Chimneys and windows cracked. Plaster cracked and fell. Small objects fell. Trees and bushes shook.

Long Beach.—All ran outdoors at Naval base. Press reported police switchboards were flooded with calls. At Long Beach Naval Shipyard, the *Queen Mary,* in drydock, rocked back and forth on keel blocks for 5 minutes following the shock.

Los Angeles.—Felt by and frightened all in community. A structural engineer reported that he inspected two downtown buildings after the earthquake. Both were constructed prior to any earthquake code design criteria. Damage in both was limited almost entirely to reopened or slightly enlarged plaster cracks which resulted from the 1933 and 1952 earthquakes. There was also slight "banging" crumbling where one

building was constructed tight against the other. Intensity was generally V and below in other sections of Los Angeles.

Mecca.—Felt by all and frightened many. Concrete pipelines broke. One old water well had underground casing broken. Furniture shifted. Date palm trees, 40 feet high, danced. Partly loaded truck almost overturned. Campers reported seeing a dust cloud from rockslides in the Box Canyon area.

Moreno.—Felt by all and frightened many. Small objects shifted and fell. Trees and bushes shook. Faint earth noises. Damage slight.

Morongo Valley.—Felt by all. One crack occurred in cement block wall. Vehicles rocked. Faint earth noises.

Mountain Center.—Felt by all and frightened few. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. Loud earth noises.

Mount Laguna.—Felt by all and frightened few. Small objects shifted and fell. Trees and bushes shook; vehicles rocked. Moderate earth noises.

Murrieta.—Felt by and frightened all. Trees and bushes shook; vehicles rocked. Hanging objects swung violently.

Newport Beach.—Felt by all; awakened and frightened few. Small objects shifted. Trees and bushes shook. Faint earth noises. Press reported small pavement cracks.

Nightinggale.—Felt by all in community (Pinon Pines). Hanging objects swung violently. Moderate earth noises. Damage slight.

Niland (2 miles north of).—Felt by all. Small objects shifted and fell. Trees and bushes shook. Damage slight.

North Shore (north shore of Salton Sea). Felt by all and frightened many. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. Loud earth noises. Damage slight.

Ocotillo.—Felt by all; some frightened. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. Press reported that diners at restaurant on Highway 80 fled when center post on front porch began shifting.

Palm Desert.—Frightened all in community. Plaster cracked slightly. Small objects and books fell from bookcase. Pictures knocked askew. Hanging objects swung violently. "Neighbors ran outside, some screaming." Very loud, rumbling earth noises before and during shock. At Sugar Loaf Mountain, about 15 miles south of Palm Desert, press reported massive rockslides closed Highway 74.

Palomar Mountain.—Felt by all and frightened few. Few small objects fell. Trees shook; vehicles rocked. At Palomar Observatory, pickup truck rolled violently. Visible ground waves. Nearby large oak tree, diameter 4 feet, seemed to move about 1 inch at eye level. Press noted that a couple fishing in a stream near Palomar Mountain observed the "whole lake shaking around."

Pine Valley.—Felt by and frightened all. Small objects shifted and fell. Hanging objects swung violently.

Placentia.—Severe shake. Chandelier on 10-foot chain swung and banged against wall.

Potrero.—Felt by all and frightened many. Plaster cracked. Water in pond had moderate waves. Trees and bushes shook. Loud earth noises. No serious damage reported.

Ramona.—Felt by all and frightened many. Several bricks dislodged from chimney of old house. Plaster cracked and fell next door. Small objects fell. Trees shook. Loud earth noises. Very little damage.

Ranchita.—Felt by all; general panic. Furniture shifted. Small objects shifted and fell. Water disturbed. Trees and bushes shook. Hanging objects swung violently. Moderate earth noises.

Rancho Mirage.—Felt by all and frightened many. Plaster cracked. Small objects shifted. Trees and bushes shook. Faint earth noises.

Rancho Santa Fe.—Felt by all and frightened few. Plaster cracked. Trees and bushes shook. Faint earth noises. Press reported water splashed out of swimming pool at both ends.

Riverside.—Felt by all in vicinity of University of California. Furniture shifted. Press reported heavy losses in grocery stores due to fallen bottled goods.

Sage (Sage Fire Control Station, south of Hemet).—Felt by all and frightened few. Plaster and windows cracked. Screen fell out of window. Landslides occurred. Furniture shifted. Small objects fell. Trees and bushes shook. Loud earth noises.

Salton City (west shore of Salton Sea).—Felt by all and frightened many. Ground cracked. Plaster and windows cracked. Many dishes, lamps, and pictures were broken in homes. "All our canned and glass jars of food were broken." Water disturbed. Elevated water tanks cracked. Loud earth noises. Damage moderate to great.

San Bernardino.—Felt by many in neighborhood. Many people ran outside. Trailer (on jacks) swayed severely. Walnut tree, 1 foot diameter, swayed severely north-south.

San Diego.—Felt by and frightened all. A 9-foot concrete retaining wall in front yard had a 1/8-inch crack from top to bottom. Chandeliers swung for almost 2 minutes. About 2 miles north of downtown area furniture shifted. One 2- by 4-inch brace under house pulled loose at one end. Trees and bushes shook. Powerlines swung. Damage slight. Press reported several instances of minor damage and water sloshing from swimming pools throughout the city. Hundreds of broken windows and severed powerlines were noted in beach communities. Cracks opened on the west side of Sunset Cliffs Boulevard. Barricades were put up along the street to block off the area. Plaster cracked and fell in several buildings.

San Jacinto.—Felt by all and frightened many. Some plaster cracked, broke, and fell. Furniture shifted. Small objects overturned and fell. Hanging objects swung violently. Damage slight.

San Marcos.—Felt by all and frightened many. Some plaster cracked. Trees and bushes shook. Moderate earth noises. Damage slight.

Santa Ysabel.—Felt by all in community. Small objects fell. Trees and bushes shook; vehicles rocked.

San Ysidro.—Felt by all and frightened few. Plaster cracked. Trees and bushes shook. Damage slight.

Seeley.—Felt by all in community. Small objects shifted and fell. Trees and bushes shook; vehicles rocked. Hanging objects swung violently. Loud earth noises.

Temecula.—Felt by all and frightened many. Furniture shifted. Small objects overturned and fell. Loud earth noises.

Terwilliger Valley (about 6 miles southeast of Anza).—Felt by many. One small object fell. Lighting wires twisted. Antenna pulled from building. Trees and bushes shook. Hanging objects swung violently. Loud earth noises.

Thermal.—Felt by all and frightened many. Some dishes and windows broke. Small objects shifted and fell. Water disturbed. Trees and bushes shook; vehicles rocked. Damage slight.

Thousand Palms.—Felt by all and frightened many. Few small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. Loud earth noises.

Torrance.—Cement patio cracked. New plaster surrounding door cracked. Chandelier swayed moderately. Motion like being on a ship moored at dock.

Valley Center.—Felt by all and frightened few. Small objects shifted and fell. Hanging objects swung moderately. Loud earth noises.

Warner Springs.—Felt by all and frightened many. Furniture shifted. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. At resort, plaster cracked slightly. Some small

cracks appeared in buildings. Diners at resort ran from building. Damage slight.

West Covina.—Felt by all and frightened many. Statues on shelf shifted. Hanging objects swung violently. Heavy brass hanging lamp swung at least a foot in each direction for about 15 minutes. "It felt as if I were in a boat riding heavy swells."

Westmorland.—Felt by all in community. Small objects shifted. Press reported bricks fell from top of south wall at laundromat; walls cracked in some buildings; and much merchandise fell in market.

Whittier.—Felt outdoors by many and indoors by most. Sidewalks and playgrounds cracked. Light furniture shifted slightly. Water splashed out of pool and ran into house. Ground visibly wavy. Trees, bushes, and telephone poles shook. Light shock and dizzy sensation for about 15 seconds, then strong motion for about 20 seconds.

Wildomar.—Frightened all in community. Windows cracked. Furniture shifted. Trees and bushes shook. Hanging objects swung violently. Loud earth noises.

Yorba Linda.—Felt by all and frightened few. Furniture shifted. Trees shook; utility poles swayed. Hanging objects swung violently. Faint earth noises.

INTENSITY VI IN ARIZONA:

Horn (north of Dateland).—Felt by very few. Desk shifted 1 inch. "One 1,800-foot well pumped red clay. Production of the well dropped off 900 gallons per minute."

Yuma.—Felt by and frightened few. Reports of very few cracks in concrete walks and driveways. Some water splashed out of pools; rocking chairs rocked. "Lights dimmed several times, the only really noticeable effect."

INTENSITY VI IN MEXICO:

Mexicali (just across border from Calexico).—Press reported windows broke and that lights went out in sheriff's office.

INTENSITY V:

Altadena, Angelus Oaks, Apple Valley, Baker, Banning, Bard, Beverly Hills, Big Bear City, Blythe, Bonsall, Buena Park, Cabazon, Cantil, Cardiff-by-the-Sea, Corona, Crestline, Daggett, Desert Hot Springs, El Monte, El Toro, Encino, Etiwanda, Fawnskin, Fillmore, Fontana, Forest Falls, Fort Irwin, Garden Grove, Fountain Valley, Fullerton, Glamis, Hollywood, Huntington Beach, Kelso, La Habra, La Jolla, Lake Hughes, Lakeview, Los Alamitos, Lost Lake (north of Blythe), Lucerne Valley, Lytle Creek, Marine Corps Base (north of Twentynine Palms), Maywood, Mojave, National City, Needles, Newberry, North Hollywood, North Palm Springs, Oceanside, Ontario, Orange, Palmdale, Palm Desert, Palo Verde, Pearblossom, Perris, Piru, Pomona, Poway, Redlands, Redondo Beach, Rosemead, San Fernando, San Fernando Valley, San Gabriel, Santa Ana, Santa Monica, Saugus, Sierra Madre, Sunland, Tecopa, Twentynine Palms, Upland, Valyermo, Van Nuys, Victorville, Vidal, Vista, Walnut, White Water, Winterhaven, and Yermo.

INTENSITY V IN ARIZONA:

Ehrenberg, Quartzsite, and Topock.

INTENSITY IV:

Action, Alberhill, Amboy, Anaheim, Arvin, Baldwin Park, Barstow, Boron, Cadiz, Canoga Park, Carpinteria, China Lake, Compton, Costa Mesa, Coso Junction, Covina, Crystal Lake (north of Azusa), Cuyama, Edwards Air Force Base (near Edwards), Fairmont Reservoir (west of Lancaster), Glendale, Glendora, Goffs, Greenfield, Havasu Lake (38 miles south of Needles), Hesperia, Huntington Park, Inglewood, Inyokern area, Lake Elizabeth, Lancaster, Lynwood area, Montebello, Moorpark, Newhall, Oxnard, Parker Dam, Pinon Hills, Rialto, Ridgecrest, Rosamond, San Juan Capistrano area, San Pedro, Santa Maria, Santa Paula, Santa Susana, Sherman Oaks, South Pasadena, South San Gabriel, Tehachapi, Trona, Tujunga, Ventura, Westend, West Los Angeles, Westminster, and Wrightwood.

INTENSITY IV IN ARIZONA:

Arlington, Bullhead City, Dateland, Gadsden, Lake Havasu City, Oatman, Parker, Roll, San Luis, and Wenden.

INTENSITY IV IN NEVADA:

Cal-Nev-Air (12 miles south of Searchlight), Lake Mojave (14 miles east of Searchlight), and Las Vegas.

INTENSITY I–III:

Buttonwillow, Camarillo, Frazier Park, Fresno, Goleta, Mount Wilson, Ojai, San Onofre, Santa Barbara, and Yosemite Valley.

INTENSITY I–III IN ARIZONA:

Gila Bend, Phoenix, Wikieup, and Yucca.

April 8: 19:03:53.5*. Epicenter 33°06.8′ north, 116°02.2′ west, P. Magnitude 5.2. Aftershock of 18:28:58.7*. Intensity I–III at Kelso, Leucadia, North Palm Springs, San Diego (Point Loma), and Tujunga.

April 8: 19:12. Intensity III at Leucadia.

April 8: 19:14:54.5*. Epicenter 32°43.7′ north, 116°07.0′ west, southern California, P. Magnitude 3.2. Felt near Fallbrook.

April 8: 19:22:22.0*. Epicenter 33°10.0′ north, 116°07.4′ west, southern California, P. Magnitude 3.3. Felt at Banning.

April 8: 19:48:10.3*. Epicenter 33°06.3′ north, 116°02.2′ west, southern California, P. Magnitude 4.7. Aftershock of 18:28:58.7*. Intensity VI at Calexico. Plaster fell at theater.

April 8: 19:58:36.0*. Epicenter 33°03.3′ north, 115°59.6′ west, southern California, P. Magnitude 4.3. Felt at Calexico.

April 8: 21:30:20.7*. Epicenter 34°19.9′ north, 119°50.6′ west, southern California, P. Magnitude 2.8. Felt at Goleta.

April 9: 04:45. Felt at Descanso.

April 9: 10:31:03.8*. Epicenter 33°18.9′ north, 116°18.3′ west, southern California, P. Magnitude 4.7. Intensity III at Angelus Oaks, Banning, and Palm Springs. Also felt near Fallbrook and at the Idyllwild Ranger Station.

April 9: 10:45. Felt at Borrego Springs.

April 9: 12:00. Slight shock at Mecca.

April 10: 02:30, 10:45, 15:57:58.0*. Epicenter 33°02.7′ north, 116°00.1′ west, southern California, P. Magnitude 3.0. Press reported these shocks felt at Borrego Springs. The first was reported at the Idyllwild Ranger Station.

April 10: 02:42:37.8*. Epicenter 31°59.5′ north, 116°55.6′ west, near coast of Baja California, P. Magnitude 4.5. Intensity IV at San Diego and Lakeside (northeast of San Diego).

April 10: 05:33:04.9*. Epicenter 33°15.5′ north, 116°05.0′ west, southern California, P. Magnitude 3.9. Felt at Ocotillo Wells and Borrego Springs.

April 14: 04:55:58.9*. Epicenter 33°13.8′ north, 116°11.6′ west, southern California, P. Magnitude 4.3. Felt at Borrego Valley and Palm Springs.

April 14: 07:45, 10:30 (about). Felt at Leucadia.

April 15: 19:30:29.9*. Epicenter 33°02.6′ north, 115°59.2′ west, southern California, P. Magnitude 4.8. Intensity V at El Cajon. Also felt at El Centro.

April 17: 23:29:36.3*. Epicenter 32°16.2′ north, 117°44.1′ west, off coast of Baja California, P. Magnitude 3.5. Intensity IV at San Diego (Point Loma).

April 18: 01:32:02.9*. Epicenter 32°05.2′ north, 117°50.8′ west, off coast of Baja California, P. Magnitude 3.4. Intensity IV at San Diego (Point Loma).

April 18: 09:42:13.4*. Epicenter 34°19.2′ north, 116°55.5′ west, southern California, P. Magnitude 4.0. Felt over approximately 3,600 square miles of Riverside and San Bernardino Counties, but no damage was sustained. Intensity V at Big Bear Lake,

Fawnskin, and Running Springs; intensity IV at Crestline, Green Valley Lake, Hesperia, Highland, Lucerne Valley, Pinon Hills, Riverside, San Bernardino, Sugarloaf, and White Water; intensity I–III at Adelanto, Angelus Oaks, Cedar Glen, Cedarpines, Corona, Desert Hot Springs, Forest Falls, San Jacinto, Wrightwood, and Yucaipa.

April 18: 11:50. Intensity III in San Francisco.

April 20: 20:29, 21:03. Felt at Leucadia.

April 23: 05:18:25.4*, 05:22:34.8*. Epicenter (1) 32°06.8′ north, 116°47.1′ west; (2) 31°58.2′ north, 116°41.9′ west, Baja California, P. Magnitudes 4.2 and 4.0, respectively. Intensity IV in the San Diego area.

April 23: 08:24:11.1*. Epicenter 32°50.9′ north, 115°43.7′ west, southern California, P. Magnitude 4.1. Intensity V at El Centro. Also felt at Seeley.

April 23: 20:00, 20:32, 20:34, 20:37, 20:48. All were felt slightly at Leucadia. First shock felt at San Diego with intensity IV. Many were frightened at Mexicali, Mexico, during one or more of the shocks, but the time was not given.

April 25: 11:49:45.6*. Epicenter 38°28.6′ north, 122°43.5′ west, northern California, B. Magnitude 4.6. VII. Felt over approximately 5,000 square miles, principally in Sonoma County (see fig. 7). Minor damage, chiefly to chimneys, plaster, windows, and merchandise in stores, was sustained in Santa Rosa and immediate vicinity. Pedestal tombstones were slightly rotated on their bases at a cemetery in the north part of Santa Rosa.

INTENSITY VII:

Santa Rosa and vicinity.—On the afternoon of April 25, Charles Knudson, C&GS Seismological Field Survey, and Robert Nason, ESSA Earthquake Mechanisms Laboratory, went to Santa Rosa to survey damage. The following was excerpted from a report prepared by Mr. Nason: "Examined the Larkfield housing tract north of Santa Rosa. One house had its chimney toppled; about 20 percent of chimneys were visibly damaged. Many windows were broken. Examined Santa Rosa Memorial Park and rural cemetery in the north part of town. No gravestones were toppled, but a number of columnar pedestals were rotated. About 1½ miles east of Larkspur, several chimneys were damaged, with some bricks thrown to the ground." Press reported office workers and students throughout the city streamed from buildings. All Santa Rosa schools were evacuated. It appeared that damage was largely limited to plaster, brick chimneys, windows, and merchandise in stores. A structural engineer in Santa Rosa noted that major plaster damage occurred in old buildings. Light wood-frame buildings with plaster showed considerable cracking, chipping, and spalling. Two-story buildings had more damage than one-story structures. Practically no damage occurred in masonry and concrete buildings.

INTENSITY VI:

Calistoga.—Felt by many and frightened few. Plaster cracked and fell. Cans toppled in some stores.

Fulton (about 5 miles northwest of Santa Rosa).—Felt by and frightened all. Chimney broke. Plaster cracked. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. Damage slight.

INTENSITY V:

Bodega Bay, Cotati, Forestville, Graton, Healdsburg, Kenwood, Middletown, Occidental, Petaluma, Sabastopol, and Windsor.

INTENSITY IV:

Angwin, Annapolis, Berkeley, Bodega, Camp Meeker, Cazadero, Cobb, Daly City-Colma, Dillon Beach, Eldridge, Geyserville (near), Glen Ellen, Guerneville, Hamilton Air Force Base (north of San Rafael), Kentfield (about 2 miles southwest of San Rafael), Marshall, Monte Rio, Napa, Penn-

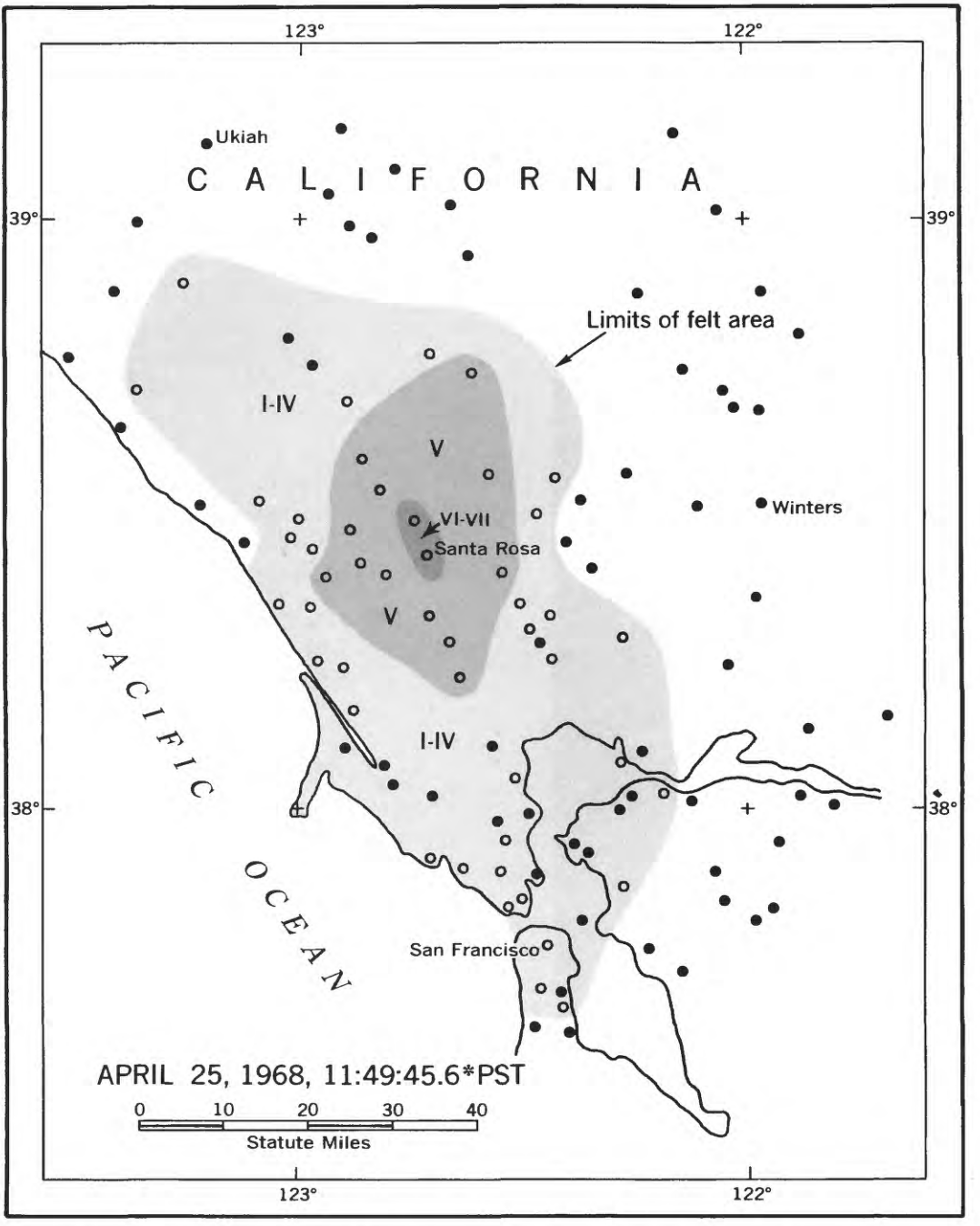

FIGURE 7.—Area affected by northern California earthquake of April 25.

grove, Saint Helena, Sonoma (north of), Stinson Beach, and Tomales.

INTENSITY I–III:

Bolinas, Boyes Hot Springs, Mare Island, Mill Valley, Port Costa, San Francisco, Sausalito, South San Francisco, Vineburg, and Yorkville.

April 28: 16:21:36.8*. Epicenter 39°32.4′

north, 122°01.4′ west, northern California, B. Magnitude 4.7. VI. Felt over approximately 10,500 square miles, principally in Butte, Glenn, and Tehama Counties. Principal damage was to merchandise in stores. Glass door broke at Chico. Plaster cracked at Willows. A well west of Tehama reportedly went dry after the earthquake.

INTENSITY VI:

Butte City.—Felt by many and frightened few. Merchandise broke in grocery store. Small objects shifted and fell.

Chico.—Felt by all and frightened few. Furniture shifted. Trees and bushes shook. Damage slight. Press reported many instances of light damage, including a broken sliding glass door at the high school; glass shelf in trophy case also broke. Several burglar alarms were activated.

Gridley.—Felt by all and frightened many. Jars and canned goods fell from shelves in stores. Trees and bushes shook. Loud earth noises.

Orland.—Felt by all and frightened many. Furniture shifted. Small objects shifted and fell. Moderate earth noises. Damage slight.

Vina.—Felt by all. Furniture shifted. Hanging objects swung violently.

Willows.—Felt by nearly all; few alarmed. Vertical plaster cracks noted. Chairs moved. Glasses fell from shelves. Stacked cans in grocery store in northwest section fell over. Moderately loud earth noises.

INTENSITY V:

Berry Creek, Brush Creek, Carmichael, Cohasset (about 17 miles northeast of Chico), Colusa, Corning, Durham, Feather Falls, Forest Ranch, Glenn, Hamilton City, Live Oak, Loomis, Nelson, Ordbend (about 10 miles northeast of Willows), Oroville, Paradise, Princeton, Proberta (about 8 miles southeast of Red Bluff), Rancho Cordova (about 8 miles northeast of Sacramento), Red Bluff, Richvale, Sacramento, Smartville, Storrie, Sutter, and Tehama.

INTENSITY IV:

Alder Springs (northwest of Elk Creek), Baxter, Clarksburg, Colfax, East Nicolaus, Elk Creek, Flournoy, Foresthill, Fruto, Garden Valley, Grass Valley-Nevada City area, Greenwood, Grizzly Flats, Ione, Magalia, Meridian (south of), Mineral, Oregon House, Palermo, Pakenta, Paynes Creek, Pleasant Grove, Pollock Pines, Rescue, Robbins, Shasta, Sheridan, Sloughhouse, Stirling City, West Sacramento, Whitmore, and Yuba City.

INTENSITY I–III:

Applegate, Belden, Butte Meadows, Downieville, Dunnigan, Lotus, North San Juan, Pulga, Roseville, Shingletown, Spring Garden, Stonyford, and Strawberry Valley.

May 2: 23:21:54.9*. Epicenter 32°41.1′ north, 117°05.6′ west, southern California, P. Magnitude 3.5. Intensity IV in San Diego and vicinity.

May 3: 13:39:57.2*. Epicenter 37°44.3′ north, 122°06.2′ west, central California, B. Magnitude 3.1. Intensity IV at Castro Valley. Also felt at Hayward.

May 11: 20:11:47.8*. Epicenter 37°40.0′ north, 122°32.1′ west, central California, B. Magnitude 2.5. Press reported the shock felt in the southwest sections of San Francisco and in the South San Francisco-Daly City areas. Those who observed this earthquake described it as "slight."

May 22: 05:26:55.5*. Epicenter 33°18.7′ north, 116°13.4′ west, southern California, P. Magnitude 4.4. Felt over approximately 3,500 square miles, but caused no damage. Intensity V at Live Oak Springs (near Boulevard), Ramona (near), and Salton City (west shore of Salton Sea); intensity IV at Coachella, Descanso, El Cajon, Idyllwild, Julian, La Quinta, Mecca, Mount

Laguna, North Shore (north shore of Salton Sea), Palm Desert, Ranchita, Santee, and Thermal; intensity I–III at Agua Caliente, Cathedral City, Poway, Rancho Mirage, San Diego (Point Loma), and San Jacinto.

May 28: 18:29:38.7*. Epicenter 35°19.8′ north, 118°30.5′ west, central California, P. Magnitude 4.0. Felt over about 1,000 square miles, but caused no damage. Intensity V at Tehachapi; intensity IV at Keene, Loraine, Piute Mountain (south of Lake Isabella), and Weldon (near); intensity I–III at Lake Isabella, Mojave, and Onyx.

May 28: 21:12:55.0*. Epicenter 35°18.9′ north, 118°30.5′ west, central California, P. Magnitude 3½. Felt at Keene and Loraine.

May 29 to June 11: See Washington and Oregon section, p. 52 for southern Oregon earthquakes felt in California during this period.

June 2: 23:05:57.2*. Epicenter 40°21′ north, 124°36′ west, near coast of northern California, B. Magnitude 3.6. Intensity IV at Ferndale.

June 9: 20:55. Slight shock felt at Pinon Hills.

June 16: 19:05:44.5*. Epicenter 40°35′ north, 124°45′ west, off coast of northern California, B. Magnitude 3.8. Intensity III at Ferndale.

June 19: 18:30. Intensity IV in north section of Eureka.

June 23 and 24: Evening. Minor tremors felt at Petrolia.

June 24: 23:05. Shock felt at ranch, 8 miles east of Petrolia.

June 25: 17:42:19.5* (main shock of a series). Epicenter 40.1° north, 124.4° west, near coast of northern California, W. Magnitude 5.5, B. VII. Felt over approximately 5,000 square miles, principally in Humboldt and Mendocino Counties (see fig. 8). Chimneys were destroyed and minor landslides were noted at Petrolia and Honeydew. Press reported the front porch was torn off one building and that ground cracks occurred along the Mattole River.

INTENSITY VII:

Honeydew.—Felt by and frightened all. Chimneys cracked, twisted, and overturned. Landslides occurred. Plaster and windows cracked. Small objects shifted and fell. Trees and bushes shook. Hanging objects swung violently. "House moved up and down." Damage slight.

Petrolia.—Felt by and frightened all. Three to five chimneys were destroyed. Moderate landslides occurred. Most all glassware in house was broken and cupboards emptied. Plaster cracked and broke; windows cracked. Furniture shifted. Hanging objects swung violently. Loud earth noises. Ten shocks were felt on this date, three within 15 minutes of the main earthquake. Damage was moderate in some homes. Near the mouth of the Mattole River, ground cracks and landslides were observed. In the Mattole Valley, a 20- by 20-foot porch on the Mattole Grange Hall collapsed; several fireplaces were damaged. Press reported the following: Cupboards torn loose from walls in home; house moved 4 inches off its underpinnings; large cracks along riverbank (Mattole River).

INTENSITY V:

Blocksburg, Briceland, Eureka, Ferndale, Fields Landing, Fort Seward, Garberville-Phillipsville area, Leggett, Loleta, Myers Flat, Redcrest, Redway, Rio Dell, and Weott.

INTENSITY IV:

Alderpoint, Arcata, Bayside, Blue Lake, Bridgeville, Burnt Ranch, Carlotta, Crannell, Cutten (about 2½ miles southeast of Eureka), Garberville, Hydesville, Kneeland, Korbel, Littleriver, Rio Dell, Scotia, Westport, and Zenia.

INTENSITY I–III:

Branscomb (6 miles west of), Cleone (2½ miles north of Fort Bragg), Covelo,

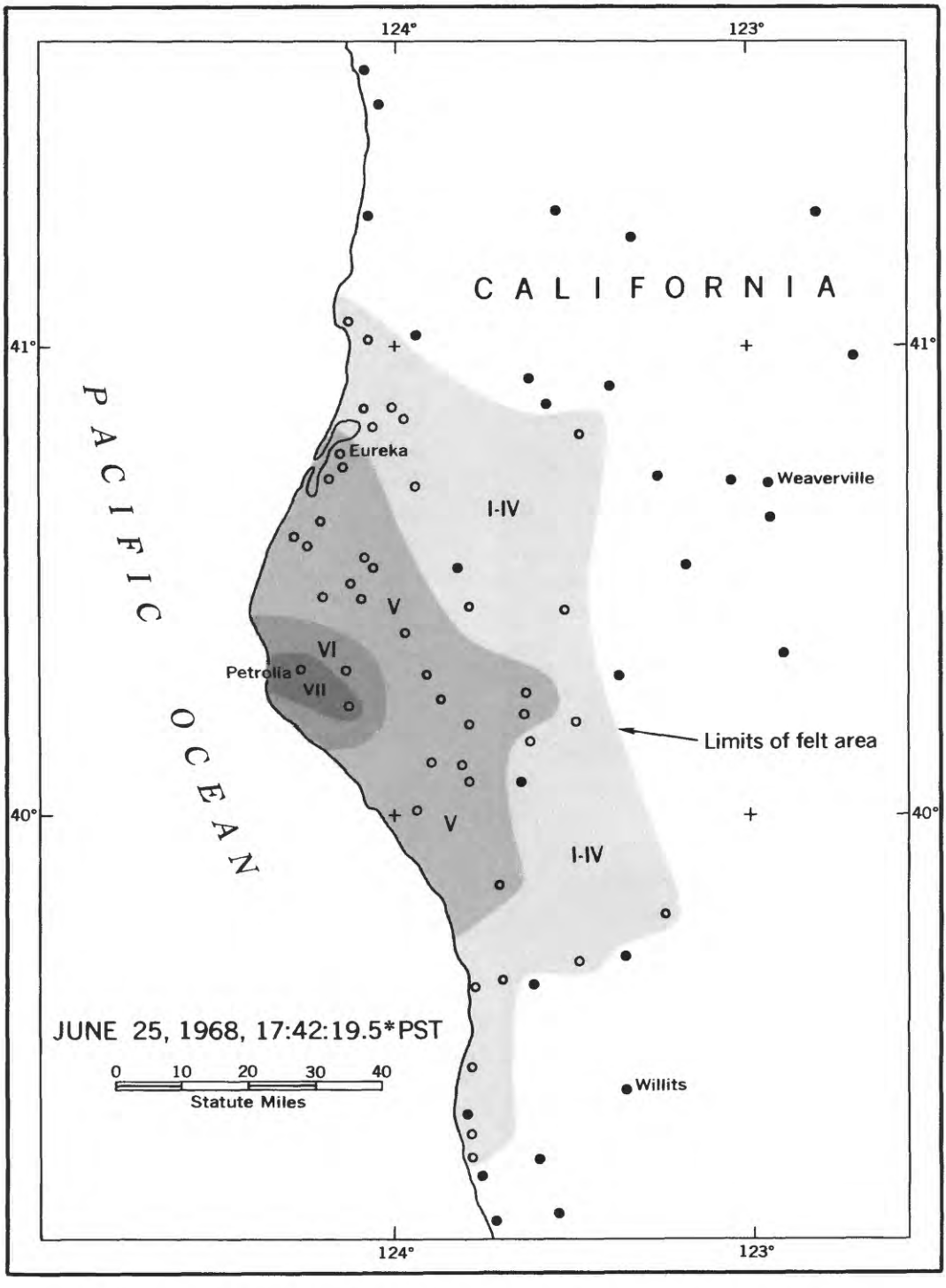

FIGURE 8.—Area affected by northern California earthquake of June 25.

Laytonville, Mad River, Mendocino, Trinidad, and Whitethorn.

June 25: 18:53:42*, 20:19:20*, 21:38:49*. Epicenter (1) 40.1° north, 124.4° west; (2) 40.1° north, 124.5° west; (3) 40.2° north, 124.8° west, near coast of northern California, W. Magnitudes 4.1, 4.2, and 4.2, respectively. Aftershocks of 17:42:19.5*. All were felt at Honeydew. The third shock was observed at Petrolia.

June 25: 21:50:28.6*. Epicenter 40.2° north, 124.6° west, near coast of northern California, W. Magnitude 4.3. Aftershock of 17:42:19.5* Felt at Ferndale, Honeydew, and Petrolia.

June 26: 02:47:46.0*. Epicenter 40.2° north, 124.4° west, near coast of northern California, W. Magnitude 4.6, B. Aftershock of 17:42:19.5*, June 25. V. Awakened all in home at Ferndale. Also felt at Petrolia, Scotia (IV), and Whitethorn.

June 26: 09:30. Felt at Petrolia.

June 26: 10:11:11.2*. Epicenter 34°12.7′ north, 119°41.5′ west, off coast of southern California, P. Magnitude 4.0. Felt over 800 square miles of the coastal areas of Santa Barbara and Ventura Counties. First of a series of shocks extending into July. Intensity V at Cachuma, Carpinteria, and Santa Claus (on coast, about 6 miles east of Santa Barbara), but no damage was sustained; intensity IV at Goleta, San Roque (about 6 miles west of Santa Barbara), and Santa Barbara; intensity I–III at Oxnard and Port Hueneme.

June 26: 13:42:31.5*. Epicenter 34°13.0′ north, 119°41.1′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.8. Intensity IV at Santa Barbara.

June 28: 16:09:46.9*. Epicenter 34°14.4′ north, 119°36.0′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.1. Felt at Santa Barbara.

June 28: 22:00 or 22:30. Felt at Pinon Hills (San Bernardino County, north of Wrightwood).

June 28: 22:33:20.9*. Epicenter 34°11.0′ north, 119°38.8′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 4.0. Felt at Santa Barbara.

June 29: 07:32:42.8*. Epicenter 34°15.0′ north, 119°39.2′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 4.1. Intensity V at Carpinteria and Santa Barbara; intensity I–III at Goleta.

June 29: 07:53:56.9*. Epicenter 34°08.6′ north, 119°37.1′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.4. Felt at Santa Barbara.

June 29: 11:12:21.3*. Epicenter 34°15.2′ north, 119°41.9′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 4.2. Intensity V at Carpinteria, Goleta, San Roque, Santa Barbara and Summerland; intensity IV at Cachuma, Los Prietos Ranger Station, and Santa Ynez; intensity I–III at Lompoc.

June 29: 11:13:57.0*. Epicenter 34°16.0′ north, 119°34.0′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 4.4. VI. At Goleta, much stock fell from shelves in stores ($2,000 damage). Bridge at Fairview Avenue overcrossing shook noticeably, sending dust and accumulated debris along whole length of bridge 2 feet into air. Spalled concrete chips and cracked tar and mortar were noted on bridge. Felt at Santa Barbara.

June 29: 11:21:50.8*. Epicenter 34°14.2′ north, 119°37.2′ west, off coast of southern California, P. Magnitude 3.5. Felt at Santa Barbara.

June 29: 12:36:33.6*. Epicenter 34°14.7′ north, 119°35.3′ west, off coast of southern California, P. Magnitude 4.0. Intensity IV at Goleta; felt at Santa Barbara.

June 30: 19:11. Intensity IV at Dos Rios.

July 1: 00:50, 10:50. Intensity IV at Petrolia.

July 1: 19:20:02.6*. Epicenter 34°12.7′ north, 119°43.1′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.5. Felt at Goleta.

July 3: 11:59. Intensity III at Scotia.

July 4: 14:00 (about). Felt at Pinon Hills in San Bernardino County.

July 4: 16:36:06.4*. Epicenter 34°11.5′ north, 119°44.0′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 4.0. Felt at Goleta and Santa Barbara.

July 4: 16:45:17.2*. Epicenter 34°07.1′ north, 119°42.1′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 5.2. VI. Felt over approximately 8,000 square miles (see fig. 9). Minor damage was sustained at Goleta, Carpinteria, and Santa Barbara. Acoustical tile and fluorescent lights fell, and windows broke at Goleta. At Carpinteria, plaster cracked and fell, chimney cracked, and lighting fixture fell. Acoustical tile lay-in panels fell at a school in Santa Barbara.

INTENSITY VI:

Carpinteria.—Felt by all and frightened many. One chimney cracked through at base and had to be rebuilt. Plaster cracked and fell. Small objects overturned and fell. Furniture shifted. Damage moderate.

Goleta.—An investigation by the Seismological Field Survey revealed acoustical tile and merchandise fell at the Food Fair Market (Plaza de Goleta shopping center). Where ceiling beams passed through a false wall, cracks enlarged. At a nearby library, acoustical tile and fluorescent lights fell. Plate glass windows broke in three stores. About 1½ miles west of the Food Fair Market area, merchandise and acoustical tile fell in a supermarket, with damage about equivalent in both markets.

Montecito.—Felt by many in community. Small objects shifted. Press reported water sloshed from toilet, and coffee sloshed from cup onto rug at one home.

Moorpark.—Felt by many and frightened few. Foundation cracked. Trees and bushes shook; vehicles rocked. Hanging objects swung violently.

Santa Barbara.—Felt by all and frightened many. Acoustical tile lay-in panels fell, and light fixture covers opened in one school. Groceries fell from shelves in markets. North of Santa Barbara on State Highway 154, six to eight football-size rocks fell in one cut section. Press reported burglar alarms were set off in the business district.

INTENSITY V:

Camarillo, Cuyama, Inglewood, Lompoc, Manhattan Beach, Newbury Park, Oak View, Ojai, Oxnard, Paradise (near, in Los Padres National Forest), Piru, Port Hueneme, Santa Paula, Saticoy, South Gate, and Ventura.

INTENSITY IV:

Agoura, Bulleton, Buena Park, Cachuma Dam (about 10 miles east of Santa Ynez), Encino, Fillmore, Frazier Park (near), Hawthorne, Huntington Beach, Huntington Park, La Canada, Lebec, Los Alamos, Los Prietos Ranger Station (about 10 miles north of Santa Barbara), Malibu, Maricopa, Meiners Oaks, New Cuyama, Newhall, North Hollywood, Northridge, Pacific Palisades, Palos Verdes Peninsula, Pasadena, Placentia, San Fernando Valley, Seal Beach, Simi, Solvang, Summerland, Sunset Beach, Surf, Tehachapi, Topanga, Venice, Whittier, and Woodland Hills.

INTENSITY I–III:

Alhambra, Altadena, Bellflower, Casmalia, Gaviota, Glendale, Guadalupe, Hollywood, Lake Hughes, Los Angeles (downtown), Los Olivos, Monterey Park, Santa Maria, Santa Susana, Taft, and Westminster.

July 4: 18:36:14.1*, 20:18:36.0*, 21:28:25.7*. Epicenter (1) 34°04.3′ north, 119°

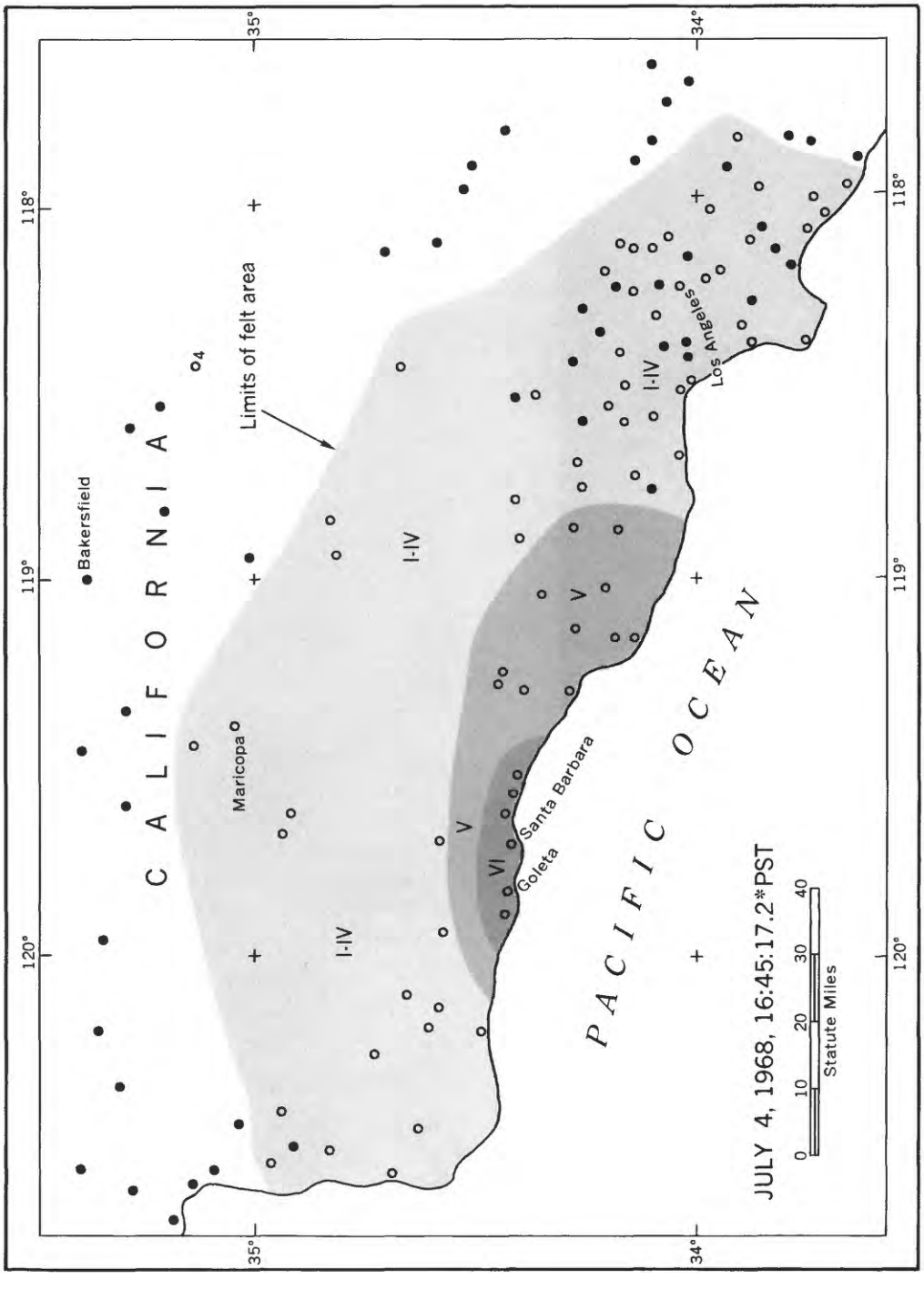

FIGURE 9.—Area affected by southern California earthquake of July 4.

43.4′ west; (2) 34°14.8′ north, 119°40.9′ west; (3) 34°13.8′ north, 119°39.1′ west, off coast of southern California in Santa Barbara Channel, P. Magnitudes 4.0, 3.5, and 3.4, respectively. All three shocks were felt at Santa Barbara. Third shock also felt at Goleta.

July 5: 01:32:46.7*, 01:36, 02:30, 07:03: 09.8*. Epicenter (1) 34°16.1′ north, 119° 40.8′ west; (4) 34°16.0′ north, 119°42.6′ west, off coast of southern California in Santa Barbara Channel, P. Magnitudes of first and fourth shocks 3.7 and 3.5, respectively. All were felt slightly at Santa Barbara.

July 6: 08:14:48.4*. Epicenter 33°56.5′ north, 118°19.2′ west, southern California, P. Magnitude 2.6. Intensity IV in the Inglewood-Los Angeles area.

July 7: 06:33:30.8*, 08:22:40.4*. Epicenter (1) 34°10.6′ north, 119°45.3′ west; (2) 34°13.5′ north, 119°45.8′ west, off coast of southern California in Santa Barbara Channel, P. Magnitudes 4.5 and 3.3, respectively. Intensity IV at Goleta. Also felt at Sandberg and Santa Barbara.

July 7: 19:31:39.2*. Epicenter 34°08.4′ north, 117°36.6′ west, southern California, P. Magnitude 3.2. Intensity IV at Etiwanda in San Bernardino County. Felt at San Bernardino.

July 8: 00:22:29.5*, 01:06:12.9*, 01:18: 37.2*, 21:40:50.0*. Epicenter (1) 34°16.6′ north, 119°38.1′ west; (2) 34°16.5′ north, 119°38.4′ west; (3) 34°15.3′ north, 119° 37.7′ west; (4) 34°15.6′ north, 119°37.4′ west, off coast of southern California in Santa Barbara Channel, P. Magnitudes 3.6, 3.6, 4.0, and 3.3, respectively. All four earthquakes were felt at Santa Barbara.

July 8: 07:18:03.3*. Epicenter 33°59.5′ north, 116°42.1′ west, southern California, P. Magnitude 3.5. Felt at Palm Springs.

July 10: 13:49:26.6*. Epicenter 34°10.8′ north, 119°40.5′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.6. Felt at Santa Barbara.

July 13: 22:00 (about). Intensity II at Millbrae.

July 19: 07:24. Intensity IV at Fort Bidwell.

July 21: 17:05:01.3*. Epicenter 39.8° north, 121.9° west, northern California, W. Magnitude 3.3, B. Felt over approximately 900 square miles, but no damage was reported. Intensity V at Artois, Chico, and Hamilton City; intensity IV at Berry Creek, Magalia, Paradise, and Richardson Springs; intensity I–III at Durham, Forest Ranch, and Glenn.

July 26: 07:30:35.7*. Epicenter 33°54.9′ north, 118°28.0′ west, southern California, P. Magnitude 2.6. Felt at Santa Monica.

July 29: 22:03:15.6*. Epicenter 34°16.0′ north, 119°38.3′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.6. Felt at Santa Barbara.

July 31: 02:10:51.9*, 04:19:43.7*, 06:58. Epicenter (1) 34°17.0′ north, 119°37.3′ west; (2) 34°13.5′ north, 119°34.7′ west, off coast of southern California in Santa Barbara Channel, P. Magnitudes of first two shocks, 3.1 and 3.6, respectively. Intensity IV at Santa Barbara.

July 31: 14:44:45.3*. Epicenter 34°15.3′ north, 119°36.8′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 4.0. Felt at Santa Barbara.

August 2: 10:15 (about), 15:53. Felt in Morongo Valley.

August 6: 02:18:40.3*. Epicenter 34°05.1′ north, 116°29.8′ west, southern California. P. Magnitude 3.8. V. Felt over approximately 2,500 square miles. Slight cracks were reported at Joshua Tree Post Office. Intensity V also reported at Angelus Oaks, Cathedral City, Cherry Valley (north of Beaumont), Desert Hot Springs, North

Palm Springs, Pioneertown, White Water, and Yucca Valley; intensity IV at Cabazon, Forest Falls, Landers, Lucerne Valley, Morongo Valley, and Palm Springs.

August 7: 21:31:09.7*. Epicenter 40.5° north, 124.5° west, near coast of northern California, B. Magnitude 4.0. Felt over about 800 square miles of Humboldt County, but no damage was noted. Intensity V at Ferndale and Fields Landing; intensity IV at Eureka, Loleta, Rio Dell, and Scotia; intensity I–III at Arcata, Carlotta, Cutten, and Korbel.

August 8: 11:41:31.6*. Epicenter 37° 24.1′ north, 121° 45.4′ west, central California, P. Magnitude 3.2. Felt at San Jose.

August 16: 04:12:17.1*. Epicenter 34° 46.9′ north, 120°21.1′ west, southern California, P. Magnitude 3.3. V. At Santa Maria, two cups and part of chandelier fell due to vertical motion; small objects shifted and overturned. Intensity IV at Casmalia (about 10 miles southwest of Santa Maria).

August 16: 23:44:42.3*. Epicenter 34° 05.9′ north, 117°21.1′ west, southern California, P. Magnitude 3.1. Intensity IV in Riverside and San Bernardino Counties at Fontana, Rialto, Riverside, and San Bernardino.

August 19: 17:31:14.3*. Epicenter 32° 43.0′ north, 115°27.2′ west, southern California, P. Magnitude 3.2. Felt at El Centro.

August 19: 22:37:22.5*. Epicenter 32° 46.6′ north, 115°29.4′ west, southern California, P. Magnitude 2.5. Felt at El Centro.

August 31: 03:13. Intensity IV at Ferndale and Scotia.

September 12: 00:44:47*. Epicenter 37° 45′ north, 118°15′ west, B. Magnitude 3.3. Intensity IV at Benton; intensity II at Bishop.

September 17: 20:33:49.8*. Magnitude 2.0. Intensity IV at Sun Valley, Nev. (about 4 miles northeast of Reno).

September 19: 04:58. Felt at Moss Landing (Pacific Gas and Electric Powerplant).

September 20: 19:18:12.5*. Epicenter 37°24.8′ north, 122°14.2′ west, central California, W. Magnitude 2.8, B. Intensity IV in the Menlo Park-Redwood City-Palo Alto area.

September 28: 21:01:43.0*, 21:07:26.8*. Epicenter 34°01.6′ north, 116°35.3′ west, southern California, P. Magnitude 2.5 for both shocks. Slight shocks were felt in Morongo Valley.

October 11: 03:07:10.8*. Epicenter 40.3° north, 125.0° west, off coast of northern California, W. Magnitude 4.2. Intensity II at Ferndale.

October 15: 04:47:53.4*. Epicenter 34° 13.0′ north, 119°40.3′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.4. Felt at Santa Barbara.

October 15: 08:07:15.2*. Epicenter 34° 13.7′ north, 119°40.9′ west, off coast of southern California in Santa Barbara Channel, P. Magnitude 3.5. Felt at Santa Barbara.

October 21: 06:30:25.5*. Epicenter 37° 57′ north, 120°18′ west, northern California, B. Magnitude 3.4. Felt over a small area of the San Francisco Bay region, principally in Contra Costa County. Intensity V at Albany, Berkeley, and El Cerrito; intensity IV at Kensington, Martinez, Moraga, Pinole, Richmond, and San Francisco; intensity I–III at Alameda, El Sobrante, and San Pablo.

October 31: 05:47. Intensity IV at Ferndale and Petrolia.

November 4: 23:45. Intensity III in the Parkfield area at the Work Ranch, 15 miles northeast of San Miguel.

November 6: 00:58:21.2*. Epicenter 35° 56.9′ north, 120°27.3′ west, central California, P. Magnitude 3.2. Intensity III in the Parkfield area at the Work Ranch, 15 miles northeast of San Miguel.

November 14: 14:13*. Very small shock felt at Mt. Rose, south of Reno, Nev.

December 11: 04:51:06.0*. Epicenter 41.0° north, 124.1° west, near coast of northern California, W. Magnitude 4.0, B. Felt over about 800 square miles of Humboldt County. Intensity V at Arcata, Eureka, and Korbel; intensity IV at Ferndale, Fields Landing, Loleta, and Samoa; intensity I–III at Blue Lake, Rio Dell, and Scotia.

December 11: 13:37:37.8*. Epicenter 37°09.7′ north, 121°33.6′ west, central California, B. Magnitude 4.0. Generally felt over about 1,200 square miles of Santa Clara and Santa Cruz Counties. Intensity IV at Coyote, Gerber Ranch (about 10 miles east of Mount Hamilton), Milpitas, Morgan Hill, and New Almaden; intensity I–III at Campbell, Felton, Gilroy, Half Moon Bay, Oakland, San Francisco, San Jose, and San Martin.

December 11: 13:45:38.5*. Epicenter 37°09.3′ north, 121°32.3′ west, central California, B. Magnitude 3.0. Felt at San Jose.

December 11: 22:14:57.6*. Epicenter 34°03.8′ north, 116°59.8′ west, southern California, P. Magnitude 3.0. Felt at Banning and Mill Creek Ranger Stations.

December 16: 00:31:22.9*. Epicenter 40.5° north, 124.4° west, near coast of northern California, W. Magnitude 3.5, B. Intensity IV in Eel River Valley and Ferndale. Also felt at Fortuna and Rio Dell.

December 17: 14:53:51.2*. Epicenter 33°02.7′ north, 115°51.8′ west, southern California, P. Magnitude 4.7. Felt over approximately 2,500 square miles, principally in Imperial and San Diego Counties. Intensity V at Agua Caliente, Ocotillo, and Seeley; intensity IV at Brawley, Calexico, Campo, Heber, Imperial, North Shore, and Potrero; intensity I–III at Alpine, Coachella, El Centro, Jacumba, La Quinta, Mount Laguna, and Pine Valley.

WASHINGTON AND OREGON

[120th Meridian or Pacific Standard Time]

January 27: 00:28:25.2*. Epicenter 45.7° north, 122.8° west, Washington-Oregon border region, W. Intensity IV at Portland, Oreg.

March 6: 05:15:05*. Magnitude 2.0, S. Felt at Kirkland, Wash.

May 26: Observer at Adel, Oreg., reported series of shocks began on May 26 (time not given) and were felt daily to June 11.

May 29: 16:35:59.8*. Epicenter 42.3° north, 119.8° west, southern Oregon, W. Magnitude 5.1. Felt at Adel and Lakeview (IV), Oreg., and Fort Bidwell and Willow Ranch (east side of Goose Lake, IV), Calif.

May 29: After 21:00. Intensity V at Adel, Oreg.

June 3: 05:27:39.7*. Epicenter 42.2° north, 119.8° west, southern Oregon, W. Magnitude 5.0. Intensity V at Lakeview and Plush, Oreg., and Fort Bidwell, Calif. Also felt at Adel, Oreg.

June 3: 18:34:15.7*. Epicenter 42.3° north, 119.9° west, southern Oregon, W. Magnitude 4.7. VI. Felt over approximately 7,000 square miles of southern Oregon and northeastern California. At Adel, Oreg., old chimneys fell or were cracked, and part of an old rock cellar fell and rest of building cracked. Ground fissured 2.5 miles northwest of Fort Bidwell, Calif., along Bidwell Creek; a house sustained some foundation cracking and shifting.

INTENSITY VI IN OREGON:

Adel.—"This was the worst shock to date.

Lasted about 30 seconds." Chimneys (all old) fell or were cracked. Stock fell off shelves in store. Part of old rock cellar wall came down, and rest of building cracked. Dishes, glassware, etc., came out of cupboard shelves. Lamps overturned. Aftershock about 10 minutes later with east-west motion.

INTENSITY VI IN CALIFORNIA:

Fort Bidwell (2.5 miles northwest of, in Bidwell Creek Canyon).—"Most severe of all the shocks." Fissure opened about 50 feet east of one house and extended at least 550 feet in a northerly direction to edge of steep bank leading down to Bidwell Creek. This fissure was roughly paralleled in places by a smaller one, ranging from several to 8 or 9 feet, east of the main fissure. The main fissure had a number of vertical drops up to about 18 inches, and the maximum gap width was about 10 inches. The initial maximum depth was about 6 feet and occurred in several places. House sustained foundation cracking and shifting, with resultant slight disturbance to door frames and walls.

INTENSITY V IN OREGON:

Paisley.

INTENSITY IV IN OREGON:

Valley Falls (23 miles north of Lakeview).

INTENSITY IV IN CALIFORNIA:

Davis Creek, Lake City, and Willow Ranch (east side of Goose Lake).

INTENSITY I–III IN CALIFORNIA:

Eagleville.

June 3: 18:38:29:0*. Epicenter 42.3° north, 119.8° west, southern Oregon, W. Magnitude 4.0. Slight damage reported at Adel.

June 3: 22:22:19.0*. Epicenter 42.2° north, 119.8° west, southern Oregon, W. Magnitude 4.3. Felt at Adel, and at Fort Bidwell, Calif.

June 4: 02:58:22.8*, 20:51:56.8*. Epicenter 42.3° north, 119.9° west, southern Oregon, W. Magnitudes 4.2 and 4.7, respectively. Felt at Fort Bidwell, Calif.

June 11: 17:20:56*, 17:46:22.4*. Epicenter (1) 42.1° north, 120.0° west; (2) 42.1° north, 119.9° west, southern Oregon, W. Magnitudes 3.4 and 4.3, respectively. Felt at Fort Bidwell, Calif.

June 11: Between 21:00 and 22:00. Very light shock felt at Fort Bidwell, Calif.

June 18: 21:51:43.0*. Epicenter 47.2° north, 122.5° west, Washington, W. Magnitude 4.0, S. Intensity IV at Auburn, Dash Point, Des Moines, Dockton, Indianola, Issaquah, Milton, Preston, Puyallup, Renton, Seattle, Tacoma, and Vashon; intensity I–III at North Bend, Port Orchard, and Wauna.

June 25: 16:43. Press reported shock in Lake County, Oreg., at this time.

June 26: 02:48. Press reported shock in Lake County, Oreg., at this time.

September 6: 04:16:32.7*. Epicenter 47.8° north, 122.8° west, about 7 miles southeast of Dabob, Wash., S. Magnitude 4.3. Felt over about 4,000 square miles, but no damage was reported. Intensity V at Baring, Edmonds, La Conner, Langley, Preston, Seabeck, and Tracyton; intensity IV at Anacortes, Blanchard, Bow, Brinnon, Carlsborg, Clallam Bay, Clinton, Concrete, Conway, Coupeville, Greenbank, Hadlock, Hansville, Index, Indianola, Lyman, Marblemount, Medina, Monroe, Mukilteo, Nordland, Oak Harbor, Olympia, Port Gamble, Poulsbo, Renton, Rolling Bay, Silvana, Stanwood, and Sultan; intensity I–III at Bremerton, Darrington, Edison, Kingston, Marysville, Orcas, Seattle, Startup, and Woodinville.

September 25: 12:09:34.2*. Epicenter 47.8° north, 122.7° west, Washington, S. Magnitude 2–2½. Aftershock of September 6 earthquake located in same region. Intensity IV at Brinnon and Port Orchard; intensity I–III at Hobart and Port Gamble.

November 30: 06:40:08.8*. Epicenter 46.5° north, 122.4° west, Washington, W. Magnitude 4.3. Felt over approximately 1,000 square miles of Lewis County. Intensity V at Ajlune, Cinebar, Glenoma, Mineral, Morton, and Mossyrock; intensity IV at Silver Creek and Toledo; intensity I–III at Davidson Lake (in area of former community of Riffe).

ALASKA

[150th Meridian or Alaska Standard Time]

January 9: 03:27:09*. Epicenter 64.9° north, 146.6° west, central Alaska, W. Felt at Eielson Air Force Base, near Fairbanks.

January 14: 07:43:10.0*. Epicenter 52.7° north, 171.2° west, Andreanof Islands, W. Magnitude 6¼, P. Intensity IV at Nikolski, Umnak Island.

February 18: 04:03:24*. Epicenter 51.7° north, 177.7° west, Andreanof Islands, W. Magnitude 4.2. Felt on Adak.

February 19: 16:45:49.2*. Epicenter 60.0° north, 142.0° west, Alaska, W. Magnitude 3.9. Felt at Yakataga.

February 19: 19:06:11.9*. Epicenter 58.4° north, 151.7° west, Kodiak Islands region, W. Magnitude 4.9. Intensity III in Anchorage.

February 20: 20:18:21.6*, 20:21:03.6*. Epicenter 52.3° north, 175.3° west, Andreanof Islands, W. Magnitudes 5.2 and 5.3, respectively. Felt on Adak.

February 21: 09:08:39.3*. Epicenter 51.4° north, 176.1° west, Andreanof Islands, W. Magnitude 4.7. Felt on Adak.

February 21: 09:30:04.9*. Epicenter 51.6° north, 176.0° west, Andreanof Islands, W. Magnitude 4.7. Felt on Adak.

February 21: 09:32:32.2*. Epicenter 51.7° north, 175.9° west, Andreanof Islands, W. Magnitude 4.8. Felt on Adak.

February 21: 11:07:56.9*. Epicenter 51.4° north, 176.0° west, Andreanof Islands, W. Magnitude 5.2. Felt on Adak.

February 21: 11:15:08.0*. Epicenter 51.4° north, 175.8° west, Andreanof Islands, W. Magnitude 4.4. Felt on Adak.

February 21: 11:28:17*. Epicenter 51.7° north, 176.0° west, Andreanof Islands, W. Magnitude 4.2. Felt on Adak.

February 21: 14:54:14.4*. Felt on Adak.

February 22: 07:46:57.4*. Epicenter 51.4° north, 176.3° west, Andreanof Islands, W. Magnitude 5.1. Felt on Adak.

February 22: 14:10:39.5*. Epicenter 51.5° north, 176.3° west, Andreanof Islands, W. Magnitude 4.6. Felt on Adak.

February 22: 15:40:12*. Epicenter 51.6° north, 177.2° west, Andreanof Islands, W. Magnitude 4.5. Felt on Adak.

February 22: 22:12:55.7*. Epicenter 51.6° north, 175.9° west, Andreanof Islands, W. Magnitude 4.5. Felt on Adak.

February 22: 23:32:26.1*. Epicenter 51.5° north, 176.3° west, Andreanof Islands, W. Magnitude 4.6. Felt on Adak.

February 23: 10:29:38.4*. Epicenter 51.9° north, 179.1° west, Andreanof Islands, W. Magnitude 5.2. Intensity III on Adak.

February 23: 11:22:06.9*. Felt at College.

February 25: 08:08:19.9*, 17:54. Epicenter 51.4° north, 176.0° west, Andreanof Islands, W. Magnitude 5.3. Felt on Adak.

February 27: 13:49:07.2*. Felt at College.

February 27: 18:04, 22:36:40.8*. Felt on Adak.

March 3: 04:23:04.1*. Epicenter 64.7° north, 147.8° west, Alaska, W. Felt at Fairbanks.

March 5: 11:18:07.7*. Epicenter 64.8° north, 147.3° west, Alaska, W. Felt at College and Fairbanks.

March 9: 17:49:25.0*. Epicenter 52.1° north, 177.3° west, Andreanof Islands, W. Magnitude 5.4. Intensity IV on Adak.

March 13: 00:55:27.9*. Epicenter 51.7° north, 176.8° west, Andreanof Islands, W. Magnitude 4.8. Intensity III on Adak.

March 14: 16:13:36*. Epicenter 64.7° north, 147.3° west, central Alaska, W. Felt at College and Fairbanks.

March 17: 00:10:47.7*. Felt at College.

March 22: 07:01:23.3*. Felt at Fairbanks.

April 1: 04:22:41*. Epicenter 64.8° north, 147.2° west, central Alaska, W. Felt at Fairbanks.

April 7: South-central Alaska. Press reported a sharp shock of moderate intensity jarred this area. Felt sharply near epicenter, about 85 miles northeast of Anchorage. Felt slightly in Anchorage and at Fort Richardson Army Post.

April 8: 00:59:25.9*. Felt at Fairbanks.

April 17: 09:52. Felt on Adak.

April 23: 10:29:14.5*. Epicenter 58.7° north, 150.0° west, Gulf of Alaska, W. Magnitude 6–6¼, P. Felt on Kodiak Island.

April 24: 05:52:38.9*. Epicenter 60.9° north, 147.5° west, southern Alaska, W. Magnitude 3.9. Felt at Palmer.

May 8: 09:06:47*. Epicenter 61.9° north, 148.7° west, southern Alaska, W. Felt at Palmer.

May 8: 21:22:47*. Epicenter 61.4° north, 149.8° west, southern Alaska, W. Felt at Palmer.

May 15: 13:13:39.3*. Felt at Fairbanks.

May 15: 18:07:14.5*. Felt at Palmer.

May 17: 20:50:27.4*. Epicenter 61.2° north, 147.6° west, southern Alaska, W. Magnitude 4.3. Felt at Palmer.

May 27: 22:11:30.2*. Felt at Fairbanks.

May 29: 05:25:39.0*. Epicenter 62.3° north, 149.1° west, central Alaska, W. Magnitude 4.0. Felt at Palmer.

June 13: 03:54:09*. Felt at Fairbanks.

June 15: 03:38:06.5*. Epicenter 61.0° north, 146.9° west, southern Alaska, W. Magnitude 4.9. Felt at Anchorage, Valdez, and Whittier.

June 22: 19:40:32.2*. Intensity II at Valdez.

July 2: 11:27:05*. Epicenter 65.0° north, 147.7° west, Alaska, W. Felt at Fairbanks.

July 5: 09:33:10.3*. Epicenter 60.9° north, 147.0° west, southern Alaska, W. Magnitude 4.1. Intensity III at Valdez.

July 12: 22:47:05.7*. Felt on Adak.

July 13: 01:49:31.6*. Felt on Adak.

July 15: 23:46:31.2*. Epicenter 64.9° north, 147.2° west, central Alaska, W. Felt at Fairbanks.

July 26: 06:08:20.9*. Felt at Fairbanks.

August 8: 05:48:53.0*. Felt at Fairbanks.

August 11: 02:37:28.1*. Epicenter 52.1° north, 179.9° west, Andreanof Islands, W. Magnitude 5.5. Felt on Adak.

August 14: 02:10:03.5*. Epicenter 60.2° north, 153.0° west, southern Alaska, W. Magnitude 4.6. Felt at Anchorage.

August 18: 12:07:24.0*. Epicenter 65.9° north, 155.2° west, central Alaska, W. Magnitude 3.9. Intensity IV at Hogatza.

August 31: 13:39:26.8*. Epicenter 64.7° north, 147.4° west, central Alaska, W. Magnitude 3.8. Felt at Fairbanks.

August 31: 16:19:41.2*. Felt at Fairbanks.

August 31: 16:45:53.2*. Epicenter 64.8° north, 147.4° west, central Alaska, W. Felt in Fairbanks area.

August 31: 18:41:47.7*. Felt at Fairbanks.

August 31: 19:08:44.2*. Epicenter 64.8° north, 147.3° west, Alaska, W. Felt in Fairbanks area.

September 1: 15:04:33.3*. Felt at Fairbanks.

September 1: 15:29:03.4*. Epicenter 64.7° north, 147.5° west, central Alaska, W. Magnitude 4.0. Felt in Fairbanks area.

September 8: 06:22:58.6*. Epicenter 64.8° north, 147.6° west, central Alaska, W. Magnitude 4.5. Felt in Fairbanks area.

September 16: 21:00:08.7*. Epicenter 64.7° north, 147.6° west, central Alaska, W. Magnitude 3.7. Felt in Fairbanks area.

September 17: 11:59:40.6*. Epicenter 51.9° north, 176.2° west, Andreanof Islands, W. Magnitude 4.3. Felt on Adak.

September 17: 15:18:34.2*. Epicenter 64.8° north, 147.6° west, central Alaska, W. Magnitude 4.1. Felt at Fairbanks.

September 20: 09:08:38.7*. Felt at Fairbanks.

September 21: 08:30:46.3*. Felt at Fairbanks.

September 21: 20:34:16.7*. Felt at Fairbanks.

September 22: 01:33:18.7*. Epicenter 51.3° north, 177.6° west, Andreanof Islands, W. Magnitude 4.2. Felt on Adak.

September 23: 20:44:16.9*. Epicenter 61.4° north, 149.9° west, southern Alaska, W. Magnitude 3.7. Intensity IV at Palmer.

September 24: 06:28:14.2*. Intensity III at Palmer.

September 28: 03:51:55.9*. Epicenter 64.8° north, 147.4° west, central Alaska, W. Magnitude 3.5. Felt at Fairbanks.

September 28: 16:02:50.2*. Felt at Fairbanks.

October 3: 01:08:38.9*. Epicenter 51.6° north, 174.1° west, Andreanof Islands, W. Magnitude 5.0. Felt on Adak.

October 7: 08:54:53.6*. Epicenter 61.4° north, 150.3° west, southern Alaska, W. Magnitude 4.2. Intensity IV at Palmer; intensity III at Anchorage and Talkeetna Railroad Depot.

October 24: 03:11:58.8*. Epicenter 64.7° north, 147.4° west, central Alaska, W. Felt at Fairbanks.

October 26: 07:03:52.3*. Epicenter 64.8° north, 147.5° west, central Alaska, W. Felt at Fairbanks.

October 29: 12:16:15.6*. Epicenter 65.4° north, 150.1° west, Alaska, W. Magnitude 6.5. VII–VIII. Felt over approximately 250,000 square miles of central Alaska (see fig. 10). A maximum intensity VII–VIII was assigned to the Hunter Creek Valley-Rampart area. It was reported that landslides, earth slumping, and fissuring were widely distributed within a radius of about 12 miles of the epicenter, with principal effects being observed in Hunter Creek Valley, less than 10 miles southeast of Rampart. Practically continuous landslides were noted on the south-facing slope of the valley over nearly its entire length (about 10 miles). Fissures were intermingled with landslides, usually contouring the south-facing slope about halfway up the mountainside. A few miles outside Rampart, a trolley cable across Hunter Creek snapped. At Rampart, on the Yukon River and the nearest village to the epicenter, a ground fissure was observed at the airport (see fig. 11). Goods toppled from shelves and equipment not bolted down shifted. Most buildings in Rampart are of log construction, probably accounting for the lack of serious

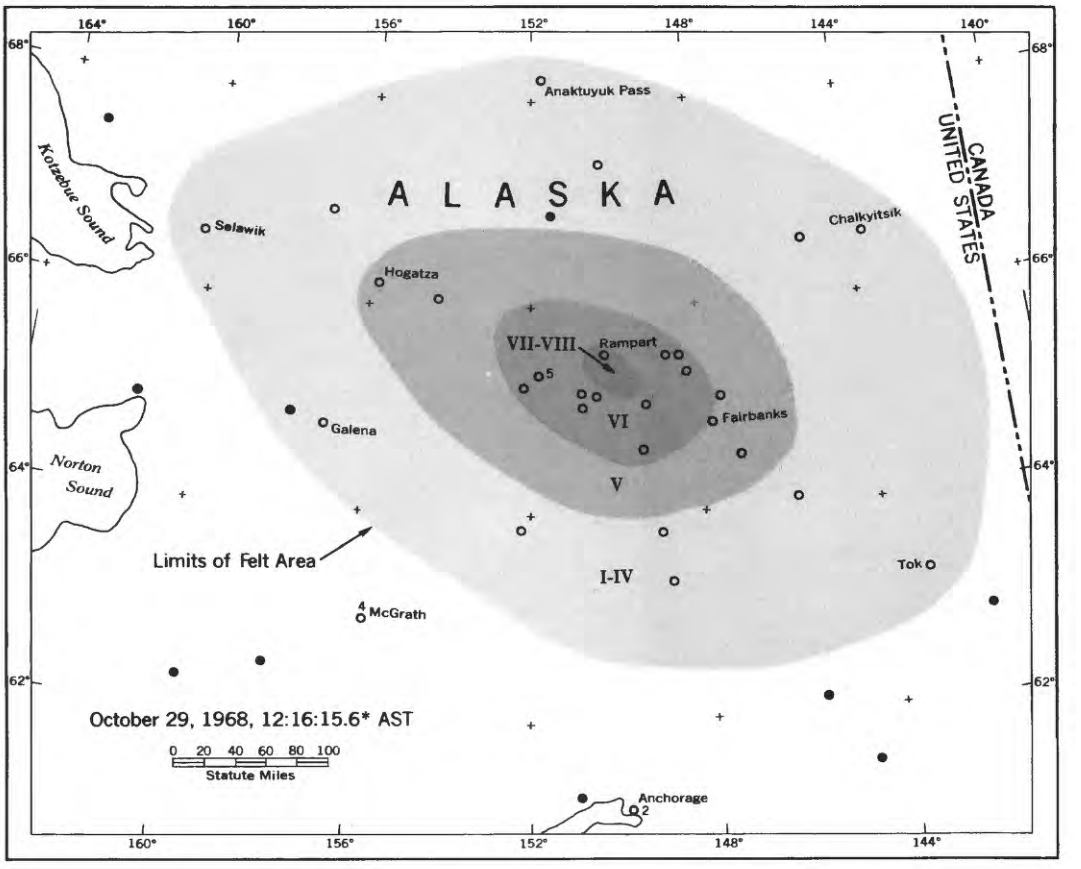

FIGURE 10.—Area affected by central Alaska earthquake of October 29.

damage. The most intensive lake ice cracking was observed in the central part of the Minto Flats area, about 50 miles southeast of the epicenter; noticeably less cracking was noted near the edges of the area. Ice on the Tanana and Yukon Rivers was broken from the banks in many places.

INTENSITY VI:

Baker Creek area (15 miles northeast of Manley Hot Springs).—Ground cracked slightly; creek water was disturbed. Loud earth noises. "Earth crack about 1½ miles north of cabin at Baker Creek."

Livengood.—Felt by all and frightened few. Kitchen floor buckled in the middle; walls settled noticeably. One window cracked. "Water level in the West Fork dropped approximately 18 inches, and in some places is running underground." Moderate rumble.

Livengood (12 miles southeast of).—Ground and river ice cracked. Trees and bushes shook; vehicles rocked. Windows cracked. Loud, booming, rumbling earth noises.

Livengood (6 miles west of; West Fork of Tolavana River on Elliott Highway).—Felt by and frightened all in home. Cabin settled a little on south side. Trees and bushes shook.

Manley Hot Springs.—Felt by all and frightened some in community. Ground cracked. Bricks fell from chimney. Cans, jars, and pictures fell; radio fell off shelf. Trees and bushes shook; vehicles rocked. Faint, rumbling earth noises.

FIGURE 11.—Ground fissure in runway of Dry Lake Airport, near Rampart.

Manley Hot Springs (8 miles north of on Eureka-Manley Road).—Ground shook very strongly. Trees shook and leaned over.

Minto.—Felt by all and frightened many in community. Ice cracked. Small objects shifted. Moderate earth noises.

Nenana.—Felt by and frightened many. Ground cracked. Plaster fell. Furniture shifted. Trees and bushes shook; vehicles rocked. Loud earth noises.

Tanana.—Felt by and frightened many. Ice cracked. Trees and bushes shook; vehicles rocked. Pictures fell from walls. Moderately loud, rumbling earth noises.

INTENSITY V:

Chalkyitsik, Chatanika, Eielson Air Force Base (southeast of Fairbanks), Fairbanks, Hogatza (Hog River), Hughes, and Tanana (8 miles northeast of at Bear Creek).

INTENSITY IV:

Cantwell, Delta Junction, Fort Yukon, Galena, Healy Fork, Kobuk, Lake Minchumina, McGrath, Selawik, Tok, and Wiseman.

INTENSITY I–III:

Anaktuyuk Pass and Anchorage.

October 29: 13:25:36.1*. Epicenter 65.6° north, 150.3° west, Alaska, W. Magnitude 4.2. Felt at Fairbanks and Manley Hot Springs.

October 29: 13:43:32.9*. Epicenter 65.6° north, 150.0° west, Alaska, W. Magnitude 3.9. Felt at Fairbanks and Manley Hot Springs.

October 29: 14:25:11.7*. Epicenter 65.6° north, 150.1° west, Alaska, W. Magnitude 4.0. Felt at Fairbanks.

October 29: 20:15:33.6*. Epicenter 65.6° north, 150.1° west, Alaska, W. Magnitude 4.0. Felt at Fairbanks.

October 30: 04:08:40.6*. Epicenter 65.4° north, 150.0° west, Alaska, W. Magnitude 3.9. Felt at Fairbanks.

October 30: 14:25:45.1*. Epicenter 65.4° north, 150.1° west, Alaska, W. Magnitude 4.5. Described as quite severe 6 miles west of Livengood. Also felt at Fairbanks and Manley Hot Springs.

October 30: 22:00:16.2*. Felt at Fairbanks.

October 31: 09:23:54.3*. Epicenter 65.5° north, 150.0° west, Alaska, W. Magnitude 4.0. Felt at Manley Hot Springs.

November 2: 09:41:46.2*. Epicenter 64.9° north, 149.4° west, central Alaska, W. Magnitude 4.4. Felt at Fairbanks, Livengood (6 miles west of), and at Manley Hot Springs.

November 2: 21:37:40.2*. Epicenter 65.6° north, 149.9° west, Alaska, W. Magnitude 4.4. Felt at Fairbanks.

November 2: 21:57:41.0*. Epicenter 65.6° north, 150.1° west, Alaska, W. Magnitude 3.9. Felt at Fairbanks.

November 2: 22:08:11.7*. Epicenter 65.6° north, 149.9° west, Alaska, W. Felt at Fairbanks and 6 miles west of Livengood.

November 3: 13:30. Felt at Manley Hot Springs.

November 6: 14:48:33.6*. Epicenter 54.3° north, 164.6° west, Unimak Island region, W. Magnitude 5.1. Felt at Cape Sarichef and Driftwood Bay.

November 10: 17:49:30.9*. Epicenter 61.6° north, 150.1° west, southern Alaska, W. Felt at Palmer.

November 10: 22:53:52.0*. Epicenter 57.3° north, 155.3° west, Alaska Peninsula, W. Magnitude 5.3. Alarmed many at Akhiok.

November 13: 09:30:09.9*. Felt on Adak.

December 7: 12:54:31.5*. Epicenter 61.8° north, 149.1° west, Alaska, W. Felt at Palmer.

December 9: 10:04:49.7*. Epicenter 51.8° north, 176.8° west, Andreanof Islands, W. Magnitude 4.2. Felt on Adak.

December 13: 02:21:15.8*. Epicenter 62.0° north, 147.9° west, central Alaska, W. Magnitude 3.8. Felt at Palmer.

December 17: 02:02:15.0*. Epicenter 60.2° north, 152.8° west, southern Alaska, W. Magnitude 6½, P. VI. At Kenai, a natural gasline feeding a power generator was severed. Frightened all at Cohoe; canned goods fell. Awakened all and frightened many 5 miles northeast of Ninilchik; small objects fell. Intensity V at Anchorage, Chugiak, Cooper Landing, Glennallen, Glenn Highway (Mile 113.5), Gulkana, Homer, Kodiak, Palmer, Seward, Sterling (Mile 86), Talkeetna, and Valdez; intensity IV at Cantwell. Also felt at Fairbanks.

December 19: 11:48:50.5*. Intensity II at Palmer.

December 26: 09:03:39.1*. Epicenter 51.5° north, 177.8° west, Andreanof Islands, W. Magnitude 4.2. Intensity II on Adak.

December 27: 18:15:55.0*. Epicenter 63.0° north, 148.2° west, central Alaska, W. Magnitude 4.6. Felt at Palmer.

December 28: 16:45:10.9*. Epicenter 61.7° north, 152.2° west, southern Alaska, W. Magnitude 4.5. Felt in the Palmer-Anchorage area.

December 29: 21:03:11.7*. Epicenter 57.6° north, 151.4° west, Kodiak Island region, W. Magnitude 5.4. Felt at Kodiak and in the Anchorage-Palmer area.

HAWAII

[150th Meridian or Hawaiian Standard Time]

NOTE: Data on the following local disturbances were determined from seismograph stations on the Islands of Hawaii and Maui by the Hawaiian Volcano Observatory of the U. S. Geological Survey.

January 9: 18:16:15.9*. Epicenter 19° 11.8′ north, 155°20.8′ west, 16 km south-

southeast of Desert seismometer at a depth of 7 km. Magnitude 3.0. Felt at Pahala.

January 9: 20:24:18.1*. Epicenter 19° 10.3′ north, 155°20.8′ west, 11 km east-northeast of Palama Point at a depth of 5 km. Magnitude 3.1. Felt at Pahala.

January 15: 07:10:47.7*. Epicenter 19° 21.3′ north, 155°08.2′ west, 4 km southeast of Makaopuhi seismometer at a depth of 10 km. Magnitude 3.0. Felt at Hilo.

January 16: 19:03:10.0*. Epicenter 19° 16.3′ north, 155°22.2′ west, 7 km south-southeast of Desert seismometer at a depth of 40 km. Magnitude 3.5. Felt at Pahala.

January 24: 14:48:44.3*. Epicenter 19° 21.2′ north, 155°01.8′ west, 5 km west of Kalapana at a depth of 8 km. Magnitude 3.7. Felt in Kilauea Summit area, Hilo, Pahoa, and Pahala.

February 1: 17:32:36.6*. Epicenter 19° 20.5′ north, 155°07.5′ west, 5 km southeast of Makaopuhi seismometer at a depth of 9 km. Magnitude 3.5. Felt at Pahala.

February 2: 07:52:53.6*. Epicenter 19° 20.2′ north, 155°09.3′ west, 3 km southeast of Makaopuhi seismometer at a depth of 9 km. Magnitude 3.2. Felt at Hilo.

February 15: 05:07:47.8*. Epicenter 19° 21.1′ north, 155°18.9′ west, 8 km southwest of Uwekahuna seismometer at a depth of 34 km. Magnitude 3.1. Felt at Pahala.

April 3: 15:06:11.1*. Epicenter 19°23.1′ north, 155°27.1′ west, 8 km northwest of Desert seismometer at a depth of 8 km. Magnitude 3.7. Felt at Pahala, Hilo, and in Kilauea Summit area.

April 10: 01:00:24.8*. Epicenter 19°23.9′ north, 155°16.9′ west, south rim of Kilauea caldera at a depth of 27 km. Magnitude 3.7. Felt in Kilauea Summit area and Pahala.

April 15: 10:30:25.5*. Epicenter 19°15.0′ north, 155°25.2′ west, 8 km northeast of Pahala at a depth of 10 km. Magnitude 3.0. Felt at Pahala.

April 18: 20:09:42.8*. Epicenter 19°22.0′ north, 155°16.8′ west, 2 km southwest of Ahua seismometer at a depth of 29 km. Magnitude 3.2. Felt in Kilauea Summit area, Pahala, and Hilo.

April 28: 04:08:59.0*. Epicenter 19°22.5′ north, 155°17.9′ west, 4 km west of Ahua seismometer at a depth of 30 km. Magnitude 4.5. Felt Island-wide.

April 28: 04:52:13.3*. Epicenter 19°21.8′ north, 155°18.4′ west, 5 km southwest of Ahua seismometer at a depth of 30 km. Magnitude 3.2. Felt in Kilauea Summit area.

April 28: 05:19:12.8*. Epicenter 19°22.5′ north, 155°16.9′ west, 2 km west of Ahua seismometer at a depth of 30 km. Magnitude 3.6. Felt in Kilauea Summit area.

April 28: 08:35:25.0*. Epicenter 19°24.9′ north, 155°26.8′ west, 11 km southwest of Mauna Loa seismometer at a depth of 8 km. Magnitude 3.4. Felt at Pahala.

May 12: 10:06:52.9*. Epicenter 19°20.2′ north, 155°44.8′ west, 17 km southeast of Hookena at a depth of 0 km. Magnitude 3.6. Felt at Kawaihae and Kealakekua.

May 29: 11:42:34.3*. Epicenter 19°25.2′ north, 155°16.3′ west, Kilauea caldera at a depth of 3 km. Magnitude 3.7. Felt in Kilauea Summit area.

June 2: 21:17:25.4*. Epicenter 19°20.8′ north, 155°07.2′ west, 6 km southeast of Makaopuhi seismometer at a depth of 9 km. Magnitude 3.1. Felt in Kilauea Summit area, Hilo, and Pahala.

June 8: 05:27:58.9*. Epicenter 19°22.1′ north, 155°17.8′ west, 4 km southwest of Kilauea caldera at a depth of 30 km. Magnitude 3.0. Felt in Kilauea Summit area and Pahala.

June 19: 04:36:18.9*. Epicenter 19°24.0′ north, 155°17.3′west, southwest rim of

Kilauea caldera at a depth of 5 km. Magnitude 3.0. Felt at Pahala.

July 2: 10:55:06.3*. Epicenter 20°00.2′ north, 155°49.3′ west, 4 km south-southeast of Kawaihae at a depth of 8 km. Magnitude 3.4. Felt at Honokaa and Kamuela.

July 2: 12:11:10.6*. Epicenter 20°03.8′ north, 155°50.2′ west, 3 km northwest of Kawaihae at a depth of 8 km. Magnitude 3.5. Felt at Honokaa and Kamuela.

July 9: 21:32:15.2*. Epicenter 19°19.2′ north, 155°13.7′ west, 8 km northwest of Apua Point at a depth of 13 km. Magnitude 3.5. Felt in Hilo, Kilauea Summit area, and Pahala.

July 21: 21:15:24.0*. Epicenter 19°22.8′ north, 155°03.2′ west, 8 km northwest of Kalapana at a depth of 10 km. Magnitude 3.3. Felt in Kilauea Summit area, Mountain View, and Hilo.

July 29: 06:21:11.9*. Epicenter 19°23.2′ north, 155°05.6′ west, 8 km east-northeast of Makaopuhi seismometer at a depth of 9 km. Magnitude 3.3. Felt at Hilo, Mount View, and in Kilauea Summit area.

July 29: 19:35:44.7*. Epicenter 19°21.0′ north, 155°06.7′ west, 7 km southeast of Makaopuhi seismometer at a depth of 10 km. Magnitude 3.7. Felt at Hilo, Mount View, Pahala, and in Kilauea Summit area.

August 1: 00:34:37.8*. Epicenter 19°20.0′ north, 155°06.8′ west, 7 km southeast of Makaopuhi seismometer at a depth of 10 km. Magnitude 4.0. Felt Island-wide.

August 2: 18:36:55.4*. Epicenter 19°51.9′ north, 155°55.1′ west, Kiholo Bay at a depth of 40 km. Magnitude 3.8. Felt at Kealakekua and Paauilo.

August 5: 10:37:18.0*. Epicenter 19°54.1′ north, 155°53.1′ west, 7 km northeast of Kiholo Bay at a depth of 5 km. Magnitude 3.1. Felt at Kealakekua.

August 7: 10:58:25.0*. Epicenter 19°19.1′ north, 155°48.2′ west, 13 km southeast of Hookena at a depth of 3 km. Magnitude 4.4. Felt in Hakalau, Pahala, Kilauea Summit area, and Naalehu.

August 9: 01:04:53.4*. Epicenter 19°23.4′ north, 155°17.0′ west, 1 km south of Kilauea caldera at a depth of 30 km. Magnitude 3.7. Felt in Kilauea Summit area, Mountain View, Hakalau, Kealakekua, and Hilo.

August 16: 13:14:00.4*. Epicenter 19° 24.1′ north, 155°17.0′ west, south rim of Kilauea caldera at a depth of 15 km. Magnitude 3.2. Felt at Pahala, Mountain View, and in Kilauea Summit area.

August 16: 16:23:37.6*. Epicenter 19° 53.2′ north, 155°22.9′ west, 5 km southwest of Keanakolu at a depth of 8 km. Magnitude 4.1. Felt Island-wide.

August 20: 16:29:40.9*. Epicenter 19° 23.2′ north, 155°25.1′ west, 7 km northwest of Desert seismometer at a depth of 8 km. Magnitude 3.3. Felt at Pahala, Mountain View, and in Kilauea Summit area.

August 21: 11:28:56.2*. Epicenter 19° 11.2′ north, 155°36.7′ west, 14 km north-northwest of Naalehu at a depth of 8 km. Magnitude 3.0. Felt at Pahala.

August 22: 04:09:56.0*. Epicenter 19° 22.4′ north, 155°14.1′ west, 3 km east of Ahua seismometer at a depth of 4 km. Magnitude 3.0. Felt in Kilauea Summit area.

September 2: 14:58:23.4*. Epicenter 19° 21.3′ north, 155°27.1′ west, 7 km northwest of Desert seismometer at a depth of 8 km. Magnitude 3.1 Felt in Kilauea Summit area, Pahala, Hilo, and Kealakekua.

September 5: 06:12:43.7*. Epicenter 19° 57.8′ north, 155°23.8′ west, 8 km northwest of Keanakolu at a depth of 8 km. Magnitude 3.2. Felt at Hilo.

September 7: 17:08:44.3*. Epicenter 19° 26.0′ north, 155°16.7′ west, Kilauea caldera

at a depth of 20 km. Magnitude 3.7. Felt in Kilauea Summit area, Kealakekua, Hilo, and Mountain View.

September 23: 18:11:53.3*. Epicenter 20° 10.3′ north, 155°48.5′ west, 20 km northwest of Kamuela at a depth of 8 km. Magnitude 4.1. Felt at Waipio Valley, Kawaihae, Hilo, Waimea, Kamuela, and in Kilauea Summit area.

October 25: 14:47:09.9*. Epicenter 19° 09.9′ north, 155°30.6′ west, 5 km southwest of Pahala at a depth of 8 km. Magnitude 3.7. Felt at Pahala, Kealakekua, Naalehu, and Milolii.

November 10: 10:28:45.4*. Epicenter 19° 24.5′ north, 155°29.4′ west, 13 km northwest of Desert seismometer at a depth of 7 km. Magnitude 3.3. Felt at Pahala.

November 18: 23:52:59.0*. Epicenter 19° 13.3′ north, 154°58.0′ west, 15 km south of Kalapana at a depth of 7 km. Magnitude 4.3. Felt at Hilo.

November 19: 20:43:21.1*. Epicenter 19° 22.8′ north, 155°18.0′ west, 3 km southwest of Kilauea caldera at a depth of 30 km. Magnitude 3.7. Felt Island-wide.

December 16: 16:33:03.5*. Epicenter 19° 19.9′ north, 155°12.3′ west, 5 km southwest of Makaopuhi seismometer at a depth of 10 km. Magnitude 4.7. Felt Island-wide.

December 17: 20:43. Press reports indicated a shock was felt in Kona and as far distant as Hamakua and Paauilo.

December 19: 22:16:11.1*. Epicenter 19° 20.2′ north, 155°06.8′ west, 7 km southeast of Makaopuhi seismometer at a depth of 9 km. Magnitude 3.5. Felt at Hilo, Pahala, and in Kilauea Summit area.

PANAMA CANAL ZONE

[75th Meridian Time]

December 15: 22:07:24.1*. Epicenter 7.1° north, 82.2° west, south of Panama, W. Magnitude 5.3. Felt at Balboa, Howard, and Panama.

PUERTO RICO

[60th Meridian Time]

April 12: 21:15:32.3*. Epicenter 19.0° north, 66.9° west, Puerto Rico region, W. Magnitude 5.1. Intensity IV at Central San Francisco, Guayanilla. Also felt at San Juan.

May 2: 01:29:38.2*. Epicenter 18.8° north, 69.6° west, Dominican Republic region, W. Magnitude 5.8. Felt at San Juan and Cayey.

September 3: 11:37:00.2*. Epicenter 20.6° north, 62.2° west, North Atlantic Ocean, W. Magnitude 5.9. Felt at San Juan.

October 15: 21:56:27.5*. Felt weakly at Cayey.

VIRGIN ISLANDS

[60th Meridian Time]

March 29: 16:32:01.2*. Epicenter 18.8° north, 64.8° west, Virgin Islands, W. Magnitude 4.7. Intensity IV on St. Thomas.

April 14: 21:50:33*. Epicenter 18.7° north, 64.8° west, Virgin Islands, W. Magnitude 3.8. Felt on St. Thomas (IV).

Principal Earthquakes of the World During 1968

[Listed in this section are (1) earthquakes of magnitude greater than 6¾, and those of smaller magnitude which were locally destructive and caused casualties; (2) earthquakes of unusual interest. A description of each earthquake follows the list.]

Date	Origin time G.M.T.			Region	Coordinates		Magnitude [1]	Depth [2]
					Lat.	Long.		
	h	*m*	*s*		*deg*	*deg*		*km*
Jan. 15	02	01	08.5	Sicily	37.9 N.	13.1 E.	6, P	33R
Jan. 25	09	56	48.7	do	37.8 N.	13.2 E.	5.1, C&GS	33R
Feb. 12	05	44	47.6	New Ireland region	5.5 S.	153.2 E.	7–7¼, P	74
Feb. 19	22	45	41.2	Aegean Sea	39.4 N.	25.0 E.	7¼–7½, P	7
Feb. 21	01	44	50.5	Kyushu, Japan	32.0 N.	130.6 E.	5.0, C&GS	3
Feb. 23	14	23	03.3	Brazil	6.1 S.	38.4 W.	4.5, C&GS	33R
Feb. 25	15	40	44.8	Algeria	36.8 N.	5.6 E.	4.9, C&GS	20
Apr. 1	00	42	04.2	Shikoku, Japan	32.5 N.	132.2 E.	7½–7¾, P	33R
Apr. 9	02	28	58.9	Southern California	33.1 N.	116.1 W.	6.5, P	20
Apr. 29	17	01	57.6	Iran-USSR border	39.2 N.	44.3 E.	5.3, C&GS	34
May 16	00	48	55.4	Off east coast of Honshu, Japan.	40.8 N.	143.2 E.	7.9, C&GS	7
May 16	10	39	01.6	Off coast of Honshu, Japan	41.5 N.	142.7 E.	7, P	33R
May 20	20	05	49.1	Kermadec Islands	30.7 S.	178.4 W.	7.0, C&GS	46
May 23	17	24	15.7	South Island, New Zealand	41.7 S.	171.9 E.	7.1, C&GS	21
May 28	13	27	18.7	Near north coast of western New Guinea.	2.9 S.	139.3 E.	7, P	65R
June 12	13	41	50.7	Near east coast of Honshu, Japan.	39.5 N.	142.7 E.	7.0, C&GS	44
June 19	08	13	35.0	Northern Peru	5.6 S.	77.2 W.	6.9, C&GS	28
July 1	10	45	11.9	Honshu, Japan	36.0 N.	139.3 E.	5.9, C&GS	67
July 2	03	44	48.9	Guerrero, Mexico	17.6 N.	100.3 W.	6, P	41
July 25	07	23	07.8	Kermadec Islands	30.8 S.	178.4 W.	7–7¼, P	60
Aug. 1	20	19	21.9	Luzon, Philippine Islands	16.5 N.	122.2 E.	7.3, C&GS	36
Aug. 2	14	06	43.9	Oaxaca, Mexico	16.6 N.	97.7 W.	7.1, C&GS	40
Aug. 10	02	07	04.3	Molucca Passage	1.4 N.	126.2 E.	7.6, C&GS	33R
Aug. 14	22	14	19.4	Northern Celebes	0.2 N.	119.8 E.	7.4, C&GS	23
Aug. 31	10	47	37.4	Iran	34.0 N.	59.0 E.	7.3, C&GS	13
Sept. 3	08	19	52.2	Turkey	41.8 N.	32.3 E.	6.6, C&GS	38
Sept. 20	06	00	03.5	Near coast of Venezuela	10.7 N.	62.7 W.	7, P	107D
Sept. 24	04	19	59.5	Turkey	39.2 N.	40.2 E.	5.1, C&GS	14
Sept. 25	10	38	38.4	Mexico-Guatemala border region.	15.6 N.	92.6 W.	6, P	138
Sept. 26	18	02	50.1	Kermadec Islands	30.5 S.	178.2 W.	6.8, C&GS	33R
Oct. 7	19	20	20.3	Bonin Islands region	26.3 N.	140.6 E.	7.5, P	516D
Oct. 14	02	58	47.8	Western Australia	31.5 S.	117.0 E.	6.8, C&GS	1
Nov. 3	04	49	31.8	Yugoslavia	42.1 N.	19.4 E.	5.3, C&GS	17
Nov. 9	17	01	41.1	South-central Illinois	38.0 N.	88.5 W.	5.3, C&GS	19

[1] Abbreviations following magnitude values are as follows: P, Pasadena; C&GS, Coast and Geodetic Survey.

[2] Depth followed by *R*, restrained at that value and not freely determined in solution; depth followed by *D*, restrained to agree with reported depth phrases.

FIGURE 12.—Damage in Gibellina, Sicily, as result of the January 15 earthquake.

DESCRIPTIONS OF PRINCIPAL EARTHQUAKES

January 15. Sicily. Several villages in western Sicily were destroyed by this strong shock. It toppled houses, hospitals, medieval castles, and churches in the worst disaster in this country since the 1908 Messina earthquake (see fig. 12). Damage was estimated at $250–$320 million, with 216 killed and 563 injured.

January 25. Sicily. A moderate aftershock of the January 15 earthquake killed eight persons, injured 55, and caused additional property damage.

February 12. New Ireland region. Some property damage was sustained in the area.

February 19. Aegean Sea. Cape Tripiti, at the southern end of St. Eustratios Island, sustained 20 fatalities and several injuries. Over 500 houses were leveled and 1,951 damaged. Property damage was estimated at $600,000. Moderate property damage was also sustained on nearby Lemnos Island.

February 21. Kyushu, Japan. Three persons were killed, 10 injured, and more than 2,000 houses destroyed or damaged. Highways and railroads were blocked by landslides.

February 23. Brazil. One fatality, four injuries, and minor property damage were sustained at Pereiro.

February 25. Algeria. At El Alen, one person was killed, four injured, and 100 houses destroyed.

April 1. Shikoku, Japan. Minor property damage occurred at Kyushu, where one person died and 22 were injured. A 2.3-meter tsunami was generated on the east coast of Kyushu. It destroyed four homes and capsized several fishing boats.

April 9. Southern California. The strongest California earthquake in 15 years centered in northeastern San Diego County on this date. Minor right-lateral displacement occurred on Coyote Fault; landslides occurred at several points in the Anza-Borrego Desert State Park. Many buildings were slightly damaged, with walls cracking and chimneys toppling.

April 29. Iran-USSR border. This moderate shock took 38 lives, injured 100, and destroyed 1,000 houses in the Maku area of northwestern Iran. It was reported that fissures developed on the mountainside overlooking Maku.

May 16. Off east coast of Honshu, Japan. This was the largest-magnitude earthquake since the 1964 Good Friday shock in Alaska. Forty-seven persons were killed, 281 were injured, and $131 million property damage was sustained. The port city of Hachinohe incurred the greatest damage. A tsunami was generated that inundated low-lying areas and washed ashore or sank 95 ships. Several aftershocks were reported, two of which generated small tsunamis.

May 16. Off coast of Honshu, Japan. Felt. A slight tsunami was generated during this strong aftershock.

May 20. Kermadec Islands. Felt on Raoul.

May 23. South Island, New Zealand. This earthquake was the strongest in 8 years in the area, and resulted in three deaths, 14 injuries, and damage estimated at about $3 million. The epicenter was located in rough hill country about 7 miles north of the small town of Inangahua. Major landslides occurred in the gorge of the Buller River, with slumping, fissuring, and fountaining. Bridges were badly damaged, houses razed, and railway lines distorted.

May 28. Near north coast of western New Guinea. Felt throughout the east and west Sepik Districts of New Guinea and the western area of Papua.

June 12. Near east coast of Honshu, Japan. Felt. A slight tsunami was generated.

June 19. Northern Peru. This earthquake centered in a sparsely populated area of the Amazon Basin. Moyobamba, in the Department of San Martin, was seriously affected. Forty-six persons were killed, 120 injured, and 50 houses destroyed. In a boat trip along the Mayo River, Peruvian scientists reported landslides, ground fractures, and overturned trees.

July 1. Honshu, Japan. In the Tokyo area, one person was killed and nine injured. Power and transportation were interrupted.

July 2. Guerrero, Mexico. One person died and minor damage was sustained at Cuajimalpa.

July 25. Kermadec Islands. Felt on Raoul.

August 1. Luzon, Philippine Islands. An estimated 207 residents were killed, many were injured, and widespread property damage occurred. The greatest loss of life was sustained in Manila when a six-story apartment building collapsed into a pile of rubble. A river was blocked at Maddela in the province of Nueva Vizcaya. Ground fissures were noted between Casiguran and Baler; some were reported to be 7 or more kilometers long. Damage to private buildings in Manila was extensive, with six structures of six to eight floors severely damaged. Fire ignited by the shock caused an estimated $7.5 million damage in the harbor area.

August 2. Oaxaca, Mexico. This damaging shock caused 18 fatalities and extensive property damage in the State of Oaxaca and in Mexico City. In Mexico City, many structures, including a nine-story office building, were damaged beyond repair. The shock disrupted telephone and electric services and caused general panic in many towns.

August 10. Molucca Passage. Minor damage was sutained at Menado.

FIGURE 13.—Earthquake damage to typical domed roof dwelling in the Dasht-e Bayāz, Iran, region as result of August 31 earthquake. Sections of buildings still remain standing, but most in the area were reduced to rubble.

August 14. Northern Celebes. In the Manimbaja Bay area, between Tandjung, Manimbaja, and Sabang, Sulawesi, slipping of the fault resulted in subsidence of 2 to 3 meters on part of the coast, and the apparent raising of Togian Island. Tsunami waves, reaching up to 300 meters inland, took some 200 lives and destroyed 700 houses. Wave heights were estimated at 8 to 10 meters.

August 31. Iran. The most devastating earthquake of the year struck on this date near the town of Kakh in northeastern Iran. Kenneth Bayer, a C&GS geophysicist, visited the stricken area, surveying property damage and surface faulting. Estimates indicate the shallow-depth shock took over 11,000 lives, injured thousands, and left upwards of 100,000 homeless[1]. The most severely affected area was the province of Khorassan which has a population of 1.8 million. More than 100 villages were damaged and several reduced to rubble (see fig. 13).

[1] Bayer, Kenneth C., et al., "An Investigation of the Dasht-e Bayāz, Iran Earthquake of August 31, *Bulletin of Seismological Society of America*, vol. 59, No. 5, 1969.

September 3. Turkey. This shock centered in the vicinity of Bartin, Turkey, and caused 24 deaths, 200 injuries, and destroyed over 2,000 houses. Several villages were completely razed. At Amasra, water in the Big Port first drew back 1.5 meters, leaving fish jumping on dry land, and then rose 3 meters. Huge landslides and rockfalls were observed along a 9-mile stretch of the coast of Big Port. A lake was created by landslide action at Cakraz, where the sea receded about 12–15 meters and never returned entirely to its original level.

September 20. Near coast of Venezuela. Three persons were killed at Cumana, and several were injured. A high percentage of damage was reported at small towns close to the epicentral region. The shock was felt over a wide area of Venezuela and Trinidad.

September 24. Turkey. Two were killed and 40 injured at Elazig and Bingol. The shock centered in a sparsely populated area west of Varto. Property damage was sustained in many villages in the region.

September 25. Mexico-Guatemala border region. The shock caused 20 deaths and injured 500 in Mexico's southern Chiapas region. The most severe damage occurred at the village of Acapetagua, where about half the houses were leveled and ten persons killed. Highways and railroads were blocked by landslides.

September 26. Kermadec Islands. Felt on Raoul.

October 7: Bonin Islands region. Felt.

October 14. Western Australia. The earthquake wrecked the town of Meckering and ruptured all major roads and railways nearby. A survey revealed a fracture of the earth's crust along an arc 29 kilometers in length which passed 1 kilometer northwest of Meckering. Minor damage was also sustained in Perth, the capital city.

November 3. Yugoslavia. One person was killed and five injured at Pistula. A local church and school were razed, and a score of houses demolished. Considerable damage was reported to other towns throughout southern Montenegro.

November 9. South-central Illinois. This was the strongest earthquake in the region since 1895. It was felt over all or portions of 23 states, and included isolated reports from distant localities, such as Boston, Mobile, Pensacola, and southern Ontario. Minor damage, consisting of downed chimneys, foundation cracks, and scattered instances of collapsed parapets and overturned tombstones, was sustained in Illinois, Indiana, Kentucky, and Tennessee. Magnitude 5.3.

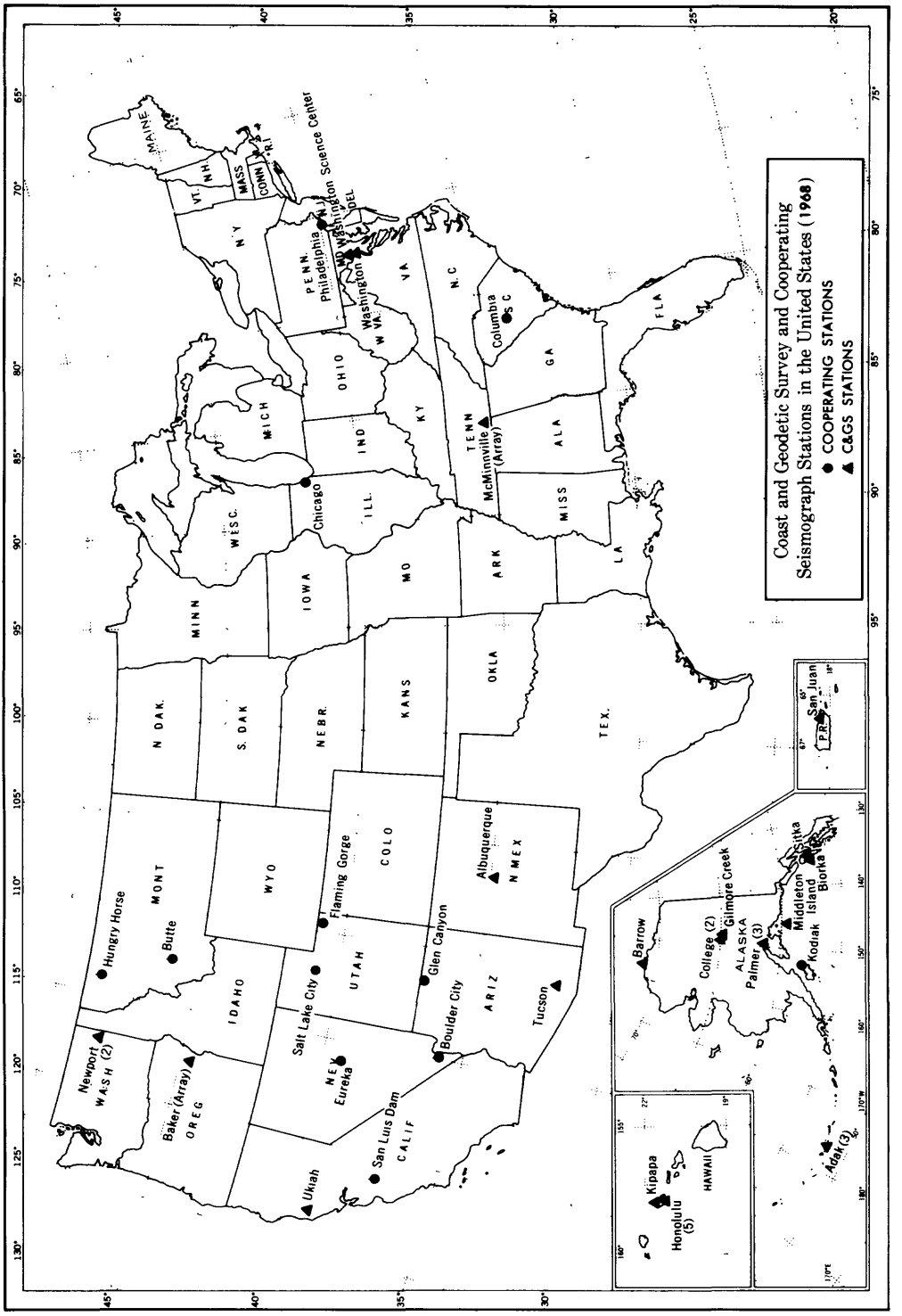

FIGURE 14.—Seismological observatories for which the National Earthquake Information Center (C&GS) publishes results.

Seismological Observatories

The Coast and Geodetic Survey publishes the results of its teleseismic and cooperating stations in the monthly *Seismological Bulletin* and quarterly *Antarctic Seismological Bulletin*. All seismogram interpretations are tabulated, together with epicenters based on the published data and instrumental results received from seismological stations in all parts of the world. Instrumental results are published for the stations which follow (see fig. 14 for station locations, excluding Balboa Heights, Byrd, Guam, and South Pole).

For detailed instrumental data regarding the stations below, including instrumentation, constants, and other information, refer to *Seismological Bulletin*, MSI-337, and *Antarctic Seismological Bulletin*, MSI-337A, January 1969. Those desiring to receive these reports as issued should request addition of their names to the CGS-7 mailing list.

Coast and Geodetic Survey Stations

Adak, Alaska (3)
Albuquerque, N. Mex.
Baker, Oreg. (Array)
Barrow, Alaska
Biorka, Alaska
Byrd, Antarctica
College, Alaska (2)
Gilmore Creek, Alaska
Guam, Mariana Islands (2)
Honolulu, Hawaii (5)
Kipapa, Hawaii
Kodiak, Alaska
McMinnville, Tenn. (Array)
Middleton Island, Alaska
Newport, Wash.
Nordman, Idaho
Palmer, Alaska (3)
San Juan, P.R.
Sitka, Alaska
South Pole, Antarctica
Tucson, Ariz.
Ukiah, Calif.
Washington, D.C.
Washington Science Center, Rockville, Md.

Cooperating Stations

Balboa Heights, Canal Zone
(The Panama Canal Co.)
Boulder City, Nev.
(Bureau of Reclamation)
Butte, Mont.
(Montana School of Mines)
Chicago, Ill.
(Univ. of Chicago-Weather Bureau, ESSA)
Columbia, S.C.
(Univ. of South Carolina)
Eureka, Nev.
(Eureka Corporation, Ltd.)
Flaming Gorge, Utah
(Bureau of Reclamation)
Glen Canyon, Ariz.
(Bureau of Reclamation)
Hungry Horse, Mont.
(Bureau of Reclamation)
Philadelphia, Pa.
(The Franklin Institute)
Salt Lake City, Utah
(Univ. of Utah)
San Luis Dam, Calif.
(Bureau of Reclamation)

(page 71 follows)

Miscellaneous Activities

GEODETIC WORK OF SEISMOLOGICAL INTEREST

The program of repeating geodetic control surveys for the purpose of detecting horizontal and vertical movement in the earth's crust was continued in 1968. Surveys for the study of horizontal movements were made by the Coast and Geodetic Survey in the following areas of California, Nevada, Washington and Oregon, and the northeastern section of the United States.

California

Imperial Valley, Vicinity of El Centro.—Final analysis of the results of the 1967 survey indicates these observations are in close agreement with those of the survey of 1954. The pattern of vectors for this interval indicates a possibility that right-lateral movement continues.

Taft-Mojave Area.—This extensive net covers a large area where the San Andreas, Garlock, White Wolf, Big Pine, and San Gabriel Faults converge. Least-squares adjustments of 1959–60 and 1957 observations were made using 18 network Geodimeter remeasurements which were completed in June 1968 by the California Department of Water Resources (CWR). Strain is more evident than fault slippage. There is an area of expansion east of the Garlock Fault and north of the San Gabriel Fault. The remainder of the net generally contracts or compresses. Along the White Wolf Fault, the Geodimeter results indicate left-lateral movement of about 9 centimeters for the interval 1959–60 to 1967. On the San Andreas, west of the junction with the Garlock and San Gabriel Faults, the Geodimeter results indicate right-lateral movement of about 9 centimeters for the 7-year period. Along the Garlock and San Andreas Faults east of the junction, results indicate strain instead of slippage.

Vicinity of Hollister (Taylor Winery Survey).—The October 1968 resurvey showed right-lateral movement of about 1.0 centimeter during the interval from the previous survey in October 1967. This rate of movement is in close agreement with the results obtained from previous resurveys, accomplished at intervals of approximately 1 year since the establishment of the net in 1957.

At the time of the 1967 resurvey of the Winery site, additional nets—HARRIS and STONE—were established across the San Andreas Fault in areas north and south of the Winery. The HARRIS site is approximately 4 kilometers northwest of the Winery site, and STONE is about 19 kilometers to the southeast. A resurvey of STONE was accomplished in October 1968. The results indicate an annual rate of movement of 1.8 centimeters. A resurvey of HARRIS is planned for completion in March 1969.

Aqueduct Surveys.—The cooperative project with the California Department of Water Resources was continued during the year. Resurveys were accomplished at seven sites along the aqueduct route. Results of the resurveys did not indicate any significant changes at four of these sites—DEVIL, CLEG, QUAIL, and SANTA.

At RIALTO site, the results show right-lateral movement on the same order of magnitude as previously reported—2 millimeters per year.

At RANCH site, results of the 1968 survey show left-lateral movement of 7 millimeters per year (the same order of magnitude as determined from previous resurveys). A continuing counterclockwise rotation of lines crossing the fault is indicated.

Results at the TEM site show that right-lateral movement continued during the interval 1966–68. The rate of movement for this period was slightly less than the 2-centimeter rate for the previous 2-year interval, 1964–66.

Nevada

In December 1968, three Hollister-type triangulation figures were established by the C&GS along unnamed faultlines in the southern part of Nevada. Following an underground atomic blast in December, re-observations were scheduled for January-February 1969 at each site to determine the effect of the blast on possible earth movement in the area of these three nets.

Washington-Oregon

At the request of Battelle Memorial Institute, Richland, Wash., a study was made to determine the possibility of horizontal earth movement in southeast Washington and northeast Oregon. Since no surveys had been made in this region, specifically for the purpose of investigating earth movement, data were investigated for stations where some repeated observations were available. Adjustments were then made to determine the possiblity of movement in the area. The results do not give any indication of tectonic movement.

Northeastern United States

At the request of the Air Force Cambridge Research Laboratories, Bedford, Mass., a study was made for the purpose of measuring possible crustal movement near the St. Lawrence Rift zone. Geodetic survey data, from 1860 to the present, of the northern end of the zone along the Lake Champlain-Hudson River Valleys were reviewed. Data for the common points and common lines of the repeat surveys were used to make least-squares adjustments. Results indicate there is no conclusive evidence of systematic crustal movement.

California and Nevada

Surveys for the study of vertical movements were made in California and Nevada in 1968. First-order leveling of about 900 miles was undertaken. Comparison of these results to previous surveys indicated some areas in the San Joaquin Valley subsided as much as 1 foot per year. Some of the leveling was carried out to complement and furnish ties to new leveling by several southern California counties listed in the last paragraph of this section.

Precise leveling measurements were made at the following Hollister-type triangulation figures located on the San Andreas, San Jacinto, Garlock, and Hayward Faults: HARRIS, TAYLOR, MIRA VISTA, OSGOOD, COLT, PEAR, RANCH, STONE, and the Buena Vista tiltmeter site.

In Nevada, levelings were conducted at NRDS and PAHROC earth movements sites in connection with an atomic blast in December 1968. Levelings were also made at BLACK, located on a fairly recent fault.

Other leveling of seismological interest was begun by the Counties of Los Angeles, Orange, Riverside, San Bernardino, and San Diego, and the City of Los Angeles. Working on a cooperative basis, the engineers of these counties have undertaken the releveling of the C&GS leveling net. Most of the leveling is being done to first-order specifications.

TSUNAMIS

Eight tsunamis were reported to the Coast and Geodetic Survey during 1968, including four that were recorded on C&GS tide gages.

On April 1, an earthquake in Shikoku,

Japan (32.5° north, 132.2° east) caused a tsunami which had a maximum peak to trough amplitude of 2.32 meters. The maximum was recorded at Aburatsu, Japan. At Attu, Alaska, the maximum amplitude was about 0.2 foot.

An earthquake on May 16 off the east coast of Honshu, Japan (40.8° north, 143.2° east) generated the largest and most widely recorded tsunami during the year. More than 33 ships were sunk along the Japanese coast. Maximum amplitudes reported from Japan were: 4.7 meters, Miyako; 6.2 meters, Kamaishi; 8.7 meters, Kuji; 5.0 meters, Urakawa; and 5.2 meters, Okkirai. Maximum wave heights as reported from U. S. tide gages were as follows:

Pacific Ocean

	ft
Guam (Apra Harbor)	0.2
Johnston Atoll	0.2
Kwajalein Atoll	0.3
Midway Island	1.6
Pago Pago (American Samoa)	0.5
Truk Islands (Moen I.)	0.2
Wake Island	0.5

Hawaii

Hilo (Hawaii I.)	1.9
Kahului (Maui I.)	3.3
Mokuoloe Island (Oahu I.)	0.3
Nawiliwili (Kauai I.)	0.4

Washington

Neah Bay	0.3

Alaska

Adak	0.5
Attu	1.0
Sitka	0.2
Unalaska	0.3

California

Alameda (Naval Air Station)	0.2
Avila Beach	0.2
Crescent City	4.1
La Jolla	0.2
Long Beach	0.7
Los Angeles (Berth 60)	0.5
Newport Bay	0.2
Rincon Island	0.2
San Diego	0.5
San Francisco	0.3
Santa Monica	1.0

An earthquake in the Kermadec Islands region on July 25 (30.8° south, 178.4° west) generated a slight tsunami which was recorded at Suva with an amplitude of 3 inches.

On August 1, an earthquake in Luzon, Philippine Islands (16.5° north, 122.2° east) generated a minor tsunami that was reported to have an amplitude of 6 to 8 centimeters in the Ryukyu Islands. The disturbance was registered on C&GS tide gages at Honolulu, Hawaii, Attu, Alaska, Guam, Mariana Islands, and Wake Island. Maximum amplitudes were: Honolulu, 0.1 foot; Attu, 0.3 foot; Wake Island, 0.3 foot; and Guam, 0.1 foot.

An earthquake on August 5 near Shikoku, Japan (33.3° north, 132.2° east) generated a minor tsunami that was recorded at Wake Island with a maximum amplitude of 0.2 foot.

A report from Indonesia stated that following the August 14 earthquake in the northern Celebes (0.2° north, 119.8° east), a tsunami killed 200 people at Mapaga and destroyed 700 houses. The waves reportedly were 8 to 10 meters high and penetrated 100 to 300 meters inland.

A report from Turkey stated that the September 3 earthquake (41.8° north, 32.3° east) generated a tsunami. The water in the Big Port at Amasra fell 1.5 meters and then rose 3 meters, reaching the houses along the coast and washing away the boats near the coffee house.

Reports of a tsunami following the earthquake of September 20 near the coast of Venezuela (10.7° north, 62.7° west) could not be verified.

Fluctuations in Well-Water Levels

In 1943, the Coast and Geodetic Survey first published the section "Fluctuations in Well-Water Levels" in its annual *United States Earthquakes* series. Data for the years 1944 through 1949 appeared in the 1949 issue of this report. It was published annually from 1950 to the present.

The following material was compiled by the Water Resources Division of the U.S. Geological Survey. Table 1 lists fluctuations caused by various sources in wells throughout the country. Table 2 lists the date, time, and location of specific earthquakes that may have been associated with recorded fluctuations in well water. Also included are the states recording the fluctuations.

Complete information on earthquakes possibly associated with the tabulations in table 1 may be obtained from the *Preliminary Determination of Epicenters* cards or *Seismological Bulletins,* both issued by the Coast and Geodetic Survey. Another source is earthquake registers from seismograph stations nearest the locality.

WELL DESCRIPTIONS

Well No. 6N-25E-3aaal. Owner, Phillip Sayer, 43°53'13" north, 113°27'23" west, Butte County. Depth, 92 feet; diameter, 4 inches; depth of casing, unknown. Aquifer, alluvium, Quaternary age.

Well No. 5N-26E-6aaal. Owner, Willard Bell, 43°47'59" north, 113°23'54" west, Butte County. Depth, 180 feet; diameter, 16 inches; depth of casing, unknown. Aquifer, alluvium, Quaternary age.

Well No. 5N-5W-24dbbl. Owner, Carl Gotsh, 43°45'22" north, 116°52'46" west, Canyon County. Depth, 98 feet; diameter, 18 inches; depth of casing, unknown. Aquifer, unknown.

Well No. 14S-27E-33cddl. Owner, U. S. Bureau of Land Management, 42°09'17" north, 113°18'15" west, Cassia County. Depth, 200 feet; diameter, 16 to 14 inches; depth of casing, 16 inch 0–92 feet, 14-inch 87–225 feet; perforated 40–50, 105–225 feet. Aquifer, alluvium, Quaternary age.

Well No. 2S-5E-36bbbl. Owner, Domingo Aguirre, 43°12'42" north, 115°48'55" west, Elmore County. Depth, 357 feet; diameter, 6 inches; depth of casing, 50 feet; open hole. Aquifer, basalt of Snake River Group, Quaternary age.

Well No. 16S-40E-29cbcl. Owner, Franklin Cemetery, 42°00'14" north, 111°49'00" west, Franklin County. Depth, 82 feet; diameter, 10 inches; depth of casing, unknown. Aquifer, alluvium, Quaternary age.

Well No. 14S-15E-28bad2. Owner, U. S. Bureau of Reclamation, 42°10'57" north, 114°42'11" west, Twin Falls County. Depth, 455 feet; diameter, 6 inches; depth of casing, 0–331 feet, perforated 231–331 feet, open hole. Aquifer, silicic volcanic rock.

Well No. 4N-26E-32cbal. Owner, U. S. Bureau of Reclamation, 43°37'50" north, 113°23'45" west, Butte County. Depth, 253 feet; diameter, 16 inches; depth of casing, 0–207 feet, open hole. Aquifer, basalt of Snake River Group, Quaternary age.

Well No. 9N-21E-14bbcl. Owner, U. S. Bureau of Land Management, 44°06'49" north, 113°56'58" west, Custer County.

Depth, 254 feet; diameter, 16 inches; depth of casing, 0–267 feet, perforated 167–267 feet. Aquifer, alluvium, Quaternary age.

Well No. 8S-42E-17cabl. Owner, Joe Torgeson, 42°43′40″ north, 111°34′41″ west, Caribou County. Depth, 119 feet; diameter, 6 inches; depth of casing, 0–21 feet. Aquifer, fractured basalt of Snake River Group (?).

TABLE 1.—*Fluctuations in well-water levels during 1968*

County and/or well number	Date	Time at recorder G.M.T.	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
ALASKA						
			ft	*ft*	*ft*	*ft*
CQ:C-1:6:3	Apr. 8	0400	10.08	0.01	0.01	0.02
13-3-25-1	Apr. 23	2030	7.535	.002	.006	.008
13-2-6-4	Apr. 23	2030	53.12	.04	.07	.11
Do	May 16	0100	54.83	.07	.09	.16
13-3-11-1	July 3	2300	17.184	.010	.006	.016
13-2-6-4	Aug. 2	1500	50.41	.005	.002	.007
Do	Aug. 10	0300	50.34	.01	.01	.02
13-3-11-1	Sept. 7	0800	17.016	.014	0	.014
13-2-6-4	Oct. 29	2230	54.140	.030	.025	.055
13-4-25-1	Dec. 17	1200	8.675	.020	.030	.050
IDAHO						
Madison 7N-38E-23dbal	Feb. 3	0515	42.33	0.03	0.03	0.06
Power 7S-30E-28bbcl	Feb. 3	1200	197.80	.07	.07	.14
Butte 5N-31E-28cccl	Feb. 12	1915	261.37	.07	.05	.12
Cassia 13S-21E-18bbcl	Feb. 12	0645	515.27	.01	.02	.03
Madison 7N-38E-23dbal	Feb. 12	0545	42.53	.02	.03	.05
Teton 4N-45E-13adal	Feb. 12	0830	198.40	.02	.02	.04
Butte 5N-31E-28cccl	Feb. 19	2345	261.58	.07	.04	.11
Cassia 13S-21E-18bbcl	Feb. 19	2345	515.44	.02	.02	.04
Madison 7N-38E-23dbal	Feb. 19	2245	42.78	.09	.09	.18
Teton 4N-45E-13adal	Feb. 20	0045	198.30	.02	.02	.04
Butte 5N-29E-23cdal	Mar. 24	2245	269.93	.01	.01	.02
Blaine 1S-19E-3ccb2	Mar. 25	1300–1500 [a]	17.46	.02	.02	.04
2S-20E-1acc2	Mar. 25	1700–1900 [a]	144.70	.05	.07	.12
Butte 6N-30E-30abal	Apr. 6	1700–1900 [a]	52.08	.04	.04	.08
Blaine 1S-19E-3ccb2	Apr. 8	2100–2300 [a]	17.97	.04	.06	.10
8S-26E-33bcbl	Apr. 8	1800–2000 [a]	107.50	.09	.07	.16
Franklin 16S-40E-29cbcl	Apr. 8	2210	11.12	.04	.04	.08
Jefferson 7N-36E-22abd4	Apr. 8	2000–2200 [a]	6.53	.07	.07	.14
Minidoka 7S-25E-19babl	Apr. 8	2100–2300 [a]	242.36	.07	.06	.13
8S-23E-2baal	Apr. 8	2200–2400 [a]	206.89	.03	.04	.07
Teton 4N-45E-13adal	Apr. 8	2215	200.88	.05	.10	.15
Twin Falls 11S-19E-17aabl	Apr. 8–9	2300–0100	323.26	.02	.02	.04
Bingham 2N-31E-35dccl	Apr. 9	0200	585.37	.05	.05	.10
Bonneville 1N-36E-1ccbl	Apr. 9	0145	155.08	.01	.01	.02

[a] Time of occurrence for monthly gage believed to be accurate to ± 1 hour. Time for all other gages believed to be accurate to ± 30 minutes.

TABLE 1.—*Fluctuations in well-water levels during 1968*—Continued

County and/or well number	Date	Time at recorder G.M.T.	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
IDAHO—Continued						
Butte 6N-25E-3aaal	Apr. 9	0115	72.79	0.02	0.04	0.06
Do	Apr. 9	1430	72.97	.01	.02	.03
5N-31E-28cccl	Apr. 9	0145	262.17	.09	.10	.19
3N-29E-14adbl	Apr. 9	0130	454.87	.16	.21	.37
Canyon 5N-5W-24dbbl	Apr. 9	0245	10.11	.03	.03	.06
Cassia 13S-21E-18bbcl	Apr. 9	0200	515.05	.12	.08	.20
14S-27E-33cddl	Apr. 9	0130	38.43	.01	.02	.03
Elmore 2S-5E-36bbbl	Apr. 9	0115	285.13	.08	.08	.16
Jefferson 7N-34E-4cdcl	Apr. 9	0215	6.88	.15	.18	.33
5N-32E-36addl	Apr. 9	0230	328.71	.03	.03	.06
5N-34E-9bdal	Apr. 9	0200	256.49	.02	.02	.04
Jerome 8S-19E-5dabl	Apr. 9	0145	273.97	.03	.03	.06
Butte 5N-26E-6aaal	Apr. 9–10	2400–0200 [a]	27.77	.03	.03	.06
Lincoln 5S-17E-26acal	Apr. 9	0300–0500 [a]	199.47	.03	.03	.06
Madison 7N-38E-23 dbal	Apr. 9	0200	43.96	.34	.32	.66
Twin Falls 14S-15E-28bad2	Apr. 9	0145	104.37	.04	.04	.08
Jerome 7S-17E-6acal	Apr. 12	0200–0400 [a]	313.81	.04	.04	.08
Minidoka 8S-25E-24bdcl	Apr. 16	1000–1200 [a]	143.31	.07	.01	.08
Canyon 5N-5W-24dbbl	Apr. 26	1545	9.84	.02	.02	.04
Cassia 13S-21E-18bbcl	Apr. 26	1415	514.96	.03	.03	.06
Elmore 2S-5E-36bbbl	Apr. 26	1300	285.06	.03	.02	.05
Jefferson 7N-34E-4cdcl	Apr. 26	1400	6.24	.02	.04	.06
7N-36E-22abd4	Apr. 26	1100–1300	6.40	.01	.01	.02
Jerome 8S-19E-5dabl	Apr. 26	1430	274.19	.01	.02	.03
Lincoln 5S-17E-26acal	Apr. 26	1300–1500	200.15	.02	.01	.03
Madison 7N-38E-23dbal	Apr. 26	1445	43.97	.04	.04	.08
Do	Apr. 26	1745	43.97	.03	.02	.05
Teton 4N-45E-13adal	Apr. 26	1700	200.04	.01	.02	.03
Butte 5N-26E-6aaal	Apr. 29	1400–1600	27.83	.04	.03	.07
Madison 7N-38E-23dbal	Apr. 30	1745	43.96	.03	.02	.05
Do	May 4	2030	43.80	.07	.05	.12
Butte 5N-31E-28cccl	May 8	1200	262.37	.02	.03	.05
Elmore 2S-5E-36bbbl	May 8	1015	285.06	.02	.02	.04
Madison 7N-38E-23dbal	May 8	1745	43.85	.08	.08	.16
Teton 4N-45E-13adal	May 8	1445	200.03	.02	.03	.05
Blaine 8S-26E-33bcbl	May 9	1100–1300	107.46	.08	.14	.22
Minidoka 8S-23E-2baal	May 10–11	2300–0100	208.87	.04	.07	.11
Butte 5N-26E-6aaal	May 12	0400–0600	27.50	.02	.02	.04
5N-31E-28cccl	May 15	2300	262.39	.04	.07	.11
Do	May 15	2315	262.40	.18	.17	.35
Do	May 15	2330	262.41	.17	.15	.32
Elmore 2S-5E-36bbbl	May 15	2300	285.07	.03	.03	.06
Do	May 15	2315	285.07	.04	.04	.08
Do	May 15	2330	285.08	.04	.03	.07
Twin Falls 11S-19E-17aabl	May 15	2200–2400	322.34	.02	.02	.04
Butte 3N-29E-14adbl	May 16	0130	455.37	.02	.02	.04
Do	May 16	0145	455.38	.04	.02	.06

[a] Time of occurrence for monthly gage believed to be accurate to ± 1 hour. Time for all other gages believed to be accurate to ±30 minutes.

TABLE 1.—*Fluctuations in well-water levels during 1968*—Continued

County and/or well number	Date	Time at recorder G.M.T.	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
IDAHO—Continued						
Cassia 13S-21E-18bbcl	May 16	0130	516.17	0.03	0.03	0.06
Do	May 16	0145	516.17	.05	.05	.10
Do	May 16	0200	516.17	.04	.04	.08
Jerome 9S-20E-1daal	May 16	0800–1000 [a]	366.66	.08	.07	.15
Madison 7N-38E-23dbal	May 16	0030	43.52	.03	.02	.05
Do	May 16	0115	43.52	.20	.20	.40
Do	May 16	0145	43.52	.05	.06	.11
Teton 4N-45E-13adal	May 16	0300	199.57	.04	.03	.07
Do	May 16	0315	199.57	.07	.05	.12
Twin Falls 14S-15E-28bad2	May 16	0045	107.32	.03	.02	.05
Jerome 9S-20E-1daal	May 22	0900–1100	366.63	.07	.08	.15
Blaine 8S-26E-27abal	May 25	1300–1500 [a]	135.40	.03	.05	.08
Twin Falls 11S-19E-17aabl	May 29	0600–0800 [a]	322.09	.02	.03	.05
Do	May 29	1300–1500	322.16	.02	.02	.04
Minidoka 4S-24E-6bbcl	June 2	2100	416.83	.03	.03	.06
Do	June 2	2030	416.81	.04	.03	.07
Madison 7N-38E-23dbal	June 12	1245	42.39	.02	.02	.04
Minidoka 8S-25E-24bdcl	June 12	0400–0600	144.31	.03	.04	.07
Blaine 1S-19E-3ccb2	June 12–13	2300–0100	11.09	.02	.02	.04
Blaine 2S-20E-1acc2	June 13	0100–0300 [a]	145.34	.04	.04	.08
Butte 5N-31E-28cccl	June 19	0915	263.21	.03	.03	.06
Madison 7N-38E-23dbal	June 19	0715	42.08	.02	.03	.05
Do	June 22	1745	41.88	.04	.02	.06
Do	June 26	0030	41.76	.02	.02	.04
Butte 5N-31E-28cccl	July 2	0630	263.83	.01	.03	.04
Madison 7N-38E-23dbal	July 2	0445	41.55	.07	.07	.14
Blaine 1S-19E-3ccb2	Aug. 2	1100–1300 [a]	10.28	.03	.03	.06
8S-26E-33bcbl	Aug. 2	1000–1200 [a]	106.78	.07	.13	.20
Butte 6N-25E-3aaal	Aug. 2	1545	68.95	.08	.06	.14
5N-31E-28cccl	Aug. 2	1500	264.71	.27	.36	.63
4N-26E-32cbal	Aug. 2	1445	199.57	.02	.01	.03
3N-29E-14adbl	Aug. 2	1645	455.78	.10	.10	.20
Cassia 13S-21E-18bbcl	Aug. 2	1515	526.17	.03	.04	.07
Custer 9N-21E-14bbcl	Aug. 2	1530	81.32	.01	.02	.03
Elmore 2S-5E-36bbbl	Aug. 2	1545	285.10	.10	.07	.17
Jefferson 7N-36E-22abd4	Aug. 2	0900–1100 [a]	7.71	.02	.02	.04
5N-32E-36addl	Aug. 2	1815	330.41	.04	.03	.07
5N-34E-9bdal	Aug. 2	1630	259.95	.02	.03	.05
Jerome 8S-19E-5dbal	Aug. 2	1530	270.91	.02	.01	.03
Lincoln 5S-17E-26acal	Aug. 2	1600	195.02	.02	.03	.05
Madison 7N-38E-23dbal	Aug. 2	1540	40.56	.36	.40	.76
Do	Aug. 2	1545	40.56	.10	.10	.20
Minidoka 7S-25E-19babl	Aug. 2	1800–2000 [a]	246.58	.01	.04	.05
8S-23E-2baal	Aug. 2	0900–1100 [a]	215.30	.04	.04	.08
Teton 4N-45E-13adal	Aug. 2	1715	154.54	.05	.08	.13
Twin Falls 11S-17E-25ddd2	Aug. 2	1545	88.71	.03	.02	.05
11S-19E-17aabl	Aug. 2	1400	324.96	.02	.01	.03
14S-15E-28bad2	Aug. 2	1645	111.36	.04	.05	.09

[a] Time of occurrence for monthly gage believed to be accurate to ± 1 hour. Time for all other gages believed to be accurate to ±30 minutes.

TABLE 1.—*Fluctuations in well-water levels during 1968*—Continued

County and/or well number	Date	Time at recorder G.M.T.	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
IDAHO—Continued						
Butte 5N-31E-28cccl	Aug. 10	0515	264.85	0.05	0.05	0.10
Elmore 2S-5E-36bbbl	Aug. 10	0430	285.05	.01	.02	.03
Twin Falls 11S-19E-17aabl	Aug. 13	2400	325.45	.02	.03	.05
Madison 7N-38E-23dbal	Aug. 14	0845	40.61	.03	.02	.05
Teton 4N-45E-13adal	Aug. 14	1530	161.89	.02	.03	.05
Butte 5N-31E-28cccl	Aug. 15	0130	264.64	.06	.06	.12
Do	Aug. 31	1230	265.21	.03	.03	.06
Madison 7N-38E-23dbal	Aug. 31	1130	39.97	.04	.03	.07
Jefferson 5N-34E-9bdal	Sept. 12	0445	259.85	.01	.05	.06
Blaine 2S-20E-1acc2	Oct. 5	1400–1600 [a]	143.10	.04	.04	.08
Butte 3N-29E-14adbl	Oct. 6	0915	455.37	.03	.02	.05
Minidoka 8S-23E-2baal	Oct. 9–10	2300–0100 [a]	209.77	.01	.03	.04
4S-24E-6bbcl	Oct. 15	1830	418.31	.02	.01	.03
Blaine 8S-26E-33bcbl	Oct. 19	1600–1800 [a]	104.87	.10	.12	.22
Butte 3N-29E-14adbl	Oct. 19	0430	455.81	.02	.01	.03
Madison 7N-38E-23dbal	Oct. 19	1715	39.92	.02	0	.02
Blaine 8S-26E-33bcbl	Oct. 20	1000–1200 [a]	104.90	.04	.09	.13
Do	Oct. 21	0900–1100 [a]	104.78	.12	.13	.25
1S-19E-3ccb2	Oct. 29	1700–1900 [a]	12.46	.01	.01	.02
Butte 3N-29E-14adbl	Oct. 29	2315	455.52	.04	.04	.08
Elmore 2S-5E-36bbbl	Oct. 29	2245	284.76	.03	.01	.04
Lincoln 5S-17E-26acal	Oct. 29	2300	194.41	.01	.02	.03
Madison 7N-38E-23dbal	Oct. 29	2245	39.84	.09	.07	.16
Teton 4N-45E-13adal	Oct. 29	0230	185.56	.03	.03	.06
Canyon 5N-5W-24dbbl	Oct. 30	0015	9.58	.01	.01	.02
Caribou 8S-42E-17cabl	Oct. 30	1300	101.65	.07	.08	.15
Jefferson 7N-34E-4cdcl	Oct. 30	0015	18.06	.03	.01	.04
Twin Falls 11S-19E-17aabl	Nov. 11	0600	327.41	.10	.12	.22
Do	Nov. 18	2200	327.45	.07	.09	.16
Do	Nov. 18	1200	327.46	.05	.05	.10
Madison 7N-38E-23dbal	Nov. 28	1115	40.84	.07	.07	.14
Do	Dec. 5	0945	40.86	.01	.01	.02
Bingham 2N-31E-35dccl	Dec. 19	1600	584.78	.02	.04	.06
Butte 5N-31E-28cccl	Dec. 19	1430	264.08	.01	.03	.04
3N-29E-14adbl	Dec. 19	1630	454.56	.09	.07	.16
Canyon 5N-5W-24dbbl	Dec. 19	1630	9.82	.02	.01	.03
Elmore 2S-5E-36bbbl	Dec. 19	1615	284.87	0	.03	.03
Lincoln 5S-17E-26acal	Dec. 19	1700	198.02	.03	.03	.06
Minidoka 7S-25E-19babl	Dec. 19	0500–0700 [a]	242.76	.04	.05	.09
8S-23E-2baal	Dec. 19	1000–1200 [a]	206.96	.01	.02	.03
INDIANA						
Ma-32	Jan. 29	1030–1100	9.91	0.03	0.04	0.07
Do	Feb. 12	0630–0650	9.66	.03	.01	.04
Do	Feb. 19	2310–2340	9.91	.06	.07	.13
Do	Apr. 1	0110–0200	10.61	.05	.04	.09

[a] Time of occurrence for monthly gage believed to be accurate to ± 1 hour. Time for all other gages believed to be accurate to ±30 minutes.

TABLE 1.—*Fluctuations in well-water levels during 1968*—Continued

County and/or well number	Date	Time at recorder G.M.T.	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
INDIANA—Continued						
Ma-32—Continued						
Do	Apr. 9	0210–0240	9.60	0.07	0.09	0.16
Do	May 8	1250–1300	10.44	.01	.02	.03
Do	May 16	0120–0250	12.23	.23	.45	.68
Do	May 16	1130–1200	11.53	.07	.01	.08
Pu-6	May 16	0500–0550	8.94	.16	.05	.21
Hr-8	May 16	0100–0120	8.47	.02	.03	.05
Fu-7	May 16	0045–0100	8.38	.04	.02	.06
Sh-2	May 16	0050–0100	18.54	.12	.05	.17
Ha-5	May 16	0130–0150	10.08	.02	.02	.04
Dw-4	May 16	0120–0150	48.70	.05	.03	.08
Ma-32	Aug. 10	0315–0350	12.80	.07	.02	.09
Do	Oct. 29	2250–2305	10.92	.02	.04	.06
Do	Nov. 9	1705–1805	10.86	0	.02	.02
Py-3	Nov. 9	1514–1550	17.97	.13	.01	.14
Ma-32	Dec. 17	1110–1115	10.52	.01	.01	.02
NEVADA						
S17/50-36dcl	Jan. 19	1820	1.86	0.13	0.16	0.29
Do	Feb. 3	0520	1.92	.04	.04	.08
S21/54-28bdl	Feb. 18	2100	23.00	.37	.46	.83
S17/50-36dcl	Feb. 19	2355	1.80	.09	.10	.19
Do	Feb. 21	1535	1.98	.04	.02	.06
S19/60-9bccl	Mar. 22	1510	121.50	.05	.06	.11
S19/53-32aaal	Apr. 25	2000	29.54	0	.01	.01
S19/60-9bccl	Apr. 26	1610	122.16	.20	.54	.74
S19/53-32aaal	Apr. 26	1400	29.54	.01	.01	.02
S17/50-36dcl	Apr. 26	1500	1.89	.49	.43	.92
S19/53-32aaal	May 6	2100	29.51	.02	.02	.04
S19/60-9bccl	May 8	1200	122.46	.03	.04	.07
S17/50-36dcl	May 8	1230	2.00	.17	.13	.30
S19/60-9bccl	May 16	0100	122.80	.21	.18	.39
S17/50-36dcl	May 16	0125	.96	.29	.26	.55
S19/53-32aaal	May 24	1600	29.54	>.54	>.46	>1.00
S19/60-9bccl	June 15	1400	124.14	.09	.10	.19
S17/50-36dcl	June 15	1600	1.98	.10	.05	.15
Do	June 26	0150	2.08	.08	.09	.17
S19/60-9bccl	June 28	1120	124.89	.01	.02	.03
S17/50-36dcl	June 28	1225	2.07	.02	.02	.04
Do	July 2	0400	2.02	.05	.05	.10
Do	July 5	0050	2.06	.06	.04	.10
S19/53-32aaal	July 9	1700	29.75	>.55	>.45	>1.00
S17/50-36dcl	July 20	2000	1.94	.04	.03	.07
Do	July 26	0705	1.97	.04	.03	.07
Do	July 28	2007	1.82	.09	.08	.17

TABLE 1.—*Fluctuations in well-water levels during 1968*—Continued

County and/or well number	Date	Time at recorder G.M.T.	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
NEVADA—Continued						
S19/60-9bccl	Aug. 2	1420	125.44	0.27	0.26	0.53
S17/50-36dcl	Aug. 8	1415	1.83	>.43	.38	>.81
Do	Aug. 10	0300±	2.07	.08	.06	.14
Do	Aug. 14	0900	1.91	.03	.03	.06
Do	Aug. 29	2245	1.96	.06	.06	.12
S19/60-9bccl	Aug. 29	2200	125.70	.08	.10	.18
S17/50-36dcl	Aug. 31	1200	1.82	.04	.04	.08
Do	Sept. 6	1400	1.97	.03	.02	.05
S19/60-9bccl	Sept. 6	1400	125.95	.04	.08	.12
S19/53-32aaal	Sept. 14	1900	30.09	.03	.04	.07
S17/50-36dcl	Sept. 17	2155	1.95	.02	.03	.05
S19/53-32aaal	Sept. 21	1500	30.10	.03	.02	.05
S17/50-36dcl	Sept. 29	1900	1.89	.02	0	.02
Do	Oct. 27	2340	1.92	.02	.02	.04
Do	Oct. 29	2250	2.03	.06	.05	.11
Do	Nov. 1	0420	1.80	.01	.01	.02
Do	Nov. 9	1740	1.90	.01	.01	.02
S19/60-9bccl	Nov. 28	1130	124.35	.08	.11	.19
S17/50-36dcl	Nov. 28	1055	1.78	.29	.27	.56
S19/53-32aaal	Dec. 11	0200	30.23	.03	.05	.08
S17/50-36dcl	Dec. 19	1635	1.91	.46	>.51	>.97
WISCONSIN						
M1-120	Aug. 1	1830	100.86	0.03	0.03	0.06
Do	Aug. 14	2330	100.68	.03	.02	.05
Do	Aug. 31	1115	100.80	.03	.02	.05
Do	Sept. 20	0530	101.17	0.03	0	.03
Do	Sept. 25	0600	101.34	.02	.01	.03
Do	Oct. 29	2230	101.75	0	.04	.04
Do	Dec. 17	1250	101.10	.01	.01	.02

NOTE: The November 9, 1968, Illinois earthquake may have caused a permanent lowering of the water table in some areas of Tennessee. An observation well at New Johnsonville, Tenn., unusually sensitive to earthquakes, showed a decrease in water level of 1.0 foot on November 9, an additional 0.6 foot on the 10th, and 0.2 on the 11th. By November 14, the water level had fallen a total of 2.2 feet. In addition, the water level in a well at Erin (Houston County), Tenn., rose 0.41 foot as a result of the quake. Another well at Dickson (Dickson County), Tenn., had a drop in water level of 0.10 foot.

TABLE 2.—*Earthquakes of 1968 believed to have caused fluctuations in well-water levels*

Date	Origin time G.M.T.	Location	States recording fluctuations
Jan. 29	10 19 05.6	Kurile Islands	Indiana
Feb. 3	05 36 14.6	Guerrero, Mexico	Idaho, Nevada
Feb. 3	11 59 13.9	Central California	Idaho
Feb. 12	05 44 47.6	New Ireland region	Idaho, Indiana
Feb. 19	22 45 41.2	Aegean Sea	Idaho, Indiana, Nevada
Apr. 1	00 42 04.2	Shikoku, Japan	Indiana
Apr. 8	03 32 48.4	Southern Alaska	Alaska
Apr. 9	02 28 58.9	Southern California (many aftershocks)	Idaho, Indiana
Apr. 23	20 29 14.5	Gulf of Alaska	Alaska
Apr. 25	19 49 45.6	Northern California	Nevada
Apr. 26	15 00 00.1	Southern Nevada (Nevada Test Site)	Idaho, Nevada
May 8	12 17 13.4	Off coast of Oregon	Idaho, Indiana, Nevada
May 16	00 48 55.4	Off east coast of Honshu, Japan (many aftershocks)	Alaska, Idaho, Indiana, Nevada
June 19	08 13 35.0	Northern Peru	Idaho
June 26	01 42 19.5	Northern California	Idaho, Nevada
July 2	03 44 48.9	Guerrero, Mexico	Idaho, Nevada
July 5	00 36 05.9	Southern California	Nevada
July 26	06 33 59.6	Chiapas, Mexico	Nevada
Aug. 2	14 06 43.9	Oaxaca, Mexico	Alaska, Idaho, Nevada
Aug. 10	02 07 04.3	Molucca Passage	Alaska, Indiana, Nevada
Aug. 14	09 19 21.8	Southern California	Idaho, Nevada
Aug. 14	22 14 19.4	Northern Celebes	Wisconsin
Aug. 31	10 47 37.4	Iran	Idaho, Nevada, Wisconsin
Sept. 6	14 00 00.1	Southern Nevada (Nevada Test Site)	Nevada
Sept. 20	06 00 03.5	Near coast of Venezuela	Wisconsin
Oct. 29	22 16 15.6	Alaska	Alaska, Idaho, Indiana, Nevada, Wisconsin
Nov. 1	03 55 50.3	Jalisco, Central Mexico	Nevada
Nov. 9	17 01 41.1	South-central Illinois	Indiana, Nevada
Nov. 28	10 36 07.7	Oaxaca, Mexico	Idaho, Nevada
Dec. 5	09 44 11.0	Iceland region	Idaho
Dec. 17	12 02 15.0	Southern Alaska	Alaska, Indiana, Wisconsin

Strong-Motion Seismograph Results

The Coast and Geodetic Survey has conducted an engineering seismology program in the United States and Latin America since 1932. The Survey, with the cooperation of State and municipal governments, private industry, and state and private educational institutions, has installed and maintained strong-motion seismographs and analyzed the seismograms. The results of the analysis have been published in Government bulletins and scientific journals, and the records, either originals or copies, have been made available to research scientists.

A list of strong-motion stations in the United States and Latin America is no longer included in this annual report. However, a report entitled *Strong-Motion Station Instrumental Data,* dated January 1969, is available from the Coast and Geodetic Survey upon request. The report gives the geographic location of each station, instrumental constants, and lists new stations and those removed during 1968. In addition, it contains a list of seismoscope stations in California, Alaska, and Arizona.

The number of strong-motion seismograph installations in the United States and Latin America increased from 196 in 1967 to 289 in 1968. Seventy-one of the 93 new stations were installed in California, 18 in Nevada, 3 in Arizona, and 1 in Oregon.

In 1960, an instrument was developed to supplement accelerograph record data. Known as a seismoscope, it records only horizontal motion and supplies data for the areas between and around strong-motion stations. By December 1968, a total of 361 of these instruments were in operation. Two hundred and fifty-nine are located in California, 98 in Alaska, and 4 in Arizona.

In 1965, the cities of Los Angeles and Beverly Hills enacted ordinances requiring the installation of strong-motion seismographs in buildings. The Los Angeles ordinance stated: "Every building over six stories in height with an aggregate floor area of 60,000 square feet or more, and every building over ten stories in height, regardless of floor area, shall be provided with three approved recording seismographs." Although this ordinance was not retroactive and applied only to permits issued for construction after July 1, 1965, its impact is quite evident from the 3-year increase in strong-motion station installations in southern California. The number of stations increased from 32 in 1965 to 131 in December 1968; those in northern California increased from 54 to 92.

Figure 15 shows the locations of strong-motion stations in the United States and Central and South America as of December 31, 1968. Table 3 gives a list of earthquakes recorded and records obtained on strong-motion instruments in 1968.

Notes pertinent to this engineering seismology program may be found in preceding issues of *United States Earthquakes* series and *Earthquake Investigations in the Western United States, 1931–1964.* The latter is much broader in scope, containing data on structural and ground vibrations with detailed descriptions of the many activities which comprise the seismological program as a whole.

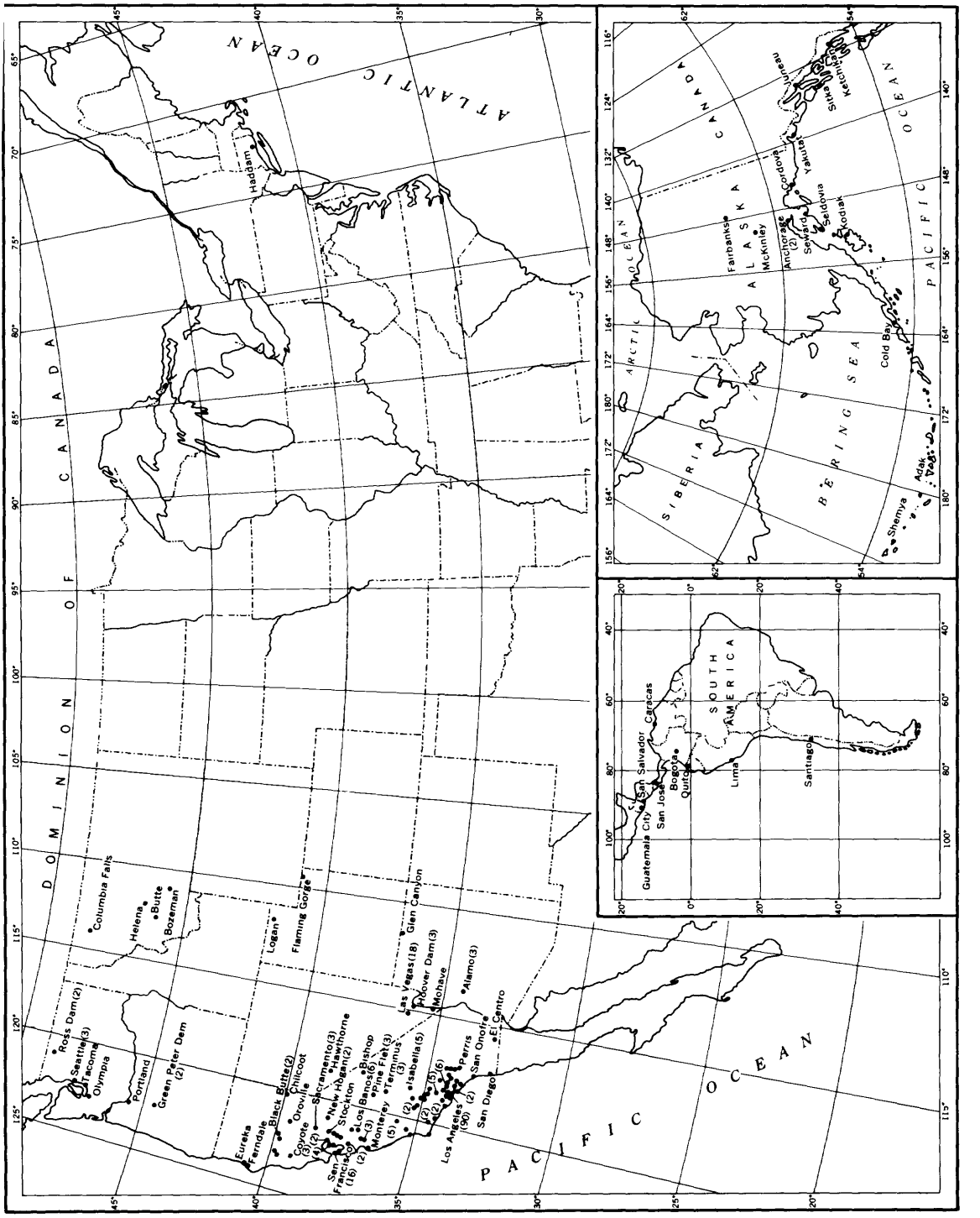

FIGURE 15.—Strong-motion stations in the western United States and Central and South America.

INTERPRETATION OF RECORDS

The analyses appearing in tables 4 and 5 are based on the assumption of simple harmonic motion. This refers especially to the computation of displacement from accelerograph records. As most accelerograph records are of irregular character, and the character of the longer-period waves are often obscured by the superposition of shorter-period waves of relatively large amplitudes, the estimates of displacement must be considered only rough approximations. These analyses are essentially condensations of material appearing in the quarterly *Engineering Seismology Bulletin,* available through mailing list CGS-5.

UNITS AND INSTRUMENTAL CONSTANTS

Quantitative results are expressed in c.g.s. units—centimeters or millimeters for displacement, and centimeters per second per second for acceleration. It is sometimes desirable to express acceleration in terms of the acceleration of gravity, indicated by *g*, which is equal to 980 cm/sec^2. For practical purposes, it is necessary to point off three decimal places to convert cm/sec^2 to *g*.

Most of the instruments have been adjusted so that each will register the maximum acceleration to be expected on the particular type of geological formation beneath the instrument. The following expectable earthquake accelerations were used in determining the accelerograph sensitivities: (a) rock foundation, 25 percent of gravity; (b) residual clay and shale, 40 percent of gravity; (c) alluvium, 70 percent of gravity; and (d) top floors of tall buildings, 100 to 200 percent of gravity. The four sensitivities may be roughly listed as 26, 19.5, 13, and 6.5 centimeters per 1.0 g, respectively.

Sensitivity of the seismographs is expressed as the deflection of the trace, or light spot, in centimeters for a constant acceleration of 1.0 g.

Damping ratio of the pendulum is the ratio between successive amplitudes when the pendulum oscillates.

SEISMOGRAM ILLUSTRATIONS

Reproductions of records in this publication (figs. 16 and 17) are tracings of the original records and must not be accepted as genuine copies. The tabulated instrumental constants refer to the original records. The tracings are intended to show the nature of the data, rather than furnish a means through which the reader can make his own measurements. Those who desire true copies for critical study should request them from the Environmental Science Services Administration, Coast and Geodetic Survey, Rockville, Md. 20852.

Acceleration and displacement scales representing the equivalent of 0.1 g and 1 inch are indicated on the tracings of the acceleration and displacement curves. The scales provide the investigator with a quick means for making rough measurements on the published curves. The measurements of period on records of this nature are dependent largely on the judgment of the person reading them, and considerable latitude must be allowed in appraising their accuracy. The aim of such analyses is primarily to give a fair picture of the magnitudes of the various elements involved. The figures tabulated should therefore not be used for important studies without first referring to the illustrations for some idea of the nature of the original records.

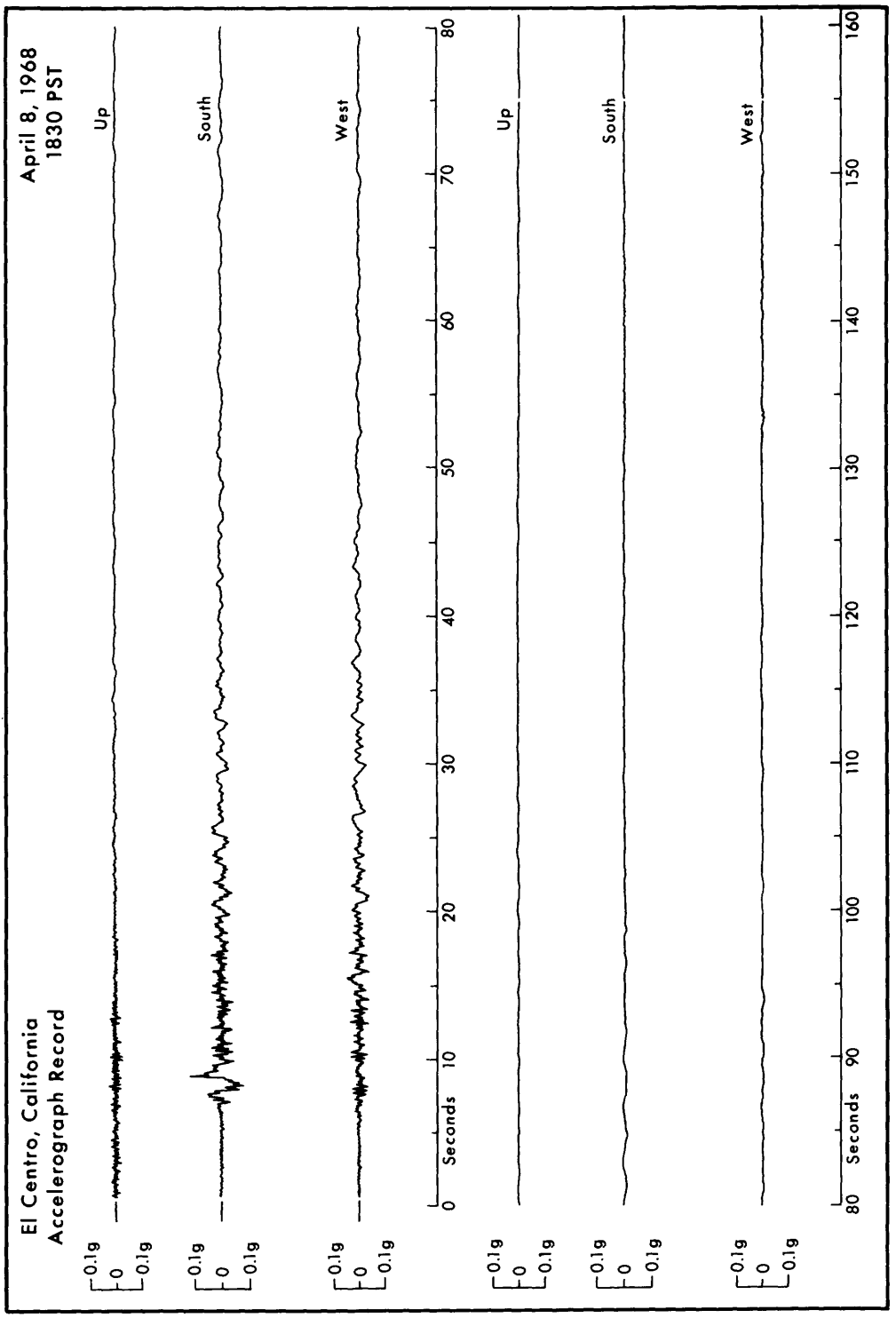

FIGURE 16.—Tracing of accelerograph record obtained at El Centro, Calif., April 8.

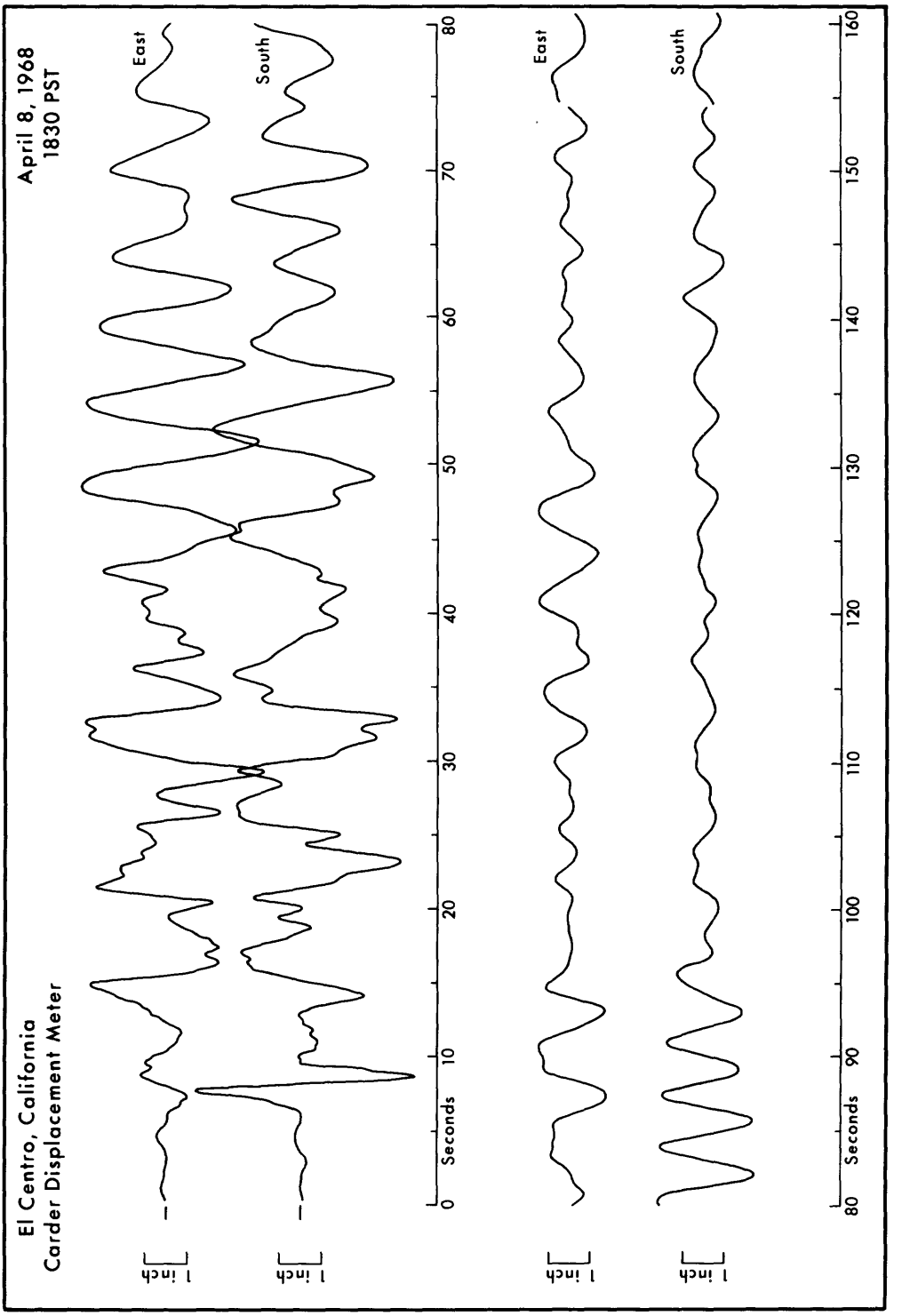

FIGURE 17.—Tracing of Carder Displacement Meter record obtained at El Centro, Calif., April 8.

TABLE 3.—*List of shocks recorded and records obtained on strong-motion instruments in 1968*

Date	Region of earthquake and recording station	Records		
		Accelero-graph	Survey displacement meter	Carder displacement meter
Apr. 8	Southern California			
	San Diego	1		
	El Centro	1		1
	Perris Reservoir	1		
	San Onofre	1*	1	
	Colton	1		
	San Bernardino, Hall of Records	1**		
	Devils Canyon	1*		
	Cedar Springs, Allen Ranch	1*		1
	Santa Ana	1		
	San Dimas, Puddingstone Reservoir	1*		
	Long Beach, Terminal Island:			1
	Utilities Bldg	1		
	Southern California Edison Plant	1		
	Santa Anita Dam	1*		
	Vernon	1		
	Pasadena, Calif. Inst. of Tech:			
	Faculty Club Bldg	1*		
	Seismology Lab	1**		
	Jet Propulsion Lab., basement	1*		
	9th floor	1*		
	Los Angeles:			
	1640 Marengo, 8th floor	1*		
	4th floor	1*		
	1st floor	1*		
	250 E. First, 17th floor	1*		
	8th floor	1*		
	1st floor	1*		
	808 S. Hill, 7th floor	1*		
	4th floor	1*		
	Street level	1*		
	646 Olive, Roof	1*		
	4th floor	1*		
	Basement	1*	1	
	Subway Terminal	1		
	Water and Power Bldg., basement	1*		
	15th floor	1*		
	7th floor	1*		
	Edison Bldg	1		
	445 Figueroa, 39th floor	1*		
	19th floor	1*		
	Basement	1*		
	Univ. of Southern California, Vivian Hall:			
	Roof	1*		
	4th floor	1*		
	Basement	1*		
	3470 Wilshire, 11th floor	1*		
	5th floor	1*		
	Subbasement	1*		
	3345 Wilshire, 12th floor	1*		
	2d floor	1*		
	Basement	1*		

TABLE 3.—*List of shocks recorded and records obtained on strong-motion instruments in 1968*—Continued

Date	Region of earthquake and recording station	Records		
		Accelerograph	Survey displacement meter	Carder displacement meter
Apr. 8	Southern California—Continued			
	Los Angeles:			
	3407 W. 6th, 8th floor	1*		
	4th floor	1*		
	Basement	1*		
	4867 Sunset Blvd., 7th floor	1*		
	2d floor	1*		
	Basement	1*		
	4680 Wilshire Blvd., 6th floor	1*		
	3d floor	1*		
	Basement	1*		
	3710 Wilshire Blvd., 11th floor	1*		
	5th floor	1*		
	Basement	1*		
	2011 Zonal, 9th floor	1*		
	5th floor	1*		
	Basement	1*		
	420 S. Grand, 17th floor	1**		
	10th floor	1**		
	2d floor	1**		
	Hollywood Storage Co., basement	1		
	Pacific Electric lot	1		
	Penthouse	1		
	120 N. Robertson, 9th floor	1*		
	4th floor	1*		
	Basement	1*		
	1901 Avenue of the Stars, 21st floor	1*		
	9th floor	1*		
	Subbasement	1*		
	945 Tiverton, 14th floor	1*		
	8th floor	1*		
	7080 Hollywood, 12th floor	1*		
	6th floor	1*		
	Basement	1*		
	University of California, Westwood Engineering Bldg	1		
	Encino, 16661 Ventura Blvd., 8th floor	1*		
	4th floor	1*		
	Basement	1*		
	8244 Orion Blvd., 8th floor	1*		
	4th floor	1*		
	1st floor	1*		
	Glendale	1*		
	Pearblossom	1*		
	San Fernando, Pacoima Dam	1*		
	Lake Hughes, No. 1 Fire Station	1*		
	Fairmont Reservoir	1		
	Castaic	1*		
	Santa Felicia Dam, Crest	1*		
	Valve House	1*		
	Gorman, Oso Pumping Plant	1*		
	Port Hueneme	1		

TABLE 3.—*List of shocks recorded and records obtained on strong-motion instruments in 1968*—Continued

Date	Region of earthquake and recording station	Records		
		Accelero-graph	Survey displacement meter	Carder displacement meter
Apr. 8	Southern California—Continued			
	Wheeler Ridge	1*		
	Isabella Dam, Main Crest	1**		
	Auxiliary Crest	1**		
	Auxiliary Abutment	1**		
	Auxiliary Control Tower	1**		1
	Cachuma Dam, Valve House	1		1
	Crest	1		
	Santa Barbara	1	1	
	Bakersfield	1		
	Taft, Lincoln School Tunnel, Roof	1*		
	Basement	1		
	Nevada			
	Las Vegas, First Nat'l Bank, Roof	1		1
	Hoover Dam, Intake Tower	1		1
	Oil House	1		1
	1215 Gallery	1		1
	Davis Dam	1**		
Apr. 20	Southern California, Bakersfield	1	1	
Apr. 28	Northern California			
	Sacramento, PT&T Bldg., Basement	1		1
	Roof	1*		
June 25	Northern California *			
	Eureka	1		
	Ferndale	1	1	
June 29	Southern California (2 shocks)			
	Santa Barbara	2		
	Cachuma Dam, Crest	2		2
	Valve House	2		2
July 4	Southern California			
	Bakersfield	1	1	
	Buena Vista (Taft)	1*		
	Cachuma Dam, Crest	1		1
	Valve House	1		1
	Castaic	1*		
	Long Beach, Southern California Edison Plant	1		
	Los Angeles:			
	1901 Avenue of the Stars, 21st floor	1*		
	9th floor	1*		
	Basement	1*		
	250 E. First, Roof	1*		
	8th floor	1*		
	Basement	1*		
	7080 Hollywood Blvd., 12th floor	1*		
	6th floor	1*		
	Basement	1*		
	Hollywood Storage Co., Penthouse	1		
	Basement	1		
	Pacific Electric lot	1		

TABLE 3.—*List of shocks recorded and records obtained on strong-motion instruments in 1968*—Continued

Date	Region of earthquake and recording station	Records		
		Accelero-graph	Survey displacement meter	Carder displacement meter
July 4	Southern California—Continued			
	Los Angeles:			
	1640 Marengo, Penthouse	1*		
	4th floor	1*		
	1st floor	1*		
	120 N. Robertson, 9th floor	1*		
	4th floor	1*		
	Basement	1*		
	8244 Orion Blvd., Roof	1*		
	4th floor	1*		
	1st floor	1*		
	945 Tiverton, 14th floor	1*		
	8th floor	1*		
	University of Southern California, Vivian Hall, Roof	1*		
	4th floor	1*		
	Basement	1*		
	3407 W. Sixth, Penthouse	1*		
	4th floor	1*		
	Basement	1*		
	3345 Wilshire Blvd., 12th floor	1*		
	2d floor	1*		
	Basement	1*		
	3710 Wilshire Blvd., 10th floor	1*		
	5th floor	1*		
	Basement	1*		
	3470 Wilshire Blvd., 11th floor	1*		
	5th floor	1*		
	Basement	1*		
	Encino, 16661 Ventura Blvd., 8th floor	1*		
	4th floor	1*		
	Basement	1*		
	2011 Zonal, 9th floor	1*		
	5th floor	1*		
	Basement	1*		
	Pasadena, Athenium	1		
	Pasadena, Cal Tech:			
	Jet Propulsion Lab., Basement	1*		
	10th floor	1*		
	Millikan Hall, basement	1*		
	Roof	1*		
	Port Hueneme	1		
	Santa Ana	1		1
	Santa Barbara	1		
	Taft, Lincoln School Tunnel, Roof	1*		
	Basement	1		
July 4 (aftershock)	Southern California, Santa Barbara	1		
Aug. 7	Northern California, Ferndale	1	1	
Aug. 31	do	1	1	

TABLE 3.—*List of shocks recorded and records obtained on strong-motion instruments in 1968*—Continued

Date	Region of earthquake and recording station	Records		
		Accelerograph	Survey displacement meter	Carder displacement meter
Between Oct. 15 and Dec. 26	Southern California, El Centro	1		1
	Southern California, El Centro (second shock)	1		1
Oct. 29	Alaska, College, College Observatory	1*		
Oct. 30 (aftershock)	Alaska, College, College Observatory	1*		

*Instrument is AR-240.
**Instrument is RFT-250.

TABLE 4.—*Summary of outstanding instrumental and noninstrumental data for 1968*

Epicenter	Recording station and distance	Location of instrument	Intensity [1]	Acceleration	Displacement [2]
El Centro, Calif., Earthquake of April 8					
				cm/sec^2	*cm*
33°12.0′ N., 116°06.9′ W., southern California, P. VII*. Mag. 6.5.	El Centro, Imperial Valley Irrigation District Substation, 41 miles.	Two-story building, very heavy construction, and heavily reinforced. Instrument in basement on concrete floor.	VI	121	5.7
College, Alaska, Earthquake of October 29					
65.4° N., 150.1° W., Alaska, W. VII-VIII*. Mag. 6.5.	College, College Observatory vault, 75 miles.	One-story building, reinforced concrete. Instrument on concrete pier.	V	110	----------

[1] Reported intensity of earthquake at recording station.
[2] Displacement is the maximum recorded at the station reporting the maximum acceleration of the earthquake. If displacement is much greater at another location, it is given along with the maximum acceleration at the same location.
*An asterisk following the intensity designation in the epicenter column indicates the maximum reported intensity of the earthquake.

TABLE 5.—*Composite of strong-motion instrumental data for 1968*

Station and component	Instrument no.	T_o	V	Sensitivity	ϵ	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of April 8										
		sec		*cm/g*		*sec*	*cm/sec²*	*sec*	*cm*	
El Centro:										
Up	208	0.067	121	13.5	8.5	0.16	33			
						0.21	31			
						2.1	5.1			
South	206	0.069	124	14.7	7.6	0.16	10			
						1.27	121			
						3.7	12			
West	207	0.067	121	13.5	8.8	0.21	47			
						0.52	18			
						1.05	55			
East	29	6.4	1.0		11.4			5.8	5.6	
								3.4	0.75	
South	28	6.8	1.0		9.4			1.26	1.6	
								5.8	5.7	
								3.7	3.1	
Perris Reservoir:										
Down	504	0.052	117	8.0	10	0.07	6.2			
S 7° W	462	0.055	105	7.9	10	0.1	12.3			
S 83° E	446	0.054	123	9.0	9.5	0.10	18.5			
San Onofre:										
N 33° E	329	0.053		7.98	10	0.15	13			
						0.35	40			
Down	304	0.052		7.58	10	0.14	45			
						0.30	35			
N 57° W	392	0.052		7.62	11.5	0.16	13			
						0.20	27			
Colton:										
Up	253	0.066	120	13.1	10	0.33	19			
East	254	0.066	125	14.0	10	0.13	18			

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity	ε	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of April 8—Continued										
South	255	0.065	124	13.4	10	0.28	23			
West	RDM	9.78	1		10			2.6	1.3	
North	LDM	9.75	1		10			3.6	1.6	
San Bernardino (Hall of Records):										
L		0.052	28	7.6*	9	0.20	4			
						0.12	4			
V		0.051	30	7.6*	11	0.13	3			
T		0.051	30	7.6*	12	0.9	18			
						0.2	4			
Devils Canyon:										
Down	137	0.051	114	7.4	9	0.31	6.6			
South	136	0.051	124	8.1	9	0.21	9.2			
East	186	0.053	116	8.1	9.5	0.21	11.0			
Cedar Springs (Allen Ranch):										
Down	228	0.061	81	7.6	7.9	0.50	2.6			
S 20° E	250	0.058	92	7.6	9.8	0.60	6.4			
N 70° E	231	0.057	94	7.6	9.3	0.12	6.4			
Santa Ana:										
Up	1022	0.062	112	10.8	8	0.53	5.5			
S 4° E	1023	0.062	117	10.8	8	0.72	13.6			
S 86° W	1024	0.063	113	10.8	8	0.72	13.6			
S 4° E	B	4.64	1.0		10			5.3	1.4	
N 86° E	A	4.74	1.0		12			6.5	1.1	
San Dimas (Puddingstone Reservoir):										
Down	321	0.050	117	7.4	9	0.2	3.9			
N 25° E	351	0.052	110	7.5	10	0.1	9.1			
						0.65	15.6			
N 65° W	268	0.051	114	7.5	10	0.2				
						0.7	9.0			
							17.0			

Long Beach (Terminal Island, Utilities Bldg.):									
Up	265	0.065		12.4	10	0.4	3.2		
North	266	0.063		12.0	10	0.4	4.9		
East	267	0.065		12.5	9	0.6	3.9		
						1.5	5.5		
East	11	1.98	0.9		10			1.5	0.6
								3.0	0.35
South	10	2.20	0.9		12			2.0	0.6
Long Beach (Terminal Island, Southern California Edison Plant):									
Up	1004	0.068		13.6	8	0.4	4.4		
S 69° W	1005	0.067		13.5	10	0.4	8.0		
N 21° W	1006	0.067		12.7	11	0.37	5.4		
Santa Anita Dam:									
Down	297	0.052	110	7.6	9.9	0.1	1.3		
N 03° E	389	0.051	119	7.6	8.3	0.2	2.6		
N 87° W	266	0.051	117	7.6	9.1	0.15	3.9		
Vernon:									
Up	256	0.064	125	10.4	9	0.27	4.7		
S 7° W	257	0.065	126	10.8	10	0.21	4.6		
						0.69	11.0		
N 83° W	258	0.065	125	11.1	7	0.21	5.5		
Pasadena (Cal Tech., Faculty Club Bldg.):									
Up	325	0.081	122	20	9	0.5	3.5		
						1.0	3.0		
South	326	0.078	118	18	9	0.55	5.5		
						0.75	6.7		
West	327	0.079	119	19	8	1.4	3.2		
						1.55	8.4		
Pasadena (Cal Tech., Seismology Lab.):									
L		0.070	17	7.6*	8	0.2	6		
V		0.069	20	7.6*	9	0.24	2		
T		0.069	17	7.6*	9	0.2	6		
						0.6	7		
Pasadena (Cal Tech., Jet Propulsion Lab., basement):									
S 8° W	123	0.064	159	16.0	9	0.77	4		
						0.20	2		
Down	115	0.064	152	15.7	9	0.42	3		
						0.3	2		

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_0	V	Sensitivity	ϵ	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of April 8—Continued										
S 82° E	120	0.066	147	15.9	10	0.9	6			
						0.33	4			
Pasadena (Cal Tech., Jet Propulsion Lab., 9th floor):										
S 8° W	119	0.066	144	15.5	10	1.12	23			
						0.36	2			
Down	118	0.062	161	15.3	10	0.17	6			
S 83° E	114	0.062	114	15.4	9	1.01	31			
						1.14	17			
						0.24	5			
Los Angeles (1640 Marengo, 8th floor):										
Down	449	0.054	106	7.6	10	0.23	5			
N 38° W	471	0.052	112	7.6	10	0.61	50			
						0.70	23			
S 52° W	447	0.052	112	7.6	10	0.60	73			
						0.56	23			
Los Angeles (1640 Marengo, 4th floor):										
Down	427	0.051	119	7.6	10	0.27	4			
N 38° W	440	0.055	101	7.6	8	0.64	27			
						0.60	12			
S 52° W	448	0.051	119	7.6	9	0.63	36			
						0.62	12			
Los Angeles (1640 Marengo, 1st floor):										
Down	419	0.048	126	7.6	9	0.23	3			
S 52° W	420	0.051	119	7.6	9	0.70	13			
S 38° E	434	0.053	111	7.6	9	1.06	12			
Los Angeles (250 E. First, 17th floor):										
Down	224	0.047	137	7.6	11	0.23	9			
N 36° E	189	0.047	139	7.6	9	1.90	42			
						0.60	11			
N 54° W	215	0.047	142	7.6	9	0.88	20			

						1.64	20		
Los Angeles (250 E. First, 8th floor):									
Down	202	0.048	131	7.6	9	0.22	3		
N 36° E	233	0.049	130	7.6	10	1.38	13		
N 54° W	205	0.049	126	7.6	9	0.88	19		
Los Angeles (250 E. First, basement):									
Down	207	0.048	131	7.6	10	0.62	2		
N 36° E	205	0.049	127	7.6	11	1.40	10		
N 54° W	241	0.049	129	7.6	9	1.11	8		
Los Angeles (808 S. Hill, 7th floor):									
Down	457	0.059	87	7.6	9	0.42	6		
N 37° E	402	0.054	106	7.6	8	0.25	13		
N 53° W	410	0.056	97	7.6	8	0.23	11		
Los Angeles (808 S. Hill, 4th floor):									
Down	V	0.055	101	7.6	10	0.46	6		
S 49° E	L	0.052	112	7.6	9	0.80	7		
S 41° W	T	0.055	101	7.6	9	0.45	10		
Los Angeles (808 S. Hill, Street level):									
Down	455	0.055	101	7.6	10	0.57	3		
S 37° W	429	0.054	105	7.6	9	2.17	11		
S 53° E	466	0.054	105	7.6	9	1.00	7		
Los Angeles (Subway Terminal):									
Up	211	0.066	118	8	12.7	0.70	5.5		
S 52° E	210	0.064	119	8	12.1	0.35	5.7		
S 38° W	209	0.066	120	8	12.9	0.70	4.6		
						1.70	7.6		
S 52° E	LDM	9.85	1	10				2.7	0.78
								1.0	0.15
								4.8	1.63
S 38° E	RDM	9.85	1	10				1.4	0.15
Los Angeles (Water and Power Bldg., basement):									
N 50° W	323	0.052		7.7	11	0.61	2.5		
Down	346	0.053		7.5	11	0.61	3.9		
S 40° W	288	0.053		7.3	10	0.37	2.7		
Los Angeles (Water and Power Bldg., 15th floor):									
N 50° W	285	0.052		7.5	9	0.22	6.5		
						2.58	15.6		
Down	290	0.052		7.4	8	0.21	6.6		
S 40° W	310	0.052		7.5	9	2.36	38		

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity	ϵ	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of April 8—Continued										
Los Angeles (Water and Power Bldg., 7th floor):										
N 50° W	242	0.058		7.9	6	0.27	8.6			
						0.77	12.3			
Down	233	0.057		7.9	9	0.22	4.9			
S 40° W	316	0.052		7.8	11	0.35	7.4			
						2.7	16			
Los Angeles (Edison Bldg.):										
Up	120	0.065	120	12.9	9.2	0.52	3.1			
S 38° W	121	0.066	121	13.2	8.9	1.30	10.5			
N 52° W	120	0.066	120	13.0	8.8	0.87	6.1			
Los Angeles (Univ. of Southern Calif., Vivian Hall, roof):										
Down	115	0.052	112	7.6	10.0	0.38	3			
N 61° W	114	0.052	112	7.6	11.0	0.50	32			
						0.52	15			
S 29° W	117	0.052	102	7.6	10.0	0.52	26			
						0.58	23			
Los Angeles (Univ. of Southern Calif., Vivian Hall, basement):										
Down	122	0.056	97	7.6	11.0	0.71	8			
N 61° W	124	0.055	101	7.6	11.0	0.37	3			
S 29° W	123	0.053	111	7.6	10.0	0.85	6			
Los Angeles (Univ. of Southern Calif., Vivian Hall, 4th floor):										
Down	120	0.058	92	7.6	10.0	0.47	3			
N 61° W	119	0.056	99	7.6	10.0	0.50	13			
						0.45	6			
S 29° W	121	0.057	96	7.6	12.0	0.62	14			
						0.58	13			
Los Angeles (3345 Wilshire, 12th floor):										
Down	222	0.047	141	7.6	10.0	0.53	5			

South	221	0.048	134	7.6	9.0	0.83	32		
						0.84	19		
East	220	0.048	132	7.6	10.0	0.68	28		
						0.74	14		
Los Angeles (3345 Wilshire, 2d floor):									
Down	212	0.049	128	7.6	9.0	0.24	4		
South	193	0.049	128	7.6	9.0	0.88	10		
East	225	0.049	126	7.6	10.0	0.72	10		
Los Angeles (3345 Wilshire, basement):									
Down	199	0.047	140	7.6	10.0	0.53	4		
South	230	0.047	138	7.6	10.0	0.72	7		
East	209	0.047	138	7.6	10.0	0.66	6		
Los Angeles (3407 W. 6th, 8th floor):									
Down	509	0.054	106	7.6	11.0	0.20	4		
South	404	0.053	111	7.6	10.0	1.50	29		
						1.35	14		
East	439	0.053	111	7.6	10.0	1.23	20		
						1.28	9		
Los Angeles (3407 W. 6th, 4th floor):									
Down	342	0.055	102	7.6	10.0	0.70	3		
South	362	0.053	111	7.6	10.0	0.57	9		
East	415	0.056	97	7.6	10.0	0.32	7		
Los Angeles (3407 W. 6th, basement):									
Down	506	0.051	119	7.6	13.0	0.30	3		
South	426	0.049	125	7.6	11.0	0.51	10		
East	397	0.051	119	7.6	10.0	0.50	8		
Los Angeles (4867 Sunset Blvd., 7th floor):									
Down	169	0.048	107	6.1	10.0	0.62	4		
S 89° W	171	0.052	92.9	6.2	10.0	0.37	35		
S 01° E		0.048	111	6.3	10.0	0.35	21		
Los Angeles (4867 Sunset Blvd., 2d floor):									
Down	172	0.048	134	7.6	10.0	0.44	3		
S 01° E	175	0.049	127	7.6	10.0	0.63	10		
N 89° E	139	0.051	119	7.6	9.0	0.43	9		
Los Angeles (4867 Sunset Blvd., basement):									
Down	V	0.049	131	7.7	10.0	0.34	3		
S 89° W	155	0.049	127	7.6	10.0	1.00	5		
S 01° E	166	0.047	129	7.2	10.0	0.73	8		

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument	T_o	V	Sensitivity	ϵ	Acceleration		Displacement	
						Period	Amplitude	Period	Amplitude
Southern California Earthquake of April 8—Continued									
Los Angeles (3710 Wilshire, 5th floor):									
Down	517	0.055	106	7.9	9.0	1.07	4		
West	526	0.052	112	7.5	11.0	0.82	17		
						0.87	11		
South	525	0.054	111	8.0	8.0	1.04	14		
Los Angeles (3710 Wilshire, 11th floor):									
Down	522	0.055	99	7.4	10.0	0.60	5		
West	515	0.055	102	7.6	10.0	0.97	31		
						1.04	17		
South	519	0.054	106	7.6	9.0	0.78	35		
						0.83	21		
Los Angeles (3710 Wilshire, basement):									
Down	514	0.052	111	7.4	10.0	0.52	3		
West	513	0.058	92	7.6	10.0	0.68	6		
South	524	0.055	102	7.6	9.0	0.39	5		
Los Angeles (2011 Zonal, 9th floor):									
Down	250	0.048	133	7.6	10.0	0.58	7		
S 62° E	188	0.049	130	7.6	10.0	0.50	49		
						0.48	17		
S 28° W	125	0.049	128	7.6	12.0	0.52	26		
						0.57	19		
Los Angeles (2010 Zonal, 5th floor):									
Down	227	0.046	142	7.6	10.0	0.47	26		
S 62° E	211	0.047	141	7.6	9.0	0.61	4		
S 28° W	218	0.048	132	7.6	9.0	0.58	14		
Los Angeles (2010 Zonal, basement):									
Down	206	0.048	131	7.6	11.0	0.68	9		
S 62° E	208	0.047	138	7.6	10.0	0.62	4		
S 28° W	219	0.048	134	7.6	11.0	0.50	7		
Glendale:									

S 70° E	106	0.050	123	7.6	8.5	0.75	19.3			
Down	121	0.050	123	7.6	10.3	0.75	16.6			
S 20° W	105	0.050	126	7.6	11.5	0.75	23.0			
Pearblossom:										
Down	494	0.057	99	8.0	8.9	0.60	4.9			
North	472	0.056	103	8.0	7.3	0.15	6.1			
West	489	0.049	114	6.7	11.1	0.20	6.1			
Lake Hughes, No. 1 Fire Station:										
Down	207	0.060	88	7.9	11.0					Not measurable
N 21° E	219	0.063	80	7.9	12.0	0.45	8.7			
N 69° W	248	0.061	85	7.8	11.0	0.50	6.2			
Fairmont Reservoir:										
Up	339	0.076	115	16.3	11.0	0.50	1.2			
N 34° W	340	0.076	119	17.0	11.0	0.50	3.1			
N 56° E	341	0.076	114	16.3	13.0	0.50	3.1			
N 34° W	81	3.59	1		10.0			1.60	0.12	
S 56° W	80	4.23	1		11.0			2.30	0.07	
Castaic:										
Down	159	0.051	123	7.6	3.3	0.25	2.6			
N 21° E	165	0.051	123	7.6	10.5	0.35	5.1			
N 69° W	172	0.050	123	7.6	11.5	0.50	7.7			
Gorman (Oso Pumping Plant):										
Down	401	0.060	95	7.6	10.0	0.69	12.8			
North	404	0.050	108	7.6	11.0	1.06	12.8			
West	450	0.050	105	7.6	10.5	0.75	12.8			
Port Hueneme:										
Up	1001	0.080	118	18.7	10.0					Not measurable
South	1002	0.080	120	19.0	9.0	0.30	2.1			
West	1003	0.079	119	18.7	10.0	1.10	2.6			
North	33	2.30	1		10.0			2.00	0.13	
West	32	2.49	1		10.0			1.80	0.12	
Bakersfield:										
Up	342	0.067	114.5	12.6	8.0	0.79	1.2			
South	352	0.066	119	12.8	9.0	0.79	2.8			
West	353	0.064	120.5	12.4	10.0	0.68	2.8			
South	RDM	9.7	1		8.0			8.3	2.76	
West	LDM	10.0	1		13.0			5.0	0.75	
								11.2	1.92	

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity	ϵ	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of April 8—Continued										
Nevada, (Las Vegas, First Nat'l Bank, roof):										
Down	218	0.151	107	60.0	9.0	2.25	3.4			
						2.40	2.8			
South	219	0.154	116	68.0	10.0	0.90	3.6			
						1.50	5.4			
West	220	0.145	122	63.0	10.0	2.37	21			
						2.50	17			
East	41	3.90	2.42		10.0			2.35	1.28	
								2.55	1.04	
Up	116	1.70	1.28		10.0			2.32	0.98	
								2.35	0.73	
South	40	3.50	2.34		10.0			2.00	0.11	
								2.00	0.41	
								4.00	0.39	
Nevada (Hoover Dam, Intake Tower):										
Up	328	0.079		19.6	10.0					Not measurable
N 45° W	329	0.082		20.8	9.0	0.87	7.3			
N 45° E	330	0.082		20.7	9.0	0.87	5.5			
S 45° W	25	5.28	1.0		14.0			0.73	0.08	
N 45° W	24	5.94	1.0		29.0			0.87	0.15	
Possible Nevada Nuclear Test of April 20										
Bakersfield:										
Up	342	0.067	115	12.6	8.0	1.00	0.5			
South	352	0.066	119	12.8	9.0	1.50	1			
West	353	0.064	120	12.4	10.0	1.30	1			
South	RDM	9.7	1		8.0			5.00	0.21	

West	LDM	10.0	1	------	13.0	------	------	3.70 1.4 5.00 3.10 1.4	0.09 0.045 0.22 0.065 0.045	
Northern California Earthquake of April 28										
Sacramento (PT&T Bldg., basement):										
Up	2004	0.071	127	15.7	9.0	1.3?	0.5	--------	--------	Irregular
East	2018	0.070	124	15.1	11.0	0.90	0.6	--------	--------	
South	2019	0.071	126	16.6	11.0	0.7?	0.4	--------	--------	Irregular
North	61	4.33	1	------	10.0	------	------	1.30 2.00	0.01 0.04	
East	62	4.90	1	------	7.5	------	------	1.2? 1.7?	0.01 0.02	Irregular Irregular
Sacramento (PT&T Bldg., roof):										
East	191	0.053	102	7.14	10.0	0.70	4	--------	--------	
Down	192	0.055	109	8.11	11.5	0.16	1	--------	--------	
North	145	0.051	119	7.54	11.0	0.60	2	--------	--------	
Southern California Earthquake of June 29										
Santa Barbara:										
Up	259	0.065	116	12.0	8.0	0.15	6	--------	--------	
N 42° E	260	0.061	116	11.9	7.5	0.28	34	--------	--------	
S 48° E	261	0.065	119	12.6	9.0	0.35	7	--------	--------	
Cachuma Dam (Crest):										
Up	361	0.062	118	12.0	7.0	0.19	4	--------	--------	
North	362	0.060	118	11.5	9.0	0.45	8	--------	--------	
East	363	0.060	118	10.7	9.0	0.38	9	--------	--------	
South	14	2.30	1	------	8.0	------	------	0.58	0.06	
East	15	2.53	1	------	9.0	------	------	0.70	0.07	
Cachuma Dam (Valve House):										
Up	364	0.062	117	11.0	11.0	0.39	3	--------	--------	
North	365	0.062	119	11.4	10.0	0.41	2	--------	--------	

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity	ε	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of June 29—Continued										
East	366	0.064	121	12.2	9.0	0.32	4			
North	30	5.49	1		11.0			1.30	0.03	
West	9	5.66	1		11.0			0.77	0.04	
Southern California Earthquake of June 29 (Aftershock)										
Santa Barbara:										
Up	259	0.065	116	12.0	8.0	0.12	7			Begins 94 sec. after onset of 11:13 PST. Compressional onset.
N 42° E	260	0.061	116	11.9	7.5	0.26	9			
S 48° E	261	0.065	119	12.6	9.0	0.13	4			
Cachuma Dam (Crest):										
Up	361	0.062	118	12.0	7.0	0.12	3			
North	362	0.060	118	11.5	9.0	0.11	3			
East	363	0.060	118	10.7	9.0	0.12	3			
South	14	2.30	1		8.0			0.65	0.01	
East	15	2.53	1		9.0			0.68	0.03	
Cachuma Dam (Valve House):										
Up	364	0.062	117	11.0	11.0	0.12	1			
North	365	0.062	119	11.4	10.0	0.17	1			
East	366	0.064	121	12.2	9.0	0.12	1.2			
North	30	5.49	1		11.0			1.20	0.01	
West	9	5.66	1		11.0			0.95	0.015	

Bakersfield:										
Up	342	0.067	115	12.6	8.0					Not measurable
South	352	0.066	119	12.8	9.0	0.82	1			
West	353	0.064	120	12.4	10.0	0.69	1			
South	RDM	9.7	1		8.0			2.60	0.12	
West	LDM	10.0	1		13.0			4.78	0.07	
Buena Vista (Taft):										
South	135	0.052	102	6.7	8.0	0.43	4			
Down	133	0.052	102	6.7	8.5	0.28	2			
East	169	0.052	95	6.4	7.0	0.30	4			
Cachuma Dam (Crest):										
Up	361	0.062	118	12.0	7.0	0.23	7			
North	362	0.060	118	11.5	9.0	0.30	7			
East	363	0.060	118	10.7	9.0	0.18	12			
East	15	2.53	1		9.0			1.92	0.13	
South	14	2.30	1		8.0			1.99	0.17	
Cachuma Dam (Valve House):										
Up	364	0.062	117	11.0	11.0	0.37	3			
North	365	0.062	119	11.4	10.0	0.48	3			
East	366	0.064	121	12.2	9.0	0.28	14			
West	CDM-9	5.66	1		11.0			1.81	0.13	
Up	CDM-2	1.94	1		3.0			1.51	0.04	
North	CDM-30	5.49	1		11.0			2.22	0.10	
Castaic:										
N 21° E	165	0.051	123	7.6	10.5	0.29	26			
Down	159	0.051	123	7.6	9.0	0.34	8			
N 69° W	172	0.050	123	7.6	11.5	0.30	24			
						0.38	21			
Long Beach (Southern Calif. Edison Plant):										
Up	1004	0.068	121	13.9	8.0	0.44	1			
S 69° W	1005	0.067	120	13.8	9.5	0.30	2			
N 21° W	1006	0.067	116	13.0	11.0	0.29	3			
Los Angeles (1901 Ave. of the Stars, 21st floor):										
N 46° W	187	0.050	124	7.6	9.0	0.36	13			
						0.40	11			
Down	190	0.048	136	7.6	9.3	0.25	2			
S 44° W	181	0.050	123	7.6	9.1	0.48	6			

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity	ε	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of July 4—Continued										
Los Angeles (1901 Ave. of the Stars, 9th floor):										
N 46° W	183	0.050	122	7.6	7.8	0.67	7			
Down	184	0.051	116	7.6	8.5	0.19	1			
S 44° W	191	0.049	131	7.6	8.8	0.34	4			
Los Angeles (1901 Ave. of the Stars, basement):										
N 46° W	182	0.051	116	7.6	9.9					Not measurable
Down	194	0.051	118	7.6	8.8					Do
S 44° W	185	0.051	119	7.6	8.5					Do
Los Angeles (250 E. First, basement):										
N 36° E	205	0.049	127	7.6	10.9	0.46	2			
						0.51	1			
Down	207	0.048	131	7.6	9.6					Not measurable
N 54° W	241	0.049	129	7.6	9.1	0.40	1			
Los Angeles (250 E. First, 8th floor):										
N 36° E	233	0.049	130	7.6	9.8	0.49	5			
Down	202	0.048	131	7.6	8.9	0.20	1			
N 54° W	205	0.049	126	7.6	9.4	0.66	4			
						0.29	3			
						0.19	1			
Los Angeles (250 E. First, roof):										
N 36° E	189	0.047	139	7.6	8.7	0.47	3			
						0.37	2			
Down	224	0.047	137	7.6	11.3	0.21	4			
N 54° W	215	0.047	142	7.6	8.5	0.67	4			
						0.22	3			
Los Angeles (7080 Hollywood Blvd., basement):										
East	137	0.044	156	7.6	8.5	0.38	1			
Down	144	0.044	159	7.6	9.0	0.18	1			
North	143	0.045	149	7.6	9.9	0.33	1			

Los Angeles (7080 Hollywood Blvd., 6th floor):										
East	152	0.049	127	7.6	9.2	0.33	3			
						1.05	4			
Down	154	0.047	140	7.6	9.7	0.17	2			
North	148	0.050	122	7.6	9.8	0.30	2			
Los Angeles (7080 Hollywood Blvd., 12th floor):										
East	142	0.048	131	7.6	7.9	1.20	5			
						0.35	3			
Down	141	0.048	134	7.6	9.2	0.18	2			
North	146	0.047	137	7.6	8.1	0.98	3			
						0.31	3			
Los Angeles (Hollywood Storage, basement):										
Up	217	0.065	121	12.8	10.0	0.37	1			
East	216	0.066	122	13.3	10.0	0.50	3			
South	215	0.064	122	12.4	7.0	0.33	2			
Los Angeles (Hollywood Storage, Penthouse):										
Up	193	0.045	121	6.3	8.0	0.50	3			
South	192	0.046	123	6.7	8.0	0.66	3			
						0.60	3			
West	191	0.045	125	6.5	8.0	0.52	15			
						0.48	10			
Los Angeles (Hollywood Storage, P.E. lot):										
Up	214	0.065	122	12.9	9.0	0.47	1			
East	213	0.065	121	12.1	8.0	0.30?	2			Irregular
South	212	0.066	120	13.2	10.0	0.34	3			
Los Angeles (1640 Marengo, 1st floor):										
S 52° W	420	0.051	119	7.6	8.9	0.22	4			
Down	419	0.048	126	7.6	9.0	0.18	1			
S 38° E	434	0.053	111	7.6	9.0	0.29	4			
Los Angeles (1640 Marengo, 4th floor):										
N 38° W	440	0.055	101	7.6	7.9	0.51	7			
						0.54	5			
Down	427	0.051	119	7.6	9.9	0.19	1			
S 52° W	448	0.051	119	7.6	8.6	0.48	14			
						0.50	11			
Los Angeles (1640 Marengo, Penthouse):										
N 38° W	471	0.052	112	7.6	10.1	0.50	14			
						0.55	13			

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity	ε	Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquake of July 4—Continued										
Down	449	0.054	106	7.6	9.9	0.22	3			
S 52° W	447	0.052	112	7.6	9.9	0.51	25			
						0.45	21			
Los Angeles (120 N. Robertson, basement):										
S 2° W	530	0.053	102	7.6	9.5	0.35	1			
Down	534	0.054	104	7.6	8.4	0.26	1			
S 88° F	533	0.057	105	7.6	9.9	0.29	2			
Los Angeles (120 N. Robertson, 4th floor):										
S 2° W	539	0.052	109	7.3	9.0	0.28	4			
Down	535	0.053	106	7.4	8.0	0.31	1			
S 88° E	538	0.056	98	7.4	10.0	0.53	6			
						0.57	6			
Los Angeles (120 N. Robertson, 9th floor):										
S 2° W	532	0.056	98.5	7.6	9.7	0.54	9			
						0.27	7			
Down	536	0.056	98.5	7.6	9.4	0.29	3			
S 88° E	528	0.054	105	7.6	9.2	0.43	10			
						0.59	8			
Los Angeles (8244 Orion, 1st floor):										
North	527	0.055	105	7.9	10.0	0.28	4			
Down	516	0.053	110	7.6	9.0	0.28	3			
West	523	0.053	110	7.6	9.5	0.30	3			
Los Angeles (8244 Orion, 4th floor):										
North	520	0.053	101	7.0	9.7	0.52	7			
						0.48	6			
Down	518	0.053	111	7.7	8.0	0.27	4			
West	511	0.053	111	7.7	10.9	0.17	6			
						0.50	6			

Los Angeles (8244 Orion, roof):										
North	512	0.053	107	7.6	11.0	0.42	15			
						0.52	16			
Down	453	0.053	108	7.6	10.0	0.33	4			
West	521	0.053	111	7.6	12.0	0.48	12			
						0.52	16			
Los Angeles (945 Tiverton, Weyburn Hall, 8th floor):										
N 78° W	555	0.060	85	7.6	10.0	0.30	6			
Down	561	0.053	108	7.5	10.0	0.16	2			
S 12° W	537	0.057	93	7.5	10.0	0.47	5			
						0.87	8			
Los Angeles (945 Tiverton, Weyburn Hall, 14th floor):										
N 78° W	554	0.054	106	7.6	9.6	0.32	5			
Down	540	0.055	100	7.6	8.6	0.17	1			
S 12° W	560	0.054	104	7.6	10.5	0.30	5			
						0.98	12			
Southern California Earthquake of July 4 (Aftershock)										
Santa Barbara:										
Up	259	0.065	116	12.0	8	0.18	3			
N 22° E	260	0.061	116	11.9	7.5	0.42	9			
S 48° E	261	0.065	119	12.6	9	0.62	4			
Southern California Earthquakes Between October 15 and December 26										
El Centro:										
Up	208	0.067	121	13.5	8.5	0.13	3			(First shock)
South	206	0.069	124	14.7	7.5	0.27?	7			Irregular
West	207	0.067	121	13.5	9.0	0.28	10			
East	29	6.40	1		11.5			0.34	0.03	
South	28	6.80	1		9.5			0.40	0.03	
North	RDM	10.15	1		10.0			0.55	0.04	
East	LDM	11.10	1		9.5			0.45	0.06	
El Centro:										
Up	208	0.067	121	13.5	8.5	0.10	13			(Second shock)
South	206	0.069	124	14.7	7.5	0.14	35			

TABLE 5.—*Composite of strong-motion instrumental data for 1968*—Continued

Station and component	Instrument no.	T_o	V	Sensitivity		Acceleration		Displacement		Remarks
						Period	Amplitude	Period	Amplitude	
Southern California Earthquakes Between October 15 and December 26—Continued										
West	207	0.067	121	13.5	9.0	0.09	20			
East	29	6.40	1		11.5			0.22	0.03	
								?	0.06+	At start
South	28	6.80	1		9.5			0.5	0.02	
								?	0.10+	At start
North	RDM	10.15	1		10.0			0.25	0.10	
East	LDM	10.10	1		9.5			1.0?	0.08	Irregular
								2.2	0.06	
Alaska Earthquake of October 29										
College (College Observatory):										
N 19° E	138	0.051	111	7.2	8.5	0.26	110			
						0.39	76			
						0.23	83			
Down	188	0.051	114	7.2	14.5	0.19	40			
N 71° W	134	0.053	104	7.2	29	0.29	120			
						0.28	93			
						0.21	79			
Alaska Earthquake of October 30 (Aftershock)										
College (College Observatory):										
N 19° E	138	0.051	111	7.2	8.5	0.27	40			
Down	188	0.051	114	7.2	14.5	0.24	10			
N 71° W	134	0.053	104	7.2	29	0.24	20			

*Asterisk following number in sensitivity column indicates RFT-250 (film record) which has sensitivity of 7.6 centimeters at a 4 magnification.

Additions and Corrections to Previous Issues

United States Earthquakes, 1964. Page 49, column 2, line 8, the word Greenwich should read "Grewingk."

United States Earthquakes, 1965. Page 7, column 1, line 3 under Montana, delete 18, V.

Page 11, column 2, January 5 earthquake, change eastern Idaho to southern Montana.

United States Earthquakes, 1966. Page 89, column 2 of table, the time for the June 28 Parkfield, Calif., earthquake should read "04:26:14.4."

United States Earthquakes, 1967. Page 11, column 2, line 7, add "Darien" before the word Greenwich.

Page 14, column 1, November 23 earthquake, move "Colome" from intensity IV to intensity V and add, "Plaster cracked."

Page 21, column 2, September 23 earthquake, delete first listed time and second magnitude.

Page 21, column 2, October 4 earthquake, change 08:20:14.0* to 03:20:14.0*.

Page 56, under Tidal Disturbances of Seismic Origin, add "The Caracas, Venezuela, earthquake of July 29 generated a small sea wave with a 3-inch amplitude recorded at the La Guaire tide gage."

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