

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

United States Earthquakes, 1967

By

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and

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# Introduction

This publication, issued by the National Earthquake Information Center of the Coast and Geodetic Survey, is a summary of earthquake activity in the United States and regions under its jurisdiction for the calendar year 1967. The sources of non-instrumental information used in the compilation include the U.S. Weather Bureau whose observers prepare periodic reports on local seismic activity; telegraphic information collected by Science Service, Washington, D.C.; bulletins of the Seismological Society of America; special reports of various institutions; newspaper clippings; and reports from interested individuals. Instrumental data used in locating earthquakes are obtained from the seismological observatories listed on page 61, and from other cooperating seismological stations located throughout the United States.

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

## EARTHQUAKE INFORMATION SERVICES

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

The first new service from the Center was an expanded earthquake reporting system that provides accurate and rapid hypocenter locations and magnitude values to the press and other interested parties. These results are available within 2 to 3 hours for earthquakes of magnitude  $6\frac{1}{2}$  or larger, with smaller events treated on request or on receipt of a press report.

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

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

and individuals desiring earthquake information.

The Coast and Geodetic Survey maintains the 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 general effects, damage, and felt area are enumerated in the quarterly *Abstracts of Earthquake Reports for the United States*. Active cooperation in this work is received from the University of California Seismographic Station at Berkeley, the Seismological Laboratory at Pasadena, and from state collaborators in seismology. The following collaborators served as agents of the Coast and Geodetic Survey in their respective states during 1967:

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

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

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

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

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

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

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

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

Among the commercial agencies on the West Coast rendering valuable services are telephone, power, oil, railroad, and insurance companies. Certain concerns interested in the manufacture of earthquake-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 headquarters at St. Louis University collects information in the central Mississippi Valley area (Rev. Dr. Victor J. Blum, S. J., Dean of the Institute of Technology). The Northeastern

Seismological Association at Weston College, Weston, Mass., (Rev. Daniel J. Linehan, S. J., in charge) undertakes similar work in the Northeastern States. Additional information is furnished by Mr. Berlen C. Moneymaker, Chief Geologist, Tennessee Valley Authority, Knoxville, Tenn., for earthquakes in the State of Tennessee, and Dr. Gerald R. McCarthy, Department of Geology, University of North Carolina, Chapel Hill, N.C., for earthquakes in the State of North Carolina.

## EPICENTER MAPS

Figure 1 is designed to show the existence of destructive and near-destructive earthquakes in the United States through 1967. In the 1963 revision of *Earthquake History of the United States, Part I*, the epicenters of several historical earthquakes (mostly in the Northeastern United States) were shifted slightly as result of the availability of more reliable information. Figure 1 has been plotted using this revised material. The smallest dot indicates the shock was strong enough to overthrow chimneys, or to affect an area of more than 25,000 square miles (intensity VII to VIII); the largest solid dot may be associated with shocks usually perceptible over more than 150,000 square miles (intensity VIII to IX); the smaller encircled dot represents an affected area greater than 500,000 square miles (intensity IX to X); the larger encircled dot represents an affected area usually greater than 1,000,000 square miles (intensity X to XII). Some of the most prominent historical earthquakes displayed in figure 1 are listed on page 4.

Figure 2 shows earthquake distribution in the United States during 1967. 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. Earthquakes in the California area are plotted when felt reports are received from several towns. Feeble earthquakes, and minor aftershocks of large earthquakes, are not

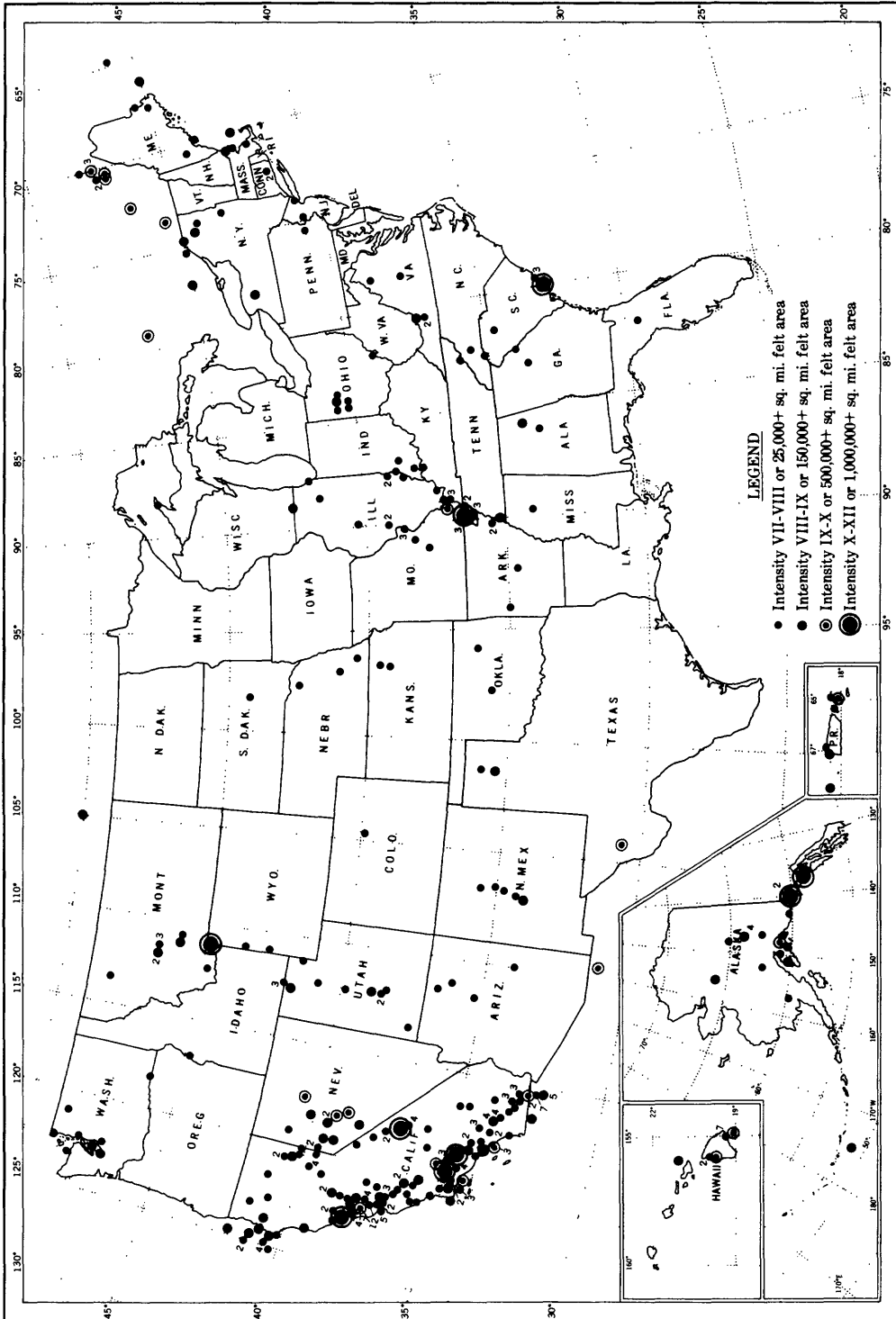


FIGURE 1.—Destructive and near-destructive earthquakes in the United States through 1967.

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

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



- V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale)
- VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale)
- VII. Everybody runs outdoors. Damage *negligible* in buildings of good design and construction; *slight to moderate* in well-built ordinary structures; *considerable* in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale)
- VIII. Damage *slight* in specially designed structures; *considerable* in ordinary, substantial buildings, with partial collapse; *great* in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX- Rossi-Forel Scale)
- IX. Damage *considerable* in specially designed structures; well-designed frame structures thrown out of plumb; *great* in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale)
- X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with their foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)
- XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
- XII. Damage *total*. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

### STRONG-MOTION SEISMOGRAPH ACTIVITIES

The maintenance of a network of strong-motion seismographs and the analysis of the records of destructive earthquake motions thus obtained are functions of the Coast and Geodetic Survey in connection with a broad, cooperative research program being conducted on the Pacific Coast with several local organizations and institutions interested in the engineering aspects of the earthquake problem. More details concerning this subject may be found on page 71, "Strong-Motion Seismograph Results." In table 3 of this section a list of the strong-motion stations now in operation is presented, and their locations are shown in figures 17 and 18 (excluding Connecticut and those located outside the United States).

The preliminary analyses of strong-motion records are published in the *Quarterly Engineering Seismology Bulletin* which is issued on mailing list CGS-5. The revised analyses are given in tables 5 and 6.

### EARTHQUAKE HISTORY

A history of the more important shocks of the country appears in Publication No. 41-1, *Earthquake History of the United States*. Part I, revised 1963 edition, includes stronger earthquakes of the United States, exclusive of California and western Nevada;

shown on this epicenter map. The numeral 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 for data on additional shocks.

The selection of isoseismal or "felt area" maps (figs 3-12) is governed largely by the size of the area affected, the minimum radius generally being about 50 miles. This means that in the case of sharp localized shocks, 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 States) will sometimes be shown. Felt and nonfelt reports from various towns are designated on the maps by open and solid circles, respectively. Intensities higher, or lower, than those in the isoseismal zone are frequently noted and are indicated by small numerals above the circles.

### TELESEISMIC RESULTS

The seismological observatories for which the Survey publishes results are listed on page 61 and their locations are shown in figure 13. During the year, the locations of 4889 epicenters were announced promptly on the *Preliminary Determination of Epicenters* cards. Those desiring to receive these cards should request addition of their names to the PDE mailing list. All seismogram interpretations are published in the monthly *Seismological Bulletin*, MSI-313 through MSI-324. These are available on the CGS-7 mailing list.

### MAGNITUDE AND INTENSITY RATINGS

Magnitude rating, stated according to the Gutenberg-Richter scale, is a measure of the energy release at the focus of an earth-

quake. It is estimated by the analysis of seismograph records as explained in the *Bulletin of the Seismological Society of America*, vol. 32, No. 3, 1942. Intensity rating, expressed on the Modified Mercalli Intensity Scale of 1931 (*see* next section), is a local measure of the effects on people and objects. It is a result of many factors, including energy release of the earthquake, distance from the epicenter, geological and topographic conditions, and structural properties of buildings. Magnitude and intensity ratings are not simply comparable.

### MODIFIED MERCALLI INTENSITY SCALE OF 1931

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

- I. Not felt except by a very few under specially favorable circumstances. (I Rossi-Forel Scale)
- II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale)
- III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale)
- 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)

<sup>1</sup> Harry O. Wood and Frank Neumann, in *Bulletin of the Seismological Society of America*, vol. 21, No. 4, December 1931.

Part II, revised 1963 edition, covers the stronger earthquakes of California and western Nevada.

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

ing 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 Special Publication 282, *Earthquake Investigation in the United States*, revised 1964 edition. A list of the active teleseismic stations, including independent and privately owned stations, is given in this report. Publication 41-1 (Parts I and II) and S.P. 282 are available from the Superintendent of Documents, Government Printing Office, Washington D.C. 20402.

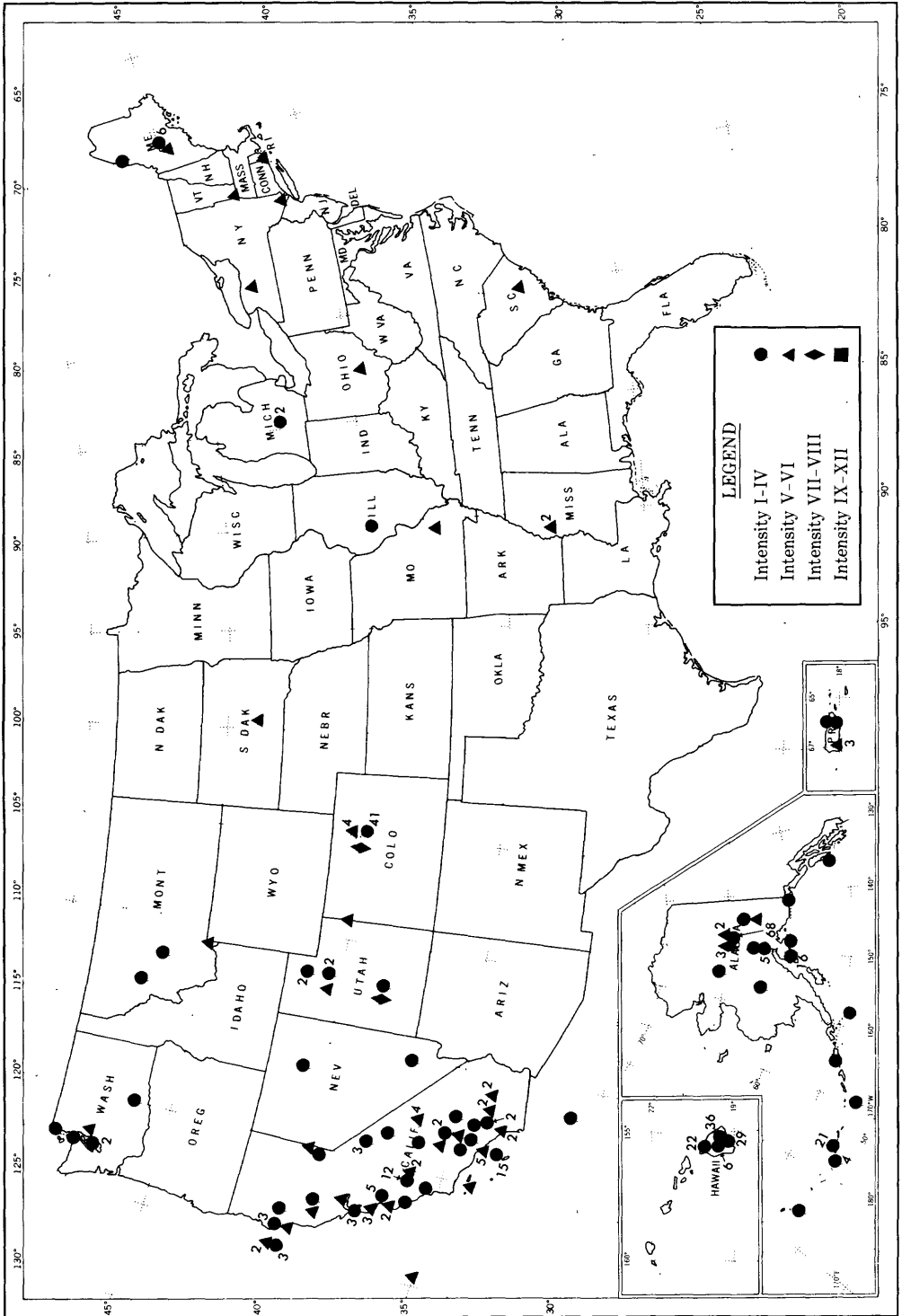


Figure 2.—United States earthquake epicenters for 1967.

# Summary of Earthquake Reports

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

Magnitude, as determined by the Rockville office, is  $m_B$  of Gutenberg-Richter and computed from the *P* phase only. The magnitude quoted is an average value determined from data forwarded by cooperative standard stations and other observatories.

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

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

## EARTHQUAKE ACTIVITY IN THE VARIOUS STATES

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

*Alaska*: (Intensity V and above). Feb. 6, V; June 20, VI; 21, VII (many aftershocks); 23, VI.

*Arkansas*: Felt Mississippi earthquake of June 4, V.

*California*: (Intensity VI and above). May 21, VI; June 14, VI; 26, VI; July 22, VI; Sept. 7, VI; 28, VI; Dec. 10, VI; 18, VI.

*Colorado*: Feb. 2(2), V; 14, V; 21; April 10, VI; 10 (13); 11 (2); 12; 22; 27, VI; 27; 28; May 11; June 19 (2); July 11; Aug. 9, VII; 9 (4); 11 (2); 12; felt Utah earthquake of Oct. 4, IV; Oct. 24; 25; 28; Nov. 14 (2); 15, V; 25; 26, VI; 26 (2); Dec. 8.

*Connecticut*: Felt New York earthquake of Nov. 22, IV.

*Hawaii*: Jan. 6; 10 (2); 22; 23; 24; 26 (2); Feb. 1 (2); 3; 7; 8; 12; 16 (2); Mar. 9; 10; 14; 22; 23; 24; 27 (2); April 6; 7; 20; May 3 (2); 13; 15; 19; 21; 24 (3); 25 (2); 26; June 8; 9 (4); 13; 24; 30; July 1; 2 (2); 5; 9 (2); 11; 21; 22; Aug. 3; 4; 5; 14 (2); 17 (3); 18 (2); 21; 27; 31; Sept. 2; 6; 8; 19; 23; 24 (2); 25; 26; 28; Oct. 9; 12; 15; 17; 27; 29; 30; 31; Nov. 3; 5; 19; 26; Dec. 7; 8.

*Illinois*: Felt Missouri earthquake of July 21, IV.

*Louisiana*: Felt Mississippi earthquake of June 4, V.

*Maine*: April 28, IV; July 1, V (2); 1(5).  
*Michigan*: Feb. 2, IV.

*Mississippi*: June 4, VI; 29, V.

*Missouri*: July 21, VI.

*Montana*: Jan. 10, V; 22, IV; Feb. 3; 28.

*Nebraska*: Felt South Dakota earthquake of Nov. 23, IV.

*Nevada*: Jan. 7, IV; Mar. 2, IV; May 7.

*New York*: June 13, VI; Nov. 22, V.

*Ohio*: April 8, V.

*Rhode Island*: Feb. 2, V.

*South Carolina*: Oct. 23, V.

*South Dakota*: Nov. 23, V.

*Tennessee*: Felt Mississippi earthquake of June 4, I-III.

*Utah*: Mar. 4, IV; 9 (2), IV; felt Nevada earthquake of May 7, IV; Sept. 23, (2), V; Oct. 4, VII; 4, IV; Dec. 7.

*Washington*: Jan. 17, IV; Feb. 13; Mar. 6, V; May 15; 25; Dec. 19.

*Wyoming*: Felt Colorado earthquake of Nov. 26, IV.

## EARTHQUAKE ACTIVITY OUTSIDE THE UNITED STATES

*Panama Canal Zone*: June 16, II; 23, I; Sept. 5, II; Dec. 26, I.

*Puerto Rico*: Feb. 1, V; 3, V; 13, V; Aug. 29; 30; Oct. 18.

*Virgin Islands*: Aug. 18.

## NORTHEASTERN REGION

[75th Meridian or Eastern Standard Time]

February 2: 08:40:09\*. Epicenter 41.4° north, 71.4° west, Narragansett Bay area, R.I., NESA. Magnitude 2.4. V. Felt over approximately 350 square miles of the Narragansett Bay area. Many were frightened at Middletown, Newport, and North Kingstown, but no damage was sustained. Intensity IV at Jamestown; intensity I-III at Adamsville.

April 28: 07:23:31.7\*. Epicenter 46.3° north, 67.9° west, west of Monticello, Me., NESA. Intensity IV at Monticello.

June 13: 14:08:54.4\*. Epicenter 42.9° north, 78.2° west, New York, W. Magnitude 3.9. VI. Felt generally over an area of approximately 3,000 square miles of western New York (see fig. 3). Slight damage to plaster and ceiling was sustained at Attica and Alabama.

### INTENSITY VI:

Alabama.—Felt by and frightened many.

Five rows of ceiling tile fell in the church sanctuary; damage slight in homes. Furniture shifted. Loud earth noises. "Sound resembled a sonic boom; many thought their furnaces had exploded. Some people neither felt nor heard the shock."

Attica.—Felt by and frightened all in community. Chimneys cracked, plaster fell, and vehicles rocked. Fluorescent light fixtures were damaged slightly. Moderately loud, thunderous earth noises.

### INTENSITY V:

Batavia.

### INTENSITY IV:

Albion, Arcade, Brockport, Buffalo, Gowanda, LeRoy, Pike, Springville, Varysburg, and Warsaw.

### INTENSITY I-III:

Depew, Elma, Lockport, Medina, North Tonawanda, and Pavilion. Reported felt by the press with no details: Akron, Alden, Cheektowaga, Clarence, East Aurora, East Concord, Hamburg, Kensington, Lancaster, Orchard Park, Tonawanda, and Wales Center.

July 1: 09:09:07\*, 10:33:32\*, 10:55:58.2\*, 11:00:42\*, 11:05:40.2\* (main shock), 11:11:18.9\*, 11:19:32.6\*. Epicenter of first, second, and fourth shocks, 44.9° north, 69.9° west, Maine, NESA; of third, fifth, sixth, and seventh shocks, 44°23' north, 69°52' west, Maine, NESA. Magnitudes 3.2, 3.2, 3.3, 2.9, 3.8, 3.5, and 2.9, respectively. V. The press reported at least six shocks, four of them noticeable, shook the Augusta and Kennebec Valley areas, but there was no damage. The strongest shock, at 11:05, was accompanied by a loud booming noise. Intensity V effects were noted at Manchester (09:09 and 11:05) and Wayne (09:09); intensity IV at Augusta (11:05), Belgrade (09:09 and others), Livermore (11:05), Oakland (10:55), Readfield (09:09 and others), Skowhegan (13:30, probably incorrect time), Vassalboro (11:05), Waterville (11:05 and others), Windslow (11:05), and Winthrop (09:09 and others); intensity I-III at Canton (10:33),

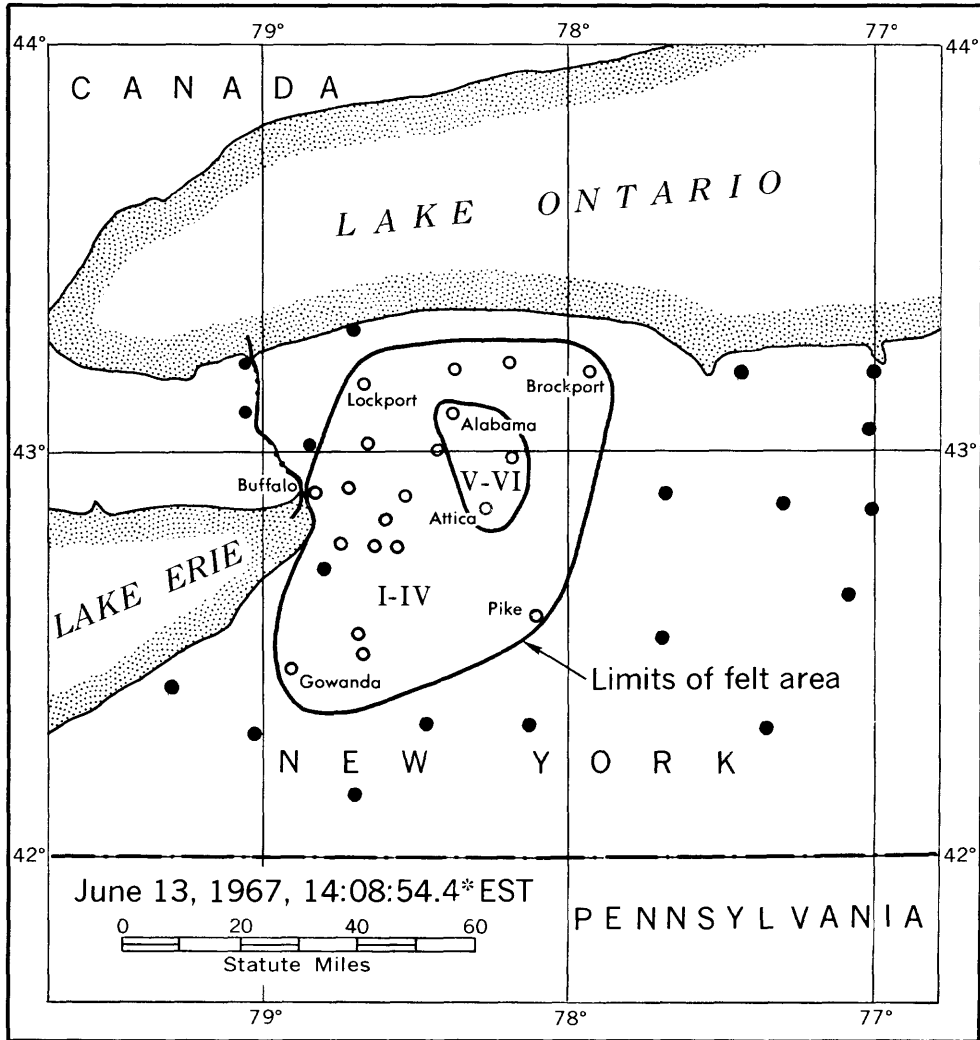


FIGURE 3.—Area affected by New York earthquake of June 13.

Farmington (11:05), and Windsor (11:05). The main shock at 11:05 was reported felt with no details at Auburn, Belgrade Lakes, Hallowell, Lewiston, Livermore Falls, Mercer, New Sharon, Norridgewock, North Monmouth, Turner, Vienna, and Wilton.

November 22: 17:10. Westchester County, N.Y. V. Felt over an area of about 400 square miles in Westchester and Rockland Counties, N.Y., and Greenwich and Stamford Counties, Conn. No damage was sustained. Intensity V effects were reported in New York at Ardsley, Chappaqua, Mount Pleasant, and

Tarrytown; intensity IV at Hartsdale, Hawthorne, Larchmont, New Rochelle, Ossining, Port Chester, Scarsdale, Tuckahoe, Valley Cottage, and White Plains, N.Y., and Cos Cob, Conn.; intensity I-III at Dobbs Ferry, New Castle, Nyack, and Peekskill, N.Y., and Greenwich and Stamford, Conn.

#### EASTERN REGION

[75th Meridian or Eastern Standard Time]

April 8: 00:40:32.3\*. Epicenter 39.6° north, 82.5° west, Ohio, W. Magnitude 4.2.

V. Felt over approximately 4,000 square miles of central and southeastern Ohio. The felt area extended from the Columbus and Sunbury areas southeast to Newark, Hebron, Lancaster, and Athens. In the central section of Columbus, four groundline windows were broken and minor plaster cracks were observed in an apartment house. Intensity V effects were also noted at Hebron and Lancaster; intensity IV at Athens (northwest of), Bexley, Logan, Newark, Pleasantville, and Sunbury.

October 23: 04:04:10\*. Epicenter 33.4° north, 80.7° west, South Carolina, W. Magnitude 3.8. V. Felt principally in the Charleston-Summerville area. Press reports stated that chunks of marl were found on the bottom of the circular drains of an underground sewage system being dug in Charleston. The same occurrence, however, was noted in mid-August and could not be connected with an earthquake at that time. Intensity V at Goose Creek where all in the community were awakened; intensity IV at Columbia, Cottageville, and Ridgeville (Givhans area, Rural Routes 2 and 3).

### CENTRAL REGION

[90th Meridian or Central Standard Time]

February 2: 00:30. Intensity IV at Lansing, Mich. Two shocks were reported, one at the time given above.

June 4: 10:14:13.6\*. Epicenter 33.6° north, 90.9° west, about 18 miles northeast of Greenville, Miss., W. Magnitude 3.8. VI. Felt over approximately 25,000 square miles of Arkansas, Louisiana, Mississippi, and Tennessee (see fig. 4). A letter from the Associate Director, School of Engineering, University of Mississippi, indicated that a few cases of cracked plaster were reported, and that one person (near the epicenter) noticed a crack about  $\frac{1}{4}$  to  $\frac{1}{2}$  inch wide and 39 feet long in his lawn.

#### INTENSITY V IN MISSISSIPPI:

Benoit, Cleveland, Greenville, Hollandale, Indianola, Kosciusko, Leland, Moorhead, Shaw, Shelby, Tchula, Utica, and Yazoo City.

#### INTENSITY V IN ARKANSAS:

Halley (2½ miles east of), Helena, and McGehee.

#### INTENSITY V IN LOUISIANA:

Darnell and Oak Grove.

#### INTENSITY IV IN MISSISSIPPI:

Charleston, Coffeeville, Coldwater, Farrell, Grenada, Hernando, Itta Bena, Lake Cormorant, Marks, Minter City, Raymond, Ripley, Rolling Fork, Satartia, and Senatobia.

#### INTENSITY IV IN ARKANSAS:

Barton, De Witt, Dumas, Eudora, Hamburg, Hughes, Lake Village, Marianna, Marvel, Rison, Warren, Watson, and Wilmot.

#### INTENSITY IV IN LOUISIANA:

Lake Providence and Tallulah.

#### INTENSITY I-III IN MISSISSIPPI:

Canton, Clarksdale, Le Flore, Port Gibson, Thornton, University, and Water Valley.

#### INTENSITY I-III IN ARKANSAS:

Forrest City, Gillett, and Star City.

#### INTENSITY I-III IN LOUISIANA:

Bonita, and Kilbourne.

#### INTENSITY I-III IN TENNESSEE:

Capleville and Memphis.

June 29: 07:57:07\*. Epicenter 33.6° north, 90.9° west, about 18 miles northeast of Greenville, Miss., W. Magnitude 3.4. V. Felt over a small area of Bolivar, Sunflower, and Washington Counties. Felt by all at Shaw, where small objects overturned and fell; intensity IV at Cleveland, Courtland, Greenville, Hollandale, Indianola, Leland, Scott, Stoneville, and Water Valley; intensity I-III at Oxford.

July 21: 03:14:48.9\*. Epicenter 37.5° north, 90.4° west, Missouri, JSA. Magnitude 3.9. VI. Felt over a considerable area of southeastern Missouri and southern Illinois. Plaster fell at Poplar Bluff, Mo.; some plaster cracked at Elvins and Fredericktown, Mo. Questionnaire canvass conducted by the Jesuit



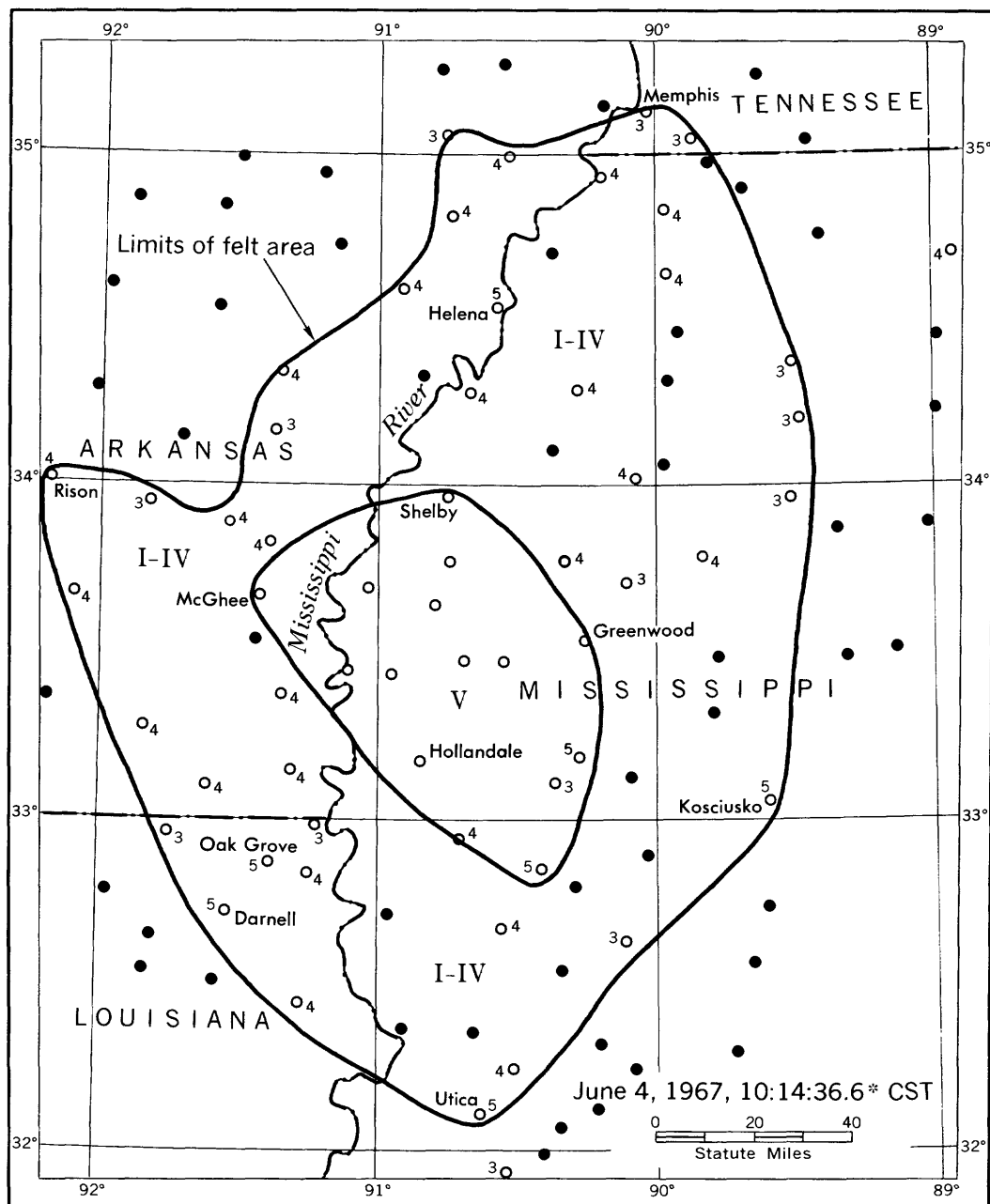


FIGURE 4.—Area affected by Mississippi earthquake of June 4.

Seismological Association (JSA), St. Louis, Mo.

INTENSITY VI IN MISSOURI:

Poplar Bluff.—Plaster fell from ceiling of court house.

INTENSITY V IN MISSOURI:

Arcadia, Courtois, Elvins, Fredericktown, Jerome, and Patton.

INTENSITY IV IN MISSOURI:

Advance, Altenburg, Alton, Annapolis,

Arbyrd, Barnhart, Belgique, Belleview, Bertrand, Black, Bonne Terre, Boss, Brazeau, Broseley, Carter, Cedar Hill, Commerce, Conran, Crystal City, Cuba, Des Arc, Desloge, Dexter, Ellington, Farmington, Farrar, Festus, Flat River, Friedheim, Frohna, Gordonville, Grandin, Greenville, Hayden, Illmo, Iron Mountain, Ironton, Knob Lick, Leora, Lodi, Lonedell, Lutesville, Malden, Marble Hill, Minnith, Moselle, Naylor, New Offenburg, New Wells, Old Appleton, Parma, Patterson, Piedmont, Pocahontas, Potosi, Rolla, Saint Albans, Saint Clair, Saint Louis, Scott City, Sedgewickville, Silva, Stanton, Sturdivant, Thomasville, Uniontown, Van Buren, Vanduser, Washington, Weingarten, Whiteoak, Williamsville, Wittenberg, and Zalma.

#### INTENSITY IV IN ILLINOIS:

Cairo, Campbell Hill, Carbondale, Chester, Dongola, Jonesboro, Maestown, Makanda, Millcreek, Murphysboro, Renault, Thebes, Tilden, Welge, and Wolf Lake. (Towns noting intensity I-III effects are not listed here. They may be found in *Abstracts of Earthquake Reports of the United States*, 3rd quarter, 1967.)

August 5: 06:37:31.5\*. Epicenter 38.3° north, 90.6° west, Missouri, JSA. Reported felt and heard in Saint Louis County.

November 23: 00:23:38.6\*. Epicenter 43.7° north, 99.4° west, South Dakota, W. Magnitude 4.4. V. Felt over a small area of southern South Dakota and northern Nebraska. Press reports indicated that houses shook and dishes fell from shelves in the Winner-Rosebud-White River areas. Many residents were frightened at Gregory, S. Dak., where furniture shifted and windows cracked slightly. Livestock stampeded through fences on some farms. Intensity IV at Colome and White River, S. Dak., and Dunning, Nebr.; intensity I-III at Carder, Chamberlain, Martin, Mission, and Stephan, S. Dak., and Ainsworth, Nebr. One isolated report stated the shock was felt by few at Douglas, Wyo.

#### WESTERN MOUNTAIN REGION

[105th Meridian or Mountain Standard Time]

January 7: 17:45 (about). Intensity IV at Tuscarora, Nev. "May have resulted from a minor local adjustment in old mine tunnels."

January 10: 04:52:53.4\*. Epicenter 45.0° north, 111.5° west, Montana, W. Magnitude 3.8. V. Awakened all in home at Hebgen Dam; felt by several. Windows, doors, and dishes rattled; loud earth noises 3 to 4 seconds before shock. Motion rapid.

January 22: Between 02:00 and 03:00. Intensity IV at Greenough, Mont.

February 2: 22:27:58\*, 22:34. Epicenter 39.7° north, 104.8° west, Colorado, W. Magnitude 4.3. V. Two heavy jars frightened many at Commerce City; few awakened. Crack in house lengthened ¼ inch. Intensity V also reported at Adams City, Brighton, Dupont, Louisville, Northglenn, Rocky Mountain Arsenal, Thompson, and Welby; intensity IV at Denver.

February 3: 13:25. Porcupine, Mont. Teacher and student at school felt vibrations which they thought may have been an earthquake.

February 14: 20:28:03.5\*. Epicenter 40.1° north, 109.1° west, Colorado, W. Magnitude 4.4. V. Felt by all in community of Rangely. Windows and doors rattled; buildings creaked.

February 21: 14:55. Intensity IV at Commerce City, Colo.

February 28: 12:52:48.9\*. Epicenter 46.6° north, 112.3° west, Montana, W. Intensity III at Helena.

March 4: 22:40:23.8\*. Epicenter 41.3° north, 111.7° west, Utah, W. Magnitude 3.5. Intensity IV at Weber Canyon and Ogden Canyon; intensity III at Huntsville.

March 9: 19:21, 22:34:58.5\*. Epicenter 40.8° north, 112.0° west, Utah, W. Magni-

tudes 2.5 and 3.0, respectively. Intensity IV at Salt Lake City.

April 10: 12:00:25.6\*. Epicenter 39.9° north, 104.8° west, Colorado, W. Magnitude 4.8. VI. Felt over an area of approximately 6,500 square miles. Slight damage, consisting of cracked plaster, broken windows, and damaged merchandise in stores, occurred in the Commerce City-Denver area. In northeast Denver at the Rocky Mountain Arsenal, 118 small windowpanes were broken. One observer reported cracks in the middle of an asphalt parking lot in the Derby area of Commerce City. Several aftershocks were noted.

#### INTENSITY VI:

Adams County Golf Course.—Ceiling beams were cracked in a building at the golf course, according to the press.

Adams City.—Felt by all in community; many were frightened. Windows, doors, and dishes rattled violently and small objects fell. Loud earth noises.

Arsenal (Rocky Mountain).—At the dispensary in the west part of the Arsenal, 118 small windowpanes were broken. The fire-house building shook and dishes and cups moved all around. Some firemen were frightened.

Boulder.—Cracks were sustained in the high school building and classes were dismissed.

Brighton (Adams County Jail).—A small section of the roof separated from the wall, allowing rain to seep in.

Commerce City.—Felt by and frightened many. Windows broke; water pipes broke in home and flooded basement apartment. Plaster cracked, broke, and fell. Stock in markets fell to floor. Loud earth noises.

Commerce City (Derby).—Felt by and frightened all; some panic. Two chimneys cracked; windows cracked. Small objects shifted, overturned, and fell. Trees and bushes shook; vehicles rocked. Cracks reported in parking lot, running in all directions, but observer was not sure all occurred during the shock.

Denver.—Felt strongly throughout the city; many were frightened. Windows and water pipe broke; large buildings shook strongly. Large chandeliers in the Capitol Building swayed alarmingly. Frightened legislators quickly moved from beneath them. Pictures fell from walls at the University of Denver; items fell from shelves in markets.

Dupont-Irondale area.—Strongly felt. Objects fell from shelves; one shelf fell to the floor. Pictures on walls turned in every direction; some fell to floor. Coffee in partially full cups spilled over table. Loud earth noises. Animals were very frightened.

Eastlake.—Felt by and frightened all in community. Trees and bushes shook; vehicles rocked. Furniture shifted. Loud earth noises.

Erie.—Felt by many and frightened few. Furniture shifted; windows, doors, and dishes rattled. Loud earth noises.

Golden.—Felt by many in community. Cracks opened in concrete deck; leaks in metal roof. Damage slight. Vehicles rocked. Animals were frightened.

Henderson.—Felt by and frightened many. Plaster cracked, broke, and fell; chimneys cracked. Small objects overturned and fell; damage moderate. Earth noises.

Lafayette.—Felt by all; few frightened. Plaster cracked; window broke. Small objects shifted. Moderate earth noises.

Lakeside.—“Lids and pans rattled; then came a terrible noise and the house started shaking.” Observer had to hold on to door to keep from falling. Everything was in commotion at once. A bottle fell out of cupboard; 2-gallon crock on drier moved 2 inches.

Lakewood.—Observer frightened. Pictures tilted on walls; bottle overturned. Floor creaked and groaned. “Seemed to be sliding off the bed and then realized feet and legs were shaking and vibrating.”

Northglenn.—Houses shook strongly. Loud rumbling earth noise. Observer on telephone dropped the phone and ran outside; house seemed to be sinking. Light on long chain swung about 2 inches east-west; planters on wall swayed north-south. Everything in house rocked.

Thornton.—Cement foundation cracked; brick along cement corner broke off. Glasses, books, and other objects fell from shelves. Houses shook strongly. Loud earth noises.

Welby.—Three trophies on wall fell in liquor store, one hitting bartender on head; glasses and bottles hit together hard. Crowns fell off the heads of two statues in chapel; three windows, about 8 feet apart, jarred open. Entire building strongly shaken.

Westminster.—Freshly raked soil around house was separated from the foundation leaving a visible crack. Possible slight cracks in building. Building shook strongly. Sharp, explosivelike booming noise.

#### INTENSITY V:

Arvada, Aurora, Barr Lake, Black Hawk, Brighton, Broomfield, Castle Rock, Coal Creek Canyon, Dacono, Dumont, East Portal, Eldorado Springs, Evergreen, Fort Lupton, Frederick, Green Mountain, Idaho Springs, Idledale, Jamestown, Louisville, Montebello, Mount Vernon Canyon, Nederland, Pinecliffe, Roggen, Silver Plume, and Ward.

#### INTENSITY IV:

Bennett area, Bergen Park, Berthoud, Bufalo, Central City, Empire, Firestone, Fort Logan, Georgetown, Hudson, Keenesburg, Kittredge, Littleton ( $\frac{1}{2}$  mile west of), Louviers, Loveland, Lyons, Mead, Milliken, Morrison, Niwot, Pine, Platteville (2 miles west of), Rollinsville (city center), Spivak, and Watkins.

#### INTENSITY I-III:

Agate, Allenspark (2 miles east of), Briggsdale, Greeley, Hygiene, Indian Hills, Johnstown, Longmont, and Pueblo.

April 10: 12:02, 12:08, 12:23, 12:26, 12:28, 12:37, 12:38, 13:08, 13:10, 13:38, 15:10, 17:00, 17:37. Denver, Colo., area. Aftershocks of earthquake at 12:00:25.6\*. The earthquake at 12:38 was intensity IV at Lakewood and Northglenn. Various of the remaining shocks (all intensity I-III) were felt at Arvada, Aurora, Brighton (about 2 miles south of), Broomfield (4 miles north-east of), Commerce City, Denver, Dupont-Irondale areas, Eldorado Springs, Erie,

Louisville, Montebello, Northglenn, Rocky Mountain Arsenal, Thornton, Welby, and Westminster.

April 11: 19:22, 22:40. Denver, Colo., area. Aftershocks of April 10 earthquake at 12:00:25.6\*. Press reports indicated the shocks were felt in the Denver area.

April 12: 02:48. Intensity IV at Commerce City, Colo. Also felt at Denver.

April 22: 19:35. Intensity IV in the Derby area of Commerce City. Also felt at Adams City, Denver (northeast section), Dupont, Northglenn and farmland to north, Thornton, and Welby. A rumble was heard at Lakewood and Spivak.

April 27: 10:24:42\*. Epicenter  $39.9^{\circ}$  north,  $104.7^{\circ}$  west, Colorado, W. Magnitude 4.4. VI. Walls and acoustical tile ceiling cracked at a school in Boulder; students were dismissed. Water in aquarium was disturbed at Commerce City; plaster cracked, small objects overturned, and nails pushed out in walls. Also felt at Golden and Longmont.

April 27: 23:43. Slight shock was felt at Commerce City and Lakewood.

April 28: 05:21. Intensity IV at Thornton, Colo. Also felt at Lakewood and Commerce City.

May 7: 11:01:36.1\*. Epicenter  $37.0^{\circ}$  north,  $115.0^{\circ}$  west, southern Nevada, W. Magnitude 4.7. Intensity IV at Gunlock, Utah. Also felt at Hiko, Nev. (III).

May 11: 18:58. Intensity IV at Commerce City, Colo. Also felt at Dupont, Irondale, Northglenn, and Thornton.

June 19: 08:39:22\*. Epicenter  $39.9^{\circ}$  north,  $104.8^{\circ}$  west, Colorado, W. Magnitude 2.9 (Colorado School of Mines). Intensity IV in the Derby area of Commerce City. Reported felt from 56th Avenue South to 112th Avenue North, and from about  $2\frac{1}{2}$  miles east of the Rocky Mountain Arsenal to about 1 mile west of the Platte River.

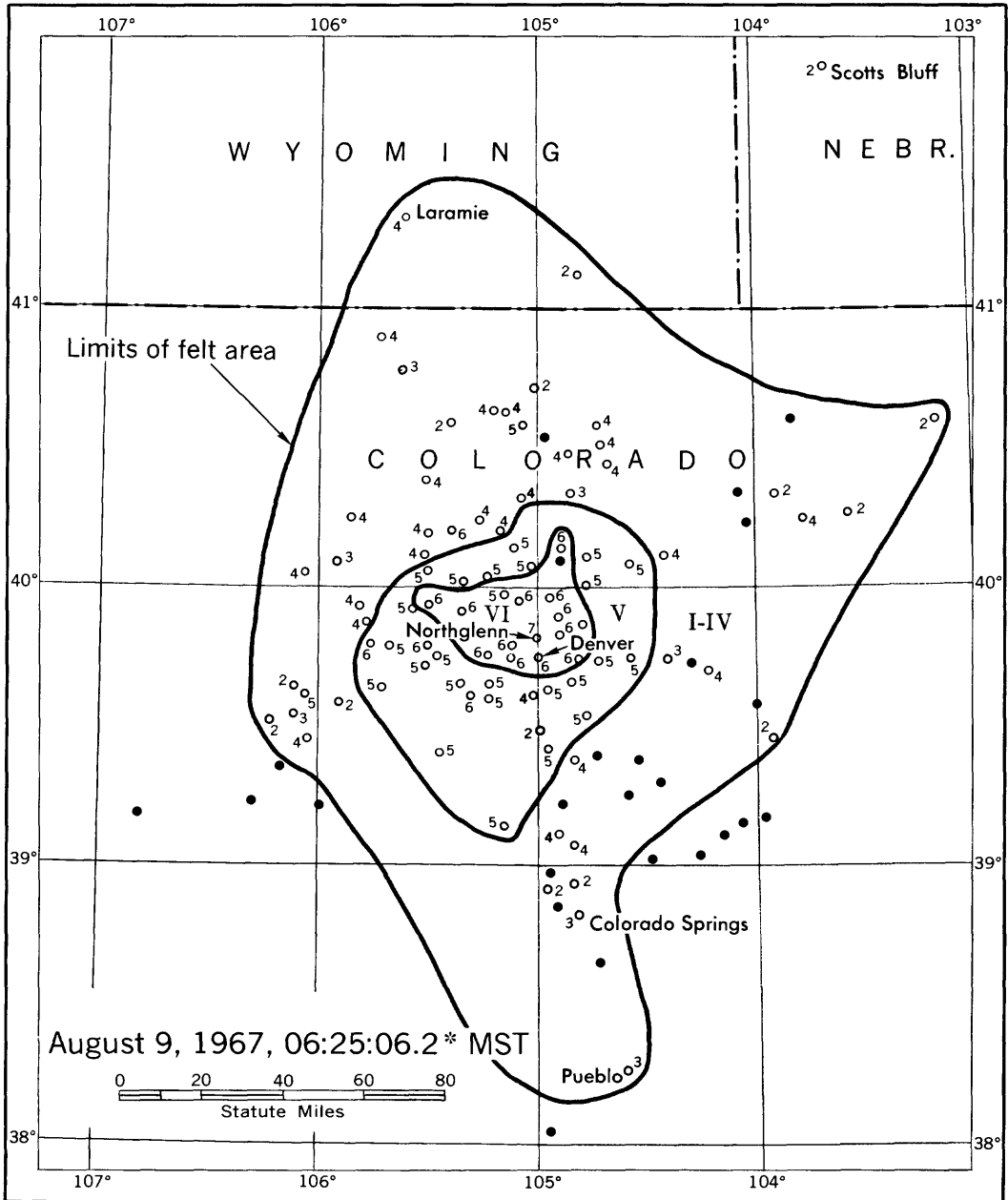


FIGURE 5.—Area affected by Colorado earthquake of August 9.

June 19: 10:47. Intensity II at Commerce City, Colo.

July 11: 18:45. Intensity III at Adams City and Commerce City, Colo.

August 9: 06:25:06.2\*. Epicenter 39.9°

north, 104.7° west, Denver, Colo., region, W. Magnitude 5.3. VII. To date, this is the strongest and most widely felt of the Denver series of shocks which began in April of 1962. The shock was felt over an area of approximately 15,000 square miles (see fig.

5). Principal damage occurred at Northglenn, a community in the northern suburbs of Denver, and consisted chiefly of broken windows, cracked plaster, and loss due to fallen merchandise in stores. Concrete pillars were damaged at a church, and acoustical tile fell at a school. One liquor store estimated damage at \$10,000 to \$12,000. At Commerce City, plate glass windows broke, and there was considerable loss due to fallen merchandise in stores. Bricks fell from a chimney in the downtown area of Denver, damaging an automobile. Officials reported that power failures, telephone services, and water mains were not affected, and there were no damages to highways. No injuries were reported.

#### INTENSITY VII IN COLORADO:

Northglenn.—Plate glass windows broke. Many homeowners reported walls and ceilings cracked. Several reported basement floors separated from walls. Numerous places of business sustained damage in varying amounts due to fallen merchandise; one reported a loss of \$10,000 to \$12,000. At a church, pillar supports to roof were damaged, and at least 20 windows were broken. Acoustical ceiling and light fixtures fell at school. One woman reported patio, sidewalk, and foundation cracks. Heavy objects moved; piano moved about 6 inches; television overturned. Many small objects shifted and fell in homes. Most reports indicated a north-south motion, with objects shifting and falling south. A light suspended on a chain swung north-south as far as it could go. Abrupt jolt and strong shaking from south. Extremely loud, explosivelike earth noises.

#### INTENSITY VI IN COLORADO:

Adams City.—Felt by all in community; awakened and frightened many. Window shade fell off house. Hanging objects swung violently. Pictures danced on walls. Cupboard doors jarred all the way out. Knickknacks twisted around. Trees and bushes shook. Abrupt, extremely hard shaking; loud earth noises.

Arvada.—Felt by all and awakened many

in community. Plaster, driveway, and windows cracked. Small objects shifted, overturned, and fell. Room was observed to vibrate rapidly back and forth. Loud rumble, then shaking; motion from east; duration about 5 seconds.

Aurora.—In the Aurora Hills area, plaster and mortar cracked. Rolling, swaying, and shaking motion. At the Fitzsimons General Hospital, car rocked east-west. Rumble from west.

Broomfield.—Felt by and awakened all in community; frightened many. Few bricks fell from chimney of old house; one window cracked slightly. House rocked very strongly. Animals were disturbed. Sharp, cracking sound; strong shaking.

Central City.—Felt by and awakened most in community; frightened many. Plaster fell. Small objects and furniture shifted. Building shuddered violently.

Coal Creek Canyon Road (between Golden and Boulder).—Boulder rolled down mountainside. Residents noted rumbling and shaking.

Commerce City.—Felt by all; awakened and frightened many. Few plate glass windows broke in stores. Cement wall and floor cracked slightly at one store. Bricks fell from chimney of old house. Few foundations slightly damaged. Plaster cracked. Considerable loss from fallen merchandise in stores. Some heavy furniture shifted; small objects fell (various directions) in many homes. Heavy shock, preceded by loud, roaring and booming earth noises; various directions of motion reported.

Denver.—Generally and sharply felt over the city, especially in the northern sections. Only a few instances of slight damage were reported. Some bricks fell from a chimney in the downtown area and damaged a car. At one place, small piece of plaster fell in basement; patio cracked. Merchandise fell and broke in some stores. Strong shaking of car felt by man while driving. Tall buildings swayed. House trailers rocked strongly; some people ran outside. Electric wires shook up

and down. Water in sink sloshed back and forth. Man in the north section of the city reported that 2 days before the shock, a powerline was observed to be touching the garage roof and that after the shock, the powerline was 6 inches above the roof. Loud, explosivelike earth noises. "Two good jolts; hard shaking at first, then rolling motion. More rumbling after first jolt. Long duration." "Two shocks, 06:25 to 06:26, which seemed to be one continuous shock. Rapid and abrupt onset; rapid, horizontal north-south motion with little vertical sensation."

Dupont.—Felt by and frightened all in community; awakened many. Man outdoors "almost went down on his knees." Felt as if the ground were spinning. Felt dizzy and nauseated. Wall bulged in. Building sounded as if it were being twisted. Small objects shifted and fell. Trees and bushes shook; vehicles rocked. Loud roar; duration 25 seconds.

Dupont (north of, farmland areas east and west of Platte River).—Strongly felt over the area. On 100th Avenue, west of Platte River, 30 or 40 windowpanes were broken at greenhouses. Damage about \$200. Few bricks fell from chimney. Full buckets of water emptied. On southeast corner of 104th Avenue and McKay Road, jars and cans fell; small objects fell and broke. Doors flew open. Coffee in cups splashed out to middle of floor. Brief jolt, then abrupt earth noise and shaking simultaneously. Direction east-west. On 112th Avenue and Highway 85, many were awakened. Lamp fell and broke; small objects fell. Roar and rumble. Not felt by person outdoors. On 114th Avenue, near Riverdale Road, west of Platte River, observers were very frightened. Visible movement of west wall. Dishes shifted and fell. Coffee splashed from cups. Terrific rumbling and cracking noise; motion south-north with east-west twist. At 120th Avenue and Riverdale Road, west of Platte River, plaster cracked. Stove moved about  $1\frac{1}{4}$  inches from south wall; refrigerator moved about 1 inch from west wall. Small objects shifted and fell.

Cabinet doors and drawers opened. Clotheslines outdoors whipped in all directions. Heavy jar and much shaking. On 124th Avenue, east of Platte River, on old Highway 85, observer thought walls would collapse. Small articles shifted. Rumble and prolonged banging noise; severe shaking.

Eastlake.—Felt by, awakened, and frightened all in community. Plaster cracked. Small objects overturned and fell; furniture shifted. Hanging objects swung violently. Trees and bushes shook; vehicles rocked. Loud earth noises.

Empire.—Felt by, awakened, and frightened many in community. Damage slight. Plaster cracked; putty cracked around door on east side. East side of post office building pulled away from the cement wall about  $\frac{1}{2}$  inch. Door on south side loosened and locks tightened, as if the building had been slightly twisted to the southwest; door on east side is now lower. Bricks have small cracks. New cement walks have cracks running north-south and one running east-west. Small objects shifted. Water disturbed. "We heard the roar and saw dishes, windows, and trees move."

Evergreen.—Felt by and awakened all; frightened few. Small objects shifted, overturned, and fell; furniture shifted; many books fell. Trees and bushes shook; vehicles rocked slightly. Man said he was almost shaken from bed. Abrupt jolt, then rumbling. Near Bear Creek, felt as if house were sliding down hill.

Firestone.—Felt by all and frightened few in community. Chair with man sitting in it moved north about 2 inches. Table, lamps, and shades shook.

Frederick.—Felt by and awakened all; frightened some. Standing person knocked back into chair. Silverware fell from cabinet to floor. Felt more like an up-and-down movement to persons lying down. Some rumble before shock; one thought furnace had exploded.

Golden.—Generally felt; some awakened.

Driveway cracked. House shook strongly; bed rocked. Moderate, rolling, and roaring sound.

Hazeltine Heights (farmland east of Platte River on old Highway 85, north of 104th Avenue, next to game bird farm).—Awakened two in home; child screamed. Objects fell in all directions. Horses very disturbed; dogs barked and ran around. At house next door, to the north, stairs pulled away from wall about  $\frac{1}{4}$  inch on north side of house; plaster blocks knocked out of stairway; small window cracked. Cups swung for 5 minutes after shock. Roaring noise awakened observers, then strong shaking from southeast. At 10401 Counter Road, paint chipped off ceiling. Pictures tilted; bottle fell. Felt as if house tilted and rolled to west. "Felt another tremor about 1:45 p.m."

Henderson and vicinity.—Felt by and frightened many. Damage slight. Plaster cracked. Fireplace moved out about  $\frac{1}{4}$  inch from wall. Merchandise fell and broke in store; small objects shifted and fell in homes (various directions); furniture shifted. Trees and bushes shook; vehicles rocked. Abrupt, loud, prolonged roar; both east-west and north-south directions indicated.

Irondale and vicinity.—Frightened observers. Several bricks fell from chimney. Walls bulged in and out. Small objects shifted and fell, mostly north-south; pictures fell off walls throughout house. Five-inch wave from west observed in swimming pool. Loud noise at first, then hard shaking.

Jamestown.—Felt by all in community; awakened and frightened many. Small objects shifted and fell; furniture shifted. Hanging objects swung moderately east-west. Loud earth noises.

Lafayette.—Felt by all in community; awakened and frightened many. Damage slight. Plaster cracked. Small objects shifted, overturned, and fell. Trees and bushes shook; vehicles rocked (man in parked car thought he had been hit). Loud earth noises, similar to sonic boom.

Lakewood.—Felt by many; awakened and frightened some. Cement driveway cracked.

Waves in swimming pool; water in aquarium sloshed back and forth. Trees shook. Bed rocked east-west. Observer had difficulty in standing and became dizzy and ill. Very loud earth noises.

Nederland.—Felt by and awakened many in community; frightened few. At Nederland Lake, a man sitting on log fishing said he was knocked off the log, and that he saw rocks roll down mountainside. Reported as the worst shock ever felt at Nederland. Everything rattled. Loud earth noises.

Pinecliffe.—Felt by and awakened all in community. Plaster cracked. Bushes shook. Heavy shaking. Moderate earth noises.

Rocky Mountain Arsenal and vicinity.—At the Public Information Center, about  $2\frac{1}{2}$  miles from 72d Avenue, plaster cracked. Coffee in cups splashed out onto table. Rolling north-south motion with two definite wave patterns. Loud rumble similar to train noise. Just north of the Rocky Mountain Arsenal, on Peoria Street, a wall cracked; plaster cracked and fell. Small objects fell. Heavy east-west shaking; duration seemed 2 minutes. One mile north of 104th Avenue and Tower Road, northeast of the Arsenal, observers were greatly frightened. Plaster cracked. Light fixture swung northeast-southwest. Rumble and heavy shaking. North of the Arsenal at 11841 96th Avenue, railroad ties, about 4 feet in the ground, quivered as if they were rubber. Water splashed from aquarium. Small objects fell in various directions. Light cord swung in circular motion. A number of other reports were received from the northeast, east, and southeast areas of the Arsenal, reporting intensities of IV to V. One observer, 5 miles northeast of the Arsenal, reported hard shaking indoors, but that the shock was not felt by anyone outdoors.

Thornton.—People were awakened and frightened. Considerable damage to merchandise in store. Corner of house loosened "again"—walls seem distorted. Small objects shifted and fell in homes; furniture shifted. Cupboard shelves fell. Gas tanks and car



shook; car rocked north-south. Clock weights swung north-south for 5 minutes after shock; bed rocked for 3 minutes. Loud earth noises, then hard shaking. Felt two aftershocks about 45 minutes later.

Welby.—Plaster badly cracked in old portion of church; plaster cracked in home. Observer thought a truck had hit the building. One terrific jolt and roaring noise.

Westminster.—Awakened and frightened people. Plaster and brick wall cracked. Hanging object fell off wall. Observed walls shaking rather strongly. Thunderous rumble, then house shook and rocked east-west.

Wheat Ridge.—Felt by, awakened, and frightened all in community. "Felt all over the Wheat Ridge area." Fire grate on incinerator fell off. Hanging objects swung moderately east-west. Earth noises similar to sonic boom, then rolling motion.

#### INTENSITY V IN COLORADO:

Bailey Park, Black Hawk, Boulder, Brighton, Cherry Creek, Coal Creek Canyon (16 miles west of Boulder on Highway 72), Dillon, Dumont, Eldora, Eldorado Springs, Englewood, Erie, Fort Collins, Fort Lupton, Green Mountain, Hudson, Idaho Springs, Idledale, Indian Hills, Louisville, Montebello, Mount Vernon Canyon (on road just above El Rancho), Niwot, Parker, Rollinsville, Sedalia, Silver Plume, Watkins, Westcreek, and Wonderview (21 miles southwest of Boulder).

#### INTENSITY IV IN COLORADO:

Allenspark (2 miles east of), Ault, Bellvue, Bergen Park, Berthoud, Breckenridge, Byers, Castle Rock, Eaton, Estes Park, Fort Logan, Fort Morgan, Fraser, Grand Lake, Greeley, Hot Sulphur Springs, Hygiene, Kittredge, Laporte, Littleton, Lyons, Morris Heights (southeast of the Arsenal), Morrison, Palmer Lake, Poudre City Resort (43 miles northwest of Fort Collins), Ward, Windsor, and Winter Park.

#### INTENSITY IV IN WYOMING:

Laramie.

#### INTENSITY I-III IN COLORADO:

Agate, Bennett, Brush, Cascade, Coal

Creek, Colorado Springs, Frisco, Glen Echo (20 miles west of Fort Collins), Granby, Lookout Mountain, Louviers, Loveland, Miliken, Montezuma, Pueblo, Red Feather Lakes, Silverthorne, Sterling, Sunshine, U.S. Air Force Academy (60 miles south of Denver), Vail, Weldona, and Wellington.

#### INTENSITY I-III IN WYOMING:

Cheyenne.

#### INTENSITY I-III IN NEBRASKA:

Scottsbluff.

August 9: 07:10 (about). Thornton, Colo. Observer felt two shocks about 45 minutes after the 06:25 earthquake.

August 9: 08:00. Denver, Colo., area (Platte River farmland area, 104th Avenue and McKay Road). Tremor felt.

August 9: 11:30 (about). Northglenn, Colo. "Thought I felt another tremor around 11:30."

August 9: 13:45. Hazeltine Heights, Colo. (north Denver area). Tremor felt.

August 11: 22:02 and 22:46 (about). Denver, Colo., region. Press reported slight shocks were felt in the Denver region.

August 12: 10:05 (about). Denver, Colo., region. Press reported a slight shock was felt in the Denver area.

September 23: 21:46:48.8\*, 22:00:28.1\*. Epicenter 40.7° north, 112.1° west, Utah, W. Magnitudes 3.7 and 3.4, respectively. V. Minor damage reported from one place; walls cracked and porch displaced. No damage was reported to law enforcement officers. Windows shook and dishes rattled in the Granger-Magna-Murray area.

October 4: 08:20:14.0\*. Epicenter 38.5° north, 112.1° west, Utah, W. Magnitude 5.2. VII. Felt over an area of approximately 15,000 square miles of Utah and northern Arizona (see fig. 6). Ceilings and walls cracked in numerous houses at Marysville. About 1 mile north of Marysville, well water was badly muddied for 24 hours. At Koo-

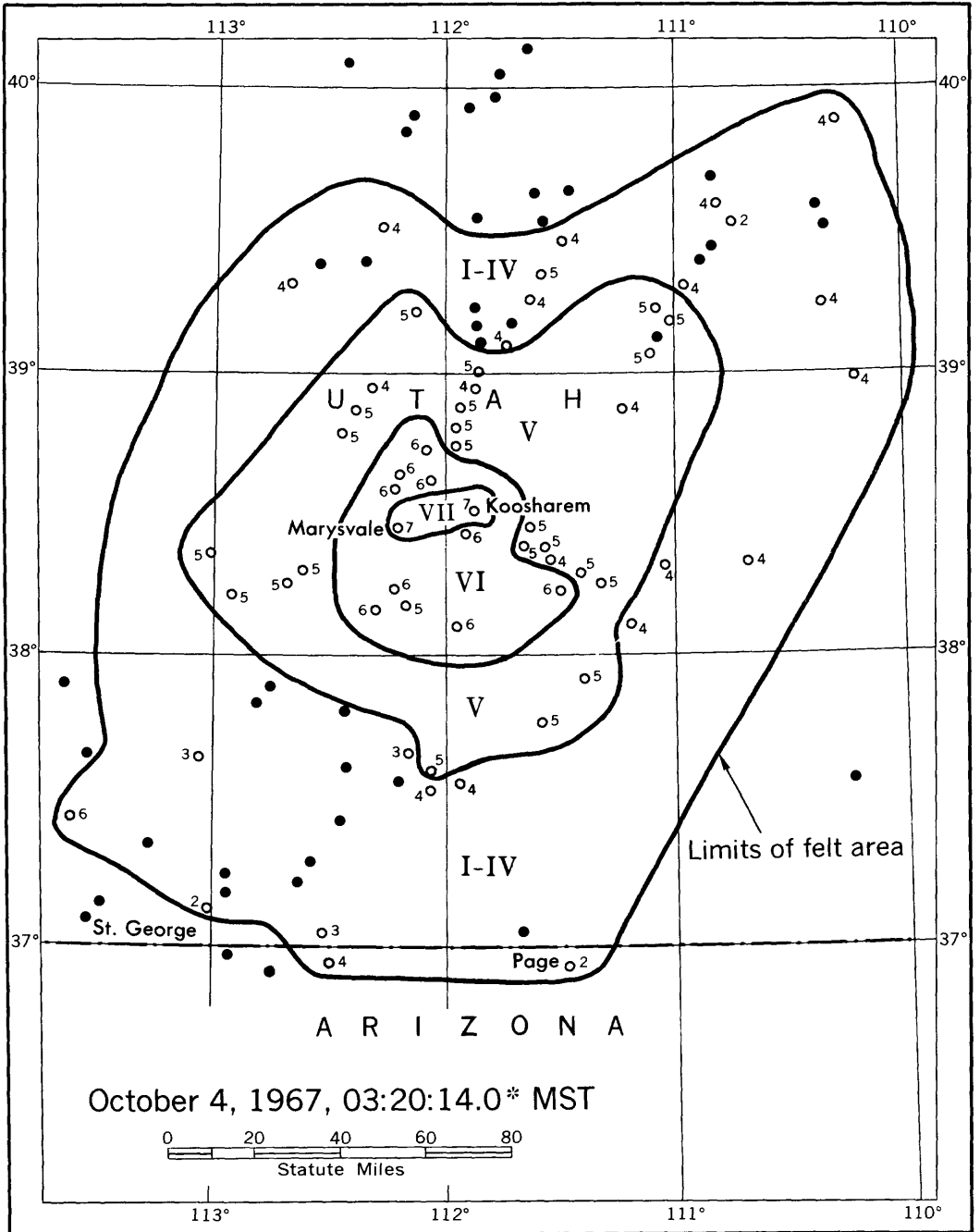


FIGURE 6.—Area affected by Utah earthquake of October 4.

share, one well was "closed off"; chimneys cracked slightly; plaster cracked. At Circleville, root cellars caved in a few places. Few chimneys were partly knocked down at

Joseph; plaster cracked; rockslides in canyons a few miles distant. At Junction City, large boulders fell from many mountains; some boulders rolled onto the highways; plaster

cracked. Rockslides occurred 5 miles south of Sevier. Plaster cracked at Antimony, Central, Richfield, Sevier, and Teasdale. Several aftershocks were reported felt. At Greenwich, about 7 miles southeast of the epicenter, seven shocks were reported felt; glasses in cupboards rattled with each tremor. At Marysville (about 10:30 a.m.) a tremor was felt which rattled mailboxes in the post office.

#### INTENSITY VII IN UTAH:

Koosharem.—Felt by and awakened all in community; frightened many. Damage slight. Chimneys cracked slightly; plaster cracked. One well "closed off." Small objects shifted and fell; furniture shifted. Hanging objects swung moderately southwest-northeast. Moderate rumbling earth noises.

Marysville.—Felt by, awakened, and frightened all in community. Damage slight. Numerous ceiling and wall cracks in brick and stone houses. One cupboard pulled from wall. Small objects shifted, overturned, and fell; furniture shifted. Pendulum clocks stopped. All drawers in home opened. Pictures askew. Loud, deep, rumbling earth noises preceded shock. "I felt three distant shocks, the second closely following the first; a slight pause between the second and third." Well water, 1 mile north of Marysville, was badly muddied for about 24 hours.

#### INTENSITY VI IN UTAH:

Annabella.—Felt by and awakened all in community. "Could hear rocks sliding in the mountains." Loud, thunderlike earth noises.

Antimony.—Felt by and awakened many in community; frightened few. Plaster cracked. Furniture shifted. Loud earth noises.

Central.—Felt by and awakened all in community; frightened many. Plaster cracked and fell. Small objects shifted, fell, and broke. Moderate earth noises.

Circleville.—Felt by, awakened, and frightened many in community. Damage slight. Root cellars caved in. Hanging objects swung moderately. Moderate earth noises.

Greenwich.—Felt by, awakened, and frightened all in community. Small objects

shifted, overturned, and fell. Direction seemed east-west. Loud earth noises. "Felt seven tremors; glasses in cupboard rattled after each shock."

Joseph.—Felt by, awakened, and frightened all in community. Damage slight. Some chimneys partially collapsed. Plaster cracked in chapel. Cans fell from store shelves. Rockslides in canyon a few miles distant. Loud, roaring earth noises.

Junction.—Felt by and awakened all adults; frightened many. Damage slight. Plaster cracked. Small objects shifted, overturned, and fell. Large boulders fell from many mountains; some boulders rolled onto highways. Moderate earth noises.

Richfield.—Felt by, awakened, and frightened many in community. Plaster cracked. Small objects shifted.

Sevier.—Felt by, awakened, and frightened all in community. Plaster cracked slightly. Small objects shifted, overturned, and fell. Rockslide 5 miles south of Sevier. Very loud earth noises preceded and followed shock.

Teasdale.—Awakened many and frightened few in community. Damage slight. Plaster cracked in some houses. Trees and bushes shook. Moderate to loud earth noises.

#### INTENSITY V IN UTAH:

Aurora, Beaver, Boulder, Castle Dale, Clawson, Ephraim, Escalante, Fremont, Glenwood, Greenville, Grover, Kanosh, Kingston, Loa, Lyman, Meadow, Milford, Minersville, Orangeville, Redmond, Scipio, Torrey, Tropic, and Venice.

#### INTENSITY IV IN UTAH:

Bicknell, Caineville, Cannonville, Emery, Fillmore, Green River, Hanksville, Henrieville, Hinckley, Huntington, Leamington, Manti, Mayfield, Nutters Ranch (about 30 miles northeast of Price), Price, Salina, Sleeping Rainbow Ranch (about 15 miles southeast of Torrey), Spring City, and Woodside.

#### INTENSITY IV IN ARIZONA:

Fredonia.

#### INTENSITY I-III IN UTAH:

Cedar City, Kanab, Rockville, Rubys Inn

(about 5 miles north of Bryce Canyon), and Wellington.

#### INTENSITY I-III IN ARIZONA:

Glen Canyon Dam Powerplant (Page).

October 4: 10:29:17.4\*. Epicenter 38.5° north, 112.0° west, Utah, W. Intensity IV at Marysville.

October 24: 23:32. Intensity IV in Denver, Colo., area (114th Avenue and Riverdale Road, north of Denver).

October 25: 21:20. Intensity III at Commerce City, Colo.

October 28: 01:00. Intensity III at Commerce City, Colo.

November 14: 03:07\* and 03:41\*. Denver, Colo., region. Magnitudes 2.9 and 2.7, respectively (Golden). Intensity IV at Commerce City. Also felt at Brighton, Broomfield, Conifer, Denver, Evergreen (south of), Golden, and in the farmland areas between Commerce City, Northglenn, Thornton, Broomfield, Eastlake, and Brighton.

November 15: 00:10:12.1\*. Epicenter 39.9° north, 104.6° west, Denver, Colo., region, W. Magnitude 3.7. V. Felt by and awakened many in community at Commerce City. "I know of only two places that had slight damage—one at Commerce City and one at Thornton." One hard, loud, slamming jolt to southwest. Denver press reported one man was knocked out of bed. Also felt at the Arsenal and 2 miles east of, Boulder, Brighton, Eastlake, and Lafayette.

November 25: 00:02\*. Commerce City, Colo. Magnitude 2.6 (Golden). Intensity IV at Commerce City, and north of Commerce City at 114th Avenue and Riverdale Road.

November 26: 22:09:22.7\*, 22:35:00.7\*, 22:42:53.3\*. Epicenters (1) 40.0° north, 104.7° west; (2) 39.9° north, 104.7° west; (3) 39.9° north, 104.9° west, Colorado, W. Magnitudes of first two shocks, 5.2 and 4.4. VI. The main shock at 22:09:22.7\* was felt over an area of approximately 17,000 square

miles (see fig. 7). This was reported to be the second largest shock since the Denver series began in April of 1962. Many persons reported it was the worst one they had ever felt. Damage was generally reported as slight, occurring principally in the suburban area of northeast Denver at Commerce City, and consisting chiefly of cracked plaster, enlargement of existing cracks, and loss due to fallen merchandise in stores. Press reported some masonry walls and basement floors were cracked. Many persons were extremely frightened and hurried into streets. Very loud, thunderous, roaring, blastlike earth noises immediately preceded the shock, which was described as having a rocking, jolting, up-and-down, twisting motion. The after-shocks at 22:35:00.7\* and 22:42:53.3\* were felt over a considerable area.

#### INTENSITY VI IN COLORADO:

Adams City.—People were awakened and frightened. Child ran screaming from basement and said, "The wall came at me." Curio shelf flew 12 feet across room. Small objects shifted and fell; mirror fell. Front and back doors on east and west sides of house opened about 1 foot. Loud rumbling; sudden, heavy shaking; several jolts. Shocks also felt at 22:35 and 22:42.

Arvada.—Felt by all in community; awakened and frightened few. "Felt more in Arvada than any previous shock." Press reported walls cracked; telephones were knocked out of order for a short time. Shock at 22:35 also felt.

Aurora.—Man fell to his knees when ground seemed to suddenly give way under him. Rubber coasters shifted south about 2 inches from under washing machine. Lamp base fastened to organ shook loose. Sudden, heavy, up-and-down, north-south motion, preceded by blastlike earth noises. Shocks also felt at 22:35 and 22:42.

Boulder.—Felt by and frightened many; awakened few. One woman reported this was the only shock which had frightened her. Plaster cracked, broke, and fell. Ground

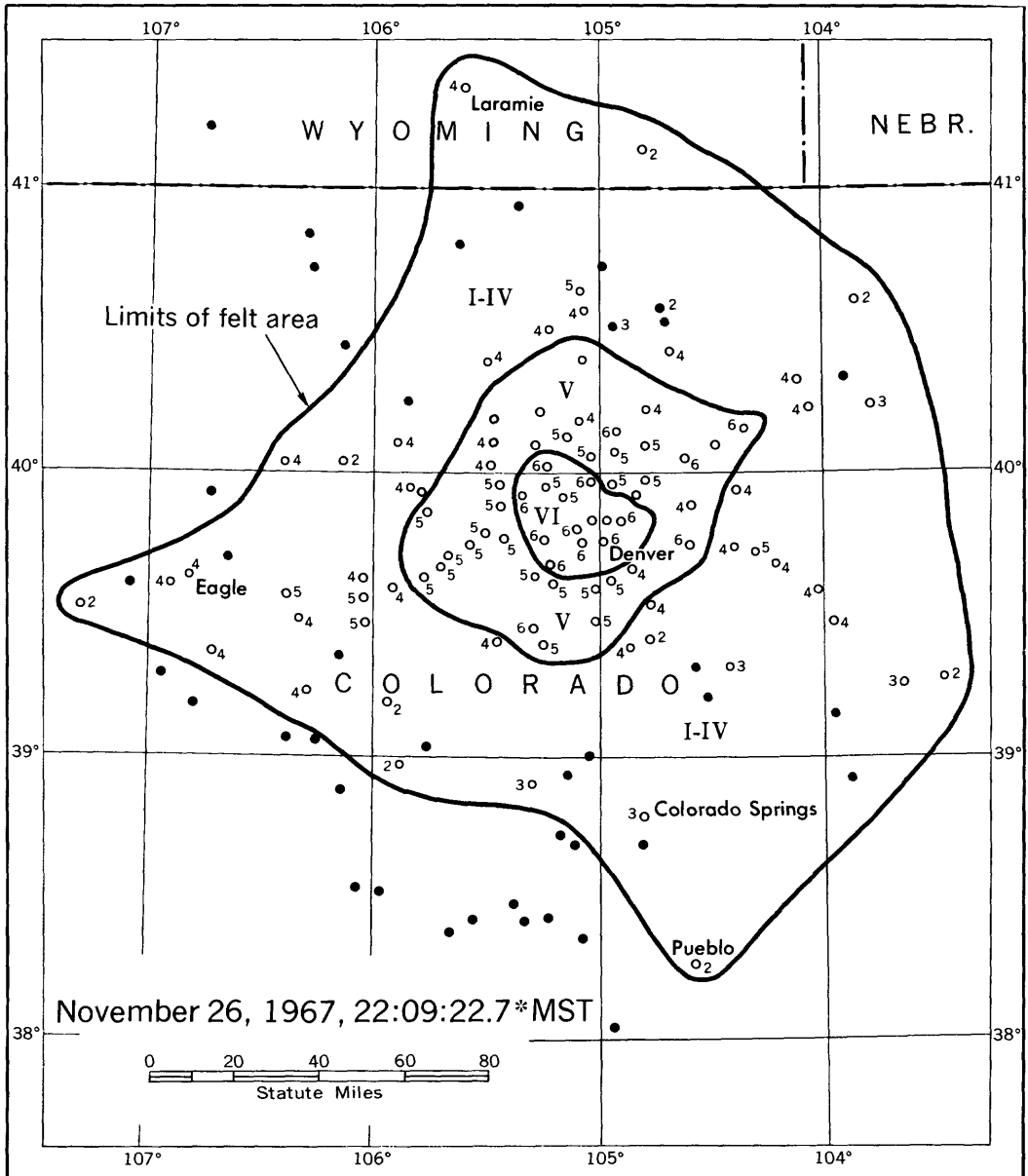


FIGURE 7.—Area affected by Colorado earthquake of November 26.

cracked. Water disturbed. Trees and bushes shook. Very loud earth noises.

Commerce City.—Felt by all; many very frightened. Some thought this was the worst shock felt so far. Merchandise fell from shelves in several stores, with one merchant reporting damage at about \$700. Articles fell from both north-south and east-west shelves.

At one business place, acoustical tile pulled away from a wall and very small pieces of plaster fell. Old plaster cracks in homes widened and lengthened. Small objects in homes shifted and fell in various directions. Extremely loud earth noises immediately preceded the shock. One reliable observer reported: "Worst one to date. Heard a heavy,

deep, loud rumbling coming from the east about 2 seconds before shock was felt. Two hard, jarring, bumping jolts about 1 second apart. Vases bounced strongly. Observer felt stairs bounce up and down so rapidly he had sensation of not touching them. Felt as if walls were leaning into middle of room. Lasted about 6 seconds." Shocks at 22:35 and 22:42 also felt.

Denver.—Generally and sharply felt over the Denver area. Press reported walls cracked at one place. Child thrown from bed; person thrown from chair. One observer reported that the wall of an old, 1-story brick house "is breaking away from roof line." Several windows broke at one location. Trees and bushes shook; vehicles rocked (people left trailers). Small objects shifted, overturned, and fell. Very loud, rumbling earth noises preceded shock; strong shaking, jolting, twisting motion. Shocks at 22:35 and 22:42 also felt.

Firestone.—Felt by all in community; awakened and frightened many. "This shock was felt much more strongly than any of the previous ones." Plaster cracked. Furniture shifted. Moderate earth noises.

Hudson.—Felt by and frightened many in community; awakened few. Plaster cracked. Loud rumble; abrupt, rapid motion from south.

Idledale.—Felt by and awakened many in community; frightened few. Water and gas lines twisted. Several windows cracked. Some items near edge of table fell to floor. Observer outside heard a gritty, rubbing sound during shock at 22:35.

Irondale.—People were frightened. Plaster cracked and fell. Felt as if a boulder had hit the house; motion east-west. Shocks at 22:35 and 22:42 also felt.

Lafayette.—Felt by all in community; awakened most; frightened few. Plaster cracked. Small objects shifted, overturned, and fell. Preceded by truck-rumbling sound; felt as if vehicle hit the building; motion from south; long duration. Shocks at 22:35 and 22:42 also felt.

Lakewood.—People were frightened. "Worst one felt so far." Plaster cracked and loosened. Chairs bounced around; pictures tilted. Bed rocked east-west. Jolting, swaying, up-and-down motion preceded by loud, rumbling and roaring earth noises. Shock at 22:35 also felt.

Pine.—Felt by many and awakened few in community. Small ground cracks. Loud roar heard.

Pinecliffe.—Felt by and awakened all in community. Plaster cracked. Small objects shifted. Motion east-west; loud earth noises. Shock at 22:35 also felt.

Rocky Mountain Arsenal area.—Residents were frightened; some reported it was the worst shock ever felt. Plaster fell; all cracks enlarged. Porch door opened about 1 foot; desk shifted 5 inches from wall. Chain hanging from ceiling jumped up and down. Water splashed from aquarium. Pictures tilted. Lights flickered. Thunderous earth noises preceded shock; hard, jolting motion. Shocks also felt at 22:35 and 22:42.

Roggen.—Felt by and awakened many in community. Plaster cracked. Furniture and small objects shifted. Vehicles rocked. Loud earth noises.

Thornton.—Residents were frightened. Items fell in grocery stores. Cracks and bricks loosened again on outside of previously damaged house. Small objects shifted and fell; pictures tilted in all directions. Weights on clock swung for 15 minutes after shock. Water sloshed in bathroom bowls; chandeliers swung in circular motion of about 2 inches. Motion rocking, jolting in north-south and east-west directions; preceded by extremely loud, thunderous and blastlike earth noises. Shocks at 22:35 and 22:42 also felt.

Watkins.—Felt by and frightened all in community; awakened few. Stucco cracked. Pictures tilted to west. Loud rumbling from west preceded shock. Shocks at 22:35 and 22:42 also felt.

Welby.—People were frightened. Fifty or 60 bottles fell from west shelves in store and broke. "Car bumper rail bent to west—

spikes pulled up 5 to 6 inches and bent—opposite direction to which car could do it.” Visible north-south movement of south wall. Abrupt, rumbling noise, similar to train. Shocks also felt at 22:35 and 22:42.

Westminster.—People were frightened. “Worst one so far.” Plaster cracked. Couch banged against east wall four or five times. Mirrors and lamp shades swayed. Dial tone on phone out for about 5 minutes. Abrupt, heavy jolt and hard shaking preceded by loud rumbling from west; long duration. Shocks also felt at 22:14, 22:35, and 22:42.

#### INTENSITY V IN COLORADO:

Allenspark (shocks also felt at 22:35 and 22:42), Black Hawk, Breckenridge, Brighton (shocks also felt at 22:35 and 22:42), Broomfield (shocks also felt at 22:35 and 22:42), Buffalo Creek, Central City (shocks also felt at 22:35 and 22:42), Dacono, Dumont, Dupont (shocks also felt at 22:35 and 22:42), Eastlake (shocks also felt at 22:35 and 22:42), Eldorado Springs, Empire, Englewood (three later shocks felt), Erie, Evergreen (shock also felt at 22:35), Fort Lupton (shock also felt at 22:35), Frederick, Frisco, Georgetown, Golden (shock also felt at 22:35), Henderson (shock also felt at 22:35), Idaho Springs, Indian Hills, Jamestown, Laporte, Littleton, Louisville (shock also felt at 22:35), Louviers, Loveland, Lyons and surrounding areas, Minturn, Mount Vernon Canyon (on Highway 40 at Lookout Mountain), Nederland, Niwot, Northglenn (shocks also felt at 22:35 and 22:42), Rollinsville, Silver Plume, Strasburg, Wheat Ridge (shock also felt at 22:35), and Winter Park (two shocks felt).

#### INTENSITY IV IN COLORADO:

Agate, Bailey, Bennett, Bergen Park (shock also felt at 22:35), Byers, Castle Rock, Cherry Creek (just west of Cherry Creek Dam), Coal Creek (about 5 miles west of Boulder; shock also felt at 22:35), Coal Creek Canyon (16 miles west of Boulder on Highway 72), Deer Trail, Dillon, Eagle, Estes Park, Fort Collins, Fraser, Granby, Greeley, Gypsum (8 miles west of), Kitredge, Kremmling,

Leadville, Longmont, Masonville, Meredith, Montebello (south of the Arsenal; shocks also felt at 22:35 and 22:42), Montezuma (foot of Loveland Pass), Orchard, Parker, Platteville, Prospect (about 5 miles south of, in area about 20 miles east of Brighton), Redcliff, Tabernash, Ward area (2½ miles east of Peak-to-Peak Highway on County Road 94), Watkins (11 miles north of; shocks also felt at 22:35 and 22:42), Wiggins, and Wonderview (21 miles southwest of Boulder; shock also felt at 22:35).

#### INTENSITY IV IN WYOMING:

Laramie.

#### INTENSITY I-III IN COLORADO:

Ault, Colorado Springs, Fairplay, Florissant, Fort Morgan, Franktown, Genoa, Glenwood Springs, Gypsum, Hartsel (6 miles west of, at Antero Reservoir), Hygiene, Keenesburg, Kiowa, Lamar, Limon, New Raymer, Parshall, Pueblo, and Timnath.

#### INTENSITY I-III IN WYOMING:

Cheyenne.

#### INTENSITY I-III IN KANSAS:

Goodland.

December 7: 06:33:22.5\*. Epicenter 41.3° north, 111.7° west, Utah, W. Magnitude 4.3. Felt at Huntsville.

December 8: 20:35. Commerce City, Colo. III. Felt by very few. Couch jerked. Slight jolt from northeast, loud noise, then a stronger jolt twisting to southeast. Duration about 5 seconds.

## CALIFORNIA AND WESTERN NEVADA

[120th Meridian or Pacific Standard Time]

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

January 1: 21:00, 21:15. Two light shocks felt at Parkfield.

January 7: 23:37:28.9\*. Epicenter 33.6° north, 118.4° west, southern California, W. Magnitude 3¾-4, P. V. This was the first of a series of 13 shocks felt on January 7 and

8. Described as a slow, rumbling earthquake, the shock jarred the coastal areas of Los Angeles County, and was felt as far inland as the San Fernando Valley according to the press. Intensity V was reported at Lomita, Palos Verdes Estates, Palos Verdes Peninsula, and Redondo Beach; intensity IV at Rolling Hills Estates. Reported felt by press at Manhattan Beach, Point Vicente, and in West Los Angeles.

January 8: 00:12:29.1\*. Epicenter  $33.5^{\circ}$  north,  $118.4^{\circ}$  west, southern California, W. Magnitude  $3\frac{1}{2}$ , P. V. Felt by, awakened, and frightened many in Palos Verdes Estates-Palos Verdes Peninsula area. Windows rattled and houses creaked. Earth noises heard.

January 8: 00:26:56.8\*. Epicenter  $33.5^{\circ}$  north,  $118.4^{\circ}$  west, southern California, W. Magnitude  $3\frac{3}{4}$ , P. V. Felt by many at Palos Verdes Estates; awakened all in home. Windows rattled and a moderate earth noise was heard. Also felt at Redondo Beach (IV).

January 8: 12:47:38\*. Epicenter  $33.5^{\circ}$  north,  $118.3^{\circ}$  west, southern California, W. Magnitude  $3\frac{1}{2}$ , P. V. Felt by all and frightened many in Palos Verdes Peninsula area. Windows and dishes rattled and low rumble was heard. Intensity IV at Harbor City, Long Beach, Redondo Beach, San Pedro, Seal Beach, and Torrance; intensity I-III at Compton, Hawthorne, and Hermosa Beach.

January 8: 15:03:48\*, 16:03\*. Epicenter  $35.6^{\circ}$  north,  $120.4^{\circ}$  west, Parkfield area, B. Magnitudes 3.0 and 2.0, respectively. Intensity IV at Parkfield.

January 10: 02:28:21.4\*. Epicenter  $39.5^{\circ}$  north,  $120.3^{\circ}$  west, northern California, W. Magnitude 4-4.2, B. Intensity IV in Truckee area.

January 13: 18:45. Magnitude 3.5, P. Intensity IV at Long Beach. Also reported felt in the southern area of Los Angeles County.

January 15: 15:26:23.6\*, 17:54:53\*. Epicenter  $37.4^{\circ}$  north,  $118.6^{\circ}$  west;  $37.4^{\circ}$  north,  $118.7^{\circ}$  west, California-Nevada border region,

W. Magnitudes 3.7 and 3.5-3.9, respectively, B. Intensity IV at Bishop and Long Valley Dam. Also felt at Independence.

January 16: 11:37:52.9\*. Epicenter  $37.4^{\circ}$  north,  $118.6^{\circ}$  west, California-Nevada border region, W. Magnitude 3.7-3.9, B. Intensity III at Bishop.

January 20: 19:19. Keene. V. Rapid motion felt by all. Windows rattled and moderate earth noises were heard.

February 15: 16:13. Intensity III at San Francisco.

February 18: 10:48:55.4\*. Epicenter  $34.1^{\circ}$  north,  $117.3^{\circ}$  west, southern California, W. Magnitude  $3\frac{1}{2}$ , P. Intensity IV at Etiwanda. Also felt at San Bernardino.

February 21: 12:45:47.5\*. Epicenter  $33.8^{\circ}$  north,  $117.7^{\circ}$  west, southern California, W. Magnitude 3.7, P. Felt in Orange County.

February 24: 18:00:32.9\*. Epicenter  $36^{\circ}$  52' north,  $121^{\circ}$  38' west, central California, B. Magnitude 2.8. V. Felt by all at Everett Mills Ranch. Doors and dishes rattled and faint noises were heard. Intensity IV at Aromas.

February 25: 07:52:08.2\*. Epicenter  $40^{\circ}$  18' north,  $123^{\circ}$  06' west, northern California, B. Magnitude 3.9-4.1. Intensity IV at Arcata and Salyer.

February 25: 13:33:47.0\*. Epicenter  $40^{\circ}$  20' north,  $124^{\circ}$  18' west, northern California, B. Magnitude 3-3.3. Intensity IV at Petrolia; intensity III near Petrolia, about 3 miles from mouth of Mattole River.

March 1: 11:21, 11:24, 11:26. Intensity IV in the Palos Verdes Peninsula area.

March 1: 23:10:58\*. Epicenter  $40.3^{\circ}$  north,  $124.5^{\circ}$  west, near coast of northern California, W. Magnitude 3.4-3.8, B. V. At Petrolia, felt by all in community. Moderate earth noises were heard. Intensity IV at Scotia and 8 miles east of Petrolia.

March 2: 06:12:49.1\*. Epicenter  $36.3^{\circ}$



north,  $117.7^{\circ}$  west, California-Nevada border region, W. Magnitude 4.4-4.6, B. V. Felt over a considerable area, principally in southern Inyo County. Frightened few at Darwin. Windows, doors, and dishes rattled and houses creaked. Loud earth noises. Felt by and awakened all at Furnace Creek Ranch. Intensity IV at Keeler and Westend, and at Beatty, Nev.

March 2: 12:02. Intensity IV in the Palos Verdes Peninsula area.

March 2: 13:43:48.0\*. Epicenter  $34^{\circ}07.1'$  north,  $117^{\circ}57.7'$  west, southern California, P. Magnitude 3.1. Felt at Pasadena.

March 6: 18:40:59.5\*. Epicenter  $36^{\circ}51.5'$  north,  $121^{\circ}27.5'$  west, west of Hollister, B. Magnitude 2.2 Reported felt in the Hollister area.

March 11: 08:03. V. Felt over a small area of Riverside County, principally in the Palm Springs area. Felt by all, awakened many, and frightened few at Morongo Valley and Palm Springs. Windows, doors, and dishes rattled. Intensity IV effects were noted at Cathedral City, Desert Hot Springs, Idyllwild, Rancho Mirage, Sky Valley, Snow Creek Village, and Thousand Palms; intensity I-III at North Palm Springs.

March 13: 13:58. Intensity IV at San Miguel, Indian Valley, and Ranchito Canyon.

March 19: 03:35. Intensity IV at Avenal.

April 5: 12:36. Slight shock felt by few at Elizabeth Lake and Lake Hughes.

April 5: 17:05:45.6\*. Epicenter  $36.2^{\circ}$  north,  $118.8^{\circ}$  west, central California, W. Magnitude 4.1. IV. Felt over an area of about 600 square miles of Tulare County. Intensity IV at Lindsay, Springville, and Three Rivers; intensity I-III at Armona, Ash Mountain (Sequoia National Park), and Strathmore.

April 18: 13:36:47.7\*. Epicenter  $34^{\circ}05.9'$

north,  $117^{\circ}42.9'$  west, southern California, P. Magnitude 2.7. Felt at Claremont.

April 19: 07:31. Felt by few at Petrolia.

April 19: 23:02:43.5\*. Epicenter  $34^{\circ}06.9'$  north,  $117^{\circ}42.7'$  west, southern California, P. Magnitude 2.3. Felt at Claremont.

April 22: 08:39:45.1\*. Epicenter  $36^{\circ}37'$  north,  $121^{\circ}16'$  west, central California, B. Magnitude 3. 4. Intensity IV effects were noted at Contival Ranch, 13 miles south of Hollister, and at Paicines. A slight aftershock was reported at Paicines.

April 27: 18:36. Intensity IV at Holy City; intensity I-III at Los Gatos and San Jose.

April 28: 09:39. Intensity IV at Avenal.

May 12: 08:00:39.2\*. Epicenter  $33^{\circ}55.8'$  north,  $118^{\circ}13.2'$  west, southern California, P. Magnitude 2. 9. Felt at Pasadena.

May 13: 05:45. Intensity IV at Etiwanda.

May 16: 16:28, 16:30. Both shocks were intensity IV at Avenal.

May 21: 06:42:34.4\*. Epicenter  $33^{\circ}30.4'$  north,  $116^{\circ}35.1'$  west, southern California, P. Magnitude 4. 7. VI. Generally felt over an area of approximately 9,000 square miles, principally in Riverside, San Bernardino, and San Diego Counties. Rocks rolled onto Highway 74 from Nightingale to Palm Desert. Near Anza, murky well water was reported. One of the two water reservoirs at Norco sustained \$30,000 to \$40,000 damage from the shock. Very slight plaster cracking was reported at Beaumont, Redlands, and Winchester, but no additional reports of damage were received from the epicentral region.

#### INTENSITY VI:

Anza-Borrego Desert State Park (Palm Canyon).—Felt by all; awakened and frightened few in community. Furniture shifted; trees and bushes shook; vehicles rocked. Loud earth noises.

Anza (about  $2\frac{1}{2}$  miles northeast of).—Felt by many and frightened few in commu-

nity. Later in the day, well water appeared murky. The well casing extends to 547 feet below the surface. The section of the pump is from the 400-foot level, indicating that a considerable amount of water could be pumped before the murky water reached the pump. Loose objects rattled severely. Moderate earth noises.

Nightingale.—Felt by all in community. Rocks rolled onto Highway 74 from Nightingale to Palm Desert. Windows rattled. Faint earth noises.

#### INTENSITY V:

Agua Caliente Springs-Vallecito Valley area, Banning, Beaumont, Cabazon, Cathedral City, Coachella, Desert Hot Springs, Hemet (5 miles east of), Homeland, Idyllwild (center of village and at Ranger Station), Joshua Tree (1 mile south of Twentynine Palms Highway), La Quinta, Moreno, Mountain Center, North Palm Springs, Palm Springs, Palomar Mountain (Palomar Observatory), Pearson area (about 15 miles southeast of Aguanga), Perris (rural area, on Highway 395), Pinyon Crest (about 12 miles east by north of Anza), Redlands, Riverside, Romoland, Sage Fire Control Station (about 10 miles south of Hemet), Salton City (near west shore of Salton Sea), San Bernardino, San Jacinto, San Juan Capistrano, Sun City (about 3 miles west of Romoland), Sunnymead, Temecula, Thousand Palms, Warner Springs, West Covina, White Water area (Snow Creek, White Water Canyon, West Palm Springs, and Painted Hills), and Winchester.

#### INTENSITY IV:

Aguanga, Alberhill, Alpine, Angelus Oaks, Bonsall, Burbank, Calimesa, Corona, Curtis, Descanso, El Cajon, Elsinore, Fallbrook, Fawnskin, Forest Falls, Gilman Hot Springs, Glendale, Highland, Indio, Jamul, Julian, Lakeview, La Verne, Mesa Grande, Morongo Valley, Mount Wilson, Norco, North Shore (north shore of Salton Sea), Norwalk, Oak Grove Ranger Station (about 8 miles southeast of Aguanga), Ontario, Palm Desert, Pauma Valley, Pine Valley, Pioneertown,

Poway, Ramona, San Marcos, Santee, Thermal, Twentynine Palms, Valley Center, and Yorba Linda.

#### INTENSITY I-III:

Azusa, Bellflower, Big Bear Lake area, Boulevard, Buena Park, Etiwanda, Leucadia, Lucerne Valley, Mount Laguna, Newport Beach, Pasadena, Pomona, Rialto, San Diego area, Walnut, and Yucca Valley.

May 24: 17:57. Intensity IV at Keene.

May 29: 19:47:28.3\*. Epicenter  $37^{\circ}16.3'$  north,  $121^{\circ}39.5'$  west, central California, southeast of San Jose, B. Magnitude 3.9. IV. Generally felt over an area of about 1,000 square miles, principally in Santa Clara and Santa Cruz Counties. Buildings creaked and loose objects rattled at Almaden, Ben Lomond, Fremont, Gilroy, Los Gatos, Milpitas, Monte Sereno, Mount Hamilton (Lick Observatory), and San Francisco; intensity I-III at Brookdale, Davenport, El Granada, La Honda, Mount Hermon, San Jose, Saratoga, and Sunnyvale.

June 1: 06:32. Intensity IV at Palos Verdes Estates.

June 5: 22:11:38.7\*. Epicenter  $35^{\circ}48.9'$  north,  $120^{\circ}25.5'$  west, central California, B. Magnitude 3.0, B. Intensity IV at the Work Ranch in southern Monterey County. Also felt in Vineyard Canyon and in Indian Valley.

June 10: 19:52:18.1\*. Epicenter  $35^{\circ}13.7'$  north,  $118^{\circ}38.9'$  west, central California, P. Magnitude 3.2. Intensity IV at Keene.

June 14: 20:58:05.5\*. Epicenter  $33^{\circ}59.8'$  north,  $117^{\circ}58.5'$  west, southern California, P. Magnitude 4. 1. VI. Felt over a large area of Los Angeles County and in some Orange County communities. At El Monte, the underground telephone cable twisted, causing service to be interrupted. Hairline foundation cracks were sustained at San Gabriel. At Whittier, a plate glass window and water pipe broke and a wall cracked. Police reported plaster fell in a residence in northern Los Angeles.

## INTENSITY VI:

El Monte.—Press reports indicate that in this area, an underground telephone cable twisted and briefly interrupted telephone service. The shock was felt by many in the community.

San Gabriel.—Felt by many throughout the area; awakened and frightened few. Hair-line cracks appeared in the foundation of a house. Loud earth noises.

Whittier.—Felt by all in community. Press reported a garage wall cracked. A large plate glass window broke on East Whittier Boulevard, and a water pipe broke on the third floor of American Savings and Loan Building. Small objects shifted, overturned, and fell. Moderate earth noises, like a sonic boom or an explosion.

## INTENSITY V:

Artesia, Azusa, Baldwin Park, Bell, Brea, Buena Park, Glendora, Hacienda Heights, Lakewood, Long Beach, Los Angeles, Lynwood, Maywood, Montebello, Mount Wilson, North Hollywood, Norwalk, Pasadena, Pico Rivera, Rowland Heights, San Dimas, Sierra Madre, South Pasadena, Temple City, Van Nuys, and West Covina.

## INTENSITY IV:

Alhambra, Altadena, Anaheim Stadium, Arcadia, Compton, Covina, Downey, Fullerton, Harbor City, Hollywood, Huntington Beach, Huntington Park, La Crescenta, La Habra, La Mirada, Los Alamitos, Monterey Park, Ontario, Orange, Pinon Hills, Pomona, Santa Ana, Santa Monica, Seal Beach, South El Monte, South San Gabriel, Stanton, Studio City, Upland, West Los Angeles, and Yorba Linda.

## INTENSITY I-III

Burbank, Chino, Glendale, Hawthorne, Northridge, Rosemead, Sunland, Westminster, Westwood, and Wilmington.

June 26: 07:15:34.9\*. Epicenter  $39^{\circ}17.3'$  north,  $123^{\circ}19.5'$  west, northern California, B. Magnitude 3.5. VI. Felt over about 1,500 square miles of Mendocino and Lake Counties. Concrete spalled slightly at Coyote Dam, a few miles northeast of Ukiah. At Red-

wood Valley, about 7 miles north of Ukiah, ceilings and chimneys cracked. At Ukiah, minor damage to brick chimneys and dishes was reported.

## INTENSITY VI:

Coyote Dam (northeast of Ukiah).—The following is excerpted from a report by the U.S. Army Corps of Engineers: The earth embankment of the dam showed no signs of movement. The outlet works suffered minor damage. The concrete on the curb of the intake tower access bridge spalled slightly at the expansion joint on the tower side of the center pier. The structural integrity of the bridge was not impaired as damage was confined to the curb area. The safety stud in the safety stud cap of the semiautomatic gate hanger for emergency gate No. 3 (right) broke. Two new spalls were found in the crown of the transition section below gate No. 3. The spalls were  $\frac{1}{2}$ -inch thick and about 6 inches long and 3 inches wide. They occurred at the construction joint about 10 feet downstream from the regulation gate. The automatic reservoir level recorder recorded a variation in reservoir level of about 0.02 foot up and down. However, this was probably caused by vibration of the pen holder and not by a seiche in the reservoir. The damage to Coyote Dam and appurtenances due to this earthquake was minimal and had no effect on the safety of the dam. Minor damage to brick chimneys and dishes occurred at Ukiah.

Redwood Valley (about 7 miles north of Ukiah).—Felt by all and frightened few in community. Chimneys cracked in three places. Groceries fell from shelves. The press reported ceilings cracked. Booming earth noises.

Ukiah.—Felt by all, awakened many, and frightened few in community. Minor damage to brick chimneys and dishes.

## INTENSITY V:

Calpella (about 5 miles north of Ukiah), and Talmage (about 3 miles southeast of Ukiah at Mendocino State Hospital).

## INTENSITY IV:

Comptche, Hales Grove, Lakeport, Navarro, Philo, Potter Valley, Upper Lake, and Willits.

## INTENSITY I-III:

Albion and Mendocino.

July 5: 17:06. Intensity IV at Parkfield.

July 11: 20:52:58.9\*. Epicenter  $34^{\circ}29.5'$  north,  $117^{\circ}57.1'$  west, southern California, P. Magnitude 3.5. V. Felt over an area of approximately 900 square miles, principally in the area from Palmdale southeast to Wrightwood. In the Antelope Valley area (no specific location given), an observer reported only a very moderate intensity at her location, but stated that about  $\frac{1}{2}$  mile from her house, a woman said her roof gave way when the post shifted. Felt by all and frightened few in community at Llano. Moderate earth noises. At Pearblossom and Palmdale, felt by all residents; awakened and frightened few. A sudden, noisy jar, with no sustained motion. Very loud earth noises, similar to a sonic boom. Duration about 45 seconds. Two definite jolts felt by many in community at Wrightwood. Small objects and furniture shifted slightly. Felt with intensity IV at Acton, Antelope Valley, Crystal Lake, Little-rock, and Valyermo; intensity I-III at Lake Hughes, Lancaster, and Leona Valley.

July 22: 01:23:26.6\*. Epicenter  $36^{\circ}32.1'$  north,  $121^{\circ}09.8'$  west, central California B. Magnitude 3.8. VI. Felt by, awakened, and frightened few in the Paicines area at the Bear Valley Fire Control Station. Plaster and bricks cracked. Small objects and furniture shifted. Hanging objects swung moderately north-south. Faint earth noises. Felt by and awakened all in home 6 miles south of Paicines. Rolling motion. In the San Benito area, felt by all in the valley and frightened few. Shaking, then settling motion. Moderate earth noises. Intensity IV at Coalinga and Idria.

July 23: 23:08:52.9\*. Epicenter  $35^{\circ}58.4'$  north,  $120^{\circ}29.8'$  west, central California, B. Magnitude 3.7. V. At the Bitterwater Pump-

ing Station, about 18 miles southeast of Cholame, felt by several and awakened many. Small objects shifted and powerlines swung. Hanging objects swung moderately. Felt by and awakened all at several ranches in Hog Canyon area 12 and 15 miles northeast of San Miguel. Described as a noisy and rough shock, with a milder, setting-type shock a few minutes later. Hanging objects swung east-west. Intensity IV at Creston, Jack Ranch (6.5 miles north of Highway 466, on Cholame-Parkfield Road), Paso Robles, and Templeton; intensity I-III at Cholame, San Miguel, and Shandon.

August 10: 16:57:11.4\*. Epicenter  $33^{\circ}30.5'$  north,  $116^{\circ}37.9'$  west, southern California, P. Magnitude 4.1. V. At Anza (base of Cahuilla Mountain on east side, Cary Road), felt by many in community; frightened few. Cracks in cement-slab floor were widened. Hanging objects swung moderately. Persons standing had feeling of unsteadiness. Lasted about 2 minutes. Moderate earth noises. Intensity IV at Cathedral City, Palm Desert, and Thermal; intensity I-III at Palm Springs, Rancho Mirage, and Warner Springs.

August 10: 20:50. Intensity III at Berkeley.

August 12: 10:57:40.7\*. Epicenter  $35^{\circ}48.1'$  north,  $120^{\circ}26.8'$  west, central California, B. Magnitude 4.1. V. At a ranch in Hog Canyon, 15 miles northeast of San Miguel, shock was described as rough. When observer returned home, bits of plaster were found on floors of nearly all the rooms, but there was no other evidence of the shock. Felt by all at the Standard Oil Pumping Station, about  $1\frac{1}{2}$  miles northeast of Shandon. Telephone wires swung. Very brief jolt of 2 to 3 seconds' duration, preceded by earth noises similar to a far-away sonic boom. At a ranch in the Estrella area, about 12 miles northeast of San Miguel, felt by several men sitting on ground. Grain combine rocked. Faint earth noises. Intensity IV at Cholame and vicinity; intensity I-III at Bitterwater Pumping Sta-

tion (about 18 miles southeast of Cholame), California Valley (Simmler area), and Pozo Guard Station (Pozo).

August 13: 00:02:08.4\*. Epicenter  $31.1^{\circ}$  north,  $116.4^{\circ}$  west, Baja California, Mexico, W. Magnitude 4.0. Intensity IV at El Centro (Imperial Irrigation District, Terminal Station).

August 13: 04:52:11.3\*. Epicenter  $34^{\circ} 26.3'$  north,  $119^{\circ} 59.6'$  west, southern California, P. Magnitude 3.8. V. At Cachuma Village, located at the foot of Cachuma Dam, felt by and awakened many in community; frightened few. Small objects fell. Trees and bushes shook; vehicles rocked. Hanging objects swung moderately north-south. Shock was reported to be similar to a sonic boom, and was accompanied by loud earth noises. "Same effects reported by people at Paradise Camp, about 10 miles east of Cachuma Village." Intensity IV at San Lucas Ranch (about  $3\frac{1}{2}$  miles west of Cachuma) and Santa Barbara; intensity I-III at Buellton.

August 25: 08:35 and 08:47. Intensity IV at Avenal (6 miles northeast of, sec. 25, T.21 S., R.17 E.).

August 29: 09:14:16.5\*. Epicenter  $40.3^{\circ}$  north,  $125.2^{\circ}$ , off coast of northern California, B. Magnitude 4.1. Intensity IV at Westport.

September 7: 04:39:17.3\*. Epicenter  $37^{\circ} 02.7'$  north,  $121^{\circ} 46.4'$  west, central California, B. Magnitude 4.7. VI. Felt over an area of approximately 6,500 square miles (see fig. 8). Field investigators reported no damage of any kind was observed in the epicentral area, near Corralitos. At San Jose, about 25 miles north of the epicenter, one person reported some cracks were observed in a cement fence and old plaster cracks were enlarged.

#### INTENSITY VI:

Corralitos area.—Felt by and awakened all in community; frightened many. Small objects shifted and fell in home; a few cans fell from shelf in grocery store. Hanging objects

swung violently north-south. One observer reported he was forced to hang on to wash basin to keep from falling. At the Corralitos Forestry Fire Station, an observer reported he heard rocks and dirt fall from banks; however, U.S. Geological Survey investigators reported the roads near Corralitos, particularly in the epicentral area 4 miles north of Corralitos, were searched for cracks, small landslides, or rock falls from road cuts, but not a single physical effect could be related to the earthquake, even though many unstable cuts were noted. Trees and bushes shook; vehicles rocked. Sharp rocking motion of about 10 to 20 seconds' duration.

Morgan Hill.—Felt by and awakened all in community. Small objects shifted. Hanging objects swung moderately. Moderate earth noises.

#### INTENSITY V:

Aptos and 3.7 miles north of, Belmont, Ben Lomond, Boulder Creek, Castroville, Chittenden area (east of Watsonville), Cienega District (south of Hollister), Colma, Coyote, Cupertino, Daly City, Felton, Freedom, Gilroy, Hollister, Jamesburg, Los Gatos, Monterey, Moss Landing, Mount Hamilton, Mount Hermon, Mount Madonna County Park (Park Headquarters,  $37^{\circ} 01'$  north,  $121^{\circ} 43'$  west), New Almaden, Palo Alto, San Carlos, San Jose, San Martin, Saratoga, Sausalito, Scotts Valley, Seaside, Soquel, South San Francisco, Tres Pinos, Watsonville, and Woodside.

#### INTENSITY IV:

Agnew, Albany, Aromas, Belvedere, Big Basin State Park, Bolinas, Brisbane, Capitola, Chualar, Danville, El Sobrante, King City, Loma Mar, Marina, Millbrae, Mill Valley, Milpitas, Mountain View, Newark, Oakland, Pacific Grove, Parkfield, Pescadero, Pinnacles National Monument, Pinole, Point Reyes Station, Redwood City, Redwood Estates, San Francisco, San Gregorio, San Lorenzo, Santa Cruz, Stinson Beach, Sunol, and Union City.

#### INTENSITY I-III:

Alviso, Berkeley, Canyon, Corte Madera,

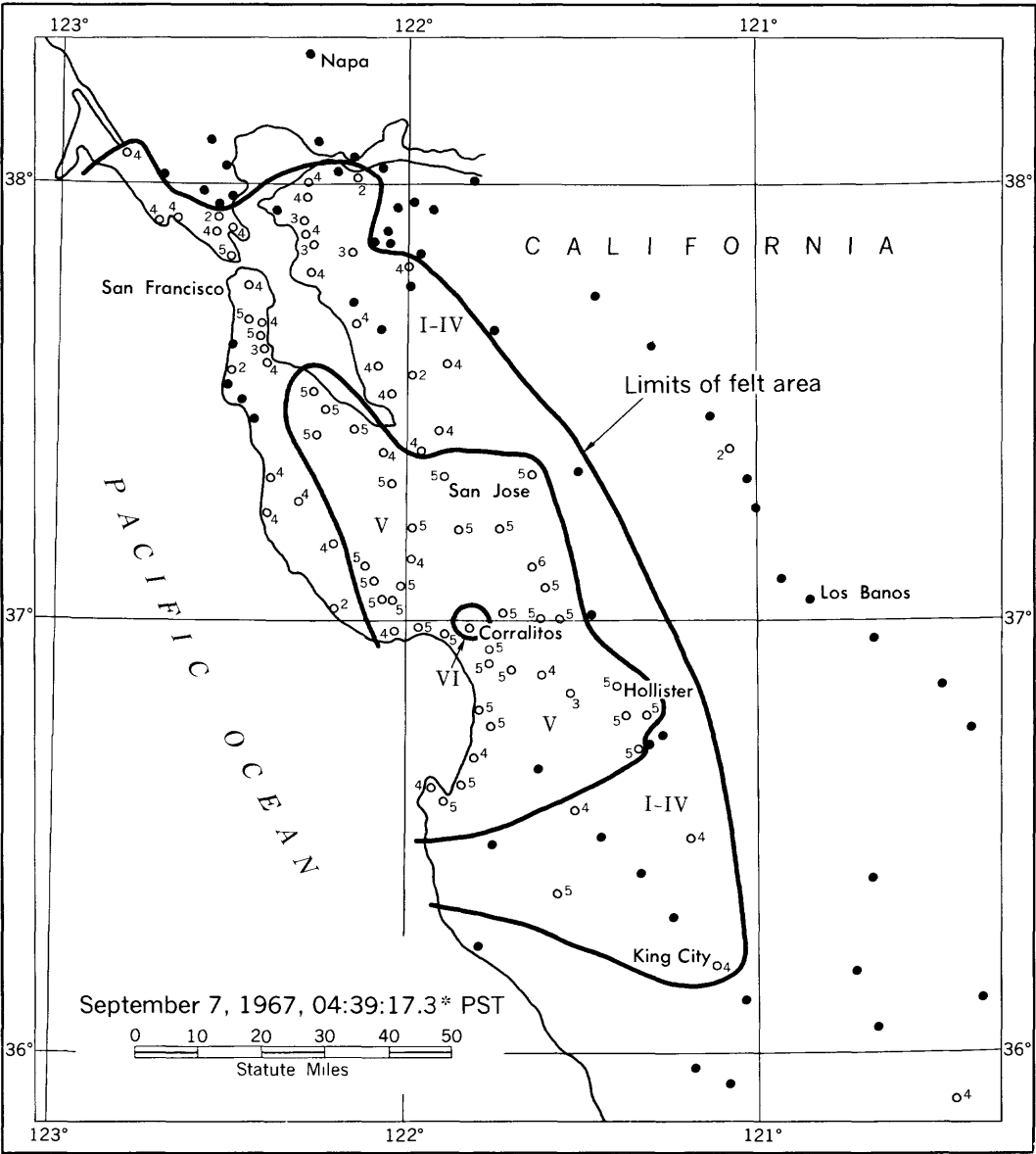


FIGURE 8.—Area affected by California earthquake of September 7.

Crows Landing, Davenport, El Cerrito, Fremont, Martinez, Montara, San Bruno, San Juan Bautista, and Santa Clara.

September 13: 21:11:38.6\*. Epicenter  $34^{\circ}14.2'$  north,  $117^{\circ}58.5'$  west, southern California, P. Magnitude 2.9. Felt at Mount Wilson.

September 19: 04:43. Intensity III at Etiwanda.

September 26: 21:32:25.1\*. Epicenter  $39^{\circ}29.7'$  north,  $120^{\circ}09.6'$  west, northern California, B. Magnitude 3.5. Intensity IV at Floriston.

September 27: 18:51:54.7\*. Epicenter  $39^{\circ}32.9'$  north,  $120^{\circ}11.1'$  west, northern California, B. Magnitude 3.8. V. Felt by all in community at Boca Dam; frightened all in home. Windows, doors, and dishes rattled; house creaked slightly. Moderate earth noises. Felt by all in community and frightened few at Truckee, where windows, doors, and dishes rattled and house shock. Felt with intensity IV at Kings Beach; intensity I-III at Norden and Sattley, and at Reno, Nev.

September 28: 07:38:35.9\*. Epicenter  $37^{\circ}13.4'$  north,  $121^{\circ}36.7'$  west, central California, about 10 km northeast of Morgan Hill on the Calveras fault, B. Magnitude 5.0. VI. Felt over an area of approximately 7,500 square miles (see fig. 9). At San Jose, plaster cracked on outside walls of house. Rockslides were observed within 3 miles of the epicenter. Small objects shifted and fell at several places.

#### INTENSITY VI:

Morgan Hill and vicinity.—Felt by all and frightened many in community at Morgan Hill. Small objects shifted, overturned, and fell. Hanging objects swung east-west. Loud earth noises. Felt by all in home at the Hewlett-Packard Ranch. "A really good shake, but no real damage." Vehicles rocked at Coe State Park. A geologist from the University of California reported rockslides were observed within 3 miles of the epicenter.

San Jose.—Felt by and frightened many in community. Plaster cracked on outside walls of house; articles fell off shelves. Trees and bushes shook; vehicles rocked. Hanging objects swung moderately east-west. Faint earth noises.

#### INTENSITY V:

Aptos, Ben Lomond, Coyote, Felton, Gilroy, Hollister, Holy City, La Honda, Mount Hamilton, Redwood City, San Martin, Santa Cruz, and Soledad.

#### INTENSITY IV:

Albany, Aromas, Bolinas, Boulder Creek, Campbell, Capitola, Freedom, Fremont, Harris Ranch (7 miles south of Hollister), Loma Mar, Los Altos, Los Gatos, Merced, Modesto, Monterey, Mount Hermon, Oakland, Pacifica, Pescadero, Redwood Estates, Richmond, San Francisco, San Gregorio, Soquel, South San Francisco, and Tamalpais Valley area (Martin County).

#### INTENSITY I-III:

Agnew's State Hospital (Agnew), Alviso, Berkeley, Carmel Valley, Los Banos, Milpitas, Pacific Grove, Patterson, Turlock, and Vernalis.

September 28: 13:08:11.6\*. Epicenter  $37^{\circ}13.6'$  north,  $121^{\circ}37.2'$  west, central California, B. Magnitude 3. 5. Aftershock of September 28 earthquake at 07:38. IV. Felt by very few at Coe State Park in the Morgan Hill area, where building creaked and rattled. Reported as much lighter 2 miles east of Morgan Hill than the shock at 07:38. Also felt at the Hewlett-Packard Ranch near Morgan Hill.

September 28: 14:29:41.2\*. Epicenter  $34^{\circ}13.1'$  north,  $118^{\circ}27.5'$  west, southern California, P. Magnitude 2.4. Felt at Los Angeles in the Wilshire District.

October 2: 08:16:10.2\*. Epicenter  $37^{\circ}56.3'$  north,  $122^{\circ}48.3'$  west, central California, B. Magnitude 2.8. Intensity IV at Forest Knolls. Also felt at San Geronimo, about 3 miles east of Forest Knolls.

October 9: 18:37:38.7\*. Epicenter  $36^{\circ}43'$

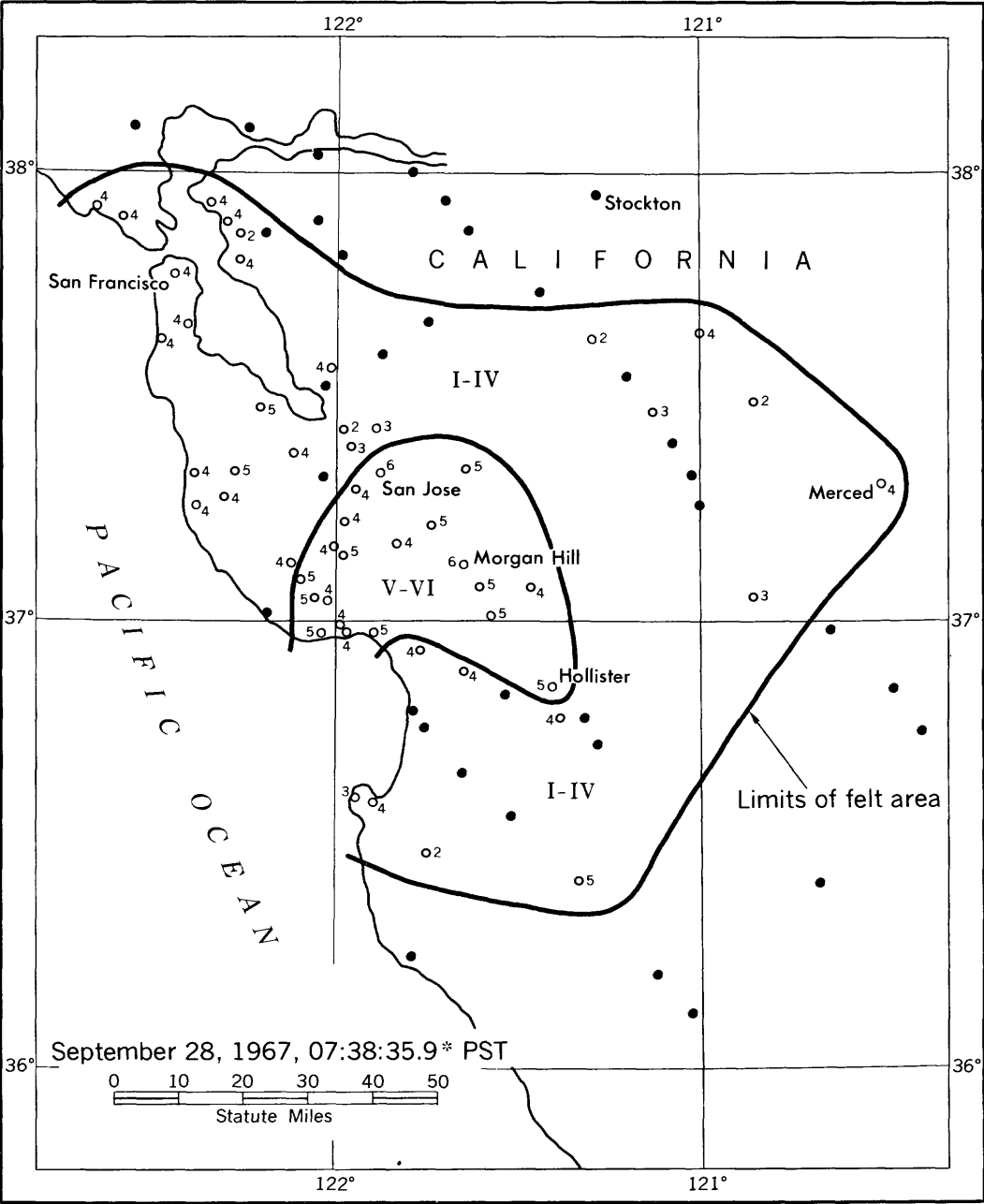


FIGURE 9.—Area affected by California earthquake of September 28.

north, 121°25' west, central California, B. Magnitude 3.2. IV. At the Almaden Winery, south of Hollister, observer reported cam was 6 to 10 inches out of frame. Intensity IV effects were also noted at Hollister, and at

the Harris Ranch, 7 miles south of Hollister; intensity III at Paicines.

October 13: 16:36:21.6\*. Epicenter 34° 09.9' north, 117°26.7' west, southern California, P. Magnitude 3.6. V. At Lytle Creek,



felt by all and frightened few in community. Windows, doors, and dishes rattled. Hanging objects swung moderately. Loud rumble. Felt with intensity IV at Colton, Riverside, and San Bernardino. Also felt at Fontana, Ontario, South San Gabriel, and Upland. "There have been a number of felt shocks since October 13 that have apparently come from essentially the same epicenter." (Letter, dated October 26, 1967, from Pasadena)

October 24: 20:56:33.9\*. Epicenter 34° 10.0' north, 117°25.7' west, southern California, P. Magnitude 2.8. Felt at San Bernardino.

November 5: 23:22:46.3\*. Epicenter 38° 21' north, 119°21' west, California-Nevada border region, B. Magnitude 3. 5. Intensity IV at the Sonora Junction Maintenance Station, about 17 miles northwest of Bridgeport, on Highway 395; intensity II at Coleville.

November 8: 23:41\*. Epicenter in Hollister area. Magnitude 2.6, B. Intensity IV at Hollister.

November 13: 16:00:52.9\*. Epicenter 35° 57.4' north, 120°30.7' west, central California, P. Magnitude 3.3. Felt at Parkfield.

November 18: 10:00:58.1\*, 10:15. Epicenter 37°50.6' north, 122°00.4' west, central California, about 20 km east-southeast of Berkeley on the Calaveras fault, B. Magnitude 3. 2. V. Felt by many at Alamo. Ceiling cracked. Small objects wobbled; leaves fell from trees. One big jolt; resembled sonic boom. "At about 10:15 two smaller shocks were felt. Each lasted about 1 second and seemed in north-south direction." At Bolinger Canyon, 4 miles from Moraga, building rocked twice, with a loud, explosivelike sound in between. Hanging objects swung violently. Felt by all and frightened few at Walnut Creek. House jolted. Felt by many at Diablo. One loud boom, followed by jerk of foundation. Also felt at Alameda Island, Castro Valley, Concord, Oakland,

San Francisco (downtown area), and Stanford.

November 20: 02:25:49.8\*. Epicenter 33° 57.0' north, 118°29.3' west, southern California, P. Magnitude 2.8. Felt at Culver City, Venice, and West Los Angeles.

November 20: 21:30:22.6\*. Epicenter 37° 25.7' north, 118°26.9' west, California-Nevada border region, B. Magnitude 4.3. V. Felt by many and frightened few at Bishop. Trees and bushes shook; vehicles rocked. Walls appeared to undulate. Chandeliers swung. Rapid, sharp jolt; then slow, rolling motion. At the Control Gorge Power Plant, about 10 to 15 miles north of Bishop, felt by all; awakened and frightened few in community. Small objects shifted. Loud earth noises 1 second before shock. Motion rapid, lasted about 4 seconds. At Bigpine, house seemed to move up and down. Rumble before and after shock which seemed to travel eastward. Also felt by all in home at Dyer, Nev. (Fish Lake Valley), where clock pendulum swung east-west.

November 29: 09:29:03.5\*. Epicenter 35° 38.8' north, 117°29.7' west, southern California, near Searles Lake, P. Magnitude 3.3. Intensity IV at Argus, on the west shore of Searles Lake.

December 5: 10:28:53.6\*. Epicenter 38.0° north, 118.3° west, California-Nevada border region, W. Magnitude 4.3. V. Felt by all in home at Luning, Nev. One plaster crack. House quivered and rattled for about 4 seconds. "A jar, preceded by a loud noise."

December 7: 01:35. Slight tremor felt at Petrolia.

December 10: 04:06:50.3\* (main shock), 04:33:54.2\*, 05:00. Epicenter of main shock 40.5° north, 124.6° west, near coast of northern California, W. Magnitudes 5.8 and 4.6, respectively. VI. The main shock was felt over an area of approximately 6,000 square miles, principally in Humboldt County (see fig. 10). Windows cracked at Ferndale and

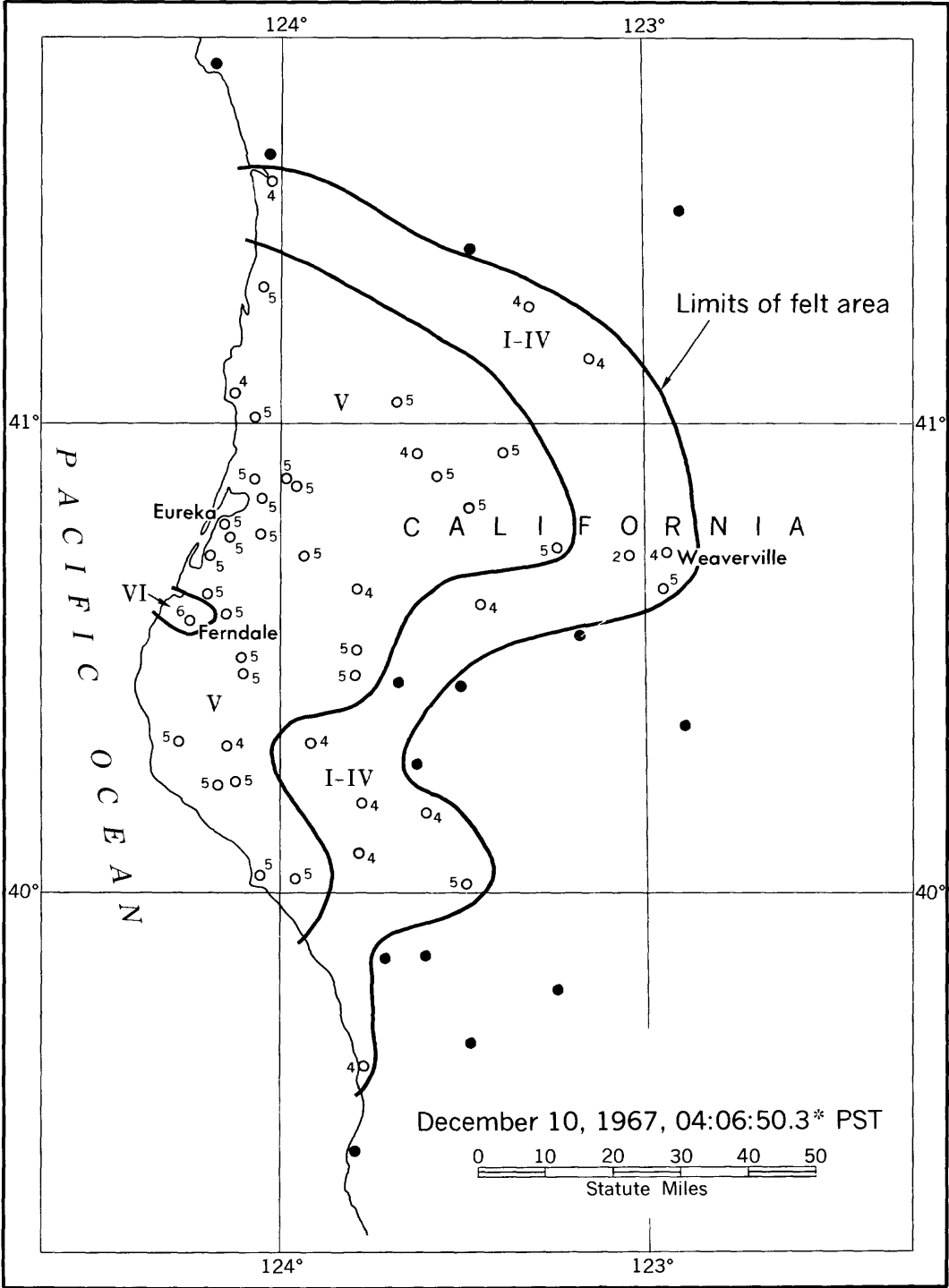


FIGURE 10.—Area affected by California earthquake of December 10.

there was some damage from fallen merchandise in stores. Large plate glass window cracked at Scotia. Chimney twisted at Crannell. Brick chimney cracked at Denny. Shelf-display goods were dislodged at Arcata, Eureka, Fortuna, and Rio Dell. At Petrolia, the aftershock at 04:33 was described as mild; the shock at 05:00, as weak.

#### INTENSITY VI:

Ferndale.—Felt by and awakened all in community; frightened many; many fled homes. Windows cracked. Groceries fell from shelves, with stock from east-west shelves sustaining the most damage. Few small objects shifted and overturned in home; books fell; mirror shifted slightly. Pendulum clocks stopped. Motion very strong and rapid at first, stopped for about 1 second, then became strong again, then subsided to a gentle rocking. Faint but distinct earth noises.

#### INTENSITY V:

Arcata, Bayside, Big Bar, Blue Lake, Bridgeville and 6 miles north of, Burnt Ranch, Crannell, Cutten (near Eureka), Denny, Douglas City, Eureka, Fields Landing, Fortuna, Freshwater, Honeydew and 2 miles west-southwest of, Hoopa, Island Mountain, Kneeland, Korbel, Loleta, Orick, Petrolia, Rio Dell, Salyer, Scotia, Shelter Cove (two shocks felt), and Whitehorn.

#### INTENSITY IV:

Alderpoint, Cecilville, Forks of Salmon, Garberville, Hyampom, Klamath, Moore Ranch (14 miles southeast of Kneeland), Petrolia (8 miles east of), Phillipsville, Trinidad, Weaverville, Weott, Westport, and Willow Creek.

#### INTENSITY I-III:

Junction City.

December 14: 10:54:35.3\*. Epicenter 37° 33.0' north, 121° 54.4' west, central California, B. Magnitude 2.5. Felt at Fremont.

December 18: 09:24:31.9\*. Epicenter 37° 00.6' north, 121° 47.3' west, central California, about 3 miles northeast of Corralitos, B. Magnitude 5.2. VI. Felt over an area of approximately 9,000 square miles (see

fig. 11). Minor damage, principally in the Corralitos-Gilroy-Watsonville area, consisted of cracked plaster and chimneys, broken windows, and broken merchandise in stores. Observer at Corralitos reported most people in the area felt only the one shock; a few reported feeling small aftershocks immediately following the main shock.

#### INTENSITY VI:

Aptos.—Quite a bit of damage to fallen merchandise in store.

Castroville.—Felt by all and frightened few in community. Stucco fell. Hanging objects swung moderately. Swaying motion, accompanied by a loud roar.

Corralitos and vicinity.—Felt by and frightened all in community. Plaster and chimneys cracked; windows and dishes broke. Sheetrock walls were damaged at one place. At another place, nails were pushed through plaster, and a door jamb was knocked out of line. Much merchandise fell in stores. In homes, furniture upset; televisions on casters slid to middle of rooms; Christmas trees overturned; clocks fell off walls. Water disturbed. Trees and bushes shook violently; vehicles rocked. Hanging objects swung violently north-south. Shock was described as one big "crunch," followed by a brief rolling motion, and accompanied by loud earth noises.

Coyote.—Felt by all and frightened many in community. Trees and bushes shook; vehicles rocked. Hanging objects swung violently north-south. Small objects shifted, overturned, and fell. Faint earth noises.

Freedom.—Felt by and frightened all in community. Damage slight. Small objects shifted, overturned, and fell. Refrigerator moved 3 inches. Trees and bushes shook. Hanging objects swung moderately north-south. Moderate earth noises.

Gilroy and vicinity.—Felt by and frightened all in community. Plaster and windows cracked. Much merchandise fell in stores and broke. Trees and bushes shook; vehicles rocked. Bed on casters rolled across room. Hanging objects swung violently east-west. Severe jolt; motion rocking north-south, then

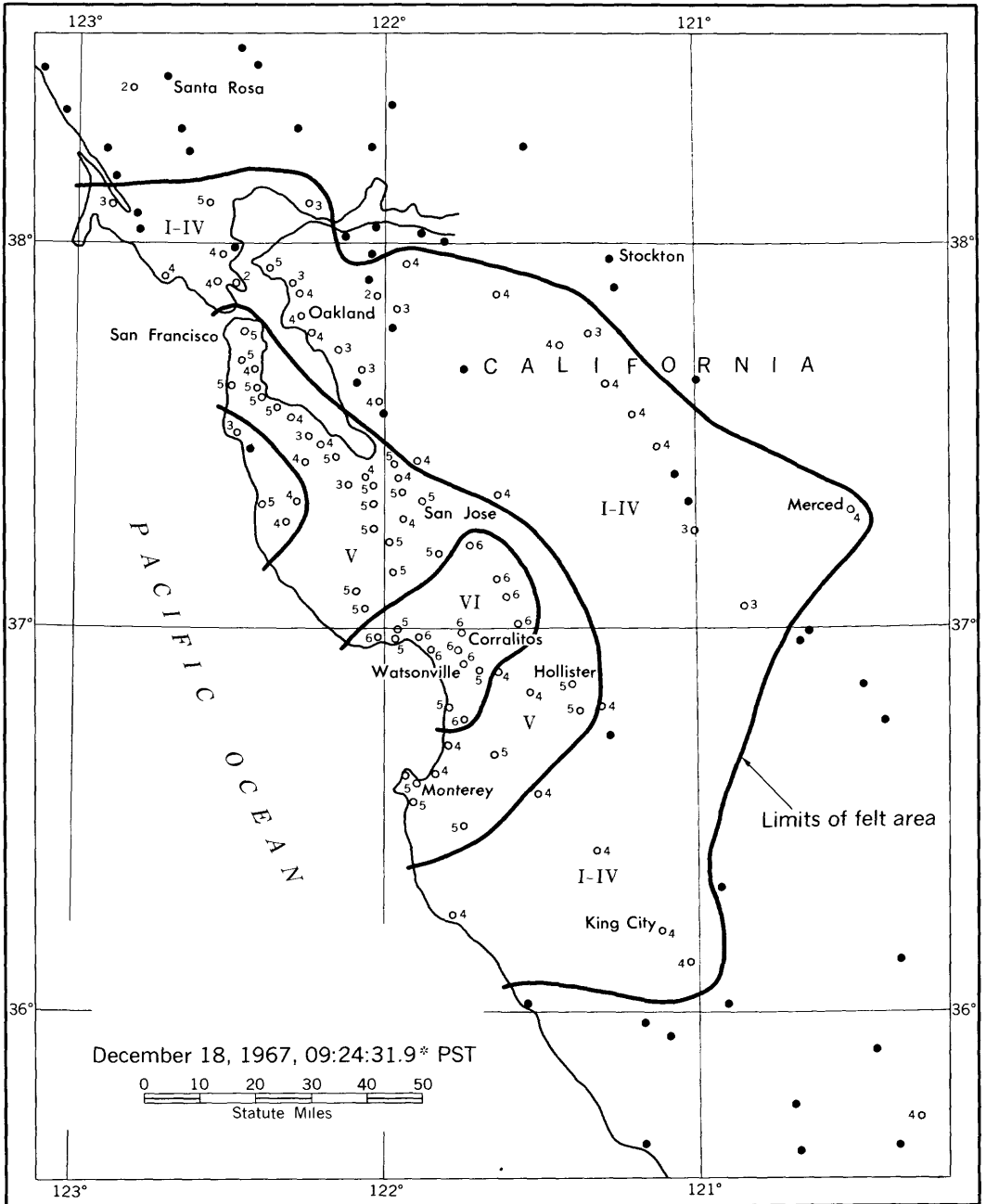


FIGURE 11.—Area affected by California earthquake of December 18.

east-west, then up and down; loud earth noises.

La Selva Beach (about 7 miles northwest of Watsonville).—Felt by all in community. Merchandise fell in store. Trees and bushes

shook; vehicles rocked. Hanging objects swung violently northwest-southeast. Loud earth noises.

Morgan Hill.—Felt by all and frightened many in community. Glass broke in home.

Groceries fell to floor, especially from east-west shelves. Trees and bushes shook; vehicles rocked. Moderate earth noises.

San Martin.—Felt by all and frightened many in community. Small objects fell. Trees and bushes shook; vehicles rocked. Hanging objects swung violently. Loud earth noises.

Santa Cruz.—Felt by all in community. Plaster cracked. Water spilled from fish aquarium in home. The needle was knocked off phonograph record at radio station, and station antenna jiggled.

Watsonville and vicinity.—Felt by and frightened all in community; few ran outdoors. Plaster cracked in City Hall basement; considerable plaster cracked and fell at a school. Merchandise fell in stores. At a nursery and pet shop, fish were flipped out of tanks, water spilled, and three empty 20-gallon fish tanks were broken. Trees and bushes shook; vehicles rocked. Hanging objects swung violently north-south. Severe shaking in north-south direction, accompanied by loud, thunderous earth noises.

#### INTENSITY V:

Alviso, Ben Lomond, Burlingame, Capitola, Carmel, Carmel Valley, Chittenden (old Chittenden Road, east of Watsonville), Cupertino, Daly City-Colma, Felton, Harris Ranch (7 miles south of Hollister), Hollister, Holy City, Los Gatos, Millbrae, Monterey, Moss Landing, New Almaden, Novato, Pacifica, Palo Alto, Richmond, Salinas, San Bruno, San Francisco, San Gregorio, San Jose, Santa Clara, Saratoga, Soquel, and Sunnyvale.

#### INTENSITY IV:

Agnew, Alameda, Aromas, Berkeley, Big Sur, Bolinas, Brisbane, Byron, Campbell, Cholame, Chualar, Clayton, King City, La Honda, Loma Mar, Marina, Merced, Mill Valley, Milpitas, Mountain View, Mount Hamilton, Oakland, Patterson, Redwood City, San Juan Bautista, San Lucas, San Mateo, San Rafael, Seaside, Soledad, South San Francisco, Tracy, Tres Pinos, Union City, Vernalis, Westley, and Woodside.

#### INTENSITY I-III:

Alamo, Albany, Banta, Belvedere-Tiburon, Diablo, El Granada, Gustine, Hayward, Inverness, Los Altos, Los Banos, San Carlos, San Leandro, Sebastopol, and Vallejo.

December 23: 20:13:42.3\*. Epicenter  $33^{\circ} 54.7'$  north,  $118^{\circ} 14.8'$  west, southern California, P. Magnitude 2.8. Felt at Inglewood and West Los Angeles.

December 29: 14:17:08.2\*. Epicenter  $37^{\circ} 31.3'$  north,  $118^{\circ} 20.4'$  west, P. Magnitude 3.3. V. Bishop (Birchim Canyon). Felt by all; frightened few. Small objects moved. Trees and bushes shook slightly. Hanging objects swung north-south. Gradual onset; strong up-and-down motion of 7 seconds' duration; preceded and followed by earth noises.

December 30: 00:04:41.1\*. Epicenter  $40.5^{\circ}$  north,  $124.3^{\circ}$  west, near coast of northern California, W. Magnitude 4.6. V. Felt over an area of approximately 2,000 square miles of Humboldt County. At Ferndale, felt by and awakened all in community; frightened many. Press reported goods tumbled from store shelves. Sharp shock, then rolling motion; duration about 30 seconds; preceded by earth noise similar to sonic boom. Most people awakened at Carlotta, where buildings shook severely. In the Starvation Flat area, about  $2\frac{1}{2}$  miles southwest of Carlotta, pictures on walls swayed. Felt by, awakened, and frightened all in home at Fields Landing. At Loleta, felt by and awakened many in community. Awakened many and frightened few in community at Rio Dell; bottles and glasses in taverns rattled. At Ryan Slough, awakened all. Awakened many and frightened few in community at Scotia; bottles and glasses rattled in taverns. Felt with intensity IV at Arcata, Bayside, Eureka, Fortuna, Honeydew, King Salmon Resort, Korbel, Miranda, and Whitethorn; intensity I-III at Garberville, Kneeland, and Weott.

December 31: 15:48:11\*. Epicenter  $35^{\circ} 40'$  north,  $120^{\circ} 25'$  west, central California, B. Magnitude 4. 3. V. One plaster crack

enlarged and two dishes broke at Parkfield. At the Work Ranch, about 8 miles northwest of Shandon, plaster flakes fell in each room; some small objects fell. Intensity V also reported at Creston, San Miguel, Shandon, and Templeton; intensity IV at Avenal and 6 miles northeast of, Cholame, Paso Robles, Pozo, San Ardo, San Luis Obispo, and Santa Margarita; intensity I-III at Atascadero and Morro Bay. The shock was also strongly felt at the Salinas Dam, about 32 miles southwest of Cholame.

## WASHINGTON AND OREGON

[120th Meridian or Pacific Standard Time]

January 17: 22:58:20.2\*. Epicenter 47.3° north, 122.6° west, Washington, W. Magnitude 3.1. S. Press reports indicated an intensity IV at Puyallup, Seattle, and Tacoma. Felt north to Edmonds.

February 13: No time given. Intensity II at Prosser, Wash.

March 6: 19:51:07.6\*. Epicenter 47.8° north, 122.7° west, Washington, W. Magnitude 4. 4. V. Felt over an area of approximately 7,500 square miles of northwestern Washington. The shock was sharp, and felt throughout the Puget Sound area, but caused no damage. Houses shook as far north as Victoria, B.C. Intensity V effects were noted at Baring, Chimacum (east of), Dash Point, Edmonds, Hadlock, Indianola, Keyport, Lowell, Preston, Quilcene, Seattle, and Silverton; intensity IV at Auburn, Beaver Lake, Bremerton, Brinnon, Clinton, Cumberland, Des Moines, Dockton, Gold Bar, Granite Falls, Greenbank, Issaquah, Kapowsin, Langley, McMillin, Manchester (north of), Milton, Mountlake Terrace, Olympia, Port Gamble, Port Ludlow, Port Orchard, Seabeck, Stanwood, Summer, Tahuya, Tracyton, and Wilkeson; intensity I-III at Alder, Allyn, Belfair, Buckley, Burley, Burton, Coupeville, Electron, Fall City, Freeland, Gig Harbor, Graham, Grapeview, Hansville, Hobart, Index, Kingston, Lakebay, Littlerock (west of),

Lynnwood, Mercer Island, Monroe, Olalla, Pacific, Portage, Port Townsend, Poulsbo, Puyallup, Richmond Beach, Rochester, Rollingbay, Seattle Heights, Skykomish, Sultan, Vashon (near), and Vaughn.

May 15: 17:01. Felt at Lynden, Wash.

May 25: 15:22:34\*. Epicenter 48.1° north, 122.8° west, Washington, W. Magnitude 4. 5. Felt at Seattle.

December 19: 13:41. A press report indicated a mild tremor was observed in portions of South Seattle and Mercer Island, Wash.

## ALASKA

[150th Meridian or Alaska Standard Time]

January 2: 07:30. Slight shock felt at Homer.

January 6: 18:55:30\*. Epicenter 51.7° north, 175.5° west, Andreanof Islands, W. Magnitude 4. 4. Felt at Adak.

January 7: 11:06:27\*. Epicenter 51.8° north, 176.6° west, Andreanof Islands, W. Magnitude 4. 3. Felt at Adak.

January 18: 00:42:59.0\*. Epicenter 60.4° north, 152.5° west, southern Alaska, W. Magnitude 4. 4. Felt at Homer.

January 28: 03:52:58.3\*. Epicenter 52.4° north, 169.5° west, Fox Islands, W. Magnitude 6¼-6½, P. Felt on Umnak.

February 5: 17:26:35.4\*. Epicenter 60.1° north, 152.8° west, southern Alaska, W. Magnitude 4. 9. Intensity III at Anchorage, Homer, Kenai (including several locations in the Kenai Peninsula), and Kodiak (Naval Air Station).

February 6: 04:48:40.1\*. Epicenter 64.8° north, 147.4° west, central Alaska, W. Magnitude 4.5. V. All residents were awakened at Nenana, Fort Greeley, Murphy Dome, Gilmore Creek, Eielson Air Force Base, and Fairbanks. The felt area was approximately 20,000 square miles.

February 10: 10:55. Intensity IV at the Anchorage International Airport.

February 16: 22:00. Intensity IV in Anchorage.

February 23: 14:23:53\*. Epicenter 51.8° north, 176.7° west, Andreanof Islands, W. Magnitude 4. 2. Felt at Adak.

February 27: 18:00:12.8\*. Epicenter 64.9° north, 148.7° west, central Alaska, W. Felt at Fairbanks, Manley Hot Springs, Murphy Dome, and North Pole.

March 19: 22:23:00.4\*. Epicenter 60.4° north, 149.5° west, Kenai Peninsula, W. Magnitude 3.9. Intensity III effects were noted in the Hill Building in Anchorage.

March 25: 18:24:13.5\*. Epicenter 64.1° north, 147.2° west, central Alaska, W. Magnitude 4.4. Intensity IV in the central section of Delta Junction.

March 30: 18:18:31.1\*. Epicenter 63.1° north, 148.5° west, central Alaska, W. Magnitude 4.6. Felt at Cantwell and High Lake Lodge.

April 3: 07:33:12.4\*. Epicenter 61.9° north, 148.5° west, southern Alaska, W. Magnitude 3.8. Intensity II at Palmer.

April 4: 10:43:03.7\*. Epicenter 60.2° north, 148.5° west, Kenai Peninsula, W. Magnitude 4.1. Felt slightly 5 miles northwest of Homer at the FAA Station.

April 11: 14:54:42.1\*. Epicenter 56.2° north, 136.0° west, southeast Alaska, W. Magnitude 4.4. Felt at Sitka.

April 16: 14:00:42.7\*. Felt at Shemya Air Force Station, Shemya Island.

April 20: 16:22:30.9\*. Epicenter 64.7° north, 146.9° west, central Alaska, W. Magnitude 4.0. Intensity IV at Fairbanks. Also felt at Aurora Lodge, Eielson Air Force Base, Lemeta, and Mile 16 and 17 on Richardson Highway.

April 28: 17:55:20.8\*. Epicenter 51.4° north, 178.3° west, Andreanof Islands, W. Magnitude 6.0. Intensity III at Adak.

April 29: 02:25:32.7\*. Epicenter 51.5° north, 178.2° west, Andreanof Islands, W. Magnitude 5.3. Intensity II at Adak.

April 30: 18:19. Felt at High Lake Lodge.

May 5: 07:06:14.9\*. Epicenter 63.7° north, 148.5° west, central Alaska, W. Magnitude 4. 9. Intensity IV at Delta Junction. Also felt at Clear, Fairbanks and 4½ Mile (Badger Road), Fort Greeley, Nenana, and Sunshine.

May 7: 20:40:29\*. Epicenter 62.1° north, 149.9° west, central Alaska, W. Magnitude 3.8. Intensity III at Palmer.

May 19: 06:43:51.2\*. Epicenter 51.8° north, 177.0° west, Andreanof Islands, W. Magnitude 4. 5. Felt at Adak.

May 31: 17:36:19.0\*. Epicenter 53.7° north, 165.6° west, Fox Islands, W. Magnitude 5.7. Intensity IV at Dutch Harbor. Also felt slightly on Adak and Umnak Islands and at Cold Bay.

June 8: 09:08:40.4\*. Felt on Adak.

June 20: 12:30, 15:00. Dot Lake (Mile 1361). VI. The second shock frightened all in the area. Water in the lake was violently disturbed; trees swayed. Intensity III at Dot Lake Lodge and on Dot Lake Lodge Campground.

June 21: 08:04:49.5\*, 08:13:02.9\* (main shock), 08:24:45.7\*. Principal shocks of the Fairbanks series. Epicenter (1) 64°45.4' north, 147°22.3' west; (2) 64.8° north, 147.4° west; (3) 64.8° north, 147.4° west, central Alaska, W. Magnitudes 5.4, 5.6, and 5.4, respectively. VII. Felt over an area of approximately 90,000 square miles (see fig. 12). Minor damage occurred in Fairbanks, and in some areas south and southeast of Fairbanks. By the end of the first week—June 28—the

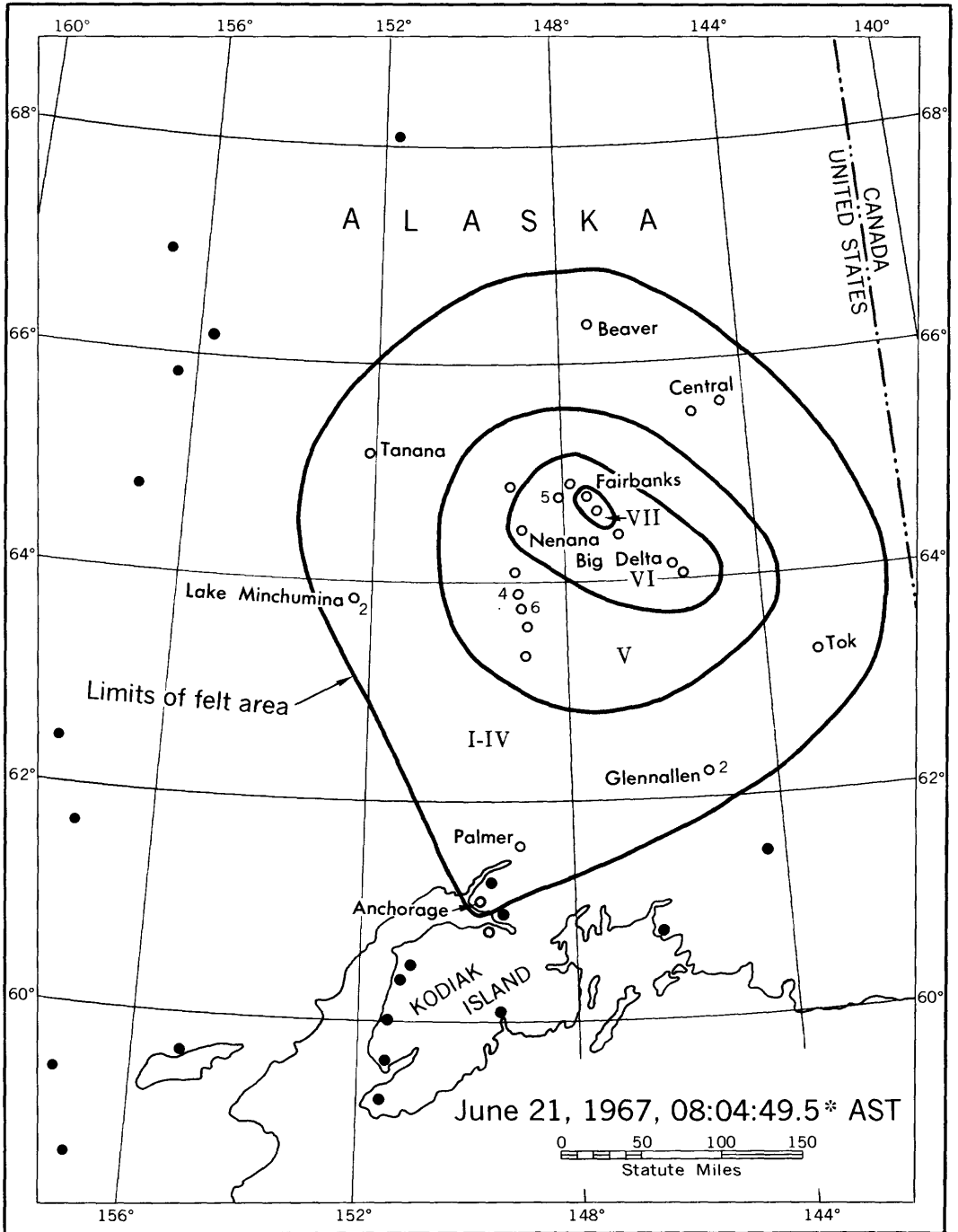


FIGURE 12.—Area affected by central Alaska earthquake of June 21.

earthquake swarm subsided from over 2,000 on the first day to about 425 daily, with nearly 6,000 aftershocks being recorded. At least 60

were felt by residents. Some aftershocks caused additional property damage at Fairbanks. For additional details on this earth-



quake series, refer to the special report prepared by the Coast and Geodetic Survey<sup>1</sup>.

#### INTENSITY VII:

Fairbanks.—The State Court and Office Building sustained the most extensive damage, with both exterior and interior cracks. Portions of hanging ceiling and some light fixtures fell; plumbing broke, causing considerable flooding. Cabinets and shelves overturned and the building was temporarily closed to the public. The Barnette, Antonia, and Federal Buildings were slightly damaged. There was considerable merchandise damage in several stores, with one reporting \$5,000 damage. Brief power outages occurred in some areas. Minor cracks were observed in a few concrete walls; several chimneys fell; windows broke; one tall chimney stack buckled. South of Fairbanks, police reported a crack in the bottom of a lake. Three parallel ground cracks, 6 feet apart, were observed at Badger Pass and Peede Road. Blue mud seeped up through the cracks. At Glenwood Drive and Lawrence Road, a resident reported his house raised about 4 inches, but had settled to about 2½ inches by June 28.

Fort Wainwright (about 5 miles southeast of Fairbanks).—Seiche action was observed in a cooling pond. The water sloshed in a north-south direction, with a maximum displacement of about 5 feet at each end. The banks slumped at the northwest corner of the pond. On the third floor of Building 1004, the east-west interior concrete-block wall completely cracked loose from the surrounding concrete columns and beam; on the second floor, an east-west interior concrete-block partition cracked.

Richardson Highway (Mile 16.5, Park Road).—Chimney offset; basement floor cracked.

Richardson Highway (Mile 17).—Sand pumped up into loamy garden soil; water spouted from the cracks. One resident re-

ported that water rose to top of well, then dropped to normal.

Richardson Highway (Mile 35).—A State Highway Department official reported that the overhead sewerline broke, spewing sewage all around.

#### INTENSITY VI:

Big Delta.—Four shocks felt very strongly.

College.—Magnetic instrumentation damaged; some knocked over. Strong aftershocks continued to cause misalignment of the systems. Shocks shook buildings at College Observatory violently; probably a cumulative effect of all the shocks knocked over the magnetic equipment at the observatory.

Delta Junction (east section).—Slight damage to buildings. Visible swaying of buildings and trees. All were frightened.

Gilmore Creek (ESSA facility).—Hairline cracks sustained, but no damage occurred to the Satellite Data Acquisition System.

Healy Canyon (5 miles north of McKinley National Park).—Small landslides were reported by a Park ranger.

Nenana (central section).—Felt by many; general alarm. Visible swaying of buildings and telephone poles; items fell from all shelves in store. Rumbling earth noises.

#### INTENSITY V:

Cantwell (three shocks around 08:10), Clear (1½ miles north of; three shocks), Ester (several shocks felt); McKinley National Park Headquarters (three shocks felt).

#### INTENSITY IV:

Beaver (08:00 and 08:10), Central (08:15 and 08:18), Healy Fork (three shocks), Minto (three shocks), Tanana (08:15), and Tok (about 08:20).

#### INTENSITY I-III:

Anchorage (08:13 and 08:24), Fort Greeley, Glennallen (two shocks), Lake Minchumina (08:12), Miller House (three shocks), and Palmer.

June 21: 12:15 (about) IV. Felt by 12 persons, outdoors, at base camp at Healy River. Abrupt onset; trembling motion.

June 21: 13:31:46.6\*. Epicenter 64°44.5'

<sup>1</sup> *The Fairbanks, Alaska, Earthquakes of June 21, 1967*, Environmental Science Services Administration, Coast and Geodetic Survey, Government Printing Office, Washington, D.C., 1968.

north, 147°25.1' west, central Alaska, W. Magnitude 3.9. Felt at College Observatory and Fairbanks

June 21: 14:27:54\*. Epicenter 64.9° north, 147.1° west, central Alaska, W. Magnitude 4.1. Felt at College Observatory.

June 22: 04:11:31\*. Epicenter 64.8° north, 147.5° west, central Alaska, W. Magnitude 3.8. Felt at College Observatory, FAA Station, and Fairbanks.

June 22: 05:36:38.9\*. Epicenter 51.7° north, 176.8° west, Andreanof Islands, W. Magnitude 5.3. Felt on Adak.

June 22: 08:57:36.4\*. Epicenter 64°49.6' north, 147°24.9' west, central Alaska, W. Magnitude 4.1. Intensity II at Clear. Also felt at Fairbanks.

June 22: 10:19. Fairbanks. Magnitude 3.8. Minor shock rumbled through the city (press).

June 22: 11:16:56.2\*. Epicenter 64°49.5' north, 147°26.1' west, central Alaska, W. Magnitude 4.1. Felt strongly at Fairbanks. Also felt at College.

June 22: 12:44, 13:08, 17:54, 19:18. Felt at College Observatory. Second shock had a magnitude of 3.6.

June 22: 20:06:23.2\*. Epicenter 64°44.7' north, 147°26.0' west, central Alaska, W. Magnitude 4.0. Felt strongly at Fairbanks.

June 22: 20:34, 20:44. Felt at College Observatory.

June 23: 01:54:33.5\*, 01:56, 01:57, 01:58, 02:01, 02:04, 05:27. Epicenter of first shock, 64°49.0' north, 147°27.3' west, central Alaska, W. Magnitude 4.6. VI. Press reported the State Court and Office Building sustained additional damage. Several new cracks appeared on walls inside and outside of the building; concrete columns extending from second to fourth floor appeared to have shifted about ¼ inch. Merchandise fell in supermarkets and stores.

June 23: 10:10:40.9\*. Epicenter 64°50.9' north, 147°19.1' west, central Alaska, W. Magnitude 3.5. Felt at Fairbanks.

June 24: 01:02:56.9\*. Epicenter 64°47.8' north, 147°30.4' west, central Alaska, W. Magnitude 3.9. Felt at Fairbanks.

June 24: 16:53. Felt at College Observatory.

June 25: 05:18:39.7\*, 07:35, 12:38. Epicenter of first shock 64°46.9' north, 147°23.0' west, central Alaska, W. Magnitude 3.3. All were felt at Fairbanks.

June 26: 04:38. Felt at Fairbanks.

June 27: 01:02, 20:57. Both were felt at College Observatory.

June 27: 21:10. Observer 8 miles north of Eielson Air Force Base reported feeling four shocks around 21:10. A man at ¾ Mile on Lawrence Road (Fairbanks) reported several small shocks were felt in the area on the 27th.

June 28: 10:28:11.3\*. Epicenter 64.8° north, 147.5° west, central Alaska, W. Magnitude 3.8. Felt at Fairbanks.

June 28: 18:53:25.0\*. Epicenter 51.7° north, 177.0° west, Andreanof Islands, W. Magnitude 4.6. Intensity III on Adak.

July 1: 13:10:07.2\*. Epicenter 54.4° north, 158.0° west, Alaska Peninsula, W. Magnitude 6¾, P. Intensity IV at Perryville. Also felt at Cold Bay and Sand Point.

July 5: 19:06:13.4\*. Epicenter 62.4° north, 147.4° west, Alaska, W. Magnitude 5.1. Intensity III at Anchorage. Also felt at Clear, Glennallen, Gulkana, and Tazlina.

July 7: 10:37. A press report stated a slight shock was felt at Fairbanks at this time.

July 7: 21:00:57\*, 23:18:17\*. Epicenter 62.3° north, 156.3° west, central Alaska, W. Magnitude 4.0 for both shocks. Intensity IV at McGrath.

July 11: 15:47:31\*. Epicenter 51.8° north,

175.0° west, Andreanof Islands, W. Magnitude 4.5. Slight shock felt at Adak.

July 15: 23:44. Earth tremor reported at Adak.

July 16: 04:39. Earth tremor reported at Adak.

July 17: 00:19. Fairbanks. "One of the strongest aftershocks to date of the June 21 earthquake series."

July 19: 08:35. Slight shock reported 5 miles northwest of Homer at the FAA Station.

July 24: 02:30. Earth tremor reported at Manley Hot Springs.

July 24: 06:18:45\*. Epicenter 65.7° north, 152.2° west, Alaska, W. Felt at Manley Hot Springs.

July 25: 04:37, 20:20. Earth tremors felt at Adak.

July 27: 06:35:41.4\*. Felt at Adak.

August 4: 00:59:26.9\*. Felt at Adak.

August 5: 13:46:22.5\*. Felt at Eielson Air Force Base and Fairbanks.

August 7: 22:58:32.3\*. Felt at Fairbanks.

August 11: 14:49:19.2\*, 14:49:37.0\*. Felt at Fairbanks.

August 12: 08:41:30.5\*. Felt at Adak.

August 13: 15:46:47.5\*. Felt sharply at Fairbanks.

August 17: 12:42:09.3\*. Epicenter 59.4° north, 151.4° west, Kenai Peninsula, W. Magnitude 5.0. Felt at Palmer.

August 17: 19:50:29.0\*. Epicenter 61.5° north, 151.0° west, southern Alaska, W. Magnitude 4.5. Felt at Palmer.

August 20: 09:24:00.9\*. Felt at College and Fairbanks.

August 22: 21:48:40.5\*. Felt at College and Fairbanks.

August 23: 00:29:33.7\*. Felt at College and Fairbanks.

August 25: 14:05:32.5\*. Felt at Fairbanks.

August 27: 23:25:30.6\*. Felt at Fairbanks.

August 30: 12:12:17.5\*. Felt at College.

September 3: 01:30:51.7\*. Epicenter 60.5° north, 151.6° west, Kenai Peninsula, W. Magnitude 4.7. Felt at Anchorage.

September 6: 12:29:18\*. Intensity IV at Clear.

September 8: No time given. Tremor felt at Adak.

September 8: 19:37:47.2\*. Felt at College.

September 10: 22:00:53.4\*. Felt at Fairbanks.

September 15: 22:31:58.4\*. Epicenter 52.0° north, 176.4° west, Andreanof Islands, W. Magnitude 5.4. Three shocks were felt at Adak, one at the time given above.

September 18: 19:54:49.1\*. Felt at College.

September 20: 17:01:19.7\*. Felt at College.

September 21: 21:10:04.4\*. Felt at College.

September 25: 09:48. Slight shock felt at Homer.

September 25: 15:10:58.3\*. Felt at College.

September 28: 05:14:55.7\*. Epicenter 59.4° north, 147.1° west, Gulf of Alaska, W. Magnitude 5.6. Felt at Cordova and at the FAA installation on Middleton Island.

October 1: 23:30:02.2\*. Felt at College.

October 9: 16:52:56.3\*. Epicenter 52.3° north, 176.1° west, Andreanof Islands, W. Magnitude 5.0. Felt at Adak.

October 10: 02:14:11.8\*. Epicenter 64.8° north, 147.2° west, central Alaska, W. Felt at Fairbanks.

October 10: 21:56:36.1\*. Epicenter 63.0° north, 151.1° west, central Alaska, W. Magnitude 4.6. Felt at Palmer.

October 25: 10:07:32.6\*. Epicenter 60.8° north, 150.4° west, Kenai Peninsula, W. Felt at Anchorage.

October 28: 00:13:09\*. Epicenter 64.8° north, 147.7° west, central Alaska, W. Felt at Fairbanks.

October 29: 09:31. Felt by very few 5 miles northwest of Homer at the FAA Station.

October 30: 13:03:12.5\*. Felt at Fairbanks.

October 31: 17:10:43\*. Felt at Fairbanks.

November 10: 08:29:57.3\*. Epicenter 62.3° north, 151.4° west, central Alaska, W. Magnitude 5.8-6.0, B. Felt in the Anchorage area.

November 16: 08:35:58\*. Felt at Anchorage.

November 17: 23:20:53.5\*. Felt at College and Fairbanks.

November 21: 11:04:07.3\*. 22:59. Both shocks were felt at Adak.

November 24: 00:13:36.8\*. Felt at Fairbanks.

November 24: 22:59:07\*. Epicenter 52.0° north, 175.2° west, Andreanof Islands, W. Magnitude 3.9. Felt at Adak.

November 26: 18:27:02.4\*. Epicenter 60.3° north, 140.8° west, southeastern Alaska, W. Magnitude 4.6. Felt at Yakataga.

November 28: 23:20:01.7\*. Felt strongly at Fairbanks.

December 3: 20:53:17.5\*. Felt at Adak.

December 11: 18:48:34.5\*. Epicenter 65.0° north, 147.3° west, Alaska, W. Felt at Fairbanks.

December 12: 23:36:24.2\*. Epicenter

65.1° north, 147.3° west, Alaska, W. Felt at Fairbanks.

December 14: 16:13:36.3\*. Felt at Fairbanks.

December 18: 18:48:38.8\*. Felt at Fairbanks.

December 19: 04:40:41.3\*. Epicenter 51.7° north, 176.9° west, Andreanof Islands, W. Magnitude 4.8. Felt at Adak.

## HAWAII

[150th Meridian or Hawaiian Standard Time]

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

January 6: 20:36:20.9\*. Epicenter 19° 22.7' north, 155°18.0' west, 4 km west of Ahua seismometer at a depth of 35 km. Magnitude 3.9. Felt at Hilo, Kamuela, Kona, Naalehu, Pahala, and in Kilauea Summit region.

January 10: 07:52:30.8\*. Epicenter 19° 23.9' north, 155°05.2' west, 10 km east-northeast of Makaopuhi seismometer at a depth of 3 km. Magnitude 3.3. Felt at Hilo.

January 10: 23:21:01.7\*. Epicenter 19° 20.2' north, 155°04.5' west, 11 km southeast of Makaopuhi seismometer at a depth of 5 km. Magnitude 3.8. Felt at Hilo and Pahoa.

January 22: 11:31:42.8\*. Epicenter 19° 23.7' north, 155°27.3' west, 9 km northwest of Desert seismometer at a depth of 8 km. Magnitude 3.7. Felt at Hilo and Paauiolo.

January 23: 16:59:14.9\*. Epicenter 19° 26.8' north, 155°26.0' west, 8 km southwest of Mauna Loa seismometer at a depth of 8 km. Magnitude 4.6. Felt Island-wide.

January 24: 12:23:36.8\*. Epicenter 19° 25.7' north, 154°56.0' west, 7 km south-southeast of Pahoa at a depth of 5 km. Magnitude 1.8. Felt at Kapoho.

January 26: 04:30:54.8\*. Epicenter 19°

27.8' north, 154°53.8' west, 6 km southeast of Pahoa at a depth of 0 km. Magnitude 2.7. Felt at Kapoho.

January 26: 04:32:03.8\*. Epicenter 19° 26.9' north, 154°54.2' west, 7 km southeast of Pahoa at a depth of 5 km. Magnitude 3.4. Felt at Kapoho.

February 1: 23:30:41.5\*. Epicenter 19° 21.7' north, 155°05.5' west, 9 km east of Makaopuhi seismometer at a depth of 5 km. Magnitude 4.5. Felt Island-wide.

February 1: 23:36:36.1\*. Epicenter 19° 21.6' north, 155°03.7' west, 12 km east of Makaopuhi seismometer at a depth of 5 km. Magnitude 2.7. Felt at Hilo.

February 3: 18:49:33.0\*. Epicenter 19° 22.4' north, 155°04.7' west, 10 km east of Makaopuhi seismometer at a depth of 5 km. Magnitude 3.1. Felt at Hilo.

February 7: 04:39:42.9\*. Epicenter 19° 18.9' north, 155°18.0' west, 8 km southwest of Ahua seismometer at a depth of 28 km. Magnitude 3.5. Felt at Hilo, Naalehu, Pahala, and in Kilauea Summit region.

February 8: 07:45:26.4\*. Epicenter 19° 34.2' north, 155°49.1' west, 12 km northeast of Kealakekua at a depth of 0 km. Magnitude 2.9. Felt at Kealakekua.

February 12: 11:45:04.8\*. Epicenter 19° 56.5' north, 155°26.8' west, 13 km southwest of Paauiilo at a depth of 8 km. Magnitude 3.7. Felt at Hilo, Honokaa, Kamuela, and Laupahoehoe.

February 16: 21:49:12.0\*. Epicenter 19° 26.8' north, 154°59.2' west, 7 km southwest of Pahoa at a depth of 0 km. Magnitude 3.3. Felt at Kapoho.

February 16: 21:52:37.0\*. Epicenter 19° 25.8' north, 154°55.8' west, 7 km south-southeast of Pahoa at a depth of 5 km. Magnitude 1.8. Felt at Kapoho.

March 9: 22:39:45.1\*. Epicenter 19°16.3' north, 155°28.8' west, 12 km southwest of

Desert seismometer at a depth of 31 km. Magnitude 2.2. Felt at Pahala.

March 10: 05:07:28.6\*. Epicenter 19° 35.7' north, 155°50.1' west, 12 km northeast of Kealakekua at a depth of 0 km. Magnitude 2.0. Felt at Kealakekua.

March 14: 18:42:28.3\*. Epicenter 19° 16.7' north, 155°13.3' west, 4 km northwest of Apua Point at a depth of 8 km. Magnitude 3.8. Felt at Hilo, Pahala, and in Kilauea Summit region.

March 22: 13:15:34.6\*. Epicenter 19° 23.2' north, 155°24.2' west, 6 km northwest of Desert seismometer at a depth of 10 km. Magnitude 2.0. Felt at Pahala.

March 23: 14:24:43.7\*. Epicenter 19° 22.9' north, 155°18.7' west, 5 km west-northwest of Ahua seismometer at a depth of 30 km. Magnitude 2.7. Felt at Pahala.

March 24: 14:58:36.5\*. Epicenter 19° 46.5' north, 155°41.0' west, 10 km south-southwest of Waikii at a depth of 8 km. Magnitude 4.3. Felt Island-wide.

March 27: 12:56:15.4\*. Epicenter 19° 19.3' north, 155°20.7' west, 5 km southeast of Desert seismometer at a depth of 3 km. Magnitude 2.7. Felt at Pahala.

March 27: 13:06:37.0\*. Epicenter 19° 22.5' north, 155°23.6' west, 4 km north of Desert seismometer at a depth of 0 km. Magnitude 2.7. Felt at Pahala.

April 6: 22:57:08.4\*. Epicenter 19°23.8' north, 155°16.4' west, 3 km northwest of Ahua seismometer at a depth of 25 km. Magnitude 4.0. Felt Island-wide.

April 7: 02:17:47.3\*. Epicenter 19°24.7' north, 155°17.7' west, 2 km south-southwest of Uwekahuna seismometer at a depth of 30 km. Magnitude 3.1. Felt in Kilauea Summit region.

April 20: 16:00:14.0\*. Epicenter 20°04.8' north, 155°51.7' west, 5 km northwest of Ka-

waihae at a depth of 8 km. Magnitude 3.6. Felt at Kamuela.

May 3: 19:00:33.3\*. Epicenter 19°22.5' north, 155°27.2' west, 8 km northwest of Desert seismometer at a depth of 8 km. Magnitude 4.5. Felt Island-wide.

May 3: 19:46:22.6\*. Epicenter 19°23.5' north, 155°27.0' west, 9 km northwest of Desert seismometer at a depth of 10 km. Magnitude 2.7. Felt at Pahala.

May 13: 16:05:08.2\*. Epicenter 19°24.2' north, 155°27.2' west, 10 km northwest of Desert seismometer at a depth of 13 km. Magnitude 3.3. Felt at Kona, Naalehu, Pahala, and in Kilauea Summit region.

May 15: 01:27:49.7\*. Epicenter 19°24.7' north, 155°25.0' west, 9 km north-northwest of Desert seismometer at a depth of 8 km. Magnitude 2.4. Felt at Pahala.

May 19: 03:52:48.1\*. Epicenter 19°23.0' north, 155°24.2' west, 5 km northwest of Desert seismometer at a depth of 8 km. Magnitude 2.5. Felt at Pahala.

May 21: 16:55:38.0\*. Epicenter 19°23.0' north, 154°49.3' west, 14 km south of Cape Kumukahi at a depth of 45 km. Magnitude 3.4. Felt at Hilo and in Kilauea Summit region.

May 24: 12:28:26.8\*. Epicenter 19°52.4' north, 155°23.5' west, 10 km northeast of Mauna Kea Summit at a depth of 0 km. Magnitude 2.6. Felt at Paauiilo.

May 24: 13:09:25.9\*. Epicenter 19°52.8' north, 155°22.0' west, 5 km southwest of Keanakolu at a depth of 0 km. Magnitude 3.0. Felt at Honokaa, Laupahoehoe, and Paauiilo.

May 24: 13:34:32.0\*. Epicenter 20°04.5' north, 155°23.2' west, 5 km northwest of Paauiilo at a depth of 10 km. Magnitude 3.2. Felt at Honokaa and Paauiilo.

May 25: 01:29:38.0\*. Epicenter 20°10.0' north, 155°23.0' west, 14 km northwest of

Paauiilo at a depth of 13 km. Magnitude 3.0. Felt at Honokaa and Laupahoehoe.

May 25: 01:33:17.5\*. Epicenter 20°02.1' north, 155°23.5' west, 2 km west of Paauiilo at a depth of 13 km. Magnitude 2.7. Felt at Laupahoehoe and Paauiilo.

May 26: 05:47:28.4\*. Epicenter 19°59.8' north, 155°24.6' west, 6 km southwest of Paauiilo at a depth of 7 km. Magnitude 3.4. Felt at Kohala, Laupahoehoe, and Paauiilo.

June 8: 13:27:57.5\*. Epicenter 19°20.9' north, 155°19.0' west, 6 km southwest of Ahua seismometer at a depth of 29 km. Magnitude 2.5. Felt in Kilauea Summit region.

June 9: 00:34:24.6\*. Epicenter 19°58.1' north, 155°23.1' west, 8 km northwest of Keanakolu at a depth of 10 km. Magnitude 2.9. Felt at Honokaa.

June 9: 03:10:05.7\*. Epicenter 19°57.2' north, 155°23.8' west, 8 km northwest of Keanakolu at a depth of 7 km. Magnitude 3.4. Felt at Hilo and Honokaa.

June 9: 04:15:54.4\*. Epicenter 19°53.3' north, 155°22.8' west, 5 km southwest of Keanakolu at a depth of 0 km. Magnitude 2.4. Felt at Honokaa.

June 9: 10:22:18.4\*. Epicenter 20°01.8' north, 155°22.3' west, 1 km southwest of Paauiilo at a depth of 7 km. Magnitude 3.1. Felt at Honokaa and Paauiilo.

June 13: 14:50:53.7\*. Epicenter 19°55.8' north, 155°23.5' west, 6 km west-northwest of Keanakolu at a depth of 5 km. Magnitude 3.6. Felt at Hilo, Honokaa, Kamuela, Laupahoehoe, and Paauiilo.

June 24: 07:42:05.5\*. Epicenter 19°52.0' north, 155°34.8' west, 8 km east-northeast of Waikii at a depth of 8 km. Magnitude 3.2. Felt at Hilo.

June 30: 22:51:54.1\*. Epicenter 19°22.7' north, 155°17.8' west, 3 km west of Ahua seismometer at a depth of 25 km. Magnitude

3. 1. Felt at Pahala and in Kilauea Summit region.

July 1: 15:03:49.5\*. Epicenter  $19^{\circ}27.2'$  north,  $155^{\circ}12.8'$  west, 9 km east-northeast of Uwekahuna seismometer at a depth of 25 km. Magnitude 4. 5. Felt Island-wide.

July 2: 15:14:59.2\*. Epicenter  $19^{\circ}22.0'$  north,  $155^{\circ}23.9'$  west, 4 km north-northwest of Desert seismometer at a depth of 9 km. Magnitude 3. 5. Felt at Hilo and Pahala.

July 2: 17:11:46.1\*. Epicenter  $19^{\circ}21.0'$  north,  $155^{\circ}30.5'$  west, 13 km west-northwest of Desert seismometer at a depth of 4 km. Magnitude 2. 8. Felt at Pahala.

July 5: 02:51:10.9\*. Epicenter  $19^{\circ}23.2'$  north,  $155^{\circ}26.7'$  west, 8 km northwest of Desert seismometer at a depth of 8 km. Magnitude 4. 1. Felt at Hilo, Kona, and Pahala.

July 9: 17:14:17.5\*. Epicenter  $19^{\circ}33.9'$  north,  $155^{\circ}17.9'$  west, 12 km northeast of Mauna Loa seismometer at a depth of 20 km. Magnitude 3. 0. Felt at Mountainview and in Kilauea Summit region.

July 9: 21:18:43.6\*. Epicenter  $19^{\circ}25.8'$  north,  $155^{\circ}26.9'$  west, 12 km northwest of Desert seismometer at a depth of 8 km. Magnitude 2. 6. Felt at Pahala.

July 11: 16:54:23.8\*. Epicenter  $19^{\circ}27.5'$  north,  $155^{\circ}37.3'$  west, 6 km southwest of North Bay seismometer at a depth of 2 km. Magnitude 3. 2. Felt in Mauna Loa Summit area.

July 21: 21:34:27.0\*. Epicenter  $19^{\circ}21.7'$  north,  $155^{\circ}25.7'$  west, 5 km northwest of Desert seismometer at a depth of 8 km. Magnitude 3.2. Felt at Pahala.

July 22: 04:30:25.5\*. Epicenter  $19^{\circ}24.9'$  north,  $155^{\circ}23.6'$  west, 9 km north of Desert seismometer at a depth of 9 km. Magnitude 2. 3. Felt at Pahala.

August 3: 19:29:09.8\*. Epicenter  $19^{\circ}13.6'$  north,  $155^{\circ}35.7'$  west, 18 km north of

Naalehu at a depth of 7 km. Magnitude 3.3. Felt at Naalehu and Pahala.

August 4: 11:33:28.1\*. Epicenter  $19^{\circ}24.7'$  north,  $155^{\circ}19.0'$  west, 3 km west-southwest of Uwekahuna seismometer at a depth of 26 km. Magnitude 2. 6. Felt at Pahala.

August 5: 05:51:51.2\*. Epicenter  $19^{\circ}23.6'$  north,  $155^{\circ}16.9'$  west, 3 km south-southeast of Uwekahuna seismometer at a depth of 26 km. Magnitude 3. 2. Felt at Pahala.

August 14: 19:23:32.8\*. Epicenter  $19^{\circ}58.4'$  north,  $155^{\circ}23.5'$  west, 16 km west-southwest of Laupahoehoe at a depth of 8 km. Magnitude 4.0. Felt at Hilo, Honokaa, Laupahoehoe, Paaui, Pahala, and in Kilauea Summit region.

August 14: 19:44:35.8\*. Epicenter  $19^{\circ}59.4'$  north,  $155^{\circ}21.9'$  west, 13 km west of Laupahoehoe at a depth of 8 km. Magnitude 3. 2. Felt at Paaui.

August 17: 01:26:56.7\*. Epicenter  $19^{\circ}23.7'$  north,  $155^{\circ}25.7'$  west, 7 km north-northwest of Desert seismometer at a depth of 8 km. Magnitude 2. 8. Felt at Pahala.

August 17: 20:41:21.7\*. Epicenter  $19^{\circ}59.1'$  north,  $155^{\circ}22.5'$  west, 14 km west of Laupahoehoe at a depth of 9 km. Magnitude 3. 9. Felt at Hilo, Honokaa, Laupahoehoe, Paaui, Pahala, and in Kilauea Summit region.

August 17: 20:44:01.5\*. Epicenter  $20^{\circ}00.3'$  north,  $155^{\circ}21.5'$  west, 13 km west of Laupahoehoe at a depth of 9 km. Magnitude 3. 2. Felt at Hilo, Honokaa, and Laupahoehoe.

August 18: 15:12:32.4\*. Epicenter  $19^{\circ}58.8'$  north,  $155^{\circ}21.8'$  west, 12 km west of Laupahoehoe at a depth of 3 km. Magnitude 3. 2. Felt at Honokaa and Paaui.

August 18: 16:07:39.4\*. Epicenter  $19^{\circ}55.9'$  north,  $155^{\circ}23.4'$  west, 16 km west-southwest of Laupahoehoe at a depth of 3 km. Magnitude 3. 3. Felt at Honokaa and Kamuela.

August 21: 22:02:58.3\*. Epicenter  $19^{\circ}09.1'$  north,  $155^{\circ}31.5'$  west, 12 km northeast of Naalehu at a depth of 8 km. Magnitude 3. 4. Felt at Naalehu and Pahala.

August 27: 07:46:19.2\*. Epicenter  $19^{\circ}18.8'$  north  $155^{\circ}13.8'$  west, 8 km southwest of Makaopuhi seismometer at a depth of 8 km. Magnitude 3. 5. Felt at Hilo, Pahala, and in Kilauea Summit region.

August 31: 07:56:23.5\*. Epicenter  $19^{\circ}19.5'$  north,  $155^{\circ}25.0'$  west, 3 km southwest of Desert seismometer at a depth of 9 km. Magnitude 3. 2. Felt at Kona, Naalehu, and Pahala.

September 2: 09:33:52.1\*. Epicenter  $19^{\circ}21.9'$  north,  $155^{\circ}16.3'$  west, 1 km southwest of Ahua seismometer at a depth of 30 km. Magnitude 3. 3. Felt in Kilauea Summit region.

September 6: 19:11:05.9\*. Epicenter  $19^{\circ}17.9'$  north,  $155^{\circ}18.4'$  west, 10 km southeast of Desert seismometer at a depth of 30 km. Magnitude 3. 1. Felt at Pahala and in Kilauea Summit region.

September 8: 02:22:32.5\*. Epicenter  $19^{\circ}25.3'$  north,  $155^{\circ}17.9'$  west, 1 km northeast of Uwekahuna seismometer at a depth of 13 km. Magnitude 4. 0. Felt Island-wide.

September 19: 13:44:57.8\*. Epicenter  $19^{\circ}23.5'$  north,  $155^{\circ}17.5'$  west, 3 km south of Uwekahuna seismometer at a depth of 5 km. Magnitude 2. 2. Felt in Kilauea Summit region.

September 23: 08:37:23.5\*. Epicenter  $19^{\circ}17.0'$  north,  $155^{\circ}22.3'$  west, 6 km south-southeast of Desert seismometer at a depth of 10 km. Magnitude 3. 6. Felt at Pahala and in Kilauea Summit region.

September 24: 17:08:18.6\*. Epicenter  $19^{\circ}25.0'$  north,  $155^{\circ}15.2'$  west, 4 km east-southeast of Uwekahuna seismometer at a depth of 35 km. Magnitude 2. 8. Felt in Kilauea Summit region.

September 24: 19:42:42.8\*. Epicenter  $19^{\circ}26.0'$  north,  $155^{\circ}15.5'$  west, 4 km east-north-

east of Uwekahuna seismometer at a depth of 35 km. Magnitude 2. 7. Felt in Kilauea Summit region.

September 25: 04:28:35.8\*. Epicenter  $19^{\circ}19.6'$  north,  $155^{\circ}21.3'$  west, 4 km east-south-east of Desert seismometer at a depth of 5 km. Magnitude 2. 6. Felt at Pahala.

September 26: 12:59:26.4\*. Epicenter  $19^{\circ}21.3'$  north,  $155^{\circ}10.6'$  west, 1 km south of Makaopuhi seismometer at a depth of 45 km. Magnitude 3. 4. Felt at Hilo and in Kilauea Summit region.

September 28: 00:05:55.0\*. Epicenter  $19^{\circ}29.0'$  north,  $155^{\circ}13.9'$  west, 9 km north-east of Uwekahuna seismometer at a depth of 20 km. Magnitude 3.2. Felt at Hilo, Pahoa, and in Kilauea Summit region.

October 9: 23:43:38.0\*. Epicenter  $19^{\circ}23.1'$  north,  $155^{\circ}29.0'$  west, 11 km west-northwest of Desert seismometer at a depth of 10 km. Magnitude 3.2. Felt at Pahala.

October 12: 20:49:11.2\*. Epicenter  $19^{\circ}34.0'$  north,  $155^{\circ}52.2'$  west, 7 km northeast of Kealakekua at a depth of 7 km. Magnitude 2. 9. Felt at Kona.

October 15: 05:57:58.7\*. Epicenter  $19^{\circ}25.2'$  north,  $155^{\circ}28.7'$  west, 13 km northwest of Desert seismometer at a depth of 5 km. Magnitude 3. 7. Felt at Hilo, Pahala, and in Kilauea Summit region.

October 17: 12:20:12.3\*. Epicenter  $19^{\circ}20.5'$  north,  $155^{\circ}26.3'$  west, 5 km west-north-west of Desert seismometer at a depth of 8 km. Magnitude 2. 8. Felt at Pahala.

October 27: 12:42:32.0\*. Epicenter  $19^{\circ}20.0'$  north,  $155^{\circ}15.5'$  west, 4 km south-south-east of Ahua seismometer at a depth of 32 km. Magnitude 3. 0. Felt in Kilauea Summit region.

October 29: 03:34:37.2\*. Epicenter  $19^{\circ}59.5'$  north,  $155^{\circ}33.9'$  west, 15 km east-south-east of Kamuela at a depth of 10 km. Magnitude 3. 8. Felt at Kamuela and Kohala.



October 30: 12:47:17.1\*. Epicenter 19° 23.0' north, 155°27.8' west, 9 km northwest of Desert seismometer at a depth of 8 km. Magnitude 2. 2. Felt at Pahala.

October 31: 18:16:56.3\*. Epicenter 19° 21.2' north, 155°17.2' west, 3 km southwest of Ahua seismometer at a depth of 25 km. Magnitude 3. 1. Felt at Pahala and in Kilauea Summit region.

November 3: 00:52:43.0\*. Epicenter 19° 49' north, 156°50' west, 80 km west-northwest of Keahole Point at a depth of 13 km. Magnitude 4.1. Felt on Oahu.

November 5: 02:20:16.8\*. Epicenter 19° 24.0' north, 155°17.6' west, 2½ km south of Uwekahuna seismometer at a depth of 5 km. Magnitude 3.4. Felt in Kilauea Summit region.

November 19: 22:58:14.6\*. Epicenter 19° 21.1' north, 155°25.0' west, 3 km northwest of Desert seismometer at a depth of 10 km. Magnitude 3. 2. Felt at Pahala.

November 26: 06:25:48.5\*. Epicenter 19° 20.8' north, 155°17.2' west, 4 km southwest of Ahua seismometer at a depth of 9 km. Magnitude 3. 3. Felt at Hilo, Mountainview, and in Kilauea Summit region.

December 7: 16:14:12.8\*. Epicenter 19° 20.3' north, 155°12.8' west, 5 km southwest of Makaopuhi seismometer at a depth of 10 km. Magnitude 3. 1. Felt at Hilo, Pahala, and in Kilauea Summit region.

December 8: 13:07:02.2\*. Epicenter 19° 25.8' north, 155°25.9' west, 11 km northwest of Desert seismometer at a depth of 8 km. Magnitude 3. 1. Felt at Pahala.

## PANAMA CANAL ZONE

[60th Meridian Time]

NOTE: Data on the following local disturbances were compiled by the Panama Canal Company, Engineering and Construction Bureau, Meteorological and Hydrographic Branch, Balboa Heights, Canal Zone.

June 16: 16:23:00.3\*. Epicenter 8.8° north, 77.6° west, Panama-Colombia border region, at a depth of 78 km, W. Magnitude 4. 4. Intensity II at Balboa Heights.

June 23: 08:20:38.3\*. Intensity I at Balboa Heights.

September 5: 01:24:38\*. Epicenter 9.8° north, 79.1° west, Panama, at a depth of 109 km, W. Magnitude 4. 0. Intensity II at Balboa Heights.

December 26: 23:59:25.5\*. Intensity I at Balboa Heights.

## PUERTO RICO

[60th Meridian Time]

February 1: 19:23. Central San Francisco. V. Felt by all; many frightened. Windows, dishes, and walls rattled. Moderate earth noises. Motion rapid.

February 3: 01:20. Central San Francisco. V. Felt by and awakened many. Windows rattled. Motion slow. "Three earthquakes were felt within three hours."

February 13: 19:56. Central San Francisco. V. Felt by all; many frightened. "The whole house rattled and shook." Loud earth noises. Motion rapid, north direction. A second shock was felt a few seconds after the first, and some residents felt another in the middle of the night.

August 29: 13:29:23.4\*. Felt in central Puerto Rico.

August 30: 06:45:29.5\*. Felt in the Cayey area.

October 18: 22:57:48.2\*. Felt at San Juan.

## VIRGIN ISLANDS

[60th Meridian Time]

August 18: 17:45:20.0\*. Epicenter 19.0° north, 64.8° west, Virgin Islands, W. Magnitude 4. 3. Felt on St. Thomas.

# 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 1967. Surveys for the study of horizontal movements were made by the Coast and Geodetic Survey in the following areas of California:

Imperial Valley, Vicinity of El Centro.—A resurvey of most of this net was accomplished. Stations to the north of latitude  $33^{\circ}$  and west of longitude  $116^{\circ}$  were not included in the resurvey. A final analysis of the results has not been completed; however, preliminary studies indicate the 1967 observations are in close agreement with the previous survey of 1955.

Taft and Mojave Area.—This network covers a large area where the San Andreas, Garlock, and White Wolf faults converge. The original survey was accomplished in 1959-60 at the request of the California State Department of Water Resources. Seventeen lines were measured with a Model 2 Geodimeter in 1960 by engineers of the Water Resources Department. Reobservations of the angles were completed in December 1967 by the Coast Survey. The engineers of the Water Resources Department have reported that 14 lines remeasured with the Geodimeter are in very good agreement with the previous measurements of 1960. A least-squares adjustment of the two sets of observations will be made after the distance remeasurements are completed.

Winery Survey, Vicinity of Hollister.—The 1967 resurvey showed right-lateral movement of about 1.2 cm during the interval since the previous survey of 1966. This rate of movement is in close agreement with the results obtained from previous resurveys, accomplished at intervals of approximately 1 year since establishment of the net in 1957.

At the time of the 1967 resurvey of the Winery site, additional nets—HARRIS and STONE—were established across the San Andreas fault in areas north and south of the winery. The HARRIS site is approximately 4 km northwest of the Winery site, and STONE is about 19 km to the southeast.

University of California, Berkeley Stadium.—A quadrilateral on the Berkeley stadium, which straddles the Hayward fault, was established in 1966 and reobserved in the latter part of 1967. The results of these surveys showed right-lateral movement of 4 mm during the 1-year period.

Aqueduct Surveys.—The cooperative project with the California State Department of Water Resources was continued during the year. Resurveys were accomplished at ten sites along the proposed aqueduct route. Results of the resurveys did not indicate any significant changes at eight of these sites. At UNION, in the vicinity of Hayward, the results showed right-lateral movement of 6 mm per year for the interval 1965-67. These results are in close agreement with previous studies carried out by engineers of the city of Hayward. Site RANCH, in the vicinity of Gorman, was established in 1964, and the

1967 resurvey showed small left-lateral movement along the Garlock fault.

About 1,950 miles of first- and second-order leveling was done in Arizona and California in 1967. Most of the leveling was carried out specifically for the study of land subsidence or upheaval. The rest was mostly releveing that will indicate differential movements of the bench marks between levelings of previous years.

Extremely precise leveling observations were made at fourteen Hollister-type polygons located in southern California. These polygons consist of about ten marks straddling major faults, such as the San Andreas, where relative displacements due to tectonic action are likely. Releveling was also done in the Taft fault area, including the Buena Vista Hills tiltmeter site.

### TILT OBSERVATIONS

Two Merrit tiltmeter stations, Table Mountain and Santiago Peak, continued in routine operation.

In 1967, tiltmeters were installed at the Buena Vista Oil Field at Taft, Calif., at ESSA's Stone Canyon Geophysical Laboratory south of Hollister on the San Andreas fault, and on Kodiak Island, Alaska.

### TIDAL DISTURBANCES OF SEISMIC ORIGIN

Three tsunamis were reported to the Coast and Geodetic Survey during 1967.

On April 11, an earthquake in the Celebes ( $3.3^{\circ}$  south,  $119.2^{\circ}$  east) generated a wave that killed 13 fishermen on boats anchored near the mouth of the Tinambung River. The wave caused serious damage in coastal villages.

On April 12, an earthquake in northern Sumatra ( $5.3^{\circ}$  north,  $96.5^{\circ}$  east) was reportedly followed by an enormous water wave at Sigli.

An earthquake on September 3 off the coast of Peru ( $10.6^{\circ}$  south,  $79.8^{\circ}$  west) was recorded on the La Punta-Callao tide gage. Maximum amplitude was 0.9 foot.

# Fluctuations in Well-Water Levels

In 1943, the Coast and Geodetic Survey first published the section "Fluctuations in Well-Water Levels" in its annual *United States Earthquakes* series. Data for the years 1944 through 1949 appeared in the 1949 issue of this report. It was published annually from 1950 to the present.

The following material was compiled by the Water Resources Division of the U.S. Geological Survey. Table 1 lists fluctuations caused by various sources in wells throughout the country. Table 2 lists the date, time, and

location of specific earthquakes that may have been associated with recorded fluctuations in well water. Also included are the states recording the fluctuations.

Complete information on earthquakes possibly associated with the tabulations in table 1 may be obtained from the *Preliminary Determination of Epicenters* cards or *Seismological Bulletins*, both issued by the Coast and Geodetic Survey. Another source is earthquake registers from seismograph stations nearest the locality.

TABLE 1.—*Fluctuations in well-water levels, January through December 1967*

| County and\or well number | Date<br>1967 | Time at<br>Recorder<br>G.M.T. | Depth to<br>water before<br>disturbance | Water-level fluctuations |          |                     |
|---------------------------|--------------|-------------------------------|---|--------------------------|----------|---------------------|
|                           |              |                               |   | From prequake level      |          | Double<br>amplitude |
|                           |              |                               |   | Upward                   | Downward |                     |

|   |          |      |           |           |           |           |
|---|----------|------|-----------|-----------|-----------|-----------|
| ALASKA                                  |          |      |           |           |           |           |
|   |          |      | <i>ft</i> | <i>ft</i> | <i>ft</i> | <i>ft</i> |
| ED:A-8:2:11.....                        | Jan. 18  | 1100 | 5.26      | 0.01      | 0.005     | 0.015     |
| CQ:C-1:6:3.....                         | June 21  | 1300 | -----     | -----     | -----     | .003      |
| ED:A-8:3:3.....                         | June 21  | 1700 | 8.063     | .001      | .002      | .003      |
| CQ:C-1:6:3.....                         | June 22  | 1300 | -----     | -----     | -----     | .05       |
| ED:A-8:2:11.....                        | Sept. 28 | 1500 | 4.270     | .005      | .015      | .02       |
| 13-4-25-1 (Formerly<br>ED:A-8:3:3)..... | Nov. 10  | 1600 | 7.021     | .001      | .004      | .005      |

|                           |         |      |        |      |      |      |
|---------------------------|---------|------|--------|------|------|------|
| IDAHO                     |         |      |        |      |      |      |
|                           |         |      |        |      |      |      |
| Madison 7N-38E-23dbl..... | Jan. 5  | 0045 | 41.64  | 0.07 | 0.06 | 0.13 |
| Teton 4N-45E-13adl.....   | Jan. 5  | 0130 | 200.15 | .02  | .02  | .04  |
| Butte 5S-31E-28cc1.....   | Jan. 19 | 1330 | 264.69 | .02  | .02  | .04  |
| Do.....                   | Feb. 9  | 1430 | 264.54 | .04  | .03  | .07  |

TABLE 1.—Fluctuations in well-water levels, January through December 1967—Continued

| County and/or well number | Date<br>1967 | Time at<br>Recorder<br>G.M.T. | Depth to<br>water before<br>disturbance | Water-level fluctuations |          |                     |
|---------------------------|--------------|-------------------------------|---|--------------------------|----------|---------------------|
|                           |              |                               |   | From prequake level      |          | Double<br>amplitude |
|                           |              |                               |   | Upward                   | Downward |                     |

|                            |          |                        |        |     |     |     |
|----------------------------|----------|------------------------|--------|-----|-----|-----|
| IDAHO—Continued            |          |                        |        |     |     |     |
| Blaine 2S-20E-1ac2-----    | Apr. 21  | 1300-1500 <sup>1</sup> | 148.76 | .18 | .05 | .23 |
| Do-----                    | May 3    | 1700-1900 <sup>1</sup> | 149.62 | .03 | .04 | .07 |
| Madison 7N-38E-23db1-----  | May 7    | 2045                   | 44.48  | .02 | .03 | .05 |
| Do-----                    | May 8    | 1830                   | 44.47  | .03 | 0   | .03 |
| Blaine 2S-20E-1ac2-----    | May 15   | 1600-1800 <sup>1</sup> | 149.94 | .07 | .02 | .09 |
| Minidoka 7S-25E-19ba1----- | May 18   | 1400-1600 <sup>1</sup> | 242.26 | .05 | .01 | .06 |
| Madison 7N-38E-23db1-----  | May 21   | 0900                   | 44.21  | .04 | .04 | .08 |
| Lincoln 5S-17E-26ac1-----  | June 1   | 0800                   | 200.11 | .03 | .05 | .08 |
| Power 7S-30E-28bb1-----    | June 17  | 1800                   | 198.51 | .01 | .03 | .04 |
| Blaine 8S-26E-33bc1-----   | June 29  | 1700-1900 <sup>1</sup> | 107.72 | .11 | .17 | .28 |
| Butte 5N-31E-28cc1-----    | July 22  | 1915                   | 265.65 | .08 | .09 | .17 |
| Power 7S-30E-28bb1-----    | Aug. 19  | 1930                   | 201.75 | .12 | .17 | .29 |
| Jerome 8S-19E-5da1-----    | Sept. 1  | 0245                   | 269.12 | .04 | .05 | .09 |
| Madison 7N-38E-23db1-----  | Sept. 9  | 2115                   | 39.73  | .01 | .01 | .02 |
| Do-----                    | Sept. 9  | 2245                   | 39.72  | .02 | .01 | .03 |
| Minidoka 4S-24E-6bbl-----  | Sept. 16 | 2130                   | 417.87 | .04 | .05 | .09 |
| Butte 5N-31E-28cc1-----    | Oct. 4   | 1930                   | 263.78 | .05 | .05 | .10 |
| Madison 7N-38E-23db1-----  | Oct. 7   | 0115                   | 39.48  | .01 | .01 | .02 |
| Blaine 8S-26E-33bc1-----   | Oct. 11  | 1400-1600 <sup>1</sup> | 104.58 | .12 | .19 | .31 |
| Madison 7N-38E-23db1-----  | Oct. 18  | 0530                   | 39.52  | .04 | .05 | .09 |
| Butte 5N-31E-28cc1-----    | Oct. 25  | 0230                   | 262.73 | .08 | .08 | .16 |
| Madison 7N-38E-23db1-----  | Dec. 10  | 1130                   | 40.93  | .03 | .01 | .04 |
| Cassia 13S-21E-18bbl-----  | Dec. 21  | 1130                   | 515.45 | .02 | .03 | .05 |
| Teton 4N-45E-13adl-----    | Dec. 24  | 2100                   | 195.14 | .01 | .02 | .03 |

|            |         |           |        |      |      |      |
|------------|---------|-----------|--------|------|------|------|
| INDIANA    |         |           |        |      |      |      |
| Ma 32----- | Jan. 4  | 0100-0130 | 10.94  | 0.04 | 0.03 | 0.07 |
| Pu 6-----  | Jan. 4  | 0030-0130 | 11.045 | .018 | .030 | .048 |
| Ma 32----- | Jan. 28 | 1550-1620 | 10.47  | .02  | .02  | .04  |
| Pu 6-----  | Feb. 9  | 1530-1600 | 11.136 | .007 | .017 | .024 |
| Ma 32----- | Feb. 9  | 1710-1745 | 10.32  | .02  | .04  | .06  |
| Do-----    | Feb. 13 | 0130-0135 | 10.44  | .01  | .01  | .02  |
| Do-----    | Dec. 20 | 0240-0310 | 10.31  | .04  | .03  | .07  |
| Pu 6-----  | Dec. 20 | 0300-0320 | 16.26  | .02  | .05  | .07  |

|                   |         |      |      |      |      |      |
|-------------------|---------|------|------|------|------|------|
| NEVADA            |         |      |      |      |      |      |
| S17/50-36dc1----- | Jan. 4  | 2130 | 1.82 | 0.08 | 0.06 | 0.14 |
| Do-----           | Jan. 19 | 1315 | 1.97 | .02  | .02  | .04  |
| Do-----           | Jan. 23 | 2040 | 1.98 | .03  | .04  | .07  |
| Do-----           | Jan. 28 | 1420 | 1.96 | .03  | .04  | .07  |
| Do-----           | May 4   | 2320 | 2.05 | .04  | .05  | .09  |

<sup>1</sup> Time of occurrence for monthly gage believed to be accurate to  $\pm 1$  hour. Time for all other gages believed to be accurate to  $\pm 30$  minutes.

TABLE 1.—*Fluctuations in well-water levels, January through December 1967—Continued*

| NEVADA—Continued          |         |      |        |     |     |     |
|---------------------------|---------|------|--------|-----|-----|-----|
| S19/60-9bcc1              | May 20  | 1500 | 121.50 | .15 | .14 | .29 |
| S17/50-36dc1              | May 20  | 1500 | 1.81   | .07 | .06 | .13 |
| Do                        | May 21  | 0740 | 1.90   | .06 | .08 | .14 |
| S19/53-32aaa1             | May 22  | 2200 | 29.00  | .01 | .01 | .02 |
| S17/50-35dc1 <sup>2</sup> | May 23  | 1610 | 1.97   | .09 | .07 | .16 |
| S19/53-32aaa1             | May 26  | 0300 | 29.01  | .01 | .01 | .02 |
| Do                        | June 8  | 2000 | 28.97  | .06 | .12 | .18 |
| Do                        | July 1  | 2230 | 29.01  | .01 | .03 | .04 |
| S17/50-36dc1              | July 30 | 0110 | 1.58   | .04 | .04 | .08 |
| Do                        | Sept. 3 | 2210 | 1.69   | .05 | .05 | .10 |
| Do                        | Oct. 4  | 1100 | 1.72   | .03 | .02 | .05 |
| Do                        | Dec. 5  | 1850 | 1.98   | .03 | .04 | .07 |
| Do                        | Dec. 10 | 1215 | 1.99   | .08 | .08 | .16 |
| Do                        | Dec. 29 | 0745 | 2.04   | .07 | .06 | .13 |

<sup>2</sup> Water level is measured above a reference point.

TABLE 2.—Earthquakes of 1967 believed to have caused fluctuations in well-water levels

| Date     | Origin time<br>G.M.T. |          |          | Location                          | States recording<br>fluctuations |
|----------|-----------------------|----------|----------|-----------------------------------|----------------------------------|
|          | <i>h</i>              | <i>m</i> | <i>s</i> |                                   |                                  |
| Jan. 4   | 20                    | 15       | 55.8     | Near coast of northern Venezuela  | Nevada                           |
| Jan. 5   | 00                    | 14       | 40.4     | Mongolia                          | Idaho, Indiana                   |
| Jan. 5   | 00                    | 42       | 13.3     | do.                               | Idaho                            |
| Jan. 18  | 11                    | 42       | 59.0     | Southern Alaska                   | Alaska                           |
| Jan. 19  | 12                    | 40       | 12.6     | Fiji Islands region               | Idaho, Nevada                    |
| Jan. 23  | 20                    | 25       | 38.3     | Revilla Gigedo Islands region     | Nevada                           |
| Jan. 28  | 14                    | 23       | 26.7     | Fox Islands                       | Nevada                           |
| Jan. 28  | 16                    | 31       | 21.1     | do.                               | Indiana                          |
| Feb. 9   | 15                    | 24       | 47.2     | Colombia                          | Idaho, Indiana                   |
| Feb. 12  | 23                    | 41       | 17.2     | Northern California               | Indiana                          |
| May 4    | 22                    | 34       | 49.7     | Gulf of California                | Nevada                           |
| May 8    | 19                    | 31       | 28       | Utah                              | Idaho                            |
| May 15   | 17                    | 08       | 57.1     | Peru                              | Idaho                            |
| May 21   | 07                    | 18       | 13       | Gulf of California                | Idaho, Nevada                    |
| May 22   | 22                    | 41       | 25.6     | Near coast of Oaxaca, Mexico      | Nevada                           |
| May 23   | 17                    | 52       | 04       | Southern Nevada                   | Nevada                           |
| May 26   | 08                    | 30       | 02       | Near Islands                      | Nevada                           |
| June 17  | 17                    | 43       | 55.2     | Guatemala                         | Idaho                            |
| June 21  | 18                    | 04       | 49.5     | Fairbanks, Alaska                 | Alaska                           |
| June 22  | 14                    | 11       | 31       | Central Alaska                    | Alaska                           |
| July 1   | 23                    | 10       | 07.2     | South of Alaska                   | Nevada                           |
| July 29  | 23                    | 59       | 58.7     | Near coast of northern Venezuela  | Nevada                           |
| Sept. 3  | 21                    | 07       | 30.8     | Off coast of Peru                 | Nevada                           |
| Sept. 9  | 20                    | 30       | 10       | Off coast of Mexico               | Idaho                            |
| Sept. 9  | 23                    | 43       | 04       | Alaska Peninsula                  | Idaho                            |
| Sept. 28 | 15                    | 14       | 55.7     | Gulf of Alaska                    | Alaska                           |
| Oct. 4   | 10                    | 20       | 14.0     | Utah                              | Nevada                           |
| Oct. 7   | 01                    | 14       | 04.1     | Near coast of central Chile       | Idaho                            |
| Oct. 18  | 04                    | 52       | 08       | Baja California                   | Idaho                            |
| Oct. 25  | 02                    | 41       | 34.4     | Utah                              | Idaho                            |
| Nov. 10  | 18                    | 29       | 57.3     | Central Alaska                    | Alaska                           |
| Dec. 5   | 18                    | 35       | 37.6     | Gulf of Alaska                    | Nevada                           |
| Dec. 10  | 12                    | 06       | 50.3     | Near coast of northern California | Idaho, Nevada                    |
| Dec. 21  | 02                    | 25       | 21.6     | Near coast of northern Chile      | Indiana                          |
| Dec. 21  | 11                    | 37       | 22.5     | Northern Colombia                 | Idaho                            |
| Dec. 24  | 20                    | 03       | 10.9     | Leeward Islands                   | Idaho                            |

# Seismological Observatories

The Coast and Geodetic Survey publishes the results of its teleseismic and cooperating stations in the monthly *Seismological Bulletin* and quarterly *Antarctic Seismological Bulletin*. All seismogram interpretations are tabulated, together with epicenters based on the published data and instrumental results received from seismological stations in all parts of the world. Instrumental results are published for the stations which follow (see fig. 13 for station locations, excluding Balboa Heights, Byrd, Guam, and South Pole).

Adak, Alaska  
Albuquerque, N. Mex.  
Balboa Heights, Canal Zone  
(The Panama Canal Co.)  
Barrow, Alaska  
Blue Mountains, Oreg.  
Boulder City, Nev.  
(Bureau of Reclamation)  
Bozeman, Mont. (two stations)  
(Montana State College)  
Butte, Mont.  
(Montana School of Mines)  
Byrd, Antarctica  
Cedar Springs, Calif.  
(State of California Dept. of Water Resources)  
Chicago, Ill.  
(Univ. of Chicago and U.S. Weather Bureau)  
College, Alaska (two stations)  
Columbia, S.C.  
(Univ. of South Carolina)  
Eureka, Nev.  
(Eureka Corporation, Ltd.)  
Flaming Gorge, Utah  
(Bureau of Reclamation)

Glen Canyon, Ariz.  
(Bureau of Reclamation)  
Guam, Mariana Islands (two stations)  
Honolulu, Hawaii  
Hungry Horse, Mont.  
(Bureau of Reclamation)  
Kipapa, Hawaii  
Kodiak, Alaska  
McMinnville, Tenn.  
Middleton Island, Alaska  
Newport, Oreg. (two stations)  
Palmer, Alaska (three stations)  
Philadelphia, Pa.  
(The Franklin Institute)  
Rapid City, S. Dak.  
(South Dakota State School of Mines)  
Salt Lake City, Utah  
(Univ. of Utah)  
San Juan, Puerto Rico  
San Luis Dam, Calif.  
(Bureau of Reclamation)  
Sitka, Alaska  
South Pole, Antarctica  
Tucson, Ariz. (two stations)  
Ukiah, Calif.  
(International Latitude Observatory)  
Washington, D.C.  
Washington Science Center, Md.

Coast and Geodetic Survey stations include: Adak, Albuquerque, Barrow, Blue Mountains, Byrd, College, Guam, Honolulu, Kipapa, Kodiak, McMinnville, Middleton Island, Newport, Palmer, San Juan, Sitka, South Pole, Tucson, Ukiah, Washington, and Washington Science Center.



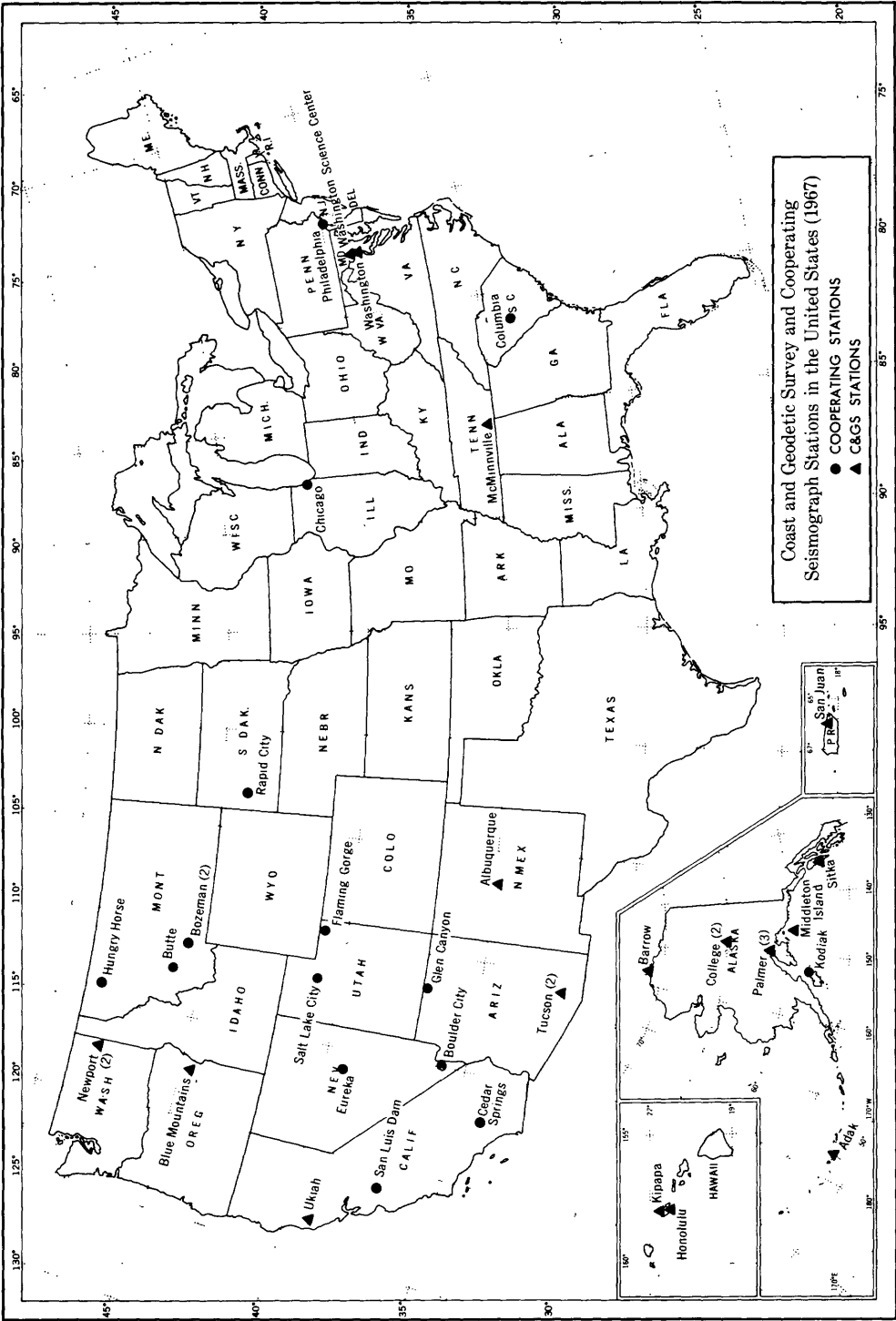


FIGURE 13.—Seismological observatories for which the Coast and Geodetic Survey (National Earthquake Information Center) publishes results.

Cooperating stations include: Balboa Heights, Boulder City, Bozeman, Butte, Cedar Springs, Chicago, Columbia, Eureka, Flaming Gorge, Glen Canyon, Hungry Horse, Philadelphia, Rapid City, Salt Lake City, and San Luis Dam.

For detailed instrumental data regarding

the stations listed above, including instrumentation, constants, and other information, refer to *Seismological Bulletin*, MSI-325, and *Antarctic Seismological Bulletin*, MSI-325A, January 1968. Those desiring to receive these reports as issued should request addition of their names to the CGS-7 mailing list.

# Principal Earthquakes of the World During 1967

[Listed in this section are (1) earthquakes of magnitude greater than  $6\frac{3}{4}$ , and those of smaller magnitude which were locally destructive; (2) earthquakes of unusual interest. A description of each earthquake follows the list].

| Date<br>1967 | Origin time<br>G.M.T. |          |          | Region                               | Coordinates |            | Magnitude <sup>1</sup>               |
|--------------|-----------------------|----------|----------|--------------------------------------|-------------|------------|--------------------------------------|
|              |                       |          |          |                                      | Lat.        | Long.      |                                      |
|              | <i>h</i>              | <i>m</i> | <i>s</i> |                                      | <i>deg</i>  | <i>deg</i> |                                      |
| Jan. 5----   | 00                    | 14       | 40.4     | Mongolia-----                        | 48.1 N.     | 102.8 E.   | 7 $\frac{1}{4}$ , P                  |
| Feb. 9----   | 15                    | 24       | 47.2     | Colombia-----                        | 2.9 N.      | 74.9 W.    | 6 $\frac{3}{4}$ , P                  |
| Feb. 14----  | 01                    | 36       | 04.7     | Andaman Islands region-----          | 13.7 N.     | 96.5 E.    | 6.8, CGS                             |
| Feb. 15----  | 16                    | 11       | 11.8     | Peru-Brazil border region-----       | 9.0 S.      | 71.3 W.    | 6 $\frac{3}{4}$ -7, P                |
| Feb. 19----  | 22                    | 14       | 35.3     | South of Java-----                   | 9.2 S.      | 113.1 E.   | 6 $\frac{3}{4}$ , P                  |
| Mar. 4----   | 17                    | 58       | 06.4     | Aegean Sea-----                      | 39.2 N.     | 24.6 E.    | 6 $\frac{3}{4}$ -7, P                |
| Mar. 13----  | 16                    | 06       | 54.3     | Off coast of southern Chile-----     | 40.1 S.     | 74.5 W.    | 7.1-7.5, B                           |
| Mar. 24----  | 09                    | 00       | 19.5     | Java Sea-----                        | 6.0 S.      | 112.3 E.   | 6.7-7.2, B                           |
| Apr. 11----  | 05                    | 09       | 12.1     | Celebes region-----                  | 3.3 S.      | 119.2 E.   | 5.2, CGS                             |
| May 1----    | 07                    | 09       | 00.5     | Greece-----                          | 39.7 N.     | 21.3 E.    | 5 $\frac{3}{4}$ -6, P                |
| June 4----   | 16                    | 14       | 13.6     | Mississippi-----                     | 33.6 N.     | 90.9 W.    | 3.8, CGS                             |
| June 21----  | 18                    | 04       | 49.5     | Fairbanks, Alaska-----               | 64.8 N.     | 147.4 W.   | 5.4, CGS                             |
| June 21----  | 18                    | 13       | 02.9     | -----do-----                         | 64.8 N.     | 147.4 W.   | 5.6, CGS                             |
| June 21----  | 18                    | 24       | 45.7     | -----do-----                         | 64.8 N.     | 147.4 W.   | 5.4, CGS                             |
| July 13----  | 02                    | 10       | 20.0     | Algeria-----                         | 35.5 N.     | 0.1 W.     | 5.0, CGS                             |
| July 22----  | 16                    | 56       | 53.3     | Turkey-----                          | 40.7 N.     | 30.8 E.    | 7 $\frac{1}{4}$ , P                  |
| July 26----  | 18                    | 53       | 01.3     | -----do-----                         | 39.5 N.     | 40.4 E.    | 5.6, CGS                             |
| July 29----  | 10                    | 24       | 24.6     | Northern Colombia-----               | 6.8 N.      | 73.0 W.    | 6 $\frac{1}{2}$ -6 $\frac{3}{4}$ , P |
| July 29----  | 23                    | 59       | 58.7     | Near coast of northern<br>Venezuela. | 10.6 N.     | 67.3 W.    | 6 $\frac{1}{2}$ , P                  |
| Aug. 13----  | 22                    | 07       | 47.5     | Pyrenees-----                        | 43.2 N.     | 0.5 W.     | 5.3, CGS                             |
| Sept. 3----  | 21                    | 07       | 30.8     | Off coast of Peru-----               | 10.6 S.     | 79.8 W.    | 6 $\frac{3}{4}$ -7, P                |
| Oct. 9----   | 17                    | 21       | 49.5     | Fiji Islands region-----             | 21.1 S.     | 179.3 W.   | 7-7 $\frac{1}{4}$ , P                |
| Oct. 25----  | 00                    | 59       | 22.6     | Taiwan region-----                   | 24.5 N.     | 122.2 E.   | 6.0, CGS                             |
| Nov. 23----  | 08                    | 35       | 49.5     | Eastern Gulf of Aden-----            | 14.5 N.     | 52.1 E.    | 6 $\frac{3}{4}$ -7, P                |
| Nov. 30----  | 07                    | 23       | 51.5     | Albania-----                         | 41.5 N.     | 20.5 E.    | 6 $\frac{1}{2}$ , P                  |
| Dec. 10----  | 22                    | 51       | 24.3     | India-----                           | 17.7 N.     | 73.9 E.    | 6 $\frac{1}{2}$ , P                  |
| Dec. 21----  | 02                    | 25       | 21.6     | Near coast of northern Chile--       | 21.8 S.     | 70.0 W.    | 7.0, P                               |
| Dec. 24----  | 20                    | 03       | 10.9     | Leeward Islands region-----          | 17.4 N.     | 61.1 W.    | 6 $\frac{3}{4}$ -7, P                |
| Dec. 25----  | 01                    | 23       | 33.6     | New Ireland region-----              | 5.3 S.      | 153.7 E.   | 6 $\frac{3}{4}$ -7, P                |
| Dec. 27----  | 09                    | 17       | 55.7     | Chile-Bolivia border region--        | 21.2 S.     | 68.3 W.    | 7, P                                 |

<sup>1</sup> Abbreviations following magnitude values are as follows: P, Pasadena; B, Berkeley; CGS, Coast and Geodetic Survey.

DESCRIPTIONS OF PRINCIPAL  
EARTHQUAKES

January 5: Mongolia. This earthquake centered in the thinly populated Hangyan Mountains where small fissures appeared. The shock was felt at Ulan Bator, the Mongolian capital, and at Irkutsk, USSR. Magnitude  $7\frac{1}{4}$ .

February 9: Colombia. Ninety-eight persons were killed and widespread property damage was sustained in Huila, Tolima, and Caqueta Provinces, south of Bogota. Although no tectonic scarps were reported, hundreds of landslides occurred on the slopes of the two Cordilleras facing the Magdalena Valley. Sand blows, ejection of sand water, water fountains, oscillations of the Magdalena River, and increase and decrease of spring waters were reported on the alluvial plain of the valley. Extensive damage to property was sustained at Neiva, Campoalegre, and Pitalito, small villages in the upper Magdalena Valley. Magnitude  $6\frac{3}{4}$ .

February 14: Andaman Islands region. About 400 km. east of the epicenter, at Bangkok, Thailand, thousands of residents ran into the streets as the earthquake rumbled through the city. No damage was reported. Magnitude 6.8.

February 15: Peru-Brazil border region. Due to its location in an uninhabited area, this strong shock was not damaging. Magnitude  $6\frac{3}{4}$ -7.

February 19: South of Java. Fifty-four were killed and 300 injured at Malang, Java, and reports indicated 2,000 houses were demolished and an additional 5,000 damaged by this earthquake. Magnitude  $6\frac{3}{4}$ .

March 4: Aegean Sea. This earthquake damaged forty houses on Skyros Island. It was felt at Athens, Greece; Sofia, Bulgaria; and in western Turkey. Magnitude  $6\frac{3}{4}$ -7.

March 13: Off coast of southern Chile. No damage. Magnitude 7.1-7.5.

March 24: Java Sea. No damage. Magnitude 6.7-7.2.

April 11: Celebes region. Thirty-seven persons were killed, 51 injured, and 75,000 evacuated from the Polmas and Madjene areas. Property damage was widespread. Magnitude 5.2.

May 1: Greece. In the mountainous area of northern Arta District, 9 were killed, 56 injured, and over 100 houses destroyed. The area of maximum intensity encompassed the villages of Drosopighi, Pramanta, Melisourgoe, and Theodoriana. Extensive earthslides occurred in the Jannina District. Magnitude  $5\frac{3}{4}$ -6.

June 4: Mississippi. This shock, centered about 18 miles northeast of Greenville, was felt over a four-state area but caused little damage. It was the third earthquake of intensity V or above to center in the state. The earthquake was observed north to Memphis, Tenn., west to Rison, Ark., south to Utica, Miss., and east to Water Valley, Miss. (See p. 12 for a more detailed description.) Magnitude 3.8.

June 21: Fairbanks, Alaska. Damage, though not severe, occurred throughout the Fairbanks area as result of three moderate earthquakes. Chimneys fell, buildings cracked, windows and water pipes broke, and cracks appeared in the ground. Over 2,000 aftershocks were recorded the first day, with a total of 6,000 recorded by the end of the first week. (See p. 43 for a more detailed description.) Magnitudes 5.4, 5.6, and 5.4.

July 13: Algeria. Ten persons died, 15 were injured, and 40 houses were destroyed at M'Khalif, a small village southeast of Oran. The shock was strongly felt throughout the area. Magnitude 5.0.

July 22: Turkey. In northwest Anatolia, 173 were killed, 183 injured, and 3,701 houses razed or made uninhabitable. Provinces most strongly affected were Sakarya, Hendek, and Aykazi. The shock originated on the extension



FIGURE 14.—San Jose apartment tower before the July 29 earthquake in Caracas, Venezuela. The structure appears to be sturdy.

of the Bolu-Abant fault in the Mudurnu Valley, an active part of the North Anatolian fault zone. An aftershock on July 30 injured 40 persons and took two additional lives in Adapazari. Additional damage was also sustained. Magnitudes  $7\frac{1}{4}$  and 5.6, respectively.

July 26: Turkey. This shock centered near the eastern end of the Anatolian fault system, in the Pulumur region. Ninety-two were killed, several injured, and about 3,000 houses were destroyed or made uninhabitable. Magnitude 5.6.

July 29: Near coast of Venezuela. Centered near the coast about 30 miles west of Caracas, this shock caused 240 fatalities, 1,536 injuries, and over \$50 million property damage. Damage was extensive in the Altamira and Los Palos Grandes sections of Caracas. Four apartment buildings, 10 to 12 stories high, collapsed, and several additional structures may have to be razed and rebuilt. Figures 14 and 15 show the San Jose apartment tower before and after the shock. Another pocket of severe damage occurred in the



FIGURE 15.—San Jose apartment tower after the July 29 earthquake. The building completely collapsed. Three additional structures of this type collapsed in Caracas.

beach area. Unusual features of this earthquake were little damage to low buildings; no evidence of surface faulting; no landslides; and no interruption of utilities. Magnitude  $6\frac{1}{2}$ .

July 29: Northern Colombia. Ten persons were killed and several homes and businesses crumbled about 150 miles north of Bogota. Almost every building was damaged in Betulia, and two persons were crushed by a falling church steeple in Libano. Magnitude  $6\frac{1}{2}$ - $6\frac{3}{4}$ .

August 13: Pyrenees. Numerous buildings were destroyed in Arette, Oloron, and Montory; one person was killed and 80 were injured. The shock was strongly felt in northern Spain. In historic time, only two strong earthquakes have centered in this region of southern France. Magnitude 5. 3.

September 3: Off coast of Peru. Felt at Lima, Peru, but no damage was sustained. Magnitude  $6\frac{3}{4}$ -7.

October 9: Fiji Islands region. Due to its location, this earthquake caused no damage. Magnitude  $7\frac{1}{4}$ .

October 25: Taiwan region. Two persons were killed at Hualien, 23 houses collapsed, and several structures were badly damaged. Heavy property damage also occurred at Ilan, about 25 miles southeast of Taipei. Magnitude 6. 0.

November 23: Eastern Gulf of Aden. Due to its location in an unpopulated area, this shock caused no damage. Magnitude  $6\frac{3}{4}$ -7.

November 30: Albania. The earthquake centered along the Albania-Yugoslavia border in the vicinity of Debar, Yugoslavia, and

Shupenze, Albania. Eighteen persons were killed, 204 were injured, and 70 percent of the living quarters were left unsafe for habitation. In Debar, nearly 1,000 durable buildings were destroyed or damaged beyond repair. Magnitude  $6\frac{1}{2}$ .

December 10: India. Centered in the vicinity of Koynanagar, about 160 miles southeast of Bombay, this shock killed 177 persons, injured over 2,000, and left 50,000 homeless. Property damage was limited to Koynanagar and several nearby villages. At Koynanagar, all of the dwellings were damaged, with 25 percent completely ruined. Magnitude  $6\frac{1}{2}$ .

December 21: Near coast of northern Chile. The shock caused one death and several injuries, and inflicted severe property damage at Quillagua and Tocopilla, two small villages near the earthquake's epicenter. Eighty percent of the structures were destroyed at Quillagua; Tocopilla sustained damage to about 20 percent of its buildings, several of which will have to be razed and reconstructed. Figure 16 shows a concrete-wood structure that collapsed at Tocopilla. Numerous roads were damaged or blocked by earthslides in the area. Magnitude 7.0.

December 24: Leeward Islands region. Not felt due to its location. Magnitude  $6\frac{3}{4}$ -7.

December 25: New Ireland region. Felt on New Britain Island. Magnitude  $6\frac{3}{4}$ -7.

December 27: Chile-Bolivia border region. The shock was widely felt, but caused no damage. Magnitude 7.



FIGURE 16.—Concrete-wood dwelling nearly destroyed by the December 21 earthquake at Tocopilla, Chile.

# Strong-Motion Seismograph Results

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 required 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 Publication No. 41-2, *Earthquake Investigations in the Western United States, 1931-1964*. The latter is much broader in scope and contains data on structural and ground vibrations, with detailed descriptions of the various activities which comprise the seismological program as a whole.

A list of the strong-motion stations in operation is presented in table 3, and their locations (excluding Connecticut and those outside the United States) are shown in figures 17 and 18. Table 4 gives a list of earthquakes recorded and records obtained on strong-motion instruments in 1967.

## 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 are often obscured by the superposition of shorter-period waves of relatively large amplitudes, the estimates of displacement must be considered only rough approximations. These analyses are essentially condensations of ma-

terial appearing in the quarterly *Engineering Seismology Bulletin*, available through mailing list CGS-5.

## UNITS AND INSTRUMENTAL CONSTANTS

Quantitative results are expressed in c.g.s. units—centimeters or millimeters for displacement, and centimeters per second per second for acceleration. It is sometimes desirable to express acceleration in terms of the acceleration of gravity, indicated by  $g$ , which is equal to 980 cm/sec<sup>2</sup>. For practical purposes, it is necessary to point off three decimal places to convert cm/sec<sup>2</sup> to  $g$ .

Most of the instruments have been adjusted so that each will register the maximum acceleration to be expected on the particular type of geological formation beneath the instrument. The following expectable earthquake accelerations were used in determining the accelerograph sensitivities: (a) rock foundation, 25 percent of gravity; (b) residual clay and shale, 40 percent of gravity; (c) alluvium, 70 percent of gravity; and (d) top floors of tall buildings, 100 to 200 percent of gravity. The four sensitivities may be roughly listed as 26, 19.5, 13, and 6.5 centimeters per 1.0  $g$ , respectively.

Sensitivity of the seismographs is expressed as the deflection of the trace, or light spot, in centimeters for a constant acceleration of 1.0  $g$ .

Damping ratio of the pendulum is the ratio between successive amplitudes when the pendulum oscillates.



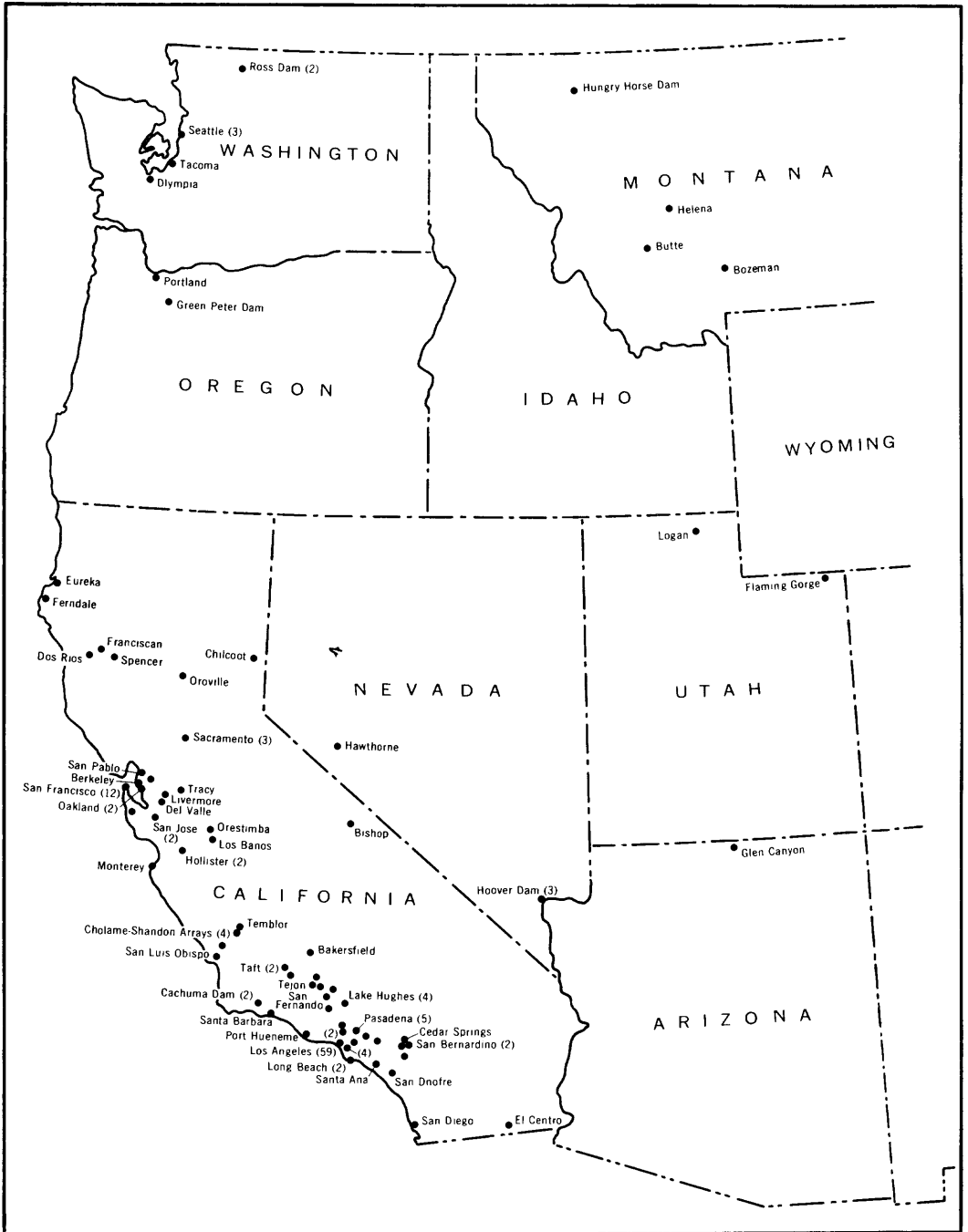


FIGURE 17.—Strong-motion stations in the western United States.

## SEISMOGRAM ILLUSTRATIONS

Reproductions of records in this publication (fig. 19) are tracings of the original records and must not be accepted as genuine copies. The tabulated instrumental constants refer to the original records. The tracings are intended to show the nature of the data rather than furnish a means through which the reader can make his own measurements. Those who desire true copies for critical study should request them from the Environmental Science Services Administration, Coast and Geodetic Survey, Rockville, Md. 20852.

Acceleration and displacement scales representing the equivalent of 0.1 g and 1 inch

are indicated on the tracings of the acceleration and displacement curves. The scales provide the investigator with a quick means for making rough measurements on the published curves. The measurements of period on records of this nature are dependent largely on the judgment of the person reading them, and considerable latitude must be allowed in appraising their accuracy. The aim of such analyses is primarily to give a fair picture of the magnitudes of the various elements involved, 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.—Coast and Geodetic Survey and affiliated strong-motion stations in operation as of December 31, 1967

| Station   | C&GS<br>accelerograph | Displacement<br>meter | Weed  | AR-240<br>accelerograph |
|---|-----------------------|-----------------------|-------|-------------------------|
| NORTHERN CALIFORNIA   |                       |                       |       |                         |
| Berkeley, University of California, Haviland Hall.....                                  | 1                     | 1                     | ----- | -----                   |
| Bishop, Los Angeles Water Department, garage.....                                       | 1                     | -----                 | ----- | -----                   |
| Chilcoot, Frenchman Reservoir, CWR.....   | 1                     | -----                 | ----- | -----                   |
| Cholame-Shandon Array No. 2, CWR.....   | -----                 | -----                 | ----- | 1                       |
| Cholame-Shandon Array No. 5, CWR.....   | -----                 | -----                 | ----- | 1                       |
| Cholame-Shandon Array No. 8, CWR.....   | -----                 | -----                 | ----- | 1                       |
| Cholame-Shandon Array No. 12, CWR.....  | -----                 | -----                 | ----- | 1                       |
| Del Valle, Sanitorium Nurses Home, basement, CWR.....                                   | -----                 | -----                 | ----- | 1                       |
| Dos Rios, CWR.....  | -----                 | -----                 | ----- | 1                       |
| Eureka, Federal Building.....   | 1                     | -----                 | ----- | -----                   |
| Ferndale, City Hall.....  | 1                     | 1                     | ----- | -----                   |
| Franciscan, CWR.....  | -----                 | -----                 | ----- | 1                       |
| Gorman, Oso Pumping Plant.....  | -----                 | -----                 | ----- | 1                       |
| Grapevine, Tehachapi Pumping Plant, CWR.....  | -----                 | -----                 | ----- | 1                       |
| Hollister, San Andreas Geophysical Lab., University<br>of California, Harris Ranch..... | -----                 | -----                 | ----- | *                       |
| Hollister, City Hall.....   | 1                     | 1                     | ----- | 1**                     |
| Livermore, Lawrence Radiation Lab., Building 110,<br>basement.....                      | 1                     | -----                 | ----- | -----                   |
| Los Banos, San Luis Reservoir Pumping and Gener-<br>ating Plant, CWR.....               | -----                 | -----                 | ----- | 1                       |
| Monterey, City Hall.....  | -----                 | -----                 | 1     | -----                   |
| Newville, CWR.....  | -----                 | -----                 | ----- | 1                       |
| Oakland, City Hall, basement.....   | 1                     | 1                     | ----- | -----                   |

CWR—California State Department of Water Resources.

\*Mark II Prototype accelerograph.

\*\*MO-2 Prototype accelerograph.

TABLE 3.—Coast and Geodetic Survey and affiliated strong-motion stations in operation as of December 31, 1967—Continued

| Station  | C&GS<br>accelerograph | Displacement<br>meter | Weed | AR-240<br>accelerograph |
|--|-----------------------|-----------------------|------|-------------------------|
| NORTHERN CALIFORNIA—Continued  |                       |                       |      |                         |
| Oakland, Chabot Observatory.....                                       |                       |                       | 1    |                         |
| Orestimba, CWR.....  |                       | 1                     |      |                         |
| Oroville, Seismograph Station, CWR.....                                | 1                     | 1                     |      |                         |
| Pleasant Hill, Diablo Valley College.....                              | 1                     | 1                     |      |                         |
| Redwood City, KGEI Radio Station.....                                  |                       |                       |      | 1                       |
| Redwood City, Sequoia Hospital.....                                    |                       |                       |      | 1                       |
| Redwood City, Yacht Harbor.....  |                       |                       |      | 1                       |
| Sacramento, Federal Building.....                                      |                       |                       | 1    |                         |
| Sacramento, Pacific Telephone and Telegraph<br>Building, basement..... | 1                     | 1                     |      |                         |
| Roof.....  |                       |                       |      | 1                       |
| San Francisco, Alexander Building, basement.....                       | 1                     | 1                     |      |                         |
| 11th floor.....  | 1                     |                       |      |                         |
| 16th floor.....  | 1                     |                       |      |                         |
| San Francisco, Bethlehem Pacific Building, basement.....               | 1                     | 1                     |      |                         |
| 12th floor.....  | 1                     | 1                     |      |                         |
| San Francisco, 450 Sutter Building, basement.....                      |                       |                       | 1    |                         |
| 29th floor.....  |                       |                       | 1    |                         |
| San Francisco, Federal Building.....                                   | 1                     | 1                     |      |                         |
| San Francisco, Shell Building, 21st floor.....                         |                       |                       | 1    |                         |
| 29th floor.....  |                       |                       | 1    |                         |
| San Francisco, Southern Pacific Building, basement.....                | 1                     | 1                     |      |                         |
| San Francisco, State Building, basement.....                           |                       | 1                     |      |                         |
| San Jose, Piedmont Valve Yard, CWR.....                                |                       |                       |      | 1                       |
| San Jose, Bank of America Building, basement.....                      | 1                     |                       |      |                         |
| San Pablo, Contra Costa Junior College.....                            | 1                     | 1                     |      |                         |
| Santa Margarita, Salinas Dam.....                                      |                       |                       |      | 1                       |
| Stockton, Empire Tract, CWR.....                                       | 1                     |                       |      |                         |
| Temblor, Cholame, CWR.....   |                       |                       |      | 1                       |
| Tracy, Delta Pumping Plant, CWR.....                                   | 1                     | 1                     |      |                         |

## SOUTHERN CALIFORNIA

|   |   |   |  |   |
|---|---|---|--|---|
| Arcadia, Santa Anita Reservoir.....                                 |   |   |  | 1 |
| Bakersfield, Harvey Auditorium.....                                 | 1 | 1 |  |   |
| Cachuma Dam, Crest Station.....                                     | 1 | 1 |  |   |
| Cachuma Dam, Valve House Station.....                               | 1 | 1 |  |   |
| Castaic, Old Ridge Route, CWR.....                                  |   |   |  | 1 |
| Cedar Springs, Allen Ranch, CWR.....                                |   |   |  | 1 |
| Colton, Southern California Edison Building.....                    | 1 | 1 |  |   |
| El Centro, Imperial Valley Irrigation District Sub-<br>station..... | 1 | 2 |  |   |
| Encino, 16661 Ventura Blvd., basement.....                          |   |   |  | 1 |
| 4th floor.....  |   |   |  | 1 |
| 8th floor.....  |   |   |  | 1 |
| Fairmont Station, Fairmont Reservoir.....                           | 1 | 1 |  |   |
| Glendale, 633 E. Broadway, Municipal Services<br>Building.....      |   |   |  | 1 |

TABLE 3.—Coast and Geodetic Survey and affiliated strong-motion stations in operation as of December 31, 1967—Continued

| Station  | C&GS<br>accelerograph | Displacement<br>meter | Weed | AR-240<br>accelerograph |
|--|-----------------------|-----------------------|------|-------------------------|
| SOUTHERN CALIFORNIA—Continued  |                       |                       |      |                         |
| Lake Hughes Array No. 1, CWR.....  |                       |                       |      | 1                       |
| Lake Hughes Array No. 4, CWR.....  |                       |                       |      | 1                       |
| Lake Hughes Array No. 9, CWR.....  |                       |                       |      | 1                       |
| Lake Hughes Array No. 12, CWR.....   |                       |                       |      | 1                       |
| Long Beach, Utilities Building.....  | 1                     | 1                     |      |                         |
| Long Beach, Terminal Island, Southern California<br>Edison Plant.....          | 1                     |                       |      |                         |
| Los Angeles, Edison Building.....  | 1                     |                       |      |                         |
| Los Angeles, Hollywood Storage Co., basement.....                              | 1                     |                       |      |                         |
| Penthouse.....   | 1                     |                       |      |                         |
| Adjacent Pacific Electric lot.....   | 1                     |                       |      |                         |
| Los Angeles, Occidental Life Building, basement.....                           | 1                     |                       |      |                         |
| 11th floor.....  | 1                     |                       |      |                         |
| Los Angeles, Subway Terminal, subbasement.....                                 | 1                     | 1                     |      |                         |
| Los Angeles, Water and Power Building, "B" level.....                          |                       |                       |      | 1                       |
| 7th floor.....   |                       |                       |      | 1                       |
| 15th floor.....  |                       |                       |      | 1                       |
| Los Angeles, Westwood Engineering Building, Uni-<br>versity of California..... | 1                     | 1                     |      |                         |
| Los Angeles, 808 S. Hill.....  |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| 8th floor.....   |                       |                       |      | 1                       |
| Los Angeles, 1640 Marengo, 1st floor.....                                      |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| Penthouse.....   |                       |                       |      | 1                       |
| Los Angeles, 1901 Avenue of the Stars, subbasement.....                        |                       |                       |      | 1                       |
| 9th floor.....   |                       |                       |      | 1                       |
| 21st floor.....  |                       |                       |      | 1                       |
| Los Angeles, 1st and San Pedro, basement.....                                  |                       |                       |      | 1                       |
| 8th floor.....   |                       |                       |      | 1                       |
| 17th floor.....  |                       |                       |      | 1                       |
| Los Angeles, 7080 Hollywood Blvd., basement.....                               |                       |                       |      | 1                       |
| 6th floor.....   |                       |                       |      | 1                       |
| 12th floor.....  |                       |                       |      | 1                       |
| Los Angeles, 646 S. Olive, basement.....                                       |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| Roof.....  |                       |                       |      | 1                       |
| Los Angeles, 8244 Orion Blvd., 1st floor.....                                  |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| Roof.....  |                       |                       |      | 1                       |
| Los Angeles, 120 N. Robertson, 2d basement.....                                |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| 9th floor.....   |                       |                       |      | 1                       |
| Los Angeles, 4867 Sunset Blvd., basement.....                                  |                       |                       |      | 1                       |
| 2nd floor.....   |                       |                       |      | 1                       |
| 7th floor.....   |                       |                       |      | 1                       |
| Los Angeles, 945 Tiverton, subbasement.....                                    |                       |                       |      | 1                       |
| 8th floor.....   |                       |                       |      | 1                       |
| 14th floor.....  |                       |                       |      | 1                       |

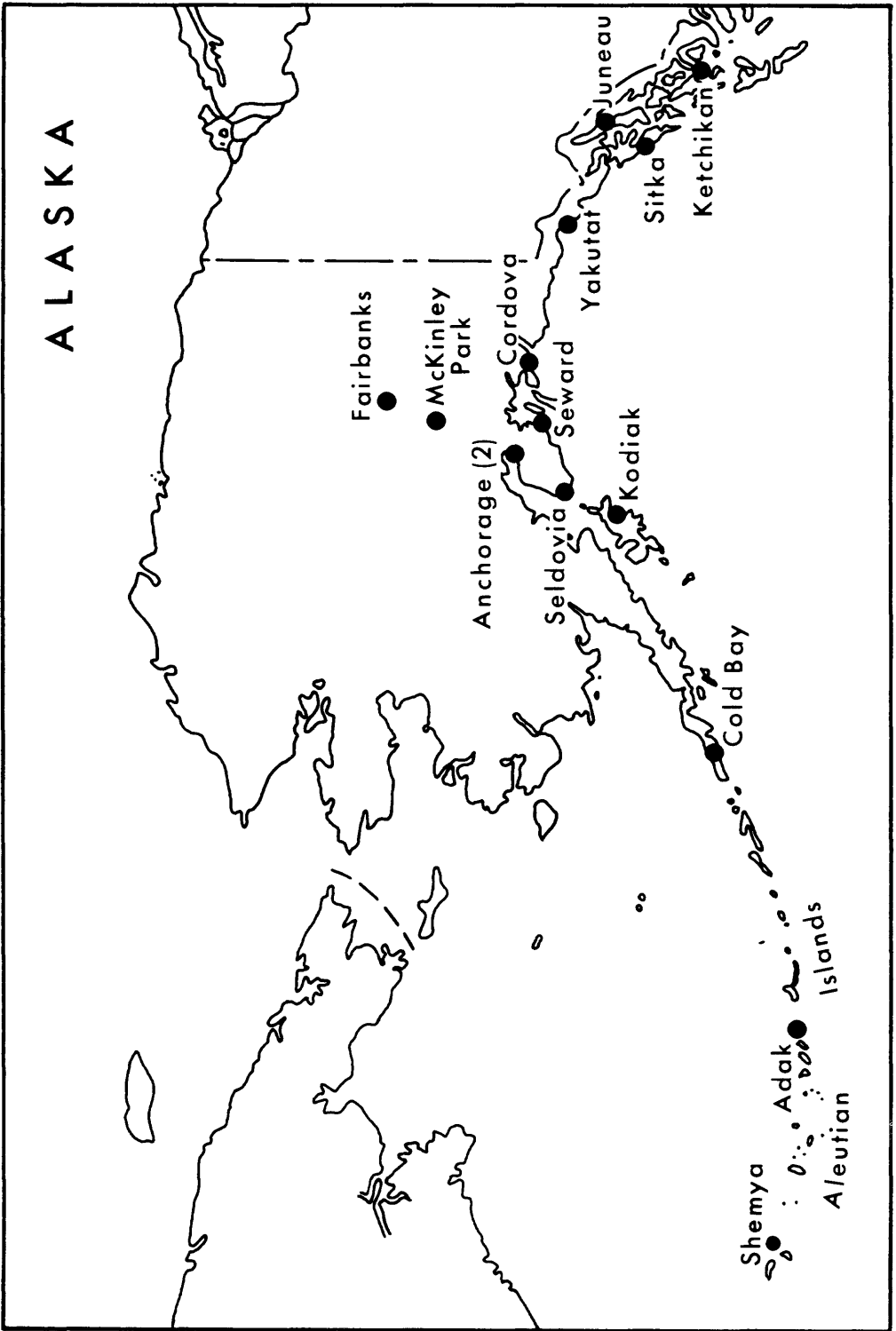


FIGURE 18.—Strong-motion stations in Alaska.

TABLE 3.—Coast and Geodetic Survey and affiliated strong-motion stations in operation as of December 31, 1967—Continued

| Station  | C&GS<br>accelerograph | Displacement<br>meter | Weed | AR-240<br>accelerograph |
|--|-----------------------|-----------------------|------|-------------------------|
| SOUTHERN CALIFORNIA—Continued  |                       |                       |      |                         |
| Los Angeles, 3470 Wilshire Blvd., subbasement.....                             |                       |                       |      | 1                       |
| 5th floor.....   |                       |                       |      | 1                       |
| 11th floor.....  |                       |                       |      | 1                       |
| Los Angeles, 4680 Wilshire Blvd., basement.....                                |                       |                       |      | 1                       |
| 3rd floor.....   |                       |                       |      | 1                       |
| 6th floor.....   |                       |                       |      | 1                       |
| Los Angeles, 445 Figueroa, subbasement.....                                    |                       |                       |      | 1                       |
| 19th floor.....  |                       |                       |      | 1                       |
| 39th floor.....  |                       |                       |      | 1                       |
| Los Angeles, 3407 W. 6th, basement.....  |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| Penthouse.....   |                       |                       |      | 1                       |
| Los Angeles, 3710 Wilshire, basement.....                                      |                       |                       |      | 1                       |
| 5th floor.....   |                       |                       |      | 1                       |
| 10th floor.....  |                       |                       |      | 1                       |
| Los Angeles, University of Southern California, Vivian<br>Hall, basement.....  |                       |                       |      | 1                       |
| 4th floor.....   |                       |                       |      | 1                       |
| Roof.....  |                       |                       |      | 1                       |
| Pasadena, California Institute of Technology, Faculty<br>Club Building.....    | 1                     |                       | 1    | -----                   |
| Millikan, basement.....  |                       |                       |      | 1                       |
| Millikan, 10th floor.....  |                       |                       |      | 1                       |
| Pasadena, J.P.L., basement.....  |                       |                       |      | 1                       |
| 9th floor.....   |                       |                       |      | 1                       |
| Pearblossom, Pumping Plant, CWR.....   |                       |                       |      | 1                       |
| Perris, Perris Reservoir, CWR.....   |                       |                       |      | 1                       |
| Port Hueneme, Navy Laboratory.....   | 1                     | 1                     |      | 1                       |
| San Bernardino, Devils Canyon, CWR.....  |                       |                       |      | 1                       |
| San Bernardino, Federal Building.....  |                       |                       | 1    | -----                   |
| San Diego, Light and Power Co., Service Building.....                          | 1                     |                       |      | -----                   |
| San Dimas, Puddingstone Reservoir.....   |                       |                       |      | 1                       |
| San Fernando, Pacoima Dam.....   |                       |                       |      | 1                       |
| San Luis Obispo, City Recreation Building.....                                 | 1                     |                       |      | -----                   |
| San Onofre, Southern California Edison Co., Nuclear<br>Generating Station..... |                       |                       |      | 1                       |
| Santa Ana, Orange County Engineering Building.....                             | 1                     |                       |      | -----                   |
| Santa Barbara, Court House.....  | 1                     |                       |      | -----                   |
| Santa Felicia Dam, Outletworks.....  |                       |                       |      | 1                       |
| Santa Felicia Dam, Crest.....  |                       |                       |      | 1                       |
| Taft, Buena Vista, CWR.....  |                       |                       |      | 1                       |
| Taft, Lincoln School Tunnel.....   |                       |                       |      | 1                       |
| Tejon, Fort Tejon, CWR.....  |                       |                       |      | 1                       |
| Vernon, Central Manufacturing District Terminal<br>Building.....               | 1                     |                       |      | -----                   |
| Wheeler Ridge, CWR.....  | 1                     |                       |      | -----                   |

TABLE 3.—Coast and Geodetic Survey and affiliated strong-motion stations in operation as of December 31, 1967—Continued

| Station  | C&GS<br>accelerograph | Displacement<br>meter | Weed | AR-240<br>accelerograph |
|--|-----------------------|-----------------------|------|-------------------------|
| OUTSIDE CALIFORNIA   |                       |                       |      |                         |
| <i>Alaska:</i>   |                       |                       |      |                         |
| Adak, U.S. Naval Base, C&GS Seismic Vault.....                                 |                       |                       |      | 1                       |
| Anchorage, Alaska Methodist University, Gould<br>Hall.....                     |                       |                       |      | 1                       |
| Anchorage, U.S. Post Office and Court House.....                               |                       |                       |      | 1                       |
| Cold Bay, Alaska Control Tower.....  |                       |                       |      | 1                       |
| Cordova, Mt. Eccles Elementary School.....                                     |                       |                       |      | 1                       |
| Fairbanks, C&GS Observatory.....   |                       |                       |      | 1                       |
| Juneau, U.S. Bureau of Commercial Fisheries,<br>Biological Lab., Auke Bay..... |                       |                       |      | 1                       |
| Ketchikan, U.S. Coast Guard Base, BOQ.....                                     |                       |                       |      | 1                       |
| Kodiak, U.S. Naval Base, Seismic Vault.....                                    |                       |                       |      | 1                       |
| McKinley Park, University of Alaska.....                                       |                       |                       |      | 1                       |
| Seldovia, High School Gym, basement.....                                       |                       |                       |      | 1                       |
| Seward, Wesleyan Hospital.....   |                       |                       |      | 1                       |
| Shemya, Composite Heights.....   |                       |                       |      | 1                       |
| Sitka, C&GS Observatory.....   |                       |                       |      | 1                       |
| Yakutat, Federal Aviation Association Hangar.....                              |                       |                       |      | 1                       |
| <i>Arizona:</i>  |                       |                       |      |                         |
| Glen Canyon.....   | 1                     | 1                     |      |                         |
| <i>Connecticut:</i>  |                       |                       |      |                         |
| Haddam, Yankee Atomic Power Plant.....   |                       |                       |      | 1                       |
| <i>Montana:</i>  |                       |                       |      |                         |
| Bozeman, Montana State College, Engineering<br>Building.....                   | 1                     |                       |      |                         |
| Butte, Montana School of Mines, Metallurgy<br>Building.....                    | 1                     |                       |      |                         |
| Columbia Falls, Hungry Horse Dam.....  | 1                     |                       |      |                         |
| Helena, Carroll College.....   | 1                     |                       |      |                         |
| <i>Nevada:</i>   |                       |                       |      |                         |
| Hawthorne, U.S. Naval Ammunition Depot.....                                    | 1                     |                       |      |                         |
| Hoover Dam, 1215 Gallery.....  | 1                     | 1                     |      |                         |
| Hoover Dam, Intake Tower.....  | 1                     | 1                     |      |                         |
| Hoover Dam, Switchyard Oilhouse.....   | 1                     | 1                     |      |                         |
| <i>Oregon:</i>   |                       |                       |      |                         |
| Green Peter Dam, Crest Station.....  |                       |                       |      | 1                       |
| Green Peter Dam, Abutment Station.....   |                       |                       |      | 1                       |
| <i>Utah:</i>   |                       |                       |      |                         |
| Flaming Gorge.....   | 1                     | 1                     |      |                         |
| Logan, Utah State University, Administration<br>Building.....                  | 1                     |                       |      |                         |
| <i>Washington:</i>   |                       |                       |      |                         |
| Olympia, Highway Test Laboratory.....  | 1                     |                       |      |                         |
| Ross Dam, Block 16, Crest Station.....   | 1                     |                       |      |                         |
| Ross Dam, Right Bank Station.....  | 1                     |                       |      |                         |
| Seattle, Federal Office Building.....  | 1                     | 1                     |      |                         |
| Seattle, Port of Seattle Dry Commodity Building.....                           | 1                     |                       |      |                         |
| Seattle, First National Bank.....  | 1                     |                       |      |                         |
| Tacoma, County-City Building.....  | 1                     | 1                     |      |                         |

TABLE 3.—Coast and Geodetic Survey and affiliated strong-motion stations in operation as of December 31, 1967—Continued

| Station                        | C&GS<br>accelerograph | Displacement<br>meter | Weed | AR-240<br>accelerograph |
|--------------------------------|-----------------------|-----------------------|------|-------------------------|
| OUTSIDE THE UNITED STATES      |                       |                       |      |                         |
| <i>Central America:</i>        |                       |                       |      |                         |
| Guatemala City, Guatemala..... | 1                     |                       |      |                         |
| San Jose, Costa Rica.....      | 1                     |                       |      |                         |
| San Salvador, El Salvador..... | 1                     | 1                     |      |                         |
| <i>South America:</i>          |                       |                       |      |                         |
| Bogota, Colombia.....          | 1                     |                       |      |                         |
| Caracas, Venezuela.....        | 1                     |                       |      |                         |
| Lima, Peru.....                | 1                     |                       |      |                         |
| Quito, Ecuador.....            | 1                     |                       |      |                         |
| Santiago, Chile.....           | 1                     |                       |      |                         |
| Total.....                     | 71                    | 35                    | 9    | 116                     |

TABLE 4.—List of shocks recorded and records obtained on strong-motion seismographs in 1967

| Date<br>1967 | Region and recording station   | Records       |                                 |                                 |      |
|--------------|--|---------------|---------------------------------|---------------------------------|------|
|              |  | Accelerograph | Survey<br>displacement<br>meter | Carder<br>displacement<br>meter | Weed |
| Feb. 9....   | South America, Quito, Ecuador.....   | 1             |                                 |                                 |      |
| Mar. 1....   | Northern California, Ferndale.....   | 1             | 1                               |                                 |      |
| June 14....  | Southern California, Pasadena, Calif. Institute of<br>Technology, Faculty Club Building..... | 1             |                                 |                                 |      |
|              | Los Angeles, 1640 Marengo, 1st floor.....  | 1*            |                                 |                                 |      |
|              | 4th floor.....   | 1*            |                                 |                                 |      |
|              | Penthouse.....   | 1*            |                                 |                                 |      |
| June 21....  | Alaska, Fairbanks, University of Alaska, Duck-<br>ering Hall, basement.....                  | 1*            |                                 |                                 |      |
| July 23....  | Northern California, Cholame-Shandon Array<br>No. 2.....                                     | 1*            |                                 |                                 |      |
| Aug. 13....  | Southern California, Cachuma Dam, Valve<br>House Station.....                                | 1             |                                 | 1                               |      |
|              | Cachuma Dam, Crest Station.....  | 1             |                                 | 1                               |      |
| Sept. 7....  | Northern California, San Francisco, Southern<br>Pacific Building, basement.....              | 1             |                                 | 1                               |      |
|              | San Francisco, Bethlehem Building, basement.....   | 1             |                                 | 1                               |      |
|              | 12th floor.....  | 1             |                                 | 1                               |      |
|              | Redwood City, KGEI Radio Station.....  | 1*            |                                 |                                 |      |
|              | Hollister, City Hall.....  | 1*            |                                 |                                 |      |
| Sept. 28.... | Northern California, San Francisco, Bethlehem<br>Building, basement.....                     | 1             |                                 | 1                               |      |
|              | 12th floor.....  | 1             |                                 | 1                               |      |
|              | Hollister, City Hall.....  | 1*            |                                 |                                 |      |
|              | San Jose, Bank of America Building.....  | 1             |                                 |                                 |      |
| Oct. 15....  | Costa Rica, San Jose.....  | 1             |                                 |                                 |      |



TABLE 4.—List of shocks recorded and records obtained on strong-motion seismographs in 1967—Continued

| Date<br>1967 | Region and recording station  | Records       |                           |                           |      |
|--------------|---|---------------|---------------------------|---------------------------|------|
|              |   | Accelerograph | Survey displacement meter | Carter displacement meter | Weed |
| Dec. 10      | Northern California, Eureka, Federal Building                           | 1             |                           |                           |      |
|              | Ferndale, City Hall   | 1             | 1                         |                           |      |
| Dec. 18      | Northern California, San Francisco, Southern Pacific Building, basement | 1             |                           | 1                         |      |
|              | San Francisco, Bethlehem Building, basement                             | 1             |                           | 1                         |      |
|              | 12th floor  | 1             |                           | 1                         |      |
|              | San Francisco, Alexander Building, basement                             | 1             |                           | 1                         |      |
|              | 11th floor  | 1             |                           |                           |      |
|              | 16th floor  | 1             |                           |                           |      |
|              | San Francisco, Federal Building   | 1             |                           | 1                         |      |
|              | Hollister, City Hall  | 1*            |                           | 1                         |      |
|              | Hollister, City Hall  | 1*            |                           |                           |      |
|              | Sacramento, basement  | 1             |                           | 1                         |      |
|              | Del Valle   | 1*            |                           |                           |      |
|              | Redwood City, KGEI Radio Station  | 1*            |                           |                           |      |
|              | Stockton  | 1             |                           |                           |      |
| Dec. 31      | Northern California, Cholame-Shandon Array No. 2                        | 1*            |                           |                           |      |
|              | Cholame-Shandon Array No. 5   | 1*            |                           |                           |      |
|              | Cholame-Shandon Array No. 8   | 1*            |                           |                           |      |

\*Instrument is AR-240.

TABLE 5.—Summary of outstanding instrumental and noninstrumental data for 1967

| Epicenter   | Recording station and distance | Location of instrument                                   | Intensity <sup>1</sup> | Acceleration               | Displacement <sup>2</sup> |
|---|--------------------------------|--|------------------------|----------------------------|---------------------------|
| FERNDAL, CALIF., EARTHQUAKE OF DECEMBER 10                  |                                |  |                        |                            |                           |
| 40.5° N., 124.6° W., northern California, W. VI*. Mag. 5.8. | Ferndale, City Hall, 20 miles. | Two-story wood-frame structure on concrete ground floor. | VI                     | cm/sec <sup>2</sup><br>274 | cm                        |

<sup>1</sup> Reported intensity of earthquake at recording station.<sup>2</sup> Displacement is the maximum recorded at the station reporting the maximum acceleration of the earthquake. If displacement is much greater at another location, it is given along with the maximum acceleration at the same location.

\* An asterisk following the intensity designation in the epicenter column indicates the maximum reported intensity of the earthquake

TABLE 6.—Composite of strong-motion instrumental data for 1967

| Station and component                             | Instrument no. | T <sub>0</sub> | V   | Sensitivity | ε    | Acceleration |                     | Displacement |           | Remarks |
|---|----------------|----------------|-----|-------------|------|--------------|---------------------|--------------|-----------|---------|
|   |                |                |     |             |      | Period       | Amplitude           | Period       | Amplitude |         |
| COLOMBIA, SOUTH AMERICA, EARTHQUAKE OF FEBRUARY 9 |                |                |     |             |      |              |                     |              |           |         |
| Quito, Ecuador:                                   |                |                |     |             |      |              |                     |              |           |         |
| Down.....   | 350            | 0.068          | 123 | 14.0        | 8.0  | sec          | cm/sec <sup>2</sup> | sec          | cm        |         |
| E-W.....  | 351            | 0.066          | 125 | 14.0        | 10.0 | 1.10         | 2                   | ---          | ---       |         |
| N-S.....  | 285            | 0.065          | 126 | 13.0        | 10.0 | 1.30         | 4                   | ---          | ---       |         |
|   |                |                |     |             |      | 1.20         | 3                   | ---          | ---       |         |
| NORTHERN CALIFORNIA EARTHQUAKE OF MARCH 1         |                |                |     |             |      |              |                     |              |           |         |
| Ferndale:   |                |                |     |             |      |              |                     |              |           |         |
| Down.....   | 247            | 0.067          | 125 | 14          | 9.0  | 0.29         | 2                   | ---          | ---       |         |
| S 44° W.....                                      | 248            | 0.067          | 125 | 14          | 6.5  | 0.25         | 4                   | ---          | ---       |         |
| N 46° W.....                                      | 249            | 0.065          | 123 | 13          | 9.0  | 0.26         | 4                   | ---          | ---       |         |
| S 46° E.....                                      | RDM            | 9.85           | 1.0 | ---         | 11.0 | ---          | ---                 | 0.70         | 0.03      |         |
| S 44° W.....                                      | LDM            | 10.35          | 1.0 | ---         | 11.0 | ---          | ---                 | 0.60         | 0.02      |         |
| SOUTHERN CALIFORNIA EARTHQUAKE OF JUNE 14         |                |                |     |             |      |              |                     |              |           |         |
| Pasadena (Cal. Tech. Faculty Club Bldg.):         |                |                |     |             |      |              |                     |              |           |         |
| Down.....   | 325            | 0.081          | 122 | 20.0        | 9.0  | 0.19         | 4                   | ---          | ---       |         |
| South.....  | 326            | 0.078          | 118 | 18.0        | 9.5  | 0.13         | 13                  | ---          | ---       |         |
| West.....   | 327            | 0.079          | 119 | 19.0        | 8.0  | 0.26         | 8                   | ---          | ---       |         |
| Los Angeles (1640 Marengo St., 1st floor):        |                |                |     |             |      |              |                     |              |           |         |
| S 27° W.....                                      | 420            | 0.053          | 119 | 8.4         | 10.0 | 0.12         | 6                   | ---          | ---       |         |
| Down.....   | 419            | 0.052          | 126 | 8.4         | 9.0  | 0.11         | 4                   | ---          | ---       |         |
| S 63° E.....                                      | 434            | 0.052          | 111 | 7.4         | 10.5 | 0.19         | 7                   | ---          | ---       |         |

TABLE 6.—Composite of strong-motion instrumental data for 1967—Continued

| Station and component                               | Instrument no. | T <sub>0</sub> | V   | Sensi-<br>tivity | c    | Acceleration |                | Displacement |                | Remarks      |
|---|----------------|----------------|-----|------------------|------|--------------|----------------|--------------|----------------|--------------|
|   |                |                |     |                  |      | Period       | Ampli-<br>tude | Period       | Ampli-<br>tude |              |
| SOUTHERN CALIFORNIA EARTHQUAKE OF JUNE 14—Continued |                |                |     |                  |      |              |                |              |                |              |
| Los Angeles (1640 Marengo St., 4th floor):          |                |                |     |                  |      |              |                |              |                |              |
| N 63° W.....  | 440            | 0.057          | 101 | 8.2              | 9.0  | 0.19         | 12             |              |                |              |
| Down.....   | 427            | 0.053          | 119 | 8.4              | 10.5 | 0.12         | 5              |              |                |              |
| S 27° W.....  | 448            | 0.054          | 119 | 8.5              | 8.5  | 0.14         | 20             |              |                |              |
| Los Angeles (1640 Marengo St., Penthouse):          |                |                |     |                  |      |              |                |              |                |              |
| N 63° N.....  | 471            | 0.054          | 112 | 8.3              | 10.0 | 0.21         | 12             |              |                |              |
| Down.....   | 449            | 0.054          | 106 | 7.6              | 10.0 | 0.62         | 8              |              |                |              |
| S 27° W.....  | 447            | 0.055          | 112 | 8.5              | 10.0 | 0.08         | 7              |              |                |              |
| University of Alaska (Duckering Hall, basement):    |                |                |     |                  |      | 0.26         | 23             |              |                |              |
| South.....  | 138            | 0.0503         | 111 | 7.6              | 17.1 | 0.46         | 13             |              |                |              |
| Down.....   | 188            | 0.0503         | 115 | 7.8              | 13.3 | 0.09         | 55             |              |                |              |
| East.....   | 134            | 0.0526         | 104 | 7.8              | 13.3 | 0.13         | 52             |              |                |              |
|   |                |                |     |                  |      | 0.41         | 55             |              |                |              |
| CENTRAL CALIFORNIA EARTHQUAKE OF JULY 23            |                |                |     |                  |      |              |                |              |                |              |
| Cholame-Shandon Array No. 2:                        |                |                |     |                  |      |              |                |              |                |              |
| N 51° E.....  | 110            | 0.0656         | 76  | 8.1              | 9.0  | 0.07         | 24             |              |                | Not readable |
| Down.....   | 254            | 0.0564         | 98  | 7.7              | 8.0  |              |                |              |                |              |
| N 39° W.....  | 372            | 0.0533         | 120 | 8.5              | 5.5  | 0.08         | 15             |              |                |              |
| SOUTHERN CALIFORNIA EARTHQUAKE OF AUGUST 13         |                |                |     |                  |      |              |                |              |                |              |
| Cachuma Dam (valve house):                          |                |                |     |                  |      |              |                |              |                |              |
| Down.....   | 364            | 0.061          | 117 | 11               | 8.5  | 0.07         | 9              |              |                |              |

CENTRAL CALIFORNIA EARTHQUAKE OF SEPTEMBER 7

|                      |     |       |      |     |     |      |     |      |      |
|----------------------|-----|-------|------|-----|-----|------|-----|------|------|
| North.....           | 365 | 0.062 | 119  | 11  | 8.0 | 0.09 | 7   | ---  | ---  |
| East.....            | 366 | 0.063 | 121  | 12  | 8.0 | 0.10 | 16  | ---  | ---  |
| West.....            | 9   | 5.6   | 1.0  | --- | 8.5 | ---  | --- | 0.27 | 0.02 |
| Down.....            | 2   | 1.9   | 1.1  | --- | 4.0 | ---  | --- | 0.68 | 0.02 |
| North.....           | 30  | 5.5   | 1.0  | --- | 9.5 | ---  | --- | 0.55 | 0.02 |
| Cachuma Dam (crest): |     |       |      |     |     |      |     |      |      |
| Down.....            | 361 | 0.064 | 119  | 12  | 7.0 | 0.11 | 11  | ---  | ---  |
| North.....           | 362 | 0.063 | 118  | 12  | 8.5 | 0.08 | 24  | ---  | ---  |
| East.....            | 363 | 0.060 | 118  | 11  | 8.5 | 0.16 | 13  | ---  | ---  |
| East.....            | 15  | 2.55  | 0.83 | --- | 9.0 | ---  | --- | 0.59 | 0.02 |
| South.....           | 14  | 2.32  | 0.89 | --- | 7.5 | ---  | --- | 0.47 | 0.05 |

|   |        |       |     |     |      |      |     |      |      |
|---|--------|-------|-----|-----|------|------|-----|------|------|
| San Francisco (Southern Pacific Bldg., basement): |        |       |     |     |      |      |     |      |      |
| Down.....   | 196    | 0.065 | 115 | 12  | 9.5  | 0.26 | 2   | ---  | ---  |
| N 45° W.....                                      | 195    | 0.067 | 117 | 13  | 9.0  | 0.48 | 5   | ---  | ---  |
| N 45° E.....                                      | 194    | 0.067 | 116 | 13  | 9.5  | 0.50 | 3   | ---  | ---  |
| S 45° W.....                                      | 42     | 3.6   | 1.0 | --- | 10.5 | ---  | --- | 0.81 | 0.03 |
| N 45° W.....                                      | 43     | 4.0   | 1.0 | --- | 10.5 | ---  | --- | 1.00 | 0.02 |
| Hollister (City Hall):                            |        |       |     |     |      |      |     |      |      |
| North.....  | AR-240 | 0.060 | --- | 7.5 | 15.0 | 0.21 | 4   | ---  | ---  |
| Down.....   | ---    | ---   | --- | --- | ---  | ---  | --- | ---  | ---  |
| West.....   | ---    | 0.060 | --- | 7.5 | 15.0 | 0.23 | 4   | ---  | ---  |
| San Francisco (Bethlehem Bldg., basement):        |        |       |     |     |      |      |     |      |      |
| Down.....   | IV     | 0.066 | 115 | 13  | 9.0  | 1.50 | 2   | ---  | ---  |
| West.....   | V      | 0.068 | 119 | 14  | 12.5 | 0.35 | 4   | ---  | ---  |
| North.....  | VI     | 0.067 | 118 | 13  | 9.0  | 0.30 | 7   | ---  | ---  |
| South.....  | CDM-A  | 4.35  | 1.0 | --- | 12.5 | ---  | --- | 1.13 | 0.05 |
| West.....   | CDM-B  | 5.07  | 1.0 | --- | 10.5 | ---  | --- | 0.79 | 0.03 |
| San Francisco (Bethlehem Bldg., 12th floor):      |        |       |     |     |      |      |     |      |      |
| Down.....   | I      | 0.046 | 113 | 5.9 | 7.0  | 0.16 | 5   | ---  | ---  |
| West.....   | II     | 0.046 | 120 | 6.4 | 8.0  | 0.20 | 3   | ---  | ---  |
| North.....  | III    | 0.045 | 120 | 6.1 | 9.0  | 0.34 | 4   | ---  | ---  |
| South.....  | CDM-T  | 3.9   | 1.0 | --- | 10.0 | ---  | --- | 0.93 | 0.06 |
| West.....   | CDM-L  | 4.0   | 1.0 | --- | 9.0  | ---  | --- | 1.77 | 0.04 |

TABLE 6.—Composite of strong-motion instrumental data for 1967—Continued

| Station and component | Instrument no. | T <sub>s</sub> | V | Sensitivity | ε | Acceleration |           | Displacement |           | Remarks |
|-----------------------|----------------|----------------|---|-------------|---|--------------|-----------|--------------|-----------|---------|
|                       |                |                |   |             |   | Period       | Amplitude | Period       | Amplitude |         |

|  |     |       |     |     |      |      |    |  |  |  |
|--|-----|-------|-----|-----|------|------|----|--|--|--|
| CENTRAL CALIFORNIA EARTHQUAKE OF SEPTEMBER 7—Continued |     |       |     |     |      |      |    |  |  |  |
| Redwood City (KGEI Radio Station):                     |     |       |     |     |      |      |    |  |  |  |
| N 42° E.....   | 129 | 0.050 | 91  | 5.7 | 9.5  | 0.49 | 13 |  |  |  |
| Down.....  | 431 | 0.054 | 112 | 8.2 | 11.0 | 0.11 | 3  |  |  |  |
| N 48° W.....   | 127 | 0.053 | 97  | 6.7 | 11.0 | 0.17 | 7  |  |  |  |

|   |        |        |     |      |      |      |    |      |      |  |
|---|--------|--------|-----|------|------|------|----|------|------|--|
| CENTRAL CALIFORNIA EARTHQUAKE OF SEPTEMBER 28 |        |        |     |      |      |      |    |      |      |  |
| San Jose (Bank of America):                   |        |        |     |      |      |      |    |      |      |  |
| Down.....                                     | 202    | 0.067  | 120 | 13.0 | 8.0  | 1.08 | 1  |      |      |  |
| N 59° E.....                                  | 201    | 0.066  | 122 | 13.0 | 6.5  | 0.60 | 2  |      |      |  |
| S 31° E.....                                  | 200    | 0.066  | 120 | 13.0 | 9.0  | 0.76 | 2  |      |      |  |
| Hollister (City Hall):                        |        |        |     |      |      |      |    |      |      |  |
| North.....                                    | AR-240 | 0.060  |     | 7.5  | 15.0 | 0.29 | 10 |      |      |  |
| Down.....                                     |        | 0.060  |     | 7.5  | 15.0 | 0.23 | 4  |      |      |  |
| West.....                                     |        | 0.060  |     | 7.5  | 15.0 | 0.19 | 10 |      |      |  |
| Hollister (City Hall):                        |        |        |     |      |      |      |    |      |      |  |
| Down.....                                     | 238    | 0.067  | 123 | 14.0 | 8.0  | 0.23 | 3  |      |      |  |
| South.....                                    | 239    | 0.065  | 124 | 13.0 | 7.5  | 0.28 | 10 |      |      |  |
| West.....                                     | 240    | 0.065  | 122 | 13.0 | 8.0  | 0.22 | 8  |      |      |  |
| West.....                                     | 5      | 2.21   | 1.0 |      | 10.0 |      |    | 1.21 | 0.08 |  |
| North.....                                    | 6      | 2.12   | 1.0 |      | 12.5 |      |    | 1.56 | 0.05 |  |
| San Francisco (Bethlehem Bldg., basement):    |        |        |     |      |      |      |    |      |      |  |
| Down.....                                     | IV     | 0.0673 | 115 | 12.9 | 11.0 | 0.33 | 1  |      |      |  |
| West.....                                     | V      | 0.0688 | 119 | 14.0 | 12.0 | 0.39 | 1  |      |      |  |
| North.....                                    | VI     | 0.0670 | 118 | 13.0 | 10.0 | 0.63 | 1  |      |      |  |
| South.....                                    | CDM-A  | 4.3    | 1.0 |      | 15.0 |      |    | 0.91 | 0.02 |  |
| West.....                                     | CDM-B  | 5.0    | 1.0 |      | 12.0 |      |    | 0.94 | 0.01 |  |

## San Francisco (Bethlehem Bldg., 12th floor):

|            |       |        |     |       |      |       |       |       |       |
|------------|-------|--------|-----|-------|------|-------|-------|-------|-------|
| Down.....  | I     | 0.0457 | 113 | 5.86  | 9.0  | 0.15  | 2     | ----- | ----- |
| West.....  | II    | 0.0448 | 120 | 5.97  | 10.0 | 0.24  | 2     | ----- | ----- |
| North..... | III   | 0.0456 | 120 | 6.19  | 10.0 | ----- | ----- | ----- | ----- |
| South..... | CDM-T | 3.90   | 1.0 | ----- | 10.8 | ----- | ----- | 1.34  | 0.03  |
| West.....  | CDM-L | 3.94   | 1.0 | ----- | 11.0 | ----- | ----- | 1.63  | 0.04  |

## NICARAGUA-COSTA RICA EARTHQUAKE OF OCTOBER 15

|                       |     |        |       |     |      |      |    |       |       |
|-----------------------|-----|--------|-------|-----|------|------|----|-------|-------|
| San Jose, Costa Rica: |     |        |       |     |      |      |    |       |       |
| "L".....              | 480 | 0.0516 | ----- | 7.6 | 11.0 | 0.32 | 22 | ----- | ----- |
| "T".....              | 349 | 0.0510 | ----- | 7.6 | 10.0 | 0.27 | 19 | ----- | ----- |
| Down.....             | 485 | 0.0519 | ----- | 7.6 | 10.0 | 0.36 | 18 | ----- | ----- |
|                       |     |        |       |     |      | 0.53 | 17 | ----- | ----- |
|                       |     |        |       |     |      | 0.32 | 18 | ----- | ----- |
|                       |     |        |       |     |      | 0.29 | 13 | ----- | ----- |

## NORTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 10

|                       |     |        |     |       |      |      |      |       |       |
|-----------------------|-----|--------|-----|-------|------|------|------|-------|-------|
| Ferndale (City Hall): |     |        |     |       |      |      |      |       |       |
| Up.....               | 247 | 0.0659 | 125 | 13.4  | 10.0 | 0.84 | 33   | ----- | ----- |
| S 44° W.....          | 248 | 0.0661 | 125 | 13.5  | 11.0 | 0.46 | 15   | ----- | ----- |
|                       |     |        |     |       |      | 0.23 | 274  | ----- | ----- |
|                       |     |        |     |       |      | 0.35 | 89   | ----- | ----- |
|                       |     |        |     |       |      | 0.25 | 51   | ----- | ----- |
| N 46° W.....          | 249 | 0.0649 | 123 | 12.8  | 12.8 | 0.43 | 34   | ----- | ----- |
|                       |     |        |     |       |      | 0.46 | 130  | ----- | ----- |
|                       |     |        |     |       |      | 0.66 | 91   | ----- | ----- |
| S 44° W.....          | RDM | 10.5   | 1.0 | ----- | 15.0 | 0.27 | 34   | ----- | ----- |
| S 46° E.....          | LDM | 9.5    | 1.0 | ----- | 14.0 | 0.62 | 23   | ----- | ----- |
|                       |     |        |     |       |      | 1.53 | 1.93 | ----- | ----- |
|                       |     |        |     |       |      | 3.19 | 0.63 | ----- | ----- |
|                       |     |        |     |       |      | 1.86 | 1.74 | ----- | ----- |
|                       |     |        |     |       |      | 1.69 | 0.65 | ----- | ----- |

TABLE 6.—Composite of strong-motion instrumental data for 1967—Continued

| Station and component                                   | Instrument no. | T <sub>0</sub> | V    | Sensitivity | c    | Acceleration |           | Displacement |           | Remarks |
|---|----------------|----------------|------|-------------|------|--------------|-----------|--------------|-----------|---------|
|   |                |                |      |             |      | Period       | Amplitude | Period       | Amplitude |         |
| NORTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 10—Continued |                |                |      |             |      |              |           |              |           |         |
| Eureka (Federal Building):                              |                |                |      |             |      |              |           |              |           |         |
| Down.....   | 250            | 0.0663         | 115  | 11.1        | 3.0  | 0.17         | 8         |              |           |         |
| N 79° W.....  | 251            | 0.0664         | 121  | 13.2        | 10.0 | 0.63         | 19        |              |           |         |
| S 11° E.....  | 252            | 0.0668         | 121  | 13.4        | 10.0 | 0.47         | 21        |              |           |         |
| NORTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 18           |                |                |      |             |      |              |           |              |           |         |
| San Francisco (Southern Pacific Bldg., basement):       |                |                |      |             |      |              |           |              |           |         |
| Down.....   | 196            | 0.065          | 115  | 12          | 8.5  | 0.44         | 6         |              |           |         |
| N 45° W.....  | 195            | 0.067          | 117  | 13          | 1.01 | 0.48         | 14        |              |           |         |
| N 45° E.....  | 194            | 0.067          | 116  | 13          | 9.5  | 0.52         | 10        |              |           |         |
| S 45° W.....  | 42             | 3.49           | 1.0  |             | 11.5 |              |           | 1.42         | 0.16      |         |
| N 45° W.....  | 43             | 3.96           | 1.0  |             | 10.0 |              |           | 0.95         | 0.16      |         |
| Hollister (City Hall):                                  |                |                |      |             |      |              |           |              |           |         |
| Down.....   | 238            | 0.067          | 123  | 14          | 9.0  | 0.17         | 13        |              |           |         |
| South.....  | 239            | 0.065          | 124  | 13          | 13.0 | 0.63         | 19        |              |           |         |
| West.....   | 240            | 0.065          | 122  | 13          | 8.5  | 0.49         | 15        |              |           |         |
| West.....   | 5              | 2.20           | 1.0  |             | 12.0 |              |           | 1.41         | 0.17      |         |
| North.....  | 6              | 2.10           | 1.0  |             | 10.5 |              |           | 1.14         | 0.31      |         |
| Redwood City (KGEI Radio Station):                      |                |                |      |             |      |              |           |              |           |         |
| N 42° E.....  | 129            | 0.0503         | 91.4 | 5.74        | 10.0 | 0.29         | 34        |              |           |         |
| Down.....   | 431            | 0.0542         | 112  | 8.17        | 11.0 | 0.30         | 13        |              |           |         |
| N 48° W.....  | 127            | 0.053          | 96.6 | 6.74        | 11.0 | 0.31         | 20        |              |           |         |
|   |                |                |      |             |      | 0.32         | 17        |              |           |         |
| San Francisco (Bethlehem Bldg., basement):              |                |                |      |             |      |              |           |              |           |         |
| Down.....   | IV             | 0.067          | 115  | 13          | 10.5 | 0.47         | 4         |              |           |         |
| West.....   | V              | 0.069          | 119  | 14          | 11.5 | 0.42         | 9         |              |           |         |





TABLE 6.—Composite of strong-motion instrumental data for 1967—Continued

| Station and component                                   | Instrument no. | T <sub>0</sub> | V   | Sensitiv-<br>ity | e    | Acceleration |                | Displacement |                | Remarks        |
|---|----------------|----------------|-----|------------------|------|--------------|----------------|--------------|----------------|----------------|
|   |                |                |     |                  |      | Period       | Ampli-<br>tude | Period       | Ampli-<br>tude |                |
| NORTHERN CALIFORNIA EARTHQUAKE OF DECEMBER 18—Continued |                |                |     |                  |      |              |                |              |                |                |
| Del Valle:  |                |                |     |                  |      |              |                |              |                | Not measurable |
| North.....  | 144            | 0.052          | 113 | 7.7              | 12.0 | 0.30         | 3              | -----        | -----          |                |
| Down.....   | 168            | 0.052          | 118 | 7.8              | 11.5 | 0.18         | 3              | -----        | -----          |                |
| West.....   | 167            | 0.051          | 118 | 7.8              | 9.5  | 0.45         | 4              | -----        | -----          |                |
| Sacramento:   |                |                |     |                  |      |              |                |              |                |                |
| Down.....   | 2004           | 0.070          | 127 | 16.0             | 9.0  | -----        | -----          | -----        | -----          |                |
| East.....   | 2018           | 0.070          | 124 | 15.0             | 11.0 | -----        | -----          | -----        | -----          |                |
| South.....  | 2019           | 0.071          | 126 | 16.0             | 11.0 | -----        | -----          | -----        | -----          |                |
| North.....  | 61             | 4.33           | 1.0 | -----            | 10.0 | -----        | -----          | -----        | -----          |                |
| East.....   | 62             | 4.90           | 1.0 | -----            | 7.5  | -----        | -----          | -----        | -----          |                |
| CENTRAL CALIFORNIA EARTHQUAKE OF DECEMBER 31            |                |                |     |                  |      |              |                |              |                |                |
| Cholame-Shandon Array No. 8:                            |                |                |     |                  |      |              |                |              |                |                |
| N 51° E.....  | 313            | 0.051          | 118 | 7.5              | 10.5 | 0.12         | 10             | -----        | -----          |                |
| Down.....   | 396            | 0.052          | 109 | 7.3              | 1.0  | 0.10         | 6              | -----        | -----          |                |
| N 39° W.....  | 368            | 0.051          | 113 | 7.3              | 9.0  | 0.37         | 27             | -----        | -----          |                |
| Cholame-Shandon Array No. 5:                            |                |                |     |                  |      |              |                |              |                |                |
| N 51° E.....  | 258            | 0.054          | 119 | 8.5              | 10.5 | 0.33         | 12             | -----        | -----          |                |
| Down.....   | 156            | 0.054          | 103 | 7.5              | 9.0  | 0.18         | 5              | -----        | -----          |                |
| N 39° W.....  | 164            | 0.051          | 109 | 7.0              | 4.0  | 0.28         | 24             | -----        | -----          |                |
| Cholame-Shandon Array No. 2:                            |                |                |     |                  |      |              |                |              |                |                |
| N 51° E.....  | 210            | 0.065          | 76  | 8.0              | 10.5 | 0.27         | 11             | -----        | -----          |                |
| Down.....   | 254            | 0.056          | 98  | 7.6              | 9.5  | 0.29         | 6              | -----        | -----          |                |
| N 39° W.....  | 372            | 0.053          | 120 | 8.2              | 3.0  | 0.31         | 21             | -----        | -----          |                |

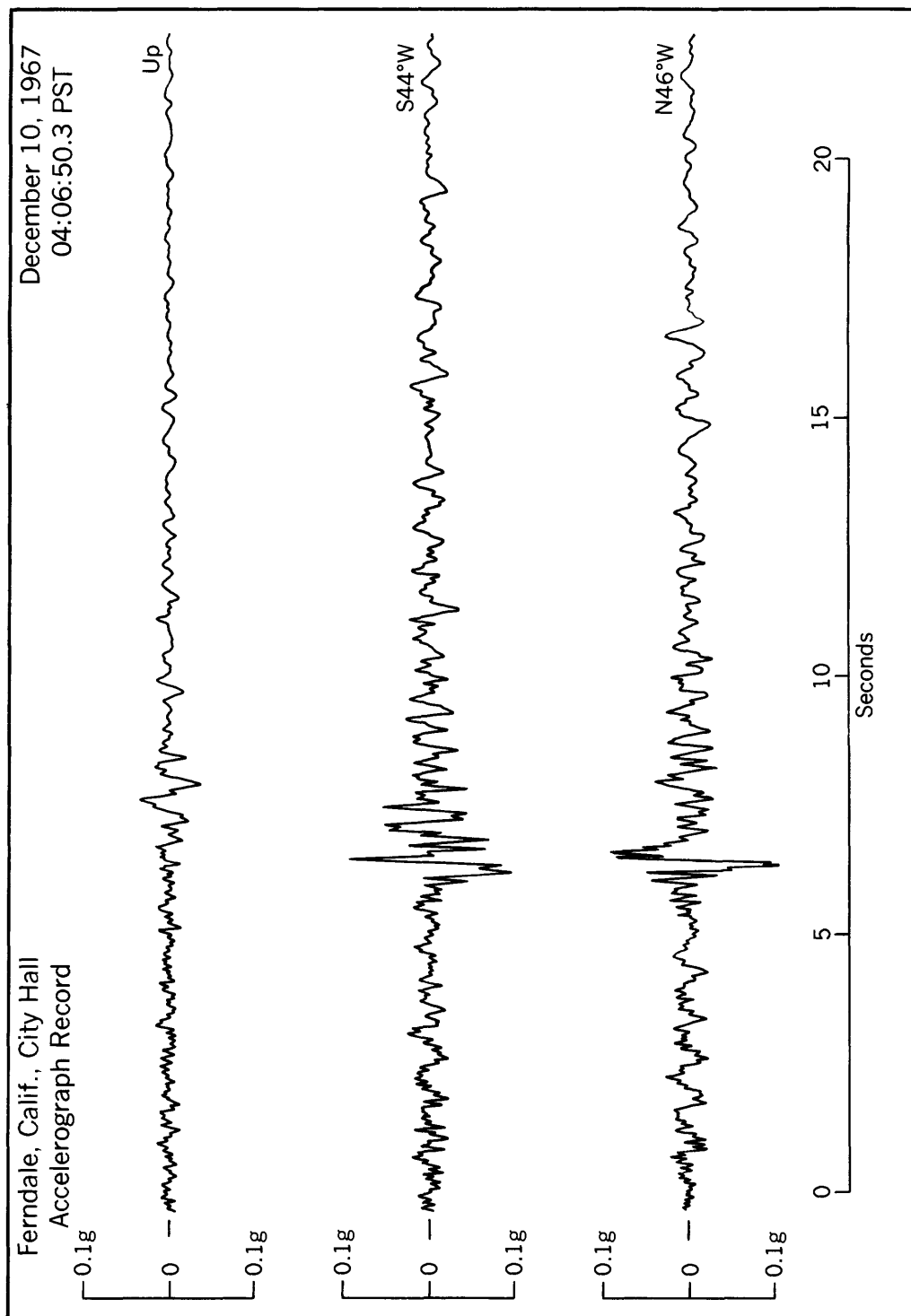


FIGURE 19.—Tracing of accelerograph record obtained at Ferndale, Calif., December 10.

## Additions and Corrections to Previous Issues

*United States Earthquakes, 1957 through 1962:* On page 2 of each issue, "vol. 12" in the footnote should read "vol. 21".

*United States Earthquakes, 1961:* Page 96, column 4, July 23 earthquake, "18.5 N." should read "18.5 S"; the same change should be made on page 41, column 2, line 10 from bottom.

*United States Earthquakes, 1963:* Page 7, column 2, line 5 of Earthquake Activity in the Various States, "October 16, IV" should read "October 16, VI".

*United States Earthquakes, 1963:* Page 55, column 1, line 12, "1934-1964" should read "1931-1964".

*United States Earthquakes, 1964:* Page 4, column 2, line 27, "page 182" should read "page 82".

*United States Earthquake, 1964:* Page 9, column 2, March 12 earthquake, "38.2° north" should read "33.2° north".

*United States Earthquakes, 1964:* Page 10, column 1, May 12 earthquake, "04:45:14.1\*" should read "01:45:14.1\*".

*United States Earthquakes, 1964:* Page 60, column 1, May 28 earthquake, "12:51" should read "12:47:38.0\*. Epicenter 53.7° north, 167.8° west, depth about 33 km, W. Magnitude 4.7."

*United States Earthquakes, 1965:* Page 7, column 2, line 28, "14:00" should read "14:00 E.D.T."

*United States Earthquakes, 1965:* Page 29, column 2, line 5, "September 72" should read "September 27".

*United States Earthquakes, 1965:* Page 52, column 1, February 5 earthquake, "15:41: should read "15:40:33.2\*. Epicenter 53.2° north, 161.9° west, south of Alaska, depth about 33 km, W. Magnitude 6¾, P."

*United States Earthquakes, 1966:* Page 72, Tidal Disturbances of Seismic Origin. A report received subsequent to the publishing of the 1966 annual earthquake report stated that an earthquake in the Solomon Islands (10.4° south, 160.8° east) on June 15, 1966, generated a tsunami. It was recorded on the tide gage at Point Cruz, Honiara, Guadalcanal, with a maximum amplitude of 6 inches.