UNITED STATES EARTHQUAKES

1938

SERIAL No. 629

U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY - WASHINGTON

U. S. DEPARTMENT OF COMMERCE
JESSE H. JONES, Secretary
COAST AND GEODETIC SURVEY
Leo Otis Colbert, Director

Serial No. 629

UNITED STATES EARTHQUAKES

1938

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CONTENTS

ILLUSTRATIONS

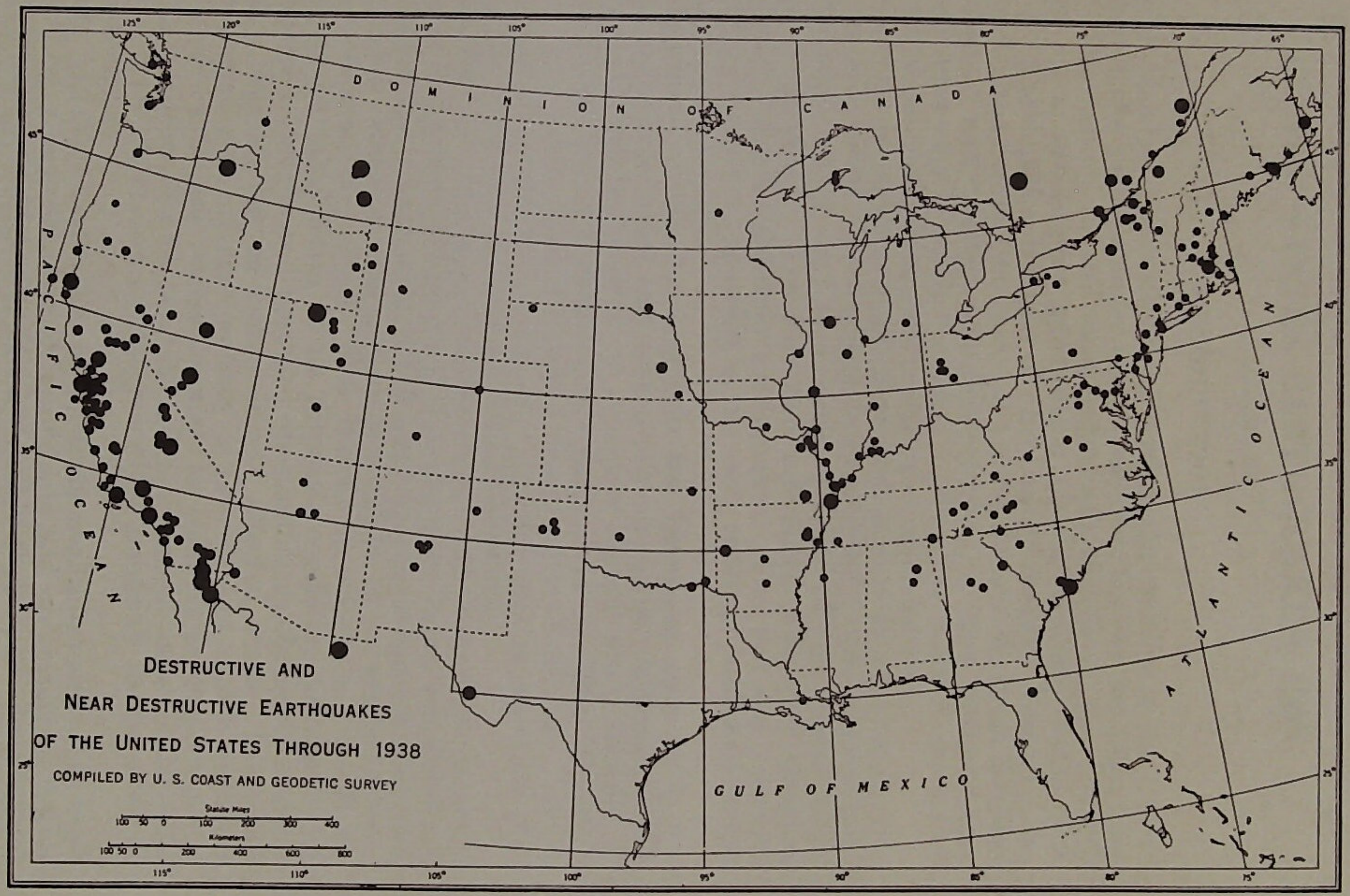

Figure 1.—Destructive and near destructive earthquakes of the United States through 1938.

UNITED STATES EARTHQUAKES, 1938

INTRODUCTION

This publication is a summary of earthquake activity in the United States and the regions under its jurisdiction for the calendar year 1938. The history of the more important shocks of the country appears in a two-volume publication of the Bureau, Serial 609, entitled "Earthquake History of the United States. Part I: Continental United States (Exclusive of California and Western Nevada) and Alaska," and "Earthquake History of the United States. Part II: California and Western Nevada." They are revised editions of Special Publications 149 and 191 which are now obsolete.

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 a recent bulletin of the Seismological Society of America.[1] 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 and Philippine Islands are not included, and only severe shocks are included in the case of the Philippine Islands, as complete reports are published by the local seismological institutions indicated in the lists of earthquakes for those regions. 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 Bureau 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.

Sources of information.—The noninstrumental information has been furnished by a large number of individuals and organizations whose voluntary cooperation has made it possible to prepare descriptions of the earthquakes of this country with a completeness and accuracy never before attained. Lack of space prohibits giving individual

[1] 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.

credit to all of the cooperators. The principal sources of information are as follows:

United States Weather Bureau.
Central office of the Jesuit Seismological Association at St. Louis, Mo.
The Seismological Field Survey of the Bureau at San Francisco, cooperating with the Seismological Laboratory of the California Institute of Technology, the Seismological Station of the University of California, and Stanford University. 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 earthquake-resistant qualities of their products are also active, together with various organizations of structural engineers and architects.
More recently the information service has been placed on a more efficient basis through the appointment of official collaborators, usually associated with local universities.
Telegraphic reports collected by Science Service, Washington.
Bulletins of the Seismological Society of America.
Interested individuals in various parts of the country.

In addition to the above sources of information, the Coast and Geodetic Survey, or its Seismological Field Survey at San Francisco, canvasses areas affected by shocks of unusual intensity, unless such work is undertaken by other organizations such as the Jesuit Seismological Association or by State and other interested geologists. In this way the extent and the maximum intensities of all heavy shocks are determined and the data are usually sufficient to construct isoseismal maps or, at least, maps of the affected areas. The Seismological Station of the University of California, Berkeley, (Perry Byerly in charge) and the Seismological Laboratory of the California Institute of Technology, at Pasadena, cooperate actively in the canvassing program of the Seismological Field Survey at San Francisco.

Note 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 San Francisco Field Station of the Bureau.

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 new 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 motor cars 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 motor cars 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 motor cars. (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. Disturbs persons driving motor cars. (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 the air.

An asterisk (*) indicates that the time is taken from an instrumental report and is reliable. In other instances quite large deviations are frequently reported.

In the case of California, earthquakes reported as feeble are not plotted on the epicenter map of the United States nor are minor aftershocks 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 when the epicenters are determined by other organizations such as the Seismological Station of the University of California under the direction of Prof. Perry Byerly or the Seismological Laboratory of the California Institute of Technology, at Pasadena. The bulletins of these institutions should be consulted for further details and often for data on additional shocks.

Time is indicated as continuous from 0 to 24 hours, beginning and ending at midnight. Local standard time is used.

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

Special report.—Attention is invited to a special quarterly report issued by the Bureau's 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 contained in noninstrumental reports collected in the region indicated.

INSTRUMENTAL RESULTS

Teleseismic results.—On page 34 is a list of Bureau and cooperating teleseismic stations for which the Bureau publishes results. The list of epicenters which follows the station list is for the year 1937 thus filling the void in the preceding publication of this series, Serial 619. It is expected that the list for 1938 will appear in the 1939 publication. Immediate epicenter determinations are frequently made through the cooperation of Science Service, the Jesuit Seismological Association, the Coast and Geodetic Survey, and individual stations and the results broadcast without delay to Europe and points in the Pacific. Postal card reports are also issued.

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 Bureau in connection with a broad cooperative program of seismological research being carried out on the Pacific coast between the Bureau 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 Bureau's Special Publication No. 201, "Earthquake Investigations in California, 1934–35."

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.

NONINSTRUMENTAL RESULTS

EARTHQUAKE ACTIVITY IN THE VARIOUS STATES

Arizona: Slight shock at Yuma on June 5.

Arkansas: Intensity IV earthquake originating in northeastern section on September 17 felt in adjoining states. Light shocks felt in the middle southwestern part on April 25 and in the northeast corner on June 17.

California: There were no earthquakes of outstending importance during the year. Intensity VI shocks occurred on February 12, May 31, August 30, Septem-

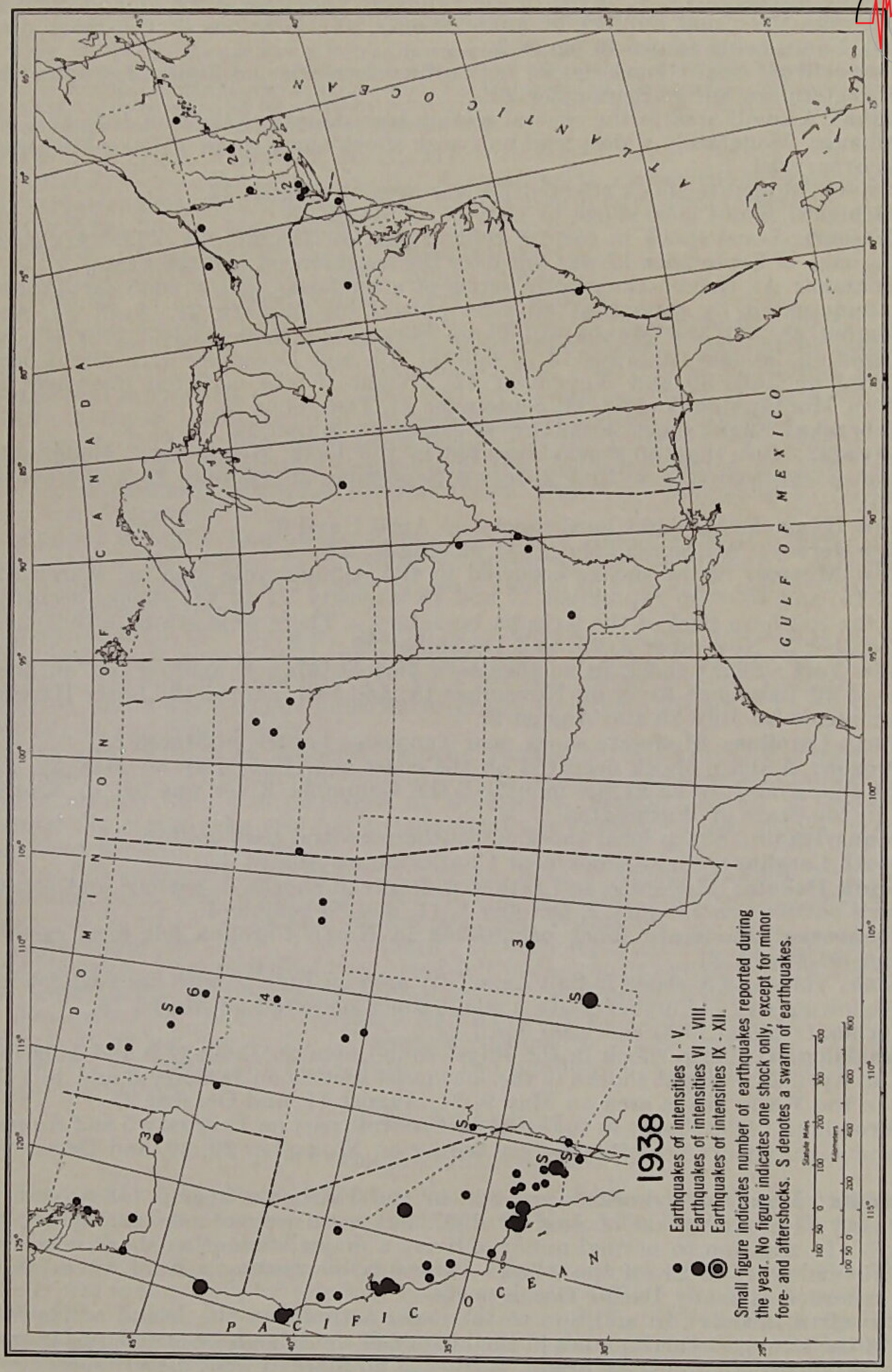

Figure 2.—Earthquake epicenters, 1938.

ber 11, and December 3 as shown in figure 7. Many localized shocks, some approaching intensity VI, occurred in the Imperial Valley on April 12 and June 5. There were the usual number of minor shocks, the locations of the more pronounced ones being shown in figure 2.

Connecticut: Slight local shocks in southwestern part on June 13, 14, and in southeastern section on September 20.

Idaho: A small area in the central section was sharply shaken on July 27.

Indiana: Moderately widespread but weak shock along shore of Lake Michigan on February 12.

Maine: Moderate shock affected Bangor area on August 22.

Michigan: Slight local shock in Detroit on March 13.

Missouri: Local shock in eastern central part on January 16. The Arkansas earthquake of September 17 was felt over the southern part of the State.

Montana: At Helena the steady series of aftershocks of the 1935 earthquake was punctuated by somewhat stronger shocks on January 21, April 24, and December 28. In the Manhattan-Three Forks area, moderately strong shocks occurred on January 10, June 13 (2 shocks), 15, and December 31. Slight ones occurred on July 30 and November 12. Slight shocks occurred elsewhere in western Montana on August 23, September 11, December 23.

Nebraska: Slight shock in northwest corner on March 24.

Nevada: More than 50 shocks were felt in the Lake Meade area, moderately strong shocks occurring on June 2, July 6, September 30, October 22, and November 10.

New Hampshire: Slight local shocks on April 1 and 3.

New Jersey: Widespread shock, V, on August 22.

New Mexico: Slight shocks occurred in the Albuquerque area on March 22, April 15, and 16. On September 17 and 18 intensity VI to VII shocks occurred near the southern part of the Arizona boundary. There were strong aftershocks on October 3, November 2, 26, and December 28.

New York: Slight shock in northeastern part on May 4; another felt on both sides of St. Lawrence River on November 18; and two more in the lower Hudson River region on July 29 and August 2.

North Carolina: Moderate shock near Tennessee border on March 31.

Oregon: A sharp shock occurred on the coast near Coos Bay on May 28. A slight shock on July 22 at the mouth of the Columbia River was felt in Astoria and in the State of Washington.

Pennsylvania: Sharp local shock in southern central part on July 15.

South Carolina: Slight shock near Charleston on August 4.

South Dakota: Moderate and rather widespread shocks in eastern and southeastern portions on January 2, October 1, 11, and November 4.

Tennessee: Moderate shock originating in North Carolina felt near eastern border on March 31.

Utah: Intensity V shock in Salt Lake City area on June 30 with light aftershock the following day. Further south a slight shock occurred on March 18.

Vermont: Slight local shock on April 12.

Washington: Sharp shock in the Puget sound area on January 6 and a lighter one on April 29. Slight shocks in the southwest section on January 3 and July 22 and in the Walla Walla area on May 9, 24, August 11, and October 27.

Wyoming: Light shocks in the southeast central part on February 5 and August 27 and slight shocks near the western border on November 29, 30, and December 1, 4.

Alaska: Many aftershocks were felt in the Fairbanks region following the intensity VIII earthquake of July 22, 1937, but none were of outstanding importance. In addition to normal minor activity a major submarine shock occurred on November 10 south of the Alaska Peninsula, generating a tidal wave which was recorded at many Pacific Ocean ports.

Hawaiian Islands: In addition to the usual activity on the Island of Hawaii, one of the strongest earthquakes in the history of the Islands occurred on January 22. Although of submarine origin, there was no marked tidal disturbance.

Philippine Islands: The strongest disturbance on August 29 reached intensity VIII in places. Other activity was of minor character.

Puerto Rico: Only one slight shock reported for the entire year.

Panama Canal Zone: There was only minor activity.

NORTHEASTERN REGION

[75TH MERIDIAN OR EASTERN STANDARD TIME]

NOTE.—In recent years a number of high-grade seismographs designed especially for recording local earthquakes have been installed in the Northeastern region greatly enhancing our knowledge of prevailing seismic activity and the accurate location of seismic foci. The bulletins of all seismographic stations in the region should therefore be consulted for additional information. "NESA" refers to the Northeastern Seismological Association having headquarters at Weston, Mass.

April 1: 17:15. Rochester, N. H., III.

April 3: —:—. Rochester, N. H. A sharp earth movement accompanied by an explosive noise shook houses in Rochester and nearby communities.

April 12: 20:—. Manchester, Vt. Slight shock.

May 4: 19:35. Malone, N. Y. Moderate shock.

June 13: 23:02. Bethel, Conn. Slight shock.

June 14: 14:30. Bethel, Conn. Very slight shock.

June 23: 22: 58.* Chelmsford, Mass. Epicenter 71°25′ north, 42°37′ west according to Weston College Seismological Observatory. Maximum intensity about IV. Area affected, about 60 square miles. See "The Chelmsford, Massachusetts, Earthquake of June 23, 1938" by Daniel Linehan, S. J., in the April 1940 number of the Bulletin of the Seismological Society of America.

July 29: 2:44. Upper Manhattan Island and the Bronx, N. Y. Sharp shock felt in parts of Westchester County and the Palisades section of New Jersey. Epicenter probably 30 miles north of New York City according to Fordham University report.

August 2: 5:02.* Southwest Connecticut and Westchester County, N. Y. Epicenter 41°05′ north, 73°42′ west, according to NESA bulletin. A shock of maximum intensity III to IV was felt from Bethel to Stamford, Connecticut, and in Westchester County, N. Y.

August 22: 7:48.* Bangor, Maine, and vicinity. Epicenter about 9 miles southwest of Bangor and about 5 miles west of Orrington, according to NESA bulletin. Maximum intensity IV to V in the region around Bangor. Area affected, about 3,500 square miles in eastern and southern Maine. The shock was not felt at any coast towns.

Intensity IV to V at Amherst, Bangor, Bucksport, Ellsworth, Hampden, and Hermon Pond. At Bangor loose objects were displaced and some windows broken. Loose objects were also displaced at Bucksport, Maine. At all of the places named the earthquake was felt by practically everyone. Some places reported rumbling sounds.

Also felt at Bar Harbor, Belfast, Costigan, East Newport, Madison, Old Town, Passadumkeag, and Waterville. Not felt at Augusta, Harrington, Lake View, Lewiston, Machais, Rockland, Skowhegan, and Wiscasset.

September 20: —:—. Connecticut. Tremors reported from Mystic, Moodus, and Norwich. An earthquake reported felt in the south central part of Hartford on September 21 was probably same shock but with error in date.

November 18: 17:19.* Northern New York and St. Lawrence River. Epicenter about 44°45′ north, 75°15′ west, according to NESA bulletin. Moderate shock felt at Ogdensburg and Canton. In Canada it was felt from Brockville to Cornwall, Ontario.

EASTERN REGION

[75TH MERIDIAN OR EASTERN STANDARD TIME]

March 31: 5:10. North Carolina-Tennessee boundary. A shock of intensity III to IV was felt over an area extending from Knoxville, Tennessee, to Asheville and Murphy, North Carolina.

July 15: 17:45. Southern Blair County, Pa. A shock of intensity V affected about 100 square miles of territory in the region of Clover Creek just west of the foot of the Tussey Mountains. An investigation in the field was made by Dr. H. Landsberg of the Pennsylvania State College. His report on the earthquake is published in the October 1938 number of the Bulletin of the Seismological Society of America. The descriptive material which follows is abstracted from that report. The macroseismic epicenter was in Clover Creek Valley about 1 mile south of Beavertown at 40°22′ north, 78°14′ west. Fallen objects were reported from Beavertown, Clover Creek Valley, and Martinsburg. At Henrietta a few dishes were broken. Wells were also affected in Clover Creek Valley. Reports were obtained from a total of 23 places.

August 4: 19:14. Near Charleston, S. C. Light shock felt at Isle of Palms, a beach resort near Charleston, S. C.

August 22: 22:36* Central New Jersey. Epicenter 40°08′ north, 74°32′ west, about 15 miles southeast of Trenton. Maximum intensity about V. Area affected, slightly less than 5,000 square miles. See map.

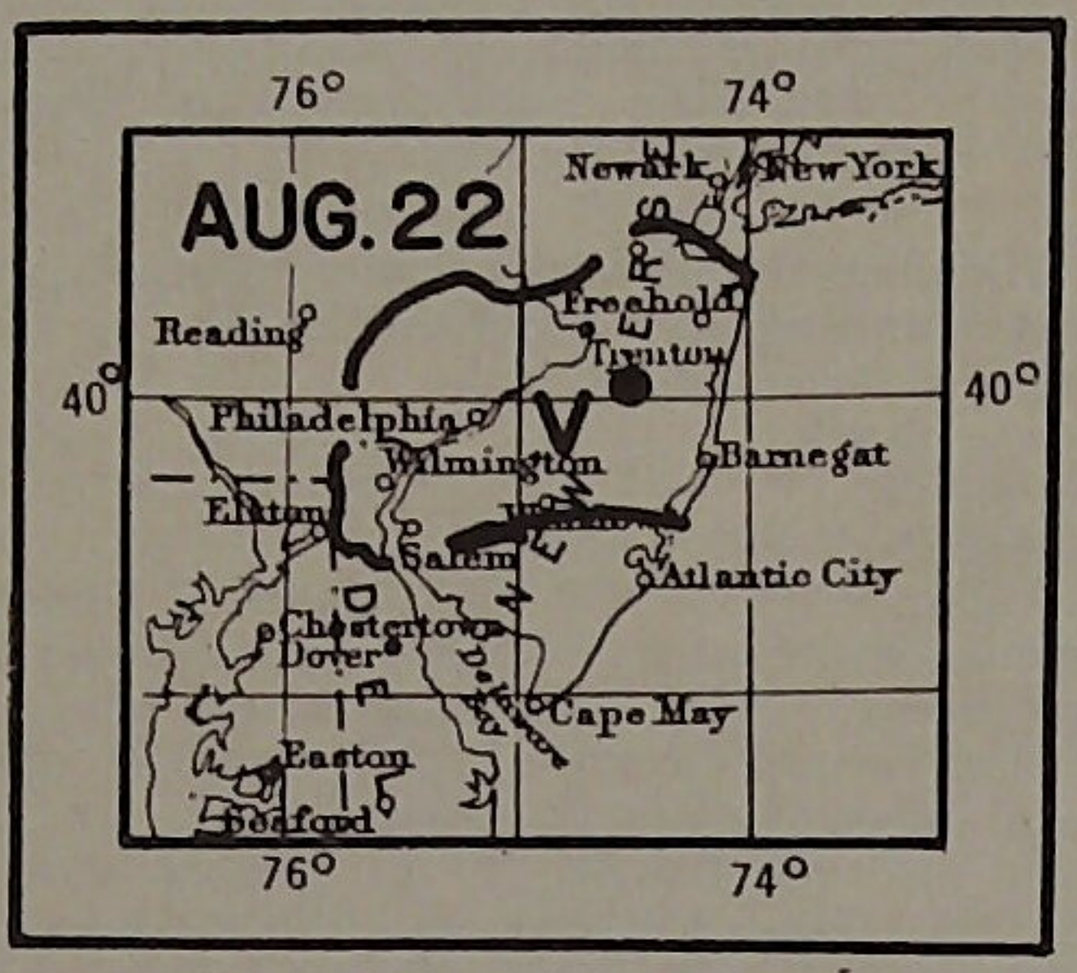

Figure 3.—Area affected by the central New Jersey earthquake of August 22, 1938.

The shock had its origin in the western corner of Monmouth County according to an analysis of instrumental data obtained at the Franklin Institute, Philadelphia, and Fordham University, New York, and this location was verified by a canvas of the affected area. Superficial damage occurred in only a few instances. An unusual feature of the disturbance was the breaking of a window in a house in Patterson, Putnam County, N. Y., 110 miles from the center of the disturbance and far outside of the affected area.

A second strong shock occurred in the same area at 4:04 on July 23, and a weaker shock at 8:11. Minor shocks occurred on the 23d at 2:10, 2:20, and 4:05. A strong aftershock occurred on August 27 at 19:36.

Intensity V: In New Jersey, at Barrington, Clarksburg, Freehold, Gloucester City, Haddonfield, Hightstown, Lakewood, New Egypt, Pitman, Roebling, South

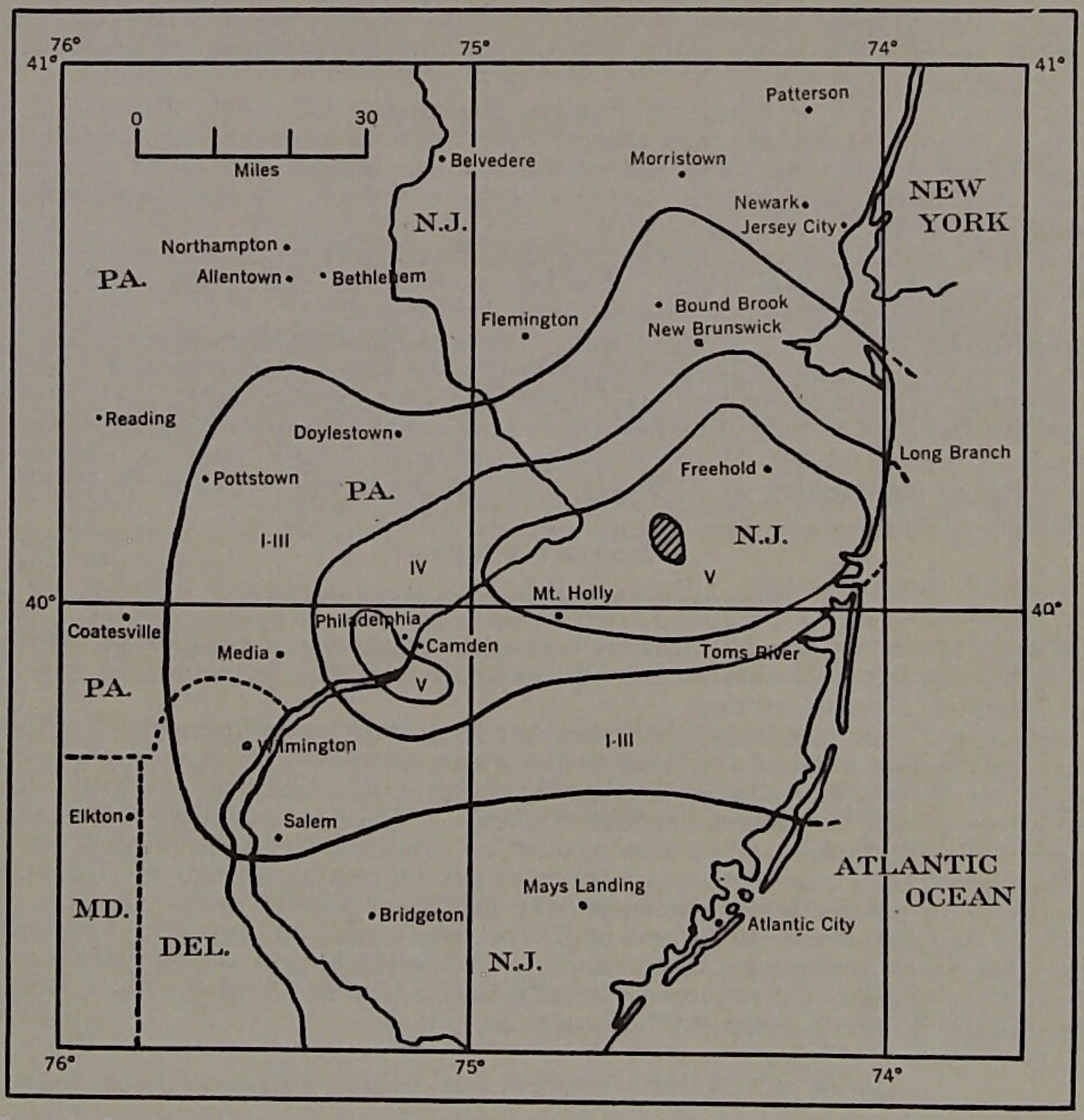

Figure 4.—Isoseismal map of the central New Jserey earthFuake of August 22, 1938, on enlarged scale.

River, Whiting, and Yardville. At Clarksburg and Hightstown the movement was noticed by persons riding in automobiles. At Gloucester City and Hightstown some glassware was broken. At Pittman some furniture was displaced. At a number of places rumbling subterranean sounds were heard.

Intensity V: In Pennsylvania, at Ardmore, Darby, Jenkintown, Morrisville, Philadelphia, Upper Darby. At Ardmore some glassware and a few windows were broken. At Darby, Morrisville, and Philadelphia loose objects moved.

Intensity IV: In New Jersey, at Asbury Park, Bernardsville, Bordentown, Camden, Clementon, Creamridge, Long Branch, Magnolia, Maple Shade, Mount Holly, Pennington, Trenton, Wenonah, Windsor, and Woodbury.

Intensity IV: In Pennsylvania, at Bristol, Bryn Mawr, Fallsington, and Glenside.

Intensity III and under: In New Jersey, at Ashland, Atco, Barnegat, Bound Brook, Chatsworth, Dover, Englishtown, Glassboro, Hopewell, Lambertville, Moorestown, Morristown, Paulsboro, Penns Grove, Salem, Princeton Junction, Swedesboro, and Williamstown.

Intensity III and under: In Pennsylvania, at Allentown, Doylestown, Downingtown, Phoenixville, Easton, and Lansdale. In Delaware at Delaware City, Claymont, Newport, and Wilmington.

Not felt in New Jersey at Absecon, Atlantic City, Bridgeton, Cape May City, Clayton, Clinton, Egg Harbor City, Flemington, Frenchtown, Hackettstown, Hammonton, High Bridge, Mays Landing, Mendham, Milford, Millville, Minotola, Morristown, Newport, Newton, Paterson, Pleasantville, Port Norris, Raritan, Richland, Sandy Hook, Vineland, Washington, and Wildwood.

Not felt in Pennsylvania at Bloomsburg, Bethlehem, Carlisle, Coatesville, Emaus, Harrisburg, Honesdale, Lancaster, Lebanon, Lewistown, Nanticoke, Northampton, Plumsteadville, Quakertown, Reading, Scranton, Shamokin, Shenandoah, Sunbury, Tunkhannock, Wilkes-Barre, and York.

Not felt in Delaware at Bridgeville, Dover, Georgetown, Harrington, Lewes, Middletown, Milford, Milton, Newark, New Castle, Port Penn, and Smyrna.

Not felt at places canvassed in New York, Connecticut, and Maryland except at Patterson, New York as stated in the beginning of this report.

CENTRAL REGION

[90TH MERIDIAN OR CENTRAL STANDARD TIME]

January 2: 11:05. South Dakota, east central part, moderate shock felt in Beadle, Clark, and Spink Counties. Maximum intensity IV.

January 16: 22:18. Perryville, Mo. Slight shock felt at St. Mary's Seminary.

February 12: 0:27.* South shore of Lake Michigan. Felt in Indiana at points 30 miles south and southeast of the Lake. Maximum intensity about IV. Felt in Illinois at Chicago, Beverly Hills, and Washington Park; in Indiana at Chesterton, Dune Park, Gary, Knox, Shelby, South Bend, and Valparaiso; and in Michigan at Kalamazoo and Paw Paw. Recorded faintly on seismographs in Chicago.

March 13: Morning. Detroit, Mich. Slight shock.

March 24: 7:11. Nebraska, northwest corner. Slight shock felt at Fort Robinson, Chadron, and Harrison. A "finger butte" near Fort Robinson collapsed from the shock.

April 25: 23:42.* Arkansas, southwest of Little Rock. Epicenter just outside of Fendley and due west of Lenox according to the Geophysics Department of St. Louis University. Felt slightly at Point Cedar, Fendley, Amity, and Alpine.

June 17: —:—. Northeastern Arkansas. Slight shock felt at Luxora and Burdette.

September 17: 9:34.* Northeastern Arkansas. Epicenter 35°28′ north, 90°20′ west, about 32 miles southwest of Jonesboro, Ark., and about 29 miles northwest of Memphis, Tenn., according to Geophysics Department of St. Louis University. Maximum intensity IV. Area affected approximately 90,000 square miles, comprising almost the whole of Arkansas, much of Tennessee, Mississippi, and Missouri, and parts of Kentucky, Illinois, and Oklahoma.

A special investigation of this earthquake was made by the Geophysics Department of St. Louis University, and a complete report on it appears in the July 1939 number of the Bulletin of the Seismological Society of America under the title "The Arkansas earthquake of September 17, 1938," by Edward J. Walter. The map in this publication is reproduced from the map appearing in the article just quoted.

The main shock was accompanied by a foreshock and aftershock.

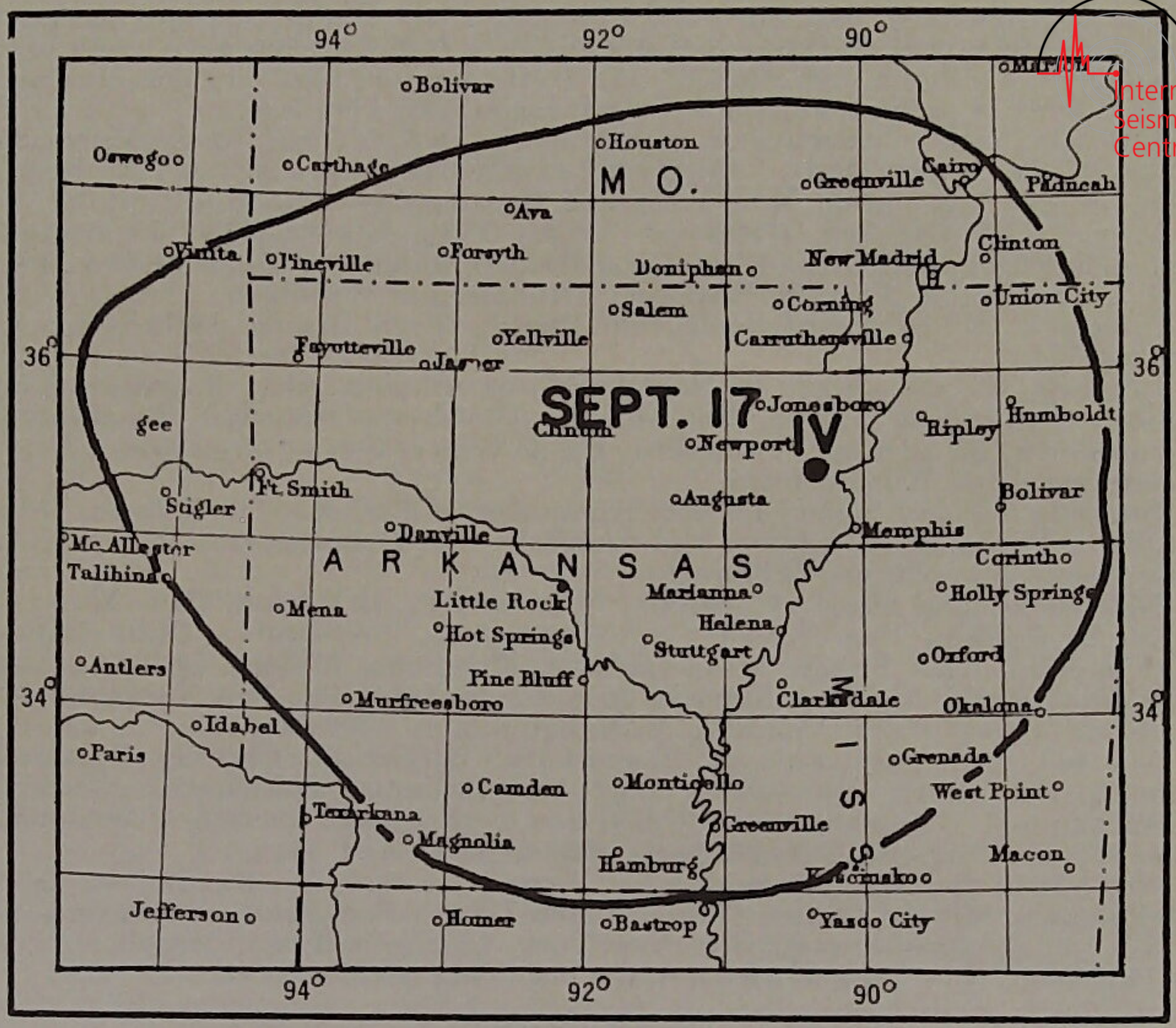

Figure 5.—Area affected by the Arkansas earthquake of September 17, 1938, based on a report by the Geophysics Department of St. Louis University.

October 1: 16:15. Southeastern section of South Dakota. Moderate shock was felt in Buffalo, Jerauld, Brule and Aurora Counties. The maximum intensity did not exceed IV.

October 11: 3:37. Sioux Falls, near eastern border of South Dakota. Maximum intensity approached V in the Sioux Falls area. Total area affected about 3,000 square miles. In Sioux Falls buildings were jarred, beds shook, dishes rattled, and pictures and other loose objects swayed. A rumbling subterranean noise came as a climax of the disturbance. The recording pens on water and electric meters at the municipal water works were jarred. The Sioux Falls police received more than 50 calls from anxious residents.

Intensity IV in South Dakota at Humboldt, Madison, Parker, Spencer, and Yankton; and in Minnesota at Hills.

Intensity III and under: In South Dakota at Canton, Centerville, Eagan, Hudson, Lennox, Salem, Sherman, and Vermillion. Not felt in South Dakota at Beresford, Brookings, Howard, Mitchell, Olidet; and in Minnesota at Luverne, Pipestone, and Worthington; in Iowa at Lester, Rock Rapids, Rock Valley, and Sheldon.

November 4: 16:10. South Dakota, slight shock felt at Academy, Lake Andes, Burke, Colome, Dallas, Gregory, and Platte; and in Nebraska at Butte, Bristow, and Spencer.

WESTERN MOUNTAIN REGION

[105TH MERIDIAN OR MOUNTAIN STANDARD TIME]

NOTE.—Only the more important of the aftershocks of the Helena, Mont., earthquakes of October 1935 are listed. Complete lists of the reports received are available in mimeographed form from the Director of the United States Coast and Geodetic Survey, Washington, D. C., and from W. E. Maughan, in charge of the local office of the United States Weather Bureau at Helena, who compiled the data.

Only the more important shocks felt at Boulder Dam are listed. The unabridged list is published in "Abstracts of Earthquake Reports for the Pacific Coast and Western Mountain Region."

January 10: 16:19. Manhattan, Mont. Moderately strong shock felt by many. Objects swung east to west. Some residents frightened.

January 21: 12:53. Helena, Mont. Moderate shock.

February 5: 9:00. Medicine Bow, Wyo. Slight shock.

March 18: Evening. Thistle, Utah. Slight shock. Felt within radius of 15 miles of Thistle.

March 22: 23:00. Los Lunas, N. Mex. Slight shock.

April 15: 14:00. Albuquerque, N. Mex. Slight shock.

April 16: 1:15. Albuquerque, N. Mex. Slight shock.

April 24: 11:23. Helena, Mont. Moderately strong shock, intensity IV, displaced a few light objects and dislodged merchandise in one store. Many persons reported hearing loud rumbling. The motion was bumping and jolting.

June 2: 21:28.* Boulder City, Nev. A moderate shock set off the accelerograph at Boulder Dam which was set to start with very slight motion. Felt by several at Boulder City and Boulder Dam.

June 5: 19:30. Yuma, Ariz. Very light shock.

June 13: 4:30. Manhattan, Mont., region. Strongest at Trident. At Logan many residents were awakened. Hanging objects swung and small objects, pictures, and dishes were displaced. At Manhattan a few residents were awakened. At Three Forks hanging objects swung north and south and many residents were awakened and frightened. At Trident plaster was cracked slightly in several homes. Many residents were awakened and frightened. Chandeliers swayed, bottles fell from shelves, pictures and many small objects were displaced.

June 13: 22:32. Manhattan, Mont., region. Strongest at Trident where the shock was of slightly less intensity than that which occurred at 4:30 on the same day. At Trident some rocks fell in a cement plant quarry and most of the disturbances reported in the earlier shock were observed again. Felt a'so at Logan, Manhattan, Three Forks, and West End.

June 15: 13:35. Manhattan, Montana, region. Strongest at Trident where a few light objects were displaced and only a few residents were alarmed. Much lighter than two preceding shocks. Felt also at Manhattan, Bozeman, Logan, Three Forks, and Butte.

June 30: 6:37.* Near Salt Lake City, Utah. In Salt Lake City the business district was shaken strongest. Many residents were awakened and there was slight swaying of suspended objects. Some trees and bushes shook slightly. Recorded on the seismograph at the University of Utah. At Murray pictures were displaced. At Saltair many were awakened and frightened. Trees and bushes shook slightly. Shock felt like an explosion several miles away. Also felt at Bingham, Canyon, and Garfield.

Not felt at the following places in Utah: Bountiful, Castle Rock, Coalville, Eureka, Farmington, Grantsville, Heber, Henefer, Kamas, Midvale, North Salt Lake, Ogden, Park City, Provo, Riverton, Tooele, Wasatch.

July 1: 11:14.* Near Salt Lake City, Utah. A very slight aftershock was felt and recorded on the seismograph of the University of Utah.

July 6: 10:20. Moderate shock felt by many in Boulder City and at Boulder Dam Power Plant.

July 27: 1:15, 1:30, and 3:00. Northwest Custer County, Idaho. Moderately strong shock reported to have centered at about 44°30′ north, 115°10′ west. Felt at Little Creek, Cougar Creek, Grayhound Lookout, Ruffneck Lookout, and Mahoney Lookout. Nearly all were awakened. Rumbling sounds were heard before and at time of shock. Hanging objects were heard striking against the walls and tin dishes rattled.

July 30: 15:45. Great Falls, Mont. Slight shock reported to have been felt by a few persons.

August and September: Gila National Forest, N. Mex. Forest rangers report almost daily occurrence of shocks in the vicinity of White Creek Ranger station on the west fork of Gila River about 40 miles northwest of Silver City. The greatest number of shocks occurred on September 19 and 20. Some of them were rather violent. Only the more important shocks are listed here. A large rock, perhaps 20 tons, was dislodged from a cliff above a C. C. C. side camp at White Creek and rolled down into the camp, breaking a corral fence. The camp was abandoned for several days.

August 4: 0:07. Helena, Mont. A moderate shock.

August 23: 4:00, about. Deer Lodge, Mont. Slight shock felt by several.

August 27: —:—. Marshall, Wyo. Slight.

September 11: 20:23. Little Bitter Root Valley, Mont. Moderate shock felt at Lonepine, Pleasant Valley, and Kalispell.

September 17: 10:20.* Arizona-New Mexico border about 33.2° north, 108.6° west. Maximum intensity VI to VII. Area affected, approximately 8,000 square miles as shown on map. The epicentral region was in a sparsely settled

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mountainous region not far from the continental divide, making it difficult to locate the exact point of maximum intensity from the noninstrumental data. The shock was reported strongest at Duncan and Clifton in Arizona, and in the southern part of Catron County, N. Mex. Later in the month it was reported that many rocks fell in the mountains near Buckhorn, N. Mex. This was the first of a series of shocks of decreasing intensity during the latter part of September.

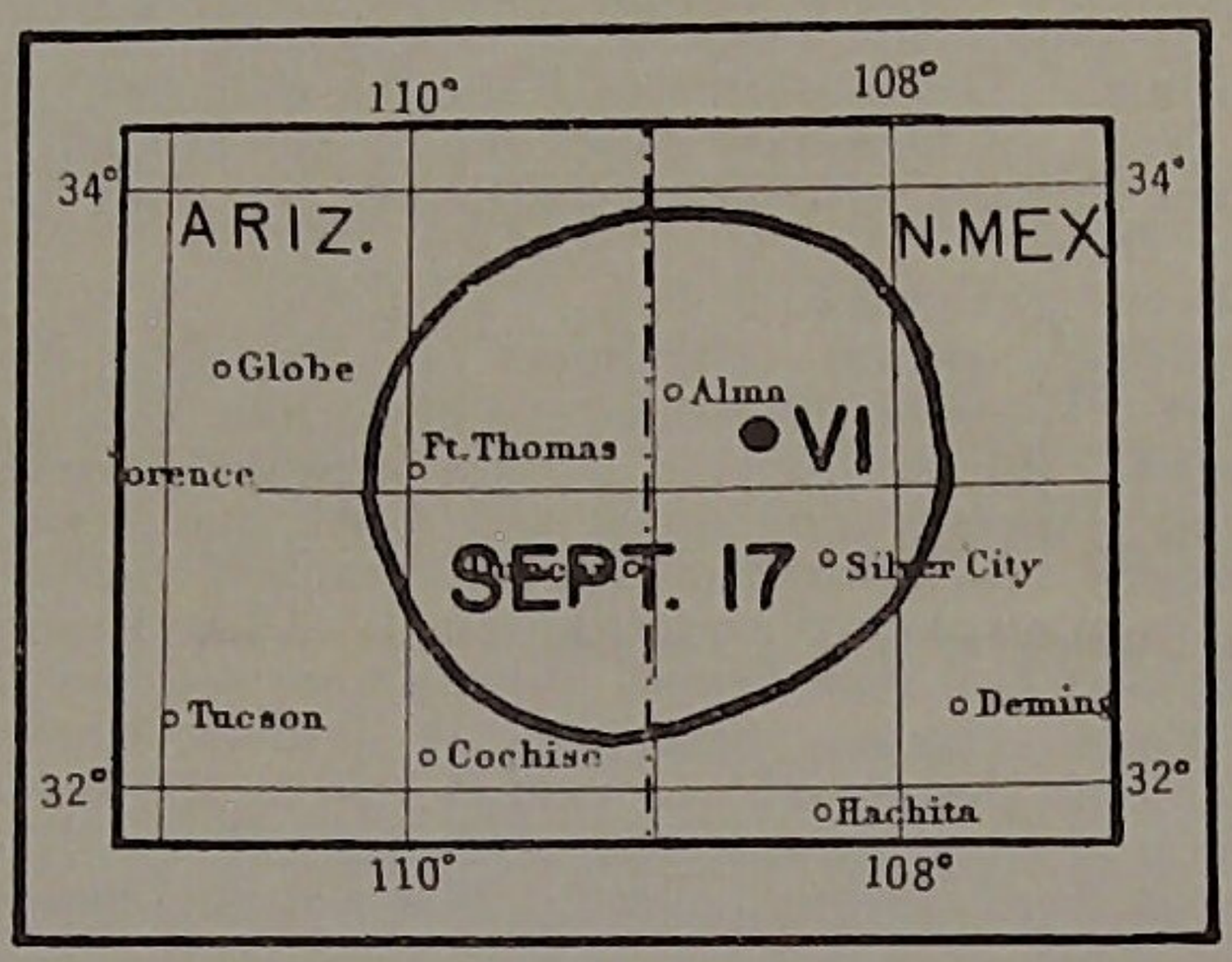


Figure 6.—Area affected by the Arizona-New Mexico border earthquake of September 17, 1938.

At Duncan, Ariz., hanging objects swung, small objects were disturbed and bottles fell from shelves. Plaster was cracked and some slight damage due to cracked walls was reported. It was reported felt outdoors by some. Roaring sounds were heard. At Clifton, Ariz., and in surrounding sections many objects were disturbed and trees and bushes were shaken. A deep rumble was heard by many. At a Forest Service ranger station near the head of the west fork of the Gila River in New Mexico, plaster fell, a chimney was cracked, and trees and bushes were shaken strongly.

The shock was also felt at Bylas, Fort Thomas, Franklin, Morenci, San Simon, Safford, and Thatcher in Arizona; and at Black Springs, Fierro, Fort Bayard, Lordsburg, Reserve, Rincon, and Tyrone in New Mexico.

None of the series of earthquakes was felt at the following places: In Arizona at Benson, Bowie, Elfrida, Oracle, Redington, San Carlos, Springerville, and Winkleman; in New Mexico at Aragon, Deming, Hachita, Lake Valley, Luna, Monticello, Red Hill, San Antonia, and Steins.

September 19: 22:40.* Arizona-New Mexico border. A strong aftershock of the earthquake of September 17. Reported strongest at Duncan, Ariz., where furnishings moved, vases overturned, and dishes broke. There was slight damage due to the cracking and fall of some old adobe walls. Many were awakened and a few frightened. It was also reported felt in Arizona at Morenci and Clifton, San Simon, and Safford; in New Mexico at Black Springs, Fort Bayard, Hillsboro, and Silver City.

September 29: 16:34.* Arizona-New Mexico border. A strong aftershock of the earthquake of September 17. Strongest at Clifton, Ariz., where some plaster fell. Also felt in Arizona at Duncan, Franklin, San Simon and Morenci, and in New Mexico at Black Springs, Fierro, Minbres, Tyrone, and Lordsburg.

September 30: 18:08.* Vicinity of Boulder Dam about 36.0° north, 114.9° west, according to Pasadena. Felt at Boulder Dam and in Boulder City. The accelerograph at Boulder Dam operated, but it was set to start for very light motion.

October 22: 6:13.* Boulder Dam region. Felt at Boulder Dam Power Plant and in Boulder City. Hanging objects swung. Sounded as though two heavy guns about a mile away had been fired.

October 31: 23:25.* Arizona-New Mexico border. Aftershock of earthquake of September 17. 33.2° north, 108.6° west. Felt at Duncan, Ariz., and Buckhorn and Cliff, N. M. Rocks fell in the mountains near Buckhorn and many people were frightened. At Cliff, N. Mex., plaster and chimneys were reported cracked. Not felt at San Simon, Ariz.

November 2: 2:00.* Arizona-New Mexico border. About 33.2° north, 108.6° west. Felt at Buckhorn, Cliff, Silver City, and Pinos Altos Mountains in New Mexico and Clifton, Ariz. Hanging objects swung at Buckhorn and many were awakened.

November 10: 17:34.* Boulder Dam. Felt by many in Boulder City and at the power plant.

November 12: 8:17. Manhattan, Mont. Slight shock felt by several.

November 26: 17:13.* Arizona-New Mexico border. About 33.2° north, 108.6° west. Strongest at Black Springs, Cliff, and Mogollon, N. Mex. Also felt at Buckhorn, Reserve, Gila, Glenwood, Morenci, and Pinos Altos, N. Mex. At

Black Springs small objects were overturned and water spilled from indoor containers.

November 29: 9:21. Grover, Wyo. Slight shock. Light shocks were also felt on November 30 at 23:05, December 1 at 13:30, and December 4 at 23:20.

December 3: 15:00. Salt Lake City, Utah. Slight shock felt in southern part of city.

December 23: 23:45. Polson, Mont. 3 miles west of Polson hanging objects swung east and west. There was visible swaying of building. Three windows were broken.

December 28: 15:10. Arizona-New Mexico border. Felt at Clifton, Ariz., and Black Springs, Cliff, Mogollon, and Redrock Valley, N. Mex. Strongest at Clifton, Ariz., where small furnishings moved and trees and bushes shook slightly.

December 28: 15:53. Helena, Mont. Moderate shock.

December 31: 0:08. Belgrade, Mont. Some canned goods shaken off the shelves of grocery stores, but shock was generally recorded as being light. Also felt at White Sulphur Springs, Mont., where small objects and pictures were displaced and subterranean sounds were heard preceding the shock.

CALIFORNIA AND WESTERN NEVADA

[120TH MERIDIAN OR PACIFIC STANDARD TIME]

NOTE.—All places are in California unless otherwise stated. "B" written after the location of an epicenter means that the location was reported by the Seismological Station of the University of California at Berkeley; Perry Byerly in charge. The 1938 results were not yet issued when this list was prepared. "P" refers likewise to the Seismological Laboratory of the California Institute of Technology and the Carnegie Institution of Washington at Pasadena. More details will be found in "Abstracts of Earthquake Reports for the Pacific Coast and Western Mountain Region."

When more than one degree of intensity is reported from a town, the town is listed under each intensity reported.

January 3: 16:29.* San Jacinto mountains about 33°28′ north, 116°35′ west, P. Felt at Banning, Coachella, Hemet, Idyllwild, San Diego, Pomona, and Thermal. Strongest at Hemet.

January 4: 20:00 (about). Mineral. Reported by residents in Manzanita Lake area.

January 5: Between 17:00 and 17:30. Santa Ynez. Three slight shocks felt by several. Trees and bushes shaken slightly.

January 10: 16:25.* Southern part of Mendocino County. Epicenter probably near Hopland, B. Felt over 1,200 square miles. See map.

INTENSITY V:

Bachelor.—Moved furnishings, overturned small objects, including books. Awakened all.

Talmadge.—Overturned small objects and vases. Books and pictures fell; dishes broken. Damage slight.

Ukiah.—Walls creaked and suspended objects swung.

Intensity IV: Blue Lakes Resort, Cloverdale, Hopland, Lakeport, Philo, Potter Valley, Preston, Ukiah, Upper Lake.

Intensity III and under: Calpella, Manchester, Nevaro, Redwood Valley, Willits. Not felt at Albion, Asti, Boonville, Geyserville, Skaggs Springs.

January 11: 10:04. Southern part of Mendocino County. Aftershock of the preceding earthquake. Felt at Bachelor, Cloverdale, Hopland, Lakeport, Preston, Talmadge, Ukiah. Not felt at Albion, Asti, Boonville, Manchester, Midlake, Philo, Redwood Valley, Skaggs Springs, Upper Lake, Willits.

January 23: 20:15.* Felt at Ontario. 34°02′ north, 117°41′ west, P.

February 7: 23:39.* Little San Bernardino Mountains. 34°03′ north, 116°26′ west, P. Felt at Palm Springs and Twenty-nine Palms.

February 12: 12:00.* At sea about 10 miles west-southwest of Santa Cruz, B. About 3,000 square miles of land area affected. See map. Maximum intensity VI.

INTENSITY VI:

Coyote.—Trees and bushes shaken. Some plaster fell.

Morgan Hill.—Trees and bushes shaken. Plaster cracked.

Santa Cruz.—Cracked a few windows and toppled a chimney. Rumbling sound similar to loud roar accompanied shock.

INTENSITY V:

Morgan Hill.—Tables, chairs, and small objects moved.

Mountain View, 5 miles southwest of.—Four severe jolts. Moved small objects.

Watsonville.—Pictures moved. Small objects and furnishings disturbed in some districts.

Intensity IV: Aptos, Belmont, Ben Lomond, Berkeley, Big Sur, Boulder Creek, Carmel, Davenport, Felton, Half Moon Bay, Lafayette, La Honda, Loma Mar, Los Gatos, Milpitas, Monterey, Morgan Hill, Moss Landing, Niles, Pacific Grove, Paradise Valley, Pigeon Point Light Station, Salinas, San Bruno, San Francisco, San Mateo, Santa Cruz, Saratoga, Seaside, Soquel, South San Francisco, Watsonville.

Intensity III and under: Alameda, Aromas, Berkeley, Boulder Creek, Brisbane, Burlingame, Castroville, Colma, Cupertino, Gilroy, Hayward, Hollister, Los Gatos, Marina, Martinez, Menlo Park, Montara, Newark, Oakland, Palo Alto, Pinnacles, Rockaway Beach, Rodeo, Salinas, San Francisco, San Juan Bautista, San Jose, San Rafael.

Not felt at Almaden, Alviso, Altamont, Antioch, Berkeley, Brentwood, Burlingame, Byron, Chualar, Concord, Crockett, Del Monte, Fort Baker, Fort Barry, Fruitvale, Gilroy, Gonzales, Greenfield, Ignacio, King City, Livermore, Los Altos, Los Banos, Los Gatos, Menlo Park, Mile Rocks Light Station, Mill Valley, Moraga, Morgan Hill, Mount Eden, Mountain View, Newman, Oakland, Palo Alto, Patterson, Pinole, Pleasanton, East Brother Island Light Station, Redwood City, Richmond, San Anselmo, San Benito, San Francisco, San Juan Bautista, San Jose, San Lorenzo, San Martin, Saratoga, Sausalito, Soledad, Suisun, Sunol, Tiburon, Tracy, Tres Pinos, Vallejo, Vernalis, Volta, Walnut Creek.

February 14: 6:25.* Los Angeles region, near Inglewood, 34°00′ north, 118°20′ west, P. Felt at Los Angeles, Huntington Park, Inglewood, and Southgate. Strongest at Inglewood and Southgate where many were awakened.

February 14: 23:45.* San Bernardino Mountains. About 34°10′ north, 116°15′ west, P. Felt at Twenty-nine Palms.

February 16: 17:18.* Off Newport Beach, about 33°34′ north, 117°59′ west, P. Felt near Huntington Beach.

March 1: 12:25. Humboldt County. Felt at Bridgeville and Petrolia. Not felt at Arcata, Eureka, Scotia.

March 14: 4:44.* Off Bolsa Chica near 33°42′ north, 118°04′ west, P. Felt at Huntington Beach.

March 23: 15:52.* Ventura County. Near Fillmore, 34°26′ north, 118°48′ west, P. Felt at Fillmore and Piru.

March 31: 9:03.* Mojave Desert, about 34°45′ north, 116°28′ west, P. Felt at Ludlow.

April 1: 11:22.* Lower California, about 32°36′ north, 115°58′ west, Elsinore fault, P. Felt at Brawley and Imperial. At Brawley some dishes were broken and liquids spilled from containers.

April 3: 10:44.* Inglewood fault, 33°50′ north, 118°14′ west, P. Felt at Long Beach, Compton, Southgate, Huntington Beach, and Maywood. At Southgate observer heard tremor before the vibrations arrived.

April 12 and 13: Imperial Valley. The more important shocks of a long series during these two days are listed below. There is some confusion regarding the reported times of individual shocks.

At El Centro objects were overturned and fine cracks appeared in some brick and plaster. Plaster cracked in two elementary schools and Easter displays in some stores toppled over. At Holtville, shocks occurred every day from April 12 to April 18. Small objects and furniture moved, trees and bushes shook. Many were frightened. The shocks were not reported felt at the following places on April 12: Anza, Borego, Cathedral, Coachella, Descanso, Edom, Indio, Keen Camp, Mecca, Mesa Grande, Palm Springs, Pine Valley, Plaster City, Rice, Santa Ysabel, Thermal.

April 12: 6:40. Imperial Valley, felt at Calexico, Calpatria, Desert Center, El Centro, Heber, and Jacumba. Probably identical with shock following.

April 12: 6:46.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Felt at Imperial, San Diego, and El Centro.

April 12: 6:57.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Felt at Aguanga and El Centro.

April 12: 7:04.* Imperial Valley, about 32°53′ north, 115°53′ west, P. Felt at Aguanga and Imperial.

April 12: 7:11.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Felt at Imperial and Calexico.

April 12: 7:29.* Imperial Valley, about 32°53′ north, 115°53′ west, P. Felt at Calexico.

April 12: 8:18.* Imperial Valley, about 32°53′ north, 115°35′ west, P. At Brawley, Calexico, and El Centro children were sent from school buildings. Small cracks appeared in one old brick school building. At El Centro dishes were shaken from shelves. At Seeley, trees and bushes were shaken. A strong-motion record was obtained at El Centro.

April 12: 8:24.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Felt at Calexico, El Centro, Imperial, San Diego, Seeley, Westmoreland, and Yuma (Ariz.). A hard shock at El Centro set the accelerograph into operation.

April 13: 10:57.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Felt at Calexico and very slightly at Yuma, Ariz.

April 13: 11:29.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Accelerograph at El Centro started but no record was obtained because paper had been used up on preceding shock. Felt at Brawley, Calexico, Calipatria, El Centro, Heber, Holtville, Pine Valley, Rosita Dam, San Diego, Seeley, and Yuma (Ariz.) In northeast section of Imperial Valley there was slight damage to buildings. Cracks appeared in the ground and land slides occurred on the banks of the Alamo and New Rivers. Not felt at Gila Bend and Quartzsite in Arizona.

April 13: 18:53* and 19:38.* Imperial Valley, about 32°53′ north and 115°35′ west, P. Both shocks felt at El Centro.

April 15: 12:08.* Imperial Valley, about 32°53′ north, 115°35′ west, P. Felt at Imperial.

April 15: 13:55. Humboldt County. Felt at Cape Mendocino, Ferndale, Punta Gorda Light Station, and Upper Mattole. Trees and bushes shaken slightly at Upper Mattole.

April 19: 5:59.* Los Angeles region. About 34° north, 118° west, P. Felt at Alhambra, Gardena, and Pasadena.

April 19: 17:58.* Near Long Beach, 33°46′ north, 118°07′ west, P. Felt at Wilmington and Long Beach.

April 19: 19:59.* Near Long Beach, 33°46′ north, 118°07′ west, P. Felt at Long Beach and Wilmington. Not felt at Maywood.

April 23: 23:43.* Vicinity of El Modena, 33°50′ north, 117°48′ west, P. Felt at Claremont, Fontana, and Ontario.

April 26: 4:19.* Near Long Beach, about 33°46′ north, 118°07′ west, P. Felt at Long Beach and Seal Beach.

April 27: 12:13.* Imperial Valley, about 32°53′ north, 115°37′ west, P. Felt at Calexico, El Modena, and San Diego.

April 27: 22:07.* Off San Diego, approximately 110 kilometers, 32°37′ north, 118°12′ west, P. Felt at Balboa and San Diego.

May 10: 2:32.* Monterey County, about 36.2° north, 121.3° west, P. Felt at Big Sur, Pinnacles, Soledad, King City, Tres Pinos, Hollister, Salinas, and Soquel. Six shocks felt at Pinnacles.

May 10: 2:41.* Monterey County, about 36.2° north, 121.3° west, P. Felt at San Benito.

May 13: 5:20.* Near Julien, 33°05′ north, 116°40′ west, P. Felt at Santa Ysabel.

May 21: 1:44.* Near Long Beach. 33°37′ north, 118°02′ west, P. Felt at Balboa, Huntington Beach, Long Beach, and Seal Beach.

May 27: 9:30. In California, about 25 miles from Reno, Nev. Felt at Calpine, Chilcoot, Downieville, Graniteville, Johnsville, Loyalton, Sattley, Sierraville, and Sierra City. Trees and bushes shaken slightly at Calpine, Chilcoot, Loyalton, Sattley, and Sierraville.

May 31. 0:34.* Santa Ana Mts. 33° 41′ north, 117° 32′ west, P. Land area of approximately 30,000 square miles in Southern California affected. See map. Felt along the coast as far north as Santa Barbara and south to San Diego. Felt inland as far as Bakersfield, the Mojave Desert and the Coachella Valley. Intensity VI was reached in several widely scattered localities. Strong motion instruments operated at Colton, Hollywood, Los Angeles, and Vernon.

INTENSITY VI:

Adelanto.—Small object overturned and knickknacks fell. Rapid motion lasted a few seconds.

Arlington.—Knickknacks fell. Many awakened and frightened. Damage slight. Rapid motion lasted 35 seconds.

Keystone.—(4 miles north of Wilmington). Vases and knickknacks overturned; many awakened and frightened. Rapid east-west motion lasted about 10 seconds.

Laguna Beach.—Moved furnishings and overturned small objects; knickknacks fell. Rapid motion lasted 3 seconds. Faint roaring sound heard before and after the shock.

Moreno.—Floor lamps were moved and plaster cracked. All awakened. Rapid motion lasted a few seconds.

Ontario.—Small objects and furnishing were moved and plaster cracked. Many awakened and frightened. Rapid motion lasted 5 seconds.

Orange.—Small objects were overturned. All awakened. Slow motion, lasted 15 to 20 seconds.

Silverado.—Small objects were overturned and knickknacks fell. Many awakened and frightened. Rapid motion lasted 10 seconds.

INTENSITY V:

Aguanga.—Hanging objects swung northeast and southwest, trees and bushes shaken moderately. Many awakened. Slow motion lasted about 10 seconds.

Anaheim.—(Kotella Substation). Hanging objects swung. Trees and bushes shook slightly. Many awakened. Slow motion lasted 10 seconds.

Arrowhead Springs.—(Hotel and vicinity). Hanging objects swung, trees and bushes shook moderately. Many awakened. Rapid motion lasted about 10 seconds.

Artesia.—Hanging objects swung and many residents were awakened. Slow motion lasted 6 seconds.

Banning.—Small objects were disturbed and many residents were awakened.

Cajon.—Felt by all. Rapid motion lasted five seconds.

Calabasas.—All awakened. East-west motion.

Camp Baldy.—Hanging objects swung, trees and bushes shook slightly. Slow motion lasting 3 to 4 minutes.

Claremont.—Hanging objects swung, trees and bushes shook slightly. Many awakened. Rapid motion lasted one second.

Compton.—Hanging objects swung and chairs moved. All were awakened and frightened. Rapid motion lasted several seconds.

Corona.—All were awakened. Rapid motion lasted 30 seconds.

El Cajon.—Pictures swayed on walls and a few people were awakened. A quick jumping motion.

Elsinore.—Hanging objects swung north and south, trees and bushes shook slightly. All were awakened and a few frightened. Rapid motion lasted 6 seconds.

El Toro.—Hanging objects swung and many residents were awakened. Rapid motion lasted 5 seconds.

Fawnskin.—Small objects moved and knickknacks fell. Many were awakened. Rapid east-west motion lasted 3 seconds.

Fontana.—Many were awakened and frightened. Motion first abrupt and then slow, lasting approximately 30 seconds. "Longest and hardest since the Long Beach earthquake."

Fullerton.—South section. Small objects disturbed. Many awakened and frightened. Moderately loud bumping sound occurred at time of shock.

Glendora.—Hanging objects swung. Frightened all in lookout tower. In the town many were awakened. Rapid motion lasted two seconds. At Tanbark Flats hanging objects swung and rapid motion lasted 10 seconds.

Huntington Park.—All were awakened. A slow east-west motion lasted several seconds.

Keen Camp.—All were awakened; felt by some outdoors. Rapid motion lasted 3 seconds.

Lakeside.—Trees and bushes shook slightly and many residents were awakened. Crashing sound heard before tremble. Rapid motion lasted 8 to 10 seconds.

Loma Linda.—Trees and bushes shook moderately. Many were awakened. Rapid motion lasted a few seconds.

Los Angeles.—High buildings swayed gently in downtown Los Angeles. Bridge lamps toppled over in homes in Hollywood and pictures and vases crashed to floors. Many residents were awakened and police and newspaper switchboards were swamped with telephone calls. There was some excitement among frightened prisoners in the County Jail on the top floor of the Hall of Justice. The motion was generally reported as slow with duration varying from 4 to 15 seconds.

Mount Wilson.—All were awakened. Slow northwest-southeast motion lasted 5 seconds.

Murrieta.—All were awakened. Rapid northeast-southwest motion lasted about ½ minute.

Newport Beach.—Hanging objects swung east and west and trees and bushes shook slightly. Many were awakened. Rapid motion lasted 8 to 10 seconds.

Pala.—Plaster cracked. Felt by many. Rapid motion lasted 2 seconds.

Pasadena.—Hanging objects swung north to south. All were awakened. Rapid north to south motion was of very short duration. At Josephine Peak lookout, hanging objects swung. Slow motion lasted approximately 5 seconds.

Piru.—Damage slight. Felt by many. Slow motion lasted less than one minute.

San Antonio.—(8 miles south of Mount Baldi). All were awakened. Rapid motion lasted about 10 seconds.

San Bernardino.—Many were awakened. Rapid motion lasted 30 seconds.

San Diego.—A large number were awakened. Slow motion lasted a few seconds only. The motion was recorded slightly on various recording instruments of the electric generating plant, station B.

San Dimas.—Some plaster was cracked. Many were awakened and frightened. Rapid motion lasted 6 seconds. At the United States Forest Service guard station many were awakened. Rapid motion lasting 6 seconds was felt by all.

San Juan Capistrano.—Hanging objects swung and small objects moved. All were awakened. Slow motion lasted 10 seconds.

San Marcos.—Many were awakened.

Santa Monica.—Hanging objects swung, trees and bushes were shaken strongly. Many were awakened and frightened. Rapid motion lasted one minute.

San Pedro.—Hanging objects swung east and west. Many were awakened. Slow east-west motion lasted several seconds.

Santee.—Pictures on walls moved. Many were awakened. Rapid motion seemed to last 1 to 2 minutes.

Sierra Madre.—(Vetter Mt.). All were awakened. Motion lasted 6 seconds.

Stanton.—Hanging objects swung. Many were awakened and freightened. Rapid motion lasted 10 seconds.

Swartout.—Hanging objects swung and small objects were displaced. Many were awakened and frightened. Rapid east-west motion.

Temecula.—Hanging objects swung, small objects and furnishings moved. Many were awakened. Slow motion lasted approximately 30 seconds.

Valyermo.—All were awakened. Rapid northeast to southwest motion lasted approximately 1 minute.

Whittier.—All were awakened.

Yucaipa.—Hanging objects swung. All were awakened and frightened. Rapid northeast to southwest motion lasted 3 seconds.

Intensity IV: Acton, Alberhill, Alhambra, Alta Loma, Alpine, Anza, Avalon, Bakersfield (Magurden Substation), Baldwin Park, Barstow, Beaumont, Bell (Laguna Bell Substation), Beverly Hills, Bloomington, Bonsall, Borego, Brea, Burbank (North section), Cabazon, Camarillo, Campo, Castaic (Warm Springs Lookout), Colton, Crestline, Del Mar, Del Rosa (Ranger Station), Descanso, Descanso (Ranger Station), Dulzura (Barrett Dam), East Highlands, Escondido, Escondido (Hodges Dam), Etiwanda, Fallbrook, Fillmore, Forest Home, Glendale, Glendora (Dalton Camp F–126), Glenn Ranch, Gorman, Hemet, Huntington Beach (5 miles north of), Idyllwild (Ranger Station), Inglewood, Irwindale, Jamul, La Canada, La Jolla, Lake Arrowhead, Lancaster, Lang, La Verne, Lemon Grove, Llano, Lomita, Long Beach (North section), Long Beach, Lucerne Valley, Manhattan Beach, Maywood, Mentone (Mill Creek Powerhouse No. 3), Mentone, Mira Loma, Monrovia, Montebello, North Hollywood, Olive View, Oxnard, Palomar Mountain, Palmdale, Palm Springs, Phelan, Pomona, Ramona, Riverside, Romoland, Rosamond, San Fernando, Santa Ana, Sierra Madre (Santa Anita Ranger station), Saugus, Saugus (substantion), Seal Beach, Seven Oaks, Summerland, Tehachapi, Torrance, Tustin, Upland, Valley Center, Valyermo, Van Nuys, Victorville, Warner Springs.

Intensity III and under: Garnet, Indio, Littlerock, Mesa Grande, Mojave, Moorpark, Muroc, Newberry, Newhall, Oceanside, San Diego (Mission Hills), San Onofre.

Not felt at Amboy, Arvin, Bakersfield, Cantil, Carpinteria, Castaic (Elizabeth Lake Canyon Guard station), Cornell, Crucero, Dulzura, Earp, El Centro, Encanto, Essex, Fairmont, Gaviota, Goleta, Helendale, Huener, Jacumba,

Julian, Ludlow, Maricopa, Mecca, Mount Laguna, Needles, Nilano, Oildale, Ojai, Palm City, Palo Verdi, Plaster City, Potrero, Puente, Randsburg, Sandberg, Santa Barbara, Santa Paula, Santa Ynez, San Ysidro, Saticoy, Shafter, Tupman, Twentynine Palms, Ventura, Vidal, Wasco, Wheeler Ridge, Wheeler Springs.

May 31: 21:17.* Near Santa Barbara, 34°33′ north, 119°41′ west, P. Awakened a few in Santa Barbara.

June 1: 0:04.* Gulf of California, about 30° north, 113° west, P. Reported felt at Mission Hills, San Diego.

June 3: 6:02.* Region of Volcano Lake, about 32°15′ north, 115°10′ west, P Felt at Calexico.

June 3: 6:38.* Region of Volcano Lake, about 32°15′ north, 115°10′ west, P. Many awakened at El Centro.

June 5: 18:42.* Imperial Valley, about 32°15′ north, 115°10′ west, P. Felt at Brawley, El Centro, Heber, Imperial, and San Diego. Not felt at Calipatria, Desert Center, Mecca, and Niland. Recorded on El Centro accelerograph.

June 5: 21:53.* Region of Volcano Lake, about 32°15′ north, 115°10′ west, P. Felt at El Centro, Holtville, and Imperial. Plaster was cracked at Holtville. Not felt at Calipatria, Desert Center, Mecca, and Niland.

June 6: 4:35.* Region of Volcano Lake, about 32°15′ north, 115°10′ west, P. Felt at Brawley, El Centro, Heber, Imperial, and San Diego. Trees and bushes were shaken strongly at Imperial; many residents were awakened and frightened. Not felt at Calipatria, Desert Center, Mecca, and Niland. Recorded on El Centro accelerograph.

June 10: 6:40.* San Bernardino Mts. 34°08′ north, 116°57′ west, P. Felt at Big Bear City, Big Bear Ranger station, Fawnskin, Running Springs, and Seven Oaks. At Big Bear City small objects were overturned and many residents awakened.

June 15: 21:59.* Terwilliger Valley, 33°28′ north, 116°35′ west, P. Felt at Aguanga, Hemet, and San Diego. Many were awakened at Aguanga.

June 15: 22:30.* San Bernardino Mts., about 34°20′ north, 117°00′ west, P. Felt at Big Bear City.

June 20: 9:54.* San Bernardino Mts. 34°20′ north, 117°00′ west, P. Felt at Big Bear City.

June 23: 14:11.* San Bernardino Mts., 34°10′ north, 117°07′ west, P. Felt at Running Springs (Keller Peak Lookout). Trees and bushes shaken slightly.

June 28: 21:34.* Off Bolsa Chico, 33°42′ north, 118°04′ west, P. Felt near Huntington Beach.

July 5: 10:06.* Santa Ana Mts., 33°41′ north, 117°32′ west, P. Felt at Alberhill, Burbank, Corona (U. S. Ranger station), Laguna Beach, Red Mountain Lookout, Southgate, Sunset Peak Lookout. Small objects were overturned at Southgate. Small objects were moved, and trees and bushes were shaken slightly at Sunset Peak Lookout near Glendora.

July 10: 8:10.* Agua Caliente fault near Verruga, about 33°10′ north, 116°25′ west, P. Reported felt at Borego.

July 10: 10:06.* Agua Caliente fault near Verruga, 33°10′ north, 116°25′ west, P. Felt at Borego, Descanso and Cuyamaca Peak Lookout, Damo Canyon (San Diego), Jamul, and Warner Springs. At Descanso and Cuyamaca Peak Lookout, hanging objects swung; small objects and light wooden chairs were displaced. Knickknacks fell. Trees and bushes were shaken slightly.

July 17: 21:40.* Near Haiwee, about 36°09′ north, 117°57′ west, P. Felt at Haiwee Power Plant Camp. Hanging objects swung and furnishings moved. Many were frightened.

July 21: 14:45.* Ventura County near Piru, about 34°30′ north, 118°56′ west, P. Felt at Reservoir Summit Lookout, vicinity of Sandberg, West Liebre Lookout, and Whitaker Peak Lookout.

August 1: 23:12.* San Diego County, near Nellie, 33°18′ north, 116°54′ west, P. Felt at Aguanga, Mesa Grande and Palomar Mountain. At Aguanga hanging objects swung. Many were awakened at Aguanga and Mesa Grande. At Palomar Mountain thunderous subterranean sounds were heard immediately before the shock.

August 4: 17:59.* Off Huntington Beach, about 33°37′ north, 118°02′ west, P. Felt at Cypress and Huntington Beach.

August 4: 20:33.* Southwest Los Angeles, about 34°03′ north, 118°22′ west, P. Felt at Los Angeles and Gardena. Hundreds of persons called police to report the disturbance. The shock jarred furniture and rattled dishes.

August 5: 18:28.* Riverside County near Cabazon, 33°56′ north, 116°45′ west, P. Felt at Cabazon and Saunders Meadows (near Idyllwild).

August 6: 14:00.* Santa Ana Mts. 33°41′ north, 117°32′ west, P. Felt at Corona and Elsinore.

August 17: 23:39.* Mojave River Sink, about 35°00′ north, 116°13′ west, P. Felt at Ludlow.

August 29: 6:48.* Balsa Chico, 33°42′ north, 118°04′ west, P. Felt at Cypress and Seal Beach. Awakened many at Cypress.

August 30: 19:18.* Near Long Beach, 33°48′ north, 118°14′ west, depth probably about 25 kilometers, P. The shock affected a land area of approximately 1,200 square miles as shown on map. It was felt along the Coast between Santa Monica and Laguna Beach and inland as far as Mt. Wilson. A maximum intensity of approximately VI was reached in the San Pedro Harbor district. Strong motion records were obtained from instruments in the Los Angeles Chamber of Commerce Building and the Los Angeles Subway Terminal Building.

INTENSITY VI:

Huntington Beach.—Some dishes were knocked from shelves.

Keystone.—(4 miles north of Wilmington). Almost all residents ran outside, some badly frightened. In one home a heavy china cabinet was overturned. Beds moved about 8 inches. Water in a pool 6 inches from the top spilled over in east-west direction.

Long Beach.—Audiences left many theatres and many residents left their houses. There was apparently no structural damage. Small objects were overturned and many dishes fell. In some stores the stock was knocked off shelves.

Los Angeles.—Many were awakened. Objects were observed swinging and displaced.

San Pedro.—Press reports that firemen moved their equipment from the City Hall, fearing collapse of building, but the building was undamaged.

Seal Beach.—Vases were overturned and many residents were frightened. East-west motion felt outdoors. The shock was registered on recording voltmeters at the power station.

INTENSITY V:

Artesia.—Few were frightened. Direction of motion northeast.

Beverly Hills.—Hanging objects swung. Small objects and furniture were displaced.

Compton.—Doors swung and many residents were frightened.

Gardena.—Hanging objects swung. Felt by all.

Harbor City.—Trees and bushes were shaken moderately. Many were frightened.

Huntington Park.—Felt by all.

La Fresa Substation (Gardena).—Felt by all, few frightened.

Lomita.—Many were awakened and frightened.

Maywood.—Hanging objects swung east and west. Trees and bushes were shaken slightly. Shock was accompanied by rumble from the east.

Pico.—Hanging objects swung. A few residents were frightened.

Stanton.—Hanging doors and objects swung in approximately a north-south direction. Many were awakened and frightened.

Sunset Beach.—North-northeast motion felt by many. Hanging objects swung and trees and bushes were shaken. A few were awakened and frightened.

Torrance. Hanging objects swung; many residents were frightened. Felt outdoors by few.

Wilmington.—Northwest-southeast motion felt outdoors by some. A few residents were awakened and many frightened. Hanging objects swung.

Intensity IV: Bell, Coldbrook Guard station (Azusa), Hermosa Beach, Huntington Beach, Irvine, La Mirada, Manhattan Beach, Newport Beach, Palos Verdes Estates, Redondo Beach, San Pedro, Santa Ana, Venice, Whittier.

Intensity III and under: Brea, Culver City, El Toro, Fullerton, Hollywood, Inglewood, Laguna Beach, La Habra, Mira Loma, Mount Wilson.

Not felt at Acton, Alberhill, Alta Loma, Baldwin Park, Camp Baldy, Camarillo, Castaic, Claremont, Cornell, Corona, Del Luz, Elsinore, Etiwanda, Glendora, Gorman, Hueneme, Irwindale, La Canada, Littlerock, Moreno, North Hollywood, Perris, Piru, Pomona, Rialto, Riverside, Roscoe, San Bernardino, San Clemente, San Juan Capistrano, Santa Anita, Santa Monica, Saugus, Silverado, Simi, Swartout, Valyermo, Van Nuys, Ducor (4 miles north of), Wildomar.

August 30: 21:34.* Aftershock of preceding earthquake near Long Beach, 33°48′ north, 118°14′ west, P. Felt at Gardena, Long Beach, and Manhattan Beach.

September 2: 4:02.* Near Long Beach, 33°48′ north, 118°14′ west, P. Felt at Long Beach.

September 2: 12:39. Redwood Valley. Felt generally in the Valley about 10 miles north of Ukiah. Windows rattled and hanging objects swung.

September 7: 5:13.* Felt at Long Beach and San Pedro, 33°47′ north, 118°07′ west, P.

September 11: 22:10.* Off shore near Cape Mendicino, about 40.3° north, 124.8° west. About 20,000 square miles of land area affected as shown on map. The earthquake was felt along the coast as far north as Brookings, Oreg., and as far south as Elk, Calif.

It extended inland to La Moine, Redding, Mineral, and Johnsville, not far from the Nevada border. A maximum intensity of approximately VI was experienced in some towns near the coast. The highway through the Redwoods was reported as being littered with fallen branches from trees. Many cases of crossed telephone lines were reported by telephone linemen. A strong-motion record was obtained at Ferndale, but a similar instrument at Eureka did not operate.

The shock was felt for 45 seconds aboard the United States Coast and Geodetic Survey Ship *Guide* stationed in Shelter Cove at Point Delgada. Rumbling sounds, coming from seaward, were heard before any motion was felt, and seemed to progress in an easterly direction on land. Weak shocks were observed on the ship on the 12th at 14:03, and on the 13th at 16:41. On October 14th at 9:01 a slight shock was observed when the ship was about 3 miles from Shelter Cove en route to Oakland.

INTENSITY VI:

Alder Point.—Felt outdoors by some. Dishes broken.

Bridgeville.—A few articles knocked off shelves in store. Dishes broken. Many awakened and frightened. Slow motion lasted 20 seconds.

Eel Rock.—Small objects and furnishings moved, chimneys cracked. All awakened and frightened. Slow motion.

Ferndale.—Hanging objects swung and small objects were displaced. All were awakened and some frightened. Motion lasted 15 or 20 seconds. One chimney cracked and rotated a few degrees but did not fall. Telephone lines out of town were out of order for some time.

Fortuna.—Hanging objects swung; some bottles fell from shelves. Many were awakened and frightened. Motion lasted about 9 seconds.

Garberville.—Small objects were overturned; trees and bushes were shaken slightly. Hanging objects swung east and west. Many were awakened but few frightened. Rapid motion lasted five seconds.

Grizzly Creek.—(Seven miles west of Bridgeville.) Small objects were displaced and small packages and bottles were overturned. Slow motion, lasted several seconds. Felt outdoors in an approximate north-south direction.

Harris.—Water spilled from containers. All were awakened and many frightened.

Holmes.—Small objects and furnishings were displaced, some vases overturned. Liquids spilled over sides of containers. Awakened all but frightened few.

Ocean House.—(Near Cape Mendicino.) Vases overturned and knickknacks fell. A few awakened.

Pepperwood.—Overturned vases, small objects and furniture. Dishes broke and wallpaper cracked. One chimney fell. Rapid north and south motion lasted 60 seconds.

Scotia.—Small objects and furnishings moved, steam radiator badly shaken, telephone wires sagged, trees and bushes shook slightly. Awakened all and frightened many. Slow north-south motion lasted about 15 seconds. About 5 seconds seemed to elapse between preliminary tremors and main shock.

Shively.—Hanging objects swung; pendulum clocks started. Small objects and vases overturned and water spilled from indoor containers. Knickknacks and books fell. All were awakened and a few frightened. East-west motion lasted 6 or 8 seconds.

Upper Mattole.—Hanging objects swung and small objects moved. All were awakened and many frightened. Rapid motion lasted about one minute.

Weott.—Hanging objects swung east and west. Some small objects were overturned. Trees and bushes shook moderately. All were awakened and many frightened. Slow east-west motion lasted about 4 seconds.

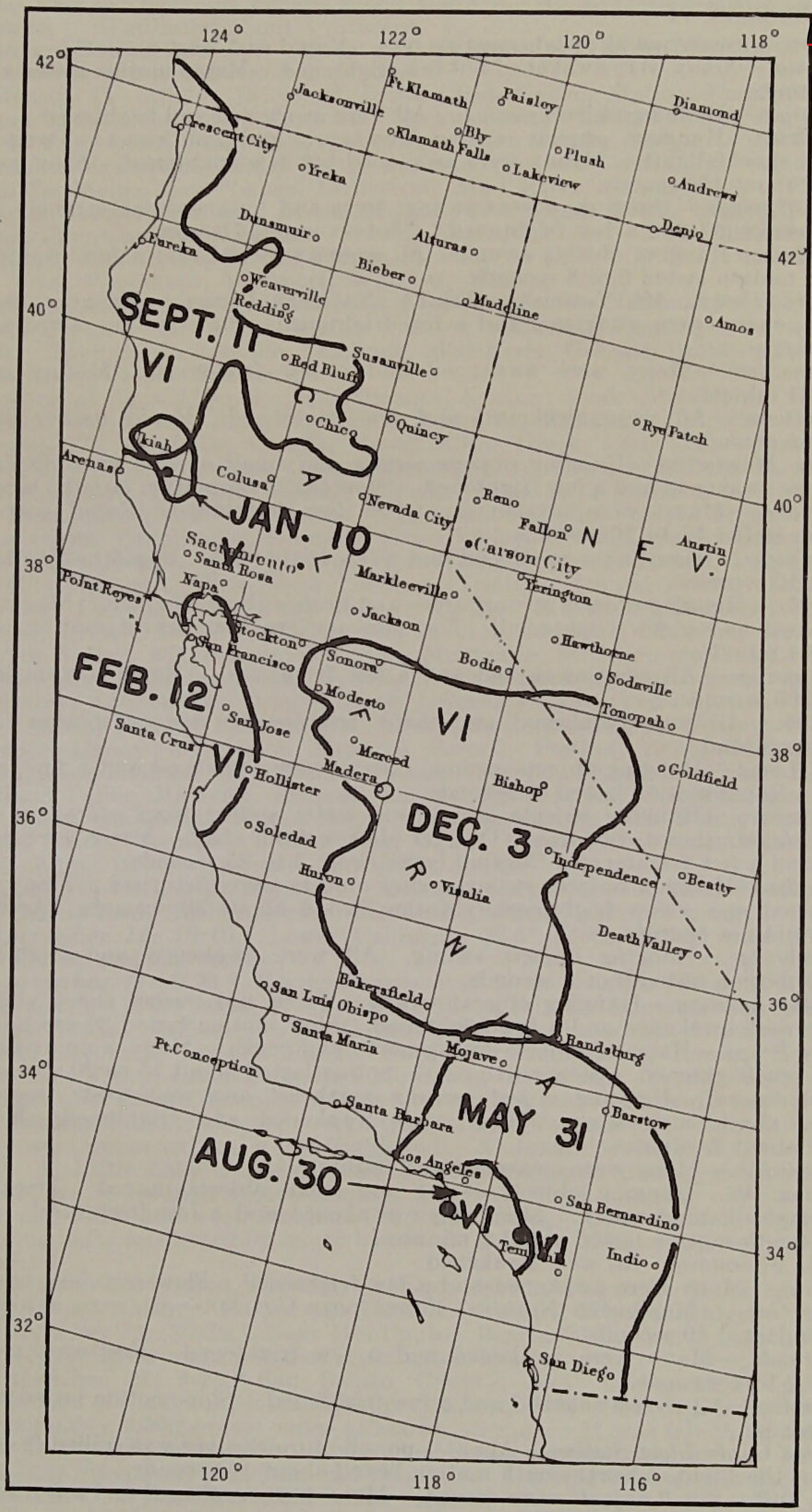


Figure 7.—Areas affected by the more important earthquakes of California and western Nevada in 1938.

INTENSITY V:

Alton.—Awakened all; frightened no one. Rapid east-west motion.

Arcata.—Many were awakened but few frightened. Rapid motion lasted about 10 seconds.

Bayside.—Hanging objects swung. All were awakened and frightened.

Beatrice.—Hanging objects swung northeast and southwest. Trees and bushes shook slightly. Many were awakened but few frightened. Slow motion lasted about 15 seconds.

Bell Springs.—Hanging objects swung; trees and bushes shook strongly. All were awakened and a few frightened. Motion lasted 7 seconds.

Benbow.—Hanging objects swung. All were awakened and a few frightened. Rapid motion lasted 6 to 8 seconds.

Board Camp, Mt. Lookout.—(Trinity National Forest). Hanging objects swung, many were awakened and a few frightened. Slow motion lasted about 10 seconds.

Branscomb.—Many were awakened and a few frightened. Motion lasted about 1 minute.

Capetown.—All were awakened and few frightened. Rapid motion lasted about 5 seconds.

Cape Mendocino.—Hanging objects swung and small objects were displaced. All were awakened and a few frightened. Slow east-west motion lasted 5 seconds.

Carlotta.—Many were awakened and a few frightened. Rapid east-west motion lasted 15 to 20 seconds.

Comptche.—Many were awakened and a few frightened. Rapid motion lasted about 10 seconds.

Covelo.—Hanging objects swung; trees and bushes shook slightly. Many were awakened and a few frightened. The slow northeast-southwest motion lasted about 1 minute.

Cummings.—All were awakened and a few frightened. Rapid motion lasted about 30 seconds.

Cutten.—All were awakened and many frightened. Abrupt motion lasted about a second.

Del Loma.—Hanging objects swung. Many were awakened and a few frightened. Rapid motion lasted 30 seconds.

Ettersburg.—Hanging objects swung and water spilled from containers in a northwest-southeast direction. One jar shaken from shelf. Many were awakened and a few frightened. Motion lasted from 5 to 25 seconds.

Eureka.—Hanging objects swung; many objects were disturbed. Many were awakened and a few frightened. Motion lasted about 30 seconds. Accelerograph did not operate.

Fernbridge.—Hanging objects swung. All were awakened and frightened. Rapid motion lasted 2 or 3 seconds.

Fields Landing.—Hanging objects swung. Trees and bushes shook slightly. Many were awakened and a few frightened. Slow motion lasted 30 seconds.

Fort Bragg.—Hanging objects swung north and south. Many were awakened and a few frightened. Slow north-south motion lasted about 15 or 20 seconds.

Fort Seward.—Hanging objects swung northeast and southwest; trees and bushes shook moderately. Many were awakened and frightened. Motion lasted about 2 minutes.

Honeydew.—Many were awakened and frightened.

Island Mt.—Hanging objects swung and small objects moved. Trees and bushes shook moderately. Many were awakened and a few frightened. Slow north-south motion lasted about 2 minutes.

Lake Mountain —All were awakened.

Loleta.—Many were awakened and a few frightened. Slow east-west motion.

Low Gap.—(Mendocino National Forest near Covelo).—All were awakened; motion lasted 10 seconds.

Miranda.—Many were awakened and a few frightened. East-west motion lasted 2 to 4 seconds.

Petrolia.—All were awakened and a few frightened. Slow motion lasted about 20 seconds.

Punta Gorda Light Station.—About 1 pound of quicksilver was spilled from the float of the Light. North-south motion lasted about 15 seconds.

Rio Dell.—Small objects were moved. Many were awakened and a few frightened. Rapid motion lasted 55 seconds.

South Fork.—A few were awakened and frightened. Rapid north-south motion lasting several seconds felt outdoors.

Spy Rock.—Trees and bushes shook slightly. All were awakened. A slow east-west motion lasted about 3 minutes.

Zenia.—Knickknacks fell. Many were awakened and a few frightened. Slow east-west motion lasted about 2 minutes.

Intensity IV: Albion, Briceland, Brush Creek Ranger Station, Caspar, Chico, Clipper Mills, Cobbs, Dos Rios, Elk, Farley, Feather Falls, Forest Glen, Forest Ranch, Freshwater, Grass Valley, Harrison Gulch Ranger Station (4 miles south of Knob), Hyampom, Inskip Butte Lookout (Paynes Creek), Johnsville, Klamath, La Moine, Las Plumas, Littleriver, Mad River Ranger Station (Trinity National Forest), McCann, Mina, Mineral, Nashmead, Orick, Orland, Peanut, Piercy, Plummer Peak Lookout (Trinity National Forest), Red Bluff, Redding, Rockport, Rohnerville, Salyer, Samoa, Strawberry Valley, Trinity Center, Trinidad, Vina, Weitchpec, Westport, Whitlow, Willits, Willows.

Intensity III and under: Black Rock Lookout (Trinity National Forest), Burnt Ranch, Corning, Eel River Ranger Station (Covelo), Flourney, Forbestown, Gerber, Hayfork, Laytonville, Longvale, Mad River, Orleans, Oroville, Paradise, Smith River, Ukiah, Weaverville.

Not felt at Ager, Alder Springs, Almanor, Anthony Peak (Mendocino National Forest), Belden, Big Bar, Big Bend, Boonville, Callahan, Calpella, Calpine, Camptonville, Cecilville, Catella, Cassel, Clear Creek, Clear Lake Park, Clio, Cloverdale, Chester, Colusa, Copco, Crescent City, Cromberg, Dedrick, Denny, Dobbins, Dorris, Douglas City, Downieville, Etna, Forks of Salmon, Fort Dick, Fort Jones, Franklin Point Lookout (Mendocino National Forest), French Corral, Fruto, Glenn, Graniteville, Grenada, Grass Valley, Gridley, Happy Camp, Hayfork, Hearst, Helena, Hilts, Honcut, Hornbrook, Hopland, Inwood, Isaiah, Junction City, Kennett, Knob Peak Lookout (Trinity National Forest), Lakeport, La Porte, Ladoga, Log Springs Ranger Station (Mendocino National Forest), Lucerne, Lytton, Magalia, Manchester, Manton, Massack, Maxwell, McArthur, Meadow Valley, Middletown, Millville, Montague, Montgomery Creek, Mount Hebron, Mount Shasta, Hoopa, Nelson, North Bloomfield, North San Juan, Oak, Old Station, Olinda, Ono, Oregon House, Orleans, Osborn Guard Station (Mendocino National Forest), Palermo, Palo Cedro, Paskenta, Paxton, Peanut, Plaskett Meadows Camp (Mendocino National Forest), Platina, Philo, Point Arena, Poison Rock Lookout (Mendocino National Forest), Princeton, Pulga, Quincy, Redwood Valley, Richvale, Rumsey, Sattley, Sawyers Bar, Schilling, Scott Bar, Sites, Sloat, Smartville, Somes Bar, Spring Garden, Stewarts Point, Stonyford, Storrie, Sutter, Tennant, Trinity Alps, Ukiah, Upper Lake, Viola, Washington, Weed, White Horse, Whitmore, Yorkville, Yreka.

Not felt in Oregon at Applegate, Ashland, Carpenterville, Gold Beach, Gold Hill, Grants Pass, Harbor, Kerby, Medford, Obrien, Talent, Wonder.

September 14: 10:10.* Lower California 32.5° north, 115.6° west, P. Felt at El Centro and Claremont.

September 17: 6:23.* Northeast corner of Kern County. East of Inyoken, 35°36′ north, 117°39′ west, P. Felt generally within 125 kilometers of epicenter. Felt at Atolia, Bodfish, Brown, Caliente, Haiwee, Reservoir, Havilah Ranger Station, Inyokern, Isabella Ranger Station, Johannesburg, Keeler, Kerndale, Little Lake, Onyx, Randsburg, Red Mountain, Tehachapi, Trona, Weldon, and Westend. At Brown, hanging objects swung north and south and a few residents were awakened and frightened. At Inyokern a motion was felt outdoors by some. Many were awakened and a few frightened. At Johannesburg many were awakened. At Little Lake hanging objects swung; trees and bushes shook slightly. At Randsburg hanging objects swung. At Tehachapi hanging objects swung north and south and a few residents were awakened. At Trona moderately loud rumbling noise was heard by many before the shock. Most of the residents were awakened.

Not felt at Bakersfield, Bartlett, Cartago, Darwin, Fairmont, Helendale, Maywood, Mojave, Muroc, Rosamond, Shoshone, Tecopa, Wheeler Ridge.

September 25: 20:38.* Near Huntington Beach, 33°37′ north, 118°02′ west, P. Felt slightly 5 miles north of Huntington Beach.

September 27: 4:23.* San Benito County, 36.3° north, 120.9° west, P. Earthquake of maximum intensity approximately V was felt over a land area of approximately 9,000 square miles as shown on map. It was felt along the coast as far north as Pescadero, and to the south as far as San Luis Obispo. Inland it was felt at Stevinson, Mendota, and Coalinga. Damage to plaster and sidewalks reported in a few instances could not be verified.

INTENSITY V:

Big Sur.—Trees and bushes were shaken and many residents awakened.
Bryson.—All were awakened, small objects and furnishings disturbed.
Chualar.—Many were awakened and frightened.
Gonzales.—Many were awakened. Some plaster reported cracked.
Greenfield.—Many were awakened.
Harmony.—Many were awakened and a few frightened.
Hollister.—Nearly all were awakened. Hanging objects swung.
Jolon and Lockwood.—Many were awakened and frightened. Trees and bushes shook moderately.
Jungle Junction.—Objects fell from shelves.
Lockwood.—A few were awakened.
Paicines.—Small objects overturned.
Paraiso Springs.—Many were awakened.
Pinnacles.—Earthquake accompanied by continuous rumbling. Reading lamp and rocking chair rocked. All were awakened.
San Ardo.—All were awakened.
San Benito.—Many were awakened and frightened.
San Lucas.—Hanging objects swung northeast and southwest; dishes were broken. All were awakened and frightened.
Soledad.—Nearly all were awakened. Some plaster reported damaged.
Spreckels.—Awakened all and frightened many.

Intensity IV: Aldercroft Heights (1½ miles south of Alma), Alma, Ben Lomond, Cambria, Camp Ever, Castroville, Carmel, Cholame Peak Lookout (near Cholame), Creston, Dos Palos, Gilroy, King City (Bengard Ranch, near King City-Hollister Junction), King City (Forest Service), Los Banos, Marina, Mendota, Monterey, Moss Landing, Paso Robles, Priest Valley, Salinas, San Luis Obispo (Press), San Luis Obispo and Santa Margarita, Seaside, Shandon, Soquel, South Dos Palos, Stevinson, Tres Pinos, Volta, Watsonville.

Intensity III and under: Atascadero, Aptos, Boulder Creek, Bradley, Capitola, Coalinga, Glenwood, Lonoak (4 miles from Post Office), Parkfield, Pescadero, Pozo, Santa Cruz, Templeton.

Not felt at Almaden, Aromas, Atwater, Berros, Burrel, Cayucas, Cholame, Crows Landing, Cupertino, Davenport, Fairmead, Firebaugh, Glenwood, Helm, Holy City, Huron, Kettlemen City, La Honda, Los Altos, Los Gatos, Livingston, Morro Bay, Morgan Hill, Newman, Nipomo, Patterson, San Martin, San Joaquin, Salinas, Santa Cruz (8 miles north of), Summit, Tranquillity, Westhaven.

September 27: 8:20. Felt at Pinnacles and Paicines.

September 27: 9:18.* Off San Diego, about 32°42′ north, 117°24′ west, P. Felt by a few in San Diego.

October 2: 10:45.* Near Santa Barbara about 34°20′ north, 119°35′ west, P. Felt at La Cumbre Lookout, Santa Barbara, and Summerland.

October 17: 21:05.* Off Cape Mendocino, about 40° north, 124° west, P. Felt at Eureka and Upper Mattole.

October 22: 16:47.* Near Riverside. 33°50′ north, 117°24′ west, P. Felt at Corona, Hemet, and Riverside.

October 24: 5:40. San Benito County. Felt at Hollister and Pinnacles.

November 4: 10:24.* Los Angeles region. 33°59′ north, 118°18′ west, P. Felt in southwest Los Angeles.

November 9: 21:22. Probably off coast of Humboldt County. Felt at Arcata, Beatrice, Eureka, and Fields Landing. Mild tremor.

November 15: 5:48. East central part of Mendocino County.

Intensity V to VI: At Calpella, Clearlake Oaks, Potter Valley, Redwood Valley, Talmadge, and Upper Lake. At Calpella small objects and furnishings were displaced and canned goods were knocked from a shelf. All residents were awakened and a few frightened. At Clearlake Oaks small objects and furnishings were displaced. Damage slight. At Potter Valley small objects and furnishings were displaced, trees and bushes were shaken. Many were awakened and frightened. Roaring subterranean sounds were heard before the shock. At Redwood Valley small objects were overturned. All were awakened. At Talmadge small objects were overturned and chimneys were cracked. One chimney was reported to have fallen. At Upper Lake water spilled from indoor containers. Trees and bushes shook slightly.

The shock was also felt at Albion, Annapolis, Bachelor, Comptche, Dos Rios, Elk, Finley, Hopland, Kelseyville, Lakeport, Littleriver, Longvale, Manchester, Mendocino, Philo, Point Arena, Willits, and Witter Springs.

Not felt at Adams, Alder Springs, Asti, Boonville, Caspar, Clearlake Park, Cloverdale, Cobb, Covelo, Dos Rios, Fort Bragg, Geyserville, Gualala, Hearst, Lodoga, Lucerne, Madera, Middletown, Preston, Seigler Springs, Skaggs Springs, Stewarts Point, Stonyford, Spyrock, Westport, Wilbur Springs, Yorkville.

November 22: 7:30.* Near Parkfield, 35°56′ north, 120°29′ west, P. Felt at Atascadero, Cambria, Creston, Morro Bay, Parkfield, Paso Robles, Shandon, San Miguel, and Templeton. Strongest at Cambria and Shandon.

November 23: 16:48.* Near Long Beach, about 33°46′ north, 118°07′ west. Felt by many in Long Beach.

November 29: 11:21.* Southwest Los Angeles. 33°53′ north, 118°28′ west, P. Felt at Los Angeles, Beverly Hills, Gardena, Maywood, and Venice. In Los Angeles windows and dishes rattled in many homes and chandeliers swayed in downtown buildings.

November 29: 21:50. San Francisco Bay area. Reported strongest in the Marina District where many ran from their homes. In San Francisco a few hanging objects swayed and a few residents were awakened. At Belvedere chimneys and plaster were reported cracked. In Oakland hanging objects swung, trees and bushes shook slightly. The shock was felt at the following places: Belvedere, Brisbane, Burlingame, Colma, Fairfax, Fort Baker, Fort Barry, Hayward, Larkspur, Mile Rocks Light Station, Montara, Morauga, Oakland, Palo Alto, Rockaway Beach, Ross, San Bruno, San Francisco, San Pablo, San Rafael, Sausalito, Sharp Park, and Stinson Beach.

Not felt at Alamo, Alvarado, Belmont, Berkeley, Bolinas, Danville, Diablo El Cerrito, El Granada, Half Moon Bay, Hayward, Ignacio, Lafayette, La Honda, Los Altos, Manor, Menlo Park, Mill Valley, Mountain View, Newark, Oakland, Redwood City, San Carlos, San Lorenzo, Sunnyvale, Tiburon, Walnut Creek.

December 1: 8:17.* Santa Clara County. About 37° north, 121° west, P. Felt at Alviso, Ben Lomond, Chualar, Coyote, Cupertino, Gilroy, Irvington, Paso Robles, San Jose, and Saratoga. In San Jose some chimneys were reported cracked and in Saratoga some plaster was reported cracked.

Not felt at Almaden, Aptos, Aromas, Big Sur, Castroville, Davenport, Firebaugh, Gilroy, Gonzales, Greenfield, Jolon, King City, Lockwood, Los Altos, Los Banos, Los Gatos, Madrone, Marina, Mendota, Milpitas, Moss Landing, Newman, Pacific Grove, Paicines, Palo Alto, Paraiso Springs, Parkfield, San Ardo, San Benito, San Martin, San Miguel, San Simeon, Santa Cruz, Shandon, South Dos Palos, Tres Pinos, Volta, Warm Springs.

December 3: 9:42.* East-central California. 37°30′ north, 118°46′ west, southeast of Convict Lake, P. About 60 small aftershocks were recorded on the seismograph at Tinemaha during the succeeding 48 hours. Additional shocks were reported by the Pasadena Seismological Laboratory at 9:51*, 9:57*, 10:41*, 14:17*, and 14:20*.

A maximum intensity of approximately VI was reached in the Owens Valley region. The shock was felt over an area of approximately 24,000 square miles in south-central California and a small area in southwest Nevada as shown on the map. It was felt in the San Joaquin Valley as far north as Stockton and approximately to Bakersfield on the south. No structural damage was reported from the central area due probably to the fact that the region is very sparsely settled. In the mountains west of Bishop, a boulder about 6 feet in diameter was reported to have crashed into a house causing considerable damage. Other mountain slides were reported as having been seen from nearby places. It was reported that rocks were loosened in the Owens River Gorge and buildings and pipe lines damaged. In San Joaquin Valley towns in the vicinity of Fresno, pictures fell from walls in some cases. A strong-motion record was obtained on the accelerograph at Bishop.

INTENSITY VI:

Del Piedra.—Liquids spilled from indoor containers in northeast direction. Typewriter moved 6 inches.

Independence.—Rocks loosened in Owens River Gorge with damage to buildings and pipe line.

Terra Bella.—Small objects and furnishings were displaced and some overturned.

Visalia.—Hanging objects swung and candles toppled from holders. Furniture moved slightly. Liquids spilled from containers in northerly direction.

INTENSITY V:

Cedar Grove.—Felt by some outdoors; direction of motion north and south. Many were frightened.

Dunlap.—Small objects and furnishings displaced.

Fresno.—Many objects were displaced; a slight movement of beds and other furniture on free-moving casters. Chandeliers swayed violently and in some cases dishes were broken. Occupants of tall downtown buildings reported violent shaking but no damage. Police were deluged with telephone calls. Trees and bushes were shaken slightly.

Laws.—Hanging doors swung in a northeast-southwest direction. Objects on stove were displaced and knicknacks fell. Trees and bushes were shaken strongly.

Mammoth Lakes.—Hanging objects swung and liquids spilled in indoor and outdoor containers in a northeasterly direction. Shock was preceded by a roar or rumble by about 2 seconds.

Mather.—Hanging objects swung; pictures and mirrors were displaced. Felt outdoors by some. Roaring noise heard.

Pinehurst.—Small objects were displaced.

Pineridge.—Liquids spilled from containers in a northeast-southwest direction. Electric light wires were shaken.

Porterville.—Chandeliers and lights swayed and some clocks stopped. Police headquarters had many telephone calls, some from outlying districts.

Stanislaus.—Small objects were displaced.

Intensity IV: Ahwahnee, Auberry, Benton, Big Creek, Bigpine, Bishop, Burrel, Cathay, Cholame, Clovis, Coarsegold, Cutler, Deep Springs, Delano, Dyer, Nevada; El Portal, Fairmead, Famoso, Friant, Hanford, Isabella, Ivanhoe, Jamestown, June Lake, Kernville, Laton, Lemon Cove, Little Lake, Little Lake (north to Mono County), Lost Hills, Mendota, Mountain Ranch, Mount Montgomery, Nevada; Miramonte, Navelencia (25 miles east of Fresno), North Fork, Onyx, Owenyo, Raymond, Riverdale, Sand Canyon, Sequoia National Park, Sonora (2 miles northeast of), Stratford, Squaw Valley, Three Rivers, Trimmer Springs (Forest Service), Tulare, Vestal, (4 miles northwest of Ducor), Wawona, Westhaven, Woodlake, Yosemite National Park.

Intensity III and under: Aroma, Avenal, Bodfish, Corcoran, Coulterville, Dinuba, Goshen, Groveland, Le Grand, Lindsay, Modesto, Oakdale, Oasis, Oilfields, Pinedale, Rector Substation (Visalia), Selma, Snelling, South Dos Palos, Stockton, Vernalis.

Not felt at Academy, Alpauch, Bakersfield, Bartlett, Bowler, Bridgeport, Byron, California Hot Springs, Coalinga, Coleville, Copperopolis, Crows Landing, Darwin, Ducor, El Granada, Escalon, Exeter, Firebaugh, Helm, Herndon, Hollister, Holt, Huron, Incline, Jackson, Keeler, Kettleman City, La Grange, Lathrop, Linden, Long Barn, Mineralking, Livingston, Lodi, Los Banos, Manteca, Milton, Mono Lake, Patterson, Peters, Pinnacles, Pixley, Planada, Pond, Porterville, Randsburg, Reedley, Ripon, Saltdale, San Andreas, Sanger, Sheepranch, Tehachapi, Tipton, Tracy, Traner, Trona, Turlock, Vernalis, Volta, Waterford, Wasco, Weldon, Westend, Westley.

Not felt in Nevada at Beatty, Goldfield, Hawthorne.

December 3: 19:26.* Vicinity of Elsinore Lake about 33°40′ north, 117°13′ west, P. Felt at Hemet.

December 6: 19:38.* Inglewood fault, 34°00′ north, 118°25′ west, P. Felt over a comparatively small land area in Los Angeles County as shown on map. Maximum intensity IV to V. The shock was reported heaviest in the western section of Los Angeles, Hollywood, Beverly Hills, and Santa Monica. In some places people ran into the streets. Chandeliers swayed, and in a few places cracks were reported appearing in stucco walls and tile floors. Felt at Burbank, Glendale, Hollywood, La Vina, Los Angeles, Maywood, Palms, Pasadena, Santa Monica, and Venice.

December 16: 2:48.* Mono County, near Benton, about 37°40′ north, 118°25′ west, P. Felt in Benton.

December 17: 5:20.* San Bernardino region. Near Arlington. About 33°55′ north, 117°29′ west, P. Felt at Hemet and San Bernardino. In San Bernardino hanging objects swung slightly and many residents were awakened.

December 22: 19:20. San Francisco Bay area. Felt at Berkeley, Emeryville, Fort Baker and Fort Barry, Lafayette, Moraga, Pinole, and San Pablo. In Berkeley the shock was felt by nearly all. Hanging objects swung. At Fort Baker and Fort Barry, trees and bushes shook slightly.

Not felt at Almaden, Alameda. Alamo, Alviso, Brisbane, Colma, Diablo, Hayward, Lafayette, Los Altos, Los Gatos, Mile Rocks Light Station, Milpitas, Mountain View, Morgan Hill, Newark, Palo Alto, Pleasanton, Redwood City, San Carlos, San Francisco, San Jose, San Lorenzo, San Ramon, Saratoga, South San Francisco, Sunol, Sunnyvale, Walnut Creek, Warm Springs.

December 27: 2:09.* San Bernardino Valley. Near Etiwanda, 34°08′ north, 117°32′ west, P. Felt at Alta Loma, Cajon, Crestline, Pomona, and San Bernardino. A distinct rumbling was heard in San Bernardino. Residents were awakened in all of the places listed.

WASHINGTON AND OREGON

[120TH MERIDIAN OR PACIFIC STANDARD TIME]

NOTE.—More details will be found in "Abstracts of Earthquake Reports for the Pacific Coast and Western Mountain Region."

January 3: 6:15 approximately. Ariel Dam, Cowlitz County, and West Central part of Skamania County near Cowlitz County line, in Washington. Slight shock felt.

January 6: 5:11.* Puget Sound region. Epicenter probably in Puget Sound about 10 miles northwest of Seattle. Strongest at Kingston, Port Orchard, and Seattle. Recorded lightly on the seismograph at the University of Washington in Seattle. Many were awakened and some frightened. Loose and hanging objects were displaced. Also felt at Coupeville, East Concrete, Everett, Hartford, Nisqually entrance to Rainier National Park, Possession, Sedro-Woolley, Skykomish, and Yacolt.

Not felt at Aberdeen, Anacortes, Ariel Dam, Arlington, Bellingham, Blaine, Buckley, Cathlamet, Cedar Falls, Centralia, Chimacum, Clallam Bay, Clearwater, Darrington, Forks, Friday Harbor, Glacier, Grapeview, Grays Harbor, Hoquiam, Kalama, Kent, Kosmos, La Grande, Lester, Longmire, Longview, Moclips, Monroe, Mount Baker Lodge, Naselle, Oakville, Olga, Olympia, Packwood, Parkway, Port Angeles, Prindle, Randle, Raymond, Rockport, Landsburg, Satsop, Scenic, Shelton, Snoqualmie, South Bend, Stabler, Tacoma, Vancouver, Vashon Island.

April 29: 21:35, about. Arlington, Wash. Moderate shock. Furniture shaken.

May 9: 1:00. Walla Walla, Wash. Very slight.

May 24: 9:42. Walla Walla, Wash. Two slight abrupt tremors a short interval apart.

May 28: 2:14.* Probably off coast of northern part of Coos County, Oregon. At Gardiner trees and bushes were shaken. At North End small objects and furnishings moved and pictures fell. Many were awakened. Also felt at Allegany, Booth, Charleston, Cooston, Empire, Marshfield, Powers, Reedsport, Portland, and Westlake. Nearly all of these places are in Coos County.

Not felt at Arago, Broadbent, Bullards, Camas Valley, Cushman, Elkton, Florence, Langlois, McKinley, Myrtle Point, Port Orford, Siltcoos, Sitkum, Summer, Umpqua, Winchester Bay.

July 22: 18:50. Astoria, Oregon, and southwest section of Pacific County, Wash. Moderate shock, rattled dishes and frightened a few residents. One observer noted freshly fallen rocks from seal cliff at 19:00.

August 11: 10:52. Milton, Oregon. Trees and bushes shaken slightly.

October 27: 15:10. Dry Creek and Milton, Oregon. Slight shock. Trees and bushes shaken at Dry Creek.

ALASKA

[150TH MERIDIAN TIME]

Year 1938: Fairbanks. Aftershocks, presumably of the destructive earthquake of July 22, 1937, were reported on January 25, 28, and 30; February 2, 4, 5, 6, 7, 9, 17, 24; March 6 (sharp shock at 7:36); May 3; June 2, 5, 8, 9, 27; July 22; August 28; September 11, 13 (four shocks), 24, 25, and 26; November 16, 24; December 8, 9, 18, 29, and 30 (four shocks). Nearly all of these aftershocks were light, seldom exceeding intensity III. A few of the stronger ones were also felt at nearby places.

February 24: 22:50 and 23:26. Anchorage. Slight shocks.

February 26: 0:50 and 5:22. Anchorage. Slight shocks.

March 17: 8:01 and 10:29. Anchorage, slight shocks.

March 23: 4:23. Juneau. Slight shock.

April 15: 18:47. Juneau. Slight shock.

April 18: 13:24. Juneau. Slight shock.

June 11: 9:18. Juneau. Slight shock.

November 10: 10:18.* Strong submarine earthquake south of Alaska peninsula and east of Shumagin Islands. Epicenter 55.2° north, 158.5° west. Recorded instrumentally all over the world. On the nearby Alaska peninsula little or no damage was reported, but this territory is largely uninhabited. The highest

intensity reported was VI at False Pass, Unimak Island. It was felt also at Port Miller and Anchorage. Port Miller reported aftershocks at 14:15 and 16:00.

The feature of the earthquarke was the seismic sea wave which was registered on tide gages at Sitka, Dutch Harbor, Seward, Alaska, and Honolulu, T. H. Reproductions of the marigrams showing the tidal wave characteristics are shown in figure 8.

November 14: 23:40. Port Molar, Alaska peninsula. Slight shock.

December 30: 2:15. Anchorage. Slight shock.

HAWAIIAN ISLANDS

NOTE.—In the case of these islands with their many earthquakes of volcanic origin, only the stronger ones are listed. Reports of the Hawaiian Volcano Observatory under the jurisdiction of the National Park Service give all details. "HVO" indicates that the epicenter given was determined by the Hawaiian Volcano Observatory.

January 9: 15:17.* Near Kilauea Volcano, Hawaii. 19°24.8′ north, 155° 15.2′ west, HVO. Felt by many at C. C. C. camp, on southeast rim of Kilauea crater, and by several near the National Park headquarters.

January 22: 22:03.* A strong submarine earthquake off the north coast of Maui was felt throughout the Hawaiian Islands and caused considerable damage on Maui. Maximum intensity VII to VIII. Damage was estimated at $150,000. A few persons were injured by land slides.

The epicenter as located from instrumental data from nearby and distant stations is a point about 40 miles east of the Island of Molokai and about 120 miles from Honolulu and Hilo. The computed coordinates are 21.2° north, 156.1° west. If the shock had occurred on land the affected area would have been approximately 250,000 square miles.

No tidal wave occurred. Among the unusual phenomena reported were flashes of light in the sky before and during the earthquake. Some reported flashes after the shock and one observer reported seeing a meteor fall.

In the following description of the earthquake the information will be given according to the effects in the various islands in the following order: Maui, Molokai, Lanai, Hawaii, Oahu, and Kanai. A detailed report on the earthquake will be found in The Volcano Letter of the Hawaiian Volcano Observatory for March 1938.

Island of Maui.—Report prepared in the office of the local engineer gives the following information on damage to roads, waterworks, and pipe lines on the Island. Landslides occurred in the Lahaina Pali section, on the road between Hono Kahua and Hono Kahau, on the Kahakoloa Road, along the Hana belt road from Kapiki gulch to Waikane bridge beyond Wailua, on the Kipahulu-Kaupo trail, on the Ulupalakua Road towards Kanaio, and on the road to the Waiiakamoi intake. In many cases the roads were blocked and emergency crews worked day and night to clear them. There were many bad cracks in the road beds all over the Island, and occasionally boulders rolled into the roads.

The Olinda reservoir was so badly cracked that its capacity dropped from 8 million gallons to 1 million gallons. The steel storage dam on the Wailuku-Kahului line was damaged. Pipe lines broke and water washed out the foundation causing the tank to buckle. The Kaupo water line was broken and buried under large slides. About 250 feet of pipe on the Lahaina intake were broken by a big rock slide. The Kaupakulua water tank was demolished due to faulty turnbuckles, but the wooden sections of the tank were not damaged. A wooden flume at Waiakamoi intake was demolished. There was considerable damage of similar nature at other places in the Island. Residents were warned to boil all water used for drinking purposes. At *Hamakuapoko* some jewels and ornaments were thrown to the floor and broken. Cracks appeared in an old stone stable. There was general panic.

At *Hana* a landslide occurred on the north side of Kanai Hill which is the remains of an old cinder cone 390 feet high. One chimney fell and a transformer was dislodged from a telephone pole. Many loose objects fell and some plaster was thrown down. A large well-built cistern was broken. Valves in Hana storage tanks broke, causing considerable loss of kerosene. Many were panic stricken as crowds rushed from theatres. Flashing lights were seen by many immediately after or during quake, brilliant as lightning but steadier.

At *Kailua* some chimneys were cracked and plaster fell. A few windows were broken and concrete steps cracked.

At *Keanae* light fixtures swung and dishes and supplies were thrown to the floor. At *Kihei* there was visible swaying of trees and general alarm, no damage.

At *Kula* cracks appeared on the Heleakala road, the widest being 1½ inches. There were landslides on the road to Hana. Pipe lines running in all directions were damaged. Windows were broken and walls cracked. Many vases, dishes, etc., fell from shelves. Pictures fell in a few instances. Small slides were reported on nearby roads.

At *Lahaina* the water reservoir was cracked and the main waterline damaged by landslides. Some damage was done in a fruit orchard through falling boulders, one of which penetrated a caretaker's house several inches. One chimney fell and a few walls were cracked. Some plaster was thrown down. Water in aquarium spilled over and many loose objects were displaced. Chairs, pianos and ice boxes were reported to have moved from 6 inches to 1 foot.

At *Paia:* "Except for a book, a picture, a globe, and two dishes found on the floor, and a small chip out of the concrete around the fireplace opening, there were no signs of a disturbance. Small objects on shallow shelves and table lamps were unmoved."

At *Sprecklesville* much china and glassware was broken, in one case the loss amounting to about $25. Water pipes were broken and a few chimneys fell. Landslides occurred on the nearby roads. A few plate glass windows were broken, power lines were damaged, and some bridges cracked. General alarm prevailed.

At *Pauwela Point Light* on the east side of Kahului Harbor, a flange casting on the lantern footing cracked but the light still operated. Water tanks shifted on foundations. Keeper reported that motion was so strong he could hardly stand. Ground nearby cracked and there were some slides.

At *Wailuku* there was considerable damage to the county water system as previously stated. A new grade crossing elimination structure apparently settled, cracking the road, throwing the sidewalk out of line and cracking the concrete guard rail and masonry abutment. There was slight damage to the Kress store and to the Wailuku Armory, both new structures. In some instances plaster was shaken loose and cornices damaged. Two fishermen were partially buried by a land slide at Maliko gulch but suffered only minor bruises. Crowds rushed from theatres and many left their homes, some panic stricken.

Island of Molokai.—At *Kalaupapa* cracks appeared in the walls of the Kalawao Catholic church. Six breaks in 8-inch pipe line along base of Waikolu Pali were caused by falling boulders. Several landslides were reported. There were no reports of displaced objects.

At *Kaunakakai* one steel 4-inch pipe was pulled apart at one point and damaged at several joints. Several empty pop bottles fell over on floor. Felt by everyone except those in moving automobiles. School clocks stopped at 10:05.

At *Mahalehua* light objects were displaced in east-west direction; standing plates rolled east to west. A small amount of soil fell from cliffs along nearby roads. Only a few were alarmed.

At *Molokai Light Station* (largest United States light in the Pacific) the mechanism was deranged and the light was out about 15 minutes. One and one-half quarts of mercury were thrown out of mercury vat. Dishes rattled. Landslides occurred about 4 or 5 miles southeast of the station.

At *Puuohoku Ranch* cement floors cracked in several range buildings, and all jars, tins, etc. fell from shelves in the ranch store in all directions. Some large stones fell on nearby roads. There was general alarm.

Island of Lanai.—Slides generally occurred on bare spots with no vegetation or very little. Fishermen on windward side reported seeing first a bright flash between Maui and Molokai seaward, then sea surface assumed a gelatin-like appearance with ripples moulded in after which quake was felt. The sea was calm before the quake. In the town some glass was broken and chips were knocked from a few fireplaces. In some cases stock on the shelves of stores was thrown over. Bottles were thrown off shelves in a number of houses. Pictures on walls were displaced. Many rushed outdoors and there was general alarm.

Island of Oahu.—At *Barber's Point Light Station.* Swaying motion felt but no damage to the station.

At *Honolulu* light boxes and some crockery were jarred from shelves. In a building of the University of Hawaii some plaster fell and old cracks appeared to have widened considerably. Some organ pipes at the Central Union church were thrown out of their sockets. There was considerable excitement and some alarm. The seismograph at the University of Hawaii was dismantled.

At *Makapuu Point Light and Radio Beacon Station* several minor cracks appeared on plaster walls and two storm panes of tower lantern cracked. All occupants of buildings rushed outside.

At *Kaneohe* some plaster fell from buildings and dishes were broken. Drop-lights swayed. Many were alarmed.

At *Waipahu* canned goods and other loose objects were displaced. A 6-inch pendulum clock stopped. Telephone wires were observed swaying. Many were awakened and alarmed but those walking outside failed to notice the shock.

At *Wahiawa* one loose object fell from moulding on a wall and a few other loose objects were disturbed. Nearly all residents ran outdoors.

Island of Hawaii.—At North Kohala small landslides occurred in road cuts along ocean cliffs and one crack appeared in the ground at the edge of Pololu Valley. Slight cracks appeared in one building. Some cement poles were chipped, and one old flume fell. Dishes were broken, some chandeliers fell, and refrigerator doors opened. A few were alarmed.

At *Kauholo Point Light Station* a few plates and kitchen utensils fell over but were not broken. Along the Hamakua coast landslides were reported between Laupahoehoe and Hakalau. The shock was felt by everyone.

At *Honomu* all loose objects including a piano moved back and forth. Residents more excited than alarmed.

At *Hilo* ornaments in some homes were broken and furniture disarranged. Lights swayed, windows rattled, and pictures were displaced. Buildings and trees swayed visibly. There was general alarm.

At *Kahoolawe* a pipe line was broken by a small landslide and a cistern was cracked. There was visible swaying of trees. At the Cape Kumakahi Light Station the shock was noticed by only a few.

At *Kalae Light Station* the motion was observed by only one person. At the Hawaiian Volcano Observatory, some of the seismographs were dismantled.

Island of Kauai.—At *Lihue* a swaying motion was felt by many. Cracks were reported to have appeared in a plantation store.

At *Kilauea Point Light Station* it was felt by the station personnel.

At *Waimea* a 6-inch drop cord and shade swayed about 3 inches in an east-west direction. The shock was observed by most of the population and many rushed to the streets.

At Sea.—The shock was felt distinctly by two vessels—the American steamer *President Coolidge* in latitude 22°53′ north, longitude 155°19′ west, and by the American steamer *Montebello* in latitude 22°20′ north, longitude 155°34′ west. Both of these vessels were en route from Honolulu to California.

See also effect on ocean surface reported by fishermen on windward side of Lanai, page 29.

February 17: 2:18.* Mauna Loa, Hawaii. Near Puu Ulaula, 19°33.0′ north, 155°27.0′ west, HVO. Felt strongly in Kona, and Hawaii National Park. Felt slightly by many in Hilo.

February 28: 21:40.* Kilauea Crater, Hawaii. 19°24.8′ north, 155°17.1′ west, HVO. Felt in park headquarters area.

March 3: 15:00. Honolulu, Oahu. Slight shock felt in widely separated parts of city not recorded on seismograph at University of Hawaii.

March 7: 5:56.* Mauna Loa, Hawaii 19°42.0′ north, 155°32.0′ west, about 8 miles southwest of Hilo, HVO. Felt in Hilo, Kona, and Hawaii National Park.

March 21: 17:30.* Ewa, Oahu. Felt near United States Coast and Geodetic Survey magnetic observatory and recorded at Honolulu.

May 28 and 29: A large number of moderate and slight earthquakes were reported beginning at 6:32 on the 28th. In Hawaii National Park in Kilauea Military Camp some reached an intensity of IV to V.

July 2: 14:20.* Hawaii, 6 miles southeast of Volcano observatory. 19°23.0′ north, 155°11.5′ west, HVO. Felt at Kapapala and in National Park area.

October 25: 12:18*. Hawaii, 18 miles south southwest Hilo, 19°27.8′ north, 155°09.5′ west, HVO. Felt by many in Hilo and by few in Hawaii National Park.

October 27: 18:11.* Hawaii, near Hualalai, 19°42.0′ north, 155°50.2′ west, HVO. Felt by many in Kona and at Naalehu.

PHILIPPINE ISLANDS

[120TH MERIDIAN (EAST) TIME]

NOTE.—In the case of these islands with their many minor earthquakes, only the stronger ones are listed. Reports of the Weather Bureau of the Philippine Islands give all details. Instrumental times given below are arrival times of the first preliminary tremors recorded at Manila unless otherwise stated. The intensities are according to the R-F scale. Practically all of the information given in this report is taken from the seismological reports of the Weather Bureau of the Philippine Islands.

January 12: 21:40.* Virac, Cataduanes, intensity V.

January 19: 4:49.* Southeast Luzon. Virac, IV; Capalonga, III.

February 5: 5:56.* S. Luzon. Epicenter in region of Cataduanes Island. Virac, VI; Legaspi, V; Daet, Sorsogon and Antimonan, IV.

February 23: 8:55.* Central Luzon, 16.2° north, 120.5° east, according to the Manila Observatory. Felt over a radius of about 100 kilometers.

March 11: 0:23.* Eastern Mindanao, epicenter in southern part of Philippine Deep according to the Manila observatory. Felt strongly at Santa Cruz and Davao, and lightly at Port Lamon and Lingiz in Gurigao.

May 23: 16:23.* Off Luzon in the China Sea. Felt very strongly at Vatac. V at Vigan, IV at Laoag. Felt slightly in Ambulong and also in Hong Kong, China.

June 27: 4:35.* Samai, Calbayog, IV.

July 25: 5:43.* Luzon and Samar. VI to VII at Calbayog; III in Bulan, Legaspi, Sorsogon and Tabaco.

August 29: 11:23.* Southeast Luzon and Visayan Islands. Epicenter in Samar Sea near the south end of Masbate, 12°05′ north, 124°05′ east according to the Manila observatory. VII to VIII in Cataingan, VI at Calbayog and IV to V in Segaspi.

November 13: 12:55. Mindanao, Samar, and Leyte. Epicenter in the Philippine Deep according to the Manila observatory. V at Dapa and Butuan.

PUERTO RICO

[60TH MERIDIAN TIME]

December 1: San Juan. Slight shock.

PANAMA CANAL ZONE

[75TH MERIDIAN TIME]

NOTE.—Instrumental times given below are the arrival times of the first recorded phases on the seismograph at Balboa Heights unless otherwise stated.

February 4: 21:25.* Balboa Heights, II. Slight damage reported in Cali, Colombia.

May 12: 2:36.* Balboa Heights. Intensity I or less.

May 21: 2:44.* Intensity III in Canal Zone and Panama. No damage.

August 4: 11:07.* Cristobal, II.

August 22: 11:30.* Pacific Side of Canal Zone, II.

August 31: 23:21.* Balboa Heights, III. Felt generally throughout Canal Zone.

October 27: 13:14.* Balboa Heights, I–II.

MISCELLANEOUS ACTIVITIES

GEODETIC WORK

During the year 1938 triangulation and traverse were executed in five different localities in California for the investigation of earth movements. Three of these projects, in the vicinity of Maricopa, Gorman and Palmdale, consisted of triangulation and traverse. Bench marks which had been established previously were used as traverse stations. These bench marks were closely spaced and located on both sides of the fault zones. The traverse stations were connected with adjacent triangulation stations by short arcs of triangulation A similar project was started in the vicinity of Brea but was not completed. Here the triangulation observations were made but no traverse was done. Reconnaissance was done in four other areas, in the vicinity of Cajon Pass, Whitewater, Moreno and Inglewood but no observations were made. Reobservations were made from Point Reyes to Petaluma along the arc of triangulation which had been established in 1930 for the study of earth movements.

The adjustment of these arcs of triangulation has not been completed and final adjusted positions are not yet available.

248577—40——5

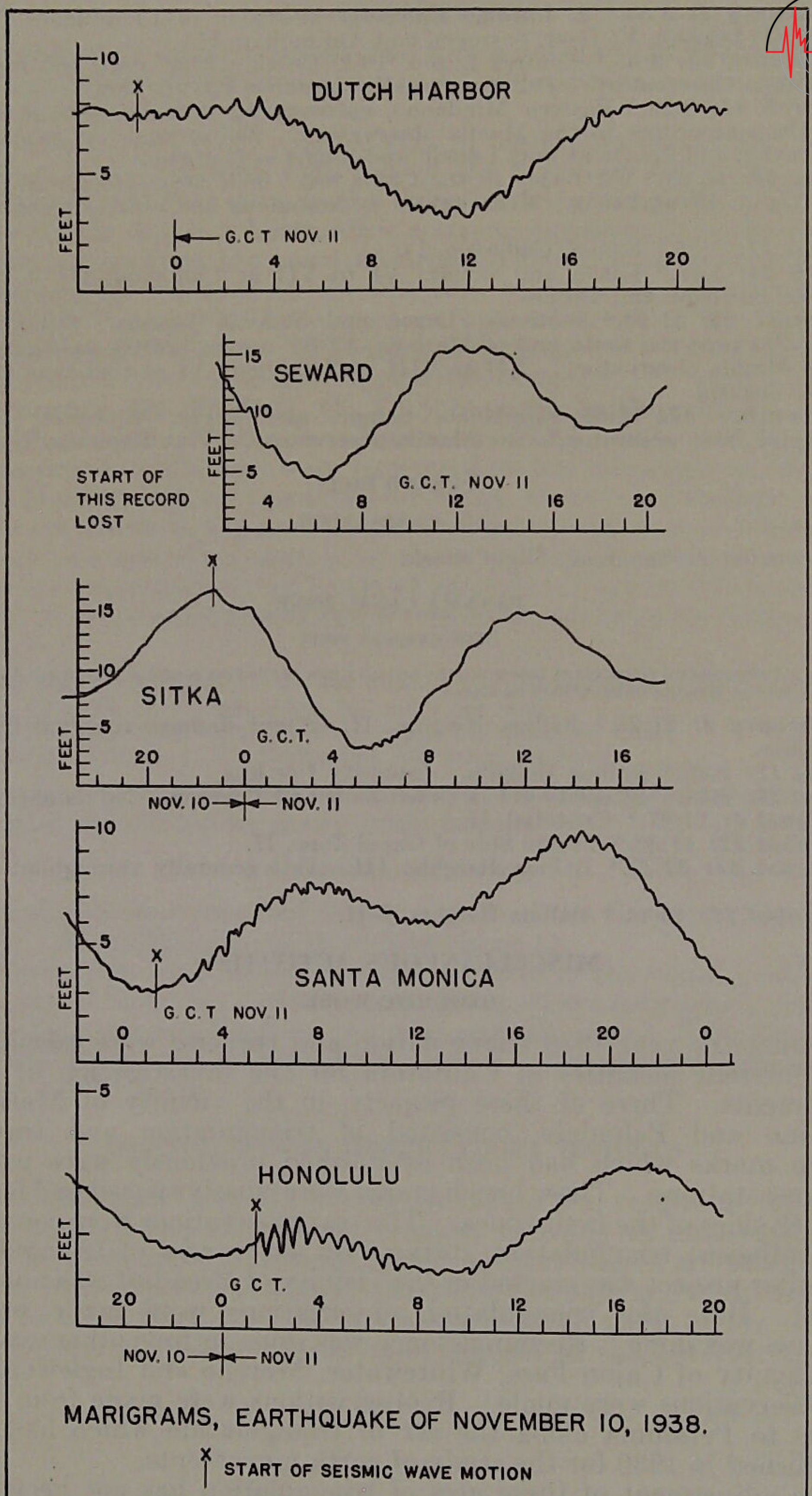


Figure 8.—Tracings of marigrams showing seismic sea waves at time of Alaskan earthquake of November 10, 1938.

TIDAL OBSERVATIONS

The following data on seismic sea waves during 1938 were obtained from the marigrams of the Coast and Geodetic Survey and reported from miscellaneous sources.

March 6: 15.5h local time. Waves of 30-minute period and range of 1.5 to 2.0 inches were recorded on the Honolulu tide gage. Epicenter 8° south, 165° east, in the Solomon Islands region.

March 22: About 3 hours after a strong earthquake in the Queen Charlotte Islands of the coast of British Columbia, a weak seawave was apparently recorded on the tide gage at Santa Monica, Calif.

May 19: Waves 2 to 3 meters high were observed in the Strait of Macassar, and oscillations of about 3-inch range were recorded on the gage at Santa Monica, Calif. Epicenter 1° north, 119° east.

November 10: 20:18 G. C. T. Submarine earthquake off south coast of Alaskan Peninsula. Epicenter 55.2° north, 158.5° west. Well recorded oscillations were registered on the tide gages at Seward, Dutch Harbor, Sitka, Honolulu and Santa Monica. Tracings of the records are shown in Figure 8 for all stations except Seward where the gage was not operating until after the arrival of the waves.

The (1) Greenwich Civil Times of arrival, (2) epicentral distances, and (3) average velocities of the waves from epicenter to station, are as follows:

Dutch Harbor, 22:30 G. C. T., 340 miles, 155 miles per hour.
Sitka, 22:40 G. C. T., 900 miles, 390 miles per hour.
Santa Monica, 25:20 G. C. T., 2425 miles, 485 miles per hour.
Honolulu, 25:20 G. C. T., 2390 miles, 480 miles per hour.

The path to Dutch Harbor was through water 80 fathoms or less in depth and obstructed by many small islands.

HYDROGRAPHIC WORK

Four shocks were reported felt by vessels of the Coast and Geodetic Survey. See California shock of September 11.

In connection with offshore seismic activity in the vicinity of Cape Mendocino, California, early hydrographic surveys indicated a vertical submarine scarp running east and west near the cape. This has been confirmed by recent surveys which reveal a definite scarp in about latitude 40°18′ north.

SEISMOLOGICAL OBSERVATORY RESULTS

The Coast and Geodetic Survey publishes the results of its teleseismic stations and cooperating stations monthly 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 to the Director of the Bureau.

Instrumental results are published for the following observatories:

Balboa, Canal Zone (The Panama Canal).
Bozeman, Mont. (Montana State College).
Burlington, Vt. (University of Vermont).
Butte, Mont. (Montana School of Mines).
Chicago, Ill. (University of Chicago and United States Weather Bureau).
College, Alaska (University of Alaska).
Columbia, S. C. (University of South Carolina).
Des Moines, Iowa (Private station, M. M. Seeburger, Director).
East Machias, Maine (Massachusetts Institute of Technology).
Honolulu, Hawaii (University of Hawaii).
Huancayo, Peru (Carnegie Institution of Washington).
Montezuma, Chile (Smithsonian Institution).
Philadelphia, Pa. (The Franklin Institute).
Salt Lake City, Utah (University of Utah).
San Juan, P. R.
Seattle, Wash. (University of Washington).
Sitka, Alaska.
Tucson, Ariz.
Ukiah, Calif. (International Latitude Observatory).

San Juan, Sitka, Tucson, and Ukiah are Coast and Geodetic Survey stations; Bozeman, Butte, Chicago, College, Columbia, Honolulu, and Salt Lake City are cooperative stations; Balboa, Burlington, Des Moines, East Machias, Huancayo, Montezuma, Philadelphia, and Seattle are independent stations. All readings are made or revised at the Washington office except those for Balboa.

The epicenter results for 1938 are not available as this publication goes to press but it is expected that they will be published in "United States Earthquakes, 1939."

The following table shows the epicenter results for 1937 which were incomplete at the time the 1937 publication, Serial 619, went to press.

TABLE 1.—*Summary of instrumental epicenters for 1937*

1937	Greenwich civil time at origin	Region and focal depth	Coordinates of provisional epicenter [1]	
			Latitude	Longitude
	h *m*		°	°
Jan. 2	22 33.6	Pacific Ocean off Mexico. Depth normal	17.8 N.	105.0 W.
Jan. 5	11 09.2	Southeast of Japan. Depth about 500 km	27.5 N.	139.0 E.
Do	21 37.9	Pacific Ocean off Japan. Depth normal	31 N.	132 E.
Jan. 7	6 11.9	....do	38.5 N.	142.2 E.
Do	13 20.5	Tibet. Depth normal	35.5 N.	98.0 E.
Jan. 11	13 21.2	South coast of Mexico. Depth normal	16.0 N.	93.9 W.
Jan. 23	10 55.8	Solomon Islands. Depth normal	6 N.	154 E.
Jan. 25	6 34.0	....do	10.1 S.	163.0 E.
Feb. 4	10 32.8	Pacific Ocean off Vancouver Island. Depth normal	49.0 N.	129.0 W.
Feb. 7	4 41.6	Off Eureka, Calif. Depth normal. See Berkeley report.	40.4 N.	125.1 W.
Feb. 17	9 15.3	Pacific Ocean off Japan. Depth normal	43 N.	150 E.
Feb. 19	9 09	Western Nevada. By Pasadena	38.3 N.	118.3 W.
Feb. 21	6 02.6	Pacific Ocean off northern Japan. Depth normal	44.3 N.	150.0 E.
Do	22 28.9	....do	43 N.	148 E.
Feb. 22	1 18.4	Pacific Ocean off west coast of Mexico. Depth normal	17 N.	104 W.
Do	2 54.0	Kurile Islands	45.3 N.	148.0 E.
Do	13 24.0	Pacific Ocean off northern Japan	44.3 N.	149.5 E.
Feb. 23	0 48.2	Pacific Ocean off northern Japan. Depth normal	44.2 N.	149.5 E.
Feb. 27	1 15.6	Pacific Ocean east of Japan. Depth normal	37 N.	142 E.
Mar. 2	14 47.6	Near Anna, Ohio. By St. Louis	40.4 N.	84.2 W.
Mar. 5	14 47	Monterey Bay (Calif.) region. By Berkeley and Pasadena.	36.7 N.	121.7 W.
Mar. 8	10 31.2	San Francisco Bay area. By Berkeley and Pasadena	37.8 N.	122.2 W.
Mar. 9	5 44.7	Near Anna, Ohio. By St. Louis	40.4 N.	84.1 W.
Do	15 40	Costa Rica near Panama border	9.1 N.	83.1 W.
Mar. 14	11 55.9	Damage at Taltal, Chile. Depth about 80 km	25.0 S.	69.5 W.
Mar. 16	15 45.8	Northern Luzon. Depth about 80 km	17.9 N.	121.0 E.
Mar. 17	13 59.8	Pacific Ocean off Costa Rica. Depth normal	8.8 N.	84.0 W.

[1] In some cases, Pasadena epicenters for instance, the locations and origin times are known much more accurately than indicated in this table. See text in "United States Earthquakes, 1937" and the monthly instrumental reports for further details.

TABLE 1.—*Summary of instrumental epicenters for 1937*—Continued

1937	Greenwich civil time at origin	Region and focal depth	Coordinates of provisional epicenter	
			Latitude	Longitude
	h *m*		°	°
Mar. 19	18 12.0	La Sarena and Coquimba, Chile. Depth nearly 80 km	30.4 S.	70.8 W.
Mar. 23	0 44.4	Pacific Ocean between Easter Island and Chile. Depth normal.	36.5 S.	97.8 W.
Mar. 25	16 49.2	Southern California. By Pasadena	33.5 N.	116.6 W.
Do	20 04	....do	33.5 N.	116.6 W.
Mar. 26	21 09.1	Off Cape Mendocino, Calif. Depth normal	40.6 N.	127 W.
Mar. 29	6 18.8	Pacific coast of Costa Rica. Depth normal	8.9 N.	83.6 W.
Do	7 49.8	Southern Peru. Depth near 80 km	16.6 S.	71.1 W.
Do	12 07.6	Pacific Ocean off Panama. Depth normal	4.5 N.	83.0 W.
Apr. 1	17 20.6	Pacific Ocean southwest of Samoa. Depth normal	15 S.	173 W.
Apr. 3	3 52	Probably in region of Caroline Islands in western Pacific.	----------	----------
Apr. 5	6 56.6	New Guinea. Depth normal	1.1 S.	133.2 E.
Apr. 13	5 08.5	Near Panama-Costa Rica border. Depth normal	8.7 N.	82.9 W.
Apr. 16	3 01.6	Near Tonga Islands in South Pacific. Depth about 300 km.	20.5 S.	177.6 W.
Apr. 20	15 24	Southern California. By Pasadena	33.9 N.	117.5 W.
Apr. 29	18 11.5	North Atlantic Ocean. Depth normal	56.4 N.	32.1 W.
Do	18 52.6	Pacific Ocean, south of Alaska peninsula. Depth normal.	54.3 N.	161.5 W.
Do	20 18.9	Siberia. Depth near 350 km	46.2 N.	136.9 E.
May 1	12 21.3	Pacific Ocean south of Easter Island. Depth normal	33.5 S.	106.5 W.
May 4	5 08.9	Kenai Peninsula, Alaska. Depth normal	59.5 N.	151 W.
May 5	21 15.5	Pacific Ocean in Mariana Islands. Depth near 250 km	17.1 N.	145.0 E.
May 7	14 10.9	Pacific Ocean south of Alaska peninsula	54.7 N.	162 W.
May 9	14 46.7	Pacific Ocean off Kurile Islands. Depth normal	44.8 N.	149.1 E.
May 12	2 45.0	North coast of New Guinea. Depth about 120 km	4.0 S.	145.0 E.
May 13	9 18.3	Off west coast of Mexico. Depth normal	18 N.	105.5 W.
May 15	10 26.6	Probably in region of Easter Island	----------	----------
May 16	11 38	Probably Solomon Islands region. Deep focus	----------	----------
May 21	13 12.2	Southwestern Colombia, near Ecuador border. Depth normal.	2.3 N.	78.1 W.
May 23	8 12.4	Atlantic Ocean. Depth normal	3.1 S.	28.5 W.
May 24	0 40.5	Pacific Ocean, region of Galapagos Islands. Depth normal.	3 N.	95 W.
May 28	2 42.7	West Indies. Depth normal	15.0 N.	60.5 W.
Do	15 36.0	Lower Mexico. Depth about 160 km	17.5 N.	92.8 W.
Do	19 56.1	Bonin Islands, western Pacific Ocean. Depth about 500 km.	24.7 N.	142.1 E.
May 29	2 00.1	....do	25 N.	142 E.
May 31	15 31.9	Solomon Islands. Depth about 80 km	6.7 S.	154.0 E.
June 2	21 03.9	Off west coast of Mexico. Depth normal	18.6 N.	108.6 W.
June 7	4 03.2	Pacific Ocean off Central America	5 N.	92 W.
June 8	22 29.5	Near Mexico-Guatemala border. Depth about 160 km	16.2 N.	87.6 W.
June 13	23 23.8	Near west coast of Mexico. Depth normal	15.5 N.	98.0 W.
June 14	12 30.8	Southwest of Fiji Islands. Depth normal	22 S.	171 E.
Do	13 10.3	....do	20.8 S.	169.9 E.
June 18	9 07.5	California, Modoc County. By Berkeley	41.1 N.	120.0 W.
June 19	17 07.4	South of Fiji Islands. Depth about 630 km	25.8 S.	178.0 E.
June 21	15 13.0	Off coast of Peru. Depth normal	8.3 S.	79.8 W.
June 24	3 26.8	Probably off west coast of Mexico, south of Lower California.	----------	----------
Do	13 11.6	Pacific Ocean off Costa Rica. Depth normal	8.2 N.	84.0 W.
Do	20 00.0	Atlantic Ocean southwest of Azores. Depth normal	35.5 N.	35.9 W.
July 1	6 00.9	Probably off Mazatlan, Mexico	----------	----------
Do	9 54.7	Probably off southeast coast of Greenland	----------	----------
Do	11 49.7	Off west coast of Sumatra. Depth normal	2.5 N.	96 E.
Do	14 53.5	Probably near western Panama	----------	----------
July 2	2 36.9	Queen Charlotte Islands, south Pacific Ocean. Depth normal.	13 S.	165 E.
July 4	5 55.1	Solomon Islands. Depth normal	8 S.	162 E.
July 8	12 51.1	Pacific Ocean off Colombia. Depth normal	2.3 N.	84.4 W.
July 9	17 27.8	Southeastern Peru. Depth about 150 km	15 S.	71 W.
July 11	17 19.4	Off west coast of Mexico. Depth normal	20.5 N.	108.5 W.
July 18	1 01.3	Pacific Ocean east of Unalaska. Depth normal	54 N.	165 W.
July 19	19 35.4	Ecuador. Depth about 170 km	1.7 S.	75.2 W.
July 22	17 09.6	Near Fairbanks, Alaska. Depth normal	64.4 N.	145.5 W
July 25	13 12.9	Cook Inlet, Alaska. Depth normal	60.0 N.	151.5 W.
July 26	3 47.2	South of Vera Cruz, Mexico. Depth 80 km	18.5 N.	95.7 W.
Do	19 56.5	Near east coast of Japan. Depth about 80 km	38.6 N.	151.8 E.
July 31	20 35.	Eastern China. Depth normal	35 N.	116 E.
Aug 1	10 06.7	Gulf of California. Depth normal	25 N.	110 W.
Do	10 41.0	Eastern China. Depth normal	35 N.	115 E.
Aug 2	3 26.9	Northern Peru. Depth 400 km	4.7 S.	73 W.
Do	15 45.7	Kurile Islands. Depth normal	48.7 N.	155.4 E.
Aug 4	22 35.2	Near Nicobar Islands, Bay of Bengal. Depth normal	4.7 N.	94.6 E.
Aug 5	14 43.8	Off east coast of New Guinea. Depth normal	5.2 S.	150.6 E.

TABLE 1.—*Summary of instrumental epicenters for 1937*—Continued

1937	Greenwich civil time at origin	Region and focal depth	Coordinates of provisional epicenter	
			Latitude	Longitude
	h *m*		°	°
Aug 9	14 39.6	Sea of Japan. Depth normal	28 N.	139 E.
Do	19 18.9	South of Japan. Depth normal	28.0 N.	141.2 E.
Aug. 10	16 06.2	Off west coast of Costa Rica. Depth normal	10.1 N.	86.0 W.
Aug. 11	0 55.9	East of Java. Depth 600 km	7.0 S.	116.1 E.
Aug. 13	11 47.7	South Pacific Ocean. Depth normal	57 S.	130 W.
Aug. 15	4 27.2	Northern Luzon, P. I. Depth normal. By Coast and Geodetic Survey.	19.4 N.	122.2 E.
Aug. 17	13 10.2	Southeast of Japan. Depth normal	30 N.	139 E.
Aug. 18	15 06.4	Atlantic Ocean near St. Paul Islands. Depth normal	0	30 W.
Aug. 20	6 37.9	South Indian Ocean. Depth normal	28 S.	68 E.
Do	11 59.3	Near Alabat Island, Philippines. By Manila	14.2 N.	122.1 E.
Aug. 21	23 02	Southeast of Japan. Depth normal	31 N.	143 E.
Aug. 22	11 31.7	Atlantic Ocean off northeastern Brazil. Depth normal.	6.6 N.	35.7 W.
Aug. 24	18 27.9	South of Samoa. Depth normal	17.4 S.	172.1 W.
Do	20 13.5	Pacific Ocean off Panama. Depth normal	4.8 N.	88.7 W.
Aug. 26	11 25.7	Northern Argentina. Depth normal	27.2 S.	66.3 W.
Do	18 54.2	Off southwest coast of Japan. Depth normal	31.2 N.	131.8 E.
Aug. 31	2 28.9	Northwest of New Hebrides Islands. Depth normal	13 S.	167 E.
Do	6 48.2	Off coast of Chile. Depth normal	20.1 S.	72.2 W.
Do	14 15.2	Northern Burma. Depth normal	26.5 N.	97 E.
Sept. 1	8 38.8	Pacific Ocean near Kermadec Islands. Depth normal	32 S.	179 W.
Do	16 35	Southern California. By Pasadena	34.1 N.	117.6 W.
Do	17 24.3	Off southern coast of Mexico. Depth normal	16 N.	94.1 W.
Do	21 41.2	Northeast of New Zealand. Depth normal	34.0 S.	176.8 W.
Sept. 2	12 21	Lower California. By Pasadena	32.5 N.	115.6 W.
Sept. 3	18 48.1	Aleutian Islands. Depth normal	52 N.	178 W.
Sept. 4	3 39.6	Ecuador. Depth normal	0.5 S.	80 W.
Do	6 14.3	New Hebrides Islands. Depth normal	17 S.	173 E.
Sept. 7	22 33.9	Gulf of California. Depth normal	31.7 N.	113.6 W.
Do	23 11.3	----do	31.1 N.	113.1 W.
Sept. 8	0 40.1	Sandwich Islands, South Atlantic Ocean. Depth about 150 km.	55 S.	29 W.
Do	16 10.5	Off coast of Ecuador. Depth normal	0 N.	81 W.
Sept. 9	5 29	Off coast of northern Peru. Depth normal	5 S.	84 W.
Sept. 15	0 50.3	Off coast of Ecuador. Depth normal	1 S.	82 W.
Do	12 27.5	Solomon Islands. Depth normal	10.3 S.	161.8 E.
Do	19 30.0	South Pacific Ocean. Depth normal	10 S.	113 W.
Do	23 48.8	Off southwest coast of Guatemala. Depth normal	14 N.	91.6 W.
Sept. 17	9 30.9	Sandwich Islands, South Atlantic Ocean	57 S.	26 W.
Sept. 20	7 03.8	Off southwest coast of Mexico. Depth normal	18.4 N.	105.5 W.
Sept. 21	7 46.8	French Indo-China. Depth normal	21 N.	102 E.
Do	9 39.8	Northeast of Celebes Island. Depth normal	2 N.	126.7 E.
Do	21 03.6	Bering Sea off coast of Siberia. Depth normal	60 N.	174 E.
Sept. 22	3 12.0	Philippine Islands; felt in southeastern Luzon. By Manila.	12.0 N.	124.0 E.
Sept. 23	13 06.0	Solomon Islands. Depth normal	6 S.	153 E.
Sept. 24	2 40.2	Northern Colombia. Depth normal	8 N.	75 W.
Sept. 25	4 29.8	North of the Azores. Depth normal	45.9 N.	25.0 W.
Do	7 28.0	Southern Nicaragua. Depth normal	11 N.	85 W.
Do	15 05	Gulf of California. Approximate location by Pasadena	29 N.	115 W.
Do	15 10	----do	29 N.	115 W.
Sept. 26	5 51.8	Southern Ecuador. Depth normal	3.3 S.	77.6 W.
Sept. 27	8 55.2	Off southern coast of Java. Depth about 70 km	9.4 S.	110.2 E.
Sept. 28	2 29.4	Southeast Alaska. Depth normal	58.6 N.	137.7 W.
Do	6 20.8	Off southern coast of Guatemala. Depth normal	14 N.	91.4 W.
Do	18 19.4	Guatemala. Depth normal	14.7 N.	92 W.
Sept. 29	11 30.3	Off Vancouver Island, B. C. Depth normal	49.6 N.	128.4 W.
Sept. 30	21 34.1	Near Tonga Islands. Depth normal	21.3 S.	176.3 W.
Oct. 1	19 16.6	Tonga Islands. Depth normal	22.2 S.	175 W.
Oct. 2	16 22.4	Near Peru-Bolivia border. Depth normal	14.7 S.	69.9 W.
Oct. 3	3 38.0	Near Samoa. Depth normal	12.1 S.	175 W.
Oct. 4	7 40.5	Polynesia, south of Cook Islands. Depth normal	26.8 S.	163.1 W.
Oct. 5	6 21.6	Gulf of California. Depth normal	24 N.	110 W.
Oct. 6	9 47.2	Mexico. Depth normal	17.7 N.	98.5 W.
Do	17 04.7	Solomon Islands. Depth normal	7.0 S.	153.8 E.
Do	21 47.5	Atlantic Ocean east of Pernambuco, Brazil. Depth normal.	9 S.	22 W.
Oct. 11	21 24.2	South Pacific Ocean between Easter Island and Chile. Depth normal.	29 S.	93 W.
Do	15 59.8	Southwest of El Salvador	13.3 N.	92.0 W.
Oct 12	20 50.7	North of Caldera, Chile. Depth normal	26.2 S.	69.8 W.
Oct. 17	4 46.7	Pacific Ocean southeast of Japan. Depth normal	28.5 N.	139 E.
Oct. 20	5 47.5	El Salvador. Depth normal	13.3 N.	88.0 W.
Oct. 23	16 53.4	Off North Island, New Zealand. Depth normal	37.4 S.	177.8 E.
Oct. 24	11 36.2	Southeast Alaska. Depth normal	61 N.	147 W.
Do	14 12.4	Off coast of Chile. Depth normal	22.5 S.	71.6 W.
Oct. 25	10 33.1	East of Central New Zealand. Depth normal	43 S.	179 E.
Do	23 20.6	Kurile Islands. Depth normal	49 N.	156 E.

TABLE 1.—*Summary of instrumental epicenters for 1937*—Continued

1937	Greenwich civil time at origin	Region and focal depth	Coordinates of provisional epicenter	
			Latitude	Longitude
	h *m*		°	°
Oct. 27	0 21.3	Central Chile. Depth normal	34 S.	72 W.
Nov. 1	8 35.3	Northern Chile. Depth normal	24.9 S.	70.3 W.
Nov. 2	10 54.7	Solomon Islands. Depth normal	4 S.	149 E.
Do	17 54.9	Southern Peru. Depth normal	15.9 S.	74 W.
Nov. 5	22 24.6	Near Lima, Peru. Depth normal	12.5 S.	77 W.
Nov. 7	9 08.6	Northeast of Huancayo, Peru. Depth normal	9.4 S.	72.4 W.
Nov. 9	10 21.8	South Pacific Ocean between Easter Island and Chile. Depth normal.	36 S.	97 W.
Nov. 13	9 50.6	Northeast of North Island, New Zealand. Depth normal.	29.9 S.	177.1 W.
Do	17 53.8	---do	33 S.	176.4 W.
Nov. 14	10 57.9	Northeast Afghanistan. Depth normal	37.5 N.	71 E.
Nov. 15	0 51.1	Pacific Ocean west of Callao, Peru. Depth normal	14.6 S.	82.4 W.
Do	21 37.5	Northeastern India. Depth normal	35 N.	78 E.
Nov. 18	2 48.0	Eastern New Guinea. Depth normal	5.9 S.	146.8 E.
Nov. 22	4 12.8	Off Point Arguello, Calif. By Pasadena	34.6 N.	120.8 W.
Nov. 26	10 45.1	North of Formosa, in China Sea. Depth normal	24 N.	124 E.
Nov. 27	13 32.6	South Atlantic Ocean near Sandwich Islands. Depth normal.	54.5 S.	24.5 W.
Nov. 28	5 24.0	Southwest of Sumatra. Depth normal	1 S.	98 E.
Nov. 30	0 40.1	Near Nicobar Islands, Bay of Bengal. Depth normal	5 N.	91 E.
Do	12 57.8	East central Africa. Depth normal	4.9 N.	35.9 E.
Dec. 5	5 42.0	Pacific Ocean off El Salvador. Depth normal	13 N.	90.5 W.
Dec. 6	4 34.2	Pacific Ocean off Cape Inuboe, Japan. Depth normal	33.8 N.	142.1 E.
Do	21 07.7	Northeast Nicaragua. Depth Normal	14.4 N.	83.9 W.
Do	21 43.1	Atlantic Ocean off Nicaragua. Depth normal	13.3 N.	81.6 W.
Dec. 7	18 00.7	---do	13.7 N.	82.2 W.
Dec. 8	2 25.3	---do	14.2 N.	81.1 W.
Do	8 32.1	East of Formosa. Depth normal	22.9 N.	121.5 E.
Dec. 10	13 29.0	Off southeast Japan. Depth normal	38 N.	142 E.
Dec. 12	14 03.8	East of Caldera, Chile. Depth normal	25.3 S.	70.0 W.
Dec. 13	18 54.0	East of Formosa. Depth normal	22.3 N.	122.6 E.
Do	22 59.1	Atlantic Ocean northeast of Puerto Rico. Depth normal.	26 N.	51 W.
Dec. 16	8 28.3	Celebes Islands. Depth normal	1.0 N.	121.6 E.
Do	17 35.5	Aegean Sea, west of Turkey. Depth normal	36.2 N.	24.0 E.
Dec. 17	7 19.0	East of Valparaiso, Chile. Depth normal	32.8 S.	71.6 W.
Do	9 32.2	East of Formosa. Depth normal	23.1 N.	121.8 E.
Dec. 18	13 17.9	Eastern Turkestan. Depth normal	43 N.	71 E.
Do	20 49.1	West coast of Panama. Depth normal	7.8 N.	81.1 W.
Dec. 22	3 37.2	Off southwest coast of Mexico. Depth normal	17.0 N.	107.0 W.
Do	7 35.1	---do	17.3 N.	105.8 W.
Dec. 23	13 18.0	---do	16.4 N.	98.4 W.
Do	23 21.2	---do	16.0 N.	99.0 W.
Dec. 24	3 23.5	Near Concepcion, Chile. Depth normal	36.8 S.	73.0 W.
Do	4 35.3	Off southwest Mexico. Depth normal	16.0 N.	98.7 W.
Do	6 20.6	Near Lima, Peru, Depth normal	10.3 S.	75.4 W.
Dec. 25	1 29.7	Off northern Australia. Depth normal	8.8 S.	127.6 E
Dec. 26	23 43.4	El Salvador. Depth normal	11.7 N.	90.3 W.
Dec. 28	3 09.4	North of Australia. Depth normal	8.3 S.	126.0 E.
Do	6 19.4	Atlantic Ocean near St. Paul Islands. Depth normal.	0.2 N.	29.0 W.
Dec. 30	11 41.1	Off southwest Mexico. Depth normal	16.9 N.	97.7 W.
Dec. 31	17 41.4	---do	15.9 N.	98.5 W.

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 four preceding issues of this series, Serials 579, 593, 600, 610 and 619, 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 in scope, containing data on structural and ground vibration 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.

The reader is referred to Serial 610 for further comments on the interpretation of strong-motion seismograph records, especially with reference to the use and evaluation of integration methods. No records for the current year were subjected to this type of analysis. Because of the press for time it has not been possible to entirely complete the projects in strong-motion analysis mentioned in preceding issues.

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.^{2} For practical purposes it is only necessary to point off three decimal places to convert cm/sec.^{2} 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.^{2} 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.^{2}, 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 foot.
1cm/sec.=0.03281 ft./sec.
1cm/sec.^{2}=0.03281 ft./sec.^{2}
1cm=10 mm.
0.1 g=98 cm/sec.^{2}=3.215 ft./sec.^{2}

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

Seismogram illustrations.—Reproductions of seismograms are usually tracings of the original record and must not be accepted as genuine copies. The illustrations are intended to show the nature of the data rather than furnish a means through which the reader can make his own measurements. It is realized that the slightest variations in the copy can easily lead to misleading conclusions. Those who desire true copies for critical study should address the Director of the Bureau for further particulars.

The tabulated instrumental constants refer to the original records. The tracings appearing in this publication are reduced so that if the constants are applied to them a correction will be necessary because

of the reduction. The reductions are approximately in the ratio of 1.6 to 1.

TABLE 2.—*List of shocks recorded and records obtained on strong-motion seismographs in 1938*

Date, epicenter, and recording station	Records	
	Accelero-graph	Displace-ment meter
April 12; Imperial Valley: El Centro	1	
May 31; Santa Ana Mountains:		
Los Angeles Chamber of Commerce Bldg	2	
Los Angeles Subway Terminal Bldg	2	1
Vernon	1	
Hollywood Storage Co. Bldg	3	
Colton	1	1
June 2: Boulder Dam: Oil House	2	
June 5: Imperial Valley: El Centro	1	
June 6: Imperial Valley: El Centro	1	
August 30: Near Long Beach:		
Los Angeles Chamber of Commerce Bldg	2	
Subway Terminal Bldg	2	
September 11: Northern California: Ferndale	1	
September 30: Near Boulder Dam:		
1215 Gallery	1	
Intake tower	1	
Oil House	1	
December 3: Owens Valley region: Bishop	1	
December 6: Southern California: Westwood	1	
Totals	24	2

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 3 in this issue, and 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 3 or from the illustrations. For convenience certain fundamental information on the earthquakes will be repeated from the noninstrumental part of the publication.

The records have been given a second reading and some differences will therefore be noted from the preliminary figures which appeared in the Progress Reports for the same period. 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 an idea of the nature of the original records.

IMPERIAL VALLEY EARTHQUAKE OF APRIL 12

Epicenter approximately 8 miles north of El Centro. Intensity about VI at El Centro where dishes were reported shaken from shelves. Local in Imperial Valley.

El Centro.—Figure 9. The accelerograph record shows a rather sharp disturbance similar to that recorded at the same station on June 5. Maximum acceleration is at start of record.

SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 31

Epicenter in an uninhabited part of the Santa Ana Mts. Intensity was VI at some widely scattered places and must have been considerably greater in epicentral area. It affected a land area of about 30,000 square miles and was the most severe shock of the year in southern California.

Los Angeles Chamber of Commerce Bldg.—Figure 9. About 50 miles northwest of epicenter. Intensity IV to V in Los Angeles. Basement and top floor accelerographs. 11th floor record is of rather rhythmic type and prolonged. Ground and top floor accelerations respectively 3 and 9 cm/sec.^{2}

Los Angeles Subway Terminal Bldg.—Figure 10. About 50 miles northwest of epicenter. Intensity IV to V in Los Angeles. Basement accelerograph and displacement meter and top floor accelerograph. Activity somewhat weaker than at Chamber of Commerce Bldg. and top floor motion not so smooth. Ground and top floor accelerations respectively 3 and 10 cm/sec.^{2}

Vernon, Central Manufacturing District Warehouse.—Figure 11. About 45 miles northwest of epicenter. Intensity IV to V in Los Angeles but probably higher at the station which is on alluvium. Basement accelerograph. Accelerations considerably greater than at other Los Angeles ground stations. Maximum, 9 cm/sec.^{2}

Hollywood Storage Co. Bldg.—Figure 12. About 55 miles northwest of epicenter. Intensity IV to V in Los Angeles area. Accelerographs in basement, penthouse, and on adjoining lot. Ground motions are of about same intensity as at Chamber of Commerce Building. Free swaying of structure evident in penthouse record. Ground and penthouse accelerations respectively 5 and 14 cm/sec.^{2}

Colton.—Figure 11. About 30 miles northeast of epicenter. Intensity about IV. Accelerograph and displacement meter on ground floor in C. E. Co. substation building. Acceleration during first few seconds was much greater than maximum recorded on the ground in the Los Angeles area. Otherwise, records are generally similar. Maximum acceleration 33 cm/sec.^{2}

EARTHQUAKE OF JUNE 2 NEAR BOULDER DAM

This was a very weak local shock, barely felt. The accelerograph operated only because the starter was adjusted to unusually high starting sensitivity.

No Figure. The data for only the oil house record are tabulated. On the intake tower record there is just a bare trace of activity. Gallery 1215 accelerograph did not function because the paper had been used up through accidental shorting of the starting pendulum circuit.

IMPERIAL VALLEY EARTHQUAKE OF JUNE 5

Epicenter about 22 miles northeast of El Centro. Intensity IV to V in the Valley.

El Centro.—Figure 13. The record is comparable with that of April 12. Because of the greater distance, the June 5 shock must have been stronger at the origin.

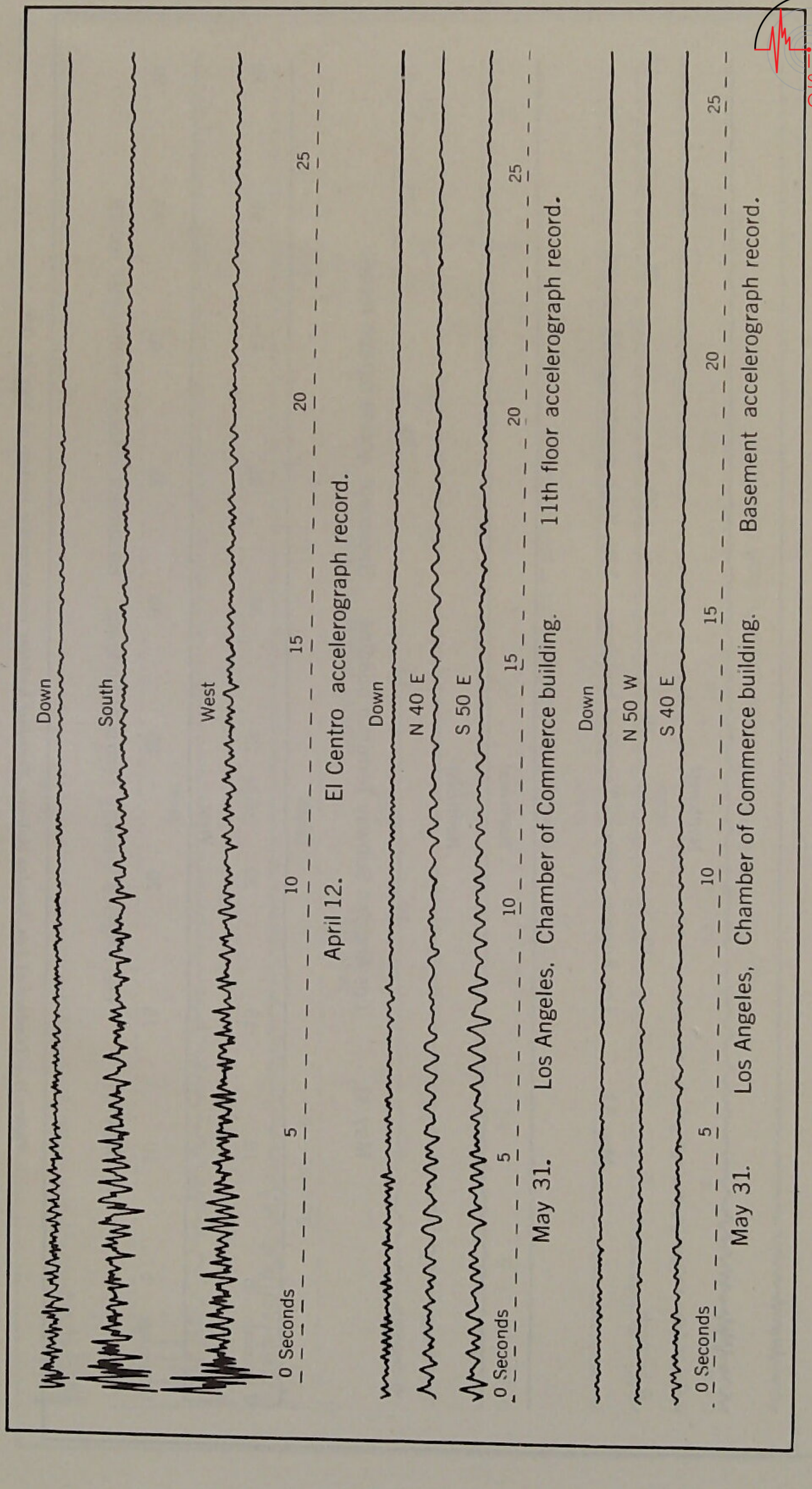


Figure 9.—Tracings of El Centro strong-motion record of April 12, and Los Angeles Chamber of Commerce building records of May 31, 1938.

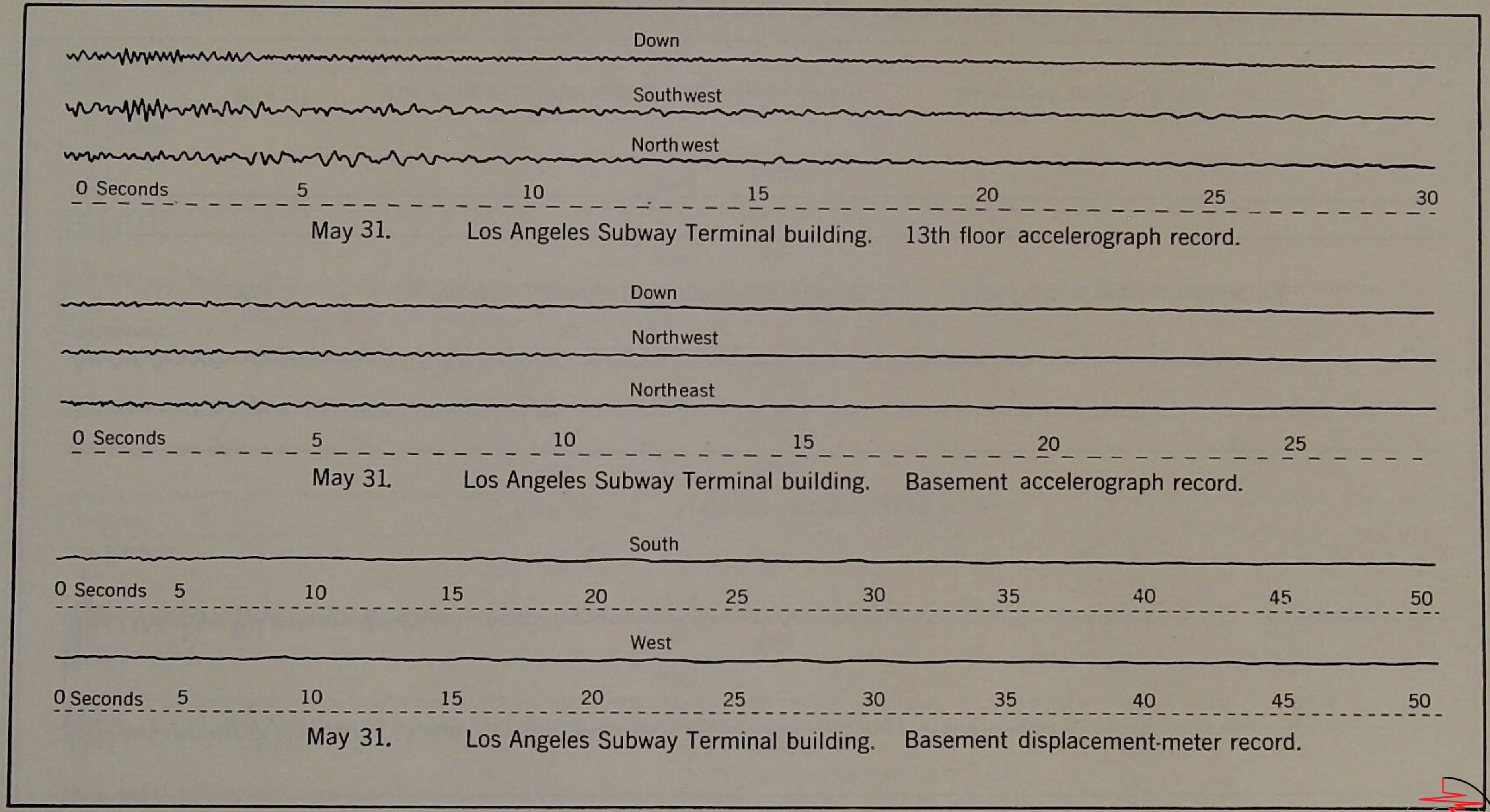


Figure 10.—Tracings of Los Angeles Subway Terminal building strong-motion records of May 31, 1938.

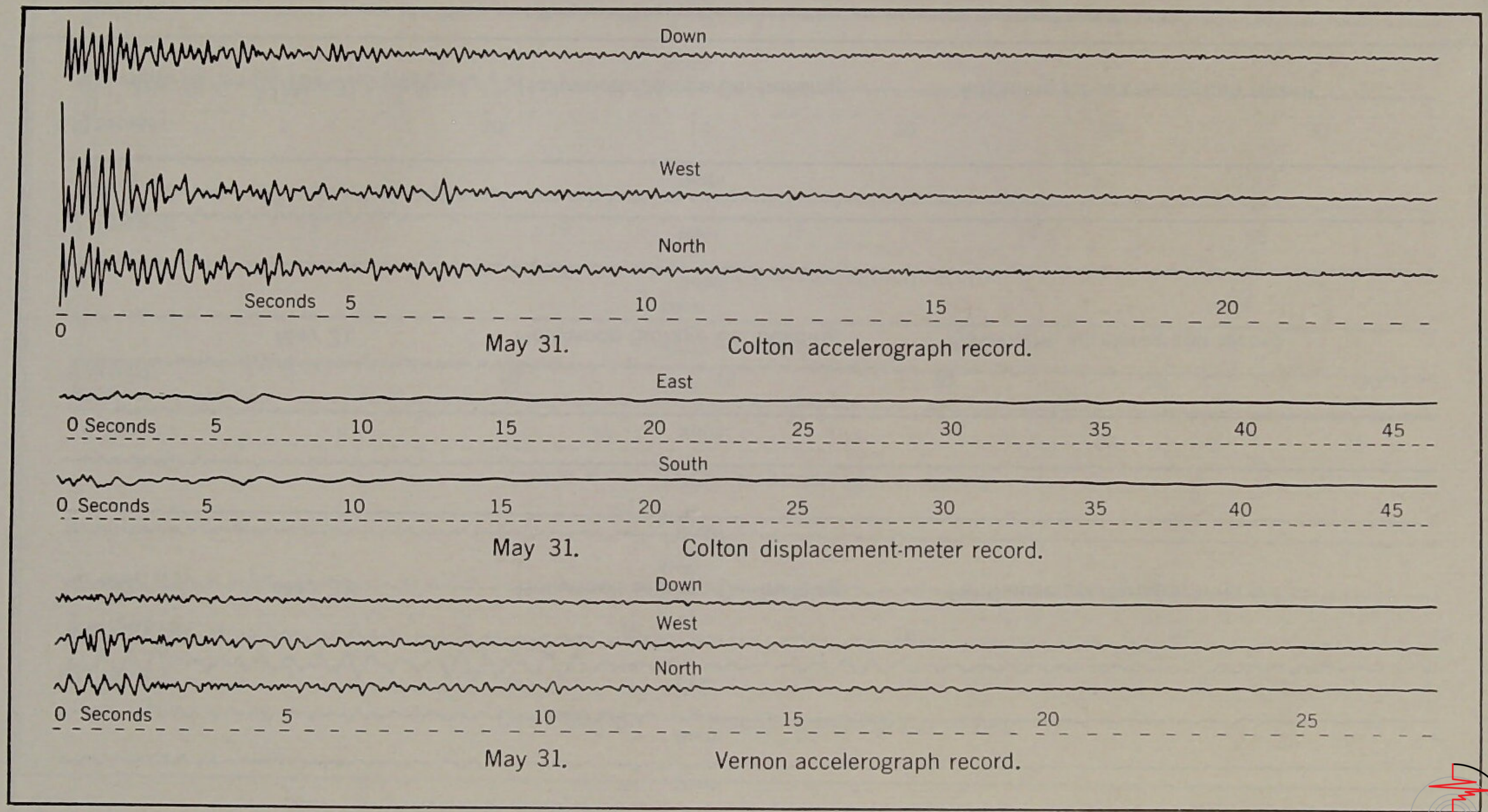


Figure 11.—Tracings of Colton and Vernon strong-motion records of May 31, 1938.

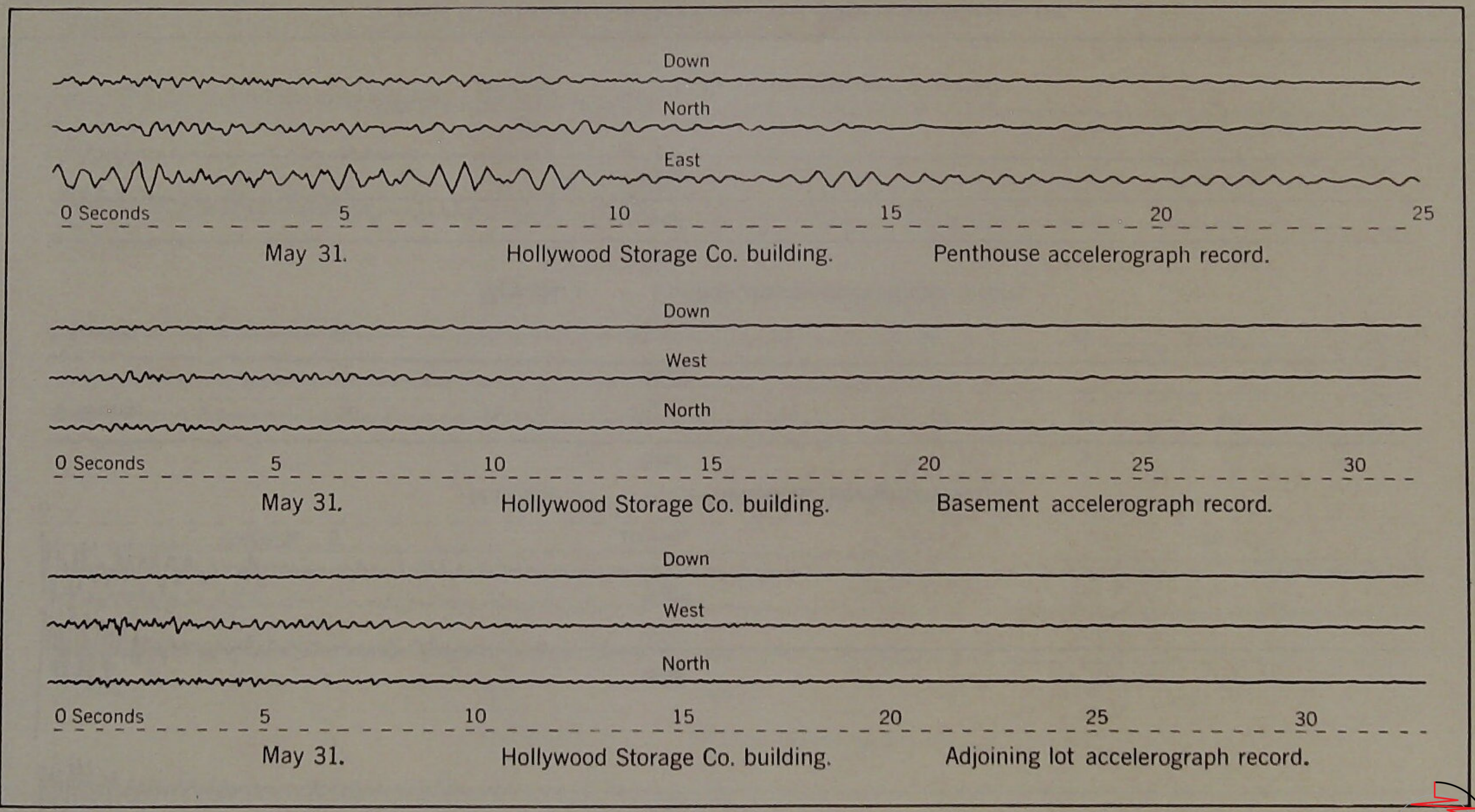


Figure 12.—Tracings of Hollywood Storage Company building strong-motion records of May 31, 1938.

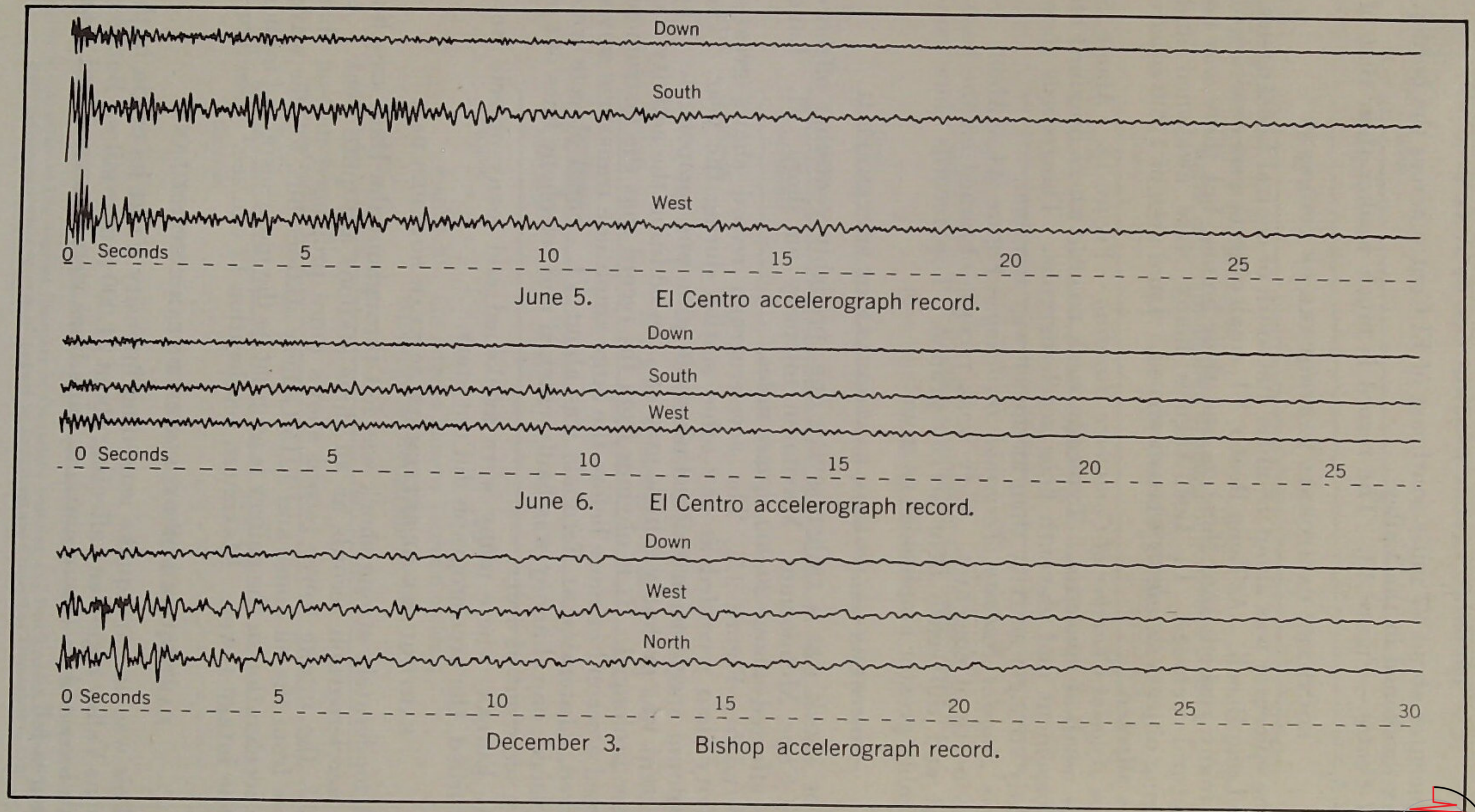


Figure 13.—Tracings of El Centro strong-motion records of June 5 and 6, and Bishop record of December 3, 1938.

IMPERIAL VALLEY EARTHQUAKE OF JUNE 6

Epicenter about 27 miles southeast of El Centro across the border. Many awakened in the Valley.

El Centro.—Figure 13. The record is much weaker than that of June 5.

SOUTHERN CALIFORNIA EARTHQUAKE OF AUGUST 30

The epicenter was about 18 miles due south of central Los Angeles, near Long Beach. At Long Beach, VI, small objects were overturned and many rushed from theaters and their homes, but there was no structural damage. In Los Angeles many were awakened and hanging objects swung or were displaced. Land area of 1,200 square miles affected.

Los Angeles Chamber of Commerce Building.—Figure 14. About 18 miles north of epicenter. Typically weak records where obtained on the basement and eleventh floor accelerographs. The records show slightly stronger activity than at the subway terminal.

Los Angeles Subway Terminal Building.—Figure 14. About 18 miles north of epicenter. Very weak records obtained on the basement and thirteenth floor accelerographs. Top records show considerably greater amplitudes as usual.

NORTHERN CALIFORNIA EARTHQUAKE OF SEPTEMBER 11

The shock was a rather severe one, probably centering offshore near Cape Mendocino. Maximum intensity on shore, VI. Land area affected, about 20,000 square miles.

Ferndale.—Figure 15. The accelerograph record shows greater activity than recorded at any other station during the year. The maximum acceleration reached nearly 0.1g on one component. The resultant was probably a little greater. In addition the activity was rather prolonged. It is obvious from the record that the instrument started a second or more before the large amplitude transverse waves arrived. Intensity at Ferndale was about VI. Small objects were displaced, one chimney was badly cracked and telephone lines out of town were out of order.

At Eureka, where many were awakened and many objects were disturbed, the accelerograph did not start.

EARTHQUAKE OF SEPTEMBER 30 NEAR BOULDER DAM

A moderately strong shock was felt throughout the Dam area but the accelerograph records at all three stations are quite weak. As usual, the intake tower record shows more prolonged motion than those from the oil house and 1215 Gallery stations but, for one wave, the acceleration in the gallery is as great as the more sustained motion in the intake tower. Maximum acceleration 12 cm./sec.^{2} See figure 16.

EARTHQUAKE OF DECEMBER 3 NEAR CONVICT LAKE

This was an earthquake exceeding intensity VI at its origin in the Owens Valley region and affecting about 24,000 square miles. Boulders were loosened in the mountains, pipe lines were damaged and some pictures fell.

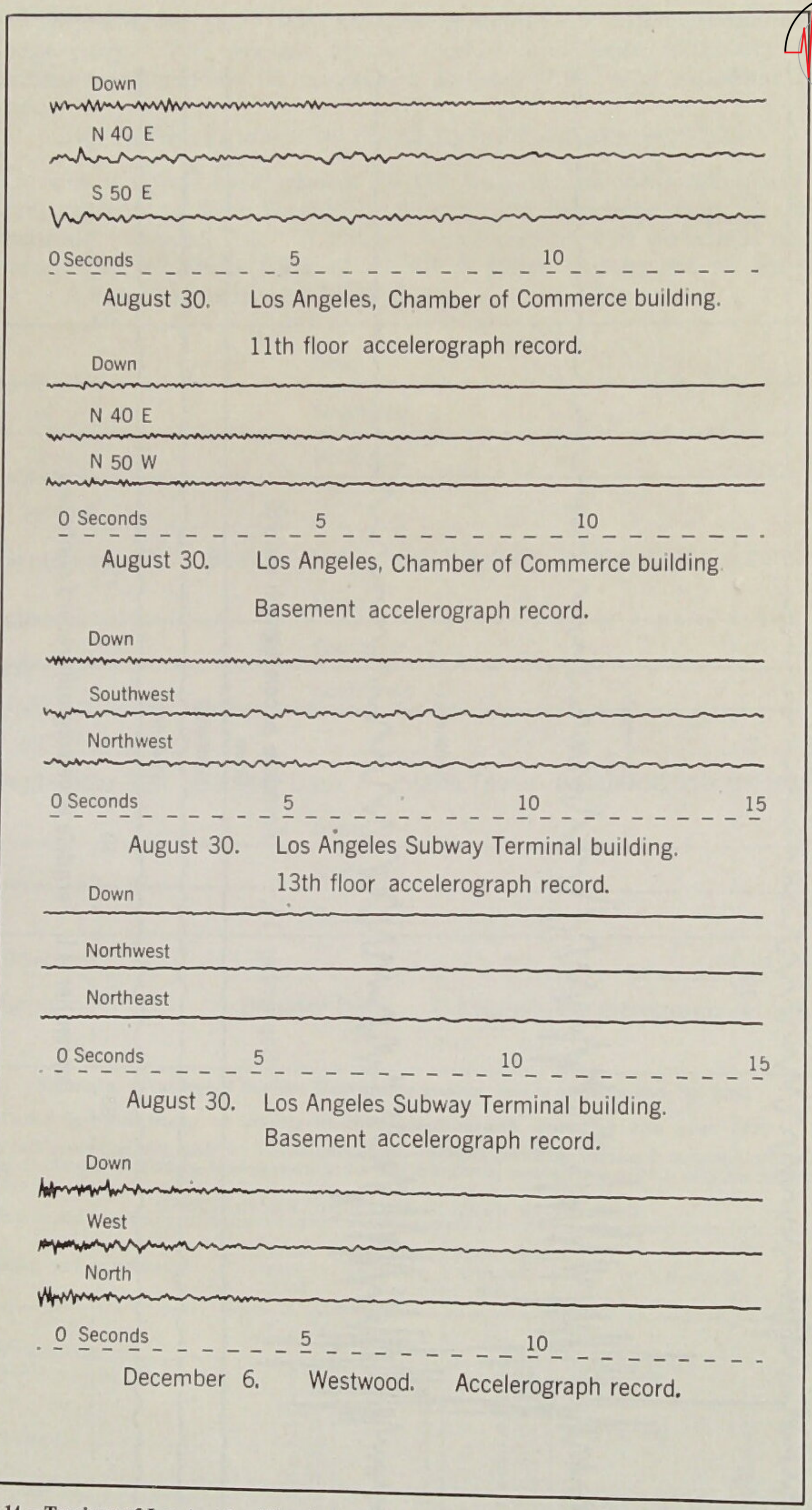
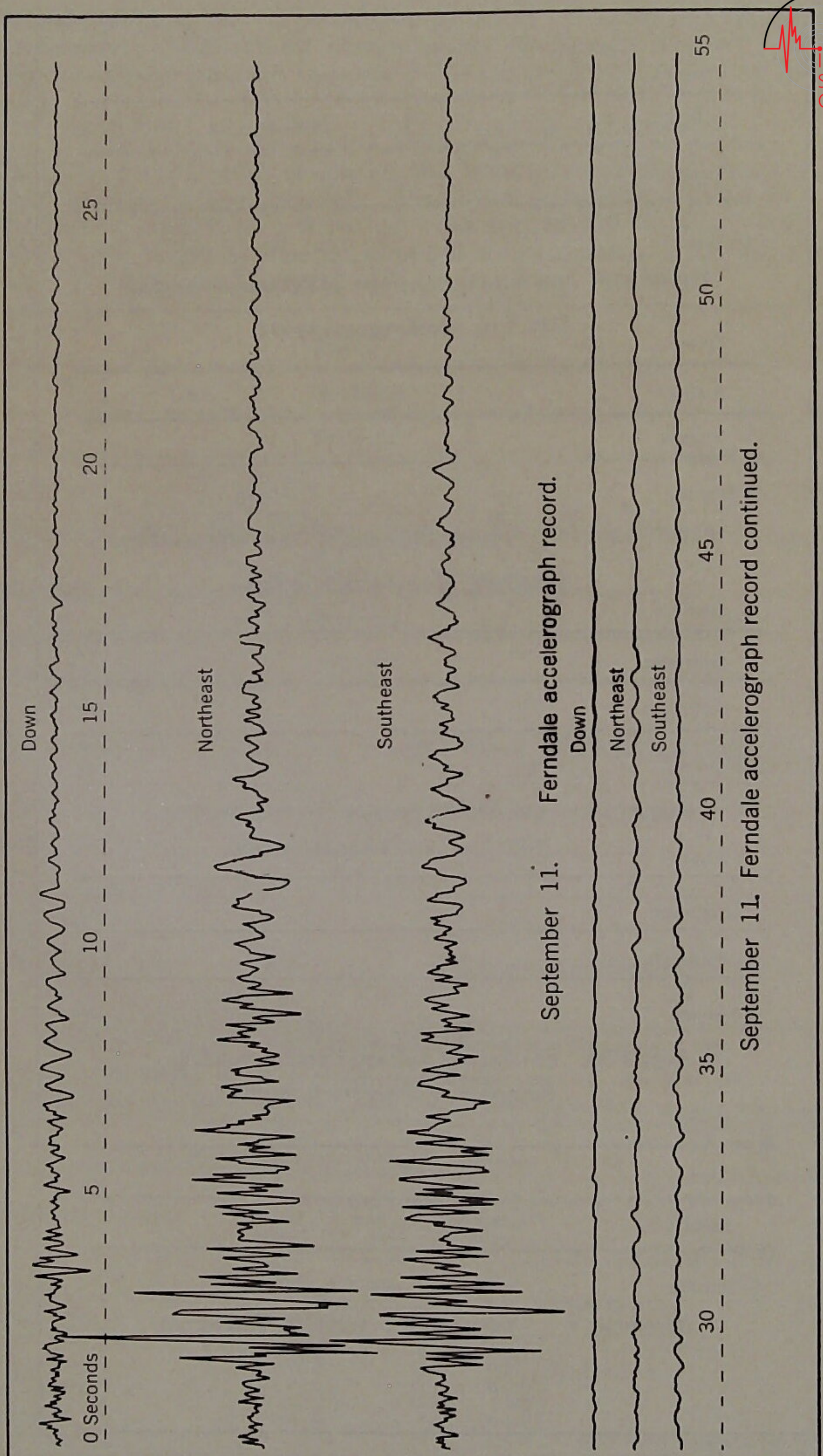


Figure 14.—Tracings of Los Angeles Chamber of Commerce building and Los Angeles Subway Terminal building strong-motion records of August 30, and Westwood record of December 6, 1938.



September 11. Ferndale accelerograph record.

September 11. Ferndale accelerograph record continued.

Figure 15.—Tracing of Ferndale strong-motion record of September 11, 1938.

Bishop.—Figure 13. The station is about 25 miles southeast of the epicenter. The record shows rather moderate intensity with maximum acceleration 15 cm./sec.^{2} Intensity IV was reported from Bishop.

SOUTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 6

This was a small local shock on the Inglewood fault affecting the western section of Los Angeles. Maximum intensity was IV to V.

Westwood.—Figure 14. A rather weak record was obtained on the accelerograph which is located about 5 miles northwest of the epicenter. A maximum intensity of 9 cm./sec.^{2} was recorded.

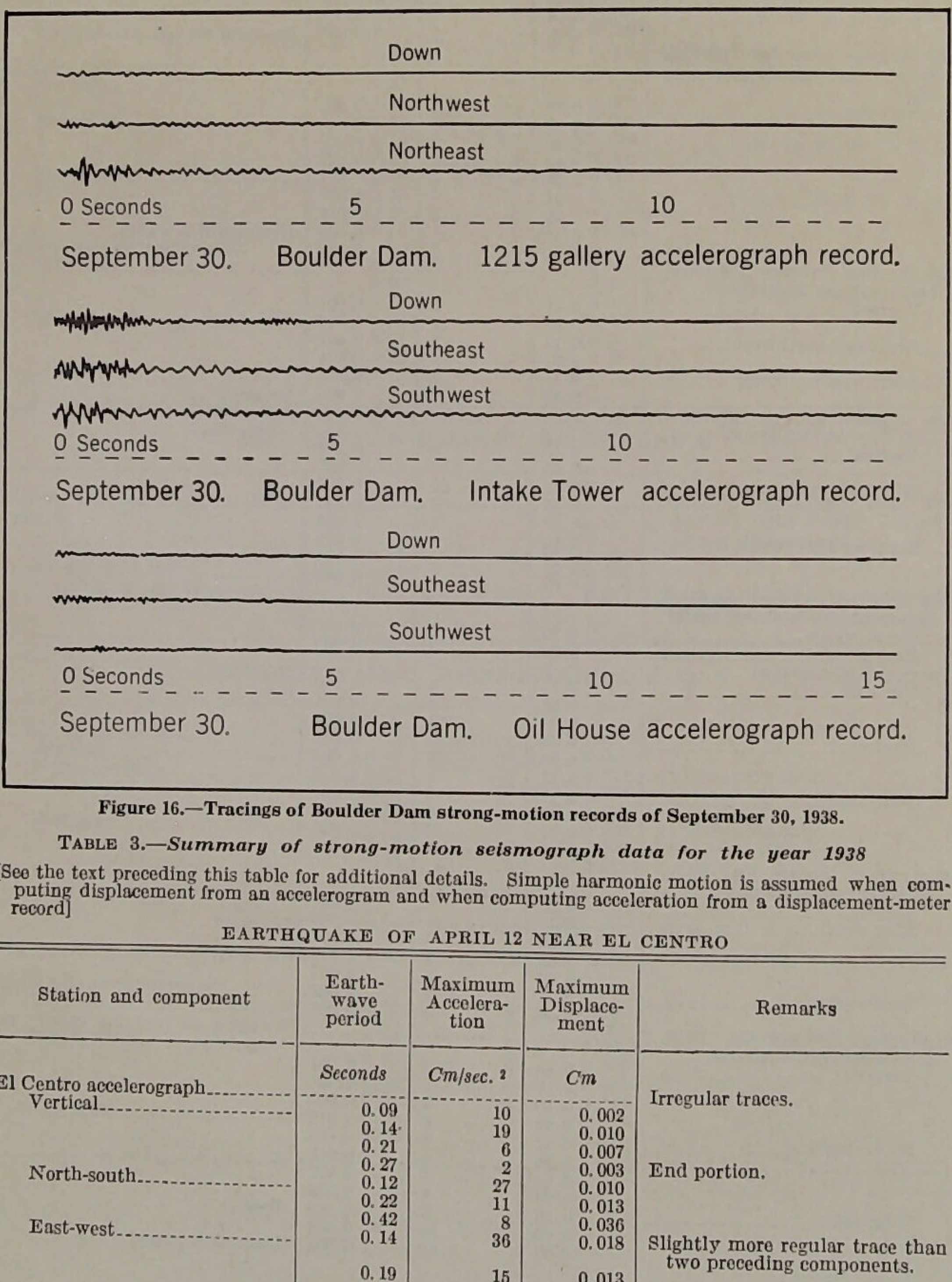


Figure 16.—Tracings of Boulder Dam strong-motion records of September 30, 1938.

TABLE 3.—*Summary of strong-motion seismograph data for the year 1938*

[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]

EARTHQUAKE OF APRIL 12 NEAR EL CENTRO

Station and component	Earth-wave period	Maximum Acceleration	Maximum Displacement	Remarks
	Seconds	*Cm/sec.*^{2}	*Cm*	
El Centro accelerograph				
Vertical	0.09	10	0.002	Irregular traces.
	0.14	19	0.010	
	0.21	6	0.007	
	0.27	2	0.003	End portion.
North-south	0.12	27	0.010	
	0.22	11	0.013	
	0.42	8	0.036	
East-west	0.14	36	0.018	Slightly more regular trace than two preceding components.
	0.19	15	0.013	
	0.22	11	0.013	

TABLE 3.—*Summary of strong-motion seismograph data for the year 1938*—Continued

SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 31

Station and component	Earth-wave period	Maximum Acceleration	Maximum Displacement	Remarks
	Seconds	*Cm/sec.²*	*Cm*	
Los Angeles Chamber of Commerce Bldg., basement accelerograph:				
Vertical	0.16	1	0.001	
	0.27	1	0.002	
S. 40° W.-N. 40° E.	0.15	3	0.002	
	0.27	2	0.003	
S. 50° E.-N. 50° W.	0.14	2	0.001	
	0.39	2	0.007	Irregular waves.
Los Angeles Chamber of Commerce Bldg., 11th floor accelerograph:				
Vertical	0.16	5	0.003	
	0.17	3	0.002	
S. 40° W.-N. 40° E.	0.30	9	0.020	
	0.42	6	0.027	
	1.23	2	0.077	
N. 50° W.-S. 50° E.	0.24	6	0.009	
	0.28	9	0.018	
	0.38	8	0.029	Long train of waves.
	1.15	1	0.017	
Los Angeles Subway Terminal, basement accelerograph:				
Vertical	0.11	2	0.001	
	0.33	2	0.006	
Southeast-northwest	0.12	3	0.001	
	0.37	1	0.004	
Southwest-northeast	0.11	2	0.001	
	0.42	2	0.009	Irregular.
Los Angeles subway terminal, 13th floor accelerograph.	----------	----------	----------	Horizontal components very irregular.
Vertical	0.15	8	0.004	
	0.24	5	0.007	
Northeast-southwest	0.17	10	0.007	
	0.56	3	0.024	
	0.70	2	0.025	
Southeast-northwest	0.16	4	0.002	
	0.29	5	0.010	
	0.58	5	0.042	
Los Angeles subway terminal, basement displacement-meter:				
North-south	0.40	5	0.02	
East-west	0.52	3	0.02	
Vernon accelerograph:				
Vertical	0.13	4	0.002	
	0.21	4	0.004	
	0.26	1	0.002	
East-west	0.10	4	0.001	
	0.20	3	0.003	
	0.37	4	0.014	
South-north	0.10	3	0.001	
	0.26	4	0.007	
	0.29	3	0.006	
	0.38	9	0.033	
Hollywood Storage Co. Bldg., basement accelerograph:				
Vertical	0.36	2	0.006	
East-west	0.18	1	0.001	
	0.26	4	0.007	
	0.35	3	0.010	
	0.42	2	0.009	
South-north	0.23	2	0.003	
	0.40	2	0.008	
Hollywood Storage Co. Bldg., penthouse accelerograph.	----------	----------	----------	Swaying of building clearly recorded.
Vertical	0.10	2	0.001	
	0.13	2	0.001	
	0.38	2	0.007	
	0.49	3	0.018	
South-north	0.23	6	0.008	
	0.36	6	0.019	
	0.40	4	0.015	
	0.50	4	0.025	
West-east	0.20	3	0.003	Few.
	0.46	14	0.075	
	0.50	14	0.089	Dominant period.

TABLE 3.—*Summary of strong-motion seismograph data for the year 1938*—Continued

Station and component	Earth-wave period	Maximum Acceleration	Maximum Displacement	Remarks
	Seconds	*Cm/sec.²*	*Cm*	
SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 31—continued				
Hollywood Storage Co. Bldg., adjoining P. E. lot accelerograph.				Motion irregular on all components.
Vertical	0.10	1	0.001	
	0.40	1	0.004	
East-west	0.23	5	0.006	
	0.35	6	0.018	
	0.40	3	0.013	
South-north	0.13	4	0.002	
	0.24	3	0.004	Irregular.
Colton accelerograph:				
Vertical	0.14	27	0.013	
	0.16	11	0.007	
East-west	0.11	3	0.001	
	0.19	33	0.030	
	0.36	4	0.013	
South-north	0.10	6	0.001	
	0.13	25	0.011	
	0.21	13	0.015	
	0.34	6	0.018	
Colton displacement-meter:				
West-east	0.24	27	0.04	
	0.97	3	0.08	
	1.55	1	0.05	
North-south	0.30	9	0.02	
	0.94	1	0.03	
	1.32	2	0.06	
BOULDER DAM EARTHQUAKE OF JUNE 2				
Boulder Dam oil house accelerograph.				Duration less than 1 sec. Extremely light shock. See text about other records.
Vertical	0.08	8	0.001	
N. 45° W.-S. 45° E	0.10	3	0.001	
N. 45° E.-S. 45° W	0.10	16	0.004	Trace displayed only on one side of axis.
IMPERIAL VALLEY EARTHQUAKE OF JUNE 5				
El Centro accelerograph:				
Vertical	0.12	14	0.005	
North-south	0.14	35	0.017	At beginning only.
	0.15	10	0.006	
	0.19	11	0.010	
East-west	0.11	31	0.009	At beginning only.
	0.15	10	0.006	Long wave train.
	0.23	9	0.012	
IMPERIAL VALLEY EARTHQUAKE OF JUNE 6				
El Centro accelerograph:				
Vertical	0.10	4	0.001	
	0.20	1	0.001	
North-south	0.09	5	0.001	
	0.15	5	0.003	
	0.17	6	0.004	
	0.21	4	0.005	
East-west	0.14	6	0.003	
	0.19	7	0.006	

TABLE 3.—*Summary of strong-motion seismograph data for the year 1938*—Continued

Station and component	Earth-wave period	Maximum Acceleration	Maximum Displacement	Remarks
	Seconds	*Cm/sec.²*	*Cm*	
SOUTHERN CALIFORNIA EARTHQUAKE OF AUGUST 30				
Los Angeles Chamber of Commerce Bldg., basement accelerograph:				No definitely prevailing period on any component.
Vertical	0.10	2	0.001	
	0.17	1	0.001	
S. 40° W.-N. 40° E.	0.14	3	0.002	
	0.30	1	0.002	
S. 50° E.-N. 50° W.	0.13	2	0.001	
	0.40	1	0.004	
Los Angeles Chamber of Commerce Bldg., 11th floor accelerograph:				
Vertical	0.15	5	0.002	Regular waves.
S. 40° W.-N. 40° E.	0.21	5	0.006	
	0.37	2	0.007	
N. 50° W.-S. 50° E.	0.18	2	0.002	
	0.22	2	0.003	
	0.35	5	0.015	
Los Angeles subway terminal, basement accelerograph:				
Vertical	0.11	2	0.001	
	0.44	1	0.005	
Southeast-northwest	0.35	1	0.003	
Southwest-northeast	0.37	1	0.003	
Los Angeles subway terminal, 13th floor accelerograph:				
Vertical	0.12	4	0.002	
Northeast-southwest	0.12	2	0.001	
	0.62	2	0.020	
	0.72	4	0.053	
Southeast-northwest	0.12	2	0.001	
	0.33	3	0.008	
	0.61	3	0.028	
NORTHERN CALIFORNIA EARTHQUAKE OF SEPTEMBER 11				
Ferndale accelerograph				Motion complex on all components.
Vertical	0.11	6	0.002	
	0.18	26	0.022	
	0.37	6	0.020	
	0.41	13	0.056	
Southwest-northeast	0.18	93	0.075	Rather sustained.
	0.21	13	0.014	
	0.31	20	0.050	
	0.39	26	0.100	
	0.67	3	0.032	In end portion.
	0.77	25	0.375	
Northwest-southeast	0.18	75	0.061	Rather sustained.
	0.66	9	0.100	
	0.74	10	0.140	
	0.97	20	0.480	
EARTHQUAKE NEAR BOULDER DAM, SEPTEMBER 30				
Boulder Dam intake tower accelerograph:				
Vertical	0.10	12	0.003	
	0.25	1	0.002	
Northwest,southeast	0.10	5	0.001	
	0.27	3	0.005	
Northeast-southwest	0.22	7	0.008	
Boulder Dam oil house accelerograph:				
Vertical	0.12	1	0.001	
Northwest-southeast	0.14	2	0.001	
	0.10	1	0.001	
Northeast-southwest	0.10	1	0.001	
Boulder Dam, 1215 gallery accelerograph:				
Vertical	0.15	2	0.001	
	0.10	1	0.001	
Southeast-northwest	0.15	2	0.001	
Southwest-northeast	0.13	12	0.005	
	0.25	1	0.002	

TABLE 3.—*Summary of strong-motion seismograph data for the year 1938*—Continued

OWENS VALLEY EARTHQUAKE OF DECEMBER 3

Station and comoonent	Earth-wave period	Maximum Accelera-tion	Maximum Displace-ment	Remarks
	Seconds	*Cmfsec.²*	*Cm*	
Bishop accelerograph				Very irregular trace on all components.
Vertical	0.10	1	0.001	
	0.29	2	0.005	
	0.59	1	0.009	
East-west	0.10	3	0.001	
	0.23	11	0.015	
	0.30	1	0.003	
	0.36	10	0.032	
South-north		15		
	0.20	7	0.007	
	0.29	17	0.035	
	0.50	2	0.013	

SOUTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 6

Westwood accelerograph		7		Irregular.
Vertical	0.11	9	0.003	
East-west		7		
	0.08	5	0.001	
	0.38	4	0.014	
North-south	0.10	7	0.002	
	0.38	1	0.004	

TABLE 4.—*Instrumental constants of strong-motion seismographs in 1938*

EARTHQUAKE OF APRIL 12 NEAR EL CENTRO

Station and instrument	Orientation of instrument [1]	Pendulum period	Static magnification	Sensitivity [2]	Damping ratio	Instrument number
		Sec.		*Cm.*		
El Centro accelerograph	Up–Down	0.096	115	2.54	8	V–55
	N.-S	0.098	104	2.67	7	L–56
	E.-W	0.098	109	2.41	8	T–57

SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 31

Los Angeles, Chamber of Commerce Building:						
Basement accelerograph [3]	Up–Down	0.09.8	105	2.66	9	V–28
	S. 40° W.-N. 40° E	0.100	114	2.78	10	L-9
	S. 50° E.-N. 50° W	0.096	104	2.63	9	T–26
Eleventh floor accelerograph [3]	Up–Down	0.100	109	2.69	10	V–25
	S. 40° W.-N. 40° E	0.098	117	2.90	10	L–3
	N. 50° W.-S. 50° E	0.100	109	2.86	8	T–18
Los Angeles, Subway Terminal Building:						
Basement accelerograph [3]	Up-Down	0.099	74	1.83	8	V–111
	SE.-NW	0.097	80	2.01	10	L–91
	SW.-NE	0.098	82	2.07	9	T–101
Basement displacement meter [3]	N.-S	9.85	1.14		8	R–15
	E.-W	9.85	1.14		9	L–15
Thirteenth floor accelerograph [3]	Up-Down	0.100	81	2.04	10	V–112
	NE.-SW	0.110	84	2.14	9	L–92
	SE.-NW	0.100	82	2.07	10	T-102
Vernon accelerograph	Up-Down	0.100	106	2.63	9	V–66
	E.-W	0.100	107	2.65	9	L–64
	S.-N	0.097	107	2.60	9	T–65
Hollywood Storage Co. Building:						
Basement accelerograp [3]	Up-Down	0.100	86	2.20	7.5	V–115
	E.-W	0.100	81	2.16	10	L–95
	S.-N	0.100	80	2.16	9	T–105
Penthouse accelerograph [3]	Up-Down	0.098	82	2.06	9	V–113
	S.-N	0.104	79	2.20	7.5	L–93
	W.-E	0.100	80	2.03	10	T–103

See footnotes at end of table.

TABLE 4.—*Instrumental constants of strong-motion seismographs in 1938*—Continued

Station and instrument	Orientation of instrument	Pendulum period	Static magnification	Sensitivity [2]	Damping ratio	Instrument number
		Sec.		*Cm.*		
SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 31—continued						
Hollywood Storage Co. Bldg.—Con.						
P. E. Lot accelerograph [3]	Up-Down	0.101	85	2.04	10	V–114
	E.-W	0.102	84	2.12	10	L–94
	S.-N	0.100	81	2.04	10	T–104
Colton accelerograph	Up-Down	0.098	100	2.40	8	V–58
	E.-W	0.102	102	2.67	8	L–59
	S.-N	0.097	104	2.58	9	T–60
Colton displacement meter	W.-E	10.0	1.14	-------	9	R–16
	N.-S	10.05	1.14	-------	9	L–16
EARTHQUAKE OF JUNE 2 AT BOULDER DAM						
Boulder Dam:						
Oil house accelerograph	Up-Down	0.104	88	2.40	9.0	V–148
	N. 45° W.-S. 45° E	0.106	75	2.13	9.6	L–146
	N. 45° E.-S. 45° W	0.101	75	6.94	8.5	T–147
EARTHQUAKES OF JUNE 5 AND 6 NEAR EL CENTRO						
El Centro accelerograph	Up-Down	0.097	115	2.53	8	V–55
	N.-S	0.100	104	2.63	7.5	L–56
	E.-W	0.100	109	2.41	7.5	T–57
SOUTHERN CALIFORNIA EARTHQUAKE OF AUGUST 30						
Los Angeles, Chamber of Commerce Building:						
Basement accelerograph [3]	Up-Lown	0.090	105	2.66	8	V–28
	S. 40° W.-N. 40° E	0.100	114	2.78	10	L–9
	S. 50- E.-N. 50° W	0.097	104	2.63	8	T–26
Eleventh floor accelerograph [3]	Up-Down	0.099	109	2.69	9	V–25
	S. 40° W.-N. 40° E	0.098	117	2.90	11	L–3
	N. 50° W.-S. 50° E	0.100	109	2.86	8	T–18
Los Angeles, Subway Terminal Building:						
Basement accelerograph [3]	Up-Down	0.099	74	1.83	7	V–111
	SE.-NW	0.097	80	2.01	10	L–91
	SW.-NE	0.098	82	2.07	9	T–101
Thirteenth floor accelerograph [3]	Up-Down	0.100	81	2.04	10	V–112
	NE.-SW	0.100	84	2.14	8	L–92
	SE.-NW	0.100	82	2.07	10	T–102
NORTHERN CALIFORNIA EARTHQUAKE OF SEPTEMBER 11						
Ferndale accelerograph	Up-Down	0.097	100	2.43	10	V–10
	SW.-NE	0.099	109	2.76	7	L–4
	NW.-SE	0.099	110	2.77	10	T–15
EARTHQUAKE OF SEPTEMBER 30 NEAR BOULDER DAM						
Boulder Dam:						
1215 Gallery accelerograph [3]	Up-Down	0.103	77	2.06	10.2	V–142
	S. 45° E.-N. 45° W	0.104	75	2.05	9.9	L–140
	S. 45° W.-N. 45° E	0.103	74	1.99	9.9	T–141
Intake tower accelerograph [3]	Up-Down	0.101	81	2.09	7.0	V–145
	N. 45° W.-S. 45° E	0.100	90	2.29	8.3	L–143
	N. 45° E.-S. 45° W	0.099	87	1.85	8.7	T–144
Oil house accelerograph [3]	Up-Down	0.104	87	2.38	10.3	V–148
	N. 45° W.-S. 45° E	0.099	83	2.06	9.3	L–146
	N. 45° E.-S. 45° W	0.100	80	2.02	12.0	T–147

See footnotes at end of table.

TABLE 4.—*Instrumental constants of strong-motion seismographs in 1938*—Continued

EARTHQUAKE OF DECEMBER 3 NEAR BISHOP

Station and instrument	Orientation of instrument	Pendulum period	Static magnification	Sensitivity [2]	Damping ratio	Instrument number
		Sec.		*Cm.*		
Bishop accelerograph	Up-Down	0.101	108	2.78	10	V–23
	E.-W	0.100	107	2.70	12	L–36
	S.-N	0.098	108	2.70	10	T–19

SOUTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 6

Westwood accelerograph	Up-Down	0.098	114	2.78	10	V–30
	E.-W	0.097	111	2.55	10	L–5
	S.-N	0.098	108	2.61	10	T–34

[1] The direction on the left ("Up" in the first case) indicates the direction of the pendulum displacement relative to instrument pier which will displace the trace upward on the original seismogram.

[2] The sensitivity is the number of centimeters deflection on the seismogram that corresponds to 100 cm/sec.[2] of acceleration. The deflection corresponding to 1/10 gravity may be obtained by multiplying the sensitivity tabulated by 0.98. (See p. 38.)

[3] Instruments at these places are wired to start simultaneously.

TABLE 5. *List of strong-motion seismograph stations, 1938*

Station and foundation	Instrument	Date of installation
NORTHERN CALIFORNIA		
Berkeley: University of California: Solid rock	Accelerograph	November 1932.
Eureka: Federal Building: Alluvium	Accelerograph and displacement meter.	May 1933.
Ferndale: City Hall: Alluvium	Accelerograph	Do.
Oakland:		
City Hall: Alluvium:		
Sixteenth floor	do	November 1934.
Basement	do	June 1933.
Chabot Observatory: Solid rock	Weed seismograph	Do.
Sacramento: Federal Building: Alluvium	Accelerograph	Do.
San Francisco:		
Alexander building: Alluvium:		
Sixteenth floor	do	November 1934.
Eleventh floor	do	October 1935.
Basement	do	November 1934.
450 Sutter: Rock:		
Twenty-eighth floor	Weed seismograph	October 1933.
Basement	do	November 1934.
Golden Gate Park: Rock	do	December 1935.
Shell Building: Rock:		
Twenty-eighth floor	do	October 1933.
Twenty-first floor	do.[1]	August 1938.
Subbasement	do	October 1933.
Southern Pacific Building: Alluvium and made ground:		
Fourteenth floor	Accelerograph	October 1934.
Basement	Accelerograph and displacement meter.	December 1932.
State Building: Sand and gravel	do	April 1933.
San Jose:		
Bank of America Building: Alluvium:		
Thirteenth floor	Accelerograph	September 1932.
Basement	do	Do.
Suisun Bay Bridge: S. P. R. R. bridge pier: Rock	do	Do.
SOUTHERN CALIFORNIA		
Bishop: Office Los Angeles Water Department: Alluvium.	do	June 1933.
Colton: Southern California Edison Co. substation: Alluvium.	Acceleration and displacement meter.	January 1933.

See footnotes at end of table.

TABLE 5.—*List of strong-motion seismograph stations, 1938*—Continued

Station and foundation	Instrument	Date of installation
NORTHERN CALIFORNIA—continued		
El Centro: Nevada—California Power Co. terminal station [2]: Alluvium.	Accelerograph	July 1932.
Hollywood:		
Hollywood Storage Co. warehouse: Alluvium:		
Penthouse	do	June 1933.
Basement	do	Do.
Adjoining Pacific Electric lot [3]	do	December 1934.
Long Beach: Public Utilities Building: Alluvium	do	July 1932.
Los Angeles:		
Chamber of Commerce: Alluvium:		
Eleventh floor	do	November 1934.
Basement	Accelerograph and Weed seismograph.	June 1933.
Edison Building: Hardpan or clay	Accelerograph	December 1934.
Subway Terminal: Hardpan or clay:		
Thirteenth floor	do	Do.
Subbasement	Accelerograph and displacement meter.	August 1932.
Central Manufacturing District Warehouse at Vernon: Alluvium.	Accelerograph	July 1932.
Pasadena: California Institute of Technology: Alluvium.	Accelerograph, displacement meter and Weed seismograph.	May and June 1933.
San Bernardino: County Courthouse: Alluvium	Weed seismograph	June 1933.
San Diego: Consolidated Gas and Electric Co.: Alluvium.	Accelerograph	July 1932.
Santa Ana: County Courthouse: Alluvium	Weed seismograph	June 1933.
Santa Barbara: County Courthouse: Alluvium	Accelerograph	Do.
Westwood: University of California at Los Angeles: Alluvium.	do	Do.
MISCELLANEOUS		
Boulder Dam, Nev.:		
Intake tower: Solid rock	do	May 1937.
1215 Gallery: Solid rock	do	Do.
Oil house: Solid rock	do	Do.
Bozeman, Mont.: Montana State College: Alluvium and glacial drift.	do	September 1936.
Butte, Mont.: Montana School of Mines: Igneous rock.	do	Do.
Hawthorne, Nev.: U. S. Naval Ammunition Depot: Alluvium.	do	November 1936.
Helena, Mont.: Federal Building: Rock	do	September 1936.
Miraflores, Canal Zone: Concrete locks: Tuff and alluvium.	do	April 1935.
Missoula, Mont.: Montana State University: Sedimentary rock.	do	September 1936.

[1] The Weed seismograph was originally installed on the twenty-third floor in May 1934. It was moved to its present location in August 1938.

[2] Change of name from Southern Sierras Power Co. in 1938.

[3] The instrument on the Pacific Electric Co. lot in Hollywood is in a separate small building several hundred feet from the Hollywood Storage Co. building, and should provide data which will be at least partly free from vibrations set up in the ground by the building itself. It is connected with the 2 accelerographs in the Hollywood Storage Co., making a set of 3 instruments in one locality operating under different conditions. They are connected electrically for simultaneous starting and time marking.

DESCRIPTIONS OF STRONG-MOTION STATIONS

The following is a list of station descriptions previously published in issues of the "United States Earthquakes" series, and includes only stations at which records have been obtained since their establishment.

The year, in parenthesis, is the calendar year covered by the publication for which the serial number is given.

Berkeley. Serial 619 (1937).
Eureka. Serial 593 (1934).
Ferndale. Serial 593 (1934).
Oakland. Serial 593 (1934).
Alexander Building, San Francisco. Serial 619 (1937).
Golden Gate Park. Serial 593 (1934).
Southern Pacific Building, San Francisco. Serial 579 (1933).
State Building, San Francisco. Serial 619 (1937).
San Jose. Serial 579 (1933).
Suisan Bay Bridge. Serial 579 (1933).
Bishop. Serial 593 (1934).
Colton. Serial 610 (1937).
El Centro. Serial 593 (1934).
Hollywood. Serials 579 and 593 (1933 and 1934).
Long Beach. Serial 579 (1933).
Los Angeles Chamber of Commerce Building. Serials 579 and 593 (1933 and 1934).
Los Angeles Edison Building. Serial 593 (1934).
Los Angeles Subway Terminal Building. Serials 579 and 593 (1933 and 1934).
Vernon. Serial 579 (1933).
Pasadena. Serial 579 (1933).
San Bernardino. Serial 619 (1937).
San Diego. Serial 593 (1934).
Santa Ana. Serial 579 (1933).
Santa Barbara. Serial 593 (1934).
Westwood. Serial 579 (1933).
Boulder Dam. Serial 619 (1937).
Hawthorne. Serial 619 (1937).
Helena. Serial 600 (1935).
Panama Canal Zone. Serial 593 (1934).

TILT OBSERVATIONS

During 1938 three tiltmeters were kept in operation on the grounds of the University of California at Berkeley with the active cooperation of the Seismological Station of that institution. Two of the meters required visible readings but a third automatically recorded pictures of the interferometer fringes every hour. A graphical representation of the results obtained is shown in figure 17. There were no outstanding tilts that could be associated with local earthquake activity.

ADDITIONS AND CORRECTIONS TO PREVIOUS PUBLICATIONS

1935, October 1931. In Serial 600 "United States Earthquakes, 1935," page 86, table 4—Analysis of Helena, Mont., accelerograph records for the main shock of October 31—change next to last figure in period column from 0.940 to 0.159.

1937. March 2: 8.48.* Anna, Ohio, earthquake. In Serial 619, "United States Earthquakes, 1937," only preliminary information was given. It was stated that an investigation of the shock was being undertaken by the Geophysics Department of St. Louis University. The results of that investigation are being published in a forthcoming number of the Bulletin of the Seismological Society of America in an article entitled "A Micro-seismic Study of the Ohio Earthquakes of March 1937," by A. J. Westland and Ross R. Heinrich. The following information is taken from the manuscript of that report through the courtesy of the authors in order that the salient features may be readily available in this series of publications.

The instrumental epicenter as announced in a Preliminary Bulletin of the Jesuit Seismological Association, and adopted in the final report just mentioned, is 40.4° north, 84.2° west, a point in the immediate vicinity of Anna. More than 1,200 reports were collected and an isoseismal map constructed. A maximum intensity of VII (Modified Mercalli Scale of 1931) was found in the epicentral region near Anna, and the affected area covered approximately 70,000 square miles. No loss of life was reported, nor serious injury. The principal damage was to chimneys and brick buildings. Details of the effects of the

earthquake in the epicentral area are based on visits to the area by Revs. A. J. Westland, S. J. and V. C. Stechschulte, S. J., early in April.

See following notes on the earthquake of March 8, 1938, for phenomena common to both shocks.

1937. March 8: 23:45.* Anna, Ohio, earthquake, second strong shock. The March 8 earthquake is described in detail in the article by A. J. Westland and Ross R. Heinrich, already mentioned. The following information is taken from that report.

The instrumental epicenter is the same as that computed for the shock of March 2. The March 8 shock appears to have been of noticeably greater intensity. Damage in the town of Anna was much greater and could possibly be considered as reaching VIII. Practically every chimney was broken or twisted and many foundations and walls were cracked. The area affected was some 150,000 square miles as against 70,000 square miles for the earlier shock.

Outstanding phenomena common to both earthquakes were the rotation of tombstones and subsurface changes revealed by changes in the activities of wells. Marked changes in the behavior of wells were reported from Huntsville, New Knoxville, and Botkins. At Huntsville a spring which was dry for 8 years began spouting water like a well, and at New Knoxville the flow of the artesian wells was increased to a stream about 18 feet high.

PUBLICATION NOTICES

To make immediately available the results of its various activities to those interested, the Coast and Geodetic Survey maintains mailing lists of persons and firms desiring to receive notice of the issuance of charts, Coast Pilots, maps, and other publications.

Should you desire to receive such notices, you may use the form given below, checking the list covering the subjects in which you are interested.

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DEAR SIR: I desire that my name be placed on the mailing lists indicated by check below, to receive notification of the issuance of publications referring to the subjects indicated:

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- ☐ 109–J. Traverse.
- ☐ 109–K. Seismology.
- ☐ 109–L. Terrestrial magnetism.
- ☐ 109–M. Tides.
- ☐ 109–N. Topography.
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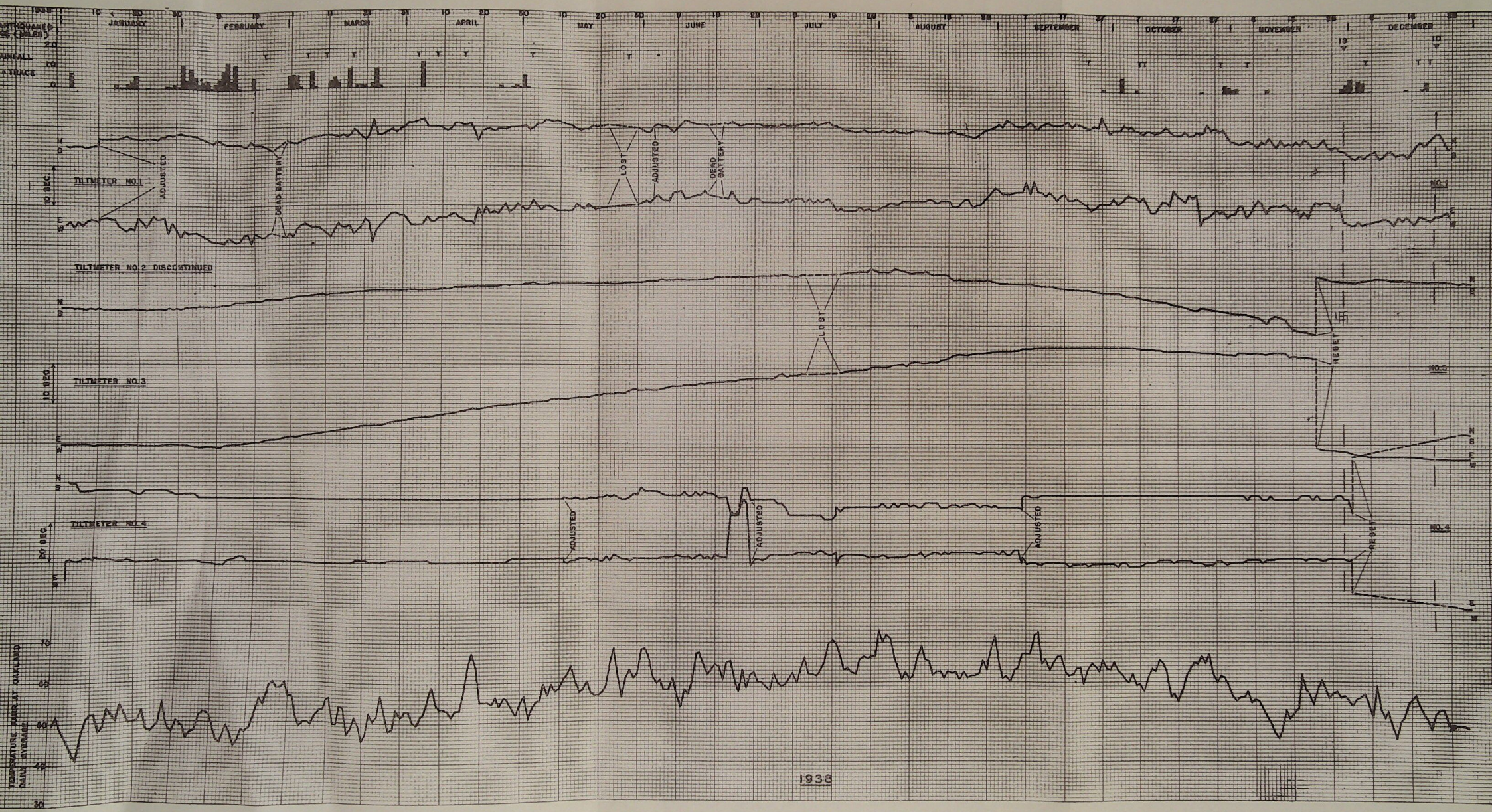

Figure 17.—Tilt and temperature curves for 1938.