DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

United States Earthquakes, 1953

By

Leonard M. Murphy
William K. Cloud

Open-File report 84-953

Prepared in cooperation with National Oceanic and Atmospheric Administration.

This report has not been reviewed for conformity with U.S. Geological Survey editorial standards.

1984

CONTENTS

ILLUSTRATIONS

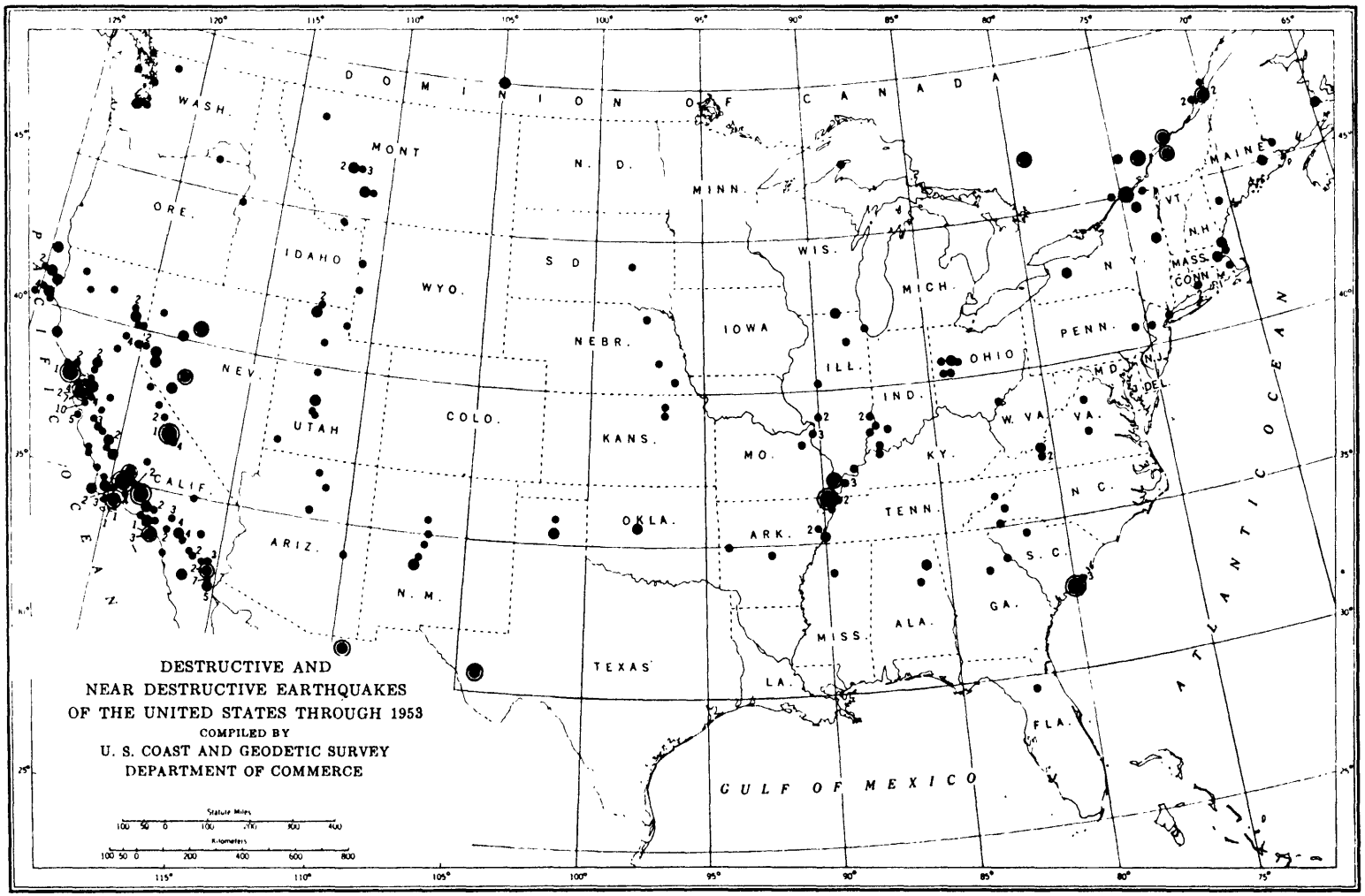

FIGURE 1.—Destructive and near destructive earthquakes in the United States through 1953.

UNITED STATES EARTHQUAKES, 1953

INTRODUCTION

This publication is a summary of earthquake activity in the United States and regions under its jurisdiction for the calendar year 1953. The sources of noninstrumental information used in the compilation include the United States Weather Bureau, whose observers prepare periodic reports on local seismic activity; telegraphic information collected by Science Service, Washington, D. C.; Bulletins of the Seismological Society of America; special reports of the Jesuit Seismological Association and the Northeastern Seismological Association; the *Hawaiian Volcano Letter;* newspaper clippings; and reports from interested individuals. Instrumental data used in locating earthquakes are obtained from the network of Coast and Geodetic Survey stations listed on page 40 and from other cooperating seismological stations in the United States and throughout the world.

The Coast and Geodetic Survey endeavors to coordinate efforts in collecting all types of earthquake information with the special object of correlating instrumental earthquake locations with noninstrumental reports received from the epicentral areas. This is done by local organizations making intensive regional investigations in California and elsewhere, and, when necessary, by the Coast and Geodetic Survey. This information serves to adequately map the seismic areas of the country and promote public safety through a better understanding of earthquake phenomena. Since the success of the general information service depends largely on the cooperation of local officials and citizens, all are urged to fill out and return earthquake questionnaires.

Earthquake information services.—The Coast and Geodetic Survey maintains a Seismological Field Survey in San Francisco to collect earthquake information and make field investigations of strong shocks in the Pacific coast and western mountain States. Details concerning damage, destruction, and other effects are enumerated in the quarterly *Abstracts of Earthquake Reports for the Pacific Coast and the Western Mountain Region.* This report is available on request from the Director of the Coast and Geodetic Survey, Washington 25, D. C. Active cooperation in this work is received from the University of California Seismographic Station, Berkeley (Dr. Perry Byerly, in charge); and the Seismological Laboratory, Pasadena (Dr. Beno Gutenberg, Director); as well as State Collaborators in Seismology. The following Collaborators served as agents of the Coast and Geodetic Survey in their respective States in 1953:

Arizona.—Dr. Eldred D. Wilson, University of Arizona, Tucson.
Colorado.—Prof. C. A. Heiland, Heiland Research Corp., Denver.
Montana.—Prof. Stephen W. Nile, Montana School of Mines, Butte.
Nevada.—Dr. David B. Slemmons, University of Nevada, Reno.
New Mexico.—Prof. Stuart A. Northrop, University of New Mexico, Albuquerque.
Oregon.—Dr. Ira S. Allison, Oregon State College, Corvallis.
Utah.—Prof. J. Stewart Williams, Utah State Agricultural College, Logan.
Washington.—Prof. Howard A. Coombs, University of Washington, Seattle.
Wyoming.—Prof. Horace D. Thomas, University of Wyoming, Laramie.

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

In other parts of the country the Jesuit Seismological Association with central office at St. Louis University collects information in the central Mississippi Valley area (Rev. Dr. James B. Macelwane, S. J., Dean of the Institute of Technology). The Northeastern Seismological Association with headquarters at Weston College, Weston, Mass. (Rev. Daniel J. Linehan, S. J., in charge), undertakes similar work in the northeastern States.

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

MODIFIED MERCALLI INTENSITY SCALE OF 1931

(ABRIDGED)

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

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

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

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

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

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

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

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

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

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

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

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

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

Epicenter maps.—Figure 1 is designed to show the existence of destructive and near destructive earthquakes in the United States through 1953. The smallest dot indicates the shock was strong enough to overthrow chimneys or affect an area of more than 25,000 square miles (intensity VII to VIII); the largest solid dot may be associated with damage ranging from several thousand dollars to one hundred thousand dollars, or to shocks usually perceptible over more than 150,000 square miles (intensity VIII to IX); the smaller encircled dots represent damage ranging from approximately one hundred thousand to one million dollars, or an affected area greater than 500,000 square miles (intensity IX to X); the larger encircled dots represent damage of a million dollars or more, or an affected area usually greater than 1,000,000 square miles (intensity X to XII).

Figure 2 shows earthquake distribution in the United States during 1953. In a few cases where instrumental control is not satisfactory or where results of investigations are inadequate, the plotted epicenters should be considered as showing the existence of the earthquake rather than the precise location.

In figures 1 and 2, those earthquakes occurring in the California area are plotted when felt reports are received from several places. 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 number after a dot indicates the number of shocks which have occurred at or near the location shown. Bulletins of the University of California Seismographic Station, Berkeley, and the Seismological Laboratory, Pasadena, should be consulted for further details regarding epicenters and often for data on additional shocks.

The selection of isoseismal or "felt area" maps (figs. 3–6) is governed largely by the size of the area affected, the minimum radius generally being of the order of 50 miles. In the case of sharp localized shocks this means that some earthquakes of intensity VI (mostly in California) will not be shown on such maps whereas others of intensity IV and V (largely in the eastern and central areas) will be shown.

Teleseismic results.—On page 40 is a list of Survey and cooperating teleseismic stations for which the Survey publishes results. During the year the locations of 176 epicenters were announced promptly on *Preliminary Determination of Epicenter* cards and an additional 543 locations were reported weekly on *Supplement* cards. Those desiring to receive these cards should request addition of their name to the PDE mailing list. All seismogram interpretations are published in the quarterly *Seismological Bulletin*, MSI series, available on mailing list CGS–7 from the Director, U. S. Coast and Geodetic Survey, Washington 25, D. C. During the year 1954, MSI–129 through 132 for the first through the fourth quarter 1947, MSI–133 for the first quarter 1948 and MSI–157 through 168 for the monthly bulletins of 1954.

Magnitude-intensity correlation.—Magnitude, given according to the Richter-Gutenberg scale, is used extensively as a measure of the energy of an earthquake at the focus. An explanation of this scale is given in the *Bulletin of the Seismological Society of America*, volume 32, No. 3, 1942. This scale, derived from an empirical formula based on instrumental results, should be distinguished from the intensity scale which is a measure at any distance from the focus of the effects on animate and inanimate objects, including damage to buildings. The following comparison is given between the magnitude and intensity designations for normal depth earthquakes in southern California.

Magnitude	2.2	3	4	5	6	7	8	8.5
M–M Intensity	1.5	2.8	4.5	6.2	7.8	9.5	11.2	12.0

333315—55 —2

Strong-motion seismograph results.—The maintenance of a network of strong-motion seismographs and analysis of the records of destructive earthquake motions thus obtained are functions of the Bureau in connection with a broad cooperative program of research being carried out on the Pacific Coast with a number of local organizations and institutions interested in the engineering aspects of the earthquake problem. The details of this program are described in S. P. 201, *Earthquake Investigations in California*, 1934–35.

The preliminary analyses of strong-motion records are published in the *Quarterly Engineering Seismology Bulletin* which is available upon request from the Director, U. S. Coast and Geodetic Survey, Washington 25, D. C. The revised analyses are given in table 1.

Earthquake history.—A history of the more important shocks of the country appears in Serial 609, *Earthquake History of the United States.* Part I covers continental United States and Alaska, exclusive of California and western Nevada; Part II covers the stronger earthquakes of California and western Nevada. The first part was revised in 1947 and the latter in 1951.

A history of minor activity is covered largely in a series of references listed in Serial 609, in recent reports of the Coast and Geodetic Survey, and in the *Bulletin of the Seismological Society of America*, volume 29, No. 1, January 1939. The last two references give detailed information for all California earthquakes. The last one contains all information appearing in early catalogs published by the Smithsonian Institution.

A summary of the earthquake program as carried out in the United States is briefly outlined in S. P. 282, *Earthquake Investigation in the United States*, revised 1953. The major organizations and stations are listed together with a list of the independent and/or privately operated stations. This publication is available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 20 cents.

NONINSTRUMENTAL RESULTS

NOTE.—The following symbols are used to indicate authority for times or reported epicenters: P, reported by the Seismological Laboratory, California Institute of Technology, Pasadena; B, reported by the Seismographic Station, University of California, Berkeley; BC, reported by the Boulder City office of the United States Coast and Geodetic Survey; NESA, reported by the Northeastern Seismological Association, Weston, Mass.; JSA, reported by the Jesuit Seismological Association, St. Louis, Mo.; and W, reported by the Washington Office, United States Coast and Geodetic Survey.

An asterisk (*) indicates instrumental origin time of the earthquake when coordinates of the epicenter are given. Otherwise, instrumental times shown with asterisks are those of first motions.

When more than one degree of intensity is reported from a town, the town is listed under the highest intensity reported. More details will be found in the quarterly *Abstracts of Earthquake Reports for the Pacific Coast and the Western Mountain Region*, MSA series, issued on mailing list *CGS-3* by the United States Coast and Geodetic Survey, Washington 25, D. C.

EARTHQUAKE ACTIVITY IN THE VARIOUS STATES

NOTE.—The intensities of the earthquakes for which no ratings are given range from I to IV.

Arizona: May 4, III; October 8, V.

Arkansas: May 12, III.

California: (Intensity V and above) February 3, V (2); 19, V; March 5, V; 16, V; 21, V; April 28, V; May 1, V; 24, V, VI (2); June 13, VII; October 7, V; 13, V; 21, V; November 12, V; 23, V (2); December 15, V; 16, VI.

Connecticut: March 27, V.

Idaho: September 9, IV.

Illinois: September 11, VI; December 30, IV.

Kentucky: December 31, IV.

Missouri: February 11, IV.

Montana: March 8, IV; May 11, III; August 7, IV; 8, VI, II; 14, IV; 15, IV (2); November 23, V.

Nevada: February 3, 15, 16; 28, III; March 2, IV; 9, IV; 10, IV; 21, V; 24, III; 25, III; April 10; May 3, 12, 18 (2); 19, IV; 22, 24; July 12. IV; 13, III; September 18, III; 25, VI; 28, III; October 9, IV, III; 11, IV; 12, 13, III.

New Hampshire: May 11, IV.

New Jersey: August 16, IV.

New York: April 25, IV.

Ohio: May 7, IV; June 11, IV.

Oklahoma: March 16; 17, VI; June 6, IV.

Oregon: November 4; December 15, VI.

South Dakota: December 21; December 31, IV.

Tennessee: January 26; February 17, IV; 18, IV; November 10, IV.

Utah: April 17, IV; May 23, V; July 29, V; August 16, IV; October 21, V; 24.

Vermont: March 30, III; 31, V.

Virginia: February 7, IV.

Washington: February 24, IV; April 10, IV; 27, III; May 26, IV; July 11.

Wyoming: March 15, IV; April 26, IV; June 4, IV.

EARTHQUAKE ACTIVITY OUTSIDE THE UNITED STATES

Alaska: January 11, 16 (2), 28, 29; February 5, 13; 18, IV; 19, 21; March 5, 16; April 9, 10, 13, 19, 21, 25; May 5, 7, 12, 14, 19, 20, 23, 27; June 9 (2), 19, 20, 27; July 4, 17, 19, 23, 26, 31; August 28; September 12, 20, 22, 27, 28; October 7, 8, 13, 15, 22; December 4, 15, 17 (2), 18.

Hawaii: January 3 (2), 7, 8, 9 (4), 13, 15 (2), 23; February 12, IV; 22; March 6 (2), 23, 25, 26, 27; April 10, 14, 24; May 19, 22, 24 (2), 25, 26, 27, 29; June 4, 9, 15, 27; July 15, 26 (2), 28; August 1, 4, 6, 8, 21 (2), 23, 24; September 3, 23, 27; October 2, 8, 9 (2), 15, 22, 27 (4), 28 (4), 31; November 22 28, 29 (2), 30; December 1, 9, 16.

Panama Canal Zone: January 20, V; February 7; March 19, II; August 4, II; September 1, II

Puerto Rico: February 21; July 6.

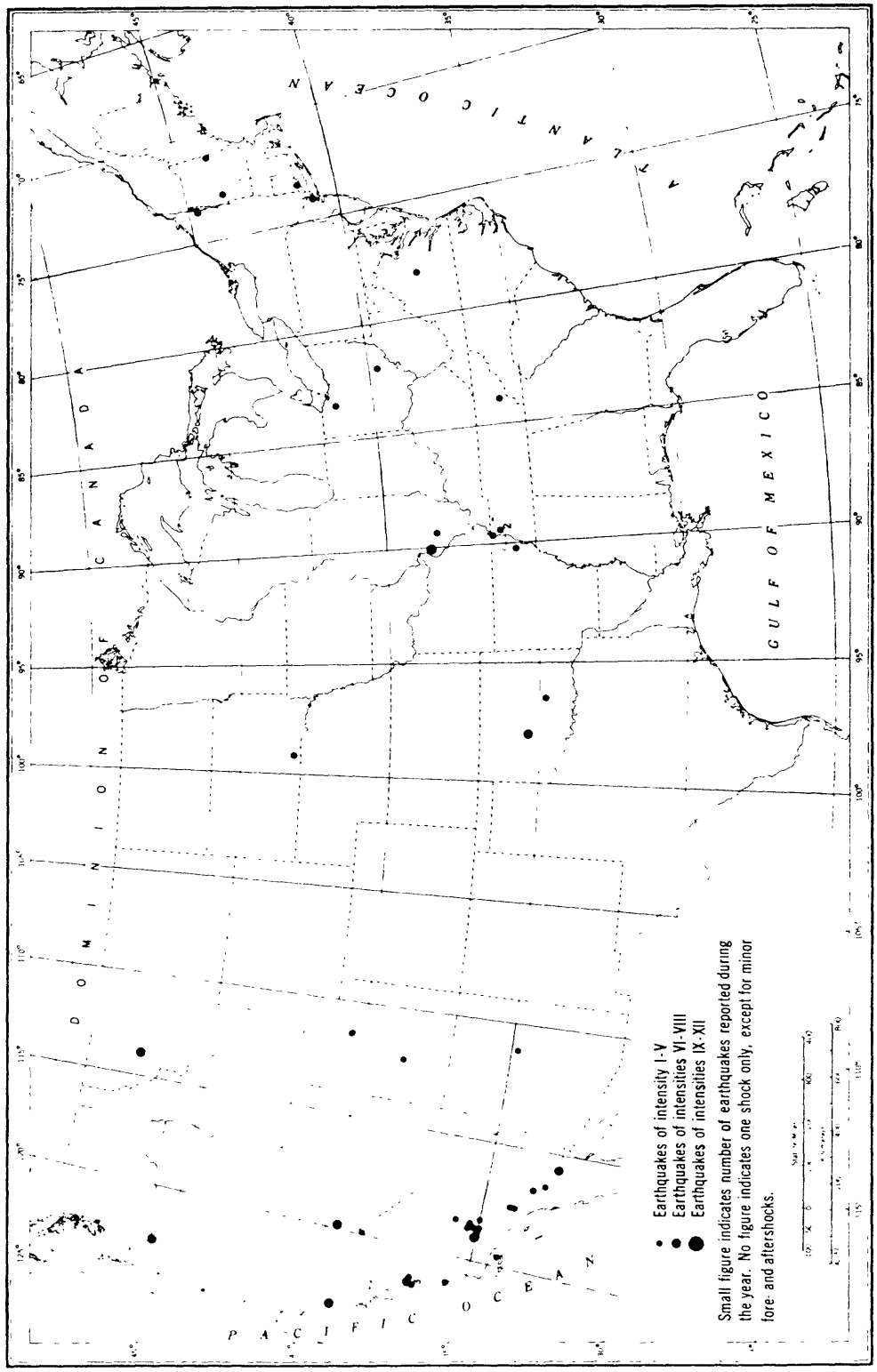

FIGURE 2.—United States earthquake epicenters, 1953.

NORTHEASTERN REGION

(75TH MERIDIAN OR EASTERN STANDARD TIME)

March 27: 03:50. Stamford, Conn. V. Quake shook southwestern Connecticut and adjacent Westchester County. Many awakened and frightened at Stamford; police switchboards flooded. Many homes jarred; two story brick building trembled; radiators beat a weird tattoo against floor of police station. At Greenwich felt by and alarmed many; sounded like a double explosion; surface sounds (creaking of buildings and rattling of buildings) heard by many. At New Canaan few awakened; buildings creaked and loose objects rattled. A sump pump in cellar was thrown out of position—fell to the north. Felt by and awakened several at Darien and Norwalk. At Wilton felt by several and scattered reports of rumbling sounds. In New York several awakened and frightened at Port Chester and felt at Harrison (by many), Mamaroneck, and Rye.

March 30: 21:50. Brandon, Vt. III. Slight foreshock of the following west-central Vermont earthquake. Felt by several.

March 31: 07:59:06*. West-central Vermont. V. Felt strongly along a 40-mile path extending from Brandon on the north to Ludlow and Weston on the south. Recorded by the seismograph stations at Burlington, Vt., and Weston, Mass.

INTENSITY V:

Rutland.—Felt by many; awakened and frightened few. Some furniture moved; houses quivered; sounded like furnace exploded or truck crashed. Felt with varying degrees of intensities within the city limits.

Brandon.—Awakened many (in Brandon State School), and frightened many. Small objects moved; houses trembled; water spilled; knickknacks fell.

INTENSITY IV:

Leicester.—Felt by several and frightened few. Rattled windows and dishes; rumbling heard by many.

Ludlow.—Felt by many. Rattled windows, dishes and stove lids. Felt like vibrations of a heavy truck.

Pittsfield.—Felt by many; frightened all who heard it.

Pittsford.—Felt by many; frightened few. Several objects disturbed and buildings creaked.

Proctor.—Felt by all; frightened many.

Randolph.—Felt by many; frightened few. Windows and dishes rattled.

Rochester.—Felt by all. Felt like a heavy truck.

Weston.—Felt by few. Dishes rattled.

Woodstock.—Felt by many. Moved vase on table; trees shaken slightly. Car felt as if it shivered.

INTENSITY IV IN NEW YORK:

Comstock.—Felt by few. Rattled windows.

Whitehall.—Felt by few. Rattled windows.

INTENSITY I TO III: Bethel, Bridgewater Corners, Castleton, Fair Haven, Mendon Mountain, North Clarendon, Norwich, Plymouth, Springfield, Tyson, Wallingford, West Rutland, and Windsor.

INTENSITY I TO III IN NEW YORK: Granville.

April 25: 20:20. Plattsburgh, N. Y. IV. Felt by many. Many calls to newspapers and police and radio stations. Sounded like a slight rumble or explosion. Also felt at Ausable Forks and Cadyville (one instance of cracked plaster).

May 11: 01:13:17*. Conway, N. H. IV. Epicenter placed in the Conway-Ossipee area by the Weston Observatory. At Conway awakened few and felt by several. Mirror in dresser rattled. At Madison awakened, frightened and felt by few. Lasted several seconds and rattled windows. Also felt at Silver Lake (2 miles from Madison), North Sandwich, and Tamworth.

EASTERN REGION

(75TH MERIDIAN OR EASTERN STANDARD TIME)

February 7: 03:00 (about). Goochland-Cumberland County border, Va. IV. Felt in small area near Goochland-Cumberland County border. Felt by many at Cartersville, New Canton, Rock Castle, Pemberton, and Sabot where reports were received of buildings and windows shaking, heavy earth rumbling, and sounds like explosion. At Richmond, report of a house and bed trembling violently.

August 16: 23:22:50*. Bergen County, N. J. IV. Felt in most of Bergen County, some northern New Jersey communities and adjoining areas of Rockland and Westchester Counties, New York and Morningside Heights, a section of New York City. In New Jersey, felt by many and accompanied frequently by sound effects at Closter, Dumont, Fairview, Garfield and Haworth. In addition, at Hackensack, dishes rattled and calls swamped police headquarters: at New Milford few alarmed and houses shook; at Oradell many observed disturbed objects and slight swaying of trees.

In New York at Irvington felt by several; rattling of loose objects; swaying of lamps, tables, and ash trays; sounded like an explosion.

Intensity I to III in New Jersey at Bergenfield, Bogota, Hoboken, Cliffside Park, Cresskill, Edgewater, Fort Lee, Leonia, Northvale, Norwood, Ridgefield, Ridgefield Park, Rochelle Park, and Teaneck.

Intensity I to III in New York at Larchmont, Yonkers, Yorktown Heights, Sloatsburg, and Tarrytown.

CENTRAL REGION

(90TH MERIDIAN OR CENTRAL STANDARD TIME)

January 26: 17:18*. Finley, Tenn. Centered near Finley and also felt in Boothspoint and Lane. The St. Louis and Florissant seismographs recorded faint traces.

February 11: 04:50:54*. Epicenter 36.5° north, 89.5° west, New Madrid, Mo., JSA. IV. Reports of intensity IV from Dorena, Kewanee, Marston, New Madrid, Parma, Point Pleasant, and Risco, Missouri, and Hornbreak, Trigrett, and Tiptonville, Tennessee, where dishes and w ndows rattled, houses shook and few awakened. Also felt in Catron, Conran, Gobler, Hermondale, Lilbourn, and Tallapoosa, Missouri; Hickman, Kentucky; and Elbridge, Tennessee.

February 17: 05:45 and 18:17. Finley, Tenn. IV. Felt by several. Windows and dishes rattled in some homes.

February 18: 23:05. Finley, Tenn. IV. Windows rattled in several homes. Duration only a few seconds.

March 16: 06:50. Union City, Okla. Slight tremor felt.

March 17: 07:12 and 08:25. Concho, Okla. VI. Felt by many inside. Minor damage; foundation, garage floor, and plaster cracked at one location. Dishes moved on table; picture twisted on walls; sensation of building coming down. Intensity V in Union City where several felt the shock. Dishes broke; houses quivered; kitchen cabinet doors shook open. In Minco felt by several; time alarm set off; dishes rattled on table and table and floor trembled. In Okarche light fixtures swayed to north and coffee in cups rippled. Felt by several in El Reno and Piedmont, and felt in Calumet and Edmond.

May 7: 17:32. Crooksville, Ohio. IV. Startled many residents. Windows and dishes rattled; buildings quivered in the downtown area; sounded like a distant explosion. Ohio Power building shook. Also felt on a hill a mile south of the power building and in Roseville.

May 12: 12:50. Lepanto, Ark. III. Felt by several. Felt as one quick jolt lasting less than a second. One report of floor shaking.

June 6: 11:40. Ada, Okla. IV. Felt by several. Duration about 15 seconds. Windows rattled.

June 11: (p. m., no time given). Toledo, Ohio. IV. Pictures knocked off walls in Toledo and suburbs; hundreds of telephone calls to police and newspapers. Houses shaken in Adams, Springfield and Sylvania.

September 11: 12:26:28*. Epicenter 38.6° north, 90.1° west, southwest Illinois, JSA. VI. Minor damage occurred in Roxana when cement block foundations and plaster cracked. Cans and jars knocked off grocer's shelves. Intensity V in Edwardsville where many rushed to the street from the courthouse and other downtown buildings and in Mitchell where cans fell off a refrigerator and strong vibrations were reported.

INTENSITY IV: Alhambra, Aviston, Belleville, Bethalto, Caseyville, Centerville Station, Collinsville, Columbia, Cottage Hills, Coulterville, East Alton, East Carondelet, Glen Carbon, Godfrey, Hartford, Hecker, Hoyleton, Lebanon, Marine, Maryville, Mascoutah, Millstadt, New Baden, O'Fallon, Radom, Sparta, St. Jacob, Summerfield, Troy, Venice, Wood River, and Worden.

INTENSITY IV IN MISSOURI: Berkeley, Bridgeton, Florissant, House Springs, St. Louis, West Alton, and Winfield.

INTENSITY I TO III: Addieville, Bartelso, Beckemeyer, Breese, Bunker Hill, Carlyle, East St. Louis, Freeburg, Grafton, Mount Olive, Mulberry Grove, New Memphis, Pocohontas, Trenton, and Wilsonville.

INTENSITY I TO III IN MISSOURI: Festus, and Maryland Heights.

November 10: (about 10:00). Knoxville, Tenn. IV. Windows rattled and ground shook. Other reports from Burlington and Inskip.

December 21: 16:43. Zeona, S. D. The shock, reported by a single observer, caused considerable vibration of a house and table and was accompanied by a heavy rumbling sound. An oil prospecting crew was operating in the area but the observer who was well acquainted with their area of operation, felt that this disturbance was a natural earthquake.

December 30: (about 16:00). Centralia, Ill. IV. Slight tremor shook Centralia, nearby Carlyle, and Mount Vernon. Windows were shaken and a "loud rumble" was reported by many.

December 31: 14:30. Burke, S. D. IV. Several reported explosionlike noise, shaking of the ground, and rattling of doors and windows. Also reported at Jamison, Nebr.

December 31: 20:30. Woodland Park, Ky. IV. Felt by several in Woodland Park. Report of house and chest shaking and furnace switching on. Also felt in Allais and Hazard.

WESTERN MOUNTAIN REGION

(105TH MERIDIAN OR MOUNTAIN STANDARD TIME)

February 3: 11:48:15*. Boulder City, Nev. Felt slightly.

February 15: 20:11:58*. Boulder City, Nev. Felt by one person.

February 16: 00:27:16*. Boulder City, Nev. Felt by one person.

February 28: 13:45:05*. Boulder City, Nev. III. Felt by several.

March 2: 13:46:40*. Boulder City, Nev. IV. Felt by many.

March 8: 18:39:34*. Helena, Mont. IV. Felt by many. Buildings creaked; loose objects rattled. Some people were alarmed and a few left theater. Main feature was the loud rumbling and bumping subterranean sounds heard before, during, and after shock. Felt by several at Austin about 10 miles northwest of Helena.

March 9: 20:05:20*. Boulder City, Nev. IV. Felt by nearly all. Windows and doors rattled.

March 10: 22:24:14*. Boulder City, Nev. IV. Felt by many.

March 15: 08:30. Alta, Wyo. IV. Felt by many. Buildings creaked; loose objects rattled. Thunderous subterranean sounds heard before and during shock.

March 24: 19:35:46*. Boulder City, Nev. III. Felt by several.

March 25: 20:04:45*. Boulder City, Nev. III. Felt by several.

April 10: 16:40:08*. Boulder City, Nev. Felt by one person.

April 17: 22:15. Monroe, Utah. IV. Felt by many; awakened few. Bed shook; windows and loose objects on dresser rattled. Stacks of tablets in drug store slid down. Press reported houses shook and bottles on store shelves rattled. Felt slightly 1.5 miles south and 2 miles west, but not felt 2.5 miles south. Also felt at Elsinore where windows rattled. Sounds like rumbling of truck heard at both Elsinore and Monroe.

April 26: 06:50. Sheridan, Wyo. IV. Felt by some. Bed rocked; dishes rattled; electric wires swayed.

May 3: 16:43:32*. Boulder City, Nev. Felt by one person.

May 4: 07:56:14*. Yuma, Ariz. III. Felt by some.

May 11: 09:56. Helena, Mont. III. Felt by several. Lasted 2 seconds. Motion rapid.

May 12: 15:51:13*. Boulder City, Nev. Felt by one person.

May 18: 00:03:02*. Hoover Dam, Nev. Felt slightly.

May 18: 06:15:01*. Boulder City, Nev. Felt slightly.

May 19: 22:35:29*. Boulder City, Nev. IV. Felt by several in community. Doors rattled. Motion rapid.

May 22: 11:28:58*. Boulder City, Nev. Felt slightly.

May 23: 19:54:29*. Epicenter 40½° north, 111½° west, north-central Utah, W. Salt Lake City. V. Press reported a light earthquake shook southern Salt Lake and northern Utah counties, rocking houses, shifting furniture and startling residents. Residents of Lehi flooded the telephone exchange with calls. The Salt Lake Tribune received many calls from residents in and around Herriman, in the southwest corner of Salt Lake County. At Lehi a woman reported her house "bounced up and down" and telephone operators said the jolts shook their chairs and switchboards.

May 24: 20:24:55*. Boulder City, Nev. Felt slightly.

June 4: 10:02:50*, 12:24:32*. Epicenter 44½° north, 110½° west, Yellowstone National Park, Wyo., W. Old Faithful. IV. Felt by several in log house. Building creaked; loose objects rattled. Trees, bushes shaken slightly. Motion rapid.

July 12: 10:19:35*. Boulder City, Nev. IV. Felt by many.

July 29: 22:45 (about). Greenriver, Utah. V. Felt by and awakened many in community. Windows and doors rattled. Motion slow.

August 7: 00:04. Swan Lake, Mont. IV. Felt by and awakened several in community; frightened few. Dead chicken on second floor of barn (7 feet above ground) was jerked through opening. Single loud report and jerk. Awakened one person on the east shore of Flathead Lake (about 12 miles south of Bigfork).

August 8: 09:50. Flathead Lake, Mont. (on east shore about 12 miles south of Bigfork). VI. Sharp, jarring movement felt by most people. Buildings creaked; loose objects rattled. Doors on two sheds sagged, making opening and closing difficult. Man reported tractor was hard to steer. Cracks were reported in one old two-story building at Yellow Bay. Felt by many and frightened few at Swan Lake where small objects shifted and stovepipe (unsupported except at base) was tilted about 10 degrees in the direction of N 55° W (magnetic).

August 8: 18:15. Swan Lake, Mont. II. Mild shock felt by some persons. Also felt on the east shore of Flathead Lake (about 12 miles south of Bigfork).

August 14: 12:47. Lombard, Mont. (about 5 miles southeast of). IV. Walls creaked. Felt by several at Clarkston where rumble was heard. Motion jolting.

August 15: 04:45. Clarkston, Mont. IV. Windows rattled. Motion jolting.

August 15: 08:35, 08:36, 08:40. Lombard, Mont. IV. Felt by several and awakened few. Windows rattled; walls creaked. Clarkston and Toston reported only the shock at 08:35. At Clarkston windows rattled; at Toston a coffee pot vibrated.

August 16: 08:37*, 09:00*, 09:36*. Salt Lake City, Utah area. IV. Press reported three distinct but light shocks were felt by many and awakened some people. Reports came from scattered portions of Salt Lake County but the majority of reports came from westside residents of Salt Lake City in the Rose Park area. Dishes rattled. The second shock seemed sharpest to a Rose Park resident who said dishwasher and refrigerator, about ½ inch apart, bumped against each other. Reports were received from as far south as Granger and as far west as the Salt Lake Municipal Airport area. In the airport area a woman said she was awakened at 06:00 by what she considered to be an earthquake and that the subsequent shocks were also distinctly felt.

September 9: 02:30. Bonners Ferry, Idaho. IV. Felt by several. Windows and dishes rattled.

September 18: 23:35:07*. Boulder City, Nev. III. Felt by several.

September 28: 08:08:46*. Boulder City and Hoover Dam, Nev. III. Felt by several.

October 8: 13:19:46*. Epicenter 34¾° north, 111° west, W. Red Hill Ranch, Ariz. (about 35 miles southwest of Winslow). V. Sharp rumble heard. House shook. Wallpaper cracked. Felt by two persons outdoors on the west side of house in Leupp. Doors swayed; windows rattled. On State Route 65 between Macks Crossing and Bly (about 34°39′ north, 111°07′ west) a single jar like dynamite blast was felt by two people in small house trailer. Trailer shook. Subterranean sounds were heard a few seconds before shock was felt.

October 9: 15:21:13*. Boulder City and Hoover Dam, Nev. IV. Felt by many. Windows, doors, and dishes rattled.

October 9: 20:15:28*. Boulder City, Nev. III. Felt by several.

October 11: 02:48:48*. Boulder City and Hoover Dam, Nev. IV. Awakened many.

October 13: 11:35 Reno, Nev. III. Felt by few.

October 21: 20:00 (about). Panguitch, Utah area. V. Press reported a damaged potato cellar north of Panguitch appeared to be the only damage from recent earthquakes felt in this area. Tons of dirt fell into cellar when three 2-foot pine log timbers snapped. Some thought boiler or furnace had exploded. Residents of Panguitch report three sharp earthquakes were felt during the past week.

October 24: 13:50. Panguitch, Utah. Press reported people said it felt like the floor had dropped out from under foot for a fraction of an inch. Blastlike sound heard.

November 23: 06:30. Helmville, Mont. V. Clock fell from shelf. Windows, doors, and dishes rattled. Water pipe broke in basement. Motion rapid.

CALIFORNIA AND WESTERN NEVADA

(120TH MERIDIAN OR PACIFIC STANDARD TIME)

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

January 1: 09:36.9*. Epicenter 32.6° north, 117.1° west, near Tijuana, P. El Cajon-Grossmont area. "Two slight earthquakes were recorded at 9:37 A. M. and 10:22 A. M., PST. The shocks were reported felt by a few persons. . . ."—(*BSSA, April 1953.*)

January 9: 03:52:06*. Epicenter 35°17′ north, 118°35′ west, near Caliente, P. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion bumping.

January 9: 18:52:31*. Epicenter 27.5° north, 114.4° west, Lower California, P. San Diego. IV. Felt by several in community. Windows rattled; frame creaked. About seven calls came from El Cajon and Mt. Helix districts. Rumbling sound heard.

January 14: 23:25. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion bumping.

January 18: 17:12:35*. Epicenter 35°18′ north, 118°35′ west, near Caliente, P. Tehachapi. Light tremor.

January 20: 00:13:22*. Epicenter 35°19′ north, 118°30′ west, east of Caliente, P. Tehachapi. IV. Felt by most people. Buildings creaked; loose objects rattled. Motion bumping.

January 24 to 31: (no time given). Bryson (Ernest Weferling Ranch). Ten light shocks felt during period.

January 25: 04:23:11*. Epicenter 34°07′ north, 117°20′ west, near San Bernardino, P. San Bernardino. V. "Many residents of San Bernardino were awakened . . . by a sharp earthquake that apparently was not felt elsewhere in southern California."—(*BSSA, April 1953.*)

January 31: 05:35. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion trembling, abrupt onset.

January 31: 16:51.9*. Probably near Bear Mountain, P. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Moderately loud subterranean sounds like a muffled explosion heard before shock. Motion bumping, like an upward push.

January (latter part): 21:30 (about). Eagle Mountain. Shock reported felt.

February 1: 07:05. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion bumping.

February 1: 13:48:29*. Epicenter 35°19′ north, 118°30′ west, east of Caliente, P. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion trembling.

February 1: 22:16. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. One bump or jar.

February 3: 00:48. East San Francisco Bay area. Press reported residents of Albany, Berkeley, and El Cerrito felt a small earthquake. Epicenter was thought to be about 5 miles northwest of the University of California campus.

February 3: 06:50.2.* Epicenter 35.6° north, 121.1° west, near Cambria, P. V. Felt by, awakened many, and frightened few at Atascadero. Windows rattled. Awakened many at Creston. Windows rattled. Felt by and awakened many at Morro Bay. Windows, doors, and dishes rattled. Trees, bushes shaken slightly. Felt by all and awakened many at Pleyto School near Bryson. Windows rattled and walls creaked. "This was one of the more severe, longer, and abrupt shocks." Felt by and awakened many; frightened few at Santa Margarita. Motion slow at Creston; rapid at other places. Intensity IV at Ernest Weferling Ranch (Bryson), Cayucos, Paso Robles, San Luis Obispo, and Templeton. Intensity I to III at Bitterwater and Casmalia.

February 3: 20:36:16*. Epicenter 33°24′ north, 116°34′ west, near Warner Springs, P. V. Felt by all at Miramar, Palomar Mountain and Warner Springs. Windows, doors, and dishes rattled. Pictures on walls shifted at Miramar. Heavy jolt in El Cajon Valley where some people were frightened and ran outdoors. Small objects shifted and few frightened at Hausner Canyon (Campo). Motion rapid.

INTENSITY IV: Borego Valley (Ensign Ranch), Descanso, Dulzura, Escondido, Fallbrook, Grossmont, Jacumba, Julian, Lakeside, La Mesa, Mesa Grande, Pala, Ramona, Rancho Mirage, Riverside, San Diego, Santa Ysabel, and Thermal.

INTENSITY I TO III: Boulevard, Desert Hot Springs, East San Diego, El Centro, Flinn Springs (2 miles east of), Hemet, Indio, Mecca, Moreno, Perris, Potrero, Poway, San Marcos, Temecula, Thousand Palms, and Westmorland.

February 4: 18:54.2*. Small record, P. Bryson (Ernest Weferling Ranch). IV. Felt by many. Windows and doors rattled; walls creaked. Motion rapid.

February 4: 22:30*. Small shock not far from Caliente, P. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion trembling, followed by bumping.

February 6: 16:03:26*. Epicenter 37°25′ north, 118°10′ west, east of Laws, P. Laws. IV. Felt by many. House creaked. Sudden, rapid jar. Southwest side of house hit hard.

February 7: 08:42. Tehachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Heavy jar, preceded by muffled explosivelike sounds.

February 9: 06:45:54*. Epicenter 35°17′ north, 118°37′ west, near Caliente, P. Tehachapi. IV. Felt by many. Buildings creaked: loose objects rattled. Heavy jolt.

February 15: 01:10. Fall River Mills (1 mile northwest of). IV. Felt by several. Several glasses in bar broke. Disturbed objects observed by few. Abrupt drop or sway.

February 15: 07:30. Bryson (Ernest Weferling Ranch). Slight shock.

February 15: 13:00:41*, 13:04:21*. Epicenter 35°16′ north, 118°34′ west, Bear Mountain, P. Arvin. IV. Felt by many in community. Windows, doors, and dishes rattled; house creaked. Small objects shifted. Motion rapid. Felt by all at Kern Canyon Powerhouse near Bakersfield where windows rattled. Motion slow.

February 16: 11:30. Arvin. IV. Felt by several and frightened few in community. Small objects shifted. Windows, doors, and dishes rattled; house creaked. Motion rapid.

February 17: 00:06. Bryson (Pleyto School). III. Sharp jerk awakened observer. Many such shocks reported felt often two or three each day since shock of November 21, 1952.

February 18: 06:10. Bryson (Ernest Weferling Ranch). Mild shock.

February 19: 00:12:06*. Epicenter 35°18′ north, 118°30′ west, near Caliente, P. Arvin. V. Felt by and awakened many in community; frightened few. Shifted small objects. Windows, doors, and dishes rattled. Motion slow. Intensity IV at Edison and Tehachapi where it was felt by many and roaring sounds were heard. It was reported that residents of Bakersfield and surrounding areas felt a number of shocks. Also felt at Fillmore and Jawbone Aqueduct Station.

February 20: 13:18:25*. Epicenter 33°17′ north, 116°22′ west, near Borego, P. IV. Felt by many at Borego Valley (Ensign Ranch) where buildings creaked and loose objects rattled. Motion trembling. Felt by several and rattled windows at Santa Ysabel. Ended with hard jerk. Very brief and moderate at Warner Springs.

February 23: 01:10:40*. B. Pittville. IV. Felt by several in home and community; awakened all in home. Window blinds rattled. Two sharp shocks were felt in home 2½ miles north of Pittville where house creaked. Motion rapid. Felt by several at Pittville Powerhouse No. 3.

February 23: 09:11:7*. Epicenter 35°22′ north, 118°53′ west, near Bakersfield, P. Sharp shock at Bakersfield Steam Plant and Magunden Powerhouse.

February 25: 17:15. III. Felt by several in Cedarville. Lasted about 10 seconds. Motion trembling.

February 25: 19:22:01*. Epicenter 35°27′ north, 118°48′ west, Kern River Gorge, P. Brief shock felt at Bakersfield (PG&E). Motion slow.

February 25: 20:23:00*. Epicenter 35°27′ north, 118°48′ west, Kern River Gorge, P. V. Kern Canyon Powerhouse (near Bakersfield). Windows broke. Motion rapid.

March 1: 10:50. Bryson (Ernest Weferling Ranch). V. Felt by all in community. Windows and doors rattled. Motion rapid.

March 3: 19:40. Heavy blast and light tremble felt at the Pleyto School near Bryson.

March 4: 11:52:21*. Epicenter 35°04′ north, 118°26′ west, near Tehachapi, P. Tehachapi. V. Felt by all. Buildings creaked; loose objects rattled. Heavy humming and bumping sounds heard at time of shock. Motion trembling, then a jar. Reported as sharp at Palos Verdes hills.

March 4: 13:40:03*. Epicenter 33°20′ north, 115°40′ west, northwest of Niland, P. IV. Felt in business district of Westmorland, where windows, doors, and dishes rattled. Motion slow.

March 5: 04:21:33*. Epicenter 33°45′ north, 118°29′ west, near Palos Verdes, P. V. " . . . Plaster was knocked from the walls of two buildings in Hermosa Beach."—(*BSSA, April 1953.*) Awakened many at Palos Verdes where dishes rattled and beds shook. Dishes rattled and beds shook in the southwest section of Los Angeles. Press reported some residents of Redondo Beach, Hermosa Beach, and Westwood were awakened by a sharp, rolling shock. Also felt at El Segundo, Inglewood, and Manhattan Beach.

March 10: 11:50*. Small shock not far from Woody, P. Slight shock felt at Kern Canyon Powerhouse near Bakersfield.

March 10: 18:17. Light shock felt at Bakersfield (PG&E).

March 14: 09:22:36*. Epicenter 37°39′ north, 122°30′ west, B. "The Hayward area was slightly shaken by a small earthquake . . . "—(*BSSA, April 1953.*)

March 14: 21:15. El Portal. IV. Felt by and awakened some persons. Some heard rumbling sound. Motion slow.

March 16: 00:52:06*. Epicenter 36°57′ north, 121°40′ west, B. V. Awakened many in community at Gilroy. Windows rattled; walls creaked. Motion slow. Press reported scores of people were awakened at Santa Cruz. Windows rattled, dishes "danced" in cupboards, and chandeliers swung. Preceded by a dull rumbling sound. In the northeast section, buildings and trees swayed visibly. Motion swaying. Intensity IV at Monterey, Morgan Hill, San Jose, and Watsonville. Intensity I to III at Ben Lomond, San Francisco, and Sharp Park.

March 17: 21:03. III. Felt by several in home and community at the Pleyto School near Bryson. Loud rumble. Motion rapid. Few light shocks felt since this one. (Report dated April 15)

March 19: 18:57:33*. Epicenter 34°04′ north, 118°22′ west, near Beverly Hills, P. Burbank. IV. Press reported hundreds of calls were received by police from alarmed residents. Described as sharp.

March 21: 21:19:01*. Epicenter 38.8° north, 119.9° west, W. Meyers. V. Felt by all and frightened many in community. House creaked. Small objects shifted. Very loud rumble preceded and accompanied shock. Motion rapid. Intensity IV at Emigrant Gap (Blue Canyon Airport), Markleeville, Placerville, Tahoe City, and Yosemite National Park (Village Center). Also felt at Carson City and Gardnerville, Nev.

March 22: 00:00. Markleeville. Tremor felt.

March 22: 06:05. Meyers. V. Felt by and awakened many in community; frightened few. Intensity IV at Markleeville and Tahoe City where some were awakened. Motion slow.

March 22: 23:15. Tehachapi. IV. Felt by many. Lasted 2 seconds. Motion bumping.

March 23: 09:06:37*. Epicenter 34°59′ north, 118°54′ west, P. Wheeler Ridge. V. Felt by and frightened many in community. Everyone went outside. Windows, doors, and dishes rattled; house creaked. Hard, E–W jerk.

March 23: 09:42:48*. Epicenter 34°59′ north, 118°58′ west, P. Wheeler Ridge. IV. Moderately hard shock. Windows and doors rattled.

March 25: 15:40 or 16:40. Bakersfield (southwest section). IV. Felt by several in home. Windows rattled; walls creaked. Trees, bushes shaken moderately. Motion rapid, jolting.

April 1: 21:17:33*. Epicenter 35.1° north, 118.7° west, near Bear Mountain, P. Tehachapi. IV. Felt by many. Buildings creaked. Light jolt.

April 5: 22:15:17*. Epicenter 32.2° north, 116.7° west, northwest of Guadalupe, Baja California, P. El Cajon. IV. Press reported windows and doors rattled. Felt by several at San Diego. Motion rapid.

April 7: 16:59:20*. Epicenter 34.8° north, 120.6° west, near Casmalia, P. Los Alamos. IV. "Many people came out of buildings asking where the explosion had occurred."

April 8: 15:08:09*. Epicenter 35°22′ north, 118°37′ west, northwest of Caliente, P. Kernville. IV. Felt by many in post office. Windows and doors rattled. Motion rapid.

April 9: 21:11:44*. Epicenter 37.8° north, 118.2° west, east of Benton, P. June Lake. IV. Sharp jolt felt by many. Windows, doors, and dishes rattled; house creaked. Rumble heard. At Long Valley Dam (north of Bishop) it was felt by several in home. Hanging objects swung. Motion rapid at both places.

April 14: 16:29*. Epicenter 35.8° north, 121.2° west, near Bryson (epicenter doubtful), P. Bryson. IV. Windows rattled; house creaked. First heavy shock for weeks. Motion jerky.

April 14: 21:30. Bryson. Light shock.

April 28: 21:26:52*. Epicenter 35.8° north, 121.2° west, near Bryson, P. Bryson (Pleyto School). V. Felt by several; awakened all in home. Windows, doors, and radio rattled; house creaked. Small objects shifted. Blastlike sound, then strong jerk, followed by several smaller shakes. Reported as first heavy shock in several weeks.

April 29: 04:47:45*. Epicenter 35°00′ north, 118°44′ west, Tejon Ranch, P. Wheeler Ridge. V. Felt by all in community; frightened few. Windows, doors, and dishes rattled; house creaked. Motion rapid. Intensity IV at Bakersfield, Los Angeles and most suburban cities, and Tehachapi where it was felt by many and awakened some. Press reported it was the strongest shock felt in the Tehachapi area so far this year. Awakened few at Fillmore. Also reported felt at Glendale and Hollywood.

April 30: 22:48:22*. Epicenter 35°07′ north, 118°27′ west, near Tehachapi, P. Tehachapi. IV. Felt by most people. Building creaked; loose objects rattled. Light tremble, followed by heavy jolt.

May 1: 21:50:41*. Epicenter 34°06′ north, 117°38′ west, near Ontario, P. Riverside. V. Felt by, awakened, and frightened many in community. Windows and doors rattled; walls creaked. Started slow, then grew strong, ended with hard bang. Slight shock at 21:52. Intensity IV at Altadena, Cantil, Etiwanda, Fontana, Los Angeles and southwest areas, Pasadena, and Pomona. Also felt at Inglewood, San Bernardino, Corona, and Claremont. Majority of places reported abrupt motion.

May 2: 01:55. Tehachapi. IV. Felt by many. Motion trembling.

May 2: 03:56:50*. Epicenter 35°25′ north, 117°52′ west, near Garlock, P. IV. Felt by and awakened many in home at Cantil. Windows, doors, and dishes rattled. Quite sharp. Felt by many at Tehachapi. Light jolt. At Jawbone Aqueduct Station it was felt by observer in home. Motion rapid.

May 3: 06:24:25*. Epicenter 35°22′ north, 118°37′ west, north of Caliente, P. Bakersfield. IV. Described as a "good" jolt. Some objects in room swayed.

May 3: 18:30:23*. Epicenter 34°07′ north, 117°18′ west, near San Bernardino, P. IV. Reported as a very sharp, vibrating motion at Fontana. Press reported a sharp, brief shock in the San Bernardino and Riverside areas.

May 8: 00:15. Lompoc. III. Trembling north-south motion felt by two.

May 14: 01:36:09*. Epicenter 35°31′ north, 121°17′ west, off Cambria, P. Bryson. V. Small objects shifted. Windows, doors, and dishes rattled; house creaked. Shook violently at start.

May 14: 17:22:53*. Epicenter 35°07′ north, 118°42′ west, west of Cummings Valley, P. Tehachapi. IV. Felt by nearly all. Buildings creaked; loose objects rattled. Hard jar, followed by rapid trembling.

May 14: 23:15. Bryson (Pleyto School). IV. Felt by observer in home. Windows rattled; walls creaked. Light shock, motion rapid.

May 15: 11:20:50*. Epicenter 33°58′ north, 117°39′ west, near Chino, P. "A light earthquake was felt in Ontario . . ."—(*BSSA, July 1953.*)

May 19: 11:14. Fall River Mills, near (PG&E) Pit River Powerhouse No. 1. IV. Felt by many. Buildings creaked; loose objects rattled. Subterranean sounds like thunder, with slight whistling, heard at time of or slightly after shock. Some thought it was a nearby lightning strike.

May 20: 13:23. Hollister (7 miles south of). III. Felt by several in community. Lasted 2 seconds. Motion rapid.

May 23: 13:16:24*. Epicenter 37°18′ north, 121°37′ west, B. Mount Hamilton (Lick Observatory). III. Felt by many in one building and by several in homes. One jolt, accompanied by noise.

May 23: 18:08:08*. Epicenter 35°22′ north, 118°40′ west, north of Caliente, P. Bakersfield. III. Felt by several in community. Windows, doors, and dishes rattled very slightly; house creaked very slightly. Motion slow.

May 24: 16:23:30*. Epicenter 36°49′ north, 121°28′ west, B. Hollister. V. Felt by many; few alarmed. Building creaked; loose objects rattled. Disturbed objects observed by several. Window weights and chandeliers swung south-north. Trembling, followed by abrupt shock. Press reported the rolling shock knocked over some glassware and dishes. Intensity IV at Gilroy, Morgan Hill, and San Juan Bautista. Intensity III at Salinas and Santa Cruz. Thunderous rumbling subterranean sounds heard during shock at Santa Cruz.

May 24: 19:24:01*. Epicenter 35°00′ north, 119°01′ west, Wheeler Ridge, P. Caswell. VI. Press reported some supplies tumbled from shelves and buildings rocked and rolled two or three times. Intensity V at Taft where press reported some west side residents left homes and some articles were shaken from shelves in one or two homes. Intensity IV at Arroyo Grande, Bakersfield, Huasna (about 10 miles southeast of Arroyo Grande), Los Angeles and the San Gabriel Valley, Lost Hills, Saugus, and Tehachapi. Also felt at Castaic (near), Fillmore, Jawbone Aqueduct Station, and Lancaster.

May 24: 20:08:00*. Epicenter 39°22′ north, 123°16′ west, B. VI. Calpella. Felt by all in home. Small objects and furnishings shifted. Plaster cracked. Damage slight. Motion rapid. "An earthquake . . . cracked walls and twisted doors out of line . . ."—(*BSSA, July 1953.*) At Ukiah two walls were reported cracked. Felt by many. Buildings creaked; loose objects rattled. Disturbed objects observed by few. Roaring subterranean sounds heard by few. Damage slight. Motion bumping. Intensity V at Potter Valley where windows broke and slight damage reported. Intensity IV at Hopland, Lakeport, Upper Lake, and Willits. Felt like heavy object struck building in Hopland; like an explosion in Upper Lake.

May 27: 19:51:15*. Epicenter 36.0° north, 120.5° west, near Parkfield, P. Paso Robles. IV. Felt by several in home and community. Windows rattled. Motion rapid. Very sharp, brief shock felt by several in home at San Miguel. Another shock reported felt around midnight.

May 27: 22:00 (about). Bakersfield. IV. Windows and lamp shade on floor lamp rattled.

May 27: 23:00 and 23:15. Bakersfield. IV. Noticeable quivers felt. Windows rattled later on same evening, awakening observer, after which a rocking motion was felt.

May 28: 21:00 to 21:15 (about). Bakersfield. Observer reports quivers felt during recent nights which are not noticeable unless in bed or sitting very still. (The Seismological Laboratory at Pasadena reported the seismograms at Woody showed nothing to account for the "quivers" reported from Bakersfield on May 27 and 28.)

May 31: 12:38:37*. Epicenter 35°09′ north, 118°33′ west, west of Tehachapi, P. Techachapi. IV. Felt by many. Buildings creaked; loose objects rattled. Motion jerky.

June 4: 03:40. Creston. V. Felt by and awakened many in community. Windows rattled. (No earthquake recorded at this time. The Seismological Laboratory at Pasadena reported the disturbance was probably from air waves caused by explosion fired at 03:15.)

June 9: 21:28:40*. Epicenter 37°00′ north, 119°18′ west, north of Trimmer Springs, P. Reported felt at Big Creek.

June 10: 04:10:51*. Epicenter 35°06′ north, 118°31′ west, near Tehachapi. Tehachapi. IV. Felt by most people. Buildings creaked; loose objects rattled. Motion trembling and jarring.

June 12: 09:50:00*. Epicenter 37°44′ north, 122°03′ west, B. San Francisco Bay area. IV. Press reported a sharp, brief shock was felt in the Mission District of San Francisco, while other reports came from Alameda, Atherton, Moraga, and southern Oakland. In San Francisco doorbell chimes rang. At Moraga a definite jolt was felt. Vase toppled to floor and broke. Felt like an explosion in Oakland.

June 13: 14:54:05*. Epicenter 36°46′ north, 121°17′ west, B. Hollister. Press reported a sharp, brief earthquake shook Hollister and ranch houses as far away as five miles.

June 13: 20:17:28*. (main shock). Epicenter 32°50′ north, 115°40′ west, near Imperial, P. Felt over an area of approximately 4800 square miles. (See map, page 16.) Maximum intensity VII occurred in a very limited area in the Brawley-Westmorland region. Press reported some damage occurred to the Thistle Lateral Canal (3 miles south of Westmorland) where one of the canal structures was damaged and a half mile of canal bank cracked. Tokay Canal near the Dahm Ranch was cracked and there was considerable settlement of the ground. A landslide along Tamarack Road near the New River Bridge blocked off the road for several hours. Strongest aftershocks on the 14th were recorded at 20:28:56*, 20:29:58* (largest), and 20:51:52*.

INTENSITY VII:

Brawley (about 6 miles west of).—J. E. Harshman Ranch. Felt by and frightened all in vicinity. Plaster and ground cracked. Refrigerator, beds, chests, etc., moved six inches east and two to four inches south. Dishes broke. Knickknacks, books, and pictures fell. Damage slight to wood, brick, masonry, and concrete. Vertical motion. "Two more quite sharp shocks felt same evening."

Brawley (about 7 miles west of).—R. V. Moore Ranch. Felt by and frightened all in home. Trees, bushes shaken strongly. Furnishings shifted; furniture overturned. Chimneys cracked and fell. Damage considerable to brick and masonry. Motion rapid. "Have had an average of three shocks a day."

Brawley (about 7 miles west of).—Charles L. Wieman Ranch. Felt by all in community; frightened all in home. Furnishings shifted; small objects and furniture overturned. Plaster cracked and fell; books and pictures fell. China scattered and broke. Damage considerable. Motion rapid. "This was by far the most severe shock we have ever felt. It came from the north without the slightest warning, struck with terrific force and grew in intensity with a series of wrenching jerks for a minute and a half. For the first time my house, a cement stucco frame 26 x 42 feet, one and a half stories, was cracked loose from its foundation. Much plaster cracked. Bookcases toppled. Practically all furniture displaced: piano, electric stove, and refrigerator moved six inches. We immediately fled from the house. Two other severe shocks followed during the night and settling shocks have followed during the following week."

INTENSITY VI:

Brawley.—Felt by and frightened all in community. Trees, bushes shaken moderately. Small objects and furnishings shifted; small objects overturned. Knickknacks fell. Plaster cracked. Damage slight. Motion slow. Press reported two people were injured when crowds hurriedly left theater.

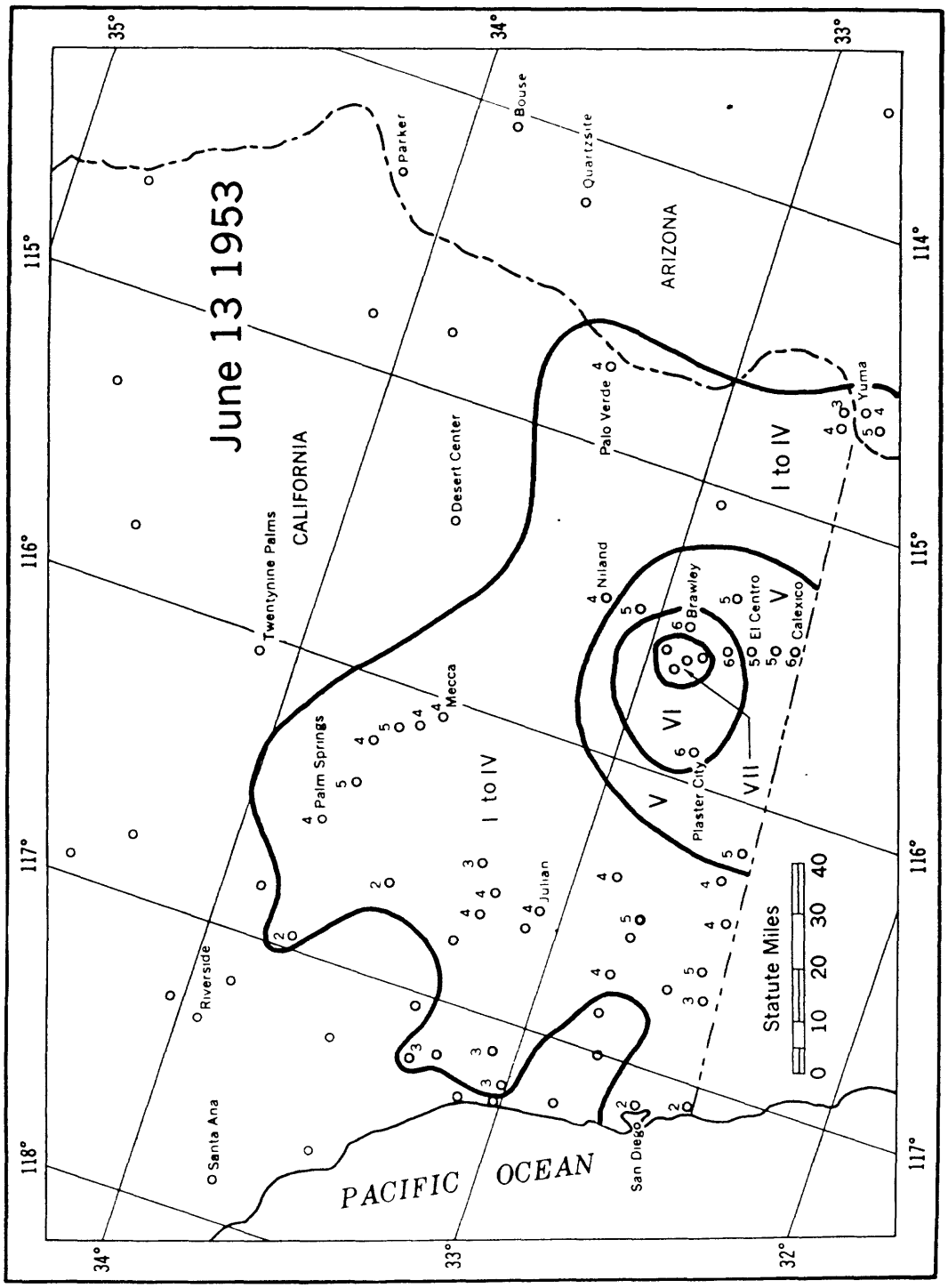

FIGURE 3.—Area affected by earthquake of June 13.

Calexico.—Felt by all and frightened many in community. Pendulum clock stopped. Small objects and furnishings shifted. Motion slow.

Imperial.—Felt by all and frightened many in community. Trees, bushes shaken strongly. Small objects and furnishings shifted; small objects overturned. Knickknacks, books, pictures, and plaster fell. Motion rapid, two sharp jerks.

Plaster City.—Felt by all and frightened many in community. Trees, and bushes shaken moderately. Small objects shifted. Motion slow.

Tamarack Ranch area.—Press reported a steady series of shocks felt in this area over the weekend. Glassware broke, lamps overturned, and houses shook strongly.

INTENSITY V: Calipatria, Coachella Valley, El Centro, Heber, Holtville, Jacumba, Pine Valley, Potrero, and Rancho Mirage.

INTENSITY V IN ARIZONA: Somerton.

INTENSITY IV: Alpine, Bard, Campo, Hipass, Indio, Julian (east of, in Mason Valley), Mecca, Mesa Grande, Mount Laguna, Niland, Palm Springs, Palo Verde, San Ysidro, Thermal, and Warner Springs.

INTENSITY IV IN ARIZONA: Yuma.

INTENSITY I TO III: Anza, Escondido, Fallbrook, Ranchita, Rancho Santa Fe, San Diego, San Jacinto, Tecate, and Winterhaven.

June 13: 20:29:58*. Aftershock of June 13. El Centro. V. Felt by all in community; frightened few. Hanging objects swung E–W. Motion slow. Very light shock felt at 20:51:52*.

June 14: 23:22:14*. Epicenter 35°10′ north, 118°37′ west, north of Cummings Valley, P. Tehachapi. IV. Felt by most people. Buildings creaked; loose objects rattled. Sharp shaking, abrupt onset. Moderately loud subterranean sounds, like heavy truck motor, heard before shock.

June 14: 09:28:29*. Epicenter 33°03′ north, 117°18′ west, near Encinitas, P. Observer stated shock of about intensity IV felt at Alpine. Very slight and brief at Poway.

June 14, 15, 16, 17, 18: Aftershocks of June 13 with epicenters at 32°50′ north, 115°40′ west. Many aftershocks from this epicenter. Among the largest were June 16, 05:03:56*; June 18, 23:51:19*; June 19, 02:01:30*, P. Brawley (about 6 miles west of). J. E. Harshman Ranch. IV. Many light shocks felt on these dates. Some rattling of windows and dishes.

June 18: 14:00 (about). Morongo Valley. IV. Felt by many in community; frightened few. Windows rattled. Motion slow. (This date may be in error and may refer to the shocks recorded on June 14 at 13:54:42* and 14:17:02*, with epicenter at 34°03′ north, 116°40′ west, west of Morongo Valley, P.)

June 19: (early morning). Aftershock of June 13; probably June 18 at 23:51:19* or June 19 at 02:01:30*. Brawley (about 6 miles west of). J. E. Harshman Ranch. IV. Awakened all in home.

June 20: 15:18:52*. Epicenter 35°22′ north, 118°30′ west, northeast of Caliente, P. Jawbone Aqueduct Station. III. Slow motion, lasted 8 seconds. Direction W–E.

June 22: 07:22:31*. Epicenter 36.0° north, 120.4° west, north of Parkfield, P. IV. Felt by several and frightened few at Coalinga. Windows, doors, and dishes rattled. Motion rapid. ". . . rattled dishes and caused buildings to creak in Paso Robles . . ."—*BSSA, October 1953.*)

June 29: 03:08:24*. Epicenter 39°43′ north, 122°23′ west, B. Orland. V. Awakened many in community. Small objects shifted. Windows rattled. Motion rapid. Intensity IV at Willows where it was felt by many. Buildings creaked; loose objects rattled. Disturbed objects observed by few. Rattling subterranean sounds heard. Motion bumping.

July 1: 14:17.3*. Epicenter 34°35′ north, 121°22′ west, off Point Arguello; location very rough, P. Point Arguello Light Station (Surf). IV. Felt by many indoors and outdoors; frightened few in home. Windows, doors, and dishes rattled. Motion rapid, jolting.

July 13: 03:00. Palmetto, Nev. (southeast of Dyer near California-Nevada border). III. Light shock, lasted 4–5 seconds. Direction S–N.

July 16: 23:15. Westport. III. Felt by observer in home. Lasted a few seconds. Motion slow.

July 20: 01:20:13*. Epicenter 33°53′ north, 117°38′ west, near Prado, P. IV. Press reported a sharp jolt awakened people from Los Angeles east to Pomona and Chino. Man in Los Angeles said his chair was shaken sharply. House creaked in Pomona. "Anyone asleep might not have felt it." Awakened and frightened few at Riverside. House creaked slightly. Mild shock. Motion swaying.

July 25: 08:13:58*. Epicenter 37°07′ north, 121°46′ west, B. IV. "An earthquake of sharp local intensity rattled windows and shook walls and ceiling fixtures in some districts of the San Francisco Bay area . . . In San Francisco the shock was felt distinctly in the Mission District, the

Marina, and North Beach, but was not felt in downtown San Francisco. It was felt as far south as San Jose . . . "—(*BSSA, October 1953.*) Felt in home and community at Pescadero.

July 28: 09:09:46*. Epicenter 35°05′ north, 119°07′ west, north of San Emigdio Ranch, P. Press reported the shock was felt near Maricopa.

July 29: 06:02:24*. Epicenter 35°21′ north, 118°32′ west, northeast of Caliente, P. "Residents of East Bakersfield and Oildale reported they felt two moderate earthquakes, one at 5:50 A. M. and the other at 6:05 A. M. . . . "—(*BSSA, October 1953*).

August 5: 04:20:59*. Epicenter 35°01′ north, 119°03′ west, near Wheeler Ridge, P. Press reported the shock as sharp at Taft and Maricopa.

August 6: 03:20:04*. Epicenter 35°03′ north, 119°08′ west, east of Maricopa, P. Cuyama (valley section). IV. Felt by many; general alarm. Buildings creaked; loose objects rattled. Very slight visible swaying of buildings and trees. Pictures swung slightly. Motion swaying. Also felt in Maricopa and Taft.

August 12: 10:33:59*. Epicenter 35°49′ north, 118°23′ west, near Kernville, P. Press reported an earthquake jolted Kernville for 10–15 seconds. Felt slightly at Bakersfield.

August 14: 20:15:41*. Epicenter 40°29′ north, 124°13′ west, B. Press reported a light earthquake jarred the Ferndale area.

August 16: 08:30:41*. Epicenter 33°05′ north, 115°40′ west, near Westmorland, P. "A slight earthquake jarred the Coachella and Imperial valleys . . . In Calipatria the jar was followed by two minor tremors."—(*BSSA, October 1953*) Reported as minor at El Centro.

August 23: 04:21:58*. Epicenter 40°29′ north, 121°45′ west, B. Mineral. V. Felt by many or all in community; awakened many. Roaring noise heard. Awakened some people at Manzanita Lake.

August 29: 18:26:26*. Epicenter 34°00′ north, 116°51′ west, north of Banning, P. Banning. IV. Felt by several in home; frightened few in community. Motion described as grinding. Felt sharply at Whitewater. Also felt at Hemet and Palm Springs.

September 3: 03:00. Shock reported felt at Creston.

September 3: 19:54:24*. Epicenter 36°02′ north, 120°17′ west, near Stone Canyon, P. IV. Felt by several in community at Creston. Windows rattled. Motion jerky. Buildings shook and windows rattled at Paso Robles.

September 4: 07:36:15*. Epicenter 35°12′ north, 118°38′ west, near Bear Mountain, P. Tehachapi. V. Felt by all. Buildings creaked; loose objects rattled. Light bumping sound heard at time of jolt. Slight trembling, increasing to heavy jolt, followed by subsiding tremors.

September 11: 22:41:16*. Epicenter 35°22′ north, 118°53′ west, near Edison, P. IV. Bakersfield area. Press reported a rolling earthquake of short duration was felt throughout the Bakersfield area. Windows shook and loose objects rattled. "A sharp earthquake jarred the Bakersfield area . . . Beds were shaken and windows and doors rattled . . . The earthquake was felt as far as Woody, northeast of Bakersfield, south to Greenfield, east to Arvin, and southwest to Taft."—(*BSSA, January 1954*).

September 12: 11:29. Tehachapi. IV. Building creaked; loose objects rattled. Bumping sounds heard with the jar. Motion vertical, then jar.

September 15: 01:45. Westport. III. Felt by observer. Lasted 3–4 seconds. Motion rapid.

September 22: 22:21:51*. Epicenter 35.7° north, 121.1° west, B. Bryson. V. Felt by all; awakened and frightened all in home. Windows and doors rattled; house creaked. Motion rapid. First shake very severe, then trembling for several seconds.

September 25: 19:34:29*. Epicenter 39.6° north, 119.8° west, W. Sharp shock felt over approximately 12,000 square miles of western Nevada and northeastern California. (See map, page 19.) Maximum intensity VI. Minor damage at Reno, Nev.

INTENSITY VI IN NEVADA:

Oilinghouse Canyon (northeast of Reno).—Press reported two people ran from a mine when a stope caved in, sending ore rattling into the main tunnel.

Reno.—Press reported two chimneys toppled, canned goods fell, and cracked plaster was reported generally throughout the northwest part of town. In a newspaper office lights swayed, pictures and framed maps were knocked askew. In the west section of town a two-story house swayed so violently electrical wires leading into the building were ripped away. There was considerable damage to plaster in the Mackay School of Mines building at the University of Nevada. Many objects were overturned in the museum. At the Weather Bureau Airport Station, in the southeast section, cracks were widened in old structures. Pendulum clock stopped. Disturbed objects observed by several.

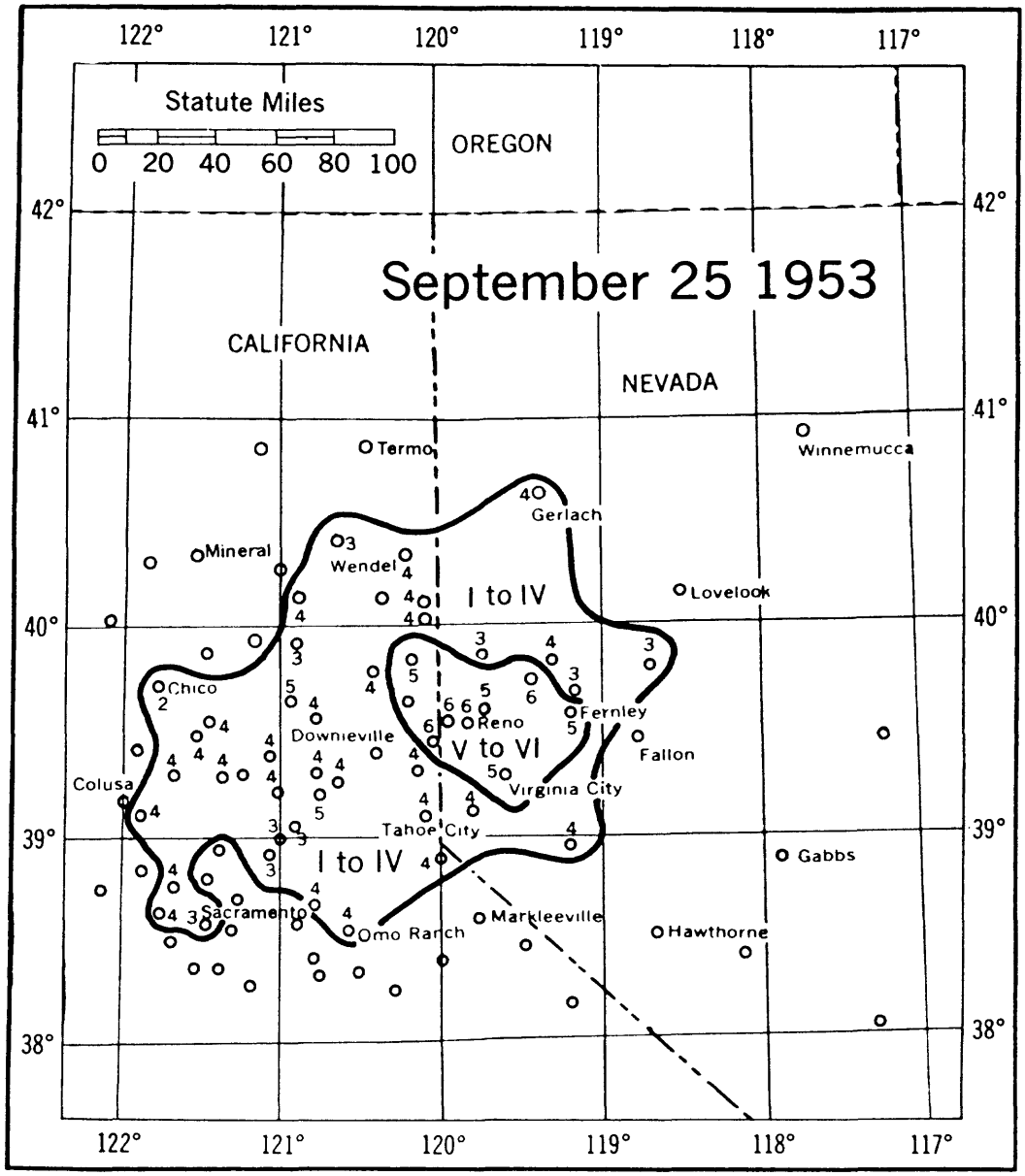

FIGURE 4.—Area affected by earthquake of September 25.

Few alarmed. Faint bumping subterranean sounds heard at time of shock and lasted about 30 seconds. Motion bumping, jarring, explosivelike. About 6 miles west of Reno on U. S. Highway 40 a small rockslide, believed to have been caused by the earthquake, covered about half of one traffic lane.

INTENSITY VI:

Floriston.—Felt by all in community. Windows and doors rattled. Plaster cracked. Motion rapid.

INTENSITY V IN NEVADA: Cinnabar Hill Ranch (south of Reno), Fernley, Sparks, and Virginia City.

INTENSITY V: Baxter, Chilcoot, and La Porte.

INTENSITY IV IN NEVADA: Carson City, Gabbs, Gerlach, Nixon, and Yerington.

INTENSITY IV: Browns Valley, Camptonville, Downieville, Doyle, Forbestown, Greenville, Gridley, Herlong, Knights Landing, Lake Spaulding (Emigrant Gap), Meridian, Meyers, Nevada City, Omo Ranch, Oroville, Placerville, Portola, Tahoe City, Truckee, Washington, Wendel, and Woodland.

INTENSITY I TO III IN NEVADA: Perrin, Pyramid, Verdi, and Wadsworth.

INTENSITY I TO III: Auburn, Bijou, Chico, Colfax, College City, Deer Creek (PG&E), Quincy, Sacramento, Sierraville, and Susanville.

September 30: 19:56:15*. Epicenter 35.3° north, 121.6° west, B. Big Sur. IV. Felt by many in community; frightened few. One very pronounced brief explosivelike jolt immediately preceded by a loud noise like thunder.

October 7: 06:59:21*. Epicenter 35°02′ north, 118°51′ west, west of Tejon Ranch, P. V. Frightened all in community at Wheeler Ridge. Windows, doors, and dishes rattled; house creaked. Small objects shifted and overturned. Motion rapid. Felt by all in camp seven miles south of Tehachapi; some alarm. Rattling of loose objects and creaking of houses heard by most everyone. Roaring subterranean sounds heard by most everyone at time of shock. Gradual onset. Intensity IV at Arvin, Bakersfield, Glendale, and Shafter. Also reported felt at Cactus Peak (Coso Range).

October 8: 04:00. Tehachapi (7 miles south of, in mountain camp). III. Felt by several. One jerk, lasting about 1 second.

October 8: 15:40:46*. Epicenter 40°19′ north, 124°25′ west, B. Ferndale. Reported as light, local shock.

October 10: 10:49.1*. Epicenter 31.8° north, 116.1° west, Baja California, P. Point Loma (San Diego). V. Felt by several. Pendulum clock stopped at Spanish Lighthouse. Lasted about 45 seconds. Motion rapid.

October 12: 11:35. Reno, Nev. "A slight earthquake was felt by a few persons . . ."—(*BSSA, January 1954*).

October 13: 10:41:03*. Epicenter 35°36′ north, 118°32′ west, west of Bodfish, P. Bodfish (Borel Powerhouse). V. Felt by all and frightened few in community. Alarm signal on oil level in large transformer bank operated. Windows and doors rattled; house creaked. Motion rapid. About 12 shocks felt in 15 minutes. Also felt strongly 12 miles north of Bodfish.

October 16: 11:53:59*. Epicenter 35°00′ north, 118°32′ west, near White Oak Lodge, P. Tehachapi. IV. Felt by most people. House creaked; loose objects rattled. Gradual onset. Moderately loud roaring subterranean sounds heard during shock.

October 21: 08:02:38*. Epicenter 34°19′ north, 119°42′ west, off Santa Barbara, P. Santa Barbara and vicinity. V. Generally felt in the Santa Barbara area. In the west section of Santa Barbara ornaments fell from shelf. Big chart on wall was partially knocked off wall. Thunderous explosivelike subterranean sounds heard by several before shock. Press reported a beer stein fell from shelf and broke. A pane of glass in a French door on El Arco Drive was cracked. Coffee splashed from cups. Hard, rolling motion. Intensity IV at Goleta, Los Prietos Ranger Station (about 22 miles northeast of Santa Barbara). Also felt at Agoura, Fillmore, Port Hueneme, and Ventura.

October 25: 21:00 (about). Slight shock felt 7 miles south of Hollister.

October 26: 07:50:57*. Epicenter 36°52′ north, 121°37′ west, B. Hollister (7 miles south of). IV. Felt by several in home. Windows and doors rattled. Motion slow.

October 29: 15:58:46*. Epicenter 36°47′ north, 121°21′ west, B. Hollister (7 miles south of). IV. Felt by several in home. Windows rattled; walls creaked. Motion slow.

October 29: 23:35:45*. Epicenter 37°38′ north, 118°18′ west, White Mountains, P. Yosemite National Park (Yosemite Village). IV. Felt by and awakened several. Windows rattled; bed shook. Also felt at Big Creek and Florence Lake powerhouses.

October 30: (no time given). Fresno. "A sharp earthquake was felt in Vermillion Valley . . ."—(*BSSA, January 1954.*)

November 4: 03:56. Bakersfield. III. Felt by observer in home. Continuous hammering motion, lasted 20–30 seconds. (Observer's time may be in error. A shock was recorded at 05:19:35* with epicenter at 35°07′ north, 118°40′ west, west of Cummings Valley, P.)

November 4: 07:31:02*. Epicenter 33°57′ north, 117°20′ west, near Riverside, P. Reported felt at Riverside and Colton.

November 5: 04:40:31*. Epicenter 35°08′ north, 118°39′ west, Cummings Valley, P. Tehachapi. IV. Felt by many. Rattling of loose objects and creaking of buildings heard by many. Hard jolt, abrupt onset.

November 5: 18:07. Tehachapi. Light tremor, lasted 1 second.

November 11: 13:52:26*. Epicenter 35°07′ north, 118°32′ west, west of Tehachapi, P. Tehachapi. IV. Felt by many. Rattling of loose objects and creaking of buildings heard by many. Subterranean sounds heard by some people west of town. Motion bumping.

November 12: 10:32:09*. Epicenter 35°35′ north, 118°28′ west, east of Bodfish, P. Bodfish. V. Felt by all. Walls creaked. Quite severe. Felt like a heavy blast. Some people said they felt a shock during the night. Felt by all at the Borel Powerhouse; frightened few in home. Caused alarms to operate in powerhouse. Cracks in walls appeared larger. Trees, bushes shaken slightly. Windows, doors, and dishes rattled; walls creaked. Subterranean sounds like rocks cracking and rolling heard.

November 19: 21:18. "A minor earthquake shook East Oakland and San Leandro . . ."—(*BSSA, January 1954.*)

November 21: 00:05 to 01:52. A series of dull thuds were reported in the areas from Mount Helix to Descanso.

November 23: 05:39:07*. Epicenter 33°06′ north, 116°27′ west, east of Julian, P. V. Awakened many and frightened few in Julian. Windows, doors, and dishes rattled; house creaked. Motion rapid. Sharp shock awakened many in Lakeside. Intensity IV at Borego Springs (Ensign Ranch), Fallbrook (4 miles south of), Hemet, San Diego, and from Mount Helix to Descanso. Intensity III at Warner Springs.

November 23: 12:39:01*. Epicenter 35°28′ north, 118°27′ west, near Havilah, P. Bodfish (Borel Powerhouse). V. Felt by many and frightened few in community. Windows and doors rattled; house creaked. Set off level alarms in large transformer bank. Rapid shaking ended with violent up-and-down movement. Intensity IV at Cantil and Tehachapi. Also felt on Bear Mountain (Kern County), Coso Junction, Kernville, 12 and 18 miles north of Bodfish, and 40 miles northwest of Bodfish.

November 23: 21:46:06*. Epicenter 35°53′ north, 116°58′ west, near Needle Peak, Panamint Range, P. Tecopa. IV. Felt by many in community. Windows, doors, and dishes rattled; house creaked. Trees, bushes shaken slightly. Motion slow.

November 25: 20:30. Oakland, 930 East 14th St. III. Felt by and frightened observer in home. North-south motion, lasted 1 minute.

November 26: 06:30:52*. Epicenter 38°45′ north, 119°45′ west, B. Markleeville. IV. Felt by several in home; awakened few. Sharp jerk.

November 26: 08:19:13*. Epicenter 35°19′ north, 118°32′ west, east of Caliente, P. IV. Windows, doors, and dishes rattled at the Kern Canyon Powerhouse (PG&E). Very decided shock. Felt by many at Tehachapi where buildings creaked and loose objects rattled. Slight tremble, abrupt onset. Also felt at Bakersfield.

November 29: 23:22:54*. Epicenter 35°20′ north, 118°31′ west, east of Caliente, P. IV. Felt sharply at Woody where people were awakened.

December 3: 16:22:51*. Epicenter 35°45′ north, 118°13′ west, north of Onyx, P. Kernville. "A sharp, short earthquake was felt . . ."—(*BSSA, January 1954.*)

December 3: 18:55 and 20:46. Oakland, 930 East 14th St. IV. Felt by observer in home and by one other person. House creaked. Prolonged quiver felt between the two shocks.

December 9: 03:53:53*. Epicenter 34°01′ north. 116°18′ west, southwest of Twentynine Palms, P. Palm Springs. "A light earthquake was felt . . ."—(*BSSA, January 1954.*)

December 9: 22:30 (about). Oakland, 930 East 14th St. IV. Slight quivering. Walls creaked.

December 10: 11:33. Oakland, 930 East 14th St. IV. Observer sitting in chair felt slight northwest shove. House creaked.

December 15: 04:44:36*. Epicenter 35°13′ north, 118°49′ west, near Arvin, P. Arvin. V. Felt by all in community. Small objects overturned, knicknacks fell, and dishes broke. One sharp horizontal motion. Felt by observer in home at Bakersfield where house creaked. Motion rapid. Also felt in the Lamont-Weedpatch areas, Jawbone Aqueduct Station, Kern Steam Plant near Bakersfield (PG&E), Maricopa, and Woody. ". . . The first shock was said to have been a sharp one, followed by a weaving motion. A rumbling sound preceding the earthquake was heard by some persons . . ."—(*BSSA, January 1954.*)

December 15: 16:04:26*. Epicenter 36°55′ north, 121°39′ west, B. Aptos. IV. Felt by many in post office. Windows and doors rattled. Motion rapid. Sharp shocks felt at Gilroy, according to the press. Intensity III at Los Gatos and Moss Landing.

December 16: 02:54:22*. Epicenter 36°33′ north, 121°24′ west, B. Hollister and 7 miles south of. V. Felt by and awakened many in community. Windows, doors, and dishes rattled; house creaked. Motion rapid.

December 16: 04:10. Gualala (6½ miles north of). III. Light shock noticed only by few persons who were awake. Motion rapid.

December 16: 15:09:39*, 20:50:30*, 21:13:12* (main shock), 21: 39:41*, 22:54:27*. Epicenter 36°55′ north, 121°40′ west, B.

15:09:39*: IV. Windows, doors, and dishes rattled at Glenwood. Motion slow. Frightened all in home at Moss Landing. Motion rapid. Press reported windows rattled in the Mission District in San Francisco and windows rattled in South San Francisco. A number of people in Santa Cruz felt a mild rolling shock and movement was described as slight in Watsonville, according to the press.

20:50:30*: IV. Felt by many in community and frightened few 7 miles south of Hollister. Windows, doors, and dishes rattled; house creaked. Motion rapid. Felt by and frightened all in home at Moss Landing. Windows and doors rattled. Motion rapid. Felt by many in home at San Juan Bautista. Walls creaked. Also felt at Milpitas, Santa Cruz, and Watsonville.

21:03. Felt by nearly all at Hollister.

21:13:12* (main shock). Felt over an area of approximately 3500 square miles. (See map, page 23.) Maximum intensity VI.

INTENSITY VI:

Chittenden Pass Road, between Chittenden Junction and Watsonville.—Press reported boulders were strewn on the road some five miles west of Chittenden Junction.

Watsonville.—Felt by many in homes and office; frightened few. Windows and doors rattled; house creaked. Small objects shifted. Trees, bushes shaken moderately. Damage slight. Motion rapid. Press reported the shock was strong enough to rock concrete buildings.

INTENSITY V: Alviso, Chualar Canyon, Gilroy, Hollister, Los Gatos, Mount Hermon, and Santa Cruz.

INTENSITY IV: Aptos, Ben Lomond, Castroville, Glenwood, Half Moon Bay, Hayward, Morgan Hill, Moss Landing, Oakland, Palo Alto, Redwood City, San Francisco, San Martin, and South San Francisco.

INTENSITY I TO III: Alameda, Bolinas, Concord, Coyote, Pescadero, Stinson Beach, Soledad (near), Sunol, and Tres Pinos.

December 16: 21:39:41*. Aftershock of December 16. IV. Felt by many in community and awakened many in home 7 miles south of Hollister. Windows, doors, and dishes rattled; house creaked. Motion rapid and slow. Felt by and frightened all in home at Moss Landing. Windows, doors, and dishes rattled. Motion rapid. Also felt at Moss Landing Steam Plant (PG&E).

December 16: 22:54:27*. Aftershock of December 16. Slight, brief shock felt at Moss Landing Steam Plant (PG&E).

December 20: 22:37:39*. Epicenter 39.4° north, 123.1° west, B. Willits. IV. Felt by several in home; awakened and frightened few. Windows and doors rattled; house creaked. Motion rapid. Lighter shock felt at 22:46.

December 21: 01:30. Willits. III. Felt by few.

December 21: 05:00. Laws. IV. Felt by several in home and community; frightened few. Hard jolt with rumbling sounds.

December 21: 13:15. Oakland, 930 East 14th St. IV. Heavy up-and-down quivering awakened observer. Lasted 1 minute.

December 22: 19:42.3*. Epicenter 37.5° north, 118.0° west, east of Bishop, P. Laws. IV. Felt by several in home. Walls creaked. Described as blastlike with rumble before jolt.

December 22: 20:01. Oakland, 930 East 14th St. III. Slight quivering, lasted 3–4 minutes.

December 23: 05:23:56* and 05:25:50*. Epicenter 32°02′ north, 118°20′ west, north of Inglewood, P. IV. Felt by many and some alarmed at the Los Angeles Airport Weather Bureau Station. Motion trembling, gradual onset. Press reported some residents were alarmed in the West Los Angeles, Culver City, South Bay, and Playa del Rey areas.

December 25: 15:43:40*. Epicenter 32°02′ north, 118°20′ west, north of Inglewood, P. IV. Press reported a short, sharp earthquake jolted the Redondo, Hermosa, Manhattan, and Palos Verdes beach areas. Also felt at the Los Angeles Airport Weather Bureau Station. Motion bumping.

December 27: 17:32:42*. Epicenter 36°54′ north, 121°37′ west, B. IV. Felt by many in community at Hollister. Felt by many in home and community 7 miles south of Hollister. Windows, doors, and dishes rattled; house creaked. Motion rapid. Windows rattled at Gilroy. Motion slow.

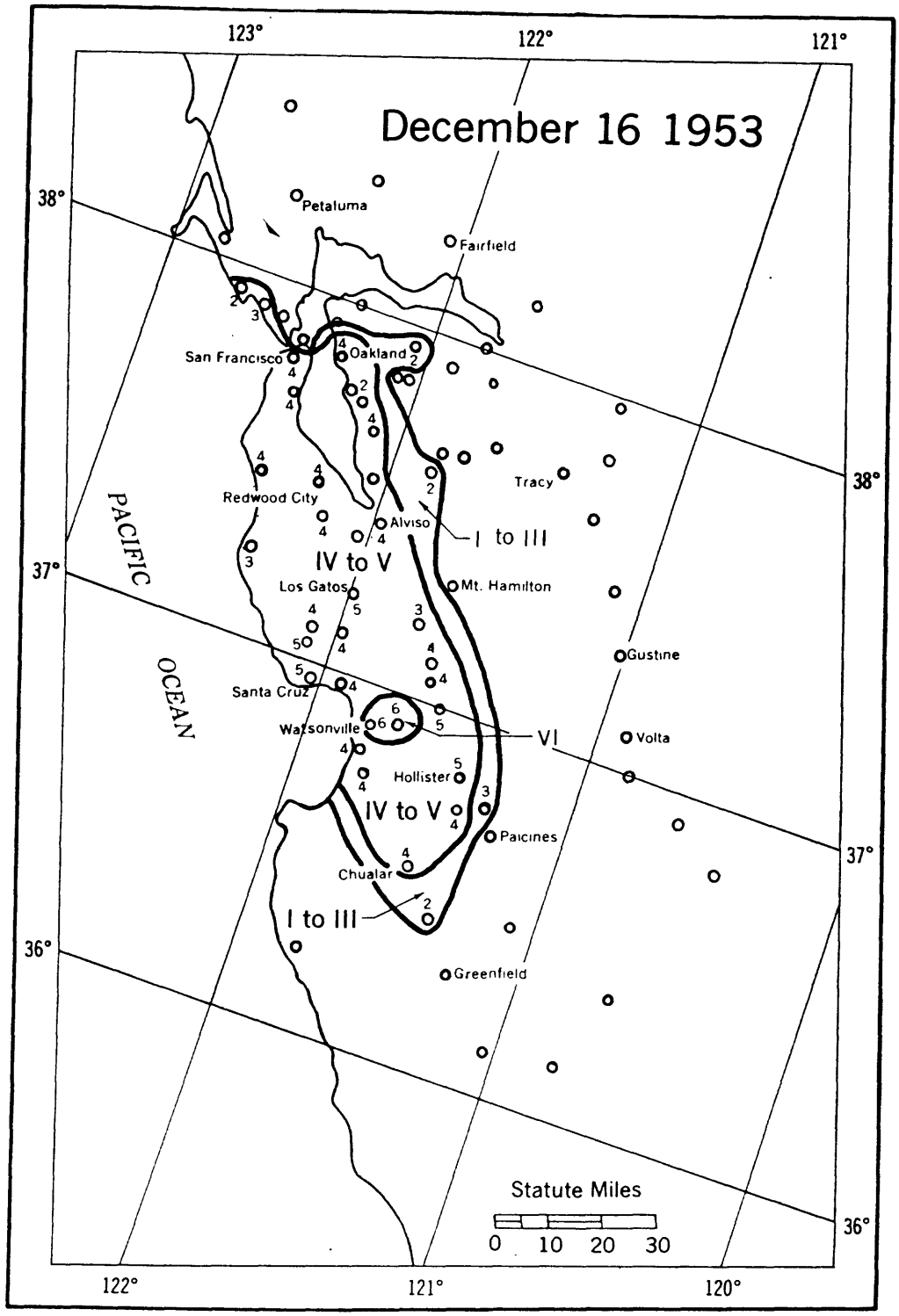

FIGURE 5.—Area affected by earthquake of December 16.

Also felt at Moss Landing Steam Plant. Press reported the shock was felt mildly in the San Francisco Bay area.

December 29: 03:46. Tehachapi. IV. Buildings creaked. Low, rumbling subterranean sounds heard before and at time of shock. Gradual onset.

WASHINGTON AND OREGON

(120TH MERIDIAN OR PACIFIC STANDARD TIME)

February 24: 11:39:05*. Epicenter very near Seattle, Wash., according to the University of Washington. IV. Press reported the earthquake as light, but felt generally throughout Seattle. Some reported dishes rattled. Building creaked and loose objects rattled at the Federal Office Building. Felt by many at the Seattle-Tacoma Airport, 15 miles south of Seattle. All reported swaying motion.

April 10: 03:07. Grays Harbor, Wash. IV. Awakened several. Felt like a heavy logging truck passed. Epicenter estimated 75 miles west of Seattle according to the University of Washington. Felt in Aberdeen from a slight to sharp jolt, in Hoquiam with a duration of a second or two, Junction City, and Willapa Bay (Coast Guard Station).

April 27: 07:30. Packwood, Wash. III. Slight shock felt by few.

May 26: 23:33. Sedro-Woolley, Wash. (about 15 miles northwest of). IV. Felt by observer. Dishes and stove rattled. Hanging gasoline lamp swung west-east.

July 11: 00:15. Seattle, Wash. Slight shock.

November 4: 13:59. Corvallis, Oreg. Number of residents reported feeling a strong but brief shock.

December 15: 20:32:12* (recorded time at Corvallis, Oreg.). Felt over an area of approximately 3,000 square miles in northwestern Oregon and across the Columbia River at a few localities in Washington. (See map, page 25.) Maximum intensity VI.

INTENSITY VI IN OREGON:

Portland.—Felt generally over the Portland area; frightened many. Some reports of plaster cracking, dishes and other objects falling, and shifting of small objects and furnishings. One report of cracked chimney and slight damage to fireplace tile. It was reported a 1-story building, facing on Broadway and abutting the Ambassador Apartments (SW. 6th Ave.) in the rear, was cracked away from the juncture. Leak developed in apartment building. Some said it felt like a strong nearby explosion; others said it felt as if a very heavy object had hit the house. Many reported a rumbling sound.

Roy.—Felt by all and frightened many. Plaster cracked. Knickknacks fell.

INTENSITY VI IN WASHINGTON:

Vancouver.—Felt by and frightened many in community. Slight damage to commercial buildings of block and concrete. Plaster cracked. Motion rapid.

INTENSITY V IN OREGON: Beaverton, Canby, Clatskanie, Hillsboro, McMinnville, and Mill City.

INTENSITY IV IN OREGON: Aurora, Buxton, Carlton, Forest Grove, Milwaukie (1 mile south of), Multnomah (near), Newberg, Oak Grove, Oregon City, Oswego, Tigard, Troutdale, and Woodburn.

INTENSITY IV IN WASHINGTON: Battle Ground and Kalama.

INTENSITY I TO III IN OREGON: Amity, Molalla, Plymouth, Rex, Saint Helena, and Salem.

Also reported felt at the following places (no details given): Dundee (¼ mile west of Red Hills), Gable (4 miles south of), Mill City, Oswego Lake (about 1 mile north and east of), Vernonia, and Williamette.

INTENSITY I TO III IN WASHINGTON: Kelso (6 miles north of).

ALASKA

(150TH MERIDIAN OR ALASKA STANDARD TIME)

January 11: 00:56. Northway. Felt by several. Lasted only a second. Light fixtures swayed gently. Pendulum clock swung north to south.

January 16: 05:55 (a. m. or p. m.) Lost River. Felt by several. Motion rapid and abrupt. Walls and frame creaked.

January 16: 20:45. Lost River. Felt by several. Lasted three or four seconds. Motion slow and beginning abrupt.

January 28: 15:20. Lost River. Felt by several. Lasted two seconds. Motion slow and beginning gradual.

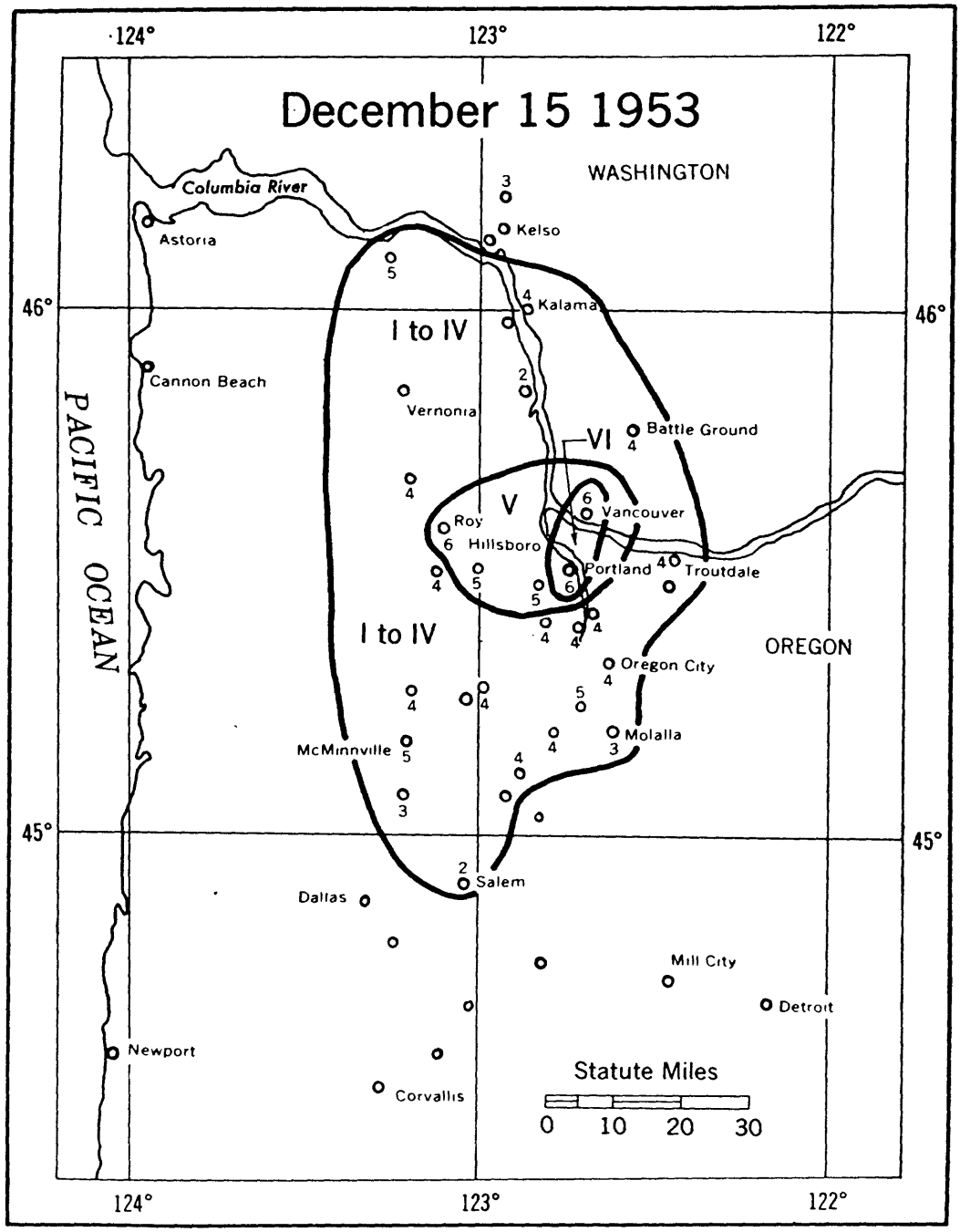

FIGURE 6.—Area affected by earthquake of December 15.

January 29: 19:32. Lost River. Felt by several. Lasted two seconds. Motion slow and beginning gradual.

February 5: 05:05. Lost River. Felt by and awakened many.

February 13: 17:40. Teller. Felt. Lasted four or five seconds.

February 18: 16:50. Anchorage. IV. Felt by many at Weather Bureau Office where bookcase swayed against wall and several other objects were disturbed. Felt by several at Merrill Field, Anchorage and also in Eklutna and Whittier.

Feburary 19: 06:25. Eklutna. Felt.

February 21: 20:20. Teller. Felt.

March 5: 20:57:26*. Epicenter 58½° north, 156½° west. Alaska Peninsula. W. Felt slightly at Homer (5 miles northwest of) and Kasilof.

March 16: 20:00. Homer. Slight shock.

April 9: 21:45. Teller. Slight shock.

April 10: 14:45. Teller. Slight shock.

April 13: 04:15. Seward. Slight shock.

April 19: 12:47:39*. Epicenter 50½° north, 179° West. W. Felt on Adak.

April 21: 22:05. Valdez. Slight shock.

April 25: 06:46:49*. Adak. Felt.

May 5: 01:30. Kagalaska Strait. Felt by personnel of Coast and Geodetic Survey ship, Pathfinder.

May 7: 22:38. Kagalaska Strait. Felt by personnel of Coast and Geodetic Survey ship, Pathfinder.

May 12: 02:39:02*. Epicenter in Andreanof Islands. Felt on Adak and Great Sitkin. Reported by Coast and Geodetic Survey ship, Pioneer. "It sounded as if the ship's hull had been struck a hard blow throughout its length and the bay appeared to be churned-up. The surface was covered with foam or white-water to the limit of visibility." Felt by several on Shemya Island. Motion was bumping then trembling in westerly direction.

May 14: 23:37:03*. Epicenter in Andreanof Islands. Felt on Adak.

May 19: 23:48:12*. Adak. Felt.

May 20: 16:15. Seward. Slight shock.

May 23: 05:00. Teller. Slight shock.

May 27: 19:00 and 20:35. Homer. Slight shocks.

June 9: 12:25. Valdez. Felt.

June 9: 14:37. Fairbanks. Buildings shook perceptibly.

June 19: 22:30. Whittier. Felt.

June 20: 03:30. Homer (5 miles northwest of). Slight shock.

June 27: 13:30. Seward. Slight shock.

July 4: 16:18:44*. Epicenter 51° north 178½° west. Andreanof Islands. W. Felt on Adak.

July 17: 12:10. Near Wonder Lake. Two slight tremors were felt on the south side of the McKinley River opposite Wonder Lake at a camp three miles east in the river basin. The shocks were of momentary duration and were only an instant apart. The tremor caused a five gallon can setting on the floor to pass through an arc of one to one and one-half inches and felt like a truck riding over a washboard road at 20 miles per hour. The tent trembled as in a gusty wind. A low rumble from the direction of Mt. McKinley was heard immediately after the second tremor. At McKinley Park, the tremor caused on the side of Mt. Brooks at 8500 feet elevation an avalanche which moved tons of basic lava rock and clay (loosened by heavy rainstorms) and formed a new lake 55 miles from the Park.

July 19: 23:47:19*. Adak. Felt.

July 23: 00:54:55*. Epicenter on Andreanof Islands. W. Felt strongly on Adak.

July 26: 12:04. Valdez. Slight shock.

July 31: 07:45. Seward. Short sharp tremor.

August 28: 00:51. Northway. Felt by several. Light fixtures swayed slightly.

September 12: 22:35. Caswell. Slight shock.

September 20: 21:13. Homer (5 miles northwest of). Slight shock.

September 22: 10:20. Valdez. Slight. Duration five seconds.

September 27: 15:55. Thompson Pass. Slight. Duration ten seconds.

September 28: 05:55. Thompson Pass. Awakened crew. Bunkhouse and bunks shook. Duration seven seconds. Slight and duration ten seconds at Valdez.

October 7: 06:00 and 09:00. Slight shocks.

October 8: 18:14. Kasilof and Seward. Slight shock.
October 13: 20:30. Homer (5 miles northwest of). Slight shock.
October 15: 11:47. Homer (5 miles northwest of). Slight shock.
October 22: 19:27. Homer (5 miles northwest of). Slight shock.
December 4: 10:00. Valdez. Slight shock. Duration two seconds.
December 15: 13:00. Valdez. Slight shock. Duration three seconds.
December 17: 20:47. Nome. Felt by several. Light fixture swayed.
December 17: 21:47 and 22:05. Teller. Slight shocks.
December 18: 04:07. Nome. Felt by several. Light fixture swayed.

HAWAIIAN ISLANDS

(HAWAIIAN STANDARD TIME)

NOTE.—Data on the following local disturbances were determined from seismograph stations operated on the island of Hawaii by the Hawaiian Volcano Observatory of the Geological Survey. "Felt locally" appearing in the summary means in the vicinity of the observatory. For additional information, see the *Volcano Letter*, Nos. 519–522.

January 3: 11:31. Epicenter 19°28′ north, 155°52′ west, central Kona, near Keei on Kealakekua. Feeble. Felt strongly in Kona.

January 3: 11:34. Very feeble. Kona aftershock. Felt in Kona.

January 7: 15:58. Very feeble. Felt at Kona.

January 8: 11:23 and 11:32. Kalahea, Kauai. Felt by several. Sounds heard by many. Windows rattled.

January 9: 09:09. Epicenter 19°21′ north, 155°31′ west, Naalehu, Kona. Felt at Kapapala.

January 9: 16:05. Very feeble. Felt at Kapapala.

January 9: 16:42. Felt in Kona. Origin central Kona.

January 9: 21:10. Epicenter 19°24′ north, 155°33′ west, southeast slope of Mauna Loa. Strong. Felt strongly over southern half of island from Hilo to Kona, and slightly as far away as Oahu.

January 13: 07:29. Very feeble. Felt quite strongly at Kapapala.

January 15: 02:05. Epicenter 19°19′ north, 155°26′ west, about 15 miles deep, southeast slope of Mauna Loa. Strong. Felt strongly on southern half of island from Hilo to Kona and slightly on Oahu.

January 15: 07:30. Tremor. Felt in Kona. Origin central Kona.

January 23: 14:18. Felt in Kona. Origin central Kona.

February 12: 06:45. Epicenter 19°17′ north, 155°27′ west, Kaoiki fault near Kapapala. Very feeble. Felt strongly at Kapapala, intensity about IV.

February 22: 02:40. Slight. Felt in Volcano district. Origin Kaoiki fault between Bird Park and Ohaikea.

March 6: 07:48. Very feeble. Felt in central Kona. Origin Kealakekua fault.

March 6: 14:26. Very feeble. Felt in central Kona, Naalehu, and Kapapala. Origin beneath summit area of Hualalai Volcano, about 30 miles deep.

March 23: 21:19. Very feeble. Felt in south Kona. Origin west slope of Mauna Loa.

March 25: 18:19. Epicenter 19°12′ north, 155°39′ west, south slope of Mauna Loa. Moderate. Felt strongly at Naalehu and Kapapala and slightly over most of the island.

March 26: 01:40. Epicenter 19°08′ north, 155°35′ west, south slope of Mauna Loa. Very feeble. Felt moderately at Naalehu and slightly as far as central Kona.

March 27: 22:30. Felt in Kona. Origin central Kona.

April 10: 11:09. Feeble. Felt in Volcano district. Origin northeast slope of Mauna Loa.

April 14: 02:20. Tremor. Felt in Kona. Origin central Kona.

April 24: 01:42. Epicenter 19°20′ north, 155°47′ west, southeast slope of Mauna Loa. Feeble. Felt in Volcano district, south Kona, and Kohala.

May 19: 18:02. Tremor. Felt in south Kona.

May 22: 23:22. Very feeble. Felt in central Kona. Origin Kealakekua fault(?).

May 24: 02:05. Slight. Felt in Volcano district. Origin Kilauea.

May 24: 02:44. Epicenter 19°26′ north, 155°27′ west, east slope of Mauna Loa. Moderate. Felt over much of Hawaii Island as far north as Kukuihaele.

May 25: 10:17. Tremor. Felt in south Kona.

May 26: 06:26. Feeble. Felt at Naalehu.

May 27: 19:33. Tremor. Felt at Kapapala.

May 29: 04:59. Epicenter 19°29′ north, 155°56′ west, Kealakekua Bay. Slight. Felt in central and south Kona, Naalehu, and Volcano district.

June 4: 18:48. Very feeble. Felt fairly strongly at Kapapala. Origin southeast slope of Mauna Loa near Kapapala.

June 9: 00:49. Slight. Felt in Hilo. Origin Kilauea(?).

June 15: 20:34. Epicenter 19°29′ north, 155°14′ west, northeast slope of Mauna Loa. Feeble. Felt in Hilo and Volcano district.

June 27: 10:47. Epicenter 19°31′ north, 155°23′ west, east slope of Mauna Loa. Moderate. Felt in Volcano district.

July 15: 04:59. Very feeble. Felt at Kapapala.

July 26: 10:18. Felt in central Kona.

July 26: 13:52. Tremor. Felt in central Kona and at Hawi.

July 28: 22:24. Tremor. Felt in central Kona. Origin central Kona.

August 1: 06:48. Epicenter 19°20′ north, 155°21′ west, southwest rift of Kilauea. Very feeble. Felt at Pahala.

August 4: 17:20. Epicenter 19°20′ north, 155°23′ west, southwest rift of Kilauea. Very feeble. Felt at Kapapala, strong; Volcano and Naalehu, slight.

August 6: 00:47. Epicenter 19°22′ north, 155°21′ west, southwest rift of Kilauea. Very feeble. Felt at Kapapala.

August 8: 03:00. Very feeble. Felt strongly in central Kona.

August 21: 19:47. Slight. Felt strongly on Mauna Loa, Kona, and Hilo. Felt throughout Hawaii as far away as Honolulu. Felt on Maui, generally weakly, but strong in Haleakula Crater.

August 21: 21:07. Very feeble. Felt in Kona.

August 23: 00:53. Strong. Felt in Kona, strong; at Naalehu and Kapapala, moderate; Volcano, slight.

August 24: 23:05. Felt strongly in central Kona. Origin central Kona.

September 3: 04:42. Very feeble. Felt at Hawaii National Park. Origin Kilauea.

September 23: 14:50. Very feeble. Felt in central Kona. Origin central Kona.

September 27: 13:20. Felt in central Kona.

October 2: 22:06. Felt in Captain Cook. Origin central Kona.

October 8: 09:22. Feeble. Felt in central Kona. Origin nine miles east of Hainoa Crater on Hualalai.

October 9: 06:16. Very feeble. Felt at Kukuihaele. Origin Kohala.

October 9: 21:53. Tremor. Felt at Pahala. Origin Mauna Loa.

October 15: 17:10. Very feeble. Felt in Captain Cook. Origin central Kona.

October 22: 14:02. Very feeble. Felt at Pepeekeo. Origin east flank of Mauna Kea.

October 27: 01:07. Strong. Felt at Volcano. Origin east rift of Kilauea south of Aloi Crater near Ainahou.

October 27: 03:37. Strong. Felt at Volcano. Origin east rift of Kilauea south of Makaopuhi Crater.

October 27: 04:30. Strong. Felt at Volcano. Origin east rift of Kilauea near Alae Crater.

October 27: 08:02. Very feeble. Felt at Naalehu. Origin southwest rift of Mauna Loa near Alika Cone.

October 28: 15:50. Very feeble. Felt at Kapapala. Origin Hilina Pali.

October 28: 17:03. Very feeble. Felt at Kapapala. Origin southwest rift of Kilauea near Ponohohoa Chasms.

October 28: 21:15. Very feeble. Felt at Kapapala. Origin south flank of Mauna Loa.

October 28: 22:58. Very feeble. Felt at Volcano. Origin east rift of Kilauea near Aloi Crater.

October 31: 06:08. Tremor. Felt in north Kona and north Kohala. Origin north flank of Hualalai.

November 22: 21:32. Moderate. Felt in Hawaii National Park and at Volcano. Origin Kilauea caldera.

November 28: 15:38. Moderate. Felt in Hawaii National Park. Origin near Kilauea caldera.

November 29: 19:44. Moderate. Felt in Hawaii National Park. Origin near Kilauea caldera.

November 29: 20:43. Strong. Felt from Hawaii National Park to Hilo. Origin east rift of Kilauea near Napau Crater.

November 30: 13:04. Slight. Felt in Hawaii National Park. Origin near Kilauea caldera.

December 1: 01:56. Tremor. Felt in Hilo. Origin northeast rift of Mauna Loa.

Dcember 9: 01:13. Slight. Felt in Hawaii National Park. Origin Kilauea caldera.

December 16: 13:00. Felt in Captain Cook. Origin Kona.

PANAMA CANAL ZONE

(60TH MERIDIAN TIME)

January 20: 05:43:09*. Epicenter 9½° north, 79½° west. Panama. W. V. Awakened many in Panama City, Colon and Canal Zone.

February 7: 05:15:38*. El Volcan and Chiriqui, Panama. Felt.

March 19: 14:19:43*. Intensity II in Balboa Heights.

August 4: 07:09:49*. Intensity II in Balboa Heights.

September 1: 23:03:44*. Intensity II in Balboa Heights.

PUERTO RICO

(60TH MERIDIAN TIME)

February 21: 18:18:06*. Felt in various parts of Puerto Rico.

July 6: 16:16:58*. Felt at Ponce.

MISCELLANEOUS ACTIVITIES

GEODETIC WORK OF SEISMOLOGICAL INTEREST

The program of repeating geodetic control surveys for the purpose of detecting horizontal and vertical movement in the earth's crust was continued in 1953.

The analysis of the repeat surveys in the vicinity of Tehachapi and Bakersfield was completed. The final results indicate a maximum horizontal displacement of about two feet and vertical movement of approximately four feet.

The arc of triangulation extending from Newport Beach to Riverside, California, was reobserved in 1953. An analysis of this survey in combination with surveys made in 1929 and 1934 is in progress at the present time. There is no evidence of any sharp displacement within this area. The studies are not sufficiently advanced at this date to make any comment concerning any small systematic movement which might be disclosed by the comparison of the surveys.

At the end of the year, the triangulation party had been instructed to reobserve the primary control along the boundary between California and Mexico with the major portion of the resurvey centered about El Centro.

TIDAL DISTURBANCES OF SEISMIC ORIGIN

Four earthquakes in 1953, one in the Atlantic and three in the Pacific, produced sea waves that were recorded by Coast and Geodetic Survey tide gages. The earthquake of May 31 near the Dominican Republic with magnitude 7–7½ was recorded at the Puerto Plata tide station with amplitude of 0.2 foot. The September 4 earthquake of Fiji Islands, magnitude 6¾, caused wave amplitudes of 0.7 foot and 0.2 foot at Pago Pago and Honolulu, respectively. The Honshu, Japan, earthquake of November 25, magnitude 8¼–8½ produced wave amplitudes of 1.1 feet and 0.7 foot at Attu and Midway, respectively. The Peruvian earthquake of December 12, magnitude 7¾, produced wave amplitudes of 3.2 feet at Talara, Peru and 0.7 foot at La Libertad, Ecuador.

FLUCTUATIONS IN WELL WATER LEVELS

INTRODUCTION

The following data are tabulated for the purpose of associating fluctuations in well-water levels with earthquakes. The data are made available by the Ground Water Branch of the United States Geological Survey. Complete information on earthquakes may be obtained from the Preliminary Determination of Epicenter and Supplement cards issued by the United States Coast and Geodetic Survey or from registers of seismographic stations nearest the locality.

Similar data for 1943 were published by the United States Coast and Geodetic Survey in Serial 672, United States Earthquakes, 1943, and those for subsequent years through 1949 appeared in Serial 748, United States Earthquakes, 1949, and Serial 755, 762, and 773, United States Earthquakes, 1950, 1951, and 1952, respectively. Descriptions of wells given here include only those that have not appeared in previous editions.

WELL DESCRIPTIONS

ARIZONA

Well No. (A–18–19) 16db, artesian, 34°58′ N., 110°20′ W., NW¼SE¼ Sec. 16, T. 18 N., R. 19 E. Owner, Aiken Smith. Depth, 325 feet; diameter, 6 inches; finish, open hole. Aquifer, Coconino sandstone.

CALIFORNIA

Well No. 26/39–11Rl, semiartesian to artesian, 5 miles northeast of Inyokern, SE¼SE¼ Sec. 11, T. 26 S., R. 39 E. Owner, Inyokern Naval Ordnance Test Station. Depth, 109 feet; diameter, 12 inches; finish, probably perforated with Mills knife. Aquifer, Pleistocene alluvium.

Well No. 20/15–32Al, artesian, Fresno county, NE¼NE¼ Sec. 32, T. 20 S., R. 16 E. Owner, Coalinga High School. Depth, 399 feet; diameter, 16 inches; finish, gravel packed. Aquifer, gravel and sand.

NORTH FLORIDA

Well No. M46, artesian, 1⅝ miles east of Samoset, NW¼NE¼ Sec. 5, T. 35 S., R. 18 E. Owner, Broquindo Corp. Depth, 600 feet; diameter, 6 inches; finish, open hole. Aquifer, Hawthorne, Tampa, and Suwannee formations.

IDAHO

Well No. 5N–29E–23cd1, nonartesian, 43°44′ N., 112°58′ W., SE¼SW¼ Sec. 23, T. 5 N., R. 29 E. Owner, U. S. Geological Survey. Depth, 401 feet; diameter, 6 inches; finish, 21 feet perforated casing. Aquifer, basalt.

Well No. 5N–32E–36ad1, nonartesian, 43°43′ N., 112°38′ W., SE¼NE¼ Sec. 36, T. 5N., R. 32 E. Owner, U. S. Geological Survey. Depth, 405 feet; diameter, 6¼ to 5 inches; finish, 40 feet perforated casing; open bottom. Aquifer, basalt.

Well No. 6N–32E–11ab1, nonartesian, 43°52′ N., 112°40′ W., NW¼NE¼ Sec. 11, T. 6 N., R. 32 E. Owner, U. S. Geological Survey. Depth, 266½ feet; diameter, 6¼ inches; finish, 35 feet perforated casing. Aquifer, basalt.

Well No. 7S–25E–19ba1, nonartesian, 42°48′ N., 113°40′ W., NE¼NW¼ Sec. 19, T. 7 S., R. 25 E. Owner, U. S. Bureau of Reclamation. Depth, 284 feet; diameter, 5 inches; finish, unknown. Aquifer, basalt.

Well No. 7S–31E–13dc1, nonartesian, 42°48′ N., 112°47′ W., SW¼SE¼ Sec. 13, T. 7 S., R. 31 E. Owner, Paul Evans. Depth, 80 feet; diameter, 5½ inches; finish, unknown. Aquifer, unknown.

Well No. 9S–22E–33ab1, nonartesian, 42°36′ N., 113°53′ W., NW¼NE¼ Sec. 33, T. 9 S., R. 22 E. Owner, U. S. Bureau of Reclamation. Depth, 257 feet; diameter, 12 inches; finish, open hole. Aquifer, basalt.

MINNESOTA

Well No. 177.22.5abd2, artesian, Wayzata, SE¼NW¼NE¼ Sec. 5, T. 117 N., R. 22 W. Owner, Hennepin County Highway Department. Depth, 483 feet; diameter, 6 inches; finish, open hole. Aquifer, sandstone.

Well No. 117.22.8dbb2, artesian, Woodland, NW¼NW¼SE¼ Sec. 8, T. 117 N., R. 22 W. Owner, Hennepin County Highway Department. Depth, 503 feet; diameter, 6 inches; finish, open hole. Aquifer, sandstone.

Well No. 117.23.11bbd, artesian, Orono, SE¼NW¼NW¼ Sec. 11, T. 117 N., R. 23 W. Owner, Oberg Boat and Supply Co. Depth, 437 feet; diameter, 6 inches; finish, open hole. Aquifer, sandstone.

Well No. 117.23.34daa2, artesian, Excelsior, NE¼NE¼SE¼ Sec. 34, T. 117 N., R. 23 W. Owner, Hennepin County Highway Department. Depth, 467 feet; diameter, 6 inches; finish, open hole. Aquifer, sandstone.

Well No. 139.47.5cdc, artesian, Clay County, SW¼SE¼SW¼ Sec. 5, T. 139 N., R. 47 W. Owner, City of Moorhead. Depth, 131 feet; diameter, 8 inches; finish, slotted casing. Aquifer, sand and gravel.

NEW JERSEY

Well No. 28.4.4.2.1, nonartesian, 40°26′ N., 74°27′ W. Owner, Robert D. Fischer. Depth, 17 feet; diameter, 4½ feet; finish, concrete well blocks. Aquifer, sand.

TENNESSEE

Well No. 79:148–1S, artesian, 35°21′ N., 89°57′ W. Owner, T. D. Ervin. Depth, 440 feet; diameter 18 to 12 inches; finish, screen 80 feet. Aquifer, sand.

UTAH

Well No. (B–6–2) 35bcc–1, artesian, near W. Ogden, SW¼SW¼NW¼ Sec. 35, T. 6 N., R. 2 W. Owner, George Lowe. Depth, 283 feet; diameter, 1½ inches; finish, perforated casing. Aquifer, Pleistocene and possibly Pliocene unconsolidated sands, gravels and clays.

WISCONSIN

Well No. Lf–57, artesian, Shullsburg, NW¼NW¼ Sec. 33, T. 1 N., R. 2 E. Owner, Coulthard Estate. Depth, 265 feet; diameter, 10 inches; finish, open. Aquifer, dolomitic limestone.

Well No. Ml–121, artesian, 5th Ave. and Marion St., So. Milwaukee, NW¼NW¼ Sec. 13, T. 5 N., R. 22 E. Owner, Milwaukee Equip. Mfg. Co. Depth, 268 feet; diameter, 8 inches; finish, open hole. Aquifer, dolomite.

HAWAII

Well No. 83, artesian, 21°18′ N., 157°51′ W. Owner, City and County of Honolulu. Depth, 509 feet; diameter, 8 to 6 inches; finish, open hole. Aquifer, Basalt of the Koolau volcanic series; aa and pahoehoe types.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*

NOTE.—Complete information on earthquakes possibly associated with the following tabulations may be obtained from the *Preliminary Determination of Epicenter and Supplement* cards issued by the U. S. Coast and Geodetic Survey, or from registers of seismographic stations nearest the locality.

ARIZONA

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
(A-18-19)16db	11-25-53	19:10	33.59	33.56	33.50	33.64	0.14
(D-21-26)2baa	12- 4-53	16:00	52.71	52.71	52.70	52.72	.02

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

CALIFORNIA

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
26/39-11R1	4-12-53	07:45	101.11	101.11	101.10	101.14	0.04
20/15-32A1	4-17-53	12:00	173.90	173.90	173.85	173.92	.07
26/39-11R1	6- 6-53	17:15	101.10	101.10	101.01	101.34	.33
15/16-20R1	11-17-53	13:00	76.43	76.43	76.40	76.46	.06
15/16-34E1	11-17-53	13:00	145.95	145.95	145.94	145.96	.02
15/16-20R1	11-25-53	17:00	76.35	76.34	76.29	76.40	.11
15/16-34E1	11-25-53	17:00	145.62	145.62	145.60	145.65	.05
15/16-20R1	12- 1-53	04:00	145.40	145.42	145.38	145.48	.10
NORTHERN FLORIDA							
D206	4-23-53	17:00	8.63	8.62	8.58	8.67	0.09
H500	4-23-53	17:00	51.75	51.75	51.74	51.76	.02
M46	4-23-53	17:00	+12.13	+12.13	+12.16	+12.12	.04
O47	4-23-53	17:30	7.17	7.16	7.14	7.18	.04
H500	4-23-53	17:40	51.75	51.75	51.74	51.75	.01
D206	4-23-53	18:00	8.62	8.60	8.60	8.62	.02
M450	4-23-53	18:00	7.78	7.77	7.76	7.78	.02
D206	4-23-53	24:00	8.59	8.60	8.54	8.70	.16
D206	5- 6-53	17:15	9.18	9.18	9.16	9.22	.06
J23	5-31-53	17:30	36.27	36.28	36.20	36.36	.16
M450	5-31-53	18:00	7.03	7.00	6.98	7.03	.05
M46	5-31-53	19:45	+8.75	+8.76	+8.73	+8.78	.05
M92	5-31-53	20:00	43.55	43.54	43.53	43.55	.02
V24	5-31-53	20:00	13.40	13.40	13.35	13.45	.10
O47	5-31-53	20:30	8.50	8.49	8.48	8.51	.03
P16	5-31-53	20:30	65.75	65.74	65.72	65.78	.06
P13	5-31-53	20:30	8.60	8.60	8.59	8.61	.02
T35	5-31-53	20:45	2.68	2.69	2.54	2.83	.29
J23	9-30-53	23:50	37.32	37.31	37.30	37.32	.02
D206	10- 1-53	00:20	8.23	8.24	8.22	8.26	.04
SOUTHERN FLORIDA							
F210	1-25-53	19:45	1.29	1.29	1.30	1.28	0.02
F291	1-25-53	19:00	1.98	1.98	2.00	1.96	.04
G553	1-25-53	21:00	4.40	4.40	4.41	4.39	.02
G580	1-25-53	19:20	2.22	2.22	2.23	2.21	.02
S19	1-25-53	19:45	1.23	1.23	1.24	1.22	.02
S68	1-25-53	19:15	.45	.45	.47	.43	.04
F291	2-26-53	16:00	1.73	1.73	1.74	1.72	.02
G553	2-26-53	17:00	4.50	4.50	4.51	4.50	.01
G580	2-26-53	16:00	2.17	2.17	2.18	2.17	.01
S19	2-26-53	16:30	.76	.76	.78	.74	.04
S68	2-26-53	16:30	−.23	−.23	−.22	−.25	.03
F210	3-19-53	08:40	.97	.97	1.01	.93	.08
F291	3-19-53	09:00	1.09	1.09	1.21	.98	.23
G518	3-19-53	08:30	1.26	1.26	1.27	1.25	.02
G553	3-19-53	08:45	3.63	3.63	3.66	3.60	.06
G580	3-19-53	08:45	1.99	1.99	2.03	1.95	.08
S19	3-19-53	08:20	.38	.38	.44	.32	.12
S68	3-19-53	08:45	−.90	−.90	−.83	−.97	.14
C130	5-31-53	20:00	2.01	2.01	2.03	1.99	.04
F210	5-31-53	20:05	1.13	1.13	1.18	1.08	.10
F291	5-31-53	19:50	.81	.81	.95	.65	.30
G218	5-31-53	19:45	3.93	3.93	4.02	3.81	.21
G518	5-31-53	19:55	1.49	1.49	1.57	1.44	.13
G553	5-31-53	19:55	3.01	3.01	3.06	2.97	.09

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

SOUTHERN FLORIDA—continued

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
G580	5-31-53	19:50	2.04	2.04	2.14	1.95	0.19
S19	5-31-53	20:05	1.62	1.62	1.75	1.50	.25
S68	5-31-53	20:05	.33	.33	.42	.24	.18
S329	5-31-53	19:55	.81	.81	.91	.70	.21
C130	11-17-53	13:45	2.90	2.90	2.92	2.88	.04
F210	11-17-53	13:50	3.04	3.04	3.10	2.97	.13
F291	11-17-53	13:50	3.85	3.85	3.99	3.71	.28
G518	11-17-53	13:50	3.75	3.75	3.81	3.69	.12
G553	11-17-53	13:50	7.30	7.27	7.30	7.25	.05
G580	11-17-53	13:50	4.65	4.64	4.71	4.57	.14
S19	11-17-53	13:50	3.18	3.18	3.30	3.08	.22
S68	11-17-53	13:40	2.19	2.19	2.23	2.15	.08
F210	11-25-53	18:45	2.42	2.42	2.44	2.40	.04
F291	11 25 53	18:30	3.34	3.34	3.36	3.33	.03
G553	11-25-53	18:30	6.80	6.80	6.82	6.79	.03
S19	11-25-53	18:30	2.51	2.51	2.53	2.49	.04
S68	11-25-53	18:30	1.51	1.51	1.53	1.50	.03
F210	12-12-53	18:00	1.66	1.66	1.67	1.65	.02
F291	12-12-53	17:00	2.76	2.76	2.78	2.74	.04
S19	12-12-53	17:00	1.90	1.90	1.91	1.89	.02
S68	12-12-53	16:30	.62	.62	.64	.61	.03
S329	12-12-53	17:00	3.15	3.15	3.16	3.13	.02

IDAHO

8S-26E-33bc1	1-11-53	21:00 23:00	98.89	98.89	98.88	98.91	0.03
8S-27E-31dd1	1-11-53	22:00 24:00	20.70	20.70	20.62	20.77	.15
6N-31E-27ba1	1-11-53	22:00 24:00	210.81	210.81	210.80	210.83	.03
4N-30E-7ad1	1-11-53	22:00 24:00	321.86	321.86	321.82	321.91	.09
6N-31E-27ba1	2- 3-53		210.74	210.74	210.73	210.75	.02
5N-29E-23cd1	2- 3-53		269.97	269.97	269.91	270.03	.12
4N-30E-7ad1	2- 3-53 2- 4-53	24:00 02:00	321.95	321.95	321.92	321.97	.05
6N-32E-11ab1	2- 3-53		207.87	207.87	207.84	207.91	.07
5N-32E-36ad1	2- 3-53 2- 4-53	24:00 02:00	327.55	327.55	327.53	327.57	.04
9S-26E-10dd1	4-26-53	20:00 21:00	73.94	73.94	73.85	73.99	.14
6N-32E-11ab1	5- 1-53	02:00	208.68	208.69	208.65	208.71	.06
9S-25E-23ca1	5-15-53	21:00	123.09	123.09	123.07	123.11	.04
5N-34E-9bd1	6- 8-53	21:00	255.91	255.91	255.89	255.94	.05
1S-30E-15bc1	6-30-53	10:30	711.49	711.49	711.41	711.54	.13
8S-26E-27ab1	7-21-53	02:00 03:00	127.53	127.53	127.47	127.67	.20
5N-31E-14bc1	7-26-53	23:00 24:00	264.16	264.16	264.11	264.20	.09
8S-26E-27ab1	7-27-53	03:00 04:00	127.40	127.41	127.33	127.56	.23
9S-26E-10dd1	7-30-53	23:00 24:00	71.67	71.67	71.66	71.69	.03
8S-26E-27ab1	8- 1-53	02:00 03:00	127.40	127.41	127.33	127.46	.13
8S-27E-31dd1	8- 3-53	20:00 21:00	19.95	19.95	19.92	19.97	.05
4N-30E-7ad1	8- 8-53	20:00 21:00	321.00	321.00	320.97	321.07	.10

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

IDAHO—continued

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
4N-30E-7ad1	8-12-53	08:00 09:00	321.11	321.11	321.09	321.12	0.03
8S-26E-27ab1	8-13-53 8-14-53	24:00 01:00	127.12	127.12	127.08	127.24	.16
8S-24E-31dc1	8-16-53	04:00	114.51	114.51	141.48	141.51	.03
9S-26E-10dd1	8-16-53	23:00 24:00	69.77	69.77	69.75	69.80	.05
8S-27E-31dd1	8-16-53 8-17-53	24:00 01:00	19.95	19.95	19.91	19.99	.08
9S-26E-10aa1	8-17-53	01:00 02:00	74.02	74.04	74.01	74.09	.08
4N-30E-7ad1	8-17-53	02:00 08:00	321.12	321.12	321.10	321.14	.04
8S-24E-31dc1	8-17-53	24:00	141.41	141.40	141.39	141.41	.02
8S-26E-27ab1	8-17-53 8-18-53	24:00 01:00	127.01	127.01	127.00	127.02	.02
4N-30E-7ad1	8-18-53	03:00 05:00	321.15	321.15	321.12	321.18	.06
8S-26E-27ab1	8-20-53	23:00 24:00	126.83	126.83	126.82	126.87	.05
5N-32E-36ad1	8-22-53	05:00 07:00	328.10	328.10	328.07	328.13	.06
8S-25E-36da1	8-30-53	23:00	97.04	97.04	97.02	97.11	.09
9S-26E-10aa1	8-31-53	17:00 19:00	72.34	72.35	72.30	72.37	.07
2N-27E-2dd1	9- 1-53	08:00 09:00	761.29	761.29	761.26	761.32	.06
9S-26E-10dd1	9- 1-53	08:00 10:00	71.03	71.04	71.01	71.05	.04
7S-31E-13dc1	9- 3-53	02:00 03:00	60.27	60.27	60.23	60.67	.44
8S-25E-36da1	9- 4-53	01:00	97.14	97.14	97.14	97.16	.02
4N-30E-7ad1	9- 7-53	15:00 16:00	321.19	321.20	321.17	321.22	.05
5S-31E-27ab1	9- 7-53	16:00 17:00	13.33	13.33	13.28	13.35	.07
7S-31E-13dc1	9- 8-53	18:00 20:00	60.32	60.30	60.25	60.70	.45
9S-26E-10dd1	9-10-53	20:00 22:00	68.73	68.72	68.70	68.75	.05
1S-30E-15bc1	9-12-53	11:45	710.73	710.71	710.64	710.73	.09
7S-31E-13dc1	9-12-53	20:00 22:00	60.32	60.24	60.21	60.62	.41
8S-25E-36da1	9-17-53	01:00 02:00	97.04	97.04	97.03	97.07	.04
9S-26E-10dd1	9-22-53	01:00 03:00	68.38	68.38	68.36	68.43	.07
9S-26E-10aa1	9-22-53	02:00 04:00	71.70	71.69	71.69	71.75	.06
9S-26E-10dd1	9-24-53	17:00 19:00	68.44	68.43	68.39	68.47	.08
9S-25E-23ca1	9-24-53	21:00 23:00	117.52	117.52	117.50	117.53	.03
8S-27E-31dd1	9-30-53	15:00	19.92	19.89	19.67	20.11	.44
6N-31E-27ba1	9-30-53	19:00 20:00	210.59	210.58	210.57	210.60	.03
4N-30E-7ad1	9-30-53	20:00 21:00	321.11	321.10	321.01	321.19	.18
5N-31E-14bc1	9-30-53	20:00 21:00	264.70	264.70	264.63	264.78	.15

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

IDAHO—continued

Well No.	Date	Time G. C. T.	Depth to water: Before disturbance	Depth to water: After disturbance	Depth to water: At highest point	Depth to water: At lowest point	Amplitude of fluctuation
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
8S-25E-36da1	9-30-53	22:00 24:00	97.15	97.14	97.12	97.16	0.03
8S-26E-33bc1	9-30-53	22:00 24:00	97.14	97.14	97.13	97.15	.03
3N-29E-14ad1	9-30-53	23:00	450.74	450.74	450.69	450.79	.10
8S-26E-27ab1	10- 7-53	16:00 18:00	126.33	126.33	126.32	126.35	.03
9S-22E-33ab1	10- 8-53	20:00 22:00	223.88	224.86	223.05	224.66	1.61
8S-26E-27ab1	10- 9-53	16:00 18:00	126.25	126.25	126.18	126.31	.13
6N-31E-27ba1	10-13-53	08:00 09:00	210.73	210.73	210.72	210.73	.01
3N-29E-14ad1	10-13-53	08:00 09:00	450.90	450.90	450.89	450.92	.03
8S-26E-33bc1	10-13-53	08:00 10:00	97.31	97.32	97.30	97.33	.03
8S-27E-31dd1	10-13-53	08:00 10:00	19.94	19.94	19.85	20.04	.19
8S-26E-27ab1	10-15-53	14:00 16:00	126.18	126.18	126.14	126.25	.11
8S-26E-26ab1	10-16-53	21:00 23:00	126.22	126.22	126.21	126.24	.03
8S-25E-36da1	10-21-53	00:00 03:00	98.33	98.33	98.30	98.36	.06
8S-26E-33bc1	10-28-53	13:00 15:00	97.40	97.40	97.39	97.41	.02
4N-30E-7ad1	11- 4-53	01:00 02:00	321.34	321.35	321.33	321.37	.04
7S-31E-13dc1	11- 9-53	15:00 17:00	60.52	60.55	60.49	60.56	.07
7S-31E-13dc1	11-12-53	16:00 18:00	60.38	60.39	60.37	60.42	.05
4N-30E-7ad1	11-17-53	12:00 13:00	321.13	321.19	321.06	321.22	.16
8S-26E-33bc1	11-17-53	13:00 14:00	97.52	97.52	97.50	97.55	.05
8S-27E-31dd1	11-17-53	14:00 16:00	19.98	20.02	19.84	20.14	.30
7S-25E-19ba1	11-21-53	18:00 19:00	232.00	232.00	231.62	232.52	.90
3N-29E-14ad1	12- 4-53	13:00 14:00	450.63	450.64	450.62	450.66	.04
8S-25E-36da1	12- 4-53	13:00 15:00	98.09	98.09	98.07	98.10	.03
4N-30E-7ad1	12- 4-53	14:00 15:00	321.09	321.09	321.01	321.10	.09
8S-25E-36da1	12- 4-53	22:00 24:00	98.21	98.21	98.20	98.22	.02
6N-31E-27ba1	12-12-53	16:00 17:00	210.74	210.73	210.71	210.78	.07
4N-30E-7ad1	12-12-53	16:00 17:00	321.28	321.26	321.24	321.32	.08
ILLINOIS							
ANL-13	1- 2-53	11:00	104.15	104.14	104.13	104.15	0.02
ANL-9	1- 5-53	05:30	91.75	91.74	91.74	91.75	.01
ANL-9	1-17-53	20:00	91.88	91.87	91.87	91.89	.02
ANL-13	2- 1-53	20:45	104.96	104.95	104.94	104.96	.02

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

ILLINOIS—continued

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
ANL-9	3- 3-53	23:30	91.78	91.79	91.78	91.79	0.01
ANL-9	3- 4-53	01:00	91.80	91.80	91.79	91.81	.02
ANL-11	3-18-53	19:45	76.69	76.70	76.69	76.70	.01
ANL-13	3-23-53	03:00	104.81	104.80	104.80	104.83	.03
ANL-9	4-23-53	16:30	91.74	91.72	91.71	91.74	.03
ANL-9	5-31-53	20:00	91.72	91.71	91.71	91.72	.01
ANL-13	6-16-53	20:00	104.40	104.41	104.40	104.42	.02
ANL-13	7-26-53	06:30	103.99	104.00	103.99	104.02	.03
ANL-9	9-10-53	01:30	92.28	92.30	92.28	92.30	.02
ANL-9	9-16-53	17:15	92.10	92.08	92.06	92.10	.04
ANL-9	9-17-53	02:30	92.10	92.11	92.09	92.12	.03
ANL-9	9-28-53	07:30	92.21	92.20	92.19	92.23	.04
ANL-9	9-29-53	04:30	92.14	92.17	92.14	92.18	.04
ANL-9	11-25-53	17:45	92.21	92.22	92.17	92.28	.11
ANL-11	11-25-53	17:45	77.39	77.40	77.37	77.42	.05
IOWA							
83-7-21K1	1- 5-53	08:30	67.97	67.97	67.93	68.01	0.08
83-7-21K1	9-30-53	23:00	70.42	70.43	70.32	70.53	.21
83-7-21K1	11- 4-53	04:00	70.45	70.43	70.38	70.50	.12
83-7-21K1	11-25-53	18:30	70.18	70.20	70.14	70.23	.09
83-7-21K1	12- 4-53	02:30	70.14	70.17	70.13	70.18	.05
MARYLAND							
Dor-Ce-22	4- 1-53	23:00	75.40	75.41	75.41	75.43	0.2
Care-Dc-56	4- 1-53	23:00	31.59	31.62	31.59	31.62	.03
Wi-Cf-3	4- 2-53	00:05	7.19	7.19	7.19	7.20	.01
Wi-Ce-13	4- 2-53	00:15	3.05	3.00	3.04	3.02	.02
MICHIGAN							
GeFL491	1-11-53	23:00	27.29	27.29	27.27	27.31	0.04
GeFL491	1-21-53	17:00	27.08	27.08	27.03	27.13	.10
GeFL491	1-21-53	19:00	27.09	27.09	27.07	27.10	.03
GeFL491	2- 1-53	02:30	27.32	27.33	27.29	27.35	.06
KoKo240	2-19-53	13:00	7.37	7.38	7.35	7.40	.05
GeFL491	5-31-53	20:30	28.74	28.73	28.71	28.77	.06
GeFL491	11- 4-53	05:00	30.57	30.57	30.53	30.61	.08
GeFL491	11-17-53	14:00	30.17	30.18	30.10	30.25	.15
GeFL491	12-12-53	18:30	30.05	30.05	29.97	30.12	.15
MINNESOTA							
117.23.11bbd	3-11-53	11:00	14.54	14.53	14.53	14.54	0.01
117.22.8dbb2	3-19-53	08:15	21.90	21.90	21.89	21.92	.03
117.23.34daa2	3-19-53	08:30	52.93	52.94	52.91	52.95	.04
117.22.5abd2	3-19-53	08:30	39.56	39.56	39.54	39.58	.04
117.23.11bbd	3-19-53	08:30	14.47	14.48	14.46	14.48	.02
139.47.5cdc	3-19-53	08:30	23.45	23.46	23.44	23.48	.04

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

NEVADA

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
S20/60—36dbbl	1- 9-53	21:00	56.12	56.12	56.00	56.22	0.22
S19/60—9bccl	4- 1-53	04:30	82.89	82.90	82.85	82.95	.10
S20/53—24caal	3- 7-53	00:30	36.74	36.75	36.71	36.84	.13
S20/60—36dbbl	7- 1-53	12:00	65.82	65.82	65.68	66.02	.34
11/24—22dcl	7-30-53	22:00	54.95	54.95	54.88	55.41	.53
11/24—22dcl	9- 1-53	14:00	55.92	55.91	55.87	56.04	.17

NEW JERSEY

31.1.6.4.8	3-11-53	01:10	−7.86	−7.86	−7.84	−7.88	0.04
31.1.6.4.8	3-18-53	20:00	−7.73	−7.73	−7.70	−7.74	.04
26.22.4.4.4	3-19-53	08:45	+30.72	+30.72	+30.79	+30.69	.10
31.1.6.4.8	3-19-53	08:50	−7.92	−7.92	−7.90	−7.92	.02
31.1.6.4.8	3-26-53	02:50	−7.84	−7.84	−7.81	−7.86	.05
31.1.6.4.8	4-23-53	17:30	−7.87	−7.87	−7.85	−7.88	.03
31.1.6.4.8	4-23-53	18:15	−7.87	−7.87	−7.86	−7.88	.02
31.1.6.4.8	5- 4-53	17:00	−6.30	−6.30	−6.24	−6.34	.10
31.1.6.4.8	5- 6-53	17:30	−7.35	−7.35	−7.17	−7.44	.27
26.22.4.4.4	5- 6-53	17:30	+30.63	+30.63	+30.66	+30.61	.05
28.4.4.2.1	6- 6-53	17:30	+60.80	+60.80	+60.81	+60.80	.01
31.1.6.4.8	10-22-53	14:00	−9.77	−9.77	−9.75	−9.78	.03
31.1.6.4.8	10-28 53	14:45	−8.61	−8.61	−8.60	−8.62	.02
31.1.6.4.8	11-25-53	18:50	−8.06	−8.06	−8.05	−8.07	.02
28.5.4.8.1	11-25-53	20:00	+3.87	+3.87	+3.87	+3.86	.01
28.5.4.8.1	11-25-53	21:00	+3.86	+3.86	+3.87	+3.86	.01
31.1.6.4.8	12- 5-53	15:20	−8.60	−8.60	−8.57	−8.61	.04
31.1.6.4.8	12-12-53	18:00	−9.47	−9.42	−9.40	−9.47	.07

NEW YORK

Sa-529	1- 5-53	08:00	47.20	47.19	47.19	47.20	0.01
Sa-529	1-11-53	23:15	47.01	47.01	47.00	47.03	.03
Q-64	2- 1-53	03:30	−.85	−.85	−.83	−.85	.02
Q-64	2-18-53	20:00	−.08	−.08	−.01	−.17	.16
Q-64	2-19-53	09:10	+.16	+.16	+.26	+.05	.21
Sa-529	3-18-53	19:45	47.08	47.07	47.06	47.09	.03
Sa-529	3-19-53	08:45	46.87	46.87	46.82	46.90	.08
Sa-529	4-23-53	17:15	46.64	46.67	46.62	46.67	.05
Q-64	4-23-53	17:45	+.29	+.30	+.46	+.12	.34
Sa-529	5- 6-53	17:15	47.63	47.64	47.62	47.64	.02
Q-64	5- 6-53	17:45	+.03	+.03	+.06	−.01	.07
Q-64	5-31-53	20:15	−.23	−.23	−.19	−.26	.07
Sa-529	5-31-53	20:30	47.45	47.44	47.44	47.46	.02
Q-64	6- 9-53	02:45	−.19	−.19	−.17	−.20	.03
Sa-529	6-15-53	18:15	48.52	48.53	48.52	48.53	.01
N-1212	8-12-53	09:45	+89.00	+89.00	+89.08	+88.83	.25
Q-64	8-12-53	09:45	−.62	−.62	−.61	−.64	.03
Q-64	8-22-53	02:30	−.61	−.61	−.60	−.62	.02
Q-64	8-25-53	03:00	−.61	−.61	−.60	−.63	.03
Q-64	9- 4-53	08:15	−.55	−.55	−.54	−.56	.02
Q-64	9- 5-53	14:50	−.68	−.68	−.67	−.68	.01
Q-64	9-30-53	23:30	−.78	−.78	−.75	−.81	.06
Sa-529	11-17 53	08:40	49.64	49.65	49.62	49.66	.04
Q-64	11-17-53	14:20	−4.00	−4.00	−3.93	−4.08	.15
Sa-529	12- 4-53	10:05	49.48	49.48	49.47	49.50	.03
Q-64	12-12-53	18:00	−1.72	−1.72	−1.65	−1.78	.13

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 32, 1953*—Continued

TENNESSEE

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
79:5-193	4- 5-53	07:30	102.84	102.83	102.82	102.84	0.02
79:148-1D	8- 6-53	18:30	47.21	47.21	47.20	47.21	.01
24:10-2	8-12-53	12:00	39.01	39.02	39.01	39.02	.01
79:8-73	8-13-53	18:00	133.20	133.19	133.18	133.25	.07
79:8-86S	9-29-53	16:20	35.85	35.85	35.83	35.86	.03
79:1-2	11-25-53	17:30	84.41	84.40	84.40	84.41	.01
79:148-1S	11-25-53	17:30	43.92	43.93	43.91	43.93	02
79:148-1S	12- 2-53	16:00	44.13	44.13	44.13	44.14	.01

UTAH

(D-5 1)14abb-1	3-18-53	19:30	48.75	48.75	48.72	48.78	0.06
(D-5-1)14abb-1	3-19-53	08:30	48.64	48.64	48.62	48.66	.04
(B-5-1)21dc-1	7- 6-53	11:15	189.48	189.48	189.32	189.61	.29
(B-5-1)21dc-1	7- 6-53	22:30	189.40	189.38	189.34	189.43	.09
(B-6-1)29abb-1	7- 6-53	11:20	+18.3	+18.3	+18.9	+18.0	.9
(B-6-1)29abb-1	7- 6-53	22:20	+18.2	+18.2	+18.3	+18.0	.3
(B-6-1)29ccc-1	7- 6-53	11:15	+15.2	+15.2	+16.7	+13.8	2.9
(B-6-1)29ccc-1	7- 6-53	22:15	+15.2	+15.2	+15.8	+14.8	1.0
(B-6-1)30cca-1	7- 6-53	11:45	31.05	31.06	30.94	31.14	.20
(B-6-1)30cca-1	7- 6-53	23:00	31.03	31.03	31.00	31.07	.07
(B-6-2)35bcc-1	7- 6-53	11:00	10.52	10.54	10.44	10.62	.18
(B-6-2)35bcc-1	7- 6-53	21:45	10.54	10.54	10.52	10.58	.06
(C-2-6)36cdd-1	7- 6-53	11:30	81.27	81.33	81.18	81.45	.27
(C-2-6)36cdd-1	7- 6-53	22:00	81.32	81.32	81.27	81.37	.10
(C-7-8)10cbd-1	7- 6-53	11:00	80.54	80.58	80.54	80.60	.06
(C-7-8)10cbd-1	7- 6-53	21:45	80.57	80.55	80.55	80.57	.02
(C-35-11)33dbc-1	7- 6-53	10:30	86.44	86.45	86.42	86.48	.06
(C-35-11)33dbc-1	7- 6-53	21:00	86.47	86.48	86.47	86.48	.01
(B-5-1)27dc-1	8-24-53	08:45	191.88	191.88	191.56	192.10	.54
(B-6-1)29abb-1	8-24-53	06:00	+15.1	+15.1	+15.2	+14.6	.6
(B-6-1)29ccc-1	8-24-53	06:00	+11.5	+11.5	+14.7	+9.0	5.7
(B-6-1)30cca-1	8-24-53	06:00	33.09	33.09	31.85	32.23	.38
(C-35-11)33dbc-1	8-24-53	06:00	89.65	89.66	89.63	89.67	.04

WISCONSIN

Ml-121	1- 7-53	05:45	64.66	64.66	64.66	64.67	0.01
Ml-36	1-12-53	17:30	183.37	183.36	183.36	183.37	.01
Ml-121	2-19-53	15:00	65.03	65.03	65.03	65.05	.02
Ml-121	2-23-53	00:00	64.98	64.99	64.97	64.99	.02
Ml-121	3- 3-53	11:00	64.72	64.72	64.71	64.74	.03
Ml-121	3- 3-53	23:00	64.41	64.39	64.30	64.42	.12
Ml-36	3- 4-53	00:15	175.06	175.06	175.05	175.08	.03
Ml-121	3- 4-53	00:30	64.46	64.41	64.40	64.48	.08
Ml-121	3-17-53	13:30	64.89	64.89	64.88	64.90	.02
Ml-121	3-18-53	19:00	64.38	64.40	64.36	64.41	.05
Ml-148	3-18-53	19:15	31.13	31.14	31.13	31.14	.01
Lf-57	3-18-53	19:15	79.51	79.50	79.45	79.56	.11
Lf-57	3-19-53	08:00	79.60	79.62	79.53	79.71	.18
Ml-148	3-19-53	08:30	31.19	31.20	31.19	31.21	.02
Lf-57	4-23-53	16:30	80.06	80.04	79.97	80.14	.17
Dg-4	5-26-53	02:30	112.15	112.11	112.08	112.15	.07
Lf-57	5-31-53	20:00	81.77	81.77	81.71	81.81	.10
Lf-57	6-15-53	18:00	81.96	81.95	81.91	81.99	.08
Lf-57	8-12-53	10:00	82.82	82.82	82.79	82.84	.05

See footnotes at end of table.

TABLE 1.—*Fluctuations in well-water levels, Jan. 1 through Dec. 31, 1953*—Continued

WISCONSIN—continued

Well No.	Date	Time G. C. T.	Depth to water				Amplitude of fluctuation
			Before disturbance	After disturbance	At highest point	At lowest point	
			ft.	*ft.*	*ft.*	*ft.*	*ft.*
Lf-57	9-30-53	23:30	83.92	83.90	83.70	84.08	0.38
Lf-57	11- 4-53	05:00	84.53	84.54	84.48	84.60	.12
Lf-57	11-17-53	13:30	84.71	84.74	84.64	84.81	.17
Lf-57	11-25-53	18:00	84.86	84.88	84.62	85.10	.48
Lf-57	12-12-53	17:30	85.15	85.13	85.07	85.20	.13
HAWAIIAN ISLANDS							
36A	1- 5-53	08:10	13.33	13.33	13.31	13.33	0.02
132	1- 5-53	08:10	14.91	14.91	14.89	14.93	.04
132	1- 5-53	10:30	14.89	14.89	14.85	14.93	.08
36A	1- 5-53	10:30	13.30	13.30	13.29	13.32	.03
36A	2-26-53	12:00	13.45	13.45	13.40	13.50	.10
132	2-26-53	12:00	15.20	15.19	15.12	15.28	.16
36A	4-23-53	16:40	15.51	15.53	15.33	15.72	.39
83	4-23-53	16:45	+2.08	+2.06	+2.13	+2.01	.12
132	4-23-53	16:50	13.75	13.77	13.66	13.87	.21
36A	9-30-53	23:00	25.41	25.39	25.42	25.39	.03
132	9-30-53	23:10	23.87	23.89	23.92	23.87	.05
36A	10- 6-53	21:55	17.54	17.53	17.52	17.55	.03
132	10- 6-53	22:05	19.10	19.11	19.09	19.13	.04
132	11- 4-53	04:20	18.87	18.87	18.81	18.97	.16
36A	11- 4-53	04:55	17.36	17.37	17.31	17.43	.12
132	11-17-53	14:20	18.48	18.47	18.46	18.49	.03
132	11-25-53	17:55	18.44	18.52	18.09	18.85	.76
83	11-25-53	18:00	1.12	1.13	1.05	1.24	.19
T-24	11-25-53	18:00	36.54	36.54	36.52	36.56	.04
36A	11-25-53	18:50	16.94	16.97	16.77	17.14	.37
1A	11-25-53	19:20	9.91	9.92	9.84	9.96	.12
36A	12-12-53	17:45	16.73	16.74	16.72	16.75	.03
132	12-12-53	17:50	18.35	18.40	18.33	18.42	.09

+Water surface above mean sea level or land surface datum.
−Water surface below mean sea level.

SEISMOLOGICAL OBSERVATORY RESULTS

The United States Coast and Geodetic Survey publishes the results of its teleseismic stations and cooperating stations in the quarterly *Seismological Bulletin.* All seismogram interpretations are tabulated together with epicenters based on the published data and instrumental results received from seismological stations in all parts of the world. Instrumental results are published for the following stations:

Balboa Heights, C. Z.
(The Panama Canal.)
Bermuda
(Meteorological Station and International Union Geodesy and Geophysics.)
Boulder City, Nev.
Bozeman, Mont.
(Montana State College.)
Burlington, Vt.
(University of Vermont.)
Butte, Mont.
(Montana School of Mines.)
Chicago, Ill.
(University of Chicago and U. S. Weather Bureau.)
College, Alaska
Columbia, S. C.
(University of South Carolina.)
Honolulu, T. H.
Hungry Horse, Mont.
Lincoln, Nebr.
(Nebraska Wesleyan University.)
Logan, Utah
(Utah State Agricultural College.)
Nelson, Nev.
New Kensington, Pa.
(Private station.)
Overton, Nev.
Philadelphia, Pa.
(The Franklin Institute.)
Pierce Ferry, Ariz.
Rapid City, S. Dak.
(South Dakota State School of Mines and Technology.)
Salt Lake City, Utah
(University of Utah.)
San Juan, P. R.
Shasta, Calif.
Sitka, Alaska
Tucson, Ariz.
Ukiah, Calif.
(International Latitude Observatory.)
Washington, D. C.

College, Honolulu, Nelson, San Juan, Sitka, Tucson, Ukiah, and Washington are United States Coast and Geodetic Survey stations.

Boulder City, Hungry Horse, Overton, Pierce Ferry, and Shasta are cooperating stations of the Bureau of Reclamation. Overton and Pierce Ferry are operated by the National Park Service personnel.

Bermuda, Bozeman, Butte, Chicago, Columbia, Lincoln, Rapid City, and Salt Lake City are cooperating university stations.

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

All readings were made or revised at the Washington Office except those for Balboa Heights. All seismograms are on file in the United States Coast and Geodetic Survey, except those for Balboa Heights, Burlington, Logan, and New Kensington, which may be obtained on loan by addressing the Seismograph Station Director: Meteorological and Hydrographic Office, Panama Canal Company, Balboa Heights, C. Z.; University of Vermont, Burlington, Vt.; Utah State Agricultural College, Logan, Utah; 508 Pershing Drive, New Kensington, Pa.

For detailed instrumental data regarding these stations, including instrumentation, constants, and other information, see *Seismological Bulletin*, MSI–141, for the first quarter of 1950. Those desiring to receive this publication as issued should request addition of their name to the *CGS–7* mailing list. All requests should be made to the Director, United States Coast and Geodetic Survey, Washington 25, D. C.

SUMMARY OF INSTRUMENTAL EPICENTERS FOR 1951

The summary of instrumental epicenters for 1951 is not available for publication at this time. However, the summary will be published as soon as the data become available. The last Seismological Bulletin to be issued covers the fourth quarter 1950.

TABLE 2.—*Principal earthquakes of the world from January through December 1953*

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

1953	Origin Time G. C. T.	Region	Coordinates of provisional epicenter		Remarks
			Latitude	Longitude	
	h m s		°	°	
Jan. 5	07 48 21*	Komandorski Islands	54½ N.	171 E.	Felt at Attu. Mag. 7.1.
5	10 06 25*	Kurile Islands	49 N.	156 E.	Depth about 40 km. Mag. 7.0.
12	17 23 40*	Kurile Islands	50 N.	156 E.	Depth about 70 km. Mag. 6.9.
Feb. 12	08 15 29*	Northern Iran	35 N.	54½ E.	973 killed, 140 injured in and around Torroud, which was destroyed. Mag. about 6½.
26	11 42 26*	Santa Cruz Islands	11 S.	164½ E.	Mag. 7.0.
Mar. 18	19 06 11*	Western Turkey	40 N.	27½ E.	1103 killed, including 998 in Yenice, 50 in Gonen, 20 in Can, and 3 in Manyas. Yenice destroyed and major damage at Gonen and Can. Felt throughout the Aegean Islands and southern Greece. Macroseismic area estimated at 200,000 square miles. Damage at $3,570,000. Mag. about 7¼.
19	08 27 57*	Windward Islands	14 N.	61 W.	Felt at Paramaribo, Dutch Guiana and Trinidad. Depth about 200 km. Mag. 7.3.
Apr. 14	13 29 26*	Acre, Brazil	7½ S.	71½ W.	Depth about 630 km. Mag. 6.6.
23	16 24 17*	New Britain	4 S.	154 E.	$13,000 damage at Rabaul. Mag. 7½.
May 6	17 16 43*	Near coast of central Chile	36½ S	73 W.	6 killed, 26 injured. $32 million damage in Concepcion, Chilian, Los Angeles, and Talcuahuano. Depth about 60 km. Mag. 7.6.
31	19 58 35*	Near north coast of Dominican Republic.	20 N.	70½ W.	Felt. Mag. 6¾.
Jun. 25	10 43 56*	Flores Island foreshock	8 S.	124 E.	Depth about 50 km.
25	10 44 57*	Off east coast of Flores Island.	8½ S.	123½ E.	Depth about 50 km. Mag. 7.1.
26	05 42 56*	Flores Island aftershock	8½ S.	124 E.	Depth about 50 km. Mag. 6.9.
Jul. 2	06 56 51*	New Hebrides Islands	19 S.	170 E.	Depth about 250 km. Mag. 7½.
26	16 53 16*	Marianas Islands	17½ N.	145 E.	Depth about 190 km. Mag. 6¾-7.
Aug. 12	09 23 50*	Near west coast of Greece	38 N.	21 E.	Largest of a swarm of about 120 earthquakes which killed 800 and injured 10,000 on the islands of Zante, Ithaca and Cephalonia. The towns of Sami, Agha Efthimia, Argostoli, and Luxouri on Cephalonia; Vathy on Ithaca and the town of Zante were destroyed. Damage estimated at $100 million dollars. Mag. about 7.1.
Sept. 10	04 05 58*	Cyprus	32½ E.	35 N.	40 killed, 100 injured, and 500 buildings destroyed in Paphos and vicinity. Mag. 6½.
14	00 26 36*	Fiji Islands	18½ S.	178½ E.	8 killed at Suva. 10-foot seismic sea wave. Depth about 60 km. Mag. 6¾.
Nov. 4	03 49 04*	New Hebrides Islands	12½ S.	166 E.	Mag. 7.4.
17	13 29 52*	Near coast of Guatemala	14 N.	92 W.	Depth about 40 km. Mag. 7.1.
25	17 48 49*	Near south coast of Honshu, Japan.	34 N.	141 E.	1 killed, and slight damage on Tomisaki and Miyakezima Islands. 10-foot seismic sea wave. Mag. 8.0.
Dec. 1	05 08 45*	Ryukyu Islands	29 N.	128 E.	Depth about 210 km. Mag. 6.9.
7	02 05 37*	Northern Chile	22 S.	68½ W.	20 injured, extensive property damage. Depth about 110 km. Mag. 7.1.
12	17 31 22*	Near coast of Peru	3½ S.	81 W.	7 killed, 20 injured, and 200 buildings destroyed in Tumbes. Minor damage at Guayaquil, Ecuador. Mag. 7.4.

*Indicates probable error of $\frac{1}{10}$ minute.

STRONG-MOTION SEISMOGRAPH RESULTS

INTRODUCTION

During 1932, the Coast and Geodetic Survey inaugurated a program of recording strong ground movements in the seismically active regions of the country to obtain basic data needed in the design of earthquake-resistant structures. Notes pertinent to this program will be found in the preceding issues of the *United States Earthquakes* series and in S. P. 201, *Earthquake Investigations in California, 1934–35*. The latter is much broader in scope than the former, and contains data on structural and ground vibrations with detailed descriptions of the various activities which comprise the seismological program as a whole. Additional descriptive material on strong-motion instruments and vibration meters will be found in S. P. 206, *Selection, Installation, and Operation of Seismographs*.

Interpretation of records.—The analyses appearing in tables 5 and 6 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 superposition of shorter period waves of relatively large amplitude, the estimates of displacement must be considered only rough approximations. These analyses are essentially condensations of material appearing in the *Quarterly Engineering Seismology Bulletin* available through mailing list *CGS–5* from the Director, United States Coast and Geodetic Survey, Washington 25, D. C.

Units and instrumental constants.—Quantitative results are expressed in c.g.s. units; centimeters or millimeters for displacement; and centimeters per second per second for acceleration. It is sometimes desirable to express acceleration in terms of the acceleration of gravity, indicated by "g" which is equal to 980 cm/sec.^{2} For practical purposes it is only necessary to point off three decimal places to convert cm/sec.^{2} to "g."

Most of the instruments have been adjusted so that each will register the maximum acceleration to be expected on the particular type of geological formation beneath the instrument. The following expectable earthquake accelerations were used in determining the accelerograph sensitivities: (*a*) rock foundation, 25 percent of gravity, (*b*) conglomerate foundations, 40 percent of gravity, (*c*) alluvium, 70 percent of gravity, and (*d*) top floors of tall buildings, 100 to 200 percent of gravity. The four sensitivities may be roughly listed as 26, 19.5, 13, and 6.5 mm. per 0.1 g., respectively.

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.

Damping ratio of the pendulum is the ratio between successive amplitudes when the pendulum oscillates in a damping medium.

Seismogram illustrations.—Reproductions of records in this publication are tracings of the original records and must not be accepted as genuine copies. The tabulated instrumental constants refer to the original records. The tracings which are approximately in the ratio of 1 : 1 are intended to show the nature of the data rather than

furnish a means through which the reader can make his own measurements. Those who desire true copies for critical study should make request to the Director of the Coast and Geodetic Survey, Washington 25, D. C.

Acceleration and displacement scales representing the equivalent of 0.1 g. and 1 inch are indicated on the tracings of the acceleration and displacement curves. The scales provide the investigator with a quick means for making rough measurements on the published curves. The measurements of periods on records of this nature are dependent largely on the judgment of the person reading them and considerable latitude must be allowed in appraising their accuracy. The aim of such analyses is primarily to give a fair picture of the magnitudes of the various elements involved, and the figures tabulated should therefore not be used for important studies without first referring to the illustrations for some idea of the nature of the original records.

TABLE 3.—*U. S. Coast and Geodetic Survey strong-motion stations in operation as of Dec. 31, 1953*

NORTHERN CALIFORNIA

Station	Accelero-graph	Displace-ment meter	Weed
Berkeley, University of California	1		
Eureka	1		
Ferndale	1	1	
Hollister, Library	1	1	
Monterey, City Hall			1
Oakland, City Hall, basement	1		
Oakland, City Hall, 16th floor	1		
Oakland, Chabot Observatory			1
Sacramento, Federal Building			1
San Francisco, Alexander Bldg., basement	1		
San Francisco, Alexander Bldg., 11th floor	1		
San Francisco, Alexander Bldg., 16th floor	1		
San Francisco, 450 Sutter St., basement			1
San Francisco, 450 Sutter St., 29th floor			1
San Francisco, Golden Gate Park	1		
San Francisco, Shell Bldg., subbasement			1
San Francisco, Shell Bldg., 21st floor			1
San Francisco, Shell Bldg., 29th floor			1
San Francisco, Southern Pacific Bldg., basement	1	1	
San Francisco, Southern Pacific Bldg., 14th floor	1		
San Francisco, State Bldg., basement	1	1	
San Jose, Bank of America, basement	1	1	
San Jose, Bank of America, 13th floor	1		
Suisun Bay Bridge	1		

SOUTHERN CALIFORNIA

Arvin	1	1	
Bishop	1		
Colton	1	1	
El Centro	1	1	
Hollywood Storage Co., basement	1		
Hollywood Storage Co., penthouse	1		
Hollywood Storage Co., adjoining P. E. Lot	1		
Long Beach	1		
Los Angeles, Edison Bldg., basement	1		
Los Angeles, Occidental Life Bldg., basement	1		
Los Angeles, Occidental Life Bldg., 11th floor	1		
Los Angeles, Subway Terminal, subbasement	1	1	
Los Angeles, Subway Terminal, 13th floor	1		
Los Angeles, Vernon, C. M. D.	1		
Pasadena, California Institute of Technology	1	1	1
San Bernardino			1
San Diego	1		

TABLE 3.—*U. S. Coast and Geodetic Survey strong-motion stations in operation as of Dec. 31, 1953*—Continued

Station	Accelero-graph	Dispiace-ment meter	Weed
SOUTHERN CALIFORNIA—continued			
San Luis Obispo	1		
Santa Ana			1
Santa Barbara	1		
Taft	1		
Westwood, University of California, Los Angeles	1		
OUTSIDE CALIFORNIA			
Bozeman, Mont., Montana State College	1		
Butte, Mont., Montana School of Mines	1		
Columbia Falls, Mont., Hungry Horse Dam, Bureau of Reclamation	1		
Hawthorne, Nev., U. S. Naval Ammunition Depot	1		
Helena, Mont., Carroll College	1		
Hoover Dam, Nev., 1215 Gallery	1		
Hoover Dam, Nev., intake tower	1		
Hoover Dam, Nev., oilhouse	1		
Logan, Utah, Utah State Agricultural College	1		
Olympia, Wash., Highway Test Laboratory	1		
Portland, Oreg., State Office Bldg	1		
Ross Dam, Wash	1		
Seattle, Wash., Army Base	1		
Tacoma, Wash., College of Puget Sound	1		
OUTSIDE UNITED STATES			
Balboa Heights, C. Z	1		
Bogota, Colombia, South Amerjca	1		
Guatemala City, Guatemala, Central America	1		
Lima, Peru, South America	1		
Quito, Ecuador, South America	1		
San Jose, Costa Rica, Central America	1		
Santiago, Chile, South America	1		
Total	57	10	11

TABLE 4.—*List of of shocks recorded and records obtained on strong-motion seismographs in 1953*

Date	Region and recording station	Records			
		Accel-ero-graph	Survey dis-place-ment meter	Carder dis-place-ment meter	Weed
Jan. 7	Costa Rica, Central America, San Jose	1			
Feb. 15	Peru, South America, Lima	1			
Mar. 5	Southern California, Westwood	1			
May 22	Southern California, Taft	1			
May 24	Northern California, Hollister	1		1	
June 13	Imperial Valley, Calif., El Centro	1		1	
Aug. 24	Guatemala, Central America, Guatemala City	1			
Sept. 4	Chile, South America, Santiago	1			
Oct. 8	Northern California, Ferndale	1	1		
Dec. 15	Southern California, Arvin	1		1	
	Total	10	1	3	

TABLE 5.—*Summary of outstanding instrumental and noninstrumental data for 1953*

Epicenter	Recording station and position [1]	Location of instrument	Intensity [2]	Maximum acceleration	Maximum displacement
		COSTA RICA EARTHQUAKE OF JAN. 7			
				cm./sec.[2]	*cm.*
9½° N., 83° W., Costa Rica	San Jose, 80 miles NW. 340°	1st floor		19	0.028
		PERU EARTHQUAKE OF FEB. 15			
12° S., 77½° W., near coast of Peru.	Lima, 30 miles E. 90°	1st floor		29	
		SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 22			
35°03′ N., 119°08.5′ W., north of Wheeler Ridge.	Taft, 20 miles NW. 350°	Underground tunnel.		17	0.047
		NORTHERN CALIFORNIA EARTHQUAKE OF MAY 24			
36°49′ N., 121°28′ W., 5 miles SW. of Hollister, V.*	Hollister, 4 miles NE. 51°	Basement	V	3	0.007
		SOUTHERN CALIFORNIA EARTHQUAKE OF JUNE 13			
32°50′ N., 115°40′ W., near Imperial, VII.*	El Centro, 7 miles SE. 162°	Subbasement	VI	44	0.049
		GUATEMALA EARTHQUAKE OF AUG. 24			
14½° N., 91° W., Guatemala	Guatemala City, 10 miles SE. 135°	Basement		11	0.066
		CHILE EARTHQUAKE OF SEPT. 4			
32° S., 71° W., near coast of central Chile, VI.*	Santiago, 100 miles SW. 196°	Basement		17	0.007
		NORTHERN CALIFORNIA EARTHQUAKE OF OCT. 8			
40°19′ N., 124°25′ W., Ferndale	Ferndale, 19 miles NE. 24°	1st floor		18	0.010
		SOUTHERN CALIFORNIA EARTHQUAKE OF DEC. 15			
35°13′ N., 118° 49′ W., near Arvin, V.*	Arvin, 1 mile SE. 137°	CDM [3]	V	59 63	0.086 .23

[1] Position of station in respect to epicenter.

[2] Reported intensity of earthquake at recording station.

[3] All displacement meter readings should be assumed as recorded maximum displacement and computed maximum acceleration.

*Following intensity designation in epicenter column, indicates maximum reported intensity of earthquake.

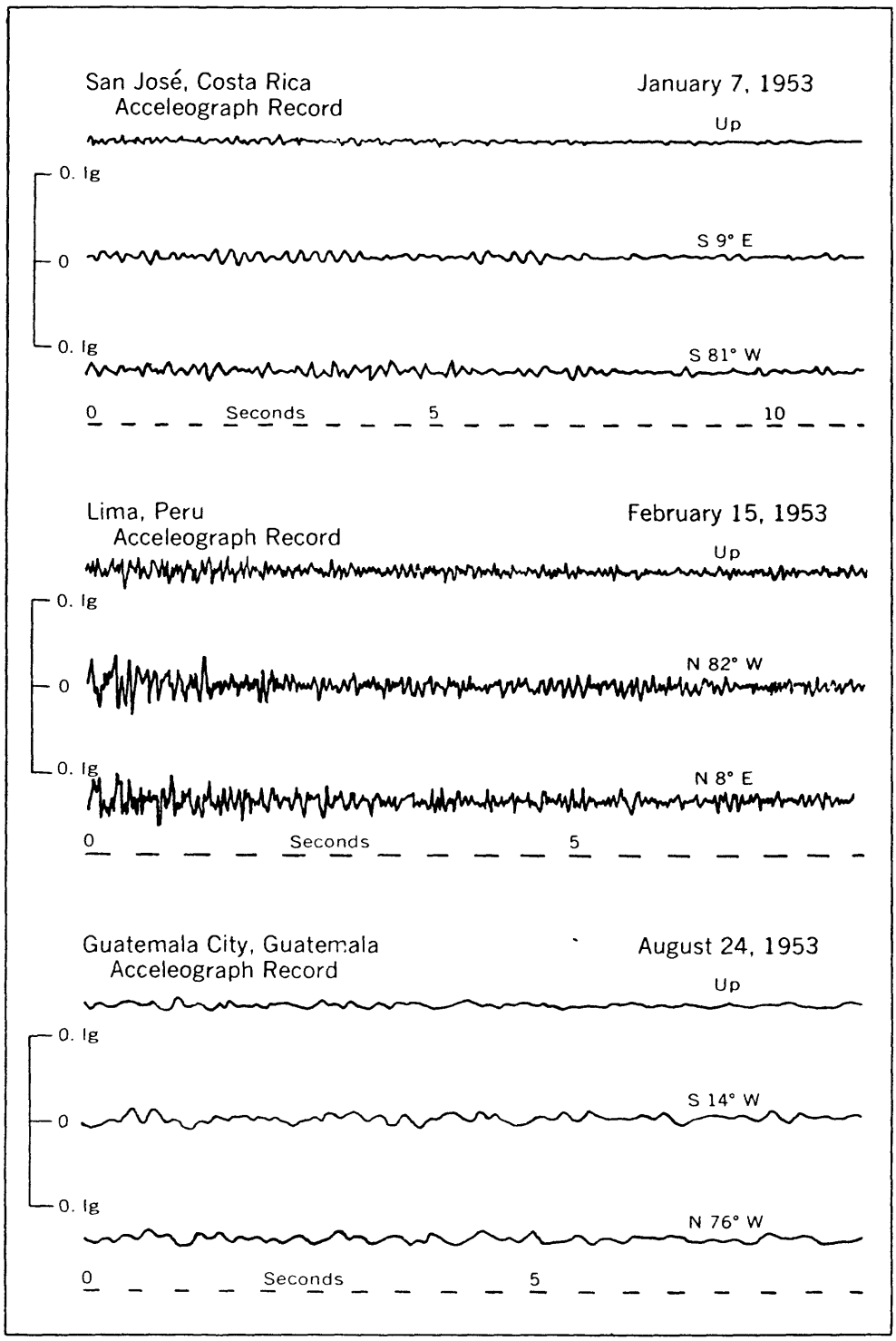

FIGURE 7.—Tracings of accelerograph records obtained at San Jose, Costa Rica, on January 7; at Lima, Peru, on February 15; at Guatemala City, Guatemala, on August 24.

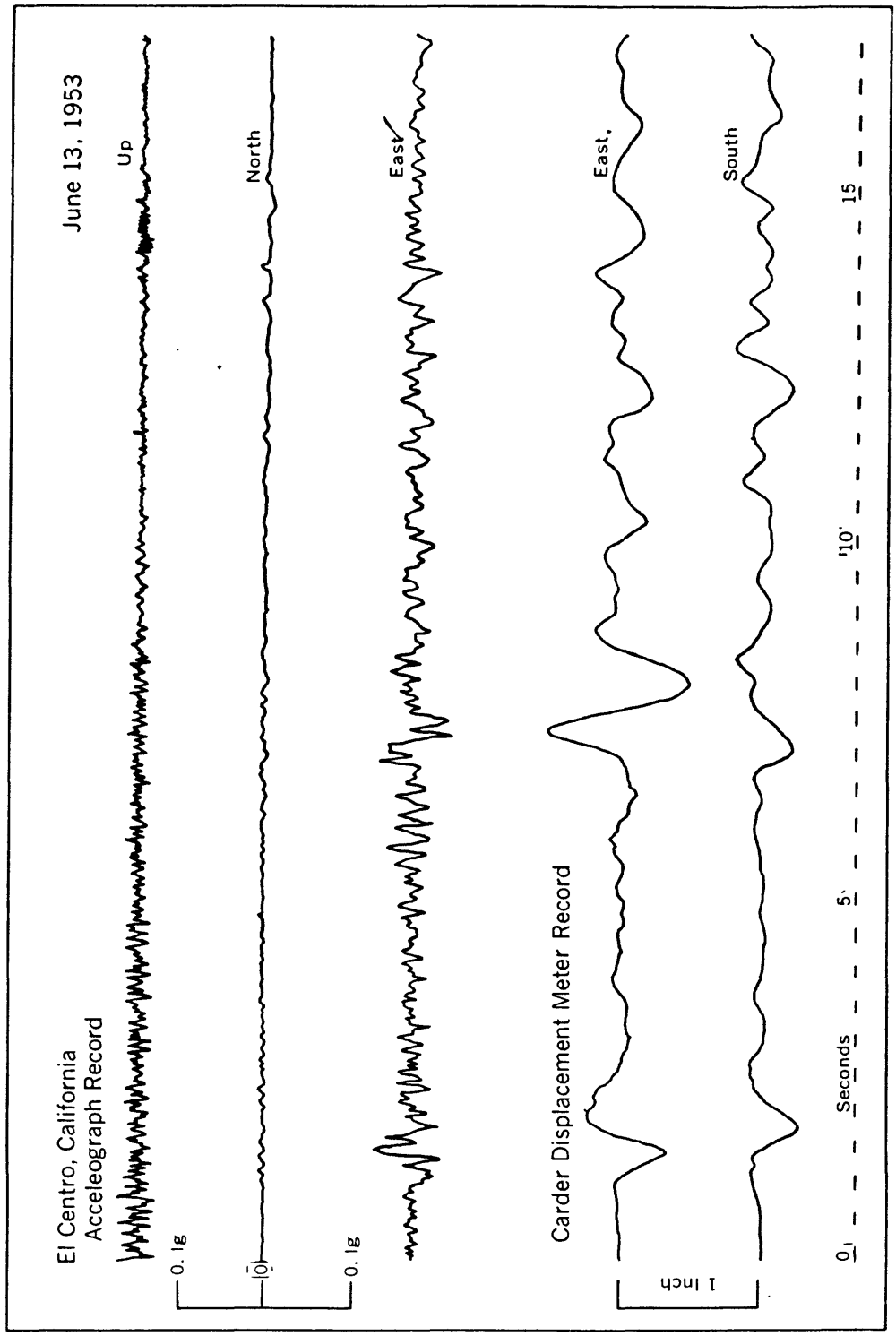

FIGURE 8.—Tracings of accelerograph and displacement meter records obtained at El Centro, Calif., on June 13.

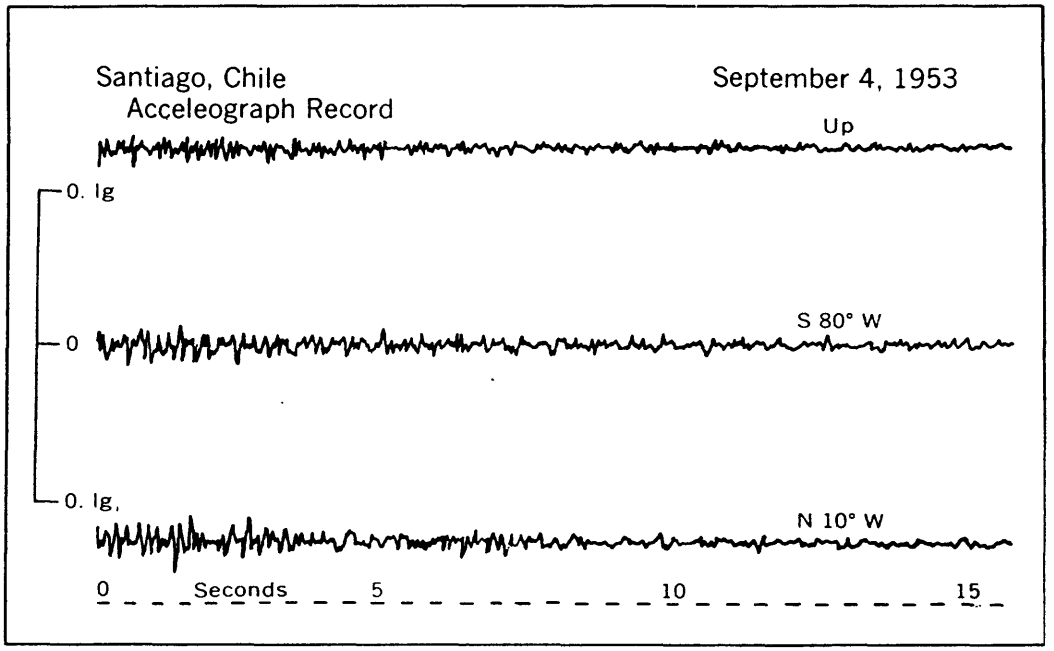

FIGURE 9.—Tracings of accelerograph record obtained at Santiago, Chile, on September 4.

TABLE 6.—*Composite of strong-motion instrumental data for 1953*

Station and component [1]	Instrument No.	T_0	V	Sensitivity [2]	ϵ	Earth wave period	Maximum acceleration	Maximum displacement	Remarks
		sec.		*cm.*		*sec.*	*cm/sec.²*	*cm.*	
COSTA RICA EARTHQUAKE OF JAN. 7									
San Jose accelerograph:									
Vertical-up	V-280	0.064	125	1.30	7	0.14	5	0.002	
SE. 171°	L-281	.064	125	1.30	8	.24	19	.028	
SW. 261°	T-282	.064	123	1.27	8	.18	9	.007	
PERU EARTHQUAKE OF FEB. 15									
Lima accelerograph:									
Vertical-up	V-286	0.064	123	1.3	8	0.07	13	----------	
NW. 278°	L-287	.063	124	1.3	8	.10	29	----------	
NE. 8°	T-288	.063	122	1.2	9	.10	23	----------	
SOUTHERN CALIFORNIA EARTHQUAKE OF MAR. 5									
Westwood accelerograph:									
Vertical-up	V-262	0.066	122	1.35	12	----------	----------	----------	No discernible trace motion.
S. 180°	L-263	.066	123	1.37	9	----------	----------	----------	Do.
W. 270°	T-264	.066	124	1.38	9	----------	----------	----------	Do.
SOUTHERN CALIFORNIA EARTHQUAKE OF MAY 22									
Taft accelerograph:									
Vertical-up	V-298	0.079	115	1.84	11	0.12	3	0.001	Recorder stopped after about 1 second.
NE. 21°	L-299	.080	122	1.99	9	.33	17	.047	
SE. 111°	T-300	.082	121	2.05	9	.2	12	.012	

See footnotes at end of table.

TABLE 6.—*Composite of strong-motion instrumental data for 1953*—Continued

NORTHERN CALIFORNIA EARTHQUAKE OF MAY 24

Station and component [1]	Instrument No.	T_0	V	Sensitivity [2]	ϵ	Earth wave period	Maximum acceleration	Maximum displacement	Remarks
		sec.		*cm.*		*sec.*	*cm/sec.²*	*cm.*	
Hollister accelerograph:									
Vertical-up	V-238	0.068	122	1.43	9	0.31	3	0.007	
SW. 181°	L-239	.066	124	1.36	7	.18	3	.002	
NW. 271°	T-240	.066	122	1.34	15	.19	3	.003	
Carder displacement meter:									
NW. 271°	5	2.52	.9		11				Very small amplitudes.
NE. 1°	6	2.32	1.1		10				Do.
SOUTHERN CALIFORNIA EARTHQUAKE OF JUNE 13									
El Centro accelerograph:									
Vertical-up	V-208	0.064	122	1.28	9	0.11	27	0.008	
N. 0°	L-206	.065	122	1.30	8	.16	10	.006	
E. 90°	T-207	.065	121	1.29	11	.21	44	.049	
Carder displacement meter:									
E. 90°	4	2.27	1.2		6	1.5	18	1.0	
S. 180°	3	2.30	1.1		8	1.4	10	.5	
GUATEMALA EARTHQUAKE OF AUG. 24									
Guatemala City accelerograph:									
Vertical-up	V-277	0.065	122	1.32	6	0.16	8	0.005	
SW. 194°	L-278	.065	121	1.29	10	.27	11	.020	
NW. 284°	T-279	.064	120	1.24	12	.51	10	.066	
CHILE EARTHQUAKE OF SEPT. 4									
Santiago accelerograph:									
Vertical-up	V-151	0.099	80	1.97	9	0.02	14	0.001	
SW. 260°	L-149	.099	82	2.02	8	.14	15	.007	
NW. 350°	T-150	.100	81	2.04	8	.08	17	.003	
NORTHERN CALIFORNIA EARTHQUAKE OF OCT. 8									
Ferndale accelerograph:									
Vertical-up	V-247	0.065	124	1.34	14	0.25	4	0.006	
SW. 224°	L-248	.067	125	1.41	10	.15	18	.010	
NW. 314°	T-249	.065	123	1.33	12	.15	8	.005	
Survey displacement meter:									
SE. 134°	13R	9.73			11				Max. displacement less than 0.1 cm.
SW. 224°	13L	10.20			10				Do.
SOUTHERN CALIFORNIA EARTHQUAKE OF DEC. 15									
Arvin accelerograph:									
Vertical-up	V-354	0.066	117	1.30	12	0.30	22	0.050	Short duration.
S. 180°	L-356	.067	120	1.37	6	.25	36	.057	Do.
NW. 270°	T-355	.065	122	1.30	6	.24	59	.086	Do.
Carder displacement meter:									
NW. 270°	2	2.09	1.4		18	.38	63	.23	Do.
N. 0°	1	2.19	1.4		17	.40	52	.21	Do.

[1] The quadrant is given first, then the pendulum direction corresponding to upward motion of the trace, the direction being measured in degrees from north around by east.

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

TILT OBSERVATIONS

Two tiltmeters at the University of California, Berkeley, were continued in operation.

CORRECTIONS TO PREVIOUS EDITIONS

Serial 773, United States Earthquakes, 1952. Page 5. Earthquakes Activity in the Various States. California: February 9, IV should read VI.

Serial 773, United States Earthquakes, 1952. Page 76. Seismogram illustrations, line 4, ratio of 1.6:1 and 2:2 should read 1.6:1 and 2:1, and line 5, November 22 should read November 21.

PUBLICATION NOTICE

To make immediately available the results of its activities the Coast and Geodetic Survey maintains mailing lists of persons and firms desiring to receive notices of the issuance of seismological publications. Should you desire to receive such notices, address your request to: Director, U. S. Coast and Geodetic Survey, Washington 25, D. C.

A list of seismological publications of the Coast and Geodetic Survey is available upon request to the above address.