

DEPARTMENT OF THE INTERIOR

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United States Earthquakes, 1946

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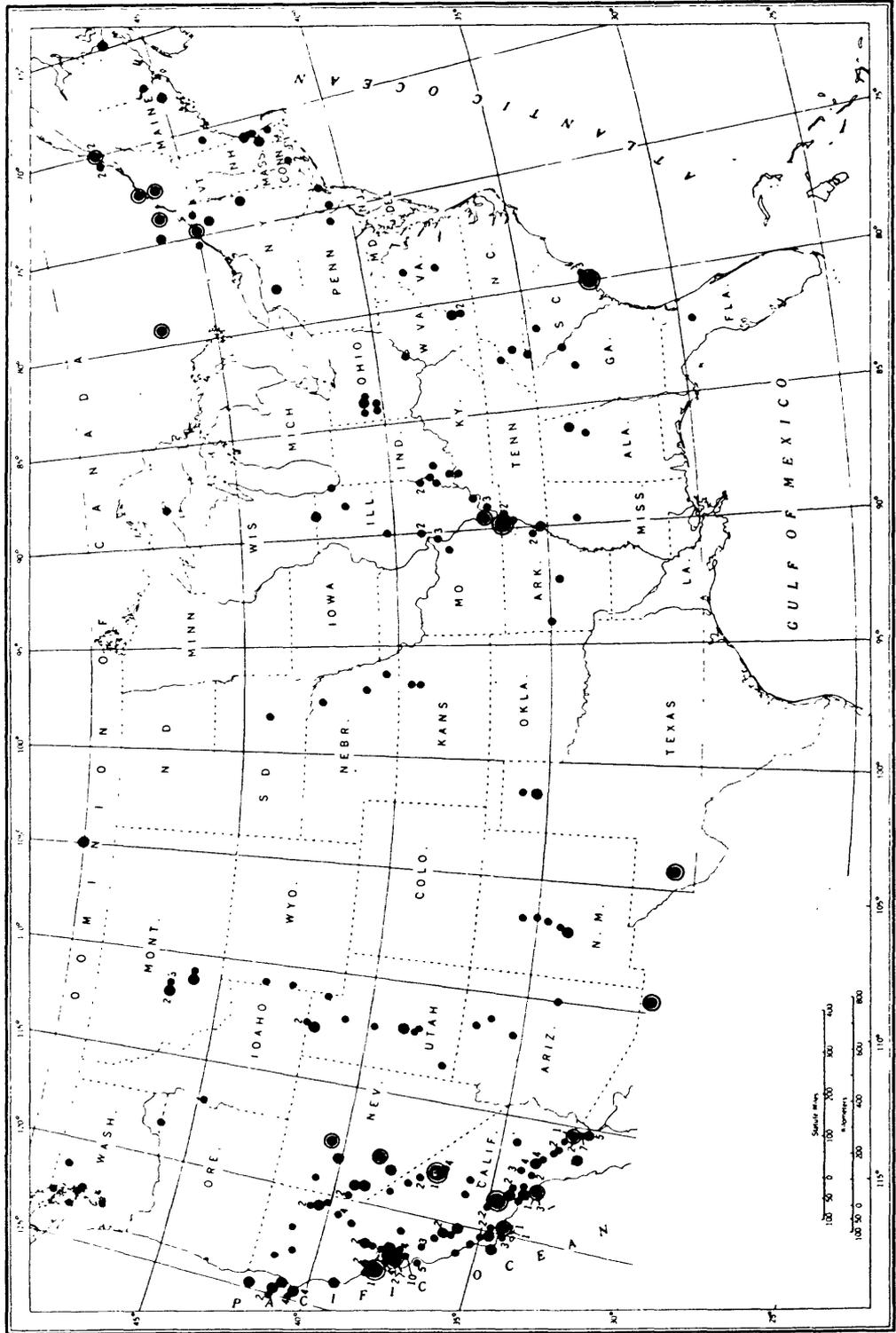


FIGURE 1.—Destructive and near destructive earthquakes in the United States through 1946.

# UNITED STATES EARTHQUAKES, 1946

## INTRODUCTION

This publication is a summary of earthquake activity in the United States and the regions under its jurisdiction for the calendar year 1946. A history of the more important shocks of the country appears in Serial 609, *Earthquake History of the United States: Part I.—Continental United States (Exclusive of California and Western Nevada) and Alaska, Revised (1947) edition*; and Part II.—*Stronger Earthquakes of California and Western Nevada, Revised (1941) edition*.

The history of minor activity is covered largely in a series of references listed in Serial 609, in recent reports of the United States Coast and Geodetic Survey, and in the *Bulletin of the Seismological Society of America*.<sup>1</sup> The last two references give very detailed information for all California earthquakes. The last one contains all of the information appearing in the early catalogs published by the Smithsonian Institution.

Earthquakes of volcanic origin in the Hawaiian Islands are not included. Complete reports are published by local seismological institutions. Earthquakes adjacent to the United States and felt within its borders are described only in a general way when detailed descriptions are published elsewhere.

*Cooperation of investigators solicited.*—In order that these publications may be as complete as possible in the more important details of earthquakes and in references, it is desired that investigators cooperate to the fullest extent, as such cooperation will be to the mutual advantage of everyone concerned. The Survey is willing to furnish investigators all information at its disposal, consisting principally of seismographic records and postcard questionnaires obtained in many instances through special canvassing of affected areas. In return it is requested that advance notices be furnished of results obtained so that abstracts and references may be inserted in these reports. An advance notice of a planned investigation might save considerable overlapping of effort and would give wider publicity to the work of the investigator.

*Earthquake information services.*—The Coast and Geodetic Survey maintains a field party in San Francisco, the Seismological Field Survey, which in addition to other duties collects earthquake information in the Pacific Coast and Western Mountain States. In this work the seismological station of the University of California, Berkeley (Dr. Perry Byerly in charge), and the Seismological Laboratory of the California Institute of Technology, at Pasadena (Dr. Beno Gutenberg in charge), cooperate actively. Among the commercial agencies on the west coast rendering valuable services are telephone, power, oil, railroad, and especially insurance companies. Certain concerns interested in the manufacture of earthquake-resistant building materials are also active together with various organizations of structural engineers and architects.

Outside of California the following Collaborators in Seismology served as agents of the Coast and Geodetic Survey in collecting earthquake information in their respective States in 1946.

*Arizona.*—Dean G. M. Butler, University of Arizona, Tucson.

*Colorado.*—Prof. C. A. Heiland, Colorado School of Mines, Golden.

*Idaho.*—Dean A. W. Fahrenwald, University of Idaho, Moscow.

*Montana.*—Dr. Francis A. Thomson, Montana School of Mines, Butte.

*Nevada.*—Prof. Vincent P. Gianella, University of Nevada, Reno.

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

*Oregon.*—Dean E. L. Packard, Oregon State Agricultural College, Corvallis.

*Utah.*—Prof. J. Stewart Williams, Utah State Agricultural College, Logan.

*Washington.*—Dr. Harold E. Culver, Washington State College, Pullman.

*Wyoming.*—Prof. Horace D. Thomas, University of Wyoming, Laramie.

In other parts of the country the Jesuit Seismological Association was active in cooperative projects. The central office of the association at St. Louis University (Rev. Dr. J. B. Macelwane, S. J., in charge) collected information in the central Mississippi River Valley area, and the seismological station at Weston College, Massachusetts

<sup>1</sup> Descriptive Catalog of Earthquakes of the Pacific Coast of the United States, 1769 to 1928. S. D. Townley and M. W. Allen, *Bulletin of the Seismological Society of America*, vol. 29, no. 1, January 1939.

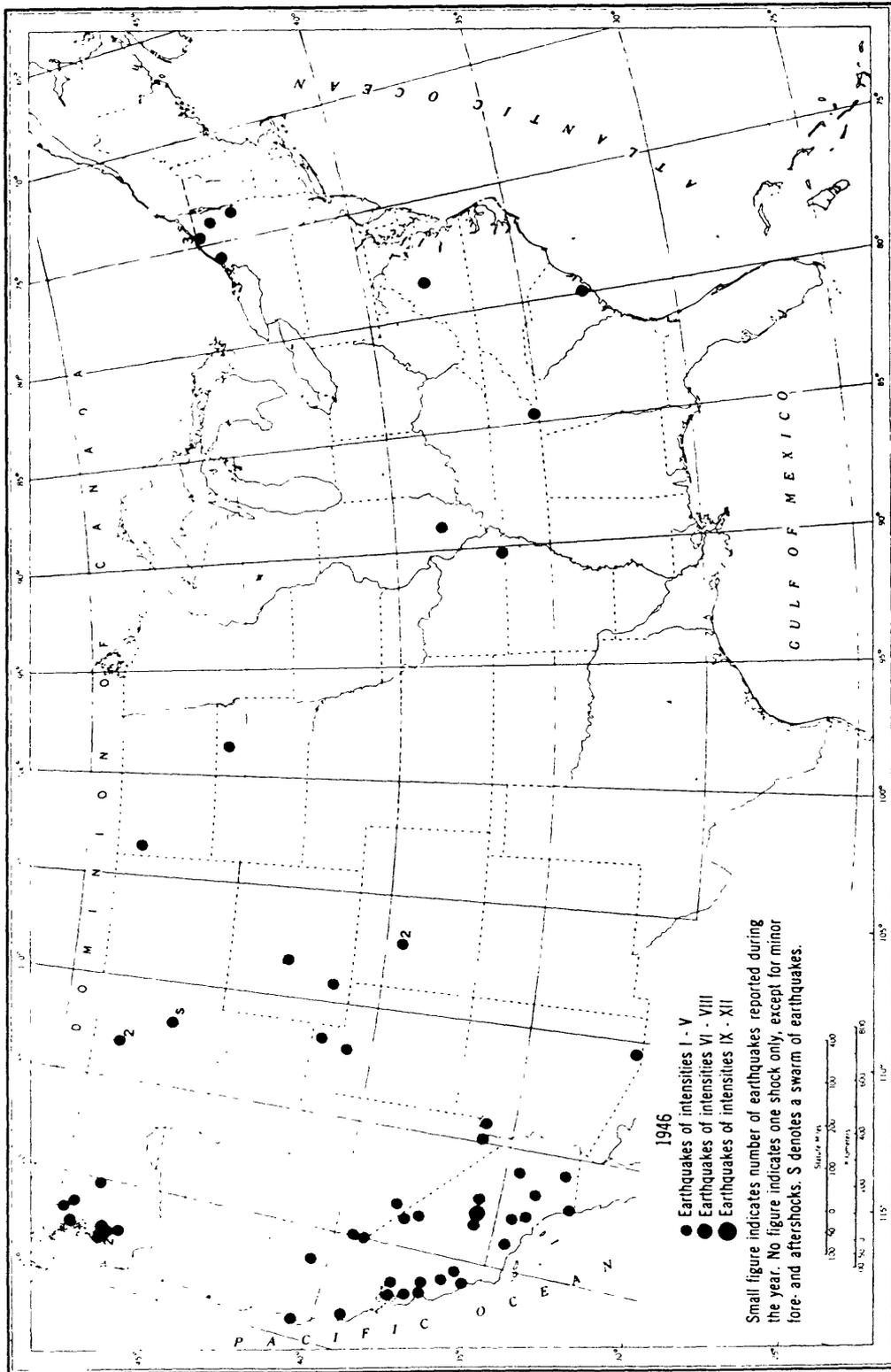


FIGURE 2.—Earthquake epicenters, 1946.

(Rev. Daniel Linehan, S. J., in charge), undertook similar work in the Northeastern States under the auspices of the Northeastern Seismological Association and in close collaboration with the Harvard Seismological Observatory. Figure 3 shows areas canvassed for earthquake information by these various organizations.

Other sources of information used in compiling this report included: (1) The United States Weather Bureau, whose observers prepare periodic reports on local seismic activity; (2) telegraphic information collected by Science Service, Washington; (3) Bulletins of the Seismological Society of America; (4) bulletins of the Northeastern Seismological Association; (5) special bulletins of the Jesuit Seismological Association; (6) Earthquake Notes; (7) reports of the Hawaiian Volcano Observatory; and (8) reports from many interested individuals.

*Notes on the regional earthquake lists.*—The destructive features of all shocks are enumerated in the abstracts, but otherwise the descriptive matter is reduced to a minimum. The original reports are open for inspection by anyone interested in unpublished details. More detailed descriptions of earthquakes on the west coast will be found in the mimeographed reports available at the office of the Supervisor, Western District, in San Francisco.

Beginning with the 1931 number of this series, Serial 553, the Coast and Geodetic Survey has used and will continue to use the modified Mercalli intensity scale of 1931, in place of the Rossi-Forel scale, to designate the intensity of earthquake activity. All intensity numbers therefore refer to the modified Mercalli scale unless otherwise designated. The reasons for this change are set forth in an article entitled "Modified Mercalli Intensity Scale of 1931," by Harry O. Wood and Frank Neumann, in the December 1931 number of the Bulletin of the Seismological Society of America, volume 21, no. 4. This article contains the original unabridged scale and also an abridged scale. The latter is given here, together with equivalent intensities according to the Rossi-Forel scale.

#### MODIFIED MERCALLI INTENSITY SCALE OF 1931

(ABRIDGED)

- I. Not felt except by a very few under especially 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.)
- 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. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale.)
- VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale.)
- VII. Everybody runs outdoors. Damage **negligible** in buildings of good design and construction; **slight** to moderate in well-built ordinary structures; **considerable** in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII—Rossi-Forel scale.)
- VIII. Damage **slight** in specially designed structures; **considerable** in ordinary substantial buildings with partial collapse; **great** in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX—Rossi-Forel scale.)
- IX. Damage **considerable** in specially designed structures; well-designed frame structures thrown out of plumb; **great** in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel scale.)
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from 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 pipe lines 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.

In the case of California, earthquakes reported as feeble are not plotted on the epicenter map of the United States, nor are minor after-shocks plotted for heavy earthquakes in California or any other region. The reader should bear in mind that the information service in California has been developed to a point not approached in any other section of the country. When the coordinates of epicenters are given, the sources of information are stated. The epicenters are frequently determined by organizations such as the Seismological Station of the University of California or the Seismological Laboratory of the California Institute of Technology. The bulletins of these institutions should be consulted for further details and often for data on additional shocks.

Within the United States the same regional arrangement has been followed as in Serial 609 previously mentioned.

*Special quarterly report.*—Attention is invited to a special quarterly report issued by the Seismological Field Survey, with headquarters at San Francisco, entitled "Abstracts of Earthquake Reports for the Pacific Coast and the Western Mountain Region." The reports are in mimeographed form and tabulate in unabridged style all information of value contained in noninstrumental reports collected in the region indicated.

*Epicenter maps.*—Figures 1 and 2 are designed to show earthquake distribution in the United States at a glance, but the reader is cautioned in accepting all epicenter locations as correct. In a few cases, especially offshore epicenters and others in uninhabited areas where instrumental control is not satisfactory or where results of investigations are overdue, the plotted epicenters may be in error. The maps must therefore be accepted as showing in some cases the existence of epicenters rather than their precise locations. The text should be consulted to appraise any individual case. This same condition prevails also to some extent in the case of isoseismal maps.

In figure 1 the smallest solid dot indicates the shock was strong enough to overthrow chimneys or affect an area of more than 25,000 square miles, intensity VII to VIII; the largest solid dot may be associated with damage ranging from several thousand dollars to one hundred thousand, or to shocks unusually perceptible over more than 150,000 square miles, intensity VIII to IX; the smaller encircled dots represent damage ranging approximately from one hundred thousand to one million dollars, or an affected area greater than 500,000 square miles, intensity IX to X; the larger encircled dots represent damage of a million dollars or more, or an affected area usually greater than 1,000,000 square miles, intensity X.

The number after a dot indicates the number of shocks which have occurred at or near the location shown. Points of origin of many of the earlier shocks are uncertain.

*Teleseismic results.*—On page 24 is a list of Survey and cooperating teleseismic stations for which the Survey publishes results. Immediate epicenter determinations are frequently made through the cooperation of Science Service, the Jesuit Seismological Association, the Coast and Geodetic Survey, and individual stations. The results are furnished by mail to cooperators.

*Strong-motion results.*—The introductory remarks in the chapter on this subject explain in detail the purpose of the work, which is primarily to furnish engineers exact information concerning ground movements in the central regions of strong earthquakes. The instrumental equipment is essentially different in type from teleseismic equipment although the principles involved are the same. Strong-motion instruments are installed mostly in the urban areas of California, and operate only when actuated by the movements of a strong earthquake.

The interpretation of strong-motion results is one of the duties assigned to the Survey in connection with a broad cooperative program of seismological research being carried out on the Pacific coast between the Survey and a number of local organizations and institutions interested in the engineering aspects of the earthquake problem. The details of this program are fully described in the Survey's Special Publication No. 201, Earthquake Investigations in California, 1934-35, which is obtainable from the Superintendent of Documents, Washington 25, D. C., for 35 cents.

Preliminary reports on strong-motion results are issued in quarterly mimeographed bulletins and sometimes in special mimeographed reports. They appear in revised form in this publication.

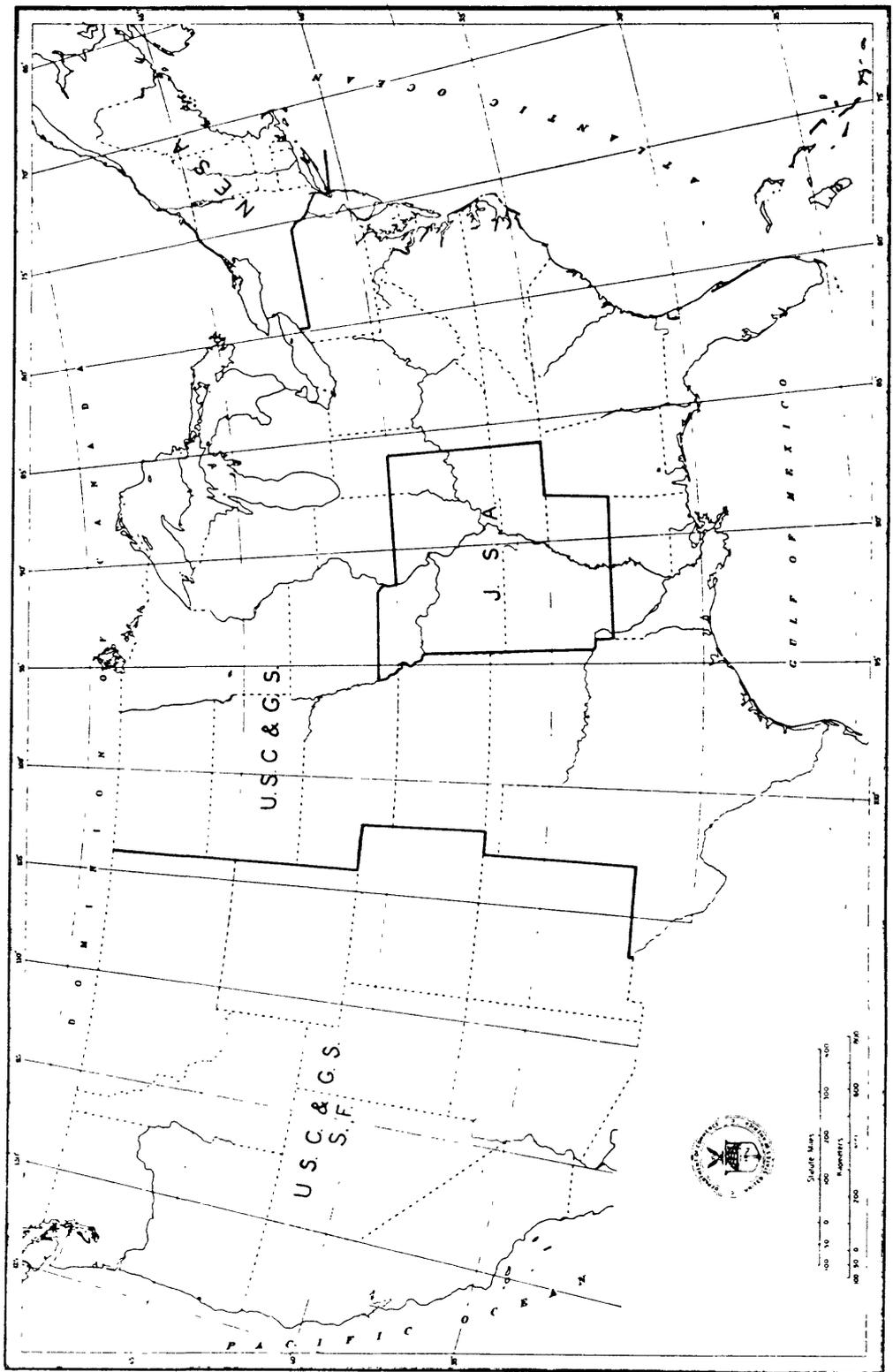


FIGURE 3.—Areas canvassed for earthquake information by various organizations: the United States Coast and Geodetic Survey, the Jesuit Seismological Association, and the Northeastern Seismological Association. The western area is covered by the San Francisco office of the Survey.

## NONINSTRUMENTAL RESULTS

NOTE.—The following symbols are used to indicate authority for the data shown.  
P—epicenter reported by the Seismological Laboratory of the California Institute of Technology at Pasadena.  
B—epicenter reported by the Seismological Station of the University of California at Berkeley.  
BC—epicenter reported by the Boulder City office of the Lake Mead Seismological Survey.  
W—epicenter reported by the Washington Office of the United States Coast and Geodetic Survey.  
An asterisk (\*) indicates instrumental origin time of the earthquake when coordinates of the epicenter are given. Otherwise, instrumental times shown with asterisks are those of first motions.  
When more than one degree of intensity is reported from a town, the town is listed under the highest intensity reported. More details will be found in the quarterly Abstracts of Earthquake Reports for the Pacific Coast and the Western Mountain Region which may be obtained from the Washington Office of the United States Coast and Geodetic Survey.

### EARTHQUAKE ACTIVITY IN THE VARIOUS STATES

**Arizona:** July 18, November 26.  
**California:** March 5, 15, 18; April 25; May 1; July 6, 18; September 27; December 18. Minor shocks are not listed here.  
**Colorado:** January 31, April 2.  
**Illinois:** February 24.  
**Missouri:** May 15, October 7.  
**Montana:** January 22; March 8, 25; July 16; August 3; September 11 (2), 23, 29; October 9, 10 (2), 26; November 2 (2); December 8, 11.  
**Nevada:** February 9, 14, 27; March 17. Minor shocks are not listed here.  
**New York:** March 15, 19 (3); June 20; September 4; November 24, 28.  
**North Dakota:** October 26.  
**South Carolina:** February 8.  
**South Dakota:** July 23.  
**Tennessee:** April 6.  
**Utah:** March 19, May 5, October 25.  
**Virginia:** May 24.  
**Washington:** February 5 (2), 6, 14, 15, 23; March 19; June 23; December 27.  
**Wyoming:** January 26, September 14.

### EARTHQUAKE ACTIVITY OUTSIDE THE UNITED STATES

**Alaska:** January 12; March 1, 11; April 1 (2), 18; June 25, 30; August 28; October 19.  
**Canal Zone:** July 12, December 11.  
**Puerto Rico:** June 4, August 4, October 4.

### NORTHEASTERN REGION

(75TH MERIDIAN OR EASTERN STANDARD TIME)

**March 15:** 23:20. Massena, N. Y. Slight shock felt.  
**March 19:** 21:01, 21:29, and 22:02. Alexandria Bay, N. Y. Sharp shocks felt by many. First began with increasing vibration followed by one single-wave motion. Last two were minor. Felt only in a schoolhouse at edge of town.  
**June 20:** 18:09. Gabriels, N. Y. Light tremor felt by many.  
**September 4:** 14:30. Massena, N. Y. Sharp shock heard and felt by many. No damage.  
**November 24:** 05:20. Massena, N. Y. Light shock felt by many. Subterranean sounds heard 8 seconds before and 4 seconds after the shock. Many awakened but no damage.  
**November 28:** About 17:00. Schroon Lake, N. Y. Sharp shock rattled windows and doors. Rumbling sound like an explosion heard. Many uncertain whether it was an earthquake or an explosion.

### EASTERN REGION

(75TH MERIDIAN OR EASTERN STANDARD TIME)

**February 8:** 13:09. Summerville, S. C. Light shock felt by several.  
**May 24:** 14:40. Albemarle County, Va. Several people in western part of county reported an explosive sound preceded the earth tremor.

### CENTRAL REGION

(90TH MERIDIAN OR CENTRAL STANDARD TIME)

**February 24:** 18:52. Centralia, Ill. The following is taken from a report by Dr. Ross R. Heinrich, of St. Louis University: "The shock had a maximum intensity of IV, modified Mercalli intensity scale, and was felt in Bartleso, Carlyle, Cartler, Centralia, Huey, Kimmundy, Odin, Patoka, Sandoval, Shattuc, and Vernon, Ill. It was recorded on the seismographs at St. Louis and Florissant, Mo. Using Walter-Birkenhauer tables the data indicate an epicentral distance of about 65 miles from St. Louis. Although indefinite these data and the macroseismic information suggest an epicenter in the region of the stronger Illinois Basin earthquake of November 17, 1937, which was on the northern extension of the DuQuoin Flexure, a minor tectonic feature on the western limb of the Illinois Basin."

**April 6:** 24:00. Cleveland, Tenn. Sharp shock like truck hitting building reported by several in and near the town. Some heard sound like distant thunder on the horizon.

**May 15:** 00:10. Marston and Doniphan, Mo. Light shock. No details.

**July 23:** 00:45. Wessington, S. Dak. Water mains cracked at two points. Generally felt from Pierre eastward to DeSmet and northward including Redfield. Strong enough to awaken sleepers in Huron.

**October 7:** 19:12:02.5.\* Epicenter by St. Louis University, 37°28' north, 90°34' west, about midway between towns of Chloride and French Mills, Mo., in vicinity of Hogan Fault. Felt over approximately 3,000 square miles in Missouri and in a small portion of Illinois. Residents of Annapolis, Lesterville, Lodi, Saco, and Vulcan reported very distinct rumblings like dynamite or big motors underground. Also felt in Missouri at Des Arc, Farmington, Jackson, Oates Tower, Perryville, St. Louis, Washington, and Webster Grove; and in Illinois at Belleville, Cairo, Edwardsville, and Waterloo.

**October 26:** 14:37. Williston, N. Dak. Light shock of about 5 seconds duration felt by many in vicinity. Also felt at Plentywood, Mont. No damage. At Williston beds swayed and dishes rattled.

## WESTERN MOUNTAIN REGION

(105TH MERIDIAN OR MOUNTAIN STANDARD TIME)

- January 7:** 16:00\* BC. Boulder City, Nev. Light 2- or 3-second shock felt by many.  
**January 8:** 04:13\* BC. Boulder City, Nev. Light shock felt.  
**January 8:** 04:32\* BC. Boulder City, Nev. Light shock felt.  
**January 22:** 06:42. Helena, Mont. Weak shock.  
**January 26:** 23:55. Thermopolis, Wyo. Mild shock rattled windows and dishes. Rumblings heard for about 10 seconds. Water in Big Horn Hot Spring at Hot Springs State Park was boiled for several hours.  
**January 31:** 15:45. Glenwood Springs, Colo. Light shock felt. Moderately loud, roaring subterranean sounds heard by many at time of shock.  
**February 14:** 03:45\* BC. Boulder City, Nev. Light shock felt.  
**February 15:** 19:12\* BC. Boulder City, Nev. Light shock felt by many. Rattled windows, doors, and dishes. Stronger of two shocks.  
**February 15:** 19:43\* BC. Boulder City, Nev. Light shock felt by many. Rattled windows and doors.  
**March 8:** 13:10. Helena, Mont. Weak shock.  
**March 10:** 17:16\* BC. Boulder City, Nev. Light shock felt by several.  
**March 10:** 22:18\* BC. Boulder City, Nev. Very light shock felt by one person.  
**March 11:** 06:46\* BC. Boulder City, Nev. Very light shock felt.  
**March 12:** 04:45\* BC. Boulder City, Nev. Light shock felt by several. Rattled windows and doors.  
**March 14:** 02:17\* BC. Boulder power plant, Nev. Light shock felt by several in control room only.  
**March 14:** 20:25\* BC. Boulder City, Nev. Light shock felt by many. Rattled windows and doors.  
**March 16:** 21:52\* BC. Boulder City, Nev. Slight quiver felt by observer in home.  
**March 19:** 14:15 and 20:00 (about). Box Elder County, Utah. Very light shocks reported on the Kunzler Ranch near Park Valley.  
**March 25:** 08:25. Helena, Mont. Very weak shock.  
**April 2:** 19:05. Riland, Colo. Light shock felt by several. Rattled windows and dishes. Walls of log house creaked.  
**May 5:** 19:30. Logan, Utah. Widely felt in western Bear River Valley from the bird refuge to Garland. Maximum intensity V reported from Garland and Tremerton where small objects shifted and vases overturned. Also felt at Bear River City, Bothell, Brigham City, Deweyville, Elwood, Evans, Fielding, Portage, Riverside, and Snowville. Recorded on seismograph at Logan.  
**June 7:** 18:42. Helena, Mont. Weak shock.  
**June 8:** 04:25. Helena, Mont. Weak shock.  
**June 12:** 12:21. Helena, Mont. Weak shock.  
**June 15:** 02:21\*, 02:38\*, and 03:30\* BC. Boulder City, Nev. Very light shocks felt.  
**July 13:** 10:14\* BC. Boulder City, Nev. Light shock felt in city and at Boulder power plant control room. Slight rumble.  
**July 14:** 09:57\* BC. Boulder City, Nev. Light shock felt by observer in home.  
**July 14:** 14:23\* BC. Boulder power plant, Nev. Light shock felt by several.  
**July 14:** 14:30\* BC. Boulder power plant, Nev. Light shock felt by several.  
**July 16:** 08:00. Helena, Mont. Weak shock.  
**July 18:** 06:27:58\* P. Parker, Ariz. Light shock felt. Rattled windows, walls creaked.  
**August 3:** 01:07. Helena, Mont. Light shock.  
**September 11:** 01:42. Helena, Mont. Light shock.  
**September 11:** 19:24. Helena, Mont. Weak shock.  
**September 14:** 05:45. Rock Springs, Wyo. Light shock felt by several. Buildings creaked and loose objects rattled.  
**September 23:** 22:02. Helena, Mont. Weak shock.  
**September 29:** 22:45. Helena, Mont. Weak shock.  
**October 2:** 04:28\* BC. Boulder City, Nev. Light shock felt by observer in home. Earth noise, followed by slight tremble 1 second later.  
**October 4:** 07:42\* BC. Boulder City, Nev. Two light shocks felt by observer in home. Rattled windows, doors, and dishes.

**October 6:** 00:19\* BC. Boulder power plant, Nev. Sharp shock felt in control room. Combination of vertical and horizontal motion.

**October 6:** 09:00\* BC. Boulder power plant, Nev. Light shock felt by all in power plant, by others outdoors.

**October 9:** 14:00. Helena, Mont. Weak shock.

**October 10:** 19:15. Helena, Mont. Weak shock.

**October 10:** 19:50. Helena, Mont. Weak shock.

**October 25:** 09:53. Magna, Utah. Light shock felt by many at schoolhouse. Rattled windows.

**October 26:** Between 13:45 and 14:30. Northeastern Montana. Quake of short duration felt quite generally throughout section. Residents at Wolf Point reported a rumble followed by one sharp tremor which gradually died away. Men working at the Nefzger Body Shop felt the quake noticeably when timbers which were jacked up suddenly slipped out and let their loads fall. Large buildings were reported to have swayed. Plentywood reported mild tremor of short duration.

**November 2:** 08:12. Helena, Mont. Weak shock.

**November 2:** 17:22. Helena, Mont. Weak shock.

**November 3:** 22:14\* BC. Boulder City, Nev. Light shock felt by several. Rattled windows.

**November 18:** 06:31\* BC. Boulder City, Nev. Light shock felt by observer in home. Rattled windows, doors, and dishes.

**November 26:** 15:49 (about). Pierce Ferry, Ariz. Light shock felt by observer. Rattled windows and doors.

**December 6:** 04:36\* BC. Boulder City, Nev. Light shock felt by a few. Rattled windows, doors, and dishes.

**December 8:** 07:10. Helena, Mont. Weak shock.

**December 11:** 06:09\* BC. Northwestern Montana. Felt over an area of approximately 3,000 square miles in northwestern Flathead Lake region. Maximum intensity of VI was reported from Kalispell, Trout Creek, Warland, and Whitefish. Press at Kalispell reported a sharp earthquake but no major damage. At many homes bric-a-brac and light articles were jarred to the floor and dishes rattled. One report of a toppled chimney was received, and several reports indicated loose plaster fell. The quake, which was of 10-second duration, started with a heavy jolt and tapered off into lesser vibrations. A rumble accompanied the quake.

#### INTENSITY VI:

*Kalispell.*—Felt by and awakened many. Felt outdoors by some. Cracked plaster and chimneys, some bricks fell. Broke dishes. Pendulum clocks stopped. Hanging objects swung and pictures fell.

*Trout Creek.*—Felt by many. Rattled dishes. Hanging objects swung northeast. Pictures were displaced.

*Warland.*—Felt in homes, few awakened. Rattled windows, doors, and dishes. Knickknacks fell.

*Whitefish.*—Awakened and frightened many. Considerable plaster cracked. Dishes rattled and walls creaked. Quake was accompanied by roar or rumble. Two-story buildings swayed.

#### INTENSITY V:

Bigfork, Columbia Falls, Jennings and Dunn Creek, and Kila.

#### INTENSITY IV:

Dayton, Eureka, Fortine, Libby, Marion, Niarada, Pablo, Polson, Rexford, and Yakt.

#### INTENSITY I TO III:

*Essex.*—Negative reports were received from 6 places in Montana and 7 places in Idaho.

#### CALIFORNIA AND WESTERN NEVADA (120TH MERIDIAN OR PACIFIC STANDARD TIME)

NOTE.—All places are in California unless otherwise stated. The Bulletin of the Seismological Society of America is referred to as the SSA Bulletin.

**January 1:** 15:56:32.\* Epicenter 32°43' north, 117°25' west, P. Localized shock in the coastal area running from La Jolla through San Diego city proper, National City, and Coronado. It was strong enough to sway buildings, knock mirrors and pictures from walls, and trip burglar alarms. San Diego residents fled their homes in fear. Rolando Village and Crown Point residents described the shock as similar to the explosion of a bomb truck in Rose Canyon the previous month.

**January 8:** 10:54:18.\* Epicenter 33°00' north, 115°50' west, P. San Jacinto Fault, about 20 miles northwest of El Centro. This earthquake was of mild intensity and was felt over an area of about 12,000 square miles in southern California. Reports of intensity V were received from scattered localities.

A strong-motion record was obtained from the accelerograph at El Centro.

#### INTENSITY V:

Dulzura, Imperial, Lakeside, Mountain Center, Palm Springs, and San Diego.

#### INTENSITY IV:

Alpine, Barrett Dam, Brawley, Cabazon, Campo, Coachello, Descanso, El Cajon, El Centro, Forest Home, Hipass, Holtville, Idyllwild, Jacumba, Julian, La Mesa, Mecca, Miramar, Mount Laguna, National City, Palomar Mountain, Plaster City, San Dimas, San Marcos, Seeley, Warner Springs, and Wildomar.

## INTENSITY I TO III:

Beaumont, Calipatria, Chula Vista, Encinitas, Fawnskin, Jamul, La Jolla, Los Angeles, Mount Wilson, Palm City, San Pedro, San Ysidro, Thermal, Twentynine Palms, and Valley Center.

Negative reports were received from 45 places.

**January 8:** 11:00 (about). Coleville. Light shock felt at Mono Observatory.

**January 13:** 08:31:15.\* Epicenter 37°19' north, 118°39' west, P. About 2 miles west of Bishop. Felt strongest at Owens River Gorge, where all were frightened. Cracked windows and chimneys. Many rocks fell down sides of canyon. Sharply felt at Adams main powerhouse and lightly felt in Nevada at Hawthorne.

**January 13:** 09:12:58.\* Epicenter 34°24' north, 117°56' west, P. Southwest of Valyermo. Felt in Los Angeles and north of Los Angeles over a small area. No damage reported. Also felt at Altadena, Glendale, La Crescenta, Pasadena, Sierra Madre, and South Pasadena.

Negative reports were received from 24 places.

**January 31:** 15:12:39.\* Epicenter 33°50' north, 118°06' west, P. North of Los Alamitos. Felt slightly at Long Beach and South Gate.

**February 9:** 18:56 (about). Bruceite, Nev. Strong tremor rattled windows. Confined to area west of foot of Paradise Mountains.

**February 10:** 03:01:18.\* Epicenter 36°10' north, 120°55' west, P. East of San Lucas. Felt over an area of approximately 2,000 square miles in west-central California. Maximum intensity V reported from San Benito.

## INTENSITY IV:

Big Sur, Chualar, Greenfield, Hollister (7 miles south of), Lonoak, San Lucas, San Miguel, Santa Cruz, and Soledad.

## INTENSITY I TO III:

King City, Moss Landing, Pacific Grove, Robles del Rio, and San Ardo.

Negative reports were received from 19 places.

**February 13:** 15:58. Fresno. Mild shock caused a low rumbling and rattled windows and dishes.

**February 14:** 09:50. Washoe Valley, Nev. "Mild earth tremors rattled windows and swung chandeliers for several minutes at 9:50 a. m., P. S. T., in homes in Washoe Valley, about 20 miles south of Reno, Nevada." (SSA Bulletin, April 1946.)

**February 15:** 04:07. Parkfield. Light shock rattled windows, doors, and dishes. Hanging objects swung. Pendulum clock facing south stopped.

**February 20:** 05:11:38.\* Epicenter 34°03' north, 118°05' west, P. Near Barton Flat. Reported felt at a cabin near San Geronio Peak.

**February 23:** 22:07:52.\* Epicenter 34°24' north, 117°48' west, P. Southeast of Valyermo. Intensity VI in Valyermo where all were awakened. Houses creaked and pictures fell. There were no intensity V reports.

## INTENSITY IV:

Big Bear City, Cabazon, Glendale, Littlerock, Los Angeles, and Pasadena.

Negative reports were received from 50 places.

**February 27:** Between 14:00 and 14:30. Gables, Nev. Three shocks in rapid succession and increasing intensity. Windows rattled. Preceded by sounds like a heavy truck. Felt only in the valley.

**March 5:** 06:05\* B. Epicenter 38.9° north, 120.1° west. Maximum intensity VI at Bijou, where all were awakened. Rattled windows, doors, and dishes. Hanging objects swung north-south. Pendulum clock facing north stopped. Trees and bushes were shaken strongly. Small objects overturned and knickknacks fell. Also felt at Camino, Camp Richardson, Homewood, Kyburz, Meyers, Tahoe, Tahoe Vista, and Woodfords. Felt in Nevada at Carson City, Lake Tahoe, Minden, Steamboat, and Virginia City.

Negative reports were received from 3 places in California and 4 places in Nevada.

**March 15:** 05:00. Grass Valley. "Several Grass Valley residents reported a severe jolt at 5 a. m., P. S. T. The tremor roused some from their sleep." (SSA Bulletin, April 1946.)

**March 15:** 05:20:01\*, 05:49:36\*, 06:00:35\*, and 11:18:54\*. Epicenter 35°44' north, 118°02.5' west, P. North of Walker Pass. These earthquakes were felt over an area of approximately 65,000 square miles. See map. The following is quoted from a report of the field investigation made by the Seismological Laboratory: "The foreshock at 05:20:01\* was felt by many persons in the area of Pasadena and Los Angeles, but the intensity there was described as slight. The main shock at 05:49:36\* in the same area was reported as notably stronger, with the effect of a long-period roll which set suspended objects swinging and nauseated sensitive persons. The strong-motion instrument at Pasadena recorded a maximum ground motion of about 1 millimeter with a period of about 2 seconds. The after-shocks at 10:18:54\* and on March 16 at 01:46\* were also felt in Los Angeles. In the epicentral region the main shock reached intensity VIII. Most of the more conspicuous effects could be referred to VII; damage to adobe structures, cracks in brick chimneys, fall of plaster. These were found in the region of Walker Pass and the South Fork of the Kern River south and west of the epicenter. In San Canyon, a few miles east of the epicenter, large boulders were rolled down onto the line of the Los Angeles Aqueduct. Part of the roof and sidewall were torn off by these boulders; this damage was repaired in about 2 days. Minor cracks were produced in the ground and in concrete along the aqueduct. *Magnitude:* The above numbers refer to local intensity. The magnitude of the main shock on the scale in use at Pasadena has been determined from the strong-

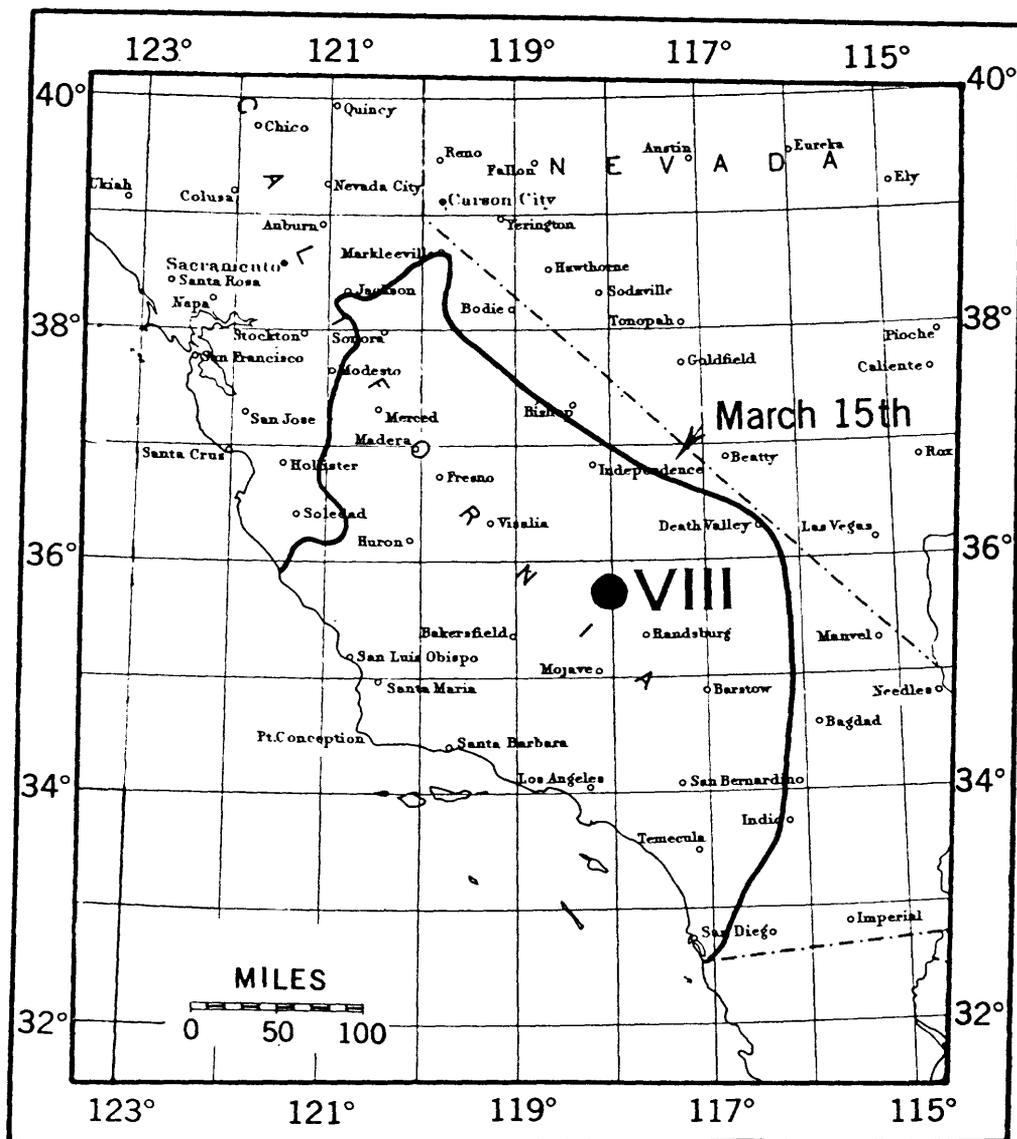


FIGURE 4.—Area affected by the earthquake of March 15.

motion record and from comparison with aftershocks as being 6.2 to 6.4. The corresponding magnitude for the Long Beach earthquake of March 10, 1933 (March 11, 1933, G. C. T.), is 6.3. The San Francisco earthquake of 1906 had a magnitude of about  $8\frac{1}{4}$ . The last previous shock of comparable magnitude in southern California occurred on October 21, 1942 (magnitude about 6.5; epicenter near Borego Valley), in eastern San Diego County,  $33.1^{\circ}$  north,  $116.1^{\circ}$  west."

#### INTENSITY VIII:

*Onyx.*—Awakened and frightened all. Houses creaked. Pendulum clocks facing northeast stopped. Trees and bushes strongly shaken. Cracked plaster, windows, walls, chimneys, and ground. Pictures and plaster fell. Considerable damage to wood, brick, masonry, and concrete. The second shock was most severe, lasting almost 1 minute in a series of four rolls. Heavy shocks occurred throughout the day, and continued for 3 days.

#### INTENSITY VII:

*Weldon.*—Awakened and frightened all. Pendulum clocks stopped. Trees and bushes strongly shaken. Shifted furnishings. Cracked plaster, windows, and chimneys. Broke dishes and windows. Damage slight to brick and masonry.

## INTENSITY VI:

*Bakersfield*.—Reported as heavy in area 20 to 40 miles east of Bakersfield. Felt by practically all. Rattled loose objects; buildings creaked. Door chimes rung. Few small plaster cracks. Hanging objects swung. Damaged basement in City Hall. Broke pipes.

*Bodfish*.—Awakened and frightened many. Some drugs and groceries fell off shelves and were broken. Rattled windows, doors, and dishes. Hanging objects swung. Cracked walls. Damage slight to concrete.

*Brown*.—Felt by and awakened all. Rattled windows, doors, and dishes. Overturned small objects. Broke dishes. Rocks rolled in hills, sound could be heard in community. Cracked cement

*Cantil*.—Felt by all. Rattled windows, doors, and dishes. Trees and bushes moderately shaken. Shifted small objects and furnishings. Cracked plaster. Slight damage to masonry and concrete

*Inyokern*.—Felt by and awakened all, frightened many. Rattled windows, doors, and dishes. Hanging objects swung. Trees and bushes moderately shaken. Shifted small objects and furnishings. Small crack in road about 2 miles north of Walker Pass.

*Isabella*.—Felt by, awakened, and frightened all. Earth seemed to have almost a continuous movement with intermittent large quakes from 05:20 to 08:10. Rocker arms on Fairview Bridge showed considerable movement; the rocker arm on the east side moved 1 inch, the rocker arm on the west side moved a complete turn.

*Johnsontdale*.—Felt by and awakened all. Rattled windows, doors, and dishes violently. Trees and bushes moderately shaken. Shifted small objects and broke dishes.

*Kernville*.—Awakened all and frightened many. Rattled windows, doors, and dishes. Walls creaked. Hanging objects swung. Overturned small objects.

*Little Lake*.—Felt by and awakened all. Walls creaked. Overturned small objects. Cracked windows and walls. Slight damage to concrete. Aqueduct showed many cracks.

*Lone Pine*.—Felt by several in house trailer. Slight damage to plaster and concrete. Trees and bushes moderately shaken. Rattled windows, doors, and dishes. Hanging objects swung.

*Mojave*.—Three shocks felt very strongly. Rattled windows, doors, and dishes. Shifted small objects and overturned vases. Felt by 3 people at ranch 7 miles south of Mojave. Dull rumbling sound heard before and during second shock. Window pane cracked.

*Newhall*.—Awakened many. Houses creaked. Hanging objects and doors swung. Cracked plaster. One half-inch water pipe broke.

*Olancho*.—Felt by and awakened all. Rattled windows, doors, and dishes. Hanging objects swung. Slight plaster cracks.

*Porterville*.—Felt by, awakened, and frightened many in hotel. Rattled windows and shifted small objects. Cracked plaster. Trees and bushes slightly shaken.

*Ridgecrest*.—Felt by and awakened all. Rattled windows, doors, and dishes. Hanging objects swung. Cracked plaster and cement floor.

*Roads End*.—Awakened and frightened all. Rattled windows, doors, and dishes violently. Hanging objects swung northeast. Overturned small objects. Big rumble when quakes came.

*San Bernardino*.—Felt by and frightened many. Pendulum clocks stopped. Cracked plaster. Overturned small objects.

*Searles Valley*.—Felt by, awakened, and frightened many. Rattled windows, doors, and dishes. Houses creaked. Cracked plaster.

*Shafter*.—Two strongest shocks awakened and frightened many. Rattled windows, doors, and dishes. Trees and bushes slightly shaken. Cracked plaster.

*Springville*.—Felt by and awakened all. Rattled windows, doors, and dishes. Shifted small objects, overturned knickknacks. Hanging objects swung.

*Sultana*.—Felt by and awakened many. Rattled windows. Shifted small objects and furnishings. Hanging objects swung.

*Tehachapi*.—Felt by, awakened, and frightened all. Rattled windows, doors, and dishes strongly. Houses creaked. Shifted small objects. Noticeable plaster cracks. Food in glass jars fell from shelves.

*Trona*.—Felt by all. Loose objects rattled and buildings creaked. Moderate rumbling at beginning. Visible swaying of buildings and trees. Minor plaster cracks. Dishes fell from shelves and water splashed from fish bowls.

*Tulare*.—Felt by all. Rattled windows, doors, and dishes. Hanging objects swung. One chimney cracked.

*Visalia*.—Felt by and awakened all. Rattled windows, doors, and dishes. Pendulum clocks stopped. Trees and bushes moderately shaken. Cracked plaster.

## INTENSITY V:

Acton, Arvin, Big Pine, Burbank, Buttonwillow, Caliente, California Hot Springs, Cartago, Castaic, Chowchilla, Coso Junction, Darwin, Death Valley, Earlimart, Fellows, Frazier Park, Fresno and vicinity, Friant, Fulton Ranger Station, Grapevine, Groveland, Hanford, Incline, Keller, Lake Hughes, Lemoncove, Long Barn, Los Alamos, Los Angeles, Lost Hills, Maywood, McFarland, Miramonte, Nipennawasse, Owenyo, Oxnard, Port Hueneme, Posey, Raisin, Rosamond, Saltdale, Sanger, Santa Barbara, Sepulveda, Shoshone, Stratford, Taft, Tecopa, Tinemaha Dam, Valyermo, Westhaven, Wheeler Ridge, Wildomar, and Yosemite National Park.

## INTENSITY IV:

Academy, Adelanto, Aguanga, Ahwahnee, Alhambra, Altadena, Amboy, Arroyo Grande, Artesia, Auberry, Baldwin Park, Barstow, Bass Lake, Beaumont, Ben Hur, Beverly Hills, Big Bear City, Bishop, Bonsall, Cabazon, Camanche, Camp Baldy, Caruthers, Casmalia, Cedar Glen, Coleville,

Compton, Corcoran, Corona, Coulterville, Covina, Cow Creek, Cuyama, Daggett, El Monte, El Nido, El Portal, El Segundo, Etiwanda, Fairmont, Fawnskin, Fillmore, Firebaugh, Fullerton, Glendale, Glendora, Glennville, Helm, Hermosa Beach, Highland, Hinkley, Hondo, Huntington Park, Huron, Independence, Indio, Inglewood, Kettleman City, Knights Ferry, Lake Arrowhead, Lancaster, Laws, Le Grand, Lemoore, Lindsay, Long Beach, Los Alamitos, Los Olivos, Lucerne Valley, Ludlow, Mariposa, McKittrick, Mendota, Monrovia, Montalvo, Moreno, Mount Wilson, Muroc, Newberry, Northfork, North Hollywood, North Long Beach, Oilfields, Ojai, O'Neals, Orange, Orange Cove, Palm City, Palm Springs, Pasadena, Patterson, Pinedale, Pineridge, Piru, Planada, Pond, Randsburg, Reedley, Riverside, Rosemead, San Diego, Sandberg, San Gabriel, Sanger, San Joaquin, San Miguel, San Pedro, Santa Ana, Santa Fe Springs, Santa Margarita, Santa Paula, Santa Ynez, Seven Oaks, Sierra Madre, Simi, Snelling, Sonora, South Gate, Terra Bella, Turlock, Twentynine Palms, Venice, Ventucopa, Ventura, Walnut, Wasco, Whittier, Wishon, Woodlake, and Wrightwood.

#### INTENSITY I TO III:

Angiola, Anza, Baker, Bartlett, Bridgeport, Cambria, Coachella, Coalinga, Colton, Culver City, Eagle Rock, Elsinore, El Toro, Encino, Forest Home, Goleta, Hemet, Knowles, Littlerock, Mecca, Morongo Valley, Newman, Oceano, Ontario, Palos Verdes Estates, Paso Robles, Placentia, Pomona, Redlands, Romoland, San Dimas, Santa Maria, Shandon, Thousand Palms, Torrance, Tranquillity, and Upland.

Negative reports were received from 85 places.

**March 15:** 21:49:23.\* Epicenter 33°57' north, 118°17' west, P. Southeast of Inglewood. Light shock distinctly felt without damage at Hawthorne, Los Angeles, Manhattan Beach, Maywood, and Venice.

**March 16:** 01:46:19\* and 01:58. Epicenter 34°44' north, 118°02.5' west, P. North of Walker Pass. Felt lightly at Los Angeles and Bakersfield.

**March 16:** 02:10, 08:05, and 08:06. Kernville. Felt generally without damage.

**March 16:** 02:20, 03:15, and 22:04:15\* P. Trona. Many awakened.

**March 16-17:** 23:30 and 01:00. Quincy. "A series of three earth shocks of brief but severe intensity was reported to have rocked homes in Quincy and the Feather River region. Residents reported feeling two shocks in quick succession about 11:40 p. m., P. S. T., on the 16th, and another shock about 1 a. m. on the 17th, all strong enough to shake buildings." (SSA Bulletin, April 1946.)

**March 17:** 00:17:02\* P. Trona. Mild shock

**March 17:** 06:45:56.\* Epicenter 38.3° north, 118.2° west, W. Southwest of Hawthorne, Nev. Felt over approximately 12,000 square miles in a sparsely inhabited region. Maximum intensity V reported from Luning. All other reports indicate a moderate shock. Felt in California at Bridgeport, Coleville, El Portal, June Lake, Kyburz, Laws, Leevining, and Yosemite National Park; and in Nevada at Carson City, Fallon, Hawthorne, Mina, Minden, Schurz, Smith, Smokey Valley, Tonopah, Wellington, Wabuska, and Yerington.

Negative reports were received from 7 places in California and 5 places in Nevada.

A strong-motion record was obtained from the accelerograph at Hawthorne.

**March 18:** 02:05:54.\* Epicenter 35.7° north, 118.0° west, P. North of Walker Pass. Felt slightly at McKittrick (Olig pump station).

**March 18:** 07:49:27\* and 07:50:43.\* Epicenter 35.7° north, 118.0° west, P. North of Walker Pass.

#### INTENSITY VI:

*Brown.*—Felt by and awakened all. Rattled windows. Trees and bushes moderately shaken. Knickknacks fell.

*Los Angeles.*—Two sharp shocks in Sand Canyon sent deluge of huge boulders down mountainside in area of Los Angeles aqueduct.

*Trona.*—Strong swaying motion. Rattled dishes and loose objects.

*Weldon.*—Felt by all. Rattled windows, doors, and dishes. Hanging objects swung. Trees and bushes moderately shaken. Shifted small objects.

#### INTENSITY V:

Coso Junction, Ducor, Little Lake, and Muroc.

#### INTENSITY IV:

Acton, Adelanto, Bodfish, Cantil, Darwin, Fawnskin, Friant, Hobo Hot Springs, Lebec, McFarland, McKittrick, Oildale, Porterville, Red Mountain, Saltdale, Wrightwood, and Yosemite.

#### INTENSITY I TO III:

Lake Arrowhead, Lake Hughes, Ludlow, and Santa Maria.

Negative reports were received from 21 places.

**March 26:** 00:38. Little Lake, 12 miles south of. Slight shock felt by several.

**March 27:** 08:30 (about). San Martin. Slight shock felt by several. Walls creaked.

**March 29:** 02:40:17.\* Epicenter 37°51' north, 121°59' west, B. Berkeley region. Moderate shock felt at Berkeley, Canyon, Lafayette, Martinez, Oakland, and San Francisco.

Negative reports were received from 27 places.

**March 29:** 03:58. Epicenter 40.9° north, 121.7° west, B. Shasta County. Light shock felt at Cassel and Fall River Mills.

**April 1-30:** Epicenter 35.7° north, 118.0° west, P. Aftershocks of March 15 earthquake. During April, 53 after shocks were either felt at the Sand Canyon or Nine Mile aqueduct stations or recorded at one or more stations of the Pasadena Seismological Laboratory.

**April 9:** 07:16:07.\* Epicenter 34°20' north, 118°41' west, P. Prairie Fork, San Gabriel River. Slight shock felt by several in Big Pine recreation area.

**April 9:** 21:16. Hollister, 7½ miles south of. Very slight shock felt by several.

**April 17:** 05:34\* P. San Martin and Watsonville. Many awakened in both towns. Recorded at Tinemaha.

**April 19:** 04:50. Santa Maria. Very slight shock. Felt.

**April 19:** 07:55:13.\* Epicenter 33°53' north, 117°18' west, P. Near Box Springs. Felt lightly at Riverside and Perris. Rocks broke loose and tumbled down slopes at Box Springs repeater station.

**April 19:** 13:00 (about). Laytonville. Felt by several.

**April 21:** 23:42.\* Epicenter 37°42' north, 121°29' west, B. South of Hollister. One quick jerk, very short. Felt by several in Vernalis.

**April 25:** 03:50. Watsonville. Shock of momentary duration awakened many in community.

**April 25:** 13:50:40.\* Epicenter, 37°33' north, 121°55' west, B. Near Santa Clara. Felt over an area of approximately 400 square miles, mainly in western Alameda County. Maximum intensity VI reported from two places; all other reports indicate a moderate shock.

#### INTENSITY VI:

*Milpitas.*—Felt by many. Rattled windows. Walls creaked and plaster was cracked.

*Pleasanton.*—Felt by many. Rattled windows. Trees and bushes moderately shaken. Water line on main street was broken.

#### INTENSITY V:

Alviso, Agnew, Mission San Jose, Moraga, Newark, and Newark substation.

#### INTENSITY IV:

Centerville, Hayward, Irvington, Niles, San Lorenzo, Sunol, and Warm Springs.

#### INTENSITY I TO III:

Alvarado, Mount Eden, Oakland, and San Leandro.

Negative reports were received from 18 places.

**April 29–May 4:** Childs Meadows, Manzanita Lake, and Mineral. A series of at least 12 shocks were felt by many. Windows and loose objects rattled. Trees and bushes slightly shaken.

**May 1:** 17:26:16.\* Epicenter 37°41' north, 121°33' west, B. Felt over an area of approximately 3,000 square miles in west-central California. Tracy felt shock more than other localities.

Strong-motion records were obtained from the accelerographs in San Francisco, Oakland, and San Jose.

#### INTENSITY VI:

*Tracy.*—Felt by all. Rattled windows, doors, and dishes. Hanging objects swung north-south. Shifted articles on shelves. Some plaster cracked.

#### INTENSITY V:

Byron and Moraga.

#### INTENSITY IV:

Agnew, Alma, Decoto, Diablo, Isleton, Irvington, Lafayette, Lathrop, Livermore, Mission San Jose, Mount Eden, Niles, Pinole, Pleasanton, Ripon, San Gregorio, San Lorenzo, San Francisco, and Sunol.

#### INTENSITY I TO III:

Ben Lomond, Berkeley, Brentwood, Canyon, Cresta Blanca, Cupertino, Manteca, Milpitas, Modesto, Oakdale, Oakland, Orinda, Pescadero, Redwood City, Sacramento, St. Mary's College, San Bruno, San Ramon, Stockton, and Vernalis.

Negative reports were received from 44 places.

**May 3–31.** Epicenter 35.7° north, 118.0° west, P. Aftershocks of March 15 earthquake. During May 20, aftershocks were either felt at the Sand Canyon or Nine Mile aqueduct stations or recorded at one or more stations of the Pasadena Seismological Laboratory.

**May 8:** 16:13:59.\* Epicenter 33°53' north, 117°18' west, P. Near Box Springs. Aftershock of April 19 shock. Felt distinctly at Riverside and Tenaja Guard Station.

**May 12:** 10:19:05.\* Epicenter 33°53' north, 117°18' west, P. Near Box Springs. Felt slightly at Riverside.

**May 12:** 17:16:57.\* Epicenter 36°03' north, 117°55' west, P. Felt at Haiwee.

**May 12:** 17:18:33.\* Epicenter 36°03' north, 117°55' west, P. Felt at Haiwee.

**May 13:** 16:28:30.\* Epicenter 37°20' north, 118°50' west, P. West of Bishop. Felt at Laws.

**May 17:** 19:55:00.\* Epicenter 37°22' north, 118°50' west, P. West of Bishop. Felt slightly at Laws.

**May 19:** 17:51:13.\* Epicenter 33°57' north, 118°09' west, P. Northwest of Downey. Slight earthquakes felt at Alhambra, Los Angeles, Pasadena, and South Gate.

Negative reports were received from 9 places.

**May 20:** 21:36:4.\* Epicenter 35.9° north, 118.5° west, P. Upper Kern River. Felt by many at Kern River powerhouse No. 3. Rattled windows and doors.

**May 22:** 11:01:53.\* Epicenter 36°08' north, 117°57' west, P. Very near Haiwee. Felt slightly at Haiwee aqueduct station.

**May 28:** 21:58.\* Epicenter about 10 miles southeast of University of California, B. Felt over a small area in East Bay region. Maximum intensity V reported from Moraga.

Strong-motion records were obtained from the accelerographs in the Southern Pacific Building, San Francisco.

#### INTENSITY IV:

Alameda, Albany, Berkeley, Canyon, Hayward, Oakland, Piedmont, Rodeo, and Walnut Creek.

#### INTENSITY I TO III:

Lafayette, Mount Eden, and Pinole.

Negative reports were received from 16 places.

**May 29:** 09:51.\* Epicenter 36°48' north 121°34' west, B. Near Hollister. Felt over very small area inland from the Monterey Bay region. Maximum intensity V reported from one locality a few miles south of Hollister where many were frightened and small objects were shifted.

A record was obtained from the Weed instrument in Hollister.

#### INTENSITY IV:

Hollister, San Juan Bautista, and San Martin.

#### INTENSITY I TO III:

Salinas and Watsonville.

Negative reports were received from 11 places.

**June 1:** 03:06:31.\* Epicenter 34°25' north, 118°50' west, P. Near Fillmore. Felt in San Pedro, Hollywood, Los Angeles, and more strongly (intensity about IV) at Camarillo.

**June 2-29:** Epicenter 35.7° north, 118.0° west, P. Aftershocks of March 15 earthquake. During June, 20 aftershocks were either felt at the Sand Canyon or Nine Mile aqueduct stations or recorded at one or more stations of the Pasadena Seismological Laboratory.

**June 4:** 03:55. Desert Center, 15 miles west of. Slight shock awakened two. Rattled light fixtures.

**June 4:** 04:05:24.\* Epicenter 33°55' north, 115°42' west, P. Pinto Basin, Little San Bernardino Mountains. Felt by several in Needles. Hanging objects swung.

**June 5:** 13:59:36.\* Epicenter 35°35' north, 118°20' west, P. Near Weldon. No damage. Felt distinctly at Borel powerhouse, Kern River powerhouse No. 3, Kernville, and Nine Mile aqueduct station.

**June 5:** 16:04:44.\* Epicenter 35°35' north, 118°20' west, P. Near Weldon. Felt distinctly at Borel powerhouse and felt lightly at Nine Mile, Jawbone, and Sand Canyon aqueduct stations.

**June 6:** 22:51. Jawbone aqueduct station. Slight shock felt.

**June 13:** 17:26\* P. Kern County. Trembling motion felt by two at Kern River powerhouse No. 1. Recorded at Tinemaha.

**June 13-14:** 22:56 to 07:30. Mineral. Series of about 20 mild shocks. Disturbed objects observed by several. Very slight movement of buildings. Pull chains of lights swung east-west. Distant, thunderous sounds heard immediately before shocks.

**June 15:** 11:46:53.\* Epicenter 32°36' north, 116°19' west, P. Near Hipass. Maximum intensity V reported from Hipass. Also felt at Alpine, Barrett Dam, Descanso, Jacumba, Julian, and San Diego. Small objects shifted. Lighting fixtures swung. Windows and dishes rattled.

**June 23:** 21:25. Mineral. Mild shock felt by several. Rattled windows, doors, and dishes.

**June 24-25:** 12:25, 18:14, and 05:18. Pasadena region. Three local tremors, all within 50 miles of Pasadena, were recorded at the California Institute of Technology within a 24-hour period, but there were no reports of any damage. The tremors were at 12:25 and 6:14 p. m., P. S. T., June 24, and at 5:18 a. m., June 25. (SSA Bulletin, October 1946.)

**June 26:** 19:16:35.\* Epicenter 33°53' north, 117°18' west, P. Near Box Springs. Short sharp shock rattled windows in Perris and Riverside. Felt by many and frightened children.

**June 29:** 21:22:18.\* Epicenter 34°02' north, 118°18' west, P. Los Angeles. Mild temor reported by residents of Beverly Hills, Culver City, Hawthorne, Inglewood, and Lawndale.

Negative reports were received from 12 places.

**July 1:** 23:28:35.\* Epicenter 34°06' north, 117°46' west, P. Near Pomona. Apparently a strictly local earthquake felt by hundreds of Claremont and Pomona residents but not reported outside the Pomona Valley region. A single, sharp jolt was felt by many and awakened many others. Claremont residents reported a very slight shock the following morning at 06:50.

**July 5:** 18:15. Sand Canyon aqueduct station. Mild shock.

**July 6:** 22:55.\* Epicenter near 40.5° north, 121.5° west, B. Lassen National Park. Felt over an area of approximately 7,000 square miles in northern California. Maximum intensity VI reported from Mill Creek, Mineral, and the Lassen National Park area, where small objects fell and canned goods were shaken from shelves.

#### INTENSITY VI:

*Mill Creek.*— Felt by and awakened all. Rattled windows, doors, and dishes. Hanging objects swung. Trees and bushes moderately shaken. Knickknacks and books fell.

*Mineral.*— Felt by and awakened all. Hanging objects swung. Overturned a few vases, some dishes fell.

## INTENSITY V:

Caribou and Grass Valley.

## INTENSITY I TO IV:

Chester, Chico, Deer Creek, Dutch Flat, Emigrant Gap, Gridley, Inwood, Las Plumas, Marysville, Milford, Oroville, Paradise, Portola, Quincy, Redding, Storrie, and Susanville.

Negative reports were received from 35 places.

**July 6:** 23:32:00.\* Epicenter 35.7° north, 118.0° west, P. Near Walker Pass. Mild shock felt at Sand Canyon Aqueduct Station.

**July 8:** 04:04. Mineral. Felt by and awakened many. Rattled windows and doors. Very slight shock felt in Caribou.

**July 8:** 19:19:01.\* Epicenter 35°40' north, 118°04' west, P. Near Walker Pass. Felt at Nine Mile and Sand Canyon aqueduct stations.

**July 13:** 04:00:33.\* Epicenter 35.7° north, 117.6° west, P. East of Inyokern. Felt at Sand Canyon aqueduct station.

**July 17:** 08:38:02.\* Epicenter 35°41' north, 117°35' west, P. East of Inyokern. Felt slightly at Nine Mile and Sand Canyon aqueduct stations.

**July 17:** 21:02:02.\* Epicenter 35°42' north, 117°41' west, P. East of Inyokern. Felt slightly at Jawbone aqueduct station.

**July 18:** 06:27:58.\* Epicenter 34°32' north, 115°59' west, P. West of Bagdad. Felt over an area of approximately 27,000 square miles in southern California. Maximum intensity VI reported from Yucca Valley, near White Water, where small objects shifted and knickknacks fell.

## INTENSITY V:

Amboy, Baker, Forest Home, Rice, and Twentynine Palms.

## INTENSITY IV:

Acton, Atwood, Beaumont, Big Bear City, Blythe, Chubbuck, Daggett, Desert Center, Essex, Etiwanda, Glendora, Hinkley, Idyllwild, Indio, Ivanpah, Lake Arrowhead, Lucerne Valley, Ludlow, Maywood, Mecca, Needles, Newberry, Palm Springs, Redlands, Romoland, San Bernardino, San Jacinto, Santa Ana, Seven Oaks, Thousand Palms, Trona, Van Nuys, Victorville, Vidal, and Wildomar.

## INTENSITY I TO III:

Anza, Artesia, Boron, Cabazon, Castaic, Coachella, Corona, Elsinore, Fall Brook, Hesperia, Jawbone Aqueduct Station, Kelso, Lake Hughes, Niland, Pasadena, Pomona, Riverside, San Clemente, San Juan Capistrano, and Upland.

Negative reports were received from 42 places.

**July 9:** 18:05. Sand Canyon aqueduct station. Mild shock.

**July 20:** 06:33. Nine Mile aqueduct station. Slight shock.

**July 22:** 07:19:33.\* Epicenter 35°44' north, 118°02' west, P. Near Walker Pass. Felt at Haiwee powerhouse and Freeman, Little Lake, Nine Mile, and Sand Canyon aqueduct stations.

**July 23:** 03:25:58.\* Epicenter 35°50' north, 118°00' west, P. Near Walker Pass. Shook house rather severely at Nine Mile aqueduct station.

**July 23:** 16:19:08.\* Epicenter 35°06' north, 119°05' west, P. North of Wheeler Ridge. Felt slightly at Taft.

**July 27:** 21:14:11.\* Epicenter 35°40' north, 117°50' west, P. Near Inyokern. Felt by several at Kern River powerhouse No. 3.

**August 2:** 20:00 (about). Eureka. "An earthquake which swayed light fixtures in Eureka homes shortly after 10 p. m., P. S. T., was registered on the University of California seismograph at Ferndale. It was classed as 'very slight' and its origin was estimated as about 20 miles north of the station." (SSA Bulletin, October 1946.)

**August 4:** 20:08.\* Epicenter, 36°53' north, 121°36' west, B. On San Andreas Fault near Alma and Los Gatos. Felt at Alviso, Aptos, Los Gatos, San Francisco, San Gregorio, and Watsonville.

**August 5:** 20:55:07.\* Epicenter 34°57' north, 120°11' west, P. East of Santa Maria. Slightly felt at Los Alamos.

**August 8:** 12:13\* B. Scotia and Upper Mattole. Very slight shock felt by observer.

**August 11:** 15:46. Kern River powerhouse No. 1. Slight shock felt by several.

**August 14:** 14:01\* B. San Francisco Bay area. Entire area trembled slightly during 45-second earthquake. No damage reported although it was particularly felt in the East Bay region where dishes and pans were shaken. Residents of Forest Hill and other areas west of Twin Peaks reported a short, sharp earthquake accompanied by a rumbling noise. The shock was also felt at Lafayette, Oakland, and Rockaway Beach.

**August 19:** 02:20. Markleeville, 5 miles south of. Slight shock felt by several.

**August 27:** 21:47:33.\* Epicenter 35°44' north, 118°12' west, P. Near Walker Pass. Felt by several at Kern River powerhouse No. 1 (Kern Canyon), and Kern River powerhouse No. 3 (near Kernville).

**August 31:** 01:15.\* Epicenter 35°37' north, 118°00' west, P. South of Walker Pass. Awakened many at Kernville and Tehachapi. Also felt by several at Kern River powerhouse No. 1.

**September 2:** 07:26\* P. Trona. Slight shock felt. Buildings creaked and loose objects rattled.

**September 9:** 03:20. Santa Maria. Slight shock felt by many. Also felt at Orcutt pump house (near Santa Maria).

**September 13:** 08:13:07.\* Epicenter 35°36' north, 117°40' west, P. East of Inyokern. Felt by several at Cantil. Rattled windows, doors, and dishes.

**September 27:** 23:19:09.\* Epicenter 33°57' north, 116°51' west, P. North of Beaumont. Felt over an area of approximately 9,000 square miles in southern California. Maximum intensity VI reported from several places, where slight damaged occurred.

#### INTENSITY VI:

*Banning.*—Felt by all and awakened many. Hanging objects swung north. Cracked plaster and overturned vases. Rattled windows, doors, and dishes. Those awake reported hearing the shock before feeling it.

*Cabazon.*—Felt by all. Cracked plaster and shifted small objects and furnishings. Knickknacks fell. Damage slight.

*Cathedral City.*—Felt by all. Overturned small objects. Rattled windows, doors, and dishes. Damage slight.

*Palm Springs.*—Felt by many. Hanging objects swung north. Cracked plaster. Trees and bushes slightly shaken. Shifted small objects. Damage slight.

#### INTENSITY V:

Aguanga, Beaumont, Fall Brook, Fawnskin, Forest Home, Hayfield Reservoir, Idyllwild, Mentone, Riverside, and White Water.

#### INTENSITY IV:

Altadena, Anaheim, Anza, Burbank, Calimesa, Coachella, Colton, Corona, Desert Center, Elsinore, Etiwanda, Hemet, Huntington Beach, Laguna Beach, La Habra, Mill Creek Canyon, Mountain Center, Norco, Perris, Pomona, Romoland, Rosemead, San Bernardino, San Dimas, San Jacinto, South Gate, Thousand Palms, Walnut, and Wildomar.

#### INTENSITY I TO III:

Balboa, Lakeview, La Mirada, Newport Beach, Redlands, San Diego, Santa Ana, Twentynine Palms, Victorville, and Warner Springs.

Negative reports were received from 50 places.

**October 1:** 11:23. San Jose. "A light earthquake felt in San Jose at 11:23 a. m., P. S. T., was recorded on the University of Santa Clara seismograph. There was no damage." (SSA Bulletin, October 1946).

**October 28.:** 14:02:38\* and 14:27:21.\* Epicenter 33°25' north, 116°54' west, P. North of Palomar Mountain. Two shocks of rapid motion; first was the larger.

**October 30:** 12:10. Canyon. Very slight shock felt.

**November 9:** 21:12:12.\* Epicenter 33°14' north, 116°32' west, P. Near Warner Springs. Felt at Borego Valley. Buildings creaked and loose objects rattled. Rumbling subterranean sounds heard before and after shock.

**November 19:** 18:08. Near Bakersfield. Felt by several at Kern River powerhouse No. 1.

**November 23:** 17:02. Eureka. Felt by many. Buildings creaked and loose objects rattled. Disturbed objects observed by many. One crack reported in a new sidewalk at Arcata.

**November 24:** 23:20. Hollister. Felt by all. Rattled windows, doors, and dishes. Walls creaked.

**November 27:** 06:44:51.\* Epicenter 35°30' north, 120°55' west, P. Near Cayucos. Awakened many at Morro Bay and Santa Margarita. Hanging objects swung, pendulum clock stopped. Trees and bushes moderately shaken. Also felt at Atascadero, Los Alamos, Pismo Beach, and San Luis Obispo.

**December 8:** 20:45. Bakersfield. Felt by several in a Kern Canyon powerhouse.

**December 18:** 06:21.\* Epicenter 40.3° north, 124.5° west, B. Northern California. Felt over an area of approximately 3,500 square miles in the coastal region. Maximum intensity VI reported from Ferndale and Capetown, near Cape Mendocino, where knickknacks, books, and pictures fell. Eureka press reports indicated the shock was the heaviest felt there since 1932.

Strong-motion records were obtained from the accelerographs located at Eureka and Ferndale.

#### INTENSITY V:

Arcata, Blue Lake, Eureka, Fields Landing, Fortuna, Honeydew, Pepperwood, Petrolia, Shelter Cove, and Upper Mattole.

#### INTENSITY IV:

Benbow, Briceland, Bridgeville, Burnt Ranch, Colusa, Cape Mendocino Light Station, Dyerville, Eftersburg, Fort Bragg, Garberville, Kneeland, Miranda, Orick, Orleans, Punta Gorda Light Station, Piercy, Redding, Rockport, Scotia, Trinidad, Trinity Center, and Westport.

#### INTENSITY I TO III:

Denny, Hoopa, and Laytonville.

Negative reports were received from 25 places.

**December 20:** 20:25. Eureka. Very light shock felt by several.

**December 22:** 12:17:41.\* Epicenter 33°58' north, 118°14' west, P. Near Huntington Park. A very small shock rocked the southwestern section of Los Angeles. No damage reported.

**December 23:** 17:40. San Jose. Two shocks felt by many. Buildings creaked and loose objects rattled. Building walls swayed.

**December 25:** 21:28:01.\* Epicenter 35.7° north, 118.0° west, P. Felt at Grand Canyon aqueduct station. Windows rattled and walls creaked.

**December 26:** 23:06:23.\* Epicenter 37.6° north, 118.8° west, P. Northern Owens Valley. Awakened all at Long Valley Reservoir. Rattled doors and dishes.

#### WASHINGTON AND OREGON

(120TH MERIDIAN OR PACIFIC STANDARD TIME)

**February 5:** 08:12.5\* BC. Ardenvoir and Chelan, Wash. Light shock felt by many at Ardenvoir, rattled dishes at Chelan. At Entiat the 3-second shock resembled an explosion and was felt by many.

**February 5:** 19:20. Marblemount, Wash. Light shock of about 30 seconds' duration. Felt by many. Rattled windows, doors, and dishes.

**February 6:** 02:11. Sedro-Woolley, Wash. Moderate shock awakened many. Sounded like black powder blast underground.

**February 14:** 19:17:47.\* Epicenter near 47.3° north, 122.9° west, W. This shock reached intensities VI and VII at many places in the Puget Sound area and was felt over about 70,000 square miles. The estimated magnitude was 5 $\frac{3}{4}$ . A few deaths were charged indirectly to the shock, and damage was estimated at \$250,000, most of it occurring in Seattle. A survey of the affected area was made by representatives of the United States Coast and Geodetic Survey and the University of Washington. The instrumental data, as well as the intensity distribution, indicated some depth of focus—of the order of 25 kilometers or more. A unique circumstance is found in the fact that the epicenter lies on the line of zero gravity anomaly in an area showing one of the sharpest gradients in the country. To the north and east of this line there is a negative anomaly of 93 milligals; to the southwest there is a positive anomaly of 33 milligals. The epicenter presumably lies along the line of greatest stress since it is almost on a line between the extreme anomalies.

At Shelton an observer reported the shock as the worst in his 56 years in the state. The absence of a zone of high intensity in the sparsely settled epicentral area is indicative of a deep focus, but not necessarily beneath the continental layers.

#### INTENSITY VII:

*Olympia.*—At the Olympia Hotel about 80 feet of cornice or "fire wall," 2 feet high, was knocked off the north wall; otherwise there were only a few plaster cracks inside the building. Many of the buildings in the statehouse group showed small plaster cracks, but there was no structural damage. There were rather frequent cases throughout the city of plaster cracks, fallen knieckknacks, and overturning of unstable objects. The populace was generally frightened.

*Seattle.*—Damage in Seattle was marked by a few spectacular cases which tend to give a false impression of the general severity of the shock. Except for these cases, cracking of plaster in either residences or buildings was rare, as were reports of broken windows and chimneys. The worst damage occurred in former tideland where buildings were constructed on pile foundations; yet even there it was spotty and with the exception of the Sears, Roebuck Building the damaged structures were generally old. The outstanding cases were the Sears, Roebuck Building, 2465 Utah Street; Fisher flour mills and grain elevator on Harbor Island; Frye & Co. packing plant, 2203 Airport Way; Seattle Port of Embarkation Building No. 14, 1500 Alaska Way; and the Smith Tower, 42 stories high, Second and Yessler streets.

The Sears, Roebuck Building is a 225-foot long structure, 9 stories high, with a 3-story tower carrying a 15,000-gallon water tank on the eleventh floor level and a 60,000-gallon tank on the twelfth floor. It is of reinforced concrete frame construction with brick veneer walls and pile foundation. Extensive cracking of plaster occurred on all floors; on several floors hollow-tile partitions were cracked; and diagonal cracks appeared in the tower and on the eighth and ninth floors. Considerable damage occurred on the seventh floor from the collapse of shelving loaded with heavy automotive parts. Broken bricks and flashing gave evidence of hammering between the main building and annex of similar construction. Damage was estimated at \$50,000.

At the Fisher flour mill a 50,000-gallon water tank was mounted on top of the 16-story grain elevator No. 3, which is of reinforced concrete and rests on 4,000 40-foot piles. The I-beams supporting the tank were twisted and the tank fell to the roof fracturing the standpipe and flooding the structure. The 40-foot steel tower supporting a similar tank on the 8-story high grain elevator No. 1 was deformed but otherwise withstood the shock.

The Frye & Co. meat packing plant was an old unreinforced brick structure 3 stories high, 140 feet long, and 70 feet wide. The floor joists apparently battered down about 80 feet of the wall 20 feet from the top on one side of the building, and pushed out over a length of 20 feet on the opposite side. Considerable machine-shop equipment was lost when the falling brick crushed a corrugated iron shed housing the shop.

The old Port of Embarkation Building at the edge of the harbor is a 3-story brick structure, 300 feet long by 50 feet wide, built on piles. The building, which was in very poor condition, was abandoned. Daylight showed through the cracks made at all four corners. A heavy safe was thrown 8 feet across the floor during the earthquake, and many filing cases overturned. Expensive ship's instruments were thrown to the floor and damaged.

In the 42-story Smith Tower Building plaster chipped from the walls of the elevator shafts above the twenty-first floor. Only one office on the thirty-second floor suffered from cracked plaster. The press reported some windows broken. During the earthquake the elevator cables were reported to have

hit the sides of the shaft, and the motion of the building badly frightened the few occupants. Observers on the tenth floor of a nearby building reported that the tower appeared to sway through many feet.

In the Marine Hospital and Public Safety Building some plaster was cracked. Both buildings are on high ground. Concrete watertank columns on a cold-storage plant were cracked, exposing the reinforcing steel. Some plaster was reported to have fallen in the 10-story County-City Building. At Salmon Terminal hundreds of cases of salmon were thrown about with some damage, and the setting off of sprinkler systems caused thousands of dollars damage to the contents of two piers. One vessel reported that the swaying motion of the pier to which it was moored was imparted to the ship. In a hospital the beds rolled back and forth. A life-size stone statue toppled from the top of Briscoe Boys School and crashed through a glass conservatory roof. An 8-foot high rock wall with poor foundation

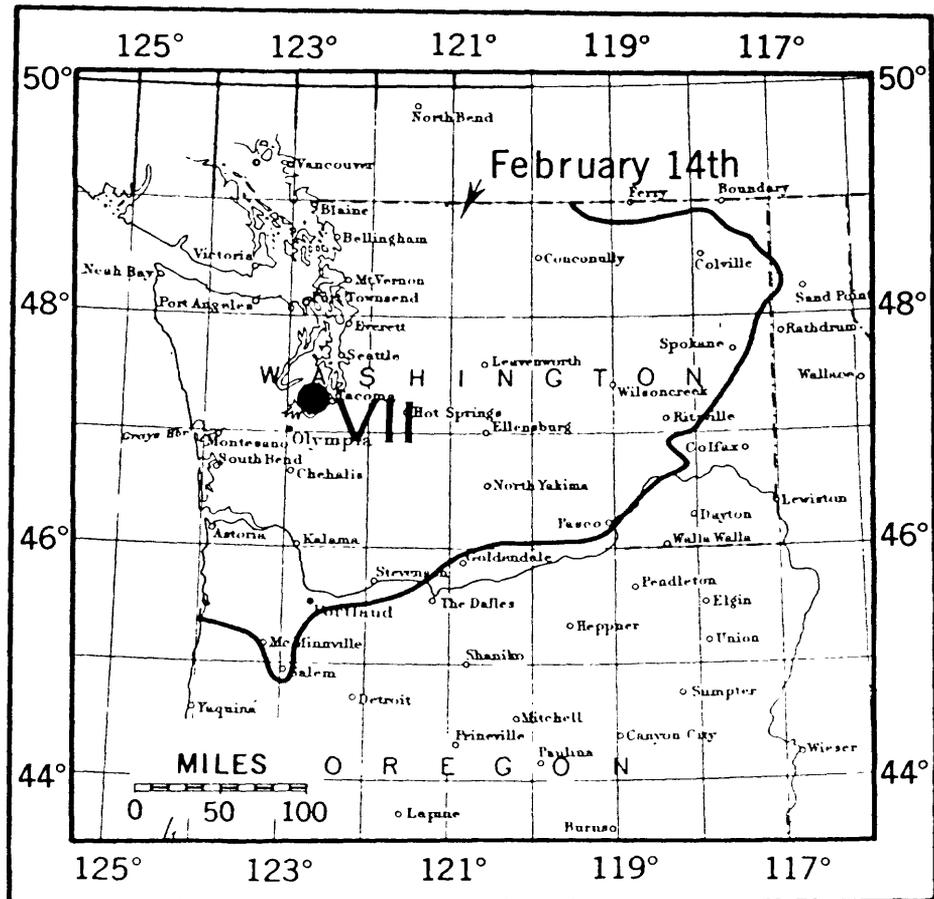


FIGURE 5.—Area affected by the earthquake of February 14.

caved in and one home reported that all the pictures fell from the walls. In the South End a blinding flash was reported from two short-circuited 25,000-volt power lines. Union Lake "boiled and bubbled."

Persons in movies, public gatherings, and diners generally took cognizance of the motion, but there was generally little serious alarm although some persons left movie houses. The most prevailing impression was that the motion was like the passing of a heavy truck. Many reported sounds preceding the shock.

*Tacoma*.—Several old brick chimneys were broken off at the roof line. At a good many places articles fell from shelves and knickknacks were knocked over. People were generally frightened. Many reported that a noise preceded the shock.

#### INTENSITY VI:

*Abandon*.—Felt generally. One outside chimney reported loosened from house. Pendulum clocks stopped.

*Anacortes*.—Some plaster cracked and small objects fell.

*Bohalla*.—Knickknacks fell. Slight damage.

*Burnton*.—"Alert" siren was set off.

*Centralia*.—A few plaster walls and a chimney cracked.  
*Cle Elum*.—Light chimney damage. Hot water tanks swayed.  
*Concrete*.—Some wall plaster cracked. Chairs moved.  
*Dabob*.—Small objects such as pictures and dishes were displaced or knocked down.  
*Darrington*.—Strong shock rattled windows and broke dishes.  
*Eatonville*.—Some plaster fell or cracked.  
*Gig Harbor*.—Cracked plaster. Small objects fell or toppled.  
*Hoodsport*.—Plaster cracked. Damage slight.  
*Index*.—Cracked plaster.  
*La Grande*.—Books and plaster fell.  
*Langley*.—Overturned small objects. Cracked plaster and broke dishes. Slight tremors felt for 15 minutes.  
*Lakebay*.—Chimneys and plaster cracked.  
*Longview*.—Roaring subterranean sounds. Buildings swayed and some plaster cracked.  
*Morton*.—Broke dishes and shook objects from shelves.  
*Mount Vernon*.—Small objects fell and overturned.  
*Nespelem*.—Slightly cracked chimneys.  
*Oakville*.—Many expected houses to collapse. Objects fell southwest. Damage slight.  
*Port Angeles*.—Most severe near water front. Cracked plaster.  
*Port Townsend*.—One store window cracked. Loud rumble heard.  
*Quilcene*.—Cracked plaster and broke dishes. Bell rang.  
*Randle*.—Books and knickknacks fell. Cracked plaster. Sound like wind in trees.  
*Seaback*.—One residence destroyed by fire as result of short circuit.  
*Shelton*.—Many left homes. Loud roaring heard. Plaster cracked.  
*Yakima, 20 miles north of*.—Oil stove overturned in railroad bunkhouse and resulting fire cut telephone trunk line between Yakima and Ellensburg.

## INTENSITY VI IN OREGON:

*Portland*.—Pictures fell and floor lamps toppled. Slight plaster cracks.

## INTENSITY V:

Ardenvoir, Battle Ground, Belfair, Bellingham, Brooklyn, Bumping Lake, Chelan, Chewelah, Coupeville, Ephrata, Everett, Fairfax, Holden, Kosmos, La Conner, Lakeside, Leavenworth, Little-rock, Longmire, Mineral, Monroe, Mud Mountain Dam, Packwood, Port Gamble, Preston, Ravensdale, Renton, Richmond Beach, Skykomish, Snohomish, Snoqualmie, Spirit Lake, Sultan, Toutle, Trinidad, Tumwater, Washougal, Wenatchee, White Salmon, and Winton.

## INTENSITY V IN OREGON:

Bay City, Multnomah, and Veronia.

## INTENSITY IV:

Adna, Ariel, Arlington, Blaine, Buckley, Cathlamet, Carson, Chehalis, Clallam Bay, Clear Lake, Colville, Congor, Coulee City, Deer Park, Diablo, Eastsound, Elbe, Electron, Ellensburg, Elma, Entiat, Forks, Glacier, Grand Coulee Dam, Greenwater, Hartford, Ilwaco, Keechelus Dam, Kalama, Lickitas, Lucerne, Merritt, Mt. Spokane State Park, Mukilteo, Naches, Naselle, Newport, Nooksack, North Head, Ocean Park, Odena, Okanogan, Palmer, Pateros, Point Roberts, Prosser, Puyallup, Quinault, Rock Island, Rockport, Satsop, San Juan County, Sedro-Woolley, Sekiu, Sequim, South Bend, Spokane, Stampede Pass, Twisp, Vancouver, Washtucna, Wellpinit, Winthrop, Yaoclt, and Yakima.

## INTENSITY IV IN OREGON:

Astoria, Hood River, Oswego, Salem, and Willamette.

## INTENSITY I TO III:

Creston, Harrington, Kelso, Laurier, Marietta, Mazama, Mt. Rainier National Park, Pasco, Republic, Valley, and Wilbur.

## INTENSITY I TO III IN OREGON:

Baker, Beaverton, Dayton, Gold Beach, Mollaba, Newberg, Rockaway, St. Helens, and Seaside. Negative reports were received from 34 places in Washington and 18 places in Oregon.

**February 15:** 04:17:15\* and 04:58:36\* BC. Northwestern Washington. Light shocks. The first was felt at Eatonville, Clear Lake, and Randle; both shocks were felt at Gig Harbor, Olympia, and Stampede Pass.

**February 23:** 00:54:53\* BC. Olympia, Wash. Moderate shock felt by several. Small objects moved and loosened plaster fell. Dishes clattered. Felt by many at Lakeview and particularly noticeable in Seattle.

**March 19:** 20:27. Issaquah and Kirkland, Wash. Moderate shock felt by many. Rattled windows, doors, and dishes. Pendulum clocks stopped. Trees and bushes moderately shaken. Also felt at Auburn, North Bend, and Pilehuck Valley.

**June 23:** 09:13:19.\* Epicenter 49.9° north, 125.3° west, in Georgia Strait, British Columbia, by Dominion Observatory, Ottawa, Canada, based on a field study of surface effects. A comprehensive study of seismographic data is being made by the observatory for future publication. This strong earthquake was felt over an area of approximately 55,000 square miles in Washington and

Oregon. See map. In the epicentral area intensity VIII may have exceeded. The bottom of Deep Bay ( $49^{\circ}25.5'$  north,  $124^{\circ}45'$  west) in Georgia Strait was reported by the Canadian Hydrographic Department to have sunk from 9 to 84 feet. There was a 10-foot vertical shift of the ground on Read Island and persistent rumblings were reported by residents. Beaches at the mouths of Cottonwood Creek and Little Shaw Creek sank 100 feet beneath the water. At another point one person was drowned when a small boat was overturned by waves set up by a nearby landslide. Near Campbell River a hillside slid 35 feet, and a house was shifted 5 feet. Waves were reported sweeping in from the sea, flooding fields and highways. Rock slides occurred along the railroad between Port Alberni and Victoria. Fishermen reported muddy water and some bottom changes in bays along the seaward coast of Vancouver Island. The magnitude was rated between 7 and  $7\frac{1}{4}$ . South of the

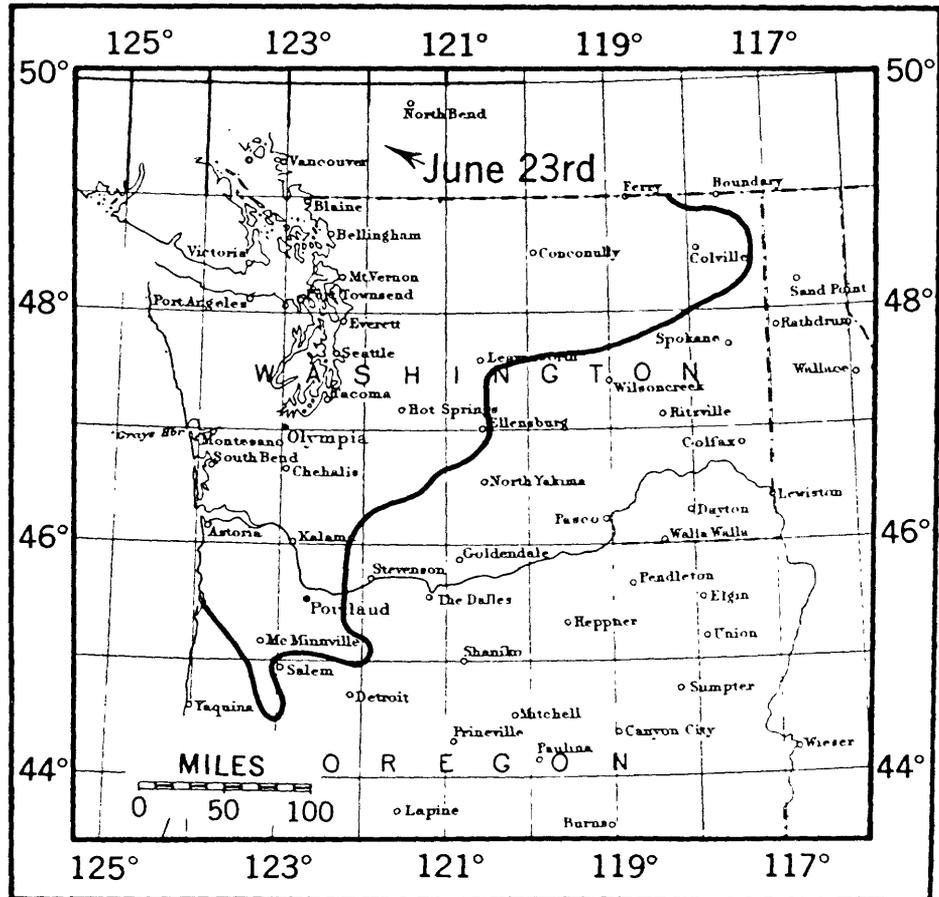


FIGURE 6.—Area affected by the earthquake of June 23.

border a special canvass for information was conducted by the United States Coast and Geodetic Survey in cooperation with the University of Washington.

At Courtenay thousands of dollars of damage was done to the interiors of buildings and many show windows were shattered. A wall was knocked from the post office building and a chimney on a school plunged through two floors. The highway between Courtenay and Comax was badly broken.

In Vancouver cracks appeared in the walls of several downtown buildings and pieces of masonry fell from the Canadian National Railways station. Several chimney fires were started, and in one district power lines were down. Lionsgate Bridge "swayed like a leaf," and a swing-span bridge was knocked open.

At Port Alberni the top of a brick front crashed to the street. At New Westminster bricks were shaken from an old building which was thrown out of alignment. The shock was reported heavy in Vancouver. Changes in terrain and fallen trees were reported in the Matsqui area a few miles north of Lynden.

South of the boundary a 20-foot crack appeared in a glacier on Big Four Mountain in Snohomish County, and at Big Four Inn several layers of rock were shaken from the fireplace and large sections of plaster fell.

## INTENSITY VI:

- Eastsound*.—Some chimneys fell.
- Everett*.—City clock stopped. Swaying power lines caused temporary interruption to service.
- Friday Harbor*.—Pendulum clocks stopped. Trees and bushes strongly shaken. Knickknacks and pictures fell.
- Grapeview*.—Some plaster cracked. Very long duration.
- La Grande*.—Few slight plaster cracks. Subterranean sounds heard during shock.
- Langley*.—Pendulum clocks stopped. Cracked plaster. Overturned small objects.
- Mount Vernon*.—Cracked plaster. Hanging objects swung. Pendulum clocks stopped.
- Northport*.—Houses swayed. Slight damage to buildings.
- Olympia*.—Pendulum clocks stopped. Slight damage to buildings. Cracked windows, and cracks from previous quakes widened in plaster and woodwork.
- Port Angeles*.—Large concrete mill reported distorted. Western Union master clock stopped. Water sloshed from pools and fish ponds.
- Port Townsend*.—Cracked plaster slightly. Pendulum clocks stopped. Slight damage to buildings. Lighting fixtures swung.
- Puyallup*.—Hanging objects swung. Pendulum clocks stopped. Shifted small objects and furnishings. Slight visible swaying of trees and buildings.
- Quinault*.—Shifted small objects and knickknacks. Cracked chimneys. Trees and bushes strongly shaken. Reported quite severe in upper Quinault Valley.
- Seattle*.—Hardest hit in Puget Sound area. In the 42-story Smith Tower Building plaster in upper half of elevator shaft fell on elevator roof. One person suffered a fatal heart attack after seeing the tower sway. Some plaster fell in County-City Building and a few bricks fell from the Sears, Roebuck Building on which the flagpole "whipped as though it would snap." An aquarium built on piles was badly shaken. Many pendulum clocks stopped. Some parts of city reported rumbling noises. A 3½-inch gap appeared between two sections of East Slough Bridge on Snoqualmie Highway. Weights on fill pipes of Standard Oil Co. swung back and forth. Landslides occurred near Glacier Park.
- Sedro-Woolley*.—Some plaster cracked. Pendulum clocks stopped. Water on lake came in light rolling swells from west to east. Moderately loud scraping and rattling subterranean sounds heard.
- Seki*.—Broke dishes. Shifted small objects. Knickknacks fell. Trees and bushes strongly shaken.
- Taloosh Island*.—Walls cracked slightly. Moderate subterranean sounds like distant thunder or cannon fire heard at time of shock. Pendulum clocks stopped. Water overflowed from full water tank. Heavy wrenches on east-west wall fell off nails. Lighthouse tower swayed.
- Tacoma*.—Some cracked walls reported in downtown buildings.

## INTENSITY V:

Blaine, Brooklyn, Camano Island, Carbonado, Carnation, Cle Elum, Colfax, Colville, Concrete, Coupeville, Darrington, Easton, Edmonds, Elma, Enumelaw, Everson, Forks, Glacier, Granite Falls, Hartford, Hoquiam, Kent, Kirkland, La Conner, Littlerock, Longmire, Marietta, Metaline Falls, Mineral, Moelips, Monroe, Neah Bay, Nespelem, North Bend, Nooksack, Olga, Omak, Oroville, Packwood, Point Roberts, Port Gamble, Port Ludlow, Poulsbo, Preston, Quilcene, Ravensdale, Rockport, Sequim, Shelton, Skykomish, Snohomish, Snoqualmie Pass, South Bend, Startup, Stehekin, Sultan, and Winslow.

## INTENSITY V IN OREGON:

Astoria, Hillsboro, Portland, Tillamook, and Vernonia.

## INTENSITY IV:

Adna, Ariel, Auburn, Bothell, Bremerton, Chehalis, Chelan, Chelan Falls, Chewelah, Clearwater, Diablo Dam, Eatonville, Ellensburg, Electron, Fairfax, Greenwater, Holden, Hoodport, Kelso, Lakeside, Leavenworth, Longview, Mazama, North Head, Oakville, Okanogan, Palmer, Port Madison, Possession, Potlatch, Randle, Raymond, Roche Harbor, Satsop, Scenic, Skagit Power Plant, Winthrop, and Woodland.

## INTENSITY IV IN OREGON:

Clatskanie, Corvallis, Multnomah, Rockaway Beach, Sherwood, Timberline Lodge, West Linn, and Willamette.

## INTENSITY I TO III:

Amboy, Conger, Elbe, Grand Coulee Dam, Laurier, Morton, Naselle, Paradise Inn, Pateros, Stampede Pass, Tonasket, Valley, Vancouver, and Vashon.

## INTENSITY I TO III IN OREGON:

Milwaukie and St. Helens.

Negative reports were received from 56 places in Washington and 28 places in Oregon.

**December 27: 08:43.** Thurston County, Wash. Mild earth tremor felt in Olympia and other Thurston County communities. Dishes rattled and houses creaked. One report of picture slightly

displaced in Tacoma. Felt slightly at Baldi, Bremerton, Hoosport, Index, North Bend, Seattle, Shelton, and Startup.

Negative reports were received from 22 places.

#### ALASKA

(150th MERIDIAN OR ALASKAN STANDARD TIME)

**January 12:** 10:26. Anchorage. Felt strongly. Also felt at Cordova.

**March 1:** 21:51. McGrath. Felt by most of population. One quick lurch. Cracks appeared in one chimney.

**March 11:** 01:20. Anchorage. Minor tremor felt by several. Windows rattled.

**April 1:** 01:57. Ketchikan. Light shock felt by two. Rattled doors and windows.

**April 1:** 02:28:58.\* Epicenter  $53\frac{1}{2}^{\circ}$  north,  $163^{\circ}$  west, W. South of Unimak Island, Alaska. Minor damage occurred to Navy buildings a short distance inland from Scotch Cap Lighthouse on the southwest coast of the island. A few minutes after the earthquake a sea wave destroyed the lighthouse and took lives of the five attendants. Effects indicate clearly that the wave reached a height of 90 to 100 feet. Minor wave damage in the Aleutians occurred at Dutch Harbor and at Ikatán Island. Many aftershocks were felt, principally on Ikatán Island. Aftershocks were also reported from Chignik, Cold Bay, Sanak Island, and the Shumagin Islands. The great distances between the instrumental epicenter and the points reporting aftershocks suggests they may not have originated at the point of the main shock.

Tidal-wave effects were disastrous in the Hawaiian Islands where 173 lives were lost and damage was estimated at \$25,000,000. A major portion of the damage occurred at Hilo. The wave was also noted at the Society and Marquesas Islands and at many points on the Pacific shores of North and South America.

Details regarding the effects of this seismic sea wave are given in references listed in the section on Tidal Disturbances of Seismic Origin, page 23.

**April 18:** 16:30. Anchorage. One light shock felt by several.

**June 25:** 20:43. Fairbanks. One light but sharp shock felt by several.

**June 30:** 17:54. Fairbanks. Light shock felt by many. Buildings creaked. Some residents awakened.

**August 28:** 18:01. Anchorage. Sharp shock felt by several. Printing press in operation was thrown out of line, breaking a moving part.

**October 19:** 04:25. Anchorage and Cordova. Light shock felt. Some people at Anchorage reported two shocks.

#### HAWAIIAN ISLANDS

(HAWAIIAN STANDARD TIME)

With the exception of minor activity near Kilauea, no earthquakes were reported in the Hawaiian Islands. Heavy damage occurred as a result of the seismic sea wave caused by the Aleutian Island earthquake of April 1. A brief discussion of the damage and references to special articles appears in the Alaska section of this publication.

#### PUERTO RICO

(60th MERIDIAN TIME)

**June 4:** 18:20. Canovas. Light shock felt.

**August 4:** 13:51. Off northeast coast of Dominican Republic. This shock was destructive over most of the Republic and was felt sharply throughout Puerto Rico and eastward across Mona Passage. Only a few instances of minor damage were reported in Puerto Rico, where the maximum intensity was VI at Comercio Plants, Maricao, and Mona Island in Mona Passage.

#### INTENSITY V:

Adjuntas, Aguirre, Arecibo, Borinquen Field, Cabo Rojo, Cayey, Coloso, Dorado, Dos Bocas, Guayama, Hato Rey, Isabela, Juana Dias, Naguabo, Orocovis, Penuelas, Ponce, Quebradillas, Rio Piedras, Roosevelt Roads, San Lorenzo, St. Isabel, Utuado, Villalba, and Yabucoa.

#### INTENSITY IV:

Barceloneta, Canovanas, Ensenada, Fajardo, Guaynabo, Humacao, Manati, San German, Santa Rita, and Santurce.

No reports received indicated an intensity of less than IV. The north and west coast was most strongly affected.

**October 4:** 10:46. Ponce. Light shock felt by many at local airfield.

#### PANAMA CANAL ZONE

(SIXTIETH MERIDIAN TIME)

**July 12:** 16:05:03.\* Balboa Heights. Slight shock felt, with intensity III.

**December 11:** 0:13:19.\* Balboa Heights. Very little shock felt by a few.

MISCELLANEOUS ACTIVITIES

GEODETIC WORK OF SEISMOLOGICAL INTEREST

From the period May 1945 to March 1946 a series of first-order level lines was run in Los Angeles County, Calif., with intensified development in the vicinity of Terminal Island. There is evidence of settlement in this area, and it is intended that this comprehensive series of leveling will be repeated in future years, and the adjustment for each repeat leveling will be on the same basis. The releveling recently accomplished is now in process of adjustment.

During the spring of 1941 repeat observations were made at about 50 triangulation stations in southern California in the vicinity of El Centro to determine what earth movements occurred because of the earthquake of May 18, 1940. The final adjustment of this work was deferred because of pressure of war activities until recently and has just been completed. The results indicate earth movements of about 10 feet at the fault line east of Calexico, Calif., diminishing as the line approaches Brawley, Calif.

TIDAL DISTURBANCES OF SEISMIC ORIGIN

Seismic sea waves resulted from four earthquakes in 1946. The Aleutian Islands earthquake<sup>1</sup> of April 1 with epicenter at 53½° north, 163° west, produced one of the world's greatest sea waves and an unusually large amount of wave-velocity data. Following studies of this and other sea waves a map was constructed at the Coast and Geodetic Survey showing seismic sea wave travel times to Honolulu. This map is available on request to the Director, United States Coast and Geodetic Survey, Washington 25, D. C. The observed and computed travel times to automatic tide recording gages in east Pacific areas gave excellent agreement. Average difference between computed and observed travel times of the waves was approximately 1 percent based on the best possible epicenter determination. Observed travel times to tide gages were:

	<i>h</i>	<i>m</i>		<i>h</i>	<i>m</i>		<i>h</i>	<i>m</i>
Honolulu.....	4	34	San Francisco.....	5	31	Tolara.....	14	31
Clayoquot.....	4	18	San Luis Obispo Bay..	5	36	Matarani.....	16	26
Neah Bay.....	4	31	Port Hueneme.....	5	54	Antofagasta.....	17	21
Crescent City.....	4	38	La Jolla.....	6	11	Valparaiso.....	18	07

The destructive Dominican Republic shock<sup>2</sup> of August 4 with epicenter at 19¼° north, 69° west, produced a small sea wave which drowned nearly 100 persons in the Matanzas area on the north coast of the island. Observed travel times to tide gages were:

	<i>h</i>	<i>m</i>		<i>h</i>	<i>m</i>
San Juan.....	0	36	Daytona Beach.....	3	59
Bermuda.....	2	07	Atlantic City.....	4	49

The aftershock of August 8 was also accompanied by a sea wave, with the following observed travel times to tide gages:

	<i>h</i>	<i>m</i>		<i>h</i>	<i>m</i>
San Juan.....	0	35	Daytona Beach.....	4	02
Bermuda.....	2	02	Atlantic City.....	4	42

On December 20 an earthquake with epicenter at 33.0° north, 135.6° east, occurred off the south coast of Honshu Island, Japan. A 10-foot sea wave was reported along the eastern shores of Shikoku and Honshu with extensive property damage and a loss of 1,997 lives.

<sup>1</sup> *The Tidal Wave of April 1, 1946*, by H. A. Rowers, Hawaiian Volcano Letter, No. 491, January-March 1946.  
*The Tsunamis of April 1, 1946, in the Hawaiian Islands*, by G. A. Macdonald, F. P. Shepard, and D. C. Cox, Pacific Science Magazine, University of Hawaii, January 1947.  
*Seismic Sea Wave of April 1, 1946*, by E. C. McKay, Transactions of the American Geophysical Union, vol. 27, No. 3, June 1946.  
*Seismic Sea Wave of April 1, 1946, as Recorded on Tide Gages*, by C. K. Green, Transactions of the American Geophysical Union, vol. 27, No. 4, August 1946.  
*Travel Times of Seismic Sea Waves to Honolulu*, by B. D. Zetler, Pacific Science Magazine, University of Hawaii, July 1947.  
<sup>2</sup> *The Dominican Earthquakes of August 1946*, by Joseph J. Lynch, S. J., and Ralph R. Bodle, Bulletin of the Seismological Society of America, vol. 38, No. 1, January 1948.

## SEISMOLOGICAL OBSERVATORY RESULTS

The Coast and Geodetic Survey publishes the results of its teleseismic stations and cooperating stations quarterly in mimeographed form. In these reports 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. These reports will be furnished upon request made to the Director of the Coast and Geodetic Survey.

Instrumental results are published for the following observatories:

<p>Balboa Heights, Canal Zone. (The Panama Canal)</p> <p>Bermuda. (Meteorological Station and International Union Geodesy and Geophysics.)</p> <p>Boulder City, Nev. (Bureau of Reclamation, National Park Service)</p> <p>Bozeman, Mont. (Montana State College)</p> <p>Burlington, Vt. (University of Vermont)</p> <p>Butte, Mont. (Montana School of Mines)</p> <p>Chicago, Ill. (University of Chicago and U. S. Weather Bureau)</p> <p>College, Alaska. (University of Alaska)</p> <p>Columbia, S. C. (University of South Carolina)</p> <p>Grand Coulee, Wash. (Bureau of Reclamation, National Park Service)</p> <p>Honolulu, T. H. (University of Hawaii)</p> <p>Huancayo, Peru. (Carnegie Institute of Washington)</p> <p>Lincoln, Nebr. (Nebraska Wesleyan University)</p>	<p>Logan, Utah. (Utah State Agricultural College)</p> <p>Montezuma, Chile. (Smithsonian Institution)</p> <p>New Kensington, Pa. (Private station)</p> <p>Overton, Nev. (Bureau of Reclamation, National Park Service)</p> <p>Philadelphia, Pa. (The Franklin Institute)</p> <p>Pierce Ferry, Nev. (Bureau of Reclamation, National Park Service)</p> <p>Rapid City, S. D. (South Dakota State School of Mines)</p> <p>Salt Lake City, Utah. (University of Utah)</p> <p>San Juan, P. R.</p> <p>Seattle, Wash. (University of Washington)</p> <p>Shasta, Calif. (Bureau of Reclamation, National Park Service)</p> <p>Sitka, Alaska.</p> <p>Tucson, Ariz.</p> <p>Ukiah, Calif. (International Latitude Observatory)</p>
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San Juan, Sitka, Tucson, and Ukiah are Coast and Geodetic Survey stations. Bermuda, Bozeman, Butte, Chicago, College, Columbia, Honolulu, Lincoln, Rapid City, and Salt Lake City are cooperative stations.

Balboa Heights, Burlington, Huancayo, Logan, Montezuma, New Kensington, Philadelphia, and Seattle are independent stations.

Boulder City, Grand Coulee, Overton, Pierce Ferry, and Shasta are cooperative stations of the Lake Mead Seismological Survey.

All readings were made or revised at the Washington Office except those for Balboa Heights and Bureau of Reclamation stations.

The provisional epicenter results for the first quarter of 1945 are listed in table 1. Epicenters of the stronger shocks of 1946 are listed in table 2.

Table 1.—Summary of instrumental epicenters for the first quarter of 1945

NOTE.—The provisional epicenters in this table are primarily intended to cover earthquakes recorded in the United States. Some of them have been determined by the Coast and Geodetic Survey, and some have been taken from the reports of other organizations and stations. An asterisk (\*) indicates probable error of one-tenth minute. In the case of the Pasadena epicenters the time is given in one-tenth minute. The epicenters reported by nearby stations are usually given preference. More detailed information will be found in the Seismological Bulletins of the Coast and Geodetic Survey and in the bulletins of other organizations and stations.

1945	Origin time G. C. T.	Region, focal depth, and remarks	Coordinates of provisional epicenter	
			Latitude	Longitude
			° ' "	° ' "
Jan. 1.	1 20 43	Baffin Bay. Mag. 7.	73	69½ W.
2	2 36 10	California. Mag. 3.5.	36 24 N.	117 55 W.
5	6 18 23*	Galapagos Islands, about 1,200 miles west of.	2 S.	107 W.
5	6 36 16	San Clemente Island, south of. Mag. 3.6.	32 36 N.	118 14 W.
6	9 36 25*	Easter Islands, about 100 miles north of.	12 S.	110 W.
7	22 25 32	California, near northwest coast. Minor damage in San Benito County. Mag. 5.1.	36.5 N.	111.8 W.
9	12 17 41*	Haiti, near north coast.	19½ N.	73 W.
11	11 56 00*	Nevada, Lincoln County. Mag. 3.8.	37.4 N.	114.9 W.
11	21 08 40*	Jamaica, off east coast. Felt throughout island.	18½ N.	76½ W.
12	18 38 27	Honshu, Japan, near southern coast. Slight damage. Mag. 6.9.	34½ N.	138 E.
12	21 59 35	Mexico, near southern coast. Felt in Chiapas. Depth about 150 kilometers.	16.0 N.	93.0 W.
16	13 36 42*	Honshu, Japan, near southern coast.	35 N.	137½ E.
17	3 59 18*	Chile, near west-central coast. Felt. Depth slightly greater than normal.	35½ S.	72 W.
18	3 12 56*	Atlantic Ocean, southeast of Greenland.	57 N.	34 W.
18	3 45 23*	do.	57 N.	34 W.
18	18 06 21*	Isthmus of Tehuantepec, near north coast. Felt in Coahuila.	18 N.	94 W.
19	5 10 44.6	California, Inglewood Fault. Felt. Mag. 3.5.	33 56.5N.	118 9.5 W.
22	7 47 51*	Dominican Republic, near north coast. Felt in Ciudad Trujillo.	20 N.	70 W.
23	21 34 11	California, near Anza. Mag. 3.5.	33 28 N.	116 42 W.
25	0 31 55*	Arctic Circle, off northeast coast of Siberia.	66 N.	173 W.
25	6 00 23*	Bonin Islands region. Depth about 100 kilometers.	27 N.	140 E.
26	4 23 56	California, near Lake Arrowhead. Felt. Mag. 3.5.	34 12 N.	117 09 W.
31	9 35 32*	Chile, near coast.	29 S.	71½ W.
Feb. 1.	10 35 47*	Loyalty Islands region.	22 S.	169 E.
1	12 13 37*	do.	22 S.	169 E.
2	2 02 30*	Southern Alaska.	60½ N.	146 W.
2	21 37 48*	Ecuador, off coast.	1½ S.	81 W.
2	23 27 50*	do.	1½ S.	81 W.
5	8 02 38*	Colombia. Felt in Valle del Cauca.	6 N.	77 W.
6	22 56 11	California, near Inglewood Fault. Felt. Mag. 3.5.	33 57 N.	118 21 W.
10	4 57 50	Honshu, Japan, off northeast coast. Felt in northern Honshu. Depth slightly greater than normal. Mag. 7.3.	41½ N.	142 E.
12	16 24 40*	Chile, near northwest coast. Felt.	32 S.	72 W.
13	11 27 13*	Atlantic Ocean, southwest of Azores.	34 N.	39 W.
14	3 01 15	Idaho. Felt in Montana, Washington, and Oregon. Mag. 6.	44.7 N.	115.4 W.
16	8 15 09	California, near Lake Arrowhead. Mag. 3.0.	34 12 N.	117 09 W.
18	6 46 25	Panama, off coast.	7 N.	82 W.
18	10 08 05	Hokkaido, Japan, off south coast. Depth slightly greater than normal. Mag. 7.0.	42 N.	144 E.
20	9 35 8*	Lower California. Mag. 4.0.	32 N.	115½ W.
26	22 14 24	Bonin Islands region. Mag. 7.1.	26 N.	143 E.
27	7 16 23*	Mexico, Bay of Tehuantepec.	15 N.	95 W.
27	9 06 53	Lower California. Mag. 3.8.	32.0 N.	115.5 W.
Mar. 1	11 19 58	Lower California. Mag. 4.4.	32 03 N.	116 09 W.
2	10 39 25	Turkey, near northern coast.	42 N.	36 E.
2	19 42 30*	Bonin Islands region. Depth about 500 kilometers.	25 N.	143 E.
3	14 13 10	California, near Borego Valley. Mag. 3.4.	32 58 N.	116 00 W.
5	12 17 05*	Tonga Islands region. Depth about 100 kilometers.	19 S.	172 W.
11	0 01 31	California, near Little San Bernardino Mountains. Mag. 3.2.	34 00 N.	116 13 W.
11	0 20 03	California, near Little San Bernardino Mountains. Mag. 3.8.	33 52 N.	116 12 W.
11	21 37 49	Honshu, Japan, off east coast. Depth slightly greater than normal. Mag. 7.2.	37½ N.	142½ E.
12	11 03 13	California, northwest of Barstow. Mag. 3.2.	35 11 N.	117 24 W.
17	23 57 53	Colombia, off coast. Felt in Panama Canal Zone. Mag. 6.4.	6.7 N.	78.1 W.
18	0 21 16*	Kermadec Islands region.	33 N.	179 W.
18	18 54 42*	Alaska Peninsula, south of.	55 N.	157 W.
18	23 18 09	Azores region. Felt.	38½ N.	29 W.
19	13 19 20*	Chile, off northern coast.	23 S.	72 W.
20	7 58 53	Tukey. Fourteen killed and hundreds injured in a series of earthquakes.	36½ N.	34 E.
20	21 55 07	California, Mojave Desert, northwest of Twentynine Palms. Mag. 5.0.	34 15 N.	116 10 W.
22	4 23 43*	Chile, north central. Possibly slightly deeper than normal.	25 S.	69 W.
23	8 13 25*	do.	25 S.	69 W.
23	23 14 15*	New Zealand, about 1,100 miles southwest of. Mag. 7.1.	61 S.	153½ E.
28	13 03 06*	New Guinea, off east coast.	5 S.	146 E.
29	4 04 17	California, northwest of Twentynine Palms. Mag. 4.2.	34 17 N.	116 11 W.
29	17 53 14	California, northwest of Twentynine Palms. Mag. 3.7.	34 17 N.	116 11 W.
31	18 50 45	Gulf of California. Mag. 5.	31 N.	114 W.
31	19 27 37	do.	31 N.	114 W.

Table 2.—Principal earthquakes of the world from January 1946 to December 1946, inclusive

NOTE.—This table lists (1) the strongest shocks of the period as revealed by seismographic records, particularly those of Western Hemisphere stations; (2) important destructive and near destructive earthquakes; (3) earthquakes of unusual interest outside the two preceding categories; and (4) magnitudes as determined by Pasadena.

1946	Origin time G. C. T.	Region	Coordinates of provisional epicenter		Remarks
			Latitude	Longitude	
Jan. 5	<i>h m s</i> 19 57 20	New Hebrides Islands region	15½ S.	167 E.	Mag. 7.3.
11	1 33 27	Eastern Manchuria	44½ N.	129½ E.	Depth about 600 kilometers. Mag. 7.2.
12	20 25 38	Alaska, off south coast	59½ N.	147½ W.	Mag. 7.2.
25	17 31 50	Switzerland, south of Bernese Alps	46½ N.	7½ E.	Felt in southwestern Switzerland.
Feb. 12	2 43 24	Northern Algeria	35¾ N.	5 E.	Destructive in Algeria, 264 persons reported killed.
15	3 17 47	Puget Sound, Wash.	47.3 N.	122.9 W.	Felt. Estimated property damage \$250,000 in Washington and Oregon. Mag. 5¼.
Mar. 15	13 49 36	California	35.7 N.	118.0 W.	Felt. Slight property damage. Mag. 6.2 to 6.4.
29	7 26 04	Ecuador, off coast	1.7 S.	80.8 W.	Felt in Ecuador.
Apr. 1	12 28 58	Aleutian Islands	53½ N.	163 W.	20-foot sea wave struck Hawaiian Islands, 173 persons killed and \$25,000,000 property damage. Light station on Unimak Island washed away. Waves recorded on west coasts of North and South America, and at many islands in the Pacific Ocean.
5	20 54 00	Crete, off west coast	35½ N.	23¾ E.	Felt in Crete.
11	1 52 24	Atlantic Ocean, off coast of Liberia	1¾ S.	13¾ W.	Mag. 7.2.
May 12	13 20 15	Azores	39½ N.	29 W.	
21	9 16 49	Windward Islands	15 N.	60½ W.	Property damage in Martinique. Depth slightly less than 100 kilometers. Mag. 7.
31	3 12 7	Turkey	39½ N.	41 E.	1,300 persons reported killed and several villages destroyed in eastern Turkey. Property damage. Mag. 7.3.
June 23	17 13 19	Georgia Strait, British Columbia	49.9 N.	125.3 W.	Felt in Vera Cruz, Oaxaca, and Chiapas. Depth about 100 kilometers. Mag. 7.
July 11	4 46 39	Mexico, Isthmus of Tehuantepec	17½ N.	93¾ W.	Mag. 6¾.
12	21 56 25	Aleutian Islands	53¾ N.	168½ W.	
16	5 26 27	Mediterranean Sea, south of Crete	34 N.	25½ E.	
Aug. 2	19 18.9	Chile, off northwest coast	26½ N.	71½ W.	2 persons killed and extensive property damage in northern Chile. Depth about 100 kilometers. Mag. 7½.
Aug. 4	17 51 06	Dominican Republic, off Samana Peninsula	19¼ N.	69 W.	About 100 persons drowned by small sea wave. Few persons killed by collapsing buildings. Very extensive property damage. Mag. 8.1.
8	13 28 28	Dominican Republic, aftershock	19½ N.	69¼ W.	Mag. 6.1.
28	22 28 16	Argentina, Province of Santiago del Estero	26¾ S.	63 W.	Depth slightly less than 600 kilometers. Mag. 7.2.
Sept. 12	15 17.2	Burma	24 N.	96 E.	Mag. 7½.
29	3 01.9	New Britain Island	5 S.	153½ E.	Mag. 7¾.
30	0 39 40	Peru, near west-central coast	14 S.	76¼ W.	Depth slightly less than 100 kilometers. Mag. 7.
Oct. 30	7 42 32	Aleutian Islands	54 N.	164½ W.	Mag. 6.9.
Nov. 2	18 28 30	Turkistan	41½ N.	72 E.	Damage reported in regions of Namanagan, Fergana, Andizhan, and Dzhalal-Abad. Mag. 7.5.
4	21 47 46	Turkmen, Union of Soviet Socialist Republics, near west coast	40 N.	54½ E.	
10	17 42 33	Peru, near northwest coast	8¾ S.	78¼ W.	Severe property damage, 800 persons killed and 500 persons injured. Mag. 7½.
12	17 28.7	Tonga Islands region	20 S.	173 W.	
Dec. 4	22 46.8	Taiwan, probably off southeast coast			53 persons reported killed and 100 houses destroyed.
20	19 19 05	Honshu Island, Japan, off south coast	33.0 N.	135.6 E.	10-foot sea wave along eastern shores of Shikoku and Honshu with very extensive property damage in same regions, 1,997 persons reported killed. Depth about 60 kilometers. Mag. 7.2.
21	10 18 50	Hokkaido, Japan, off east coast	44¼ N.	148¾ E.	

## STRONG MOTION SEISMOGRAPH RESULTS

### INTRODUCTION

During the latter part of 1932, the Coast and Geodetic Survey inaugurated a program of recording strong ground movements in the seismically active regions of the country to obtain data needed in the design of earthquake-resisting structures. Notes pertinent to the development of this program will be found in the 13 preceding issues of this series, Serials 579, 593, 600, 610, 619, 629, 637, 647, 655, 662, 672, 682, and 699, and in Special Publication 201, *Earthquake Investigations in California, 1934-35*. Material in the United States earthquakes series is restricted to the analysis of strong motion seismograph records. Special Publication 201 is much broader of scope, containing data on structural and ground vibrations and detailed descriptions of the various activities which comprise the seismological program as a whole. The reader is also referred to Special Publication 206, *Selection, Installation, and Operation of Seismographs*, for descriptive material on strong motion instruments and vibration meters in addition to similar information on teleseismic instruments.

*Interpretation of records.*—The following analyses 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 is often obscured by the superposing of shorter period waves of relatively large amplitude, the estimates of displacement must be considered as only approximate. One must refer to the illustrations of the curves themselves to evaluate the probable accuracy of the estimated displacements.

For the more important records—those involving destructive ground motions—the use of integration methods in computing velocity and displacement curves has become established practice. The accuracy of such work, as well as an appraisal of instrumental performance, has been definitely established through accelerometer shaking table tests made at, and with the cooperation of, the Massachusetts Institute of Technology. (See Bulletin of the Seismological Society of America, vol. 33, No. 1, January 1943.) In the displacement results the errors of mensuration, computation, and adjustment can be kept within a range of 1 centimeter. Errors due to minute shiftings of the zero positions of the pendulums on pivot accelerometers increase this range of error to about 2 or 3 centimeters. In both cases the errors apply only to displacements of a slow drifting type, somewhat similar to waves of about 10 seconds period and over. But they represent motions that are necessarily associated with extremely small accelerations and are therefore of no significance in engineering studies.

None of the 1946 records was strong enough to require integration.

*Units used.*—Quantitative results are expressed in c. g. s. units; centimeters or millimeters for displacement; centimeters per second for velocity; 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.<sup>2</sup> For practical purposes it is only necessary to point off three decimal places to convert cm./sec.<sup>2</sup> to "g."

Sensitivity of the seismographs is expressed as the deflection of the trace, or light spot, in centimeters for a constant acceleration of 100 cm./sec.<sup>2</sup> This means that the seismometer pendulum is tilted sideways until the effective component of the earth's gravitational field is equal to 100 cm./sec.<sup>2</sup>, or practically 0.1 g.

The following are constants which may be used in converting c. g. s. units to the customary English units:

1 cm.	= 0.3937 in.	= 0.03281 ft.
1 cm./sec.		= 0.03281 ft./sec.
1 cm./sec. <sup>2</sup>		= 0.03281 ft./sec. <sup>2</sup>
1 cm.		= 10 mm.
0.1 g.		= 98 cm./sec. <sup>2</sup> = 3.215 ft./sec. <sup>2</sup>
1 (statute) mile		= 1.609 km.

Damping ratio of the pendulum is the ratio between successive amplitudes when the pendulum oscillates under the influence of the damping force alone.

*Seismogram illustrations.*—Reproductions of seismograms are usually tracings of the original records and must not be accepted as genuine copies. They 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 address the Director of the Coast and Geodetic Survey for further particulars.

The tabulated instrumental constants refer to the original records. The tracings in this publication are reduced so that the same scales do not apply. The reductions are approximately in the ratio of 1.8 to 1.

#### NOTES ON STRONG-MOTION SEISMOGRAPH RECORDS

The practice of attempting to describe the seismograms in detail in the text is believed to be rather superfluous because the outstanding periods are listed in tables, such as table 4 in this issue. The illustrations provide a far better picture of the records than can be obtained in any other way. The following notes will therefore contain only such information on the earthquakes and the records which may not be evident from table 4 or from the illustrations. For convenience certain fundamental information on the earthquakes will be repeated from the noninstrumental part of the publication.

It is well to repeat here that, as the measurement of periods on records of this nature is dependent largely on the judgment of the person reading them, 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, and 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.

Acceleration scales are indicated on the tracings of acceleration curves by two dots, the distance between them representing the equivalent of 100 cm./sec.<sup>2</sup> when applied to the curves over which they appear. A similar scheme is adopted for other types of curves. These dots provide a quick means for making auxiliary scales in cases where an investigator desires to make rough measurements on the published curves. They are especially necessary at this time in view of the instrumental changes begun in 1942.

The pendulum periods of a number of accelerographs in southern California have been reduced from 0.1 second to about 0.07 second. Also a number of the 6-inch and 12-inch recorders have been interchanged. Most of this work was done during 1942. The purpose was to arrange the instruments so that their recording capacities would more nearly equal the accelerations which might be expected at the various station sites. As a result of previous experience the following expectable earthquake accelerations were used in determining the adjustment and placement: (a) Rock foundation 25 percent of gravity, (b) conglomerate foundations 40 percent of gravity, (c) alluvium 70 percent of gravity, (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 millimeters per 0.1 gravity, respectively. In order to realize the desired recording capacities it was necessary to shift a number of accelerographs because of the greater recording range of the 12-inch drums as compared with the 6-inch.

In the notes following table 3 listing the strong-motion records obtained during 1946 the maximum values of acceleration and displacement are given for each station. Accelerations shown may have been recorded by any one of the three components. As will be seen in table 4 maximum recorded acceleration is not necessarily associated with the same ground period as the maximum computed displacement.

**Table 3.—List of shocks recorded and records obtained on strong-motion seismographs in 1946**

Date, epicenter, and recording station	Records		
	Accelerograph	Displacement meter	Weed strong-motion seismograph
Jan. 8: Southern California: El Centro.	1		
Jan. 28: Near Lima, Peru: Lima.	1		
Mar. 15: Southern California:			
Long Beach	1		
Los Angeles Chamber of Commerce	2		
Los Angeles Subway Terminal	3	1	
Hollywood Sotrage Co.	3		
Vernon	1		
Westwood	1		
Oakland City Hall	2		
Pasadena	2	2	
San Bernardino			1
San Francisco Southern Pacific Bldg	6	2	
San Jose	6		
Santa Barbara	1		
Mar. 17: Hawthorne, Nev.: Hawthorne	1		
Mar. 29: Off coast of Ecuador: Quito	1		
May 1: Northern California:			
San Jose Bank of America	2		
San Francisco Southern Pacific Bldg	2		
San Francisco Shell Bldg			1
Oakland City Hall	2		
May 28: Northern California: San Francisco Southern Pacific Bldg	2		
May 29: Northern California: Hollister			1
Aug. 14: Northern California: San Francisco Southern Pacific Bldg	2	2	
Dec. 15: Near Quito, Ecuador: Quito	1		
Dec. 18: Northern California:			
Eureka	1	2	
Ferndale	1		
Total	45	9	3

**SOUTHERN CALIFORNIA EARTHQUAKE OF JANUARY 8**

Epicenter from local instrumental data 35°00' north, 115°50' west, San Jacinto Fault. Maximum intensity V at several scattered places.

*El Centro*.—Figure 7. Station about 153 miles SE 174° of epicenter. Intensity IV in El Centro. Maximum acceleration 8 cm./sec.<sup>2</sup> and computed maximum displacement 0.012 centimeter.

**EARTHQUAKE OF JANUARY 28 NEAR LIMA, PERU, SOUTH AMERICA**

Epicenter in the region of Lima, Peru, South America. Maximum intensity unknown.

*Lima*.—Figure 7. Maximum acceleration 5 cm./sec.<sup>2</sup> and computed maximum displacement 0.002 centimeter.

**FORESHOCK OF SOUTHERN CALIFORNIA EARTHQUAKE OF MARCH 15**

Epicenter from local instrumental data, 35°44' north, 118°02.5' west, north of Walker Pass. Maximum intensity VII at one place and intensity VI at very many places.

*Los Angeles Subway Terminal*.—Station 117 mi. SW. 186° of epicenter. Intensity V in Los Angeles. Maximum acceleration 5 cm./sec.<sup>2</sup> and computed maximum displacement 0.046 centimeter on thirteenth floor. Maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.008 centimeter in sub-basement. Maximum displacement 0.06 centimeter on displacement meter and computed maximum acceleration 1 cm./sec.<sup>2</sup>

*San Francisco Southern Pacific Building*.—Station about 279 mi. NW. 301° of epicenter. Maximum acceleration 8 cm./sec.<sup>2</sup> and computed maximum displacement 0.296 centimeter on fourteenth floor. Maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.031 centimeter in basement. Maximum displacement 0.03 centimeter recorded on displacement meter and computed maximum acceleration 3 cm./sec.<sup>2</sup> in basement.

**SOUTHERN CALIFORNIA EARTHQUAKE OF MARCH 15**

Epicenter from local instrumental data 35°44' north, 118°02.5' west, north of Walker Pass. Maximum intensity possibly VIII at one place and intensity VI at many places.

*Los Angeles Chamber of Commerce*.—Figure 9. Station 117 mi. SW. 187° of epicenter. Intensity V in Los Angeles. Maximum acceleration 22 cm./sec.<sup>2</sup> and computed maximum displacement 1.034 centimeters on eleventh floor. Maximum acceleration 12 cm./sec.<sup>2</sup> and computed maximum displacement 0.054 centimeter in basement.

*Los Angeles Subway Terminal*.—Figure 8. Station 117 mi. SW. 186° of epicenter. Intensity V in Los Angeles. Maximum acceleration 4 cm./sec.<sup>2</sup> and computed maximum displacement 0.050

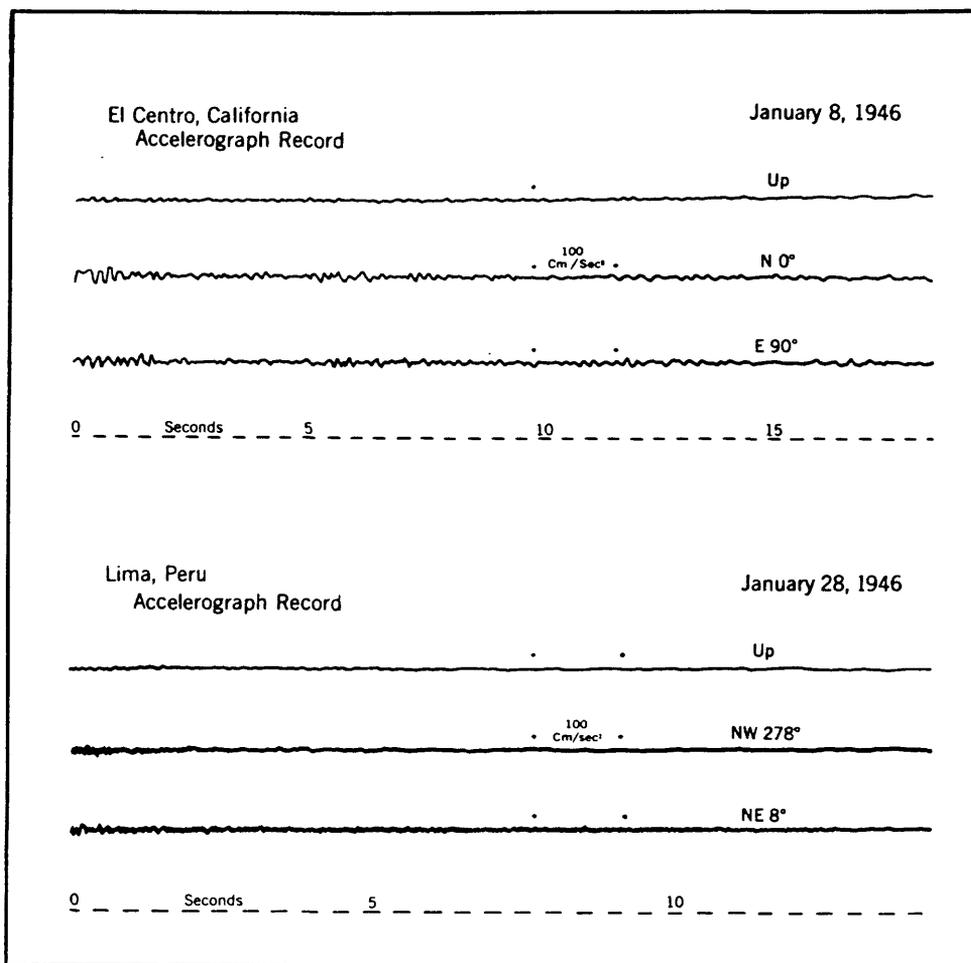


FIGURE 7.—Tracings of accelerograph records obtained at El Centro on January 8, and Lima, Peru on January 28.

centimeters on thirteenth floor. Maximum acceleration 5 cm./sec.<sup>2</sup> and computed maximum displacement 0.062 centimeter in sub-basement. Maximum displacement 0.32 centimeter recorded on displacement meter and computed maximum acceleration 4 cm./sec.<sup>2</sup> in sub-basement.

*Hollywood Storage Co.*—Figure 10. Station 114 mi. SW, 181° of epicenter. Intensity not reported in Hollywood. Maximum acceleration 16 cm. sec.<sup>2</sup> and computed maximum displacement 0.216 centimeter in penthouse. Maximum acceleration 5 cm./sec.<sup>2</sup> and computed maximum displacement 0.062 centimeter in basement. Maximum acceleration 5 cm./sec.<sup>2</sup> and computed maximum displacement 0.034 centimeter in P. E. lot.

*San Francisco Southern Pacific Building.*—Station 279 mi. NW, 301° of epicenter. Intensity not reported in San Francisco. Maximum acceleration 7 cm. sec.<sup>2</sup> and computed maximum displacement 0.210 centimeter on fourteenth floor. Maximum acceleration 1 cm. sec.<sup>2</sup> and computed maximum displacement 0.009 centimeter in basement. Maximum displacement 0.06 centimeter recorded on displacement meter and computed maximum acceleration 3 cm./sec.<sup>2</sup>

*San Jose Bank of America.*—Station 240 mi. NW, 298° of epicenter. Reported not felt in San Jose. Maximum acceleration 4 cm. sec.<sup>2</sup> and computed maximum displacement 0.268 centimeter on thirteenth floor. Surface waves scarcely perceptible on basement accelerograph.

*Pasadena.* Station 110 mi. SW, 183° of epicenter. Intensity IV in Pasadena. Maximum acceleration 4 cm. sec.<sup>2</sup> and computed maximum displacement 0.079 centimeter. Maximum displacement 0.35 centimeter recorded on displacement meter and computed maximum acceleration 11 cm. sec.<sup>2</sup>

*Santa Barbara.* Station 131 mi. SW, 228° of epicenter. Intensity V in Santa Barbara. Maximum acceleration 9 cm. sec.<sup>2</sup> and computed maximum displacement 0.193 centimeter.

*Long Beach.*—Station 135 mi. SW, 184° of epicenter. Intensity IV in Long Beach. Maximum acceleration 1 cm. sec.<sup>2</sup> and computed maximum displacement 0.029 centimeter.

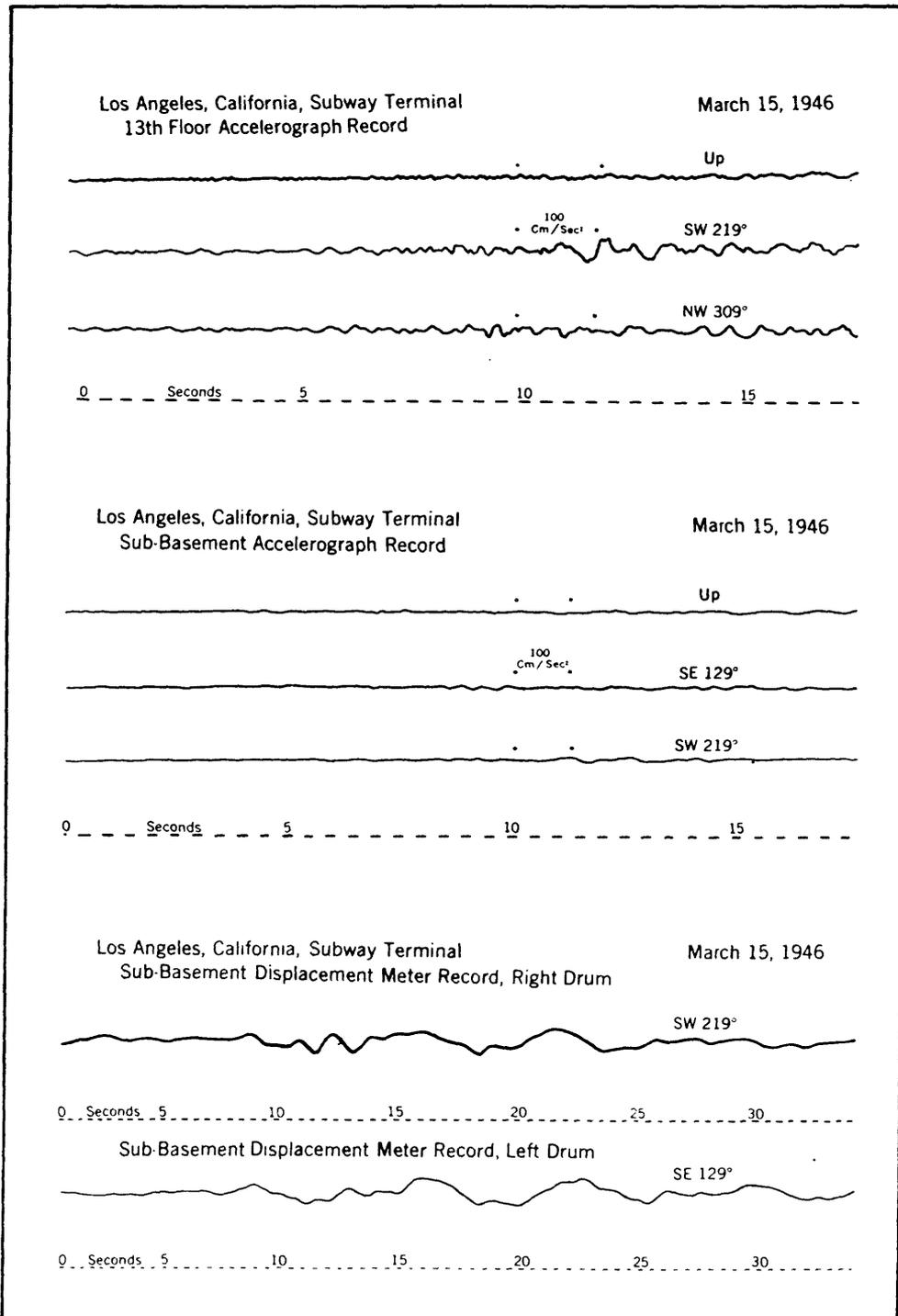


FIGURE 8. Tracings of accelerograph records obtained at Los Angeles Subway Terminal on March 15.

*Oakland City Hall.*—Station 270 mi. NW.  $303^{\circ}$  of epicenter. Intensity not reported in Oakland. Maximum acceleration 8 cm./sec.<sup>2</sup> and computed maximum displacement 0.328 centimeter on thirteenth floor. Surface waves scarcely perceptible on basement accelerograph.

*San Bernardino.*—Station 120 mi. SE.  $159^{\circ}$  of epicenter. Intensity VI at San Bernardino. Maximum displacement 0.032 centimeter recorded on Weed seismograph.

*Vernon.*—Station 120 mi. SW.  $185^{\circ}$  of epicenter. Reported not felt in Vernon. Maximum acceleration 2 cm./sec.<sup>2</sup> and computed maximum displacement 0.021 centimeter.

*Westwood.*—Figure 9. Station 117 mi. SW.  $192^{\circ}$  of epicenter. Intensity not reported in Westwood. Maximum acceleration 4 cm./sec.<sup>2</sup> and computed maximum displacement 0.024 centimeter.

#### AFTERSHOCKS OF SOUTHERN CALIFORNIA EARTHQUAKE OF MARCH 15

*Los Angeles Subway Terminal.*—Station 117 mi. SW.  $186^{\circ}$  of epicenter. Intensity III to V in Los Angeles. Maximum acceleration 5 cm./sec.<sup>2</sup> and computed maximum displacement 0.038 centimeter on thirteenth floor. Maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.006 centimeter in sub-basement. Maximum displacement 0.02 centimeter recorded on displacement meter and computed maximum acceleration 1 cm./sec.<sup>2</sup>

*Hollywood Storage Co.*—Station 114 mi. SW.  $181^{\circ}$  of epicenter. Intensity not reported in Hollywood. Maximum acceleration 2 cm./sec.<sup>2</sup> and computed maximum displacement 0.082 centimeter in penthouse. Maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.027 centimeter in basement. Surface waves scarcely perceptible on P. E. lot record.

*San Francisco Southern Pacific Building.*—Station 279 mi. NW.  $301^{\circ}$  of epicenter. Intensity not reported in San Francisco. Results of three aftershocks on fourteenth floor: Maximum acceleration 2 cm./sec.<sup>2</sup> and computed maximum displacement 0.062 centimeter, maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.031 centimeter, and maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.023 centimeter. Surface waves scarcely perceptible for two aftershocks on basement accelerograph and displacement-meter records.

*San Jose Bank of America.*—Station 240 mi. NW.  $298^{\circ}$  of epicenter. Intensity not reported in San Jose. Results of two aftershocks on thirteenth floor: Maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.084 centimeter, and maximum acceleration 2 cm./sec.<sup>2</sup> and computed maximum displacement 0.168 centimeter. Surface waves scarcely perceptible for two aftershocks on basement accelerograph.

#### HAWTHORNE, NEV., EARTHQUAKE OF MAR. 17

Epicenter from local instrumental data  $38.3^{\circ}$  north,  $118.2^{\circ}$  west, southwest of Hawthorne. Maximum intensity V at one place.

*Hawthorne.*—Station about 30 mi. NW.  $310^{\circ}$  of epicenter. Maximum acceleration 15 cm./sec.<sup>2</sup> and computed maximum displacement 0.017 centimeter.

#### EARTHQUAKE OF MAR. 29 OFF ECUADOR, SOUTH AMERICA

Epicenter from instrumental data  $1.7^{\circ}$  south,  $80.8^{\circ}$  west, off coast of Ecuador. Maximum intensity unknown.

*Quito.*—Station about 200 mi. NE. of epicenter. Surface waves scarcely perceptible.

#### NORTHERN CALIFORNIA EARTHQUAKE OF MAY 1

Epicenter in the Altamont-Tracy area,  $37^{\circ}41'$  north,  $121^{\circ}33'$  west. Maximum intensity VI at one place.

*San Francisco Southern Pacific Building.*—Figure 12. Station about 50 mi. NW.  $275^{\circ}$  of epicenter. Maximum intensity IV reported in San Francisco. Maximum acceleration 11 cm./sec.<sup>2</sup> and computed maximum displacement 0.085 centimeter on fourteenth floor. Maximum acceleration 2 cm./sec.<sup>2</sup> and computed maximum displacement 0.010 centimeter in basement. Maximum displacement 0.20 centimeter recorded in displacement meter and computed maximum acceleration 3 cm./sec.<sup>2</sup> in basement.

*San Francisco Shell Building.*—Station about 50 mi. NW.  $275^{\circ}$  of epicenter. Maximum displacement 0.002 centimeter and computed maximum acceleration 1 cm./sec.<sup>2</sup> on twenty-ninth floor.

*Oakland City Hall.*—Figure 12. Station about 40 mi. NW.  $275^{\circ}$  of epicenter. Maximum intensity III. Maximum acceleration 9 cm./sec.<sup>2</sup> and computed maximum displacement 0.234 centimeter on sixteenth floor. Surface waves scarcely perceptible on basement accelerograph.

*San Jose.*—Figure 12. Station about 35 mi. SW.  $215^{\circ}$  of epicenter. Intensity not reported. Maximum acceleration 4 cm./sec.<sup>2</sup> and computed maximum displacement 0.293 centimeter on thirteenth floor. Maximum acceleration 1 cm./sec.<sup>2</sup> and computed maximum displacement 0.020 centimeter in basement.

#### NORTHERN CALIFORNIA EARTHQUAKE OF MAY 28

Epicenter probably in east-central San Francisco Bay region. Maximum intensity V at one place.

*San Francisco Southern Pacific Building.*—Station about 10 mi. west of epicenter. Intensity not reported in San Francisco. Maximum acceleration 3 cm./sec.<sup>2</sup> and computed maximum displacement 0.079 centimeter on fourteenth floor. Surface waves scarcely perceptible on basement accelerograph. Maximum displacement 0.10 centimeter recorded on displacement meter and maximum computed displacement 5 cm./sec.<sup>2</sup> in basement.

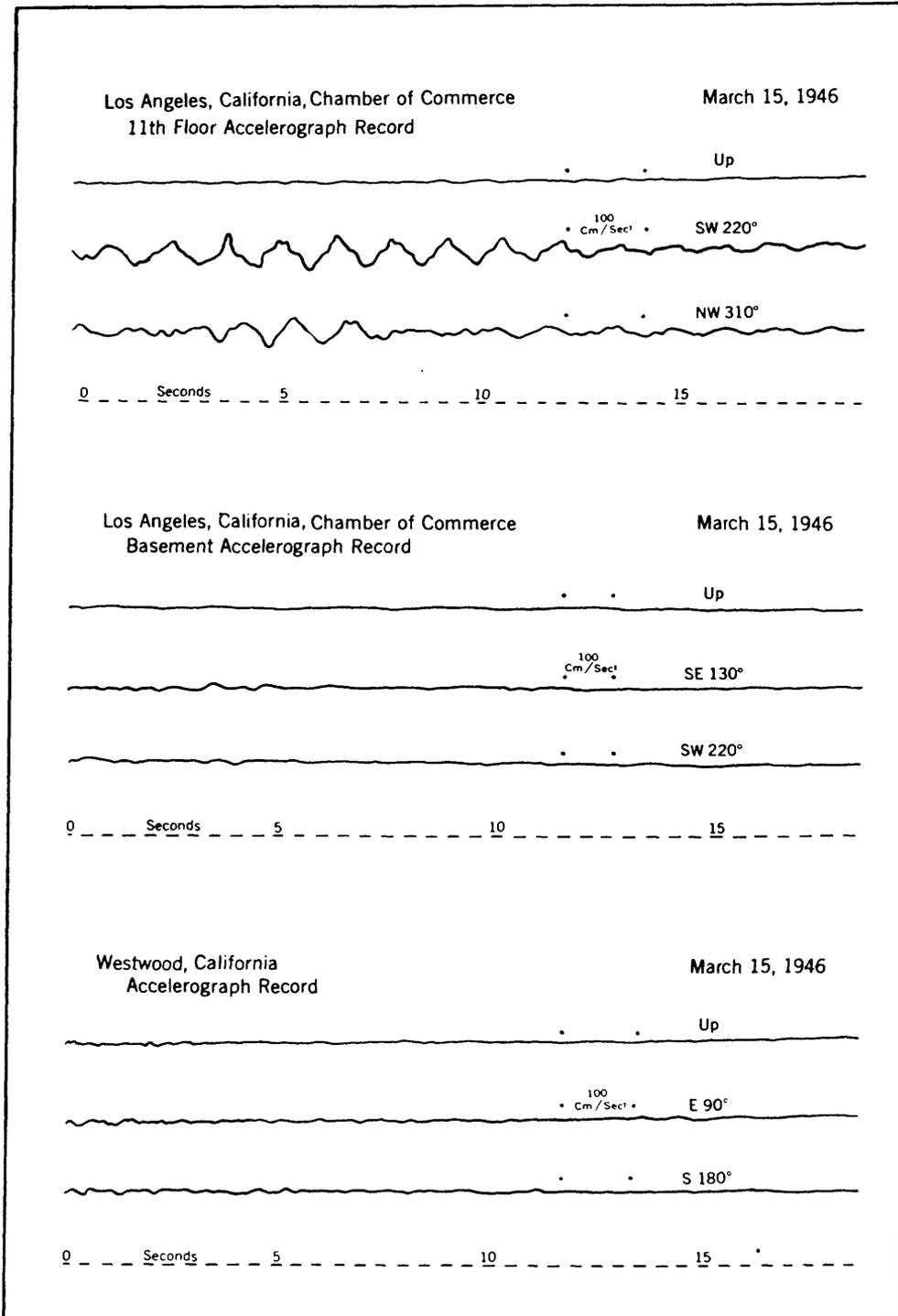


FIGURE 9.—Tracings of accelerograph records obtained at Los Angeles Chamber of Commerce and Westwood on March 15.

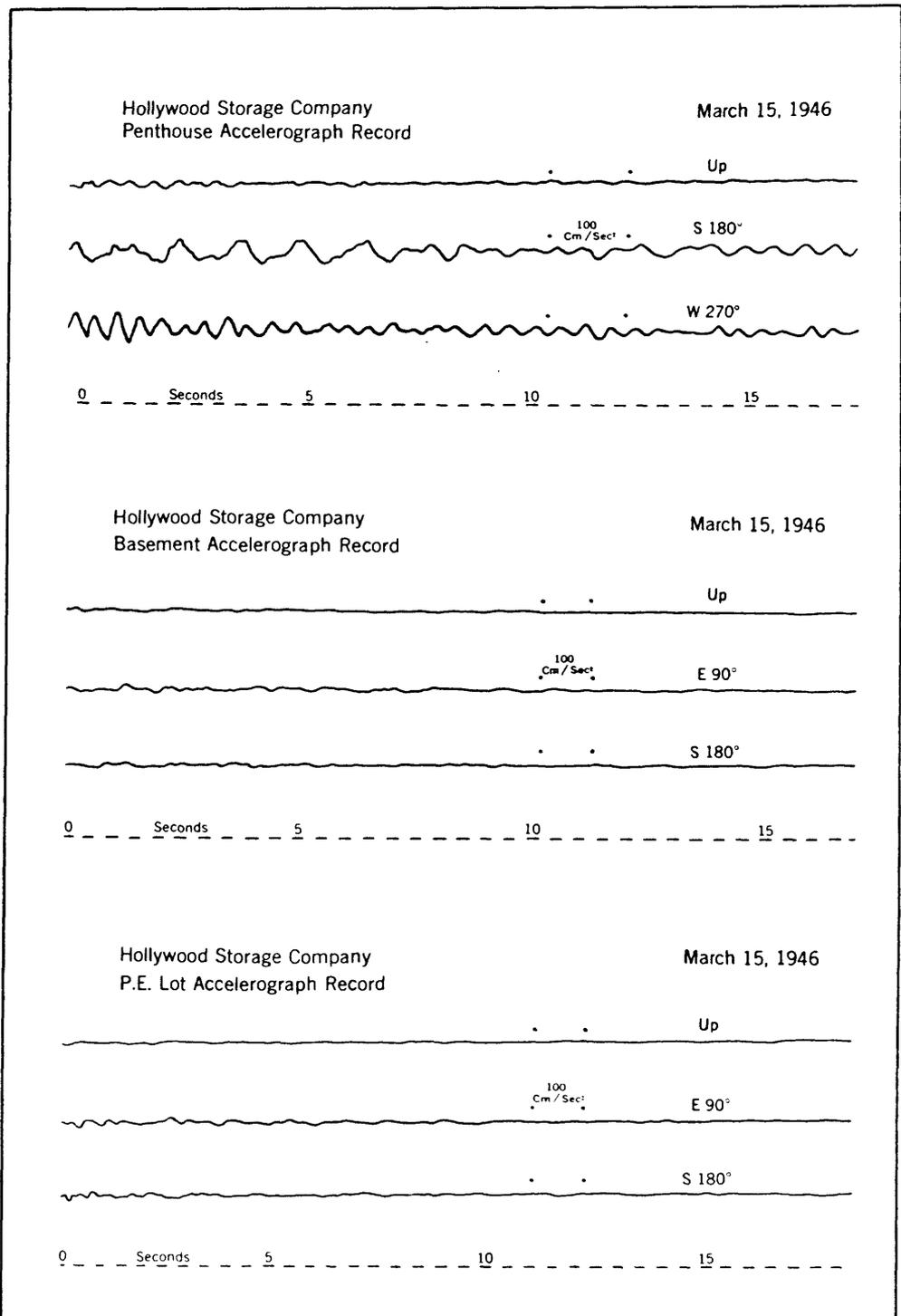


FIGURE 10.—Tracings of accelerograph records obtained at Hollywood Storage Co. on March 15.

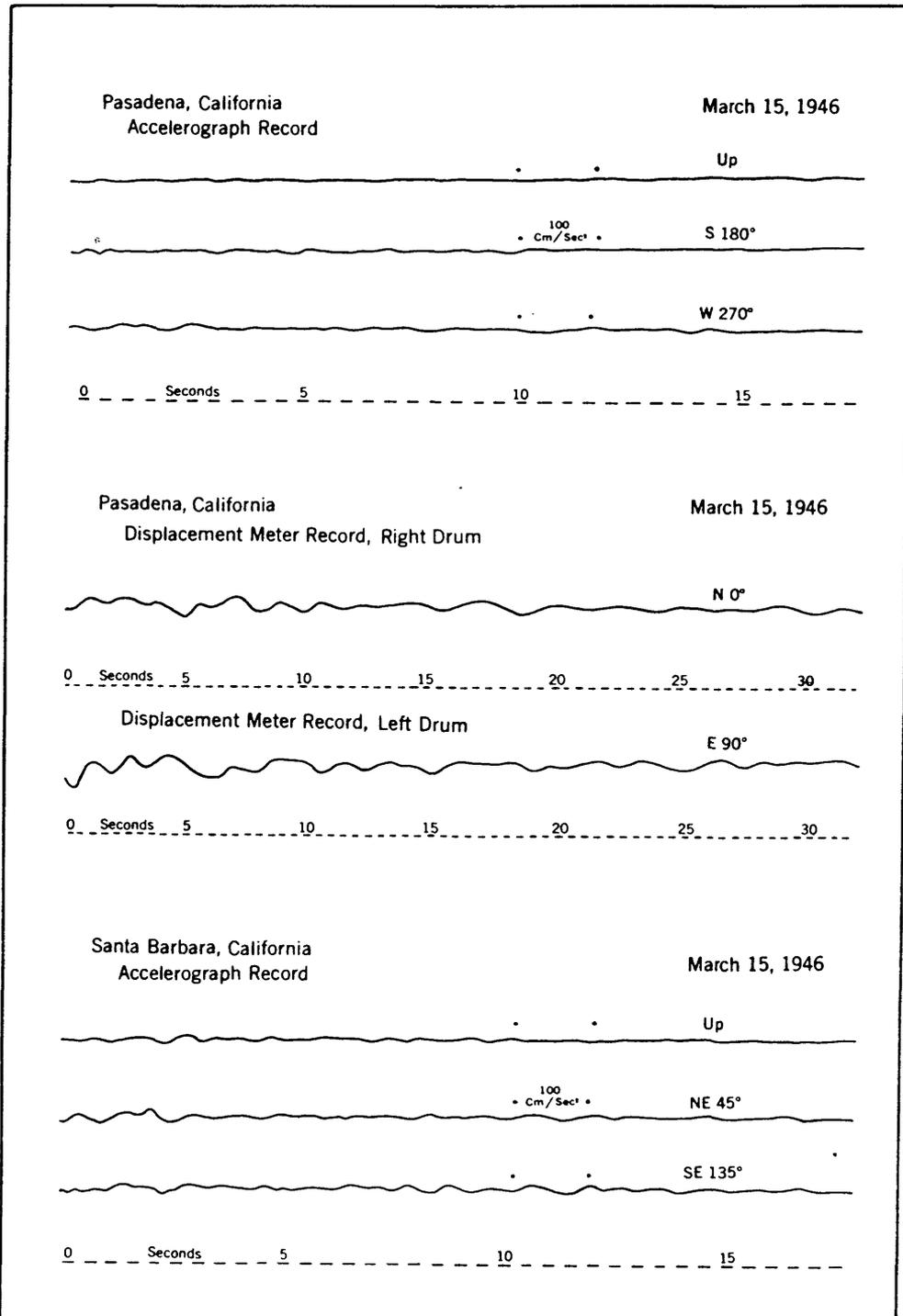


FIGURE 11.—Tracings of accelerograph records obtained at Pasadena and Santa Barbara on March 15.

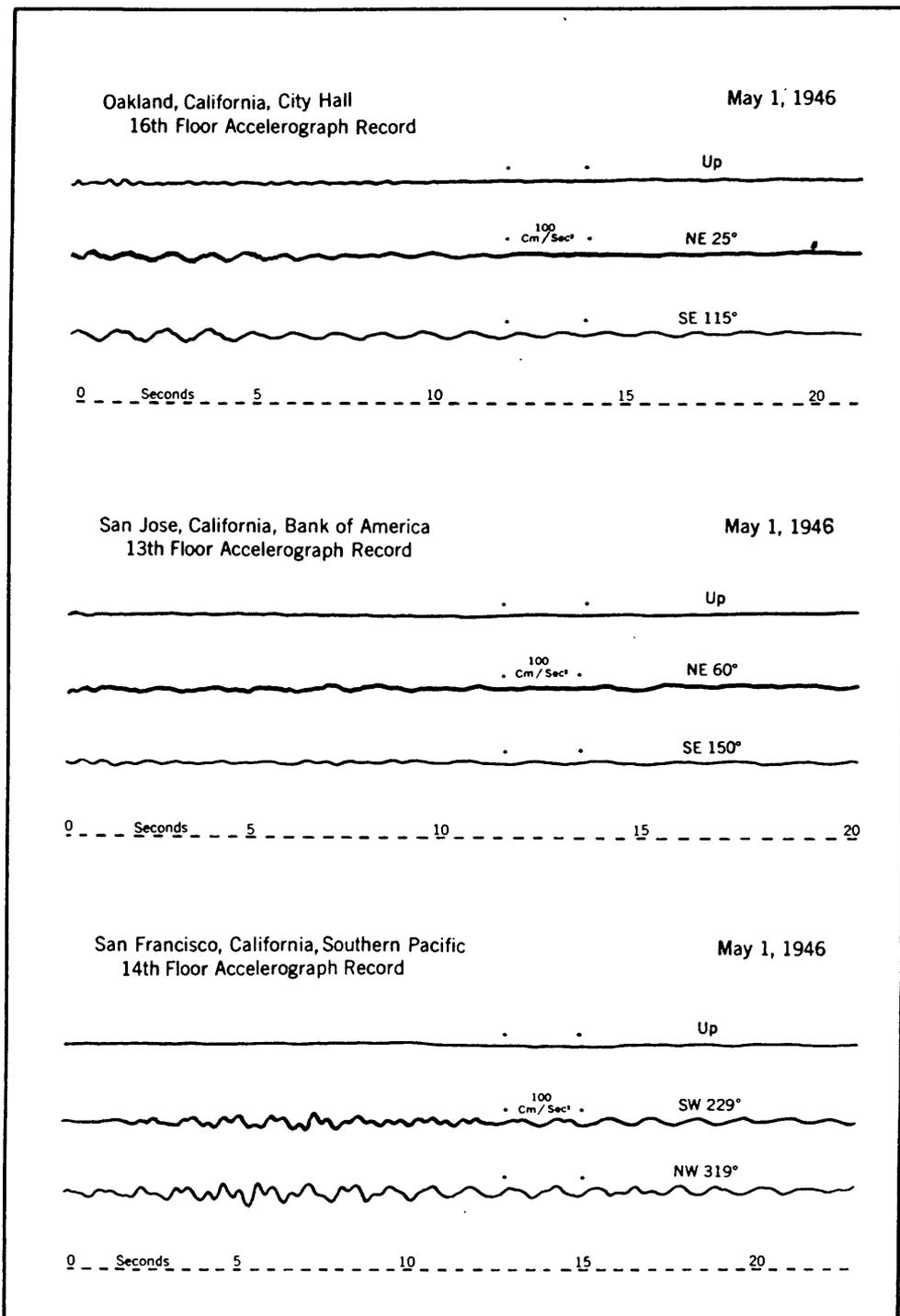


FIGURE 12.—Tracings of accelerograph records obtained at Oakland City Hall, San Jose Bank of America, and San Francisco Southern Pacific Building on May 1.

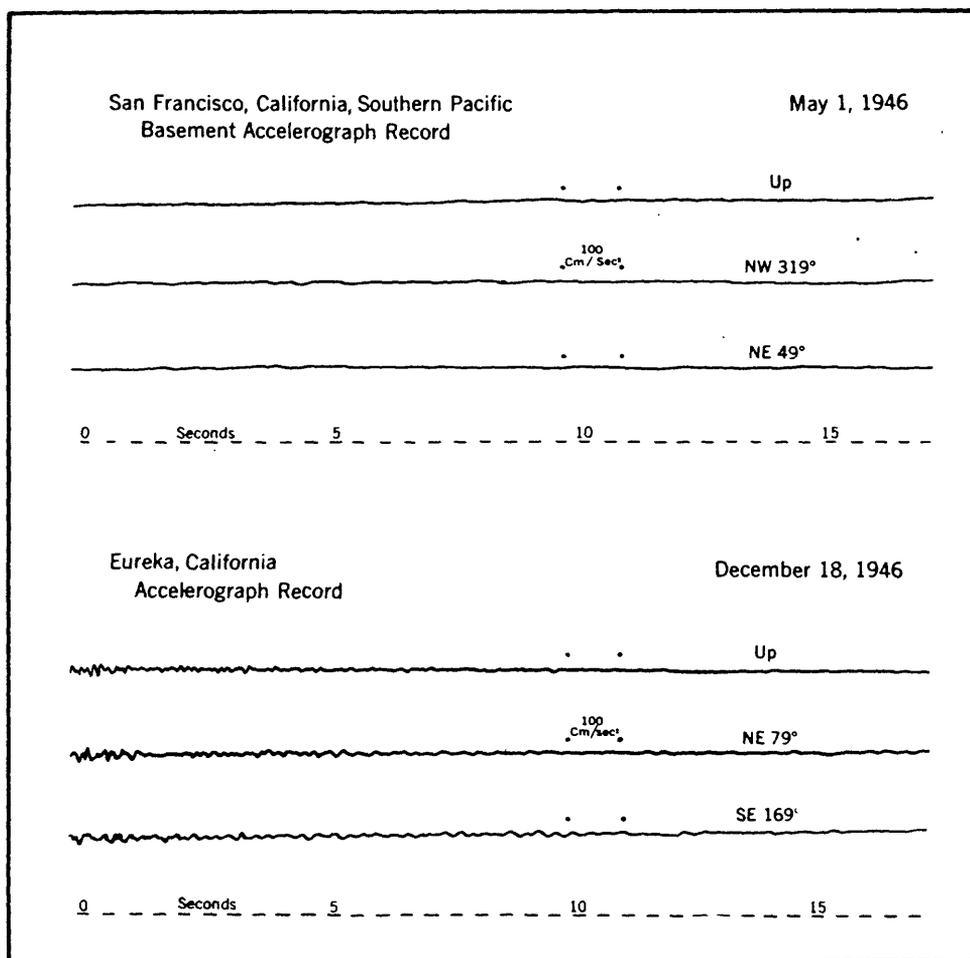


FIGURE 13.—Tracings of accelerograph records obtained at San Francisco Southern Pacific Building on May 1. and Eureka on December 18.

#### NORTHERN CALIFORNIA EARTHQUAKE OF MAY 29

Epicenter in the Hollister area. Epicenter  $36^{\circ}48'$  north,  $121^{\circ}34'$  west. Maximum intensity V near Hollister.

*Hollister*.—Station about 10 mi. NE  $70^{\circ}$  of epicenter. Maximum acceleration 4 cm./sec.<sup>2</sup> and maximum displacement 0.006 centimeter.

#### NORTHERN CALIFORNIA EARTHQUAKE OF AUGUST 14

Epicenter in the San Francisco area. Maximum intensity IV at one place.

*San Francisco Southern Pacific Building*.—Maximum acceleration 2 cm./sec.<sup>2</sup> and computed maximum displacement 0.036 centimeter on fourteenth floor. Surface waves scarcely perceptible on basement accelerograph and displacement meter.

#### EARTHQUAKE OF DECEMBER 15 NEAR QUITO, ECUADOR, SOUTH AMERICA

Epicenter in the region of Quito, Ecuador, South America.

*Quito*.—Surface waves scarcely perceptible.

#### NORTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 18

Epicenter in the Cape Mendocino area. Epicenter  $40.3^{\circ}$  north,  $124.5^{\circ}$  west. Maximum intensity VII at a few places.

*Ferndale*.—Figure 14. Maximum acceleration 56 cm./sec.<sup>2</sup> and computed maximum displacement 0.090 centimeter.

*Eureka*.—Figure 13. Maximum acceleration 13 cm./sec.<sup>2</sup> and computed maximum displacement 0.165 centimeter. Maximum displacement 0.02 centimeter recorded on displacement meter and maximum computed acceleration 4 cm./sec.<sup>2</sup>

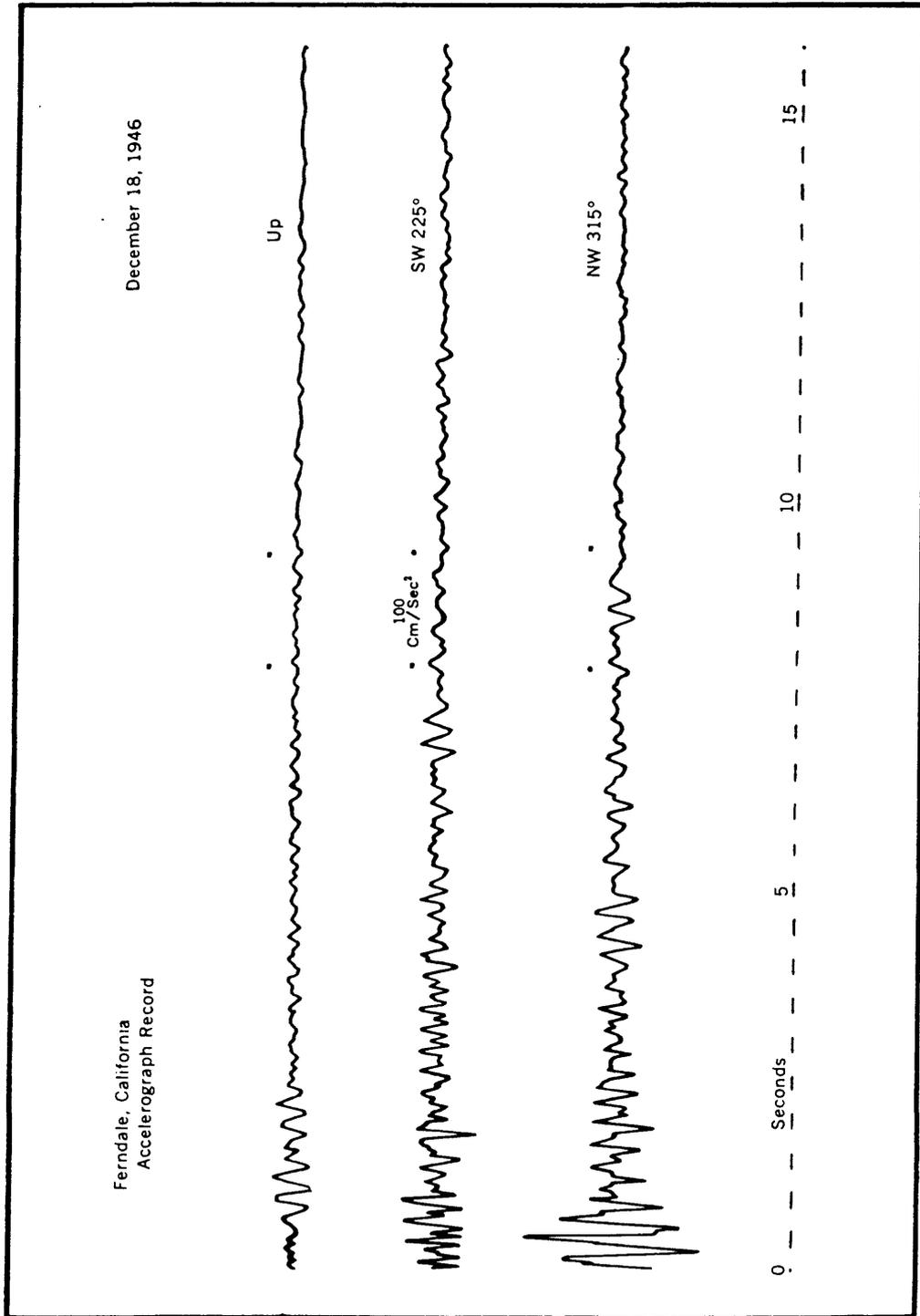


FIGURE 14.—Tracing of accelerograph record obtained at Ferndale on December 18.

**Table 4.—Summary of strong-motion seismograph data for the year 1946**

(See the text preceding this table for additional details. Simple harmonic motion is assumed when computing displacement from an accelerogram and when computing acceleration from a displacement-meter record.)

SOUTHERN CALIFORNIA EARTHQUAKE OF JAN. 8

Station and component	Earthwave period	Maximum acceleration	Maximum displacement	Remarks
El Centro accelerograph:	<i>Seconds</i>	<i>Cm./sec.<sup>2</sup></i>	<i>Cm.</i>	
Vertical-up.....	0.11	3	0.001	Irregular waves.
N. 0°.....	.18	3	.002	Weak.
	.23	8	.001	Possibly preceded by stronger motion.
	.15	7	.004	
	.20	3	.003	
E. 90°.....	.21	8	.009	Strong phase.
	.15	7	.004	
	.18	6	.005	Short periods superposed.
	.49	2	.012	

EARTHQUAKE OF JAN. 28 NEAR LIMA, PERU, SOUTH AMERICA

Lima accelerograph:				
Vertical-up.....	0.15	1	0.001	Very weak.
NW. 278°.....	.13	5	.002	
	.13	1	.001	Weak motion.
NE. 8°.....	.08	5	.001	
	.10	1	.001	Do.

FORESHOCK OF SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15

Los Angeles Subway Terminal, thirteenth floor accelerograph:				
Vertical-up.....	0.10	1	0.001	Very weak.
SW. 219°.....	.60	5	.046	Short periods superposed.
	.54	3	.022	
NW. 309°.....	.32	3	.008	Do.
Los Angeles Subway Terminal, sub-basement accelerograph:				
Vertical-up.....	.34	1	.003	Very weak.
SE. 129°.....	.50	1	.006	Do.
SW. 219°.....	.57	1	.008	Do.
Right displacement meter:				
NE. 39°.....	3.23	1	.02	Do.
Left displacement meter:				
SE. 129°.....	4.68	1	.06	Long period.
San Francisco Southern Pacific Bldg., fourteenth floor accelerograph:				
Vertical-up.....				Too weak.
SW. 226°.....	1.03	3	.081	Weak.
NW. 319°.....	1.21	8	.296	Sinusoidal waves.
San Francisco Southern Pacific Bldg., basement accelerograph:				
Vertical-up.....				Too weak.
NW. 319°.....	.77	1	.015	Very weak.
NE. 49°.....	1.09	1	.031	Do.
Right displacement meter:				
NW. 315°.....	.49	3	.02	Very weak.
	.63	3	.03	
Left displacement meter:				
NE. 45°.....	.63	2	.02	Do.
	.66	3	.03	

SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15

Los Angeles Chamber of Commerce, eleventh floor accelerograph:				
Vertical-up.....	0.72	1	0.013	Short-period waves superposed.
SW. 226°.....	1.58	22	1.034	Irregular strong waves.
	.94	3	.067	Weak.
	1.16	3	.102	
NW. 310°.....	1.24	22	.836	Strong waves.
	.84	3	.054	
	1.11	3	.091	
Los Angeles Chamber of Commerce, basement accelerograph:				
Vertical-up.....	.67	2	.023	
SE. 130°.....	.50	4	.025	Weak motion.
	.38	1	.004	
SW. 220°.....	.42	12	.054	
	.48	1	.006	Weak.

Table 4.—Summary of strong-motion seismograph data for the year 1946—Continued

## SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15—continued

Station and component	Earthwave period	Maximum acceleration	Maximum displacement	Remarks
Los Angeles Subway Terminal, thirteenth floor accelerograph:	<i>Seconds</i>	<i>Cm./sec.<sup>2</sup></i>	<i>Cm.</i>	
Vertical-up.....	.14	3	.001	Irregular waves.
SW. 219°.....	.70	4	.050	Irregular waves.
	.31	2	.005	Do.
	.61	2	.019	Sinusoidal waves.
NW. 309°.....	.68	1	.012	
	.29	1	.002	Do.
	.61	1	.009	
Los Angeles Subway Terminal, sub-basement accelerograph:				
Vertical-up.....	.21	1	.001	Do.
SE. 129°.....	.90	2	.041	Short periods superposed.
	.38	4	.015	
	.83	1	.018	
SW. 219°.....	.83	1	.018	Irregular waves.
Right displacement meter:	.70	5	.062	
NE. 39°.....	1.56	4	.27	Strong regular waves.
	3.88	1	.26	Long period.
Left displacement meter:				
SE. 129°.....	1.33	4	.18	Superposed wave.
	5.64	1	.32	Irregular long period.
Hollywood Storage Co., penthouse accelerograph:				
Vertical-up.....	.46	4	.022	Short-period waves superposed.
	.39	1	.004	
S. 180°.....	.73	16	.216	Irregular waves.
	.61	8	.075	Sinusoidal waves.
	1.41	7	.348	Do.
E. 90°.....	.41	2	.009	Do.
	.46	8	.042	Do.
	.54	12	.089	
Hollywood Storage Co., basement accelerograph:				
Vertical-up.....	.45	2	.005	Weak irregular waves.
E. 90°.....	.38	1	.004	Do.
	.37	5	.017	
S. 180°.....	.48	2	.012	Short periods superposed.
	.90	3	.062	
	.46	2	.011	
Hollywood Storage Co., P. E. lot accelerograph:				
Vertical-up.....	.50	2	.013	Weak irregular waves.
E. 90°.....	.50	1	.006	Irregular waves.
	.29	5	.011	
S. 180°.....	.50	1	.006	Do.
	.52	5	.034	
	.62	1	.010	
San Francisco Southern Pacific Bldg., fourteenth floor accelerograph:				
Vertical-up.....				Too weak.
SW. 229°.....	1.01	4	.103	Short periods superposed.
	1.03	3	.081	
NW. 319°.....	1.08	7	.210	
	1.11	6	.185	Regular waves.
San Francisco Southern Pacific Bldg., basement accelerograph:				
Vertical-up.....				Too weak.
NW. 319°.....	.56	1	.008	Very weak.
NE. 49°.....	.58	1	.009	Do.
Right displacement meter:				
NW. 319°.....	.56	3	.02	Irregular waves.
	.63	3	.02	
Left displacement meter:				
NE. 49°.....	1.48	1	.06	Do.
	.63	1	.01	
San Jose Bank of America, thirteenth floor accelerograph:				
Vertical-up.....				Too weak.
NE. 60°.....	1.63	4	.268	Sinusoidal waves.
SE. 150°.....	1.79	2	.163	Do.
San Jose Bank of America, basement accelerograph:				
Vertical-up.....				Too weak.
NE. 60°.....				Do.
SE. 150°.....				Do.
Pasadena accelerograph:				
Vertical-up.....	.61	1	.009	Irregular waves.
	.74	1	.014	
S. 180°.....	.70	3	.037	Do.
	.72	1	.013	
W. 270°.....	.88	4	.079	Do.
	.79	2	.031	
Right displacement meter:				
N. 0°.....	1.44	3	.17	Regular sinusoidal waves.
	1.05	1	.04	
Left displacement meter:				
E. 90°.....	1.12	11	.35	Possibly preceded by stronger motion.
	1.01	5	.12	

Table 4.—Summary of strong-motion seismograph data for the year 1946—Continued  
SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15—continued

Station and component	Earthwave period	Maximum acceleration	Maximum displacement	Remarks
	<i>Seconds</i>	<i>Cm./sec.<sup>2</sup></i>	<i>Cm.</i>	
Santa Barbara accelerograph:				
Vertical-up.....	.82	4	.068	Smooth regular wave.
.....	.63	2	.020	
.....	.54	2	.015	Very weak.
NE. 45°.....	.92	9	.193	Strong irregular motion.
.....	.61	2	.019	
SE. 135°.....	.98	6	.146	Irregular waves.
.....	.87	5	.096	
.....	.65	2	.021	Weak.
Long Beach accelerograph:				
Vertical-up.....	1.38			Too weak.
N. 0°.....	1.60	1	.025	Very weak.
E. 90°.....	1.08	1	.029	Do.
Oakland City Hall, sixteenth floor accelerograph:				
Vertical-up.....				Too weak.
NE. 25°.....	1.01	1	.026	Sinusoidal waves.
SE. 115°.....	1.23	8	.301	Do.
.....	1.28	8	.328	
Oakland City Hall, basement accelerograph:				
Vertical-down.....				Too weak.
SW. 205°.....				Do.
NW. 295°.....				Do.
San Bernardino Weed seismograph:				
SE. 135°.....	.79	1	.016	Very weak.
.....	1.14	1	.032	
NE. 45°.....	1.01	1	.026	Do.
Vernon accelerograph:				
Vertical-up.....	.89	1	.020	Weak.
SW. 188°.....	.61	2	.019	Short periods superposed.
.....	.87	1	.019	
NW. 278°.....	.43	2	.009	Irregular waves.
.....	.91	1	.021	
Westwood accelerograph:				
Vertical-up.....	.37	1	.003	Do.
.....	.59	1	.009	
E. 90°.....	.49	4	.024	Do.
.....	.43	1	.005	
S. 180°.....	.32	2	.005	Do.
.....	.32	3	.008	

AFTERSHOCKS OF SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15

Los Angeles Subway Terminal, thirteenth floor accelerograph:				
Vertical-up.....				Too weak.
SW. 219°.....	0.61	2	0.019	Weak.
.....	.66	1	.011	
NW. 309°.....	.51	1	.007	Do.
Vertical-up.....	.25	1	.002	
SW. 219°.....	.55	5	.038	Short periods superposed.
.....	.59	4	.035	
NW. 309°.....	.51	3	.020	Weak.
.....	.45	4	.021	
Los Angeles Subway Terminal, sub-basement accelerograph:				
Vertical-up.....	.27			Very weak.
SE. 129°.....	.50	1	.006	Do.
SW. 219°.....	.30	1	.002	Do.
Right displacement meter:				
NE. 39°.....	.36	1	.01	Weak irregular waves.
Left displacement meter:				
SE. 129°.....	1.05	1	.02	Do.
Hollywood Storage Co., penthouse accelerograph:				
Vertical-up.....				Too weak.
S. 180°.....	1.38	2	.082	Sinusoidal waves.
.....	1.17	1	.035	
E. 90°.....	.46	1	.005	Weak.
Hollywood Storage Co., basement accelerograph:				
Vertical-up.....				Too weak.
E. 90°.....				Do.
S. 180°.....	1.04	1	.027	Very weak.
Hollywood Storage Co., P. E. lot accelerograph:				
Vertical-up.....				Too weak.
E. 90°.....				Do.
S. 180°.....				Do.
San Francisco Southern Pacific Bldg., fourteenth floor accelerograph:				
Vertical-up.....				Do.
SW. 229°.....	1.11	2	.062	
NW. 319°.....	1.19	1	.036	Weak.
Vertical-up.....				Too weak.
SW. 229°.....	1.03	1	.027	
NW. 319°.....	1.11	1	.031	
Vertical-up.....	.13	1	.001	Very weak.
SW. 229°.....	.92	1	.022	Do.
NW. 319°.....	.94	1	.023	Do.

Table 4.—Summary of strong-motion seismograph data for the year 1946—Continued  
AFTERSHOCKS OF SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15—continued

Station and component	Earthwave period	Maximum acceleration	Maximum displacement	Remarks
San Francisco Southern Pacific Bldg., basement accelerograph:	Seconds	Cm./sec. <sup>2</sup>	Cm.	
Vertical-up				Too weak.
NW. 319°				Do.
NE. 49°				Do.
Vertical-up				Do.
NW. 319°				Do.
NE. 49°				Do.
Right displacement meter:				
NW. 315°				Very weak long-period waves.
Left displacement meter:				
NE. 45°	2.19			Do.
San Jose Bank of America, thirteenth floor accelerograph:				
Vertical-up				Too weak.
NE. 60°	1.82	1	.084	
SE. 150°	1.54	1	.060	
Vertical-up				Do.
NE. 60°	1.82	2	.168	Sinusoidal waves.
	1.82	2	.168	
SE. 150°	1.76	1	.078	
San Jose Bank of America, basement accelerograph:				
Vertical-up				Too weak.
NE. 60°				Do.
SE. 150°				Do.
Vertical-up				Do.
NE. 60°				Do.
SE. 150°	1.78			
HAWTHORNE, NEV., EARTHQUAKE OF MAR. 17				
Hawthorne accelerograph:				
Vertical-up	0.13	1	0.001	Very weak.
	.12	8	.003	Short periods superposed.
	.15	5	.002	
S. 180°	.15	2	.001	
	.28	15	.030	Do.
	.20	9	.009	
W. 270°	.22	2	.002	
	.09	11	.002	Strong phase.
	.26	10	.017	
	.19	5	.005	
EARTHQUAKE OF MAR. 29 NEAR QUITO, ECUADOR, SOUTH AMERICA				
Quito accelerograph				Surface waves scarcely perceptible.
NORTHERN CALIFORNIA EARTHQUAKE OF MAY 1				
San Francisco Southern Pacific Bldg., fourteenth floor accelerograph:				
Vertical-up				Very weak.
SW. 229°	0.75	11	0.157	Shorter periods superposed.
	1.02	3	.078	Regular sinusoidal waves.
NW. 319°	.43	6	.028	Wave superposed on longer period waves.
	.90	9	.185	
	.92	6	.129	Regular waves.
San Francisco Southern Pacific Bldg., basement accelerograph:				
Vertical-up	.49	1	.006	Weak.
NW. 319°	.44	2	.010	Do.
NE. 49°	.44	2	.010	Do.
	.45	1	.005	Do.
Right displacement meter:				
NE. 49°	1.20	5	.20	Weak sinusoidal waves.
Left displacement meter:				
NW. 319°	.86	3	.05	Weak irregular waves.
	.96	4	.09	
San Francisco Shell Bldg., Twenty-ninth floor Weed seismograph:				
E. 90°	.70	1	.002	Sinusoidal wave.
	.70	1	.002	
N. 0°				Very weak.

Table 4.—Summary of strong-motion seismograph data for the year 1946—Continued

NORTHERN CALIFORNIA EARTHQUAKE OF MAY 1—continued

Station and component	Earthwave period	Maximum acceleration	Maximum displacement	Remarks
Oakland City Hall, Sixteenth floor accelerograph:	<i>Seconds</i>	<i>Cm./sec.<sup>2</sup></i>	<i>Cm.</i>	
Vertical-up.....	0.36	2	0.006	Shorter periods superposed.
NE. 25°.....	.38	1	.004	Do.
SE. 115°.....	1.03	6	.162	
	1.01	3	.078	
	1.01	9	.234	
	1.06	5	.140	Regular sinusoidal waves.
Oakland City Hall, basement accelerograph:				
Vertical-down.....				Very weak.
SW. 205°.....				Do.
NW. 295°.....				Do.
San Jose Bank of America, Thirteenth floor accelerograph:				
Vertical-up.....	.19	1	.001	Weak irregular waves.
NE. 60°.....	1.28	3	.123	Shorter periods superposed.
SE. 150°.....	1.68	2	.143	Sinusoidal waves.
	.51	4	.026	Irregular waves.
	.56	3	.024	Do.
	1.70	4	.293	Sinusoidal waves.
San Jose Bank of America, basement accelerograph:				
Vertical-up.....				Very weak.
NE. 60°.....	.52	1	.007	Do.
SE. 150°.....	.47	1	.006	Do.
	.88	1	.020	Do.

NORTHERN CALIFORNIA EARTHQUAKE OF MAY 28

San Francisco Southern Pacific Bldg., fourteenth floor accelerograph:				
Vertical-up.....	0.12	1	0.001	Very weak.
SW. 229°.....	.81	1	.017	Weak.
NW. 319°.....	1.04	3	.079	Regular sinusoidal waves.
	.96	1	.023	
San Francisco Southern Pacific Bldg., basement accelerograph:				
Vertical-up.....				Very weak.
NW. 319°.....				Do.
NE. 49°.....				Do.
Left displacement meter:				
NW. 319°.....				Do.
Right displacement meter:				
NE. 49°.....	.90	5	.10	Do.

NORTHERN CALIFORNIA EARTHQUAKE OF MAY 29

Hollister Weed seismograph:				
SW. 225°.....	0.19	4	0.004	
SE. 135°.....	.42	2	.006	Irregular motion.
	.05	4	.001	
	.09	3	.001	

NORTHERN CALIFORNIA EARTHQUAKE OF AUG. 14

San Francisco Southern Pacific Bldg., fourteenth floor accelerograph:				
Vertical-up.....				Very weak long-period waves.
SW. 229°.....				Do.
NW. 319°.....	0.84	2	0.036	Irregular long-period waves.
	.88	1	.020	Do.
San Francisco Southern Pacific Bldg., basement accelerograph:				
Vertical-up.....				Very small motion.
NW. 319°.....				Do.
NE. 49°.....				Do.
Right displacement meter:				
NW. 319°.....				Very small long-period waves.
Left displacement meter:				
NE. 49°.....				Do.

EARTHQUAKE OF DEC. 15 NEAR QUITO, ECUADOR, SOUTH AMERICA

Quito accelerograph.....				Surface waves scarcely perceptible.
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Table 4.—Summary of strong-motion seismograph data for the year 1946—Continued

## NORTHERN CALIFORNIA EARTHQUAKE OF DEC. 18

Station and component	Earthwave period	Maximum acceleration	Maximum displacement	Remarks
Ferndale accelerograph:	<i>Seconds</i>	<i>Cm./sec.<sup>2</sup></i>	<i>Cm.</i>	
Vertical-up.....	0.10	3	0.001	Weak at beginning.
	.26	20	.034	Strong waves.
	.22	11	.013	Irregular waves.
	.22	7	.009	
SW. 225°.....	.11	20	.006	Possibly preceded by stronger motion.
	.14	22	.011	Strong waves.
	.13	11	.005	Irregular waves.
	.30	11	.024	Sinusoidal waves.
	.49	2	.012	Short-period waves superposed on long-period waves.
NW. 315°.....	.25	56	.090	Possibly preceded by stronger motion.
	.14	26	.013	
	.24	18	.027	Regular waves.
	.25	10	.016	Do.
	.41	2	.009	Irregular long-period waves.
Eureka accelerograph:				
Vertical-up.....	.14	8	.004	Regular waves.
	.10	3	.001	
	.12	3	.001	
NE. 79°.....	.14	6	.003	Possibly preceded by stronger motion
	1.15	5	.165	Long-period wave.
SE. 169°.....	.34	3	.009	Weak.
	.11	5	.002	Irregular motion.
	.25	3	.005	Weak.
Right displacement meter:				
SE. 169°.....	1.44	4	.02	Possibly preceded by stronger motion.
Left displacement meter:				
SW. 259°.....	1.32	1	.02	Very weak.
	1.52	1	.02	Do.

Table 5.—Instrumental constants of strong-motion seismographs in 1946

Station and instrument	Orientation of instrument <sup>1</sup>	Pendulum period	Static magnification	Sensitivity <sup>2</sup>	Damping ratio	Instrument No.
SOUTHERN CALIFORNIA EARTHQUAKE OF JAN. 8						
El Centro accelerograph No. 4.....	Up.....	Sec. 0.099	76	Cm. 1.93	12	V-10
	N. 0°.....	.099	77	1.91	8	L-4
	E. 90°.....	.100	77	1.94	11	T-15
EARTHQUAKE OF JAN. 28 NEAR LIMA, PERU, SOUTH AMERICA						
Lima accelerograph No. 44.....	Up.....	0.099	84	2.08	8.7	V-7
	NW. 278°.....	.097	85	2.03	6.7	L-2
	NE. 8°.....	.105	77	2.16	6.9	T-17
SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15						
Los Angeles Chamber of Commerce: <sup>3</sup> Eleventh floor accelerograph No. 42.....	Up.....	0.099	80	1.98	8.5	V-115
	SW. 220°.....	.098	82	2.00	9	L-95
	NW. 310°.....	.098	80	1.95	9	T-105
Basement accelerograph No. 21.....	Up.....	.067	107	1.22	10	V-28
	SE. 130°.....	.067	109	1.24	7	L-9
	SW. 220°.....	.068	111	1.28	8	T-26
Los Angeles Subway Terminal: <sup>3</sup> Thirteenth floor accelerograph No. 39.....	Up.....	.101	83	2.15	11	V-112
	SW. 219°.....	.100	81	2.05	8	L-92
	NW. 309°.....	.100	79	2.01	11	T-102
Sub-basement accelerograph No. 3.....	Up.....	.069	116	1.40	9	V-58
	SE. 129°.....	.069	118	1.43	9	L-59
	SW. 219°.....	.070	120	1.48	11	T-60
Sub-basement displacement meter No. 13.....	NE. 39°.....	10.0	1		9	
	SE. 129°.....	10.3	1		11	

See footnotes at end of table.

**Table 5.—Instrumental constants of strong-motion seismographs in 1946—Continued**  
**SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15—continued**

Station and instrument	Orientation of instrument <sup>1</sup>	Pendulum period	Static magnification	Sensitivity <sup>2</sup>	Damping ratio	Instrument No.
Hollywood Storage Co.: <sup>3</sup> Penthouse accelerograph No. 40	Up	.101	81	2.04	10	V-113
	S. 180°	.099	84	2.04	8	L-93
	E. 90°	.100	79	2.00	9	T-103
Basement accelerograph No. 22	Up	.069	105	1.26	8	V-25
	E. 90°	.070	111	1.32	9	L-3
	S. 180°	.070	110	1.36	7	T-18
P. E. lot accelerograph No. 1	Up	.069	108	1.30	9	V-66
	E. 90°	.069	108	1.30	7	L-64
	S. 180°	.069	111	1.34	8	T-65
San Francisco Southern Pacific Bldg.: <sup>3</sup> Fourteenth floor accelerograph No. 34	Up	.101	75	1.94	8	V-108
	SW. 229°	.102	73	1.92	10	L-88
	NW. 319°	.102	76	2.01	27	T-98
Basement accelerograph No. 27	Up	.068	115	1.35	10	V-110
	NW. 319°	.068	117	1.37	15	L-90
	NE. 49°	.068	111	1.30	11	T-100
Basement displacement meter No. 18	NW. 319°	9.88	1		9.4	
	NE. 49°	9.75	1		11.8	
San Jose Bank of America: <sup>3</sup> Thirteenth floor accelerograph No. 35	Up	.101	80	2.06	10	V-107
	NE. 60°	.098	78	1.91	13	L-87
	SE. 150°	.098	77	1.87	9	T-97
Basement accelerograph No. 8	Up	.069	110	1.32	15	V-49
	NE. 60°	.068	113	1.32	9	L-50
	SE. 150°	.068	116	1.36	9	T-51
Pasadena accelerograph No. 7	Up	.101	76	1.97	10	V-114
	S. 180°	.100	79	2.00	9	L-94
	W. 270°	.099	72	1.79	10	T-104
Displacement meter No. 17	N. 0°	10.4	1		11	
	E. 90°	10.0	1		13	
	Up	.101	78	2.02	7	V-55
Santa Barbara accelerograph No. 26	NE. 45°	.097	79	1.87	8	L-56
	SE. 135°	.099	77	1.91	9	T-57
	Up	.069	112	1.36	9	V-70
Long Beach accelerograph No. 24	N. 0°	.070	111	1.38	8	L-5
	E. 90°	.071	109	1.38	10.5	T-34
	Up	.103	75	2.03	8	V-109
Oakland City Hall: <sup>3</sup> Sixteenth floor accelerograph No. 37	NE. 25°	.101	78	2.00	12	L-99
	SE. 115°	.101	76	1.95	8	T-89
	Down	.067	117	1.33	10.6	V-12
Basement accelerograph No. 33	SW. 205°	.067	116	1.32	10.7	L-33
	NW. 295°	.067	112	1.27	9.7	T-16
	Up	.069	109	1.32	8.5	V-47
San Bernardino Weed seismograph No. 10	SW. 188°	.068	115	1.35	10	L-37
	NW. 278°	.067	116	1.32	9	T-48
	Up	.100	75	1.91	8	V-78
Vernon accelerograph No. 41	E. 90°	.099	75	1.87	7	L-76
	S. 180°	.097	74	1.75	8	T-77
	Up	.103	75	2.03	8	V-109

**FORESHOCKS AND AFTERSHOCKS OF SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 15**

No change in constants of instruments.

**HAWTHORNE, NEV., EARTHQUAKE OF MAR. 17**

Hawthorne accelerograph No. 25	Up	0.067	116	1.31	8	V-27
	S. 180°	.068	114	1.33	7.5	L-22
	W. 270°	.067	116	1.32	7.5	T-1

**EARTHQUAKE OF MAR. 29 NEAR QUITO, ECUADOR, SOUTH AMERICA**

Quito accelerograph No. 46	Up	0.097	83	1.98	7	V-132
	W. 270°	.097	80	1.90	8	L-125
	N. 0°	.097	83	1.97	7	T-128

**NORTHERN CALIFORNIA EARTHQUAKE OF MAY 1**

San Francisco Southern Pacific Bldg.: <sup>3</sup> Fourteenth floor accelerograph No. 34	Up	0.099	75	1.86	8	V-108
	SW. 229°	.102	73	1.92	13	L-88
	NW. 319°	.102	76	2.01	29	T-98
Basement accelerograph No. 27	Up	.067	115	1.33	14	V-110
	NW. 319°	.068	117	1.38	10	L-90
	NE. 49°	.068	111	1.31	11	T-100

See footnotes at end of table.

**Table 5.—Instrumental constants of strong-motion seismographs in 1946—Continued**  
**NORTHERN CALIFORNIA EARTHQUAKE OF MAY 1—continued**

Station and instrument	Orientation of instrument <sup>1</sup>	Pendulum period	Static magnification	Sensitivity <sup>2</sup>	Damping ratio	Instrument No.
Basement displacement meter No. 18	NW. 319°	9.81	1		13	
	NE. 49°	9.93	1		8	
San Francisco Shell Building: <sup>3</sup> Twenty-ninth floor Weed seismograph No. 2	E. 90°	.19	74	.67	2	
	N. 0°	.19	74	.67	2	
Oakland City Hall: <sup>3</sup> Sixteenth floor accelerograph No. 37	Up	.103	75	2.03	8	V-109
	NE. 25°	.101	78	2.00	12	L-99
	SE. 115°	.101	76	1.95	8	T-89
	Down	.067	117	1.33	10.6	V-12
Basement accelerograph No. 33	SW. 205°	.067	116	1.32	10.7	L-33
	NW. 295°	.067	112	1.27	9.7	T-16
	Up	.098	80	1.96	10.5	V-107
San Jose Bank of America: Thirteenth floor accelerograph No. 35	NE. 60°	.095	78	1.79	12	L-87
	SE. 150°	.096	77	1.79	9	T-97
	Up	.069	110	1.32	9	V-49
Basement accelerograph No. 8	NE. 60°	.068	113	1.32	8	L-50
	SE. 150°	.067	117	1.33	7	T-51
<b>NORTHERN CALIFORNIA EARTHQUAKE OF MAY 28</b>						
San Francisco Southern Pacific Bldg.: <sup>3</sup> Fourteenth floor accelerograph No. 34	Up	0.100	75	1.90	11.5	V-108
	SW. 229°	.102	73	1.92	12.6	L-88
	NW. 319°	.100	76	1.93	31	T-98
Basement accelerograph No. 27	Up	.067	115	1.33	14	V-110
	NW. 319°	.068	117	1.38	10	L-90
	NE. 49°	.068	111	1.31	11	T-100
Basement displacement meter No. 18	NW. 319°	9.8	1		9	
	NE. 49°	9.8	1		13	
<b>NORTHERN CALIFORNIA EARTHQUAKE OF MAY 29</b>						
Hollister Weed seismograph No. 8	SW. 225°	0.194	10.1	.96	4	
	SE. 135°	.192	10.1	.94	4	
<b>NORTHERN CALIFORNIA EARTHQUAKE OF AUGUST 14</b>						
San Francisco Southern Pacific Bldg.: <sup>3</sup> Fourteenth floor accelerograph No. 34	Up	0.099	75	1.86	8	V-108
	SW. 229°	.102	73	1.92	12.5	L-88
	NW. 319°	.101	76	1.97	9	T-98
Basement accelerograph No. 27	Up	.067	115	1.31	20	V-110
	NW. 319°	.068	117	1.37	29	L-90
	NE. 49°	.068	111	1.30	14	T-100
Basement displacement meter No. 18	NW. 319°	9.97	1		10	
	NE. 49°	9.80	1		14	
<b>EARTHQUAKE OF DECEMBER 15 NEAR QUITO, ECUADOR, SOUTH AMERICA</b>						
Quito accelerograph No. 46	Up	0.097	83	1.98	7	V-132
	W. 270°	.097	80	1.90	8	L-127
	N. 0°	.097	83	1.97	7	T-128
<b>NORTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 18</b>						
Ferndale accelerograph No. 28	Up	0.097	70	1.66	10	V-126
	SW. 225°	.089	71	1.76	12	L-124
	NW. 315°	.066	74	1.83	12	T-125
Eureka accelerograph No. 30	Up	.070	101	1.25	9	V-29
	NE. 79°	.069	106	1.27	10	L-13
	SE. 169°	.068	108	1.26	7	T-8
Displacement meter No. 13	SE. 169°	10.06	1		10	
	SW. 259°	10.04	1		10.5	

<sup>1</sup> The directions given indicate the direction of pendulum displacement relative to instrument pier, which will displace the trace upward on the original seismogram. Directions for the horizontal components are given first by quadrant followed by specific directions expressed in degrees measured from north around by east.

<sup>2</sup> The sensitivity is the number of centimeters on the seismogram that corresponds to 100 cm. sec.<sup>2</sup> of acceleration. The deflection corresponding to 1/10 gravity may be obtained by multiplying the sensitivity tabulated by 0.98.

<sup>3</sup> Instruments at this station are wired to start simultaneously.

#### **TILT OBSERVATIONS**

Two tiltmeters were operated at Berkeley, Calif., in cooperation with the University of California. The tiltgraph data obtained from these instruments during 1946 are shown in figure 15, inside back cover.

A third tiltmeter was operated intermittently at Long Beach, Calif.

#### **CORRECTIONS TO PREVIOUS PUBLICATIONS**

1945, Alaska time was published as 105th fifth meridian time. This should be 150th meridian time.

1945, page 27, the total of the Weed strong-motion seismograph column in table 3 should be 6.

## PUBLICATION NOTICES

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