DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

United States Earthquakes, 1970

By

Jerry L. Coffman

and

Carl A. von Hake

Open-File report 84-970

Prepared in cooperation with National Oceanic and Atmospheric Administration.

1984

Preface

In July 1971, a reorganization within the National Oceanic and Atmospheric Administration (NOAA) transferred the Office of Seismology and Geomagnetism and the National Earthquake Information Center from NOAA's National Ocean Survey (NOS) to NOAA's Environmental Research Laboratories (ERL), Earth Sciences Laboratories, with headquarters at Boulder, Colo. The reorganization also transferred many publishing activities relating to seismic data and earthquake information—including publication of *United States Earthquakes* for each calendar year—to NOAA's Environmental Data Service (EDS), National Geophysical Data Center. *United States Earthquakes, 1970* is issued by EDS' National Geophysical Data Center and is prepared in collaboration with ERL and other NOAA components and the Geological Survey of the U.S. Department of the Interior.

The Environmental Data Service does not approve, recommend, or endorse any proprietary product or proprietary material mentioned in this publication. No reference shall be made to the Environmental Data Service, or to this publication furnished by the Environmental Data Service, in any advertising or sales promotion which would indicate or imply that the Environmental Data Service approves, recommends, or endorses any proprietary product or proprietary material mentioned herein, or which has as its purpose an intent to cause directly or indirectly the advertised product to be used or purchased because of this Environmental Data Service publication.

Contents

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

United States Earthquakes, prepared annually since 1928, lists epicenters of all earthquakes and associated phenomena recorded in the United States and nearby territories during the year. It includes brief descriptions of earthquakes that were felt or caused damage in the United States, and summarizes all available data on shocks noted by residents of the Panama Canal Zone, Puerto Rico, and the Virgin Islands. In addition, a list of principal earthquakes of the world during the year is presented with brief accounts of their effects.

Sources of noninstrumental information used in this compilation include reports received from questionnaire canvasses; newspaper clippings; bulletins of the Seismological Society of America; special reports of other organizations; and data from the National Weather Service of NOAA, whose observers prepare periodic reports on local seismic activity.

Except for earthquakes in Hawaii, instrumental data utilized in computing earthquake locations, depths, magnitudes, and times of occurrence are obtained from NOAA and cooperating seismological observatories, both domestic and foreign.

EARTHQUAKE INFORMATION SERVICES

The National Geophysical Data Center (NGDC) of NOAA's Environmental Data Service is a focal point for the dissemination of historical seismic information for both technical and general users. NGDC services include preparing local and regional seismic histories for engineers, actuaries, and scientists; answering direct inquiries from the public concerning all aspects of historical earthquakes; and publishing annual, quarterly, and monthly summaries and revised historical earthquake reports.

Publications issued by NGDC, in addition to this annual report, include:

1. *Abstracts of Earthquake Reports for the United States.* This quarterly report gives detailed information on shocks that were felt or caused damage in the United States and nearby territories. A condensed version of these reports appears each year in the *United States Earthquakes* publication. Available from the National Geophysical Data Center, Environmental Data Service, National Oceanic and Atmospheric Administration, Boulder, Colo. 80302.

2. *C&GS Special Publication 282, Earthquake Investigation in the United States* (Revised 1969 Edition). This semitechnical booklet explains the most important facts about earthquakes and discusses major historical shocks of the United States and nearby territories. It also contains sections on seismographs and the nature of earthquakes and seismic waves. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; price 35 cents.

3. *C&GS Publication No. 41-1, Earthquake History of the United States* (Revised 1963 Edition), in two parts. Part I discusses prominent earthquakes (Modified Mercalli intensity V and above) in the United States from historical times through 1963 (exclusive of shocks in California and western Nevada). Part II describes significant earthquakes (Modified Mercalli intensity VI and above)

in California and western Nevada from historical times through 1963. Both publications contain regional tables which list epicenters or probable locations of all earthquakes, intensity, and extent of felt area. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; price 70 cents for Part I; 30 cents for Part II.

The reports above are prepared in collaboration with Environmental Research Laboratories (ERL) groups, especially the Seismological Field Survey and the National Earthquake Information Center. A list of all publications and services related to seismology is available upon request to the National Geophysical Data Center, Environmental Data Service, National Oceanic and Atmospheric Administration.

The ERL National Earthquake Information Center (NEIC) maintains an earthquake reporting system that provides accurate and rapid epicenter locations and magnitude values to the press and other interested groups. These results are available within 2 to 3 hours for earthquakes of magnitude 6½ or larger. Locations and magnitudes of smaller events are computed on request or on receipt of a press report. NEIC relies on NOAA and cooperating observatories worldwide to provide data for the earthquake reporting system.

NEIC issues the following technical seismological reports. They are available in limited numbers to cooperating seismological groups, research institutions, universities, and libraries.

1. *Preliminary Determination of Epicenters.* These twice-weekly reports list the approximate epicentral locations of all earthquakes recorded throughout the world. They contain origin time, geographic coordinates, region of occurrence, felt and damage data, depth, magnitude, and other related information on each earthquake. The *Preliminary Determination of Epicenters Monthly Listing,* a chronological listing of the twice-weekly data, is now available to the general public from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; annual subscription price, $1.50 (50 cents additional for foreign mailing); price per copy, 15 cents.

2. *Earthquake Data Report.* This twice-weekly report contains data used in the computation of the report above. It lists station arrival times, individual distances, azimuths, and traveltime residuals.

3. *Antarctic Seismological Bulletin.* This quarterly report is a register of phase readings and epicenters from Antarctic seismograph stations.

In addition to these publications, ERL publishes a bimonthly *Earthquake Information Bulletin,* which contains information on past and continuing studies in seismology, and describes techniques used in the investigation of earthquakes and related phenomena. This two-color magazine has regular departments for new publications, meetings, and earthquake descriptions. It may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; annual subscription, $1.50 (50 cents additional for foreign mailing); price per copy, 30 cents.

Both NOAA and cooperating seismic observatories throughout the world furnish data for the epicenter program of the National Earthquake Information Center. During 1970, the locations of 4,353 epicenters were announced in the twice-weekly *Preliminary Determination of Epicenters* (PDE) list. These are published as soon as sufficient information has accumulated to insure a reasonable degree of accuracy. The results are preliminary and do not agree always with later epicenters determined from additional seismic readings or from new data with critical azimuths and distances. For special studies, an inquiry should be made to the NEIC office for possible recomputations of epicenters of interest.

NEIC coordinates the collection of all types of earthquake information, with the special objective of correlating instrumentally determined earthquake locations with noninstru-

mental reports received from private and Government earthquake observers. This correlation is achieved through intensive regional investigations of earthquakes by local organizations and NEIC. Primary data are gathered by a canvass of the epicentral area using questionnaire cards. During 1970, the questionnaire program was redesigned in order to utilize electronic computer techniques. Thus, for the first time, the towns and cities receiving the cards were selected by a computer, based upon an analysis of the earthquake magnitude and projected felt area. When returned and analyzed, this information is used to map the seismic areas of the country in order to promote public safety through a better understanding of earthquake phenomena. Since the success of this data collection program depends largely on the cooperation of local officials and citizens, all who receive earthquake questionnaire cards are urged to complete and return them to the office indicated.

Active cooperation in earthquake investigations in the Pacific Coast and Western Mountain States is provided by the University of California Seismographic Station at Berkeley, the California Institute of Technology Seismological Laboratory at Pasadena, and by several seismology collaborators. The following served as collaborators to NOAA during 1970:

Arizona.—Richard T. Moore, Arizona Bureau of Mines, University of Arizona, Tucson.

Colorado.—Warren L. Longley, University of Colorado, Boulder.

Idaho.—Melvin W. Jackson, Argonne National Laboratory, Idaho Falls.

Montana.—Stephen W. Nile, 320 Ranch, Gallatin Gateway.

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

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

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

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

Commercial agencies on the West Coast that give valuable services to NOAA include telephone, power, oil, railroad, and insurance companies. Agencies interested in the manufacture of earthquake-resistive building materials are also active, as are several organizations of structural engineers and architects.

Earthquake information was collected in other parts of the country during 1970 by the following:

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

Eastern Region.—Gilbert A. Bollinger, Virginia Polytechnic Institute and State University, Blacksburg (for earthquakes in Virginia).

Central Region.—William J. Stauder, S.J., St. Louis University (for earthquakes in the central Mississippi Valley area); E. J. Walter, John Carroll University, Cleveland (for earthquakes in Ohio); and Berlen C. Moneymaker, Tennessee Valley Authority, Knoxville (for earthquakes in Tennessee).

Hawaii.—Robert Y. Koyanagi, Hawaiian Volcano Observatory, Geological Survey, U.S. Department of the Interior, Hawaii National Park.

EPICENTER MAPS

Figure 1 shows the locations of damaging earthquakes (intensity VII and above) known to have occurred in the United States from historical times through 1970. In past issues of this annual report, earthquake locations in figure 1 were plotted by (1) intensity or (2) total felt area. Intensity VII–VIII was equated with a felt area of 25,000+ square miles; VIII–IX with 150,000+ square miles; IX–X with 500,000+ square miles; and X–XII with 1,000,000+ square miles. Therefore, an intensity VI earthquake felt over a 25,000-square-mile felt area would be plotted on figure 1 in the intensity VII–VIII category, simply because of its large felt area.

Locations of earthquakes of this type no longer appear on the map. Revised and up-

dated for 1970, figure 1 now shows locations of damaging U. S. earthquakes plotted by intensity only. Small numerals beside a plotted point indicate the number of shocks that have occurred at that point. Some of the more prominent of these earthquakes are listed on page 6.

Figure 2 is a plot of 1970 earthquakes by intensity. In some instances where instrumental control was not satisfactory or where results of investigations were inadequate, the plotted epicenters show the existence, rather than the precise locations, of the earthquakes. Earthquakes in the California and western Nevada areas are plotted on figure 2 when felt reports are received from several towns. Feeble earthquakes and minor aftershocks of large earthquakes usually are not shown on this map. A numeral beside a dot indicates the number of shocks reported at that location. Bulletins of the University of California Seismographic Station at Berkeley and the California Institute of Technology Seismological Laboratory at Pasadena should be consulted for additional details on epicenters.

The selection of isoseismal or "felt area" maps (figs. 3–5) is governed largely by the size of the area affected, the minimum radius generally being about 80 km (50 miles). This means that sharp, localized shocks of intensity VI (mostly in California) may not be shown on such maps, whereas others of intensity IV and V (largely in the Eastern and Central States) often will be shown. Felt reports from towns are designated on these maps by open circles; not felt reports by solid circles. Intensities higher, or lower, than those in the specific isoseismal zones are indicated by small numerals beside the open circles.

MAGNITUDE AND INTENSITY RATINGS

Magnitude, stated according to the Richter scale, is a measure of the energy release at the focus of an earthquake as determined by the amplitudes produced on a seismogram. Although the magnitude scale has neither "top" nor "bottom" values, the highest ever recorded was magnitude 8.9 and the lowest about -3. On this logarithmic scale, a magnitude 8 earthquake represents recorded amplitudes 10 times larger than those for a magnitude 7 earthquake, 100 times larger than a shock of magnitude 6, etc.

Intensity, as expressed on the Modified Mercalli Intensity Scale of 1931 (see next section), is a measure of the effects of an earthquake on people and objects, as determined by experienced observers. It is a result of many factors, including magnitude of the earthquake, distance from its epicenter, local geological conditions, and structural properties of buildings. An earthquake in a populated city will have several intensities, depending on the local factors mentioned.

MODIFIED MERCALLI INTENSITY SCALE OF 1931

NOAA's National Geophysical Data Center and National Earthquake Information Center report all intensities on the Modified Mercalli Intensity Scale of 1931.[1] The abridged version of this scale is given below. Values in parentheses are equivalent intensities in the Rossi-Forel Scale, still used by some countries to evaluate earthquake effects.

I. Not felt except by a very few under specially favorable circumstances. (I)

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

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)

[1] Harry O. Wood and Frank Neumann, Modified Mercalli Intensity Scale of 1931. *Bulletin of the Seismological Society of America*, Vol. 21, No. 4, pp. 277-283, December 1931.

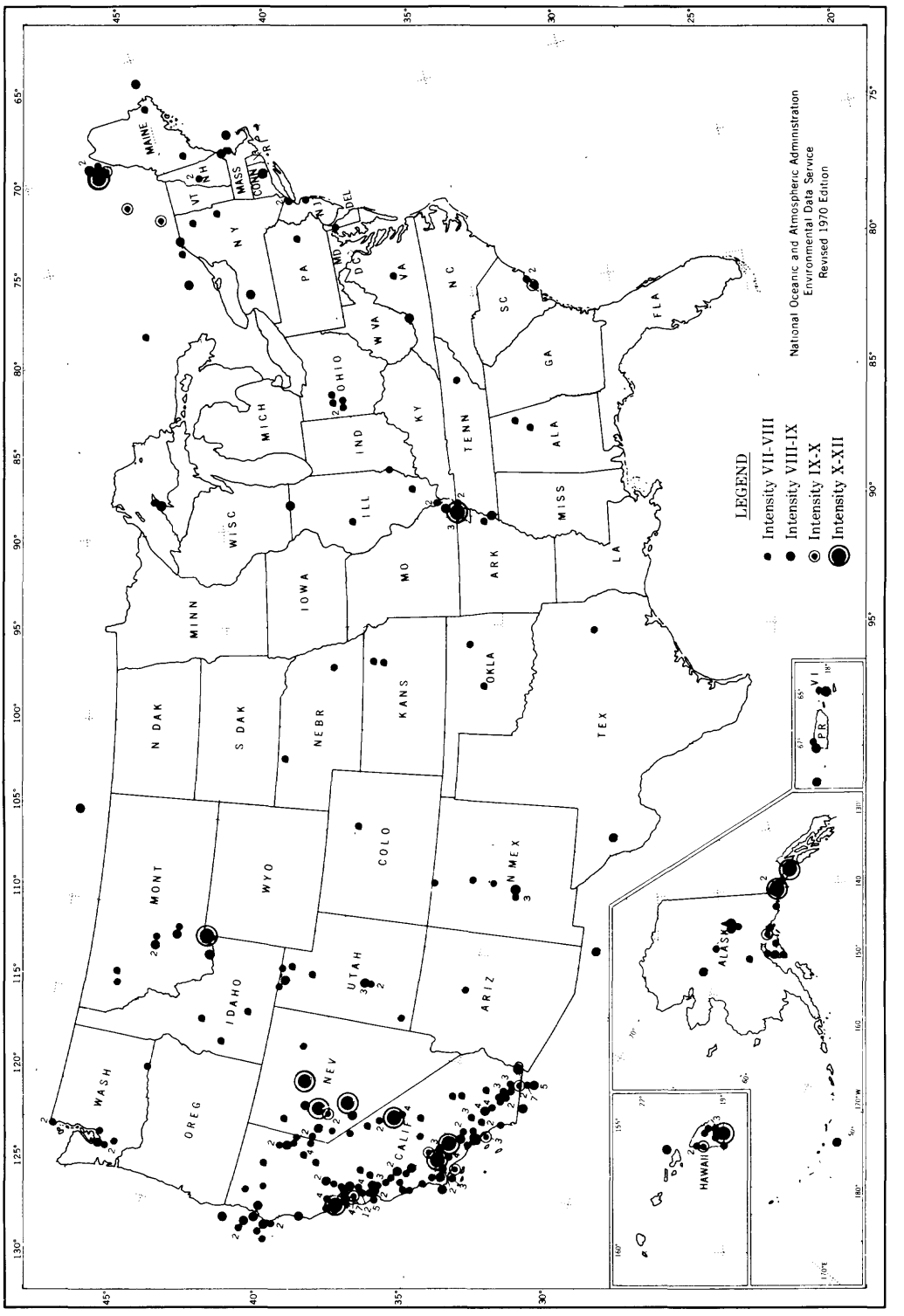

FIGURE 1.—Damaging earthquakes in the United States from earliest history through 1970.

List of Prominent Earthquakes of the United States through 1970 (see fig. 1)

Date	Locality	N. Lat.	W. Long.	Area	Modified Mercalli Intensity
		degrees	*degrees*	*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 1812 Jan. 23 1812 Feb. 7	Near New Madrid, Mo	36.6	89.6	2,000,000	XII
1812 Dec. 21	Off coast of southern California	34	120		X
1836 June 10	San Francisco Bay	38	122		IX–X
1838 June	San Francisco region	37½	122½		X
1852 Nov. 9	Near Fort Yuma, Ariz	33	114½		VIII–IX
1857 Jan. 9	Near Fort Tejon, Calif	35	119		X–XI
1865 Oct. 1	Fort Humboldt and Eureka, Calif	41	124½		VIII–IX
1865 Oct. 8	Santa Cruz Mts., Calif	37	122		VIII–IX
1868 Apr. 2	Near south coast of Hawaii	19	155½		X
1868 Oct. 21	Hayward, Calif	37½	122		IX–X
1872 Mar. 26	Owens Valley, Calif	36½	118	125,000	X–XI
1886 Aug. 31	Northwest of Charleston, S.C	32.9	80.0	2,000,000	IX–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, Calif	34½	118½		VIII–IX
1895 Oct. 31	Charleston, Mo	37.0	89.4	1,000,000	VIII
1898 Apr. 14	Mendocino County, Calif	39	124		VIII–IX
1899 Sept. 3	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 1921 Oct. 1	Elsinore, Utah	38.8	112.2		VIII
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, Calif	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

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)

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)

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)

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—)

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)

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 +)

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)

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.

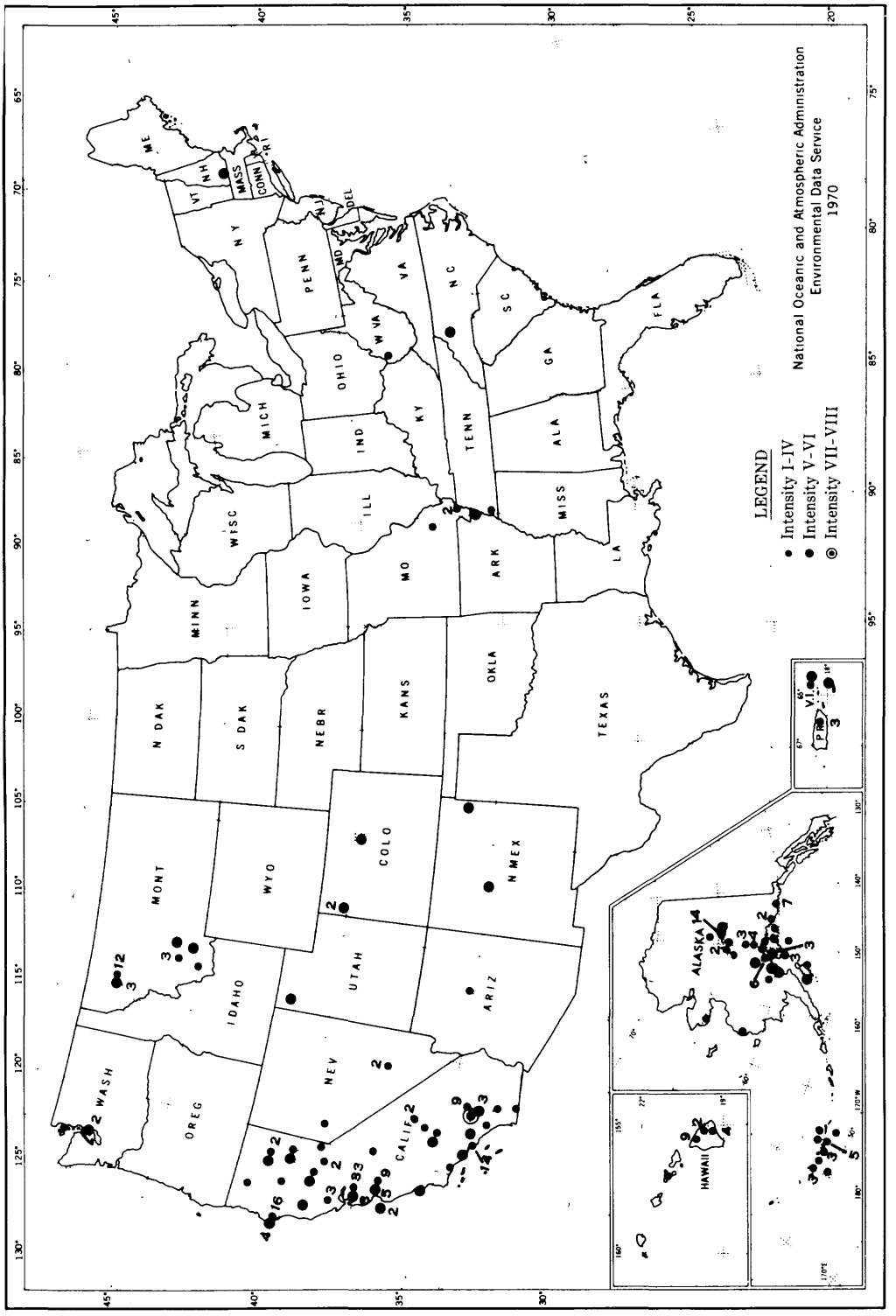

FIGURE 2.—Locations of earthquakes that were felt or caused damage in the United States during 1970.

Earthquake Descriptions

INTRODUCTION

The times of earthquake occurrences in the regions that follow are given in local standard time. Times are expressed continuously from midnight to midnight, or 0 to 24 hours. Greenwich mean times are given in parentheses, following local times, for earthquakes with quoted epicenters.

The following symbols are used to indicate authority for arrival or origin times, epicenters, and/or magnitudes. If no symbol is given, the authority is the National Earthquake Information Center of NOAA's Environmental Research Laboratories (ERL).

B—Seismographic Station, University of California, Berkeley.

P—Seismological Laboratory, California Institute of Technology, Pasadena.

JSA—Jesuit Seismological Association, St. Louis, Mo.

NESA—Northeastern Seismological Association, Weston, Mass.

BHP—Panama Canal Company, Balboa Heights, C. Z.

SLC—University of Utah, Salt Lake City.

Gol—Colorado School of Mines, Golden.

Pal — Columbia University, Lamont-Doherty Geological Observatory, Palisades, N.Y.

Butte—Montana School of Mines, Butte.

Adak—ERL Adak Observatory, Adak, Alaska.

College — ERL College Observatory, College, Alaska.

Palmer—ERL Palmer Observatory, Palmer, Alaska.

San Juan—ERL San Juan Observatory, San Juan, P.R.

Magnitude values in the descriptions of earthquakes in 1970 are either surface wave (M_S), body wave (m_b), or a local magnitude (M_L). Each represents an average of individual station magnitudes determined from reported periods and amplitudes of representative waves. All magnitudes in the regions which follow are M_L (local) unless otherwise noted. The local magnitude is determined using a formula developed by Charles F. Richter for southern California earthquakes. Surface wave magnitude is determined using a formula recommended by the International Committee on Magnitudes. Body wave magnitude is computed from *P* (primary) phases only, in the manner defined by Gutenberg and Richter. Magnitude values are preceded by the abbreviation mag. in the regional earthquake descriptions.

Roman numerals in the earthquake descriptions refer to the Modified Mercalli Intensity Scale of 1931 (see page 4), which gives about equal weight to the disturbance of inanimate objects and to personal reactions. When more than one degree of intensity is reported from a town, the town is assigned the highest intensity reported. Omission of an intensity rating indicates insufficient data. For brevity, intensity is abbreviated int. in the regions which follow.

Immediately following the Earthquake Descriptions section are tables 1 and 2. Table 1 is a 1970 listing of all earthquakes or related phenomena that were not reported felt in the regions in which they centered. This is a new addition to the *United States Earthquakes* publication, and, in conjunction with the earthquake descriptions in previous sections, gives a complete seismic picture of the

United States and nearby territories in 1970. Table 2 gives pertinent information on the principal earthquakes of the world in 1970. Perhaps incongruous in a report on U.S. earthquakes, the list is included because of its unavailability in this format in other seismological publications.

SUMMARY OF EARTHQUAKE ACTIVITY

This is a summary of earthquake data in the regions which follow. Where no intensity is given, data were insufficient to rate the effects on the Modified Mercalli Intensity Scale (see page 4).

Alaska: Jan. 5, III; 15, III; 15, V; 16; 21. Feb. 5; 18, IV; 26, III; 28, III. March 11, V; 17, II; 19; 26. Apr. 3, II; 4, IV; 7, III; 10, III; 10; 15, IV; 16; 17, V; 18; 24. May 1, IV; 10, IV. June 1, IV; 9; 19 (2). July 3, III; 6, IV; 13; 17 (2); 19; 20; 29. Aug. 1, IV; 12, II; 13, I (2); 13, V; 13; 15; 16; 18, IV (2); 24; 28; 29, IV; 29; 30, IV. Sept. 2, IV (2); 2; 16, II; 18; 23, II (2); 23. Oct. 4; 9, I, II, III; 15, III; 21; 26, IV; 26; 31, I (2); 31. Nov. 1; 2, V; 3; 13 (2); 13, I; 20, I; 20; 30. Dec. 1, II; 1, I (2); 6, I; 14, I; 19; 23, III; 25, I; 27.

Arizona: Sept. 16.

Arkansas: Nov. 16, VI.

California: (Intensity V and above). Jan. 1, V; 2, VI; 5, V. Mar. 12, V; 30, V. May 18, V; 19, V; 25, V; 26 V (2); 28, V. June 11, V (2); 11, VI; 12, VI; 13, V; 30, V. Aug. 3, VI; 13, V; 25, V; 30, V. Sept. 12, VII; 12, V (3); 13, V; 23, V. Nov. 9, V; 26, V; 30, V. Dec. 9, V; 30, V.

Colorado: Apr. 21, V; 21. May 23, V.

Hawaii: Numerous shocks were felt, but none had intensity designations (see page 33).

Illinois: Felt Arkansas earthquake of Nov. 16, III.

Kentucky: Felt Arkansas earthquake of Nov. 16, IV.

Mississippi: Felt Arkansas earthquake of Nov. 16, V.

Missouri: Mar. 26. July 6, III. Felt Arkansas earthquake of Nov. 16, V. Dec. 24, IV.

Montana: Jan. 7, IV. Feb. 3; 4 (3); 4, V; 5 (4); 22, IV; 27. Mar. 30; 30, IV. Apr. 2, IV. May 23, V. June 25, V. July 26, IV. Sept. 1, V. Oct. 18, V.

Nevada: Mar. 23, IV. Aug. 10, IV. Oct. 25, IV.

New Hampshire: Sept. 19, IV.

New Mexico: Jan. 12, VI. Nov. 3; 28, VI.

North Carolina: Sept. 9, V.

Panama Canal Zone: Jan. 9, II. July 7, II; 21, III. Dec. 4, IV.

Puerto Rico: Jan. 6. Feb. 13, IV; 14. Felt Virgin Islands earthquake of July 8, V. Aug. 20. Felt Virgin Islands earthquake of Nov. 8.

Tennessee: Jan. 7, IV. Felt North Carolina earthquake of Sept. 9, II. Felt Arkansas earthquake of Nov. 16, VI.

Texas: Felt New Mexico earthquake of Jan. 12.

Utah: Mar. 29, V.

Virginia: Felt North Carolina earthquake of Sept. 9, IV.

Virgin Islands: Apr. 18; 23, V. July 8, V. Nov. 8, IV.

Washington: Feb. 10, V. May 17. Oct. 24, V.

West Virginia: Aug. 11, IV.

NORTHEASTERN REGION

[The time is eastern standard.]

Sept. 19: 08:35:09.4 (NESA).[1] Int. **IV** at Greenfield, N.H. Int. II at Goffstown (doubtful report).

EASTERN REGION

[All times are eastern standard. If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Aug. 11: 01:14:25.5 (06:14). Epicenter 38.4° N., 82.3° W., West Virginia, at a re-

[1] Abbreviations used to indicate authority for arrival or origin times, epicenters, and/or magnitudes are explained on page 9.

strained depth of 33 km.[2] Int. **IV** at Charleston, Eskdale, Hamlin, Hurricane, and St. Albans. Questionnaire canvass was conducted by G. A. Bollinger, Virginia Polytechnic Institute and State University, Blacksburg, Va.

Sept. 9: 20:41:10.0 (Sept. 10, 01:41). Epicenter 36.1° N., 81.4° W., North Carolina, at a restrained depth of 33 km. Int. **V.** Felt over about 5,200 sq. km. (2,000 sq. mi.) of northwestern North Carolina. A few isolated felt reports also were received from the Winston-Salem region. At Zionville, near the Tennessee-North Carolina border, a basement wall cracked. At Boone, a few kilometers southeast of Zionville, a porch roof loosened slightly creating cracks. G. A. Bollinger (see previous paragraph) assisted in the collection of felt data.

INTENSITY V IN NORTH CAROLINA:

Blowing Rock.—Felt by and frightened all. Press reported law enforcement agencies were flooded with calls. An oil tank fell from the side of a building onto a parked car. Coffee spilled from cups; wall pictures were knocked askew. Two fairly violent, loud, explosive-like shocks within seconds of each other. Most thought their furnaces had exploded.

Boone.—Felt by all in immediate area. Porch roof loosened slightly at joining with main structure, creating cracks sufficient to allow water to leak through. Sensation of two successive dynamite blasts. Noticeable heaving of floor.

Deep Gap.—Felt by all. Awakened and frightened few in home and community.

Newhope.—Felt by several and awakened few. Small objects shifted; picture fell from wall.

Patterson.—Felt by all in community. Building vibrated; loose objects rattled.

Sugar Grove.—Felt by all in community. Frightened some.

Zionville.—Felt by many and frightened few in community. Basement wall cracked. Loud, booming earth noises. "Like a deep explosion with loud muffled sound and moderate vibration for a few seconds."

INTENSITY IV IN NORTH CAROLINA:

Creston, Crumpler, Glendale Springs, Grassy Creek, Jefferson, Madison, North Wilkesboro, Sparta, Todd, Valle Crucis, Warrensville, and West Jefferson.

INTENSITY IV IN VIRGINIA:

Independence.

INTENSITY I–III IN NORTH CAROLINA:

Boonville, Clemmons, Ferguson, Fleetwood, Julian (Price Campground, Blue Ridge Parkway), Lansing, Linville, Newland, Wallburg, Walnut Cove, Wilbar, and Winston-Salem.

INTENSITY I–III IN TENNESSEE:

Trade.

CENTRAL REGION

[All times are central standard. If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Jan. 7: 11:45 Int. **IV** in the Millington-Raleigh, Tenn., area. Severe enough to panic some people. Also felt at Memphis.

Mar. 26: 21:44:29.5 (Mar. 27, 03:44). Epicenter 36.5° N., 89.7° W., New Madrid, Mo., region, at a depth of 5 km., mag. 3.5, JSA. Felt at New Madrid.

July 6: 03:39:10.7 (09:39). Epicenter 37°51′ N., 90°35′ W., eastern Missouri, at a depth of 0 km., mag. 2.6, JSA. Possible rockburst. Int. **III** at Leadwood.

Nov. 16: 20:13:55.1 (Nov. 17, 02:13). Epicenter 35.9° N., 89.9° W., Arkansas, at a depth of 19 km., mag. 3.6 (m_b). Int. **VI.** Felt over a roughly circular area of about 78,000 sq. km. (30,000 sq. mi.) covering all or parts of Arkansas, Illinois, Kentucky, Mississippi, Missouri, and Tennessee (see fig. 3). At Keiser, Ark., about 35 km. southwest of the epicenter, the shock shifted furniture and caused three wall electrical outlets to burn their wires. Plaster cracked and fell at Manila, Ark., about 28 km. west of the epi-

[2] Depth was restrained at 33 km. for earthquakes whose seismogram character indicates a shallow focus, but whose depth is not determined satisfactorily by the data. This is indicated in the regions which follow by "restrained depth."

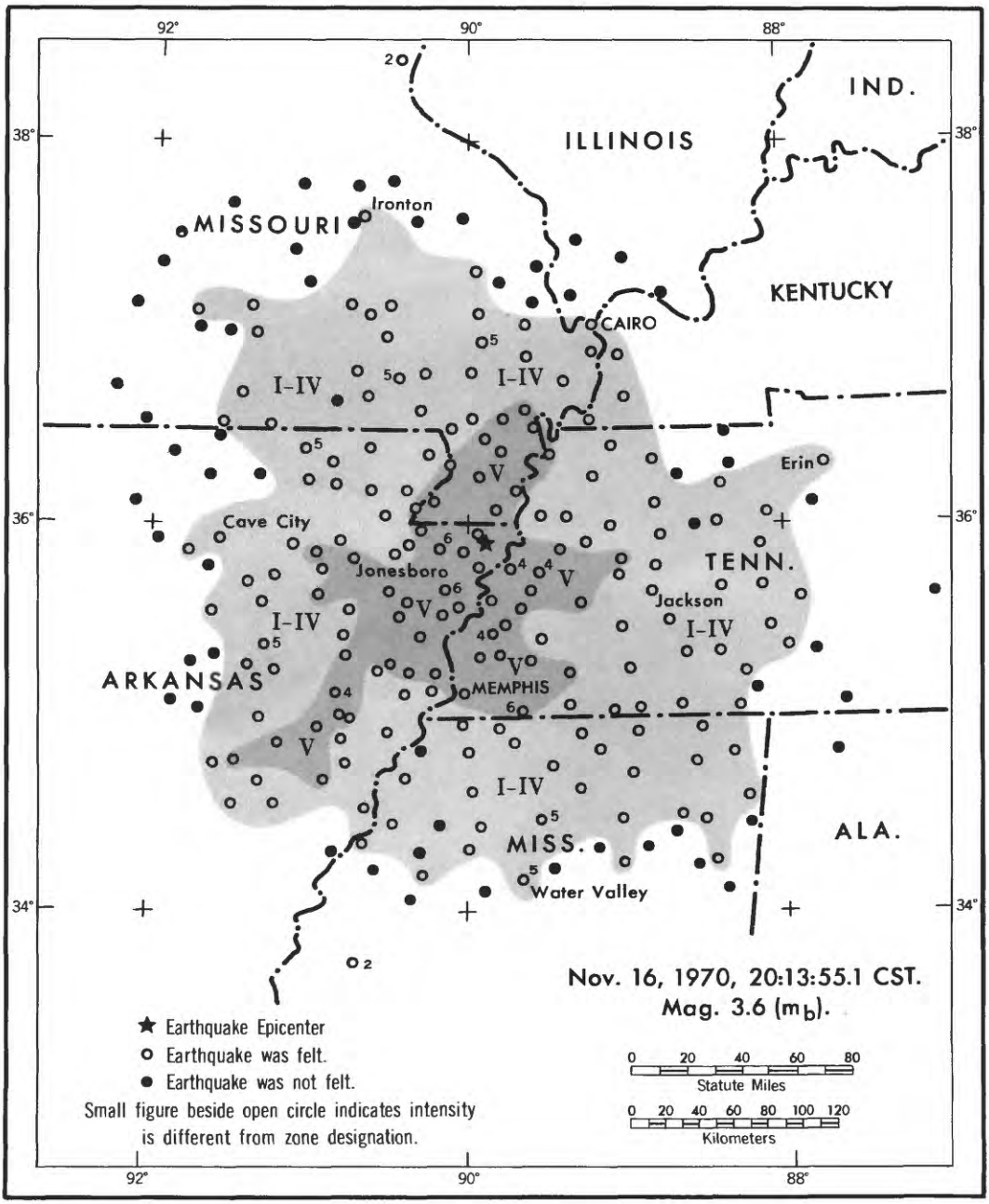

FIGURE 3.—Area affected by Arkansas earthquake of November 16.

center. Southeast of the epicenter at Collierville, Tenn., the shock cracked a chimney and flashing, permitting rain to leak into the house.

INTENSITY VI IN ARKANSAS:

Keiser.—Felt by, awakened, and frightened many. Small objects fell from table; furniture shifted; plaster cracked. "Three wall electrical outlets burned wires." Loud earth noises. Damage slight.

Manila.—Felt by all and frightened many.

Plaster cracked, broke, and fell. Earth noises. Damage slight.

INTENSITY VI IN TENNESSEE:

Collierville.—Felt by and frightened many. Chimney cracked; plaster cracked and fell. "House settled, affecting chimney and flashing. Rain the following night leaked through flashings and freshly puddied windows."

INTENSITY V IN ARKANSAS:

Aubrey, Bassett, Blytheville (damage slight), Brinkley, Crawfordsville, Dell, De Valls Bluff (doubtful report of damage to foundation and fireplace base), Earle (damage slight), Egypt (damage slight), Etowah, Forrest City, Gilmore, Joiner, Jonesboro (slight plaster cracks), Leachville, Lepanto, Luxora (plaster cracks), Madison, Marion, Marked Tree, Maynard, Nimmons, Palestine, Trumann, Tupelo (walls cracked), Vanndale, Weiner, and Wilson.

INTENSITY V IN MISSISSIPPI:

Abbeville (cracks in fireplace bricks) and Water Valley.

INTENSITY V IN MISSOURI:

Arbyrd, Braggadocio (damage slight), Hornersville, Lilbourn (small plaster cracks), Poplar Bluff, Puxico, and Senath.

INTENSITY V IN TENNESSEE:

Alamo (ceramic wall tile cracked), Brighton, Brownsville, Burlison, Covington, Drummonds, Ellendale, Fulton, Gallaway, Garland, Halls (plaster broke), Henning, Memphis (walls cracked, windows broke), Millington, Rosemark, Somerville, and Tiptonville.

INTENSITY IV IN ARKANSAS:

Alicia, Augusta, Biggers, Brickeys, Cash, Cave City, Chatfield, Clarendon, Clarkedale, Cotton Plant, Datto, Delaplaine, Fisher, Harrisburg, Haynes, Hazen, Helena, Hughes, Knobel, Marianna, McCrory, Newport, Parkin, Peach Orchard, Piggott, Pocahontas, Rector, Sedgwick, Swifton, Tuckerman, West Helena, and Wynne.

INTENSITY IV IN KENTUCKY:

Bardwell, Clinton, and Hickman.

INTENSITY IV IN MISSISSIPPI:

Baldwyn, Batesville, Boonesville, Byhalia, Corinth, Fulton, Hernando, Lamar, Lambert, New Albany, Potts Camp, Ripley, Robinsonville, Senatobia, Tunica, Walls, and Walnut.

INTENSITY IV IN MISSOURI:

Campbell, Caruthersville, Clarkton, Cooter, Dexter, Fairdealing, Fisk, Gideon, Hayti, Holland, Malden, Morley, Naylor, Pascola, Risco, Steele, Thayer, Vulcan, Wardell, and Williamsville.

INTENSITY IV IN TENNESSEE:

Adamsville, Ashport, Bath Springs, Bemis, Braden, Bruceton, Brunswick, Camden, Counce, Dyersburg, Elbridge, Enville. Finger, Finley, Friendship, Gadsden, Gates, Gibson, Henderson, Humboldt, Jacks Creek, Kenton, Lenox, Mason, McKenzie, Medina, Mercer, Middleton, Milan, Munford, Newbern, Oakfield, Obion, Parsons, Pinson, Pocahontas, Ripley, Savannah, Selmer, Tatumville, Trezevant, and Yorkville.

INTENSITY I–III IN ARKANSAS:

Apt, Beech Grove, Bono, Cherry Valley, Colt, Corning, Cushman, Diaz, Greenway, Guion, Holly Grove, Hoxie, Lake City, Marmaduke, Monette, Newark, Oil Trough, Osceola, Paragould, Pleasant Plains, Proctor, Tyronza, Ulm, Wabash, Walnut Ridge, and West Memphis.

INTENSITY I–III IN ILLINOIS:

Cairo.

INTENSITY I–III IN MISSISSIPPI:

Ashland, Burnsville, Cleveland, Coldwater, Dennis, Friars Point, Hickory Flat, Holly Springs, Lula, Marietta, Michigan City, Olive Branch, Pontotoc, Rienzi, and Sardis.

INTENSITY I–III IN MISSOURI:

Advance, Alton, Bell City, Bertrand, Bragg City, Cardwell, Deering, East Prairie, Eminence, Grandin, Greenville, Imperial. Ironton, Kennett, Marble Hill, Marston, Myrtle, Neelyville, Piedmont, Portageville, Qulin, Sikeston, Summersville, Winona, and Wyatt.

INTENSITY I–III IN TENNESSEE:

Atoka, Bolivar, Bradford, Clifton, Decaturville, Dyer, Eaton, Erin, Grand Junction, Greenfield, Henry, Holladay, Huntingdon, Jackson, Lavinia, Lexington, Linden, Martin, Michie, Milledgeville, Moscow, Ramar, Reagan, Ridgely, Saltville, Sardis, Saulsbury, Shiloh, Tigrett, Toone, Trenton, Trimble, Union City, and Wildersville.

Dec. 24: 04:17:57.1 (10:17). Epicenter 36.7° N., 89.5° W., New Madrid, Mo., region, at a depth of 12 km., mag. 4.8 (m_b). Int. **IV** at Malden. Int. I–III at Arbyrd, Canalou, Charleston, East Prairie, Fisk, Gipsy, Kennett, Poplar Bluff, Senath, and Wyatt. Questionnaire canvass was made by the Jesuit Seismological Association, St. Louis, Mo.

WESTERN MOUNTAIN REGION

[All times are mountain standard. If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Jan. 7: 03:30, 05:27:53.4 (12:27). Epicenter 45.0° N., 111.6° W., Montana, at a restrained depth of 33 km., mag. 4.9 (m_b). Int. **IV** at Hebgen Dam (Hebgen Lake) and at the 320 Ranch (about 59 km. north of West Yellowstone). Int. III about 11 km. south of Ennis.

Jan. 12: 04:21:15.4 (11:21). Epicenter 36.1° N., 103.2° W., New Mexico, at a restrained depth of 33 km., mag. 3.5 (m_b). Int. **VI.** Felt over about 9,620 sq. km. (3,700 sq. mi.) of northeastern New Mexico and Texas border areas. At Amistad, several feet of ceiling fell. Some of the adobe bricks in a wall crumbled at the public school gymnasium. Slight plaster damage was noted at Nara Visa (int. V). Also felt at Texline, Tex.

INTENSITY V:

Clapham (about 24 km. west of Sedan), Nara Visa, Pasamonte (about 14½ km. southeast of Gladstone), and Sedan.

INTENSITY I–IV:

Bueyeros, Clayton and adjacent areas, Gladstone area, Hayden, and Roy (13 and 61 km. east of).

Feb. 3: 10:25. Mild shake and noise at Proctor (Flathead Lake area), Mont.

Feb. 4: 13:21, 13:32, 14:01. Slight shocks were felt at Proctor, Mont.

Feb. 4: 16:39:54.0 (23:39). Epicenter 47.9° N., 114.2° W., Montana, at a depth of 20 km. Int. **V.** Objects danced and moved on shelves at Proctor. Very hard shock.

Feb. 5: 02:59, 03:02, 03:08, 03:56:21.7 (10:56). Epicenter 47.9° N., 114.1° W., Montana, at a depth of 28 km. Four hard tremors with prolonged rumble were felt at Proctor.

Feb. 22: 14:40:46.3 (21:40). Epicenter 47.9° N., 114.3° W., Montana, at a depth of 9 km. Int. **IV** at Proctor and Rollins. Also felt at Polson.

Feb. 27: 11:24. Brief shock felt at Proctor, Mont.

Mar. 23: 12:52:12 (19:52). Epicenter 37°45′ N., 115°59′ W., southern Nevada, at a depth [1] of 5 km., mag. 4.2, B. Int. **IV** at Adaven. Also felt at Hiko and Grim Lake.

Mar. 29: 05:40:41.2 (12:40). Epicenter 41.6° N., 113.7° W., Utah, at a depth [1] of 10 km., mag. 4.6 (m_b). Int. **V.** At Grouse Creek a pipe on top of a chimney broke loose; lamp overturned; objects in room teetered slightly. Rumbling noises. Int. IV in the Rosette area (about 8 km. west of Park Valley).

Mar. 30: 01:14:39, 16:04:48.4 (Butte). The second shock was int. **IV** at Helena, Mont. A slight tremor was reported at about 1:00 a.m. also.

Apr. 2: 04:18:11.5 (11:18). Epicenter 47.9° N., 114.1° W., northwestern Montana, at a restrained depth of 33 km. Int. **IV** at Polson (south Flathead Lake area).

Apr. 21: 01:53:52.4 (08:53), 08:05:47.5 (15:05). Epicenter 40.1° N., 108.9° W., western Colorado, at a depth of 4 km., mag. 3.9 and 3.7, respectively. Int. **V.** During the first shock small objects shifted and over-

[1] Based on evidence from available seismograms, depth was restrained by an ERL geophysicist.

turned at Rangely (about 6½ km. northwest of, at the Texas Oil Camp). Second shock also was felt.

May 23: 01:55:09.4 (08:55). Epicenter 39.9° N., 105.1° W., Colorado, at a depth [2] of 5 km., mag. 4.1 (m_b). Int. **V.** Strongest in the Commerce City area. Awakened many residents. Loud earth noises. Also felt in scattered parts of Adams City, Dupont and farmland area to the north, Henderson, Irondale, and Thornton.

May 23: 08:08:04.5 (15:08). Epicenter 47.8° N., 114.2° W., northwestern Montana, at a depth of 17 km., mag. 3.6 (m_b). Int. **V.** Felt by all at Proctor; hard shock, short duration. Shook everything on shelves, but nothing fell.

June 25: 18:26:44.6 (June 26, 01:26). Epicenter 45.6° N., 111.8° W., Montana, at a depth of 26 km., mag. 4.9 (m_b). Int. **V.** Plaster cracked and furniture shifted at Harrison; cellar entrance caved in at McAllister; goods fell from store shelves at Jeffers. Int. V also noted (no damage) at Ennis. Int. I–IV at Beardsley Stock Ranch (8 km. south of Ennis), Laurin, Pony, and Virginia City.

July 26: 01:30:38.5 (Butte). Int. **IV** at Helena, Mont.

Aug. 10: 03:48:56.4 (10:48). Epicenter 37.2° N., 115.9° W., southern Nevada, at a depth of 3 km., mag. 4.1 (m_b). Int. **IV** in the Nevada Test Site area.

Sept. 1: 05:33:50.1 (12:33), 06:38. Epicenter 47.9° N., 114.4° W., northwestern Montana, at a depth of 5 km., mag. 4.0 (m_b). Int. **V.** Felt by all at Proctor. Hard shaking; loud earth noises. Shock of less intensity felt at 06:38.

Sept. 16: 05:17. Felt at Flagstaff, Ariz.

Oct. 18: 13:06:32.6 (20:06). Epicenter 46.2° N., 111.5° W., Montana, at a depth [2] of 15 km., mag. 4.3 (m_b). Int. **V.** Felt over about 9,100 sq. km. (3,500 sq. mi.). Small objects fell to the floor at Maudlow and Radersburg. Int. IV at Three Forks, Toston, Townsend and about 6½ km. east of Townsend, Trident, and Winston. Int. I–III at Divide, Helena, Lingshire (about 6½ km. southeast of, in Smith River Canyon), Logan, Manhattan, Pony, White Sulphur Springs, and Willow Creek.

Nov. 3: 21:23:44 (SLC). Felt near Sun Crater, N. Mex.

Nov. 28: 00:40:11.6 (07:40). Epicenter 35.0° N., 106.7° W., New Mexico, at a depth of 9 km., mag. 3.8. Int. **VI.** Felt over about 3,100 sq. km. (1,200 sq. mi.), principally in the Albuquerque region. Thousands were awakened at Albuquerque. Plaster cracked, windows broke, and many small items were broken. Some thought there had been an explosion; many reported loud, explosivelike earth noises. One resident called a television station and said the roof of his barn collapsed; another said an air-conditioner on his roof shook loose and fell through a skylight. Other observers reported cracks in garage floor, exterior plaster cracks, and cracks in block fence wall. Many burglar alarms were activated. Animals were disturbed at the city zoo.

INTENSITY V:
Kirtland Air Force Base.

INTENSITY I–IV:
Belen, Corrales, Edgewood, and Los Lunas.

CALIFORNIA AND WESTERN NEVADA

[All times are Pacific standard. If an epicenter is quoted, Greenwich mean time is given in parentheses. All towns are in California unless otherwise noted.]

Jan. 1: 12:57:48 (20:57), 13:01. Epicenter 36°44′ N., 121°25′ W., central California at a depth of 11 km., mag. 3.2, B. Int. **V.** At the Harris Ranch, about 11 km. south of Hollister, furniture shifted and small objects fell. A shock also was felt at 13:01.

Jan. 2: 18:51:58.4 (Jan. 3, 02:51), 18:53:17.3 (Jan. 3, 02:53). Epicenter 37°17.9′ N., 122°05.3′ W., central California, at a depth of 6 km., mag. 3.7 and 2.7, respectively, B. Int. **VI.** The first shock was felt over about 3,120 sq. km. (1,200 sq.

[2] See footnote 1, page 14.

mi.), principally in the Cupertino area. Slight damage occurred at Cupertino. The press reported the second shock was felt also.

INTENSITY VI:

Cupertino.—Plaster cracked, broke, and fell. Damage slight. Press reported bottles toppled from shelves at a liquor store. Others reported trees, bushes, and cars shook; small objects moved.

INTENSITY V:

Big Basin (slight damage), Los Altos, Mount Hermon (slight damage), Palo Alto (plaster cracked), San Jose (slight damage), Santa Clara, and Saratoga.

INTENSITY I–IV:

Alviso, Aptos (near), Ben Lomond, Boulder Creek, Capitola, Felton, La Honda, Los Gatos, Menlo Park, Milpitas, Redwood City, Redwood Estates, Santa Cruz, Scotts Valley, and Woodside.

Jan. 4: 15:13:00.6 (23:13). Epicenter 37°31.3′ N., 121°50.1′ W., central California, at a depth of 7 km., mag. 3.4, B. Int. **IV** at Gilroy.

Jan. 5: 09:31:12.2 (17:31). Epicenter 37°31.3′ N., 121°50.1′ W., central California, at a depth of 7 km., mag. 3.3, B. Felt at Fremont, Newark, Pleasanton, and in the eastern San Jose and Sunol areas. Possibly felt at Capitola.

Jan. 5: 18:29:07.5 (Jan. 6, 02:29). Epicenter 36°31.8′ N., 121°06.9′ W., central California, at a depth of 10 km., mag. 4.0, B. Int. **V.** At Bacon Ranch, in the Pinnacles-Bear Valley area, a platter overturned in cupboard. Int. IV at the Harris Ranch, south of Hollister. Also felt at Hollister and Salinas.

Jan. 13: 22:04. Mag. 2.6, B. Int. **IV** at Ferndale.

Jan. 18: 19:42. Mag. 2¾, B. Int. **IV** at Ferndale.

Jan. 21: 03:24:02.3 (11:24). Epicenter 32°41.0′ N., 116°28.2′ W., southern California, at a depth of 8 km., mag. 4.1, P. Felt at San Diego.

Jan. 26: 07:20. Int. **IV** at Ferndale.

Jan. 30: 16:23:06.4 (Jan. 31, 00:23). Epicenter 37°48.1′ N., 122°06.4′ W., central California, at a depth of 11 km., mag. 2.3, B. Int. **III** in the Lake Chabot-San Leandro area. Also felt at Oakland.

Jan. 31: 10:20. Int. **IV** in the Mariposa area.

Feb. 8: 21:23:47.9 (Feb. 9, 05:23). Epicenter 36°47.6′ N., 121°33.3′ W., central California, at a depth of 6 km., mag. 2.9, B. Int. **II** at San Juan Bautista.

Feb. 9: 00:23 (about). Slight shock reported by one observer at San Francisco.

Feb. 13: 16:31:59.1 (Feb. 14, 00:31). Epicenter 36°53.3′ N., 121°38.7′ W., central California, at a depth of 6 km., mag. 3.0, B. Int. **IV** at the Harris Ranch, south of Hollister.

Feb. 13: 20:49:58 (Feb. 14, 04:49). Epicenter 40.3° N., 125.0° W., off coast of northern California, at a depth of 12 km., mag. 3.8, B. Int. **III** at Ferndale.

Feb. 14: 23:32:10 (Feb. 15, 07:32). Epicenter 40.2° N., 124.6° W., near coast of northern California, at a depth of 16 km., mag. 3.5, B. Int. **III** at Ferndale.

Feb. 14: 23:45. Mag. 3.0, B. Int. **III** at Ferndale.

Feb. 27: 18:05:00.1 (Feb. 28, 02:05). Epicenter 37°48.7′ N., 121°55.7′ W., central California, at a depth of 4 km., mag. 2.9, B. Felt at Danville.

Feb. 28: 19:54. Felt at Ferndale.

Feb. 28: 21:44:22.9 (Mar. 1, 05:44). Epicenter 33°59.3′ N., 118°25.8′ W., southern California, at a depth of 8 km., mag. 3.5, P. Int. **IV.** Felt mainly in the Crenshaw District and near the Los Angeles International Airport.

Feb. 28: 23:16:38 (Mar. 1, 07:16). Epicenter 40°12′ N., 124°40′ W., near coast of northern California, at a depth of 12 km., mag. 3.2, B. Slight shock felt at Ferndale, Rio Dell, and Scotia.

Mar. 1: 08:40:13 (16:40). Epicenter 40°10′ N., 124°36′ W., near coast of northern California, at a depth of 12 km., mag.

3.9, B. Int. **IV** at Ferndale and Scotia and III at Rio Dell.

Mar. 8: 03:30. Int. **III** at Concord.

Mar. 9: 08:11. Int. **III** in Los Angeles.

Mar. 12: 05:12:34 (13:12), 05:17. Epicenter 40°28′ N., 123°58′ W., northern California, at a depth of 12 km., mag. 3.8, B. Int. **V.** Felt over about 3,380 sq. km. (1,300 sq. mi.) of Humboldt County, but no damage occurred. One observer at Ferndale reported a slight aftershock at 05:17. Int. V at Carlotta, Ferndale, Miranda, Rio Dell, and Scotia. Int. I–IV at Arcata, Bayside, Eureka, Kneeland, Korbel, Loleta, Petrolia (near), Phillipsville, and Redway.

Mar. 23: 12:43:19.7 (20:43). Epicenter 33°39.1′ N., 116°47.7′ W., southern California, at a depth of 10 km., mag. 2.7, P. Felt at Palm Springs.

Mar. 23: 19:52:33.7 (Mar. 24, 03:52). Epicenter 36°17.4′ N., 118°14.2′ W., central California, at a depth of 10 km., mag. 3.7, P. Int. **IV** at Onyx and III at Olancha.

Mar. 30: 23:02:28.6 (Mar. 31, 07:02). Epicenter 36°51.5′ N., 121°21.5′ W., central California, at a depth of 10 km., mag. 4.7, B. Int. **V.** Felt from the San Francisco Bay area south to King City, an area of about 12,480 sq. km. (4,800 sq. mi.). Slight plaster damage was reported at Gilroy and Hollister. Int. V at Boulder Creek, Daly City, Cienega Road area (south of Hollister), Coyote, Freedom, Fremont, Gilroy (slight damage), Hollister (slight damage), Morgan Hill, Paicines, Salinas, San Juan Bautista, Santa Cruz, and Watsonville. Int. I–IV at Alameda, Alviso, Aptos area, Aromas, Arroyo Seco Guard Station (about 24 km. southwest of Soledad), Berkeley, Big Sur, Capitola, Castroville, King City, La Honda, Libby Ranch (about 4 km. southwest of Paicines), Los Gatos, Milpitas, Monterey, Moss Landing, Mount Hamilton, Mountain View, Newman, Oakland, Paicines area, Redwood City, San Francisco, San Jose, San Leandro, San Martin, Soledad, South San Francisco, Union City, and Walnut Creek.

Mar. 31: 15.30. Int. **IV** at Nevada City.

Apr. 22: 01:26:06.0 (09:26). Epicenter 35°48.3′ N., 118°30.2′ W., central California, at a depth of 8 km., mag. 2.5, P. Felt at Isabella.

Apr. 22: 21:26:14 (Apr. 23, 05:26). Epicenter 40°14′ N., 121°23′ W., northern California, at a depth of 10 km., mag. 3.7, B. Int. **IV** at Mill Creek and Mineral. Also reported felt at Chester.

Apr. 23: 04:45:35.6 (12:45). Epicenter 37°55.6′ N., 122°19.2′ W., central California, at a depth of 2 km., mag. 2.0, B. Felt at San Pablo.

May 2: 12:16. Int. **III** at Keeler.

May 6: 03:50:08 (11:50). Epicenter 40°10′ N., 124°35′ W., near coast of northern California, at a depth of 6 to 10 km., mag. 3.4, B. Int. **III** at Ferndale.

May 6: 05:08. Int. **III** at Ferndale. Very slight at Petrolia.

May 9: 14:27. Int. **II** at Grass Valley.

May 13: 03:46. Felt at Pit River Powerhouse No. 3 (Burney).

May 15: 17:47:24.0 (May 16, 01:47). Epicenter 34°22.4′ N., 119°43.3′ W., near coast of southern California, at a depth of 8 km., mag. 3.7, P. Felt at Santa Barbara.

May 18: 07:08:25 (15:08). Epicenter 41°27′ N., 122°49′ W., northern California, at a depth of 11 to 15 km., mag. 4.0, B. Int. **V.** Felt over about 11,700 sq. km. (4,500 sq. mi.), principally in Siskiyou and Shasta Counties. At Callahan, rocks rolled off a cliff; at Fort Jones, slight damage was reported. Press reported dishes fell from shelves at Fort Jones. Int. V also was noted at Edgewood (about 6½ km. north of Weed), Gazelle, Greenview, Sawyers Bar (about 27 km. west of Callahan), Scott Bar, and Yreka (5 km. south of). Int. I–IV at Castella, Cecilville, Coffee Creek, Etna, Eureka, Forks of Salmon, Grenada (near), Hilt, Hornbrook, Horse Creek, Iron Gate Reservoir, Klamath River, Montague, Mountain Meadow Ranch, Mount Shasta, O'Brien, Orleans, Quartz Valley, Redding, Seiad Valley, Somesbar, and Yreka.

May 19: 23:12:43 (May 20, 07:12). Epicenter 40°14′ N., 124°11′ W., near coast of northern California, in Humboldt County, at a depth of 6 to 10 km., mag. 3.6, B. Int. **V.** Felt over about 2,600 sq. km. (1,000 sq. mi.) of northern California. No damage was reported. Int. V effects occurred at Fortuna, Petrolia, Rio Dell (west of town), and Scotia. Int. IV at Carlotta, Eureka, Ferndale, Myers Flat, and Weott.

May 22: 01:40:30.6 (09:40). Epicenter 33°44.7′ N., 118°06.9′ W., near coast of southern California, at a depth of 10 km., mag. 3.0, P. Felt at Long Beach.

May 22: 02:39:58.0 (10:39). Epicenter 37°50.1′ N., 121°55.7′ W., central California, at a depth of 3.9 km., mag. 2.7, B. Felt at Danville.

May 25: 10:42:29.6 (18:42), 10:43:00.7 (18:43). Epicenters (1) 37°48.7′ N., 121° 56.6′ W.; (2) 37°48.3′ N., 121°56.8′ W., central California, near Danville, at depths of 7.6 and 6.4 km., respectively; mag. 2.7 and 2.9, respectively, B. Int. V. At the Danville Post Office, existing plaster cracks enlarged. Damage slight.

May 26: 08:00 (about). Int. **III** at the Diablo Post Office.

May 26: 14:10:24.2 (22:10), 14:10: 35.2 (22:10). Epicenter 37°48.0′ N., 121° 56.4′ W., central California, near Danville, at a depth of 4.1 km., mag. 3.0 and 3.5, respectively, B. Int. **V.** At the Danville Post Office, small objects shifted; plaster cracked slightly. Damage slight. Int. IV at the Alamo Post Office and Clayton. Int. III at the Diablo Post Office.

May 26: 15:06:44.1 (23:06), 15:33:39.9 (23:33). Epicenters (1) 37°49.3′ N., 121° 55.8′ W.; (2) 37°47.9′ N., 121°56.9′ W., central California, near Danville, at depths of 9.1 and 3.9 km., respectively, mag. 2.8 and 3.8, respectively, B. Int. **V.** At the Danville Post Office, furniture shifted slightly, plaster cracked, and existing cracks enlarged. Damage slight. Int. V effects were noted additionally at Alamo and San Ramon. Int. I–IV at Diablo, Mount Diablo State Park (Ranger Station), and San Francisco. Also reported felt at Berkeley and Walnut Creek.

May 28: 18:53:08.3 (May 29, 02:53), 18:55:49.5 (May 29, 02:55), 19:13:15.8 (May 29, 03:13). Epicenters (1) 37°49.2′ N., 121°56.7′ W.; (2) 37°48.1′ N., 121°56.5′ W.; (3) 37°49.2′ N., 121°55.8′ W., central California, near Danville, at depths of 8.7, 6.7, and 8.7 km., respectively, mag. 3.4, 3.5, and 3.1, respectively, B. Int. **V** (second shock). The shock at 18:55 enlarged cracks in one concrete foundation at Walnut Creek. It also was felt at Castro Valley, Clayton (int. IV), and Danville. The first and third shocks were felt at Clayton and Danville.

May 29: 01:00 (about). Felt near Walnut Creek.

June 6: 20:12:10 (June 7, 04:12). Epicenter 40°20′ N., 126°27′ W., off coast of northern California, at a depth of 11 to 15 km., mag. 4.7, B. Int. **IV** at Ferndale.

June 11: 15:32:56.2 (23:32), 15:39: 49.7 (23:39). Epicenters (1) 37°47.5′ N., 121°56.5′ W.; (2) 37°47.9′ N., 121°56.5′ W., central California, near Danville, at depths of 7.2 and 8.8 km., respectively, mag. 3.4 and 3.0, respectively, B. Int. **V.** At the Danville Post Office, existing plaster cracks enlarged. Also felt at Alamo (int. IV) and Walnut Creek. The second shock was felt at Danville also.

June 11: 16:00. Felt at Danville.

June 11: 16:39:25.0 (June 12, 00:39). Epicenter 37°48.9′ N., 121°56.6′ W., central California, near Danville, at a depth of 8.6 km., mag. 3.3, B. Int. **IV** at the Diablo Post Office. Also felt at Danville.

June 11: 19:30:04.0 (June 12, 03:30), 19:30:55.0 (June 12, 03:30). Epicenter 37°48.1′ N., 121°56.0′ W., central California, near Danville, at a depth of 9.1 km., mag. 4.3 and 3.9, respectively, B. Int. **VI.** The first (and main) shock was felt over about 3,380 sq. km. (1,300 sq. mi.) of the San Francisco Bay area, principally in and around Danville. This was the strongest of the Danville series of earthquakes, and it caused minor damage at Danville. The sec-

ond shock also was felt in Danville and vicinity.

INTENSITY VI:

Danville.—Press reports told of damage to several windows, a fence, a chimney, several outside brick facades, and to hundreds of items shaken from store shelves. One report stated an exterior brick pillar partially crumbled at the Greenbrook Clubhouse. A field team from the University of California, Berkeley, reported heavy furniture (including a cabinet, refrigerator, floorpot, and dishwasher) moved in various directions at one residence. Sliding doors opened and closed several times; kitchen cabinet doors opened, and canned goods fell out; ironing board fell out of closet. At a nearby residence, a water pipe broke off an outdoor well; fireplace sustained minor cracks in corners; a chimney fell; pump pipefittings broke; one window broke, one cracked. Minor damage was sustained at other residences also.

INTENSITY V:

Alamo, Canyon, Daly City, Diablo, Diablo State Park (Ranger Station), Walnut Creek, and near Walnut Creek.

INTENSITY I–IV:

Alameda, Berkeley, Castro Valley, Clayton, Concord, Hayward, Moraga, Oakland, Pleasanton, Port Costa, San Francisco, San Gregorio, and San Leandro.

June 11: 22:34:01.4 (June 12, 06:34). Epicenter 37°47.7′ N., 121°55.9′ W., central California, near Danville, at a depth of 9.6 km., mag. 3.1, B. Int. **V.** At Danville, all in home were awakened. Also felt at Moraga.

June 12: 08:03:32.1 (16:03), 08:10:51.4 (16:10). Epicenters (1) 37°48.3′ N., 121°56.3′ W.; (2) 37°48.0′ N., 121°55.7′ W., central California, near Danville, at depths of 8.7 and 9.6 km., respectively, mag. 4.2 and 3.2, respectively, B. Int. **VI.** The first shock was the strongest; the second shock also was felt in Danville and vicinity. Damage from the main shock was generally minor.

INTENSITY VI:

Danville.—The press reported much damage from broken items in stores. Residents reported existing plaster cracks enlarged; furniture shifted; glass objects broke; and doors and drawers opened. Slight damage to wooden upright support beam. Branches fell from oak tree. "Less intense than the June 11 tremor."

INTENSITY V:

Alamo and San Ramon.

INTENSITY I–IV:

Canyon, Diablo, Moraga, Orinda, San Francisco, and San Gregorio.

June 12: 14:54:39.3 (22:54). Epicenter 37°51.0′ N., 121°56.8′ W., central California, near Danville, at a depth of 14.1 km., mag. 3.1, B. Felt at Danville.

June 13: 00:55:01 (08:55), 02:13. Epicenter 40°55′ N., 121°38′ W., northern California, at a depth of 1 to 5 km., mag. 4.0 and 2.9, respectively, B. Int. **V.** Felt over about 2,600 sq. km. (1,000 sq. mi.) of northeastern Shasta County, principally in the Burney area. No damage was noted. The slight aftershock at 02:13 was felt in the Burney area also. Int. V at Burney (north of, at McArthur-Burney Falls State Park and at Pit River Powerhouse No. 3) and Fall River Mills. Intensity I–IV at Cayton Valley (about 19 km. north of Burney), Glenburn, Hat Creek, and Pit River Powerhouse No. 1 (about 8 km. southwest of Fall River Mills).

June 14: 01:11:09.8 (09:11), 01:18:10.2 (09:18). Epicenters (1) 37°48.6′ N., 121°57′ W.; (2) 37°48.7′ N., 121°56.1′ W., central California, near Danville, at depths of 10.9 and 9.0 km., respectively, mag. 2.7 and 3.0, respectively, B. Felt at Danville.

June 23: 03:21:02.8 (11:21). Epicenter 34°07.4′ N., 118°09.5′ W., southern California, at a depth of 8 km., mag. 2.5, P. Felt at Eagle Rock, Glendale, Highland Park, and La Canada.

June 30: 23:55:26 (July 1, 07:55). Epicenter 39°29′ N., 122°04′ W., northern Cali-

fornia, at a depth of 1 to 5 km., mag. 3.6, B. Int. **V.** Felt over about 3,900 sq. km. (1,500 sq. mi.) of northern California. A Chico radio station reported dishes were broken in the area; press told of plaster cracking in some older homes "in the Chico area." Int. V at Butte City, Glenn, and Willows. Int. I–IV at Chico, Delevan (about 19 km. south of Willows), Hamilton, Ordbend, and Richvale.

July 1: 10:56:59.4 (18:56). Epicenter 39°28.6′ N., 122°05.1′ W., northern California, at a depth of 12 km., mag. 3.5, B. Int. **IV** at Artois, Durham, Elk Creek, Glenn, Ordbend, Princeton, Richvale, and Willows. Int. I–III at Chico, Orland, and Williams.

July 2: 21:18:53.2 (July 3, 05:18). Epicenter 34°18.7′ N., 116°45.7′ W., southern California, at a depth of 8 km., mag. 3.3, P. Felt at Big Bear.

July 4: 21:27:54.1 (July 5, 05:27), 21:28:47.4 (July 5, 05:28). Epicenters (1) 37°49.8′ N., 121°56.2′ W.; (2) 37°48.6′ N., 121°55.6′ W., central California, near Danville, at depths of 7.0 and 7.6 km., respectively, mag. 2.6 and 2.9, respectively, B. Felt at Danville.

July 8: 01:25:30.2 (09:25). Epicenter 35°24.8′ N., 117°47.8′ W., central California, at a depth of 8 km., mag. 4.0, P. Int. **IV** at Johannesburg.

July 11: 11:01:04.2 (19:01). Epicenter 37°07.7′ N., 122°01.8′ W., central California, at a depth of 10 km., mag. 3.4, B. Reported felt in the Sunset District of San Francisco, and in the southern San Francisco Peninsula area (press). Int. **II** at Capitola.

July 14: 14:35. Int. **II** at Santa Cruz.

July 26: 03:17:29.4 (11:17). Epicenter 33°27.6′ N., 117°44.6′ W., southern California, at a depth of 8 km., mag. 3.1, P. Felt at San Clemente.

Aug. 3: 02:04:47 (10:04). Epicenter 38.9° N., 122.5° W., northern California, at a depth of 12 km., mag. 2.7, B. Felt at Lakeport.

Aug. 3: 20:14:21.4 (Aug. 4, 04:14). Epicenter 36°38.8′ N., 122°11.1′ W., off coast of central California, in Monterey Bay, at a depth of 5 km., mag. 4.7, B. Int. **VI.** Felt over about 14,300 sq. km. (5,500 sq. mi.) of the central California coastal areas (see fig. 4). Press reports indicated that a few patios and swimming pools in the Carmel Valley were cracked, and that police departments throughout the Monterey Peninsula received hundreds of calls reporting cracked plaster and broken crockery. At Carmel Valley, a swimming pool cracked; redwood beams in a building twisted, shifted, and cracked. Several telephone wires broke at Castroville. Monterey police reported a few telephone lines were knocked down. Burglar alarms activated. A picture window broke at the library. People in a theater panicked when bits of plaster fell. At a drive-in theater, the snack bar settled about a half-inch, causing some damage to the building. Loud earth noises were heard before and during the shock. Most reported it was of unusually long duration.

INTENSITY VI:

Carmel Valley (about 24 km. southeast of Monterey).—Felt by all and frightened many in community. Redwood beams in one building twisted, shifted, and cracked. Damage slight. Hanging objects swung violently. Small objects overturned and fell; furniture shifted. Loud earth noises all during the shock: faint rumbling and slight shaking for 2 to 3 minutes. Largest jolt lasted about 13 seconds. "An employee of KMBY Radio Station [Monterey] reported a swimming pool cracked at Carmel Valley."

Castroville.—Felt by all in community; frightened many. Several telephone wires broke. Hanging objects swung violently. Strong jolting and swaying shock. Loud earth noises.

Monterey.—Felt by all in community; frightened many. Plaster cracked and fell. A few telephone lines were knocked down. Window broke at library. Television set fell off table and broke. Burglar alarms were set off. People panicked at a theater (press). Loud earth noises.

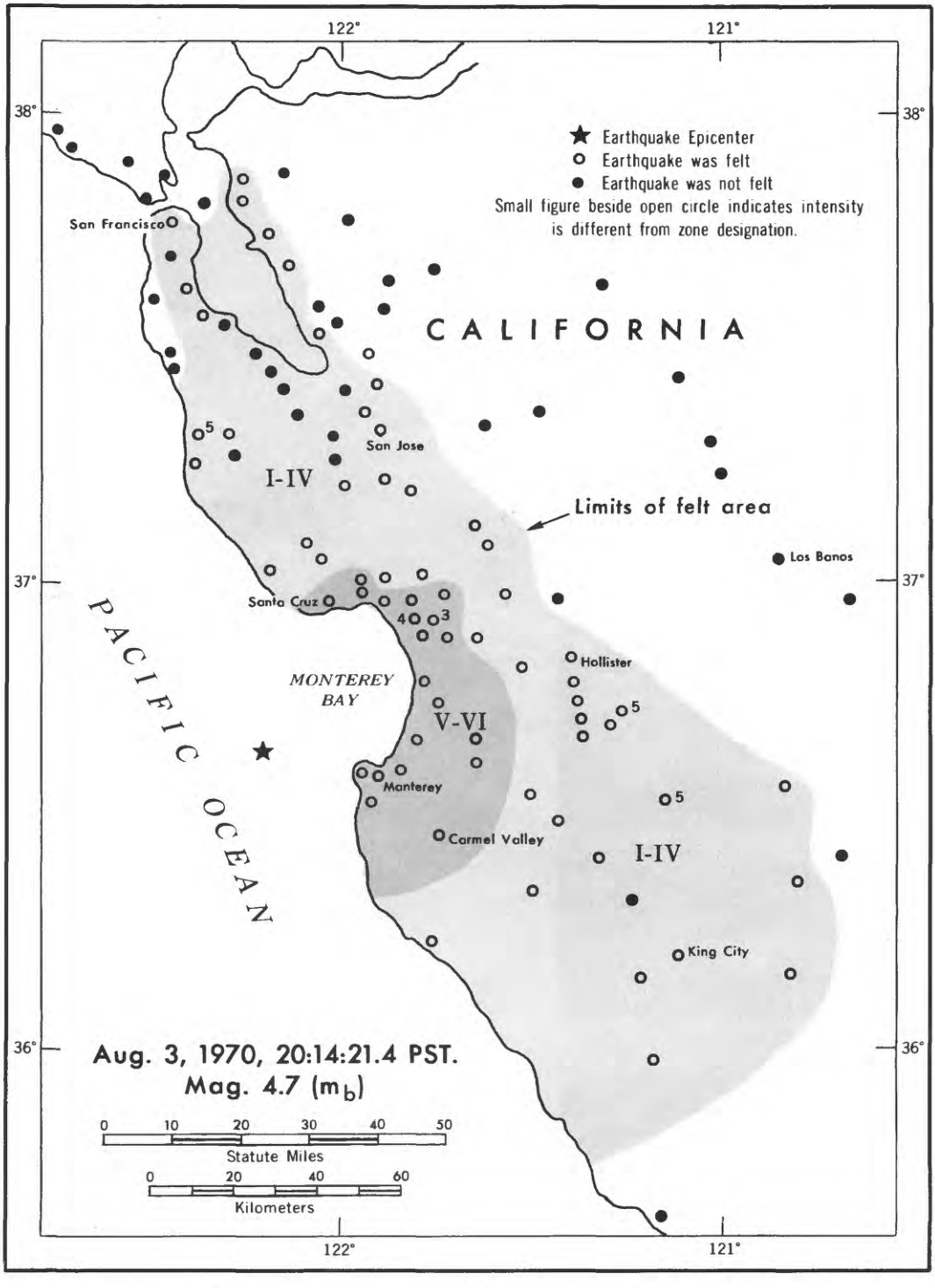

FIGURE 4.—Area affected by central California earthquake of August 3.

INTENSITY V:

Aptos, Capitola, Carmel, Chittenden Pass area (east of Watsonville, 36°54′ N., 121°36′ W.), Corralitos, Fort Ord, La Selva Beach, Marina, Moss Landing, Pacific Grove (plaster cracked slightly), Paicines, Pinnacles National Monument (about 24 km. northeast of Soledad), Salinas, San Gregorio, Santa Cruz (plaster cracked; damage slight), Seaside, Soquel, Spreckels, and Watsonville.

INTENSITY IV:

Almaden Valley area (south of San Jose city limits), Aptos (about 6 km. north of), Aromas, Ben Lomond, Big Sur, Chualar, Cienega District (south of Hollister, several locations), Freedom, Gilroy, Gonzales, Hillsborough, Hollister, Jolon, King City, La Honda, Mee Ranch (intersection of Highways 25 and 198), Milpitas, Morgan Hill, Mount Hermon, Mount Madonna County Park area (37°01′ N., 121°43′ W.), New Almaden, Paloma Station (36°21′ N., 121° 30′ W.), Pebble Beach, Pescadero, Pine Canyon (about 13 km. southwest of King City), San Bruno, San Jose, San Juan Bautista, and Soledad.

INTENSITY I–III:

Alameda, Berkeley, Davenport, Hernandez area (about 13 km. southwest of Idria, above Hernandez Dam), Libby Ranch (about 4 km. southwest of Paicines), Los Gatos, Newark, Oakland, Panoche, San Francisco, San Lorenzo, San Martin, and Watsonville area (about 6½ km. northeast of Watsonville, on Hecker Pass Road). Also reported felt (no details) at Santa Clara.

Aug. 3: 20:44:06.7 (Aug. 4, 04:44). Epicenter 36°42.5′ N., 122°04.3′ W., off coast of central California, in Monterey Bay, at a depth of 2 km., mag. 3.2, B. Felt slightly at Aptos (about 6 km. north of), Capitola, and Santa Cruz.

Aug. 11: 01:56:30.5 (09:56). Epicenter 37°54.3′ N., 122°14.5′ W., central California, at a depth of 10 km., mag. 2.4, B. Felt at Berkeley.

Aug. 13: 22:28:47.5 (Aug. 14, 06:28). Epicenter 40°09.3′ N., 123°53.7′ W., northern California, at a depth of 4 km., mag. 4.0, B. Int. **V** at Bridgeville, Carlotta, Eureka, Ferndale, Fields Landing, Fort Seward, Loleta, Petrolia, Redcrest, Redway, and Rio Dell. Int. IV at Alderpoint, Fortuna, Phillipsville, Samoa, Scotia, and Weott. Int. I–III at Blocksburg and Garberville.

Aug. 16: 08:29:05.2 (16:29). Epicenter 36°38.0′ N., 121°18.1′ W., central California, at a depth of 8 km., mag. 3.5, B. Int. **IV** at Carmel and Spreckels. Int. I–III at the Harris Ranch (south of Hollister) and Pacific Grove.

Aug. 18: 22:54:25 (Aug. 19, 06:54). Epicenter 40°12′ N., 122°45′ W., northern California, at a depth of 7 km., mag. 4.1, B. Int. **IV** at Igo, Ono and vicinity, Platina, and Redding.

Aug. 20: 19:22:38.6 (Aug. 21, 03:22). Epicenter 37°52.9′ N., 122°15.4′ W., central California, at a depth of 7 km., mag. 2.5, B. Int. **III** at Berkeley.

Aug. 22: 12:45:04 (20:45). Epicenter 40.3° N., 124.1° W., northern California, at a depth of about 31 km., mag. 3.9, B. Int. **IV** at Ferndale.

Aug. 23: 09:53:47.4 (17:53). Epicenter 36°42.3′ N., 122°06.2′ W., central California, at a depth of 2 km., mag. 3.4, B. Int. **IV** at Capitola. Also felt at Monterey and Santa Cruz (press).

Aug. 25: 07:45. Int. **II** at Ferndale.

Aug. 25: 17:08:59.9 (Aug. 26, 01:08). Epicenter 34°12.8′ N., 119°14.1′ W., southern California, at a depth of 8 km., mag. 3.6, P. Int. **V.** At Oxnard, small objects shifted. Int. I–IV at Camarillo, Carpinteria, Meiners Oaks, Oak View, Ojai, and Port Hueneme (Naval Station).

Aug. 30: 05:16:50.9 (13:16). Epicenter 36°54.6′ N., 121°29.4′ W., central California, at a depth of 10 km., mag. 3.6, B. Int. **V.** Felt by all in community at Hollister; people awakened. Many awakened at San Juan Bautista. Int. I–IV at Watsonville and Gilroy.

Aug. 31: 04:12:58.7 (12:12). Epicenter

38°06.4′ N., 121°56.8′ W., central California, at a depth of 8 km., mag. 3.6, B. Int. **I–IV** at Concord, Martinez, and Port Costa. Also reported felt at Pittsburg.

Sept. 12: 06:10:11.2 (14:10). Epicenter 34°16.0′ N., 117°31.1′ W., southern California, at a depth of 8 km., mag. 4.1, P. Foreshock of 06:30:53.0. Widely felt. Int. **IV** at Culver City and San Clemente. Int. I–III at Altadena, Chino, Corona del Mar, Crestline, Etiwanda, Fontana (8 km. north of, on Lytle Creek Road), Glendale, Los

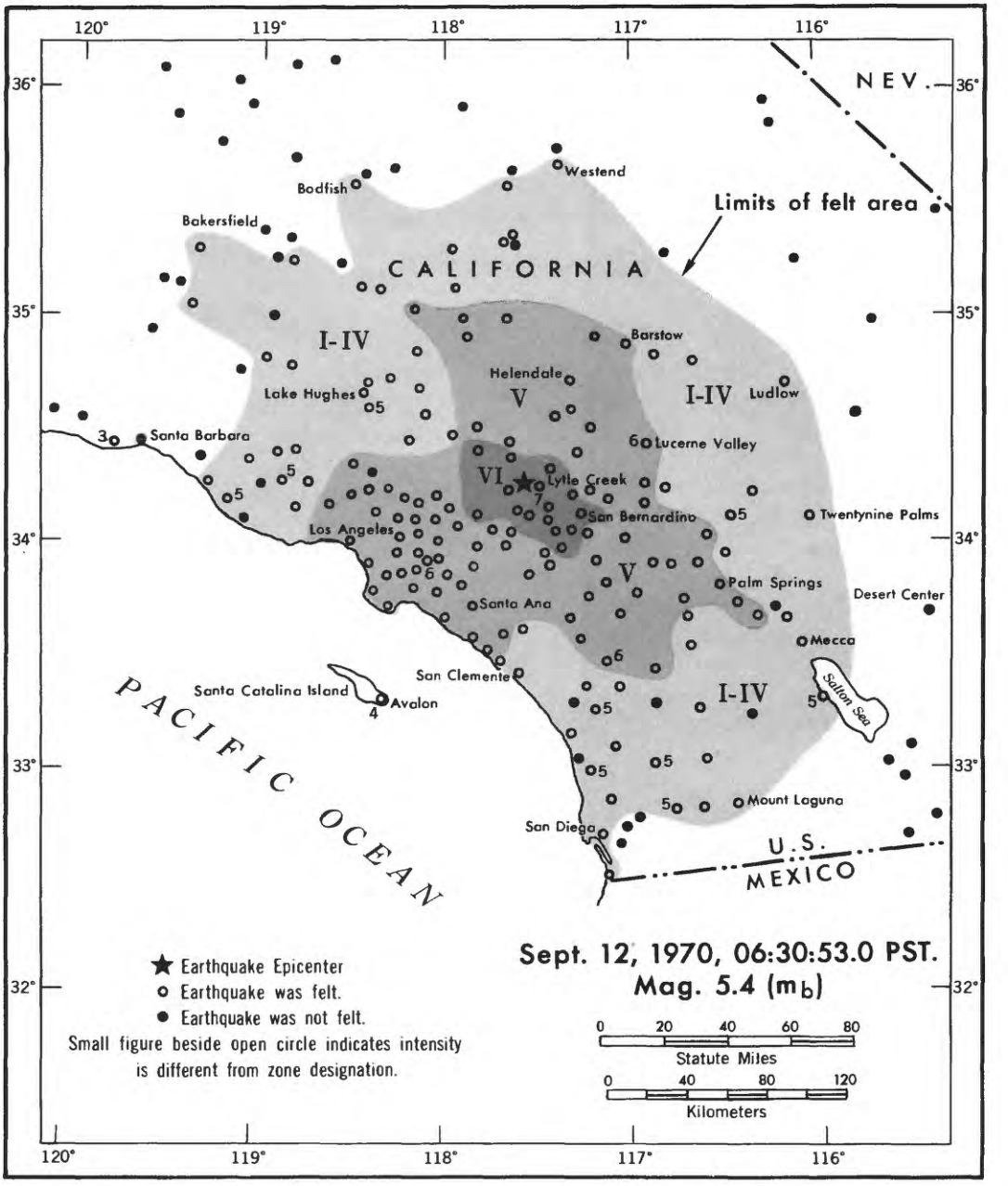

FIGURE 5.—Area affected by southern California earthquake of September 12.

Angeles (Westwood area), Newberry Springs, Riverside, San Bernardino, Santa Fe Springs, Twin Peaks, and Wrightwood.

Sept. 12: 06:30:53.0 (14:30). Epicenter 34°16.2′ N., 117°32.4′ W., southern California, at a depth of 8 km., mag. 5.4, P. Int. **VII.** Main shock of a series originating near Lytle Creek (about 24 km. northwest of San Bernardino). Felt over about 65,000 sq. km. (25,000 sq. mi.) of southern California (see fig. 5). Observer at Lytle Creek reported ground cracks, landslides, and disturbed water; chimneys, tombstones, elevated water tanks, etc., cracked, twisted, and overturned. Observers at Lytle Creek Ranger Station reported several roads were blocked by rockslides: several residents of the area noted cracked walls and broken windows (press). Forest rangers reported rockslides and broken telephone lines in the San Gabriel and San Bernardino Mountains, near the center of the shock. Rockslides were reported on the San Gabriel Canyon Road, Mount Baldy Road, and Glendora Canyon Road. Roads were passable but dangerous. The shock caused an explosion at an aerospace plant in Riverside. Power was disrupted over a wide area, extending from the Santa Monica Mountains to San Bernardino. Tall buildings swayed at Los Angeles and San Diego. People reported water sloshed from swimming pools at Los Angeles.

INTENSITY VII:

Lytle Creek.—Felt by all in community; awakened and frightened many. Ground cracks; landslides; disturbed water. Chimneys, tombstones, elevated water tanks, etc., cracked, twisted, and overturned. Windows cracked. Small objects fell; many items broke. Trees and bushes shook. Damage slight. Loud rumble. "We have been averaging two shocks a day since this shock [report postmarked Sept. 16]. Much more noise with the recent ones." At the Glenn Ranch, plaster fell from walls. Small objects and dishes fell to floor (VI).

INTENSITY VI:

Colton.—Felt by and frightened all in community. At the post office, ceiling tile fell; one beam moved about 1.3 cm. Thin, 5½-meter-long crack in concrete loading dock was reported by the press. Hanging objects swung violently south-north. Loud earth noises.

Crestline. — Felt by many. Fireplaces cracked. Trees and bushes shook; vehicles rocked. Loud earth noises.

Crestline (SW¼, sec. 13, T. 3 N., R. 4 W.).—Felt by and awakened all; frightened few. Plaster cracked. Damage slight. Telephone and electric poles and lines swayed. Trees and bushes shook. Bottles fell off shelf.

Cucamonga.—Felt by all; awakened and frightened many in community. Several roof tiles shifted and loosened. Small objects shifted. Hanging objects swung violently north-south. Faint to moderate earth noises.

Fontana.—Felt by all; awakened and frightened many in community. Ground cracks; landslides; disturbed water. Plaster cracked. Damage slight. Trees and bushes shook; vehicles rocked. Small objects shifted.

Glendora.—Felt by and awakened all; frightened many. Small portions of ceiling buckled and dropped down about 15 cm.

Glendora Canyon Road.—Rockslides occurred (press).

Highland.—Felt by all; awakened and frightened many in community. Plaster cracked. Windows broke. Damage slight. Trees and bushes shook; vehicles rocked. Small objects and furniture shifted. Hanging objects swung violently in circular motion. Moderate earth noises.

Highway 18.—Postmaster at Crest Park reported: "Landslides on Highway 18."

Lucerne Valley.—Felt by and awakened all in community; frightened few. Few residents reported cracked floors. Faint earth noises.

Mount Baldy (U.S. Forest Service recreation area).—Felt by and awakened all in community; frightened few. Landslides. Building settled very slightly on west side. Small objects overturned and fell. Trees and bushes shook.

Mount Baldy Road.—Rockslides occurred (press).

Norwalk.—Man reported the concrete foundation of his garage had a 6-meter-long crack down the center (press).

Rialto.—Felt by all in community; awakened and frightened many. Plaster cracked, broke, and fell; block cracked; windows cracked. Damage slight. Small objects shifted, overturned, and fell. Trees and bushes shook; vehicles rocked. Loud earth noises.

Riverside.—Generally felt at Riverside and vicinity. Press reported the most serious damage was at the Riverside plant of the Rohr Corporation, where a high-pressure water system was damaged, causing an explosion which slightly injured several persons. Plaster cracked in bedroom. Small objects fell. Vehicles rocked. Loud earth noises. At the Rubidoux Branch Post Office (about 3 km. northwest of Riverside), plaster and cement cracked. Small objects and furniture shifted. Hanging objects swung violently east-west. Door closed, Adding machines activated. "Could see rolling effect of cement floor. Sixteen employees headed for outdoors; two crawled under a table."

San Bernardino.—Felt by all and frightened many in community. Press reported at least a dozen downtown buildings had shattered front windows. Small objects shifted. Very heavy shock.

San Gabriel Canyon Road.—Rocks fell on San Gabriel Canyon Road (press).

Summit.—Felt by and awakened all in community; frightened few. Trees and bushes shook; vehicles rocked. Small objects fell. Loose rocks rolled (road fill).

Temecula.—Felt by all or many; frightened few. Large cracks in wall. Damage moderate.

Valyermo.—Felt by all and frightened many in community. Small objects and furniture shifted. Trees and bushes shook; vehicles rocked. Rocks on slope fell.

Wrightwood.—Felt by all in community; awakened and frightened many. Chimneys cracked; bricks fell. Severe damage to merchandise on shelves in grocery store. Furniture shifted. Water disturbed. Trees and bushes shook. Loud earth noises. "Tremors continued throughout Sept. 12. A few shocks were felt on Sept. 13, 14, and 15."

INTENSITY V:

Adelanto, Aguanga, Alpine, Altadena, Alta Loma, Anaheim, Angelus Oaks, Apple Valley (three other shocks felt), Arcadia, Arlington, Barstow, Bell, Beverly Hills, Bloomington (damage slight; no details), Blue Jay, Bonsall, Boron, Bryn Mawr, Burbank, Canoga Park, Cathedral City, Cedarpines Park, Claremont, Corona, Corona del Mar, Covina, Crest Park, Culver City, Downey, East Highlands, Edwards, Edwards Air Force Base, El Segundo, El Toro, Encino, Etiwanda, Fawnskin, Fullerton, Glendale, Green Valley, Hesperia, Hinkley (plaster cracked), Idyllwild, Irwindale (plaster cracked; damage slight), Laguna Beach, Lake Arrowhead (fluorescent light jarred loose), Lakeview, Lakewood, La Puente, La Quinta, Llano, Loma Linda, Long Beach, Los Alamitos, Los Angeles (several locations), Lytle Creek Road (8 km. north of Fontana), Malibu, Manhattan Beach, March Air Force Base, Maywood, Mile High (about 3 km. southeast of Valyermo), Mojave, Monterey Park, Montrose, Moorpark, Moreno, Morongo Valley, Murrieta, Newhall, Norco, North Hollywood, Nuevo, Ontario, Oro Grande, Oxnard, Pacific Palisades, Pacoima, Palm Springs, Palos Verdes Peninsula, Paramount (plaster cracked; damage slight), Pasadena, Pedley, Perris, Phelan (damage slight; no details), Pinon Hills, Placentia (damage slight; no details), Pomona (damage slight; no details), Ramona, Rancho Mirage, Rancho Santa Fe (some plaster cracked), Redlands, Rimforest, Rosemead, Running Springs, Salton City, San Dimas (damage slight), San Gabriel, San Jacinto (damage slight; no details), San Pedro, Santa Ana, Santa Fe Springs (outside overhang cracked), Santa Monica, Sepulveda, Sierra Madre, South

Pasadena, Sunland, Sylmar, Temple City, Tujunga, Tustin, Twin Peaks, Van Nuys, Victorville, Vista, Walnut, West Covina, White Water, Whittier (ground cracked; damage slight), Wildomar, Winchester (damage slight), Yorba Linda, Yucaipa, and Yucca Valley.

INTENSITY IV:

Acton, Antelope Acres, Anza, Avalon, Big Bear City, Bodfish, Buena Park, California City, Cantil, Carlsbad, Chino, Coachella, Compton, Descanso, East Los Angeles, Elsinore, Fallbrook, Fillmore, Frazier Park area (Cuddy Valley), Gorman, Helendale, Hemet, Huntington Beach, Huntington Park, Imperial Beach, Inglewood, Johannesburg, Julian (Wynola), Lake Hughes, Lancaster, Landers, Lebec, Littlerock, Ludlow, Miramar, Monolith, Monrovia, Mountain Center, Mount Wilson, Newberry Springs, Norton Air Force Base (near San Bernardino), Pala, Palm Desert, Pearblossom (SE¼, sec. 10, T. 4 N., R. 10 W.), Pioneertown, Piru, Randsburg, Rosamond, San Clemente, San Diego, Santa Paula, Santa Susana, Solana Beach, South Gate, South Laguna, Tehachapi, Thousand Palms, Trabuco Canyon, Tupman, Twentynine Palms, Warner Springs, West Los Angeles, Wild (about 6½ km. northeast of Helendale), and Wilmington.

INTENSITY I–III:

Cabazon, Daggett, Desert Hot Springs, Di Giorgio, Escondido, Fairmont Reservoir (about 3 km. northeast of Lake Hughes), Gardena, Goleta, Maricopa, Mecca, Mount Laguna, Palmdale, Ridgecrest, San Fernando, Thousand Oaks, Ventura, Watts area (west of), and Westend.

Sept. 12: 06:35. Felt at Etiwanda.

Sept. 12: 06:43:59.9 (14:43). Epicenter 34°13.3′ N., 117°33.0′ W., southern California, at a depth of 8 km., mag. 3.6, P. Int. **III** at Glendale. Also felt at Arcadia and Etiwanda.

Sept. 12: 08:20. Felt at Riverside.

Sept. 12: 08:33, 09:33:24.6 (17:33). Epicenter 34°13.1′ N., 117°33.3′ W., southern California, at a depth of 8 km., mag. 3.2, P. Int. **V** at Etiwanda.

Sept. 12: 10:26:28.0 (18:26), 11:20, 11:46. Epicenter 34°15.6′ N., 117°32.9′ W., southern California, at a depth of 8 km., mag. 3.5, P. Int. **V** at Etiwanda.

Sept. 12: 20:10. Felt at Wild (about 6½ km. northeast of Helendale).

Sept. 12: 20:47:48.6 (Sept. 13, 04:47). Epicenter 34°16.9′ N., 117°33.1′ W., southern California, at a depth of 8 km., mag. 4.4, P. Int. **V** at Etiwanda. Intensity I–IV at Arcadia, Crestline, Fawnskin, Highland, Los Angeles (Westwood area), March Air Force Base, Riverside, Running Springs, San Bernardino, and Wrightwood.

Sept. 13: 13:10:21 (21:10). Epicenter 40°08′ N., 125°05′ W., off coast of northern California, at a depth of 2 km., mag. 5.4, B. Int. **V** at Ferndale, Fort Seward, Rio Dell (some dishes broke), and Scotia. Int. IV at Honeydew, Loleta, Manila (Arcata area), Miranda, Myers Flat, Piercy, Redcrest, and Whitethorn. Int. I–III at Blocksburg, Eureka, Kneeland, and Redway. Also reported felt at Garberville (press).

Sept. 13: 19:07:33.4 (Sept. 14, 03:07). Epicenter 34°14.2′ N., 117°31.6′ W., southern California, at a depth of 8 km., mag. 3.2, P. Int. **IV** at Etiwanda. Observer at Wrightwood reported a few shocks were felt on Sept. 13.

Sept. 14: 03:57:00.0 (11:57). Epicenter 34°03.7′ N., 118°21.0′ W., southern California, at a depth of 8 km., mag. 3.0, P. Int. **IV** at Baldwin Hills, Culver City, and Los Angeles (southwest area, about 3 km. north of Inglewood City Hall). Int. I–III at Beverly Hills, Inglewood, and West Los Angeles area.

Sept. 14: 12:27. Int. **IV** at Etiwanda. Observer at Wrightwood reported a few shocks were felt on Sept. 14 and 15.

Sept. 15: 14:30:49.2 (22:30). Epicenter 34°13.7′ N., 117°33.0′ W., southern California, at a depth of 8 km., mag. 3.4, P. Felt in San Bernardino area.

Sept. 15 to 18: Observer at Palos Verdes

Peninsula reported: "We have had four shocks since Sept. 12."

Sept. 15 to 19: Observer at Culver City reported: "Some definite oscillations felt from Sept. 15 to 19."

Sept. 17: 16:36:56.3 (Sept. 18, 00:36). Epicenter 37°38.8′ N., 122°02.4′ W., central California, at a depth of 11 km., mag. 2.7, B. Int. **IV** at Hayward and vicinity. Also felt at San Leandro.

Sept. 17: 18:29:49.9 (Sept. 18, 02:29). Epicenter 37°42.9′ N., 122°32.1′ W., central California, at a depth of 3 km., mag. 2.5, B. Int. **IV** at San Francisco.

Sept. 20: 07:32:57 (15:32). Epicenter 33°54′ N., 118°43′ W., southern California, mag. 2.5, P. Int. **IV** in West Los Angeles area. Also felt at Inglewood.

Sept. 20: 12:58, 13:17, 15:55, 17:46. Felt slightly by observer at Culver City. Several other small shocks also felt.

Sept. 22: 20:51:27.9 (Sept. 23, 04:51). Epicenter 37°23.9′ N., 122°13.1′ W., central California, at a depth of 11 km., mag. 3.5, B. Press reported a mild tremor rattled most of the San Francisco Peninsula. Reported felt from San Francisco to Palo Alto.

Sept. 23: 00:13:44.0 (08:13), 00:33:33.0 (08:33, main shock), 00:51:17.0 (08:51), 00:59:55.0 (08:59), 01:58:14.0 (09:58). Epicenters (1) 34°00′ N., 118°17′ W.; (2) 34°00′ N., 118°17′ W.; (3) 33°54′ N., 118°20′ W.; (4) 33°54′ N., 118°20′ W.; (5) 33 50′ N., 118°21′ W., southern California, all at a depth of about 10 km., mag. 2.9, 4.2, 3.3, 3.2, and 3.2, respectively. P. Int. **V.** Awakened and frightened many in the southwest Los Angeles area. At Inglewood, the shocks were described as brief jolts. Some minor damage was reported to have occurred in the Crenshaw area. Int. V (main shock at 00:33) at Culver City (near Ballona Creek; shocks also felt at 00:13 and 00:59; continuous shocks for 2 hours kept observer awake), Hawthorne, Hermosa Beach, Inglewood and Lennox area (all five shocks felt . Los Angeles (about 3 km. north of Inglewood City Hall, five shocks felt; southeast of Baldwin Hills, distinct shocks also felt at 00:51, 00:59, and 01:58; plaster cracked at 1453 W. 64th St.; southeast of UCLA, shocks also felt at 00:51, 00:59, and 01:58), and Manhattan Beach (all five shocks felt). Int. IV at Gardena, Lawndale, Mar Vista (West Los Angeles area), Maywood (shocks also felt at 00:13, 00:51, and 00:59), and South San Gabriel (shock also felt at 01:58).

Sept. 23: 00:38:04.1 (08:38). Epicenter 37°52.3′ N., 121°54.4′ W., central California, at a depth of 6 to 10 km., mag. 2.7, B. Felt at Danville.

Sept. 23: 12:10, 13:31, 14:57. Felt at Culver City (near Ballona Creek). "Many other shocks felt through the day; usually small."

Sept. 23: 16:00. Int. **III** in southwest Los Angeles area (southeast of UCLA).

Sept. 23: 17:41 (about). Int. **IV** in southwest Los Angeles area (about 3 km. north of Inglewood City Hall).

Sept. 24: (no times given). At Culver City (near Ballona Creek), observer reported many oscillations, usually small, including one felt both indoors and outdoors; three were felt in other locations in same general vicinity.

Sept. 25: 05:18:06 (13:18). Epicenter 34°14′ N., 117°29′ W., southern California, at a depth of 8 km., mag. 3.2, P. Int. **IV** at Etiwanda. Also felt at Lytle Creek.

Sept. 25: 15:40, 18:12. Int. **IV** (18:12) at Culver City (near Ballona Creek). Several additional small shocks were felt on same day. Some motion was felt on Sept. 26.

Sept. 30: 03:54:59.0 (11:54). Epicenter 33°57′ N., 118°17′ W., southern California, at a depth of 8 km., mag. 2.5, P. Felt at Inglewood.

Oct. 4: 13:05:35.0 (21:05). Epicenter 34°09′ N., 118°07′ W., southern California, at a depth of 8 km., mag. 2.7, P. Reported felt, but no definite location was given.

Oct. 8: 09:29:18.5 (17:29). Epicenter 36°46.6′ N., 121°36.6′ W., central Cali-

fornia, at a depth of 3 km., mag. 3.0, B. Felt at Harris Ranch, south of Hollister.

Oct. 8: 23:55:06.0 (Oct. 9, 07:55). Epicenter 33°32′ N., 118°28′ W., near coast of southern California, at a depth of 8 km., mag. 3.2, P. Int. **IV.** Press reported a sharp, jolting earthquake rattled windows and dishes and awakened many South Bay residents. Reported felt at Gardena, Hermosa Beach, Palos Verdes Peninsula, Redondo Beach, and Torrance. Felt slightly at Manhattan Beach.

Oct. 11: 18:15:46.8 (Oct. 12, 02:15). Epicenter 36°46.8′ N., 121°28.5′ W., central California, at a depth of 6 km., mag. 2.4, B. Felt at Harris Ranch, south of Hollister.

Oct. 25: 23:16. Int. **IV** at Lahontan Dam near Fallon, Nev.

Oct. 26: 06:46:15 (14:46). Epicenter 40.2° N., 124.2° W., northern California, at a depth of 12 km., mag. 3.4, B. Int. **IV** at Eureka, Ferndale, Fortuna, Mattole Valley (about 13 km. upriver from Petrolia), and Rio Dell. Int. I–III at Bayside, Petrolia, and Scotia.

Oct. 27: 16:45. Int. **IV** at Healdsburg.

Oct. 30: 23:27. Int. **IV** in West Los Angeles area.

Nov. 3: 22:40:42 (Nov. 4, 06:40). Epicenter 38°50′ N., 122°45′ W., northern California, at a depth of 13 km., mag. 2.9, B. Int. **IV** about 5 km. south of Lakeport. Felt slightly at Lakeport and Upper Lake.

Nov. 8: 16:52:06.0 (Nov. 9, 00:52), 17:18:12.6 (Nov. 9, 01:18). Epicenters (1) 36°48.0′ N., 121°35.2′ W.; (2) 36°51.0′ N., 121°31.6′ W., central California, at a depth of 4 km., mag. 3.1 and 2.6, respectively, B. Int. **IV** (16:52) at Harris Ranch, south of Hollister. Shock at 17:18 was also felt. Int. III (16:52) at Salinas Airport.

Nov. 9: 05:35:52.1 (13:35). Epicenter 36°57.5′ N., 121°36.6′ W., central California, at a depth of 9 km., mag. 3.5, B. Int. **V** at Gilroy and 13 km. northeast of, and La Selva Beach (about 10 km. northeast of Watsonville), where many were awakened. Sharp jolt; loud earth noises at Gilroy. Int. IV at Almaden Winery (about 14½ km. south of Hollister), Morgan Hill, and San Juan Bautista. Int. I–III at Aptos (about 6 km. north of) and Harris Ranch, south of Hollister. Also reported felt at Watsonville.

Nov. 10: 03:19:39.3 (11:19). Epicenter 37°44.3′ N., 122°34.7′ W., near coast of central California, at a depth of 4 km., mag. 2.6, B. Press reported parts of San Francisco and the northern San Francisco Peninsula areas were shaken by a light earthquake.

Nov. 10: 23:07:22.6 (Nov. 11, 07:07). Epicenter 33°50.3′ N., 118°18.0′ W., southern California, at a depth of 8 km., mag. 2.8, P. Int. **IV.** Press reported a weak but widely felt earthquake was noted in parts of the South Bay area. Int. IV at Torrance.

Nov. 10: 23:07:22.6 (Nov. 11, 07:07). Epicenter 33°51.2′ N., 118°16.8′ W., southern California, at a depth of 8 km., mag. 2.9, P. Felt at Torrance.

Nov. 13: 08:22:54.3 (16:22), 11:30, 11:45. Epicenter 34° 11.2′N., 117°13.6′W., southern California, at a depth of 8 km., mag. 3.5, P. Int. **IV.** Generally felt over about 3,120 sq. km. (1,200 sq. mi.). Int. IV at Apple Valley (shocks also felt at 11:30 and 11:45), Calimesa, Crestline, Fawnskin, Gilman Hot Springs, Helendale, Lake Arrowhead, Montclair, Rimforest, San Bernardino, and Winchester. Int. I–III at Bloomington, Blue Jay, Cedarpines Park, Crest Park, Cucamonga, Highland, Lucerne Valley, Lytle Creek, Newport Beach, Rialto, Twin Peaks, Wrightwood, and Yucca Valley.

Nov. 16: 16:46:08 (Nov. 17, 00:46). Epicenter 40.3° N., 124.4° W., northern California, at a depth of 0 to 5 km., mag. 3.1, B. Felt slightly in southern part of Ferndale.

Nov. 21: 01:29:17 (09:29). Epicenter 39°24′ N., 120°16′ W., northern California, at a depth of 2 km., mag. 3.1, B. Int. **IV** at Floriston (north of Lake Tahoe).

Nov. 26: 07:15, 07:35:20 (15:35). Epicenter 39.5° N., 123.2° W., northern California, at a depth of 2 km., mag. 3.1, B. Int. **V.** At Willits, many were awakened.

Felt like a hard sonic boom. Shock also felt at 07:15. Intensity IV at Calpella.

Nov. 30: 22:05:59 (Dec. 1, 06:05). Epicenter 35°23′ N., 121°08′ W., off coast of central California, at a depth of 12 km., mag. 3.3, B. Int. **V.** At Bryson, many were awakened. Int. IV at Lockwood and San Ardo.

Dec. 7: 15:26:50.7 (23:26). Epicenter 38°39.9′ N., 123°04.0′ W., northern California, at a depth of 1 km., mag. 3.2, B. Int. **II** at Windsor.

Dec. 9: 01:35:48 (09:35). Epicenter 40°09′ N., 121°21′ W., northern California, at a depth of 2 km., mag. 3.6, B. Int. **V.** At Caribou (Pacific Gas and Electric camp), many were awakened. Loud earth noises. Intensity IV at Forest Ranch and Storrie. Also felt in vicinity of Rock Creek Dam.

Dec. 30: 05:04:49.0 (13:04). Epicenter 35°47′ N., 117°36′ W., central California, at a depth of 8 km., mag. 4.7, B. Int. **V.** Felt over about 9,100 sq. km. (3,500 sq. mi.) of Kern, San Bernardino, and Tulare Counties. No damage was reported. Many were awakened at Argus, China Lake, Inyokern, Onyx, and Ridgecrest; small objects fell at Argus. A few weak aftershocks were felt at China Lake. Intensity IV at California Hot Springs, Inyokern (about 3 km. north of), Johannesburg, Johnsondale, Piute Mountain area (northeast of Caliente), Randsburg, and Westend.

WASHINGTON AND OREGON

[All times are Pacific standard. If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Feb. 10: 12:21:11.8 (20:21). Epicenter 47.7° N., 122.3° W., northwestern Washington, at a depth of 33 km., mag. 3.9. Int. **V.** Felt over about 3,900 sq. km. (1,500 sq. mi.), principally in the Puget Sound region. No damage resulted. Int. V at Bothell (about 24 km. north-northwest of Seattle) and Richmond Beach (about 3 km. north of Seattle city limits). Int. IV at Annapolis, Baring, Edmonds, Freeland, Gold Bar, Index, Indianola, Mountlake Terrace, Port Orchard, Retsil, Seattle, South Colby, Sultan, and Woodinville. Int. I–III at Dockton, Duvall, Hansville, Kent, Kingston, Olalla, Port Gamble, Preston, Renton, Seattle Heights, and Silverdale. Also reported felt at Bremerton, Harper, and Southworth (press).

May 17: 21:29:54.0 (May 18, 05:29). Epicenter 48.6° N., 122.7° W., northwestern Washington, at a depth of 11 km., mag. 4.0 (m_b). Felt from Orcas Island to Seattle.

Oct. 24: 14:32:07.7 (22:32). Epicenter 47.3° N., 122.4° W., Washington, at a depth of 25 km., mag. 4.2. Int. **V.** Felt over about 5,980 sq. km. (2,300 sq. mi.) of northwestern Washington. The shock did not cause damage. Int. V at Elbe, Milton, and Puyallup. Int. IV at Auburn, Buckley, Burley, Burton, Dash Point, Dockton, Eatonville, Fort Lewis, Gig Harbor, Kapowsin, McChord Air Force Base, Manchester, Olalla, Orting, Olympia, Retsil, Seattle, South Colby, Spanaway, Sumner, Tacoma, and Vashon. Int. I–III at Anderson Island, Du Pont, East Olympia, Kent, La Grande, Lakeview, McMillin, Pacific, Port Orchard, Preston, Redondo, Roy, Seabeck, Vaughn, and Wauna.

ALASKA

[All times are Alaska standard (150° meridian). If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Jan. 5: 19:47:54.8. Mag. 3.5 (Palmer). Int. **III** at Talkeetna.

Jan. 15: 19:23:12.2 (College). Int. **III** in the College-Fairbanks area.

Jan. 15: 22:05:39.6 (Jan. 16, 08:05). Epicenter 60.3° N., 152.7° W., southern Alaska, at a depth [1] of 91 km., mag. 6.1. Int. **V.** Felt over the Cook Inlet and Kenai Peninsula areas and north in the College-Fairbanks area. No damage was reported. Int. V at Soldatna. Int. I–IV at Anchorage, College-Fairbanks area, Homer, Iliamna, Palmer, and Whittier.

[1] Depth was restrained by the computer program based on two or more compatible *pP*-phase arrival times reported and so identified.

Jan. 16: 09:00 (about). Observer at Homer reported a shock awakened him at about 09:00.

Jan. 21: 21:33:24.2 (College). Felt at Fairbanks.

Feb. 5: 19:59:42.4 (College). Felt at Fairbanks.

Feb. 18: 09:20. Int. **IV** at Cape Yakataga.

Feb. 26: 21:07:58.1 (Feb. 27, 07:07). Epicenter 50.1° N., 179.6° W., Andreanof Islands, at a depth of 20 km., mag. 5.9 (M_S). Int. **III** on Amchitka Island.

Feb. 28: 00:52:31.2 (10:52). Epicenter 52.7° N., 175.1° W., Andreanof Islands, at a depth of 162 km., mag. 6.1 (m_b). Int. **III** on Adak and Amchitka Islands.

Mar. 11: 12:38:34.6 (22:38). Epicenter 57.5° N., 153.9° W., Kodiak Island region, at a depth of 29 km., mag. 6.0 (M_S). Int. **V.** A few blocks in a wall cracked on Sitkinak Island. Int. IV at Kodiak.

Mar. 17: 12:00:12.4 (22:00). Epicenter 59.2° N., 147.9° W., Gulf of Alaska, at a depth of 47 km., mag. 4.8 (M_S). Int. **II** on Middleton Island.

Mar. 19: 13:33:29.1 (23:33). Epicenter 51.3° N., 173.8° E., Near Islands, at a depth of 16 km., mag. 6.2 (M_S). Felt strongly on Shemya Island.

Mar. 26: 22:00:52.0 (Palmer). Felt sharply at Seward.

Apr. 3: 10:19:35.8. Mag. 3.2 (Palmer). Int. **II** at Palmer.

Apr. 4: 19:58:31.7 (Apr. 5, 05:58). Epicenter 61.4° N., 152.3° W., southern Alaska, at a depth of 82 km., mag. 3.9 (m_b). Int. **IV** at Tyonek.

Apr. 7: 04:39:20.7 (14:39). Epicenter 61.8° N., 150.0° W., southern Alaska, at a depth of 50 km. Int. **III** at Palmer.

Apr. 10: 18:05:41.1 (Apr. 11, 04:05). Epicenter 59.7° N., 142.7° W., Gulf of Alaska, at a depth of 7 km., mag. 6.2 (M_S). Int. **III** at Yakutat and II at Yakataga.

Apr. 10: 18:19:39.3 (Palmer). Felt at Yakutat and on Middleton Island.

Apr. 15: 19:33:17.5 (Apr. 16, 05:33). Epicenter 59.8° N., 142.6° W., Gulf of Alaska, at a depth of 7 km., mag. 6.8 (M_S). Int. **IV** at Yakataga, III at Yakutat, and II at Cordova.

Apr. 16: 08:19:37.5 (18:19). Epicenter 59.9° N., 142.6° W., Gulf of Alaska, at a depth of 16 km., mag. 4.7. Felt at Yakataga.

Apr. 17: 22:50:40.5 (Apr. 18, 08:50). Epicenter 59.9° N., 152.8° W., southern Alaska, at a depth of 94 km., mag. 5.7 (m_b). Int. **V** at Anchorage (slight damage), Cohoe, and Homer. Int. I–III at Chitina, Cordova, Glennallen (Mile 182, Glenn Highway), Kodiak, Middleton Island, and Palmer.

Apr. 18: 15:15:46.8 (Apr. 19, 01:15). Epicenter 59.6° N., 142.8° W., Gulf of Alaska, at a depth [2] of 20 km., mag. 6.0 (M_S). Felt at Yakutat.

Apr. 24: 22:35:10.6 (Apr. 25, 08:35). Epicenter 65.5° N., 150.0° W., Alaska, at a restricted depth of 33 km., mag. 3.2 (m_b). Felt at College.

May 1: 10:58:12.5 (20:58). Epicenter 63.6° N., 149.4° W., central Alaska, at a depth of 33 km., mag. 4.2. Int. **IV** at Nenana and III at Summit. Also felt at Healy.

May 10: 11:32:53.2 (21:32). Epicenter 61.7° N., 150.0° W., southern Alaska, at a depth of 55 km., mag. 3.7 (m_b). Int. **IV** at Wasilla, III at Palmer, and II at Anchorage.

June 1: 16:59:31.3 (June 2, 02:59). Epicenter 61.6° N., 151.7° W., southern Alaska, at a depth [3] of 95 km., mag. 5.5 (m_b). Int. **IV** at Anchorage. Felt strongly at Palmer and Talkeetna.

June 9: 10:10:19.1 (20:10). Epicenter 64.9° N., 148.8° W., central Alaska, at a depth of 16 km., mag. 4.1. Felt at Dunbar and Fairbanks.

June 19: 06:38:57.1 (Palmer). Felt at Palmer.

June 19: 13:11:43.5 (23:11). Epicenter 60.3° N., 151.5° W., Kenai Peninsula, at a depth of 62 km., mag. 3.8 (m_b). Felt at Soldatna.

---

[2] Based on evidence from available seismograms, depth was restrained by an ERL geophysicist.

[3] See footnote 1, page 29.

July 3: 22:47:45.3 (July 4, 08:47). Epicenter 61.5° N., 149.4° W., southern Alaska, at a depth of 40 km., mag. 3.8 (m_b). Int. **III** at Anchorage.

July 6: 01:32:39.7 (11:32). Epicenter 64.8° N., 147.4° W., central Alaska, at a depth of 25 km., mag. 3.7. Int. **IV** at College.

July 13: 06:00:41.4 (16:00). Epicenter 60.4° N., 152.0° W., southern Alaska, at a depth of 104 km., mag. 4.8 (m_b). Felt on Kenai Peninsula and on the oil platforms in Upper Cook Inlet.

July 17: 15:48:38.9 (July 18, 01:48). Epicenter 51.4° N., 178.5° W., Andreanof Islands, at a depth of 46 km., mag. 5.9 (M_S). Felt strongly on Adak Island (press).

July 17: 16:39:59.4 (July 18, 02:39). Epicenter 51.0° N., 178.4° W., Andreanof Islands, at a restricted depth of 33 km., mag. 4.4 (m_b). Felt strongly on Adak Island (press).

July 19: 06:14:50.5. Mag. 3.3 (Palmer). Felt at Palmer.

July 20: 03:34:54.6 (College). Felt in Fairbanks area.

July 29: 16:16:08.8 (July 30, 02:16). Epicenter 60.6° N., 148.6° W., Kenai Peninsula, at a depth of 24 km., mag. 4.7. Felt at Anchorage.

Aug. 1: 23:01:05.4 (Aug. 2, 09:01). Epicenter 51.7° N., 176.9° W., Andreanof Islands, at a depth of 52 km., mag. 4.0 (m_b). Int. **IV** on Adak Island.

Aug. 12: 00:41:12.9 (10:41). Epicenter 51.4° N., 179.2° W., Andreanof Islands, at a depth of 37 km., mag. 5.0. Int. **II** on Adak Island.

Aug. 13: 13:03:40.4 (23:03). Epicenter 51.8° N., 175.5° W., Andreanof Islands, at a depth of 63 km., mag. 4.1 (m_b). Int. **I** on Adak Island.

Aug. 13: 13:04:04.5. Mag. 4.4 (Adak). Int. **I** on Adak Island.

Aug. 13: 17:39:33.5 (Aug. 14, 03:39). Epicenter 64.9° N., 147.8° W., central Alaska, at a depth [4] of 19 km., mag. 5.6. Int. **V** at College, Eielson Air Force Base, Fairbanks (minor glass breakage reported by press), and Nenana. An observer at College reported a friend heard a lot of noise, and observed cracks in the ground along the Chena River at Chena Pump Road picnic area. Int. IV at Livengood and 17 Mile, Nenana Road (shock also felt later). Int. I–III at Central, Fort Greeley, and Wiseman.

Aug. 13: 19:56:07.7 (Aug. 14, 05:56). Epicenter 64.7° N., 147.7° W., central Alaska, at a depth [4] of 15 km., mag. 4.0. Felt strongly at Fairbanks.

Aug. 15: 07:52:06.0 (College). Felt at College.

Aug. 16: 07:27:39.0 (College). Felt at College.

Aug. 18: 06:07:20.3 (16:07). Epicenter 64.7° N., 147.5° W., central Alaska, at a depth [4] of 15 km., mag. 3.4. Int. **IV** at Fairbanks. Int. III at Eielson Air Force Base.

Aug. 18: 07:52:06.3 (17:52). Epicenter 60.7° N., 145.4° W., southern Alaska, at a depth of 16 km., mag. 5.9. Int. **IV** at Anchorage and Cordova. Int. I at Palmer.

Aug. 24: 02:43:34.6 (Palmer). Felt at Kodiak.

Aug. 28: 12:08:18.5 (College). Felt at College.

Aug. 29: 06:40. Int. **IV** at Anchorage.

Aug. 29: 12:20:12.7 (College). Felt at College.

Aug. 30: 07:29. Int. **IV** at Nome.

Sept. 2: 12:04:07.9 (22:04). Epicenter 64.6° N., 150.9° W., central Alaska, at a depth of 16 km., mag. 4.6. Int. **IV** at Manley Hot Springs. Also felt at College.

Sept. 2: 19:04. Int. **IV** in Cape Romanzof area (61°47′ N., 166°02′ W.).

Sept. 2: 22:52:20.8 (Sept. 3, 08:52). Epicenter 64.6° N., 150.9° W., central Alaska, at a depth of 14 km., mag. 4.6. Felt at College.

Sept. 16: 16:41:39.0 (Sept. 17, 02:41). Epicenter 62.8° N., 150.4° W., central Alaska, at a depth of 94 km., mag. 3.9 (m_b). Int. **II** at Palmer.

Sept. 18: 16:25:31.0 (Sept. 19, 02:25).

[4] See footnote 2, page 30.

Epicenter 60.9° N., 151.5° W., Kenai Peninsula, at a depth of 66 km., mag. 4.6 (m_b). Felt at Anchorage.

Sept. 23: 11:02:54.6 (21:02). Epicenter 51.4° N., 179.4° W., Andreanof Islands, at a depth of 43 km., mag. 5.2 (m_b). Int. **II** on Adak and Amchitka Islands.

Sept. 23: 11:07:20.0 (Palmer). Int. **II** on Adak Island.

Sept. 23: 12:59:00.7 (22:59). Epicenter 64.8° N., 147.7° W., central Alaska, at a depth of 15 km. Felt at College.

Oct. 4: 11:14:51.3 (21:14). Epicenter 51.6° N., 178.9° E., Rat Islands, at a depth of 67 km., mag. 3.5 (m_b). Felt on Amchitka Island.

Oct. 9: 01:07:20.2 (11:07). Epicenter 51.4° N., 178.4° W., Andreanof Islands, at a depth of 41 km., mag. 5.2 (m_b). Int. **I** on Adak Island.

Oct. 11: 09:30. Int. **III** in the Alsek River area (about 8 km. inland from coast on the Alsek River, and about 104 km. southeast of Yakutat).

Oct. 15: 21:03:26.5 (Oct. 16, 07:03). Epicenter 62.0° N., 146.6° W., central Alaska, at a depth of 44 km., mag. 3.9 (m_b). Int. **III** at Gulkana (airport).

Oct. 21: 07:56:10.1 (17:56). Epicenter 62.4° N., 151.1° W., central Alaska, at a depth of 102 km. Felt at Palmer.

Oct. 26: 03:49:06.3 (13:49). Epicenter 61.5° N., 145.9° W., southern Alaska, at a depth of 45 km., mag. 4.7 (m_b). Int. **IV** at Valdez.

Oct. 26: 07:30:08.1 (College). Felt at Fairbanks.

Oct. 31: 04:27:04.5 (Adak). Int. **I** on Adak Island.

Oct. 31: 05:51:38.4 (15:51). Epicenter 62.2° N., 148.7° W., central Alaska, at a depth of 44 km., mag. 4.2 (m_b). Felt at Palmer.

Oct. 31: 06:08:41.7 (16:08). Epicenter 51.2° N., 179.4° W., Andreanof Islands, at a depth of 39 km., mag. 5.0 (m_b). Int. **I** on Adak Island.

Nov. 1: 07:12:00.7 (17:12). Epicenter 60.3° N., 154.2° W., southern Alaska, at a depth of 182 km., mag. 4.4 (m_b). Felt at Anchorage and Palmer, and widely felt over Cook Inlet area.

Nov. 2: 16:30:11.4 (Nov. 3, 02:30). Epicenter 62.0° N., 151.2° W., central Alaska, at a depth of 70 km., mag. 5.6 (m_b). Int. **V** at Talkeetna. Int. IV at Lake Minchumina and Summit. Int. III at Anchorage and Palmer.

Nov. 3: 13:03:13.6 (23:03). Epicenter 62.0° N., 150.7° W., central Alaska, at a depth of 57 km., mag. 3.7 (m_b). Felt at Palmer.

Nov. 13: 02:28:12.2 (College). Felt at College.

Nov. 13: 03:10:25.4 (13:10). Epicenter 51.6° N., 175.3° W., Andreanof Islands, at a depth of 51 km., mag. 4.9 (m_b). Int. **I** on Adak Island.

Nov. 13: 22:26:51.2 (College). Felt at Fairbanks.

Nov. 20: 01:13:07.3 (11:13). Epicenter 51.4° N., 178.3° W., Andreanof Islands, at a depth [5] of 34 km., mag. 4.8. Int. **I** on Adak Island.

Nov. 20: 20:54:41.8. Mag. 3.6 (Palmer). Felt at Palmer.

Nov. 30: 08:19:06.1 (18:19). Epicenter 59.7° N., 150.6° W., Kenai Peninsula, at a depth of 50 km., mag. 4.0 (m_b). Felt at Diamond Ridge and Homer.

Dec. 1: 11:09:37.2 (21:09). Epicenter 51.4° N., 175.3° W., Andreanof Islands, at a depth of 36 km., mag. 5.8 (M_S). Int. **II** on Adak Island.

Dec. 1: 16:34:59.5 (Dec. 2, 02:34). Epicenter 51.4° N., 175.2° W., Andreanof Islands, at a depth of 57 km., mag. 5.4 (m_b). Int. **I** on Adak Island.

Dec. 1: 23:03:14.6 (Dec. 2, 09:03). Epicenter 51.4° N., 175.2° W., Andreanof Islands, at a depth of 52 km., mag. 5.2 (m_b). Int. **I** on Adak Island.

Dec. 6: 13:06:43.0 Mag. 4.3 (Adak). Int. **I** on Adak Island.

Dec. 14: 17:44:01.5 (Dec. 15, 03:44).

[5] See footnote 1, page 29.

Epicenter 52.4° N., 176.2° W., Andreanof Islands, at a depth of 189 km., mag. 4.8 (m_b). Int. **I** on Adak Island.

Dec. 19: 20:01:36.1 (Dec. 20, 06:01). Epicenter 63.1° N., 151.4° W., central Alaska, at a depth of 130 km., mag. 5.3 (m_b). Felt at Anchorage, Palmer, and in the Susitna Valley area.

Dec. 23: 22:22:20.8 (Dec. 24, 08:22). Epicenter 51.5° N., 178.3° W., Andreanof Islands, at a depth of 53 km., mag. 5.3 (m_b). Int. **III** on Adak Island.

Dec. 25: 04:43:41.0 (14:43). Epicenter 51.8° N., 175.2° W., Andreanof Islands, at a depth of 64 km., mag. 4.7 (m_b). Int. **I** on Adak Island.

Dec. 27: 16:56:57.5 (Dec. 28, 02:56). Epicenter 61.6° N., 149.6° W., southern Alaska, at a depth of 47 km., mag. 3.8 (m_b). Felt at Palmer.

HAWAII [1]

[All times are Hawaiian standard. If an epicenter is quoted, Greenwich mean time is given in parentheses. Listing includes felt events with magnitude determinations of 3.0 or greater.]

Jan. 2: 12:20:32.6 (22:20). Epicenter 19°23.0′ N., 155°36.5′ W., at a depth of 11 km., mag. 3.3. Felt at Kealakekua.

Jan. 27: 09:09:09.1 (19:09). Epicenter 19°16.9′ N., 155°05.9′ W., at a depth of 4 km., mag. 3.8. Felt at Hilo and Mountain View.

Feb. 4: 06:08:25.2 (16:08). Epicenter 19°22.4′ N., 155°18.2′ W., at a depth of 28 km., mag. 3.1. Felt at Pahala.

Feb. 5: 00:20:53.3 (10:20). Epicenter 19°20.4′ N., 155°28.4′ W., at a depth of 8 km., mag. 3.5. Felt at Pahala.

Feb. 17: 20:42:35.2 (Feb. 18, 06:42). Epicenter 19°22.3′ N., 155°16.2′ W., at a depth of 27 km., mag. 3.4. Felt at Pahala.

Mar. 2: 14:30:02.9 (Mar. 3, 00:30). Epicenter 20°04.9′ N., 155°39.6′ W., at a depth of 8 km., mag. 4.0. Felt at Hilo, Laupahoehoe, Pahala, and Pahoa.

Mar. 18: 06:23:30.7 (16:23). Epicenter 19°22.7′ N., 155°03.4′ W., at a depth of 7 km., mag. 4.1. Felt at Hilo and Paauilo.

Mar. 19: 08:46:20.0 (18:46). Epicenter 19°20.5′ N., 155°16.8′ W., at a depth of 30 km., mag. 3.0. Felt at Paauilo.

Mar. 30: 02:35:26.7 (12:35). Epicenter 19°31.7′ N., 155°15.4′ W., at a depth of 28 km., mag. 4.3. Felt over eastern half of the Island.

Mar. 31: 22:30:02.3 (Apr. 1, 08:30). Epicenter 19°19.0′ N., 155°03.2′ W., at a depth of 7 km., mag. 3.8. Felt at Pahala.

Apr. 12: 09:13:43.7 (19:13). Epicenter 19°22.9′ N., 155°25.3′ W., at a depth of 11 km., mag. 4.3. Felt at Hilo and Pahala.

Apr. 14: 11:07:57.4 (21:07). Epicenter 19°27.4′ N., 155°14.4′ W., at a depth of 24 km., mag. 3.6. Felt in Kilauea Summit area.

Apr. 16: 02:25:33.5 (12:25). Epicenter 19°18.8′ N., 155°15.0′ W., at a depth of 28 km., mag. 3.2. Felt at Pahala.

Apr. 17: 12:12:13.6 (22:12). Epicenter 19°31.6′ N., 155°55.5′ W., at a depth of 10 km., mag. 4.1. Felt at Holualoa and Kealakekua.

Apr. 19: 05:30:38.8 (15:30). Epicenter 19°15.7′ N., 155°25.6′ W., at a depth of 26 km., mag. 3.2. Felt at Pahala.

Apr. 28: 15:23:05.3 (Apr. 29, 01:23). Epicenter 19°26.7′ N., 154°54.9′ W., at a depth of 2 km., mag. 3.5. Felt at Pahoa.

Apr. 30: 06:07:01.6 (16:07). Epicenter 19°22.3′ N., 155°07.8′ W., at a depth of 11 km., mag. 3.9. Felt over eastern half of the Island.

May 1: 09:00:59.2 (19:00). Epicenter 20°03.8′ N., 155°53.1′ W., at a depth of 4 km., mag. 3.7. Felt at Kamuela.

May 2: 08:47:33.9 (18:47). Epicenter 19°29.5′ N., 155°17.4′ W., at a depth of 17 km., mag. 3.0. Felt at Hilo.

May 6: 06:21:38.7 (16:21). Epicenter 19°18.0′ N., 155°15.3′ W., at a depth of 8 km., mag. 3.2. Felt at Hilo.

May 10: 05:30:53.2 (15:30). Epicenter

[1] Prepared by Robert Y. Koyanagi, Hawaiian Volcano Observatory, U.S. Department of the Interior, Geological Survey, Hawaii National Park, Hawaii.

19°22.8′ N., 155° 03.8′ W., at a depth of 9 km., mag. 4.1. Felt over eastern half of the Island.

May 13: 15:12:57.1 (May 14, 01:12). Epicenter 19°23.5′ N., 155°25.3′ W., at a depth of 8 km., mag. 3.2. Felt at Pahala.

May 15: 05:55:57.9 (15:55). Epicenter 19°22.6′ N., 155°14.4′ W., at a depth of 4 km., mag. 3.2. Felt in Kilauea Summit area.

May 15: 06:52:15.4 (16:52). Epicenter 19°23.1′ N., 155°14.2′ W., at a depth of 3 km., mag. 3.0. Felt at Hilo.

May 15: 11:04:26.5 (21:04). Epicenter 19°19.2′ N., 155°13.6′ W., at a depth of 10 km., mag. 3.8. Felt at Hilo.

May 15: 23:59:49.3 (May 16, 09:59). Epicenter 19°23.6′ N., 155°14.3′ W., at a depth of 5 km., mag. 3.6. Felt in Kilauea Summit area.

June 11: 11:22:22.4 (21:22). Epicenter 19°22.1′ N., 155°16.9′ W., at a depth of 31 km., mag. 3.6. Felt at Pahala.

June 17: 14:57:31.8 (June 18, 00:57). Epicenter 19°19.0′ N., 155°24.5′ W., at a depth of 9 km., mag. 3.4. Felt at Pahala.

June 22: 12:38:42.1 (22:38). Epicenter 19°22.5′ N., 155°25.7′ W., at a depth of 10 km., mag. 4.2. Felt over southern half of the Island.

July 10: 21:40:12.5 (July 11, 07:40). Epicenter 19°22.9′ N., 155°04.0′ W., at a depth of 6 km., mag. 3.2. Felt at Kalapana.

July 10: 21:52:32.4 (July 11, 07:52). Epicenter 19°25.5′ N., 155°04.5′ W., at a depth of 9 km., mag. 3.1. Felt at Kalapana.

July 15: 16:12:19.6 (July 16, 02:12). Epicenter 19°19.2′ N., 155°06.6′ W., at a depth of 6 km., mag. 3.5. Felt at Hilo.

July 22: 16:15:58.1 (July 23, 02:15). Epicenter 19°59.3′ N., 155°24.1′ W., at a depth of 11 km., mag. 3.8. Felt at Honokaa, Paauilo, and Papaikou.

Aug. 7: 10:23:08.0 (20:23). Epicenter 19°54.0′ N., 155°22.8′ W., at a depth of "0" km., mag. 3.7. Felt at Hilo, Honakaa, Paauhau, and Paaiulo.

Aug. 16: 07:41:53.1 (17:41). Epicenter 19°25.5′ N., 154°47.7′ W., at a depth of 51 km., mag. 4.4. Felt at Hilo.

Aug. 17: 23:28:00.5 (Aug. 18, 09:28). Epicenter 19°19.5′ N., 155°16.0′ W., at a depth of 32 km., mag. 3.5. Felt at Pahala.

Sept. 21: 01:26:36.1 (11:26). Epicenter 19°20.0′ N., 155°12.3′ W., at a depth of 10 km., mag. 4.5. Felt Islandwide.

Sept. 26: 14:37:17.7 (Sept. 27, 00:37). Epicenter 19°25.0′ N., 155°27.0′ W., at a depth of 10 km., mag. 3.4. Felt at Pahala.

Oct. 6: 20:17:58.9 (Oct. 7, 06:17). Epicenter 19°21.8′ N., 155°17.3′ W., at a depth of 32 km., mag. 3.0. Felt at Pahala.

Oct. 8: 06:13:04.5 (16:13). Epicenter 19°21.3′ N., 155°07.2′ W., at a depth of 4 km., mag. 3.3. Felt at Hilo.

Oct. 13: 08:40:01.0 (18:40). Epicenter 19°28.9′ N., 155°14.7′ W., at a depth of 27 km., mag. 3.3. Felt at Pahala.

Oct. 25: 08:32:52.8 (18:32). Epicenter 19°18.1′ N., 155°14.5′ W., at a depth of 36 km., mag. 4.2. Felt at Hilo.

Oct. 25: 09:55:28.0 (19:55). Epicenter 21°00.6′ N., 156°49.1′ W., at a depth of 8 km., mag. 4.9. Felt on (north) Hawaii, Maui, and Molokai.

Oct. 29: 07:47:30.6 (17:47). Epicenter 19°31.2′ N., 156°26.2′ W., at a depth of 10 km., mag. 4.0. Felt at Kamuela and Kula (Island of Maui).

Oct. 30: 18:50:57.4 (Oct. 31, 04:50). Epicenter 19°16.7′ N., 155°05.0′ W., at a depth of "0" km., mag. 3.2. Felt at Hilo.

Nov. 11: 17:12:41.4 (Nov. 12, 03:12). Epicenter 19°12.2′ N., 155°20.5′ W., at a depth of 37 km., mag. 3.7. Felt at Pahala.

Nov. 12: 19:46:13.8 (Nov. 13, 05:46). Epicenter 20°05.5′ N., 155°50.4′ W., at a depth of 20 km., mag. 4.3. Felt over northern half of Island.

Nov. 12: 19:57:19.1 (Nov. 13, 05:57). Epicenter 20°06.5′ N., 155°51.4′ W., at a depth of 20 km., mag. 3.2. Felt at Kamuela.

Nov. 12: 21:36:00.3 (Nov. 13, 07:36). Epicenter 20°06.8′ N., 155°50.1′ W., at a depth of 15 km., mag. 3.2. Felt at Kamuela.

Nov. 16: 04:02:51.6 (14:02). Epicenter

19°20.1′ N., 155°06.4′ W., at a depth of 5 km., mag. 3.3. Felt at Hilo and Keaau.

Nov. 18: 06:07:57.8 (16:07). Epicenter 19°52.3′ N., 155°46.8′ W., at a depth of "0" km., mag. 3.4. Felt at Kamuela.

Dec. 4: 16:45:31.1 (Dec. 5, 02:45). Epicenter 19°12.9′ N., 155°21.8′ W., at a depth of 2 km., mag. 3.3. Felt at Pahala.

Dec. 4: 21:50:40.1 (Dec. 5, 07:50). Epicenter 19°12.8′ N., 155°21.5′ W., at a depth of 5 km., mag. 3.3. Felt at Pahala.

Dec. 5: 17:59:45.1 (Dec. 6, 03:59). Epicenter 19°23.2′ N., 155°37.1′ W., at a depth of 12 km., mag. 4.0. Felt at Hilo, Kealakekua, and Kilauea Summit area.

Dec. 10: 20:28:05.9 (Dec. 11, 06:28). Epicenter 19°23.4′ N., 155°22.1′ W., at a depth of 9 km., mag. 3.6. Felt at Hilo and Pahala.

Dec. 13: 08:02:06.4 (18:02). Epicenter 19°41.4′ N., 156°05.2′ W., at a depth of 17 km., mag. 3.6. Felt at Kailua, Kona, and Kealakekua.

Dec. 20: 20:44:16.8 (Dec. 21, 06:44). Epicenter 20°12.1′ N., 155°14.6′ W., at a depth of 11 km., mag. 3.0. Felt at Paauilo.

Dec. 25: 15:43:11.1 (Dec. 26, 01:43). Epicenter 19°26.1′ N., 155°15.7′ W., at a depth of 5 km., mag. 3.0. Felt in Kilauea Summit area.

PANAMA CANAL ZONE

[All times are eastern standard. If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Jan. 9: 19:33:28.1 (Jan. 10, 00:33). Epicenter 9.5° N., 78.3° W., Panama, at a depth of 58 km., mag. 4.8 (m_b). Int. **II** at Balboa.

July 7: 21:07:11.9 (July 8, 02:07). Epicenter 9.8° N., 78.1° W., Panama, at a depth of 33 km., mag. 4.5 (m_b). Int. **II at** Balboa.

July 21: 08:28:00.7 (BHP). Int. **III** at Balboa Heights.

Dec. 4: 04:51:16.1 (09:51). Epicenter 9.8° N., 79.7° W., Panama, at a depth of 20 km., mag. 5.2 (M_S). Int. **IV** at Balboa.

PUERTO RICO

[All times are 60th Meridian.]

Jan. 6: 19:37:22.8 (San Juan). Felt at Rio Piedras.

Feb. 13: 06:54:56.7 (San Juan). Int. **IV** on Culebra (about 40 km. off the east coast of Puerto Rico) and San Juan. Int. I–III at Caguas, Cayey, Ceiba, and Humacao.

July 14: 21:17:37.3 (San Juan). Felt at Caguas and Cayey.

Aug. 20: 13:00:31.9 (San Juan). Felt at San Juan.

VIRGIN ISLANDS

[All times are 60th meridian. If an epicenter is quoted, Greenwich mean time is given in parentheses.]

Apr. 18: 02:42:00.6 (06:42). Epicenter 18.7° N., 62.7° W., Leeward Islands, at a depth [1] of 25 km., mag. 4.4 (m_b). Felt on St. Thomas Island.

Apr. 23: 11:55:33.4 (15:55). Epicenter 18.8° N., 64.3° W., Virgin Islands, at a depth of 14 km., mag. 4.4 (m_b). Int. **V** at the National Park Service Visitor's Center on St. John Island (Cruz Bay), where bookcases and furniture moved; small objects shifted. Also felt at Charlotte Amalie, St. Thomas Island.

July 8: 00:49:10.6 (04:49). Epicenter 18.0° N., 64.6° W., Virgin Islands, at a depth of 150 km., mag. 5.8 (m_b). Int. **V.** Felt strongly in the Virgin Islands, on Puerto Rico, and in the Dominican Republic. Minor damage occurred on Puerto Rico. On St. John Island, V.I., underground pipes were reportedly damaged (unsubstantiated). Press reported dishes and flowerpots were broken on Puerto Rico and in the Virgin Islands. At San Juan, P.R., felt sharply by people on top floors of high-rise hotels: beds moved. Many people rushed into the streets. Felt by women aquanauts submerged 15 meters in Great Lameshur Bay, V.I., but there was no damage to equipment. At Santo Domingo,

[1] Based on evidence from available seismograms, depth was restrained by an ERL geophysicist.

Dominican Republic, officials reported power was knocked out for a short time, and a woman was slightly injured when part of a very old rain-damaged house was knocked down. Int. V in Virgin Islands at Caneel Bay Plantation (St. John Island) and Frenchman's Bay (St. Thomas Island); on Puerto Rico at Caguas, Guayanilla (Central San Francisco), Guaynabo, Gurabo, Maunabo, Orocovis, Roosevelt Roads (U.S. Naval Station), and San Juan. Int. IV in Virgin Islands at Cruz Bay (St. John Island); on Puerto Rico at Arecibo, Bayamon (Torrimar), Culebra, Humacao (Centro Ciudad), Morovis, Rio Piedras, and Santurce.

Nov. 8: 19:10:56.9 (23:10). Epicenter 18.6° N., 64.7° W., Virgin Islands, at a depth of 66 km., mag. 4.9 (m_b). Int. **IV** at Caneel Bay Plantation and Lind Point, St. John Island. Int. II at Frenchman's Bay, St. Thomas Island. Also reported felt at San Juan International Airport and Humacao, P.R.

TABLE 1.- *Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*

[These earthquakes were not reported felt by residents in the immediate areas and therefore are not listed in the preceding sections of this report.]

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Jan. 8	17	00	33.2	34.4	121.7	Off coast of California. Mag. 4.2, B	N	4.4			0.8	18
9	07	41	16.0	52.8	168.8	Fox Islands	50	4.0			0.8	12
10	04	21	42.7	59.4	145.0	Gulf of Alaska. Mag. 4¼, Pal	N	4.9		4.9	1.1	48
13	04	22	08.3*	51.7	175.7	Andreanof Islands	45	4.0			1.2	10
14	18	44	19.3	37.5	118.3	California-Nevada border region	5 G				0.7	14
14	20	28	02.2	59.6	153.8	Southern Alaska	104	4.3			0.8	16
15	10	39	30.3	53.3	166.8	Fox Islands	37	4.3			0.7	20
15	12	56	06.5	53.3	166.8	....do	69	4.1			1.0	24
15	18	11	16.5*	37.5	118.3	California-Nevada border region	5 G				0.6	8
16	12	51	34.6*	51.4	175.8	Andreanof Islands	63	4.0			0.5	23
17	08	39	16.1	39.4	118.1	Nevada	5 G	3.6			0.5	9
17	20	11	19.6	53.3	173.6	Andreanof Isalnds	230	3.8			0.9	16
19	12	11	18.7	47.9	114 3	Montana	18	4.0			0.7	8
20	00	38	24.3	53.8	163.5	Unimak Island region	N	5.1			1.2	50
20	06	32	43.5*	53.7	163.6	....do	N	4.1			0.8	12
21	13	45	52.7*	39.0	118.2	Nevada	10 G				0.3	5
21	17	13	27.9	39.0	118.2	....do	4				0.9	11
22	03	55	32.6	51.2	177.3 E.	Rat Islands	38	5.3	5.5		1.1	96
22	12	49	23.0	39.6	110.4	Utah. Coal bump	1	4.0			1.5	13
23	03	31	29.0	53.8	163.6	Unimak Island region	N	5.1	4.8		1.1	69
23	03	44	16.2*	53.9	163.6	....do	N	4.0			1.0	16
23	06	55	45.9	53.8	163.5	....do	16	4.4			1.0	30
23	16	30	00.0A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 4.6, P; 4.4, B	0	4.6			0.0	17
25	20	21	23.1	37.6	118.7	California-Nevada border region	5 G				0.6	10
26	19	10	32.7*	53.9	163.5	Unimak Island region	N	3.9			1.1	9
26	23	51	44.1	53.8	165.5	Fox Islands	51	4.4			1.0	29
27	12	31	22.5*	60.0	152.8	Southern Alaska	123				0.6	7
30	09	15	34.9	61.5	146.6	....do	N	3.9		4.1	0.9	14
30	17	00	00.1A	37.0	116.0	Southern Nevada. Nevada Test Site. Mag. 4.7, P	0	4.6			0.0	26
30	19	59	30.6	51.3	178.6	Andreanof Islands	39	4.3			0.7	16

See footnotes at end of table.

TABLE 1.—*Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat	W. Long.							
	h.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Feb. 2	02	55	44.9	61.9	151.3	Southern Alaska	24			3.3	1.0	12
2	08	11	51.7	64.2	149.1	Central Alaska	19			3.0	0.1	7
2	23	53	26.7	64 3	149.6	....do	N			3.0	0.8	9
3	05	59	35 6*	37.9	108.3	Colorado	N	4.0			0 9	5
3	06	12	34.7	60.3	152.2	Southern Alaska	104	3.3			0.6	16
4	08	17	47.0	60 1	152.4	... do	99	3.6			0.7	16
4	17	00	00.0A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 5.8, P; 5.5, B	0	5.6			0.0	93
5	15	00	00.0A	37.2	116.0	Southern Nevada. Nevada Test Site. Mag. 4.7, P; 4.5, B	0	4.7			0.0	29
5	19	37	04.0A	37 2	116 0	Southern Nevada. Nevada Test Site. Collapse	0	4.3			0.0	19
6	06	04	39.7*	51.6	179.6	Andreanof Islands	75	3.8			0.4	8
6	09	04	55 1	62 8	149.0	Central Alaska	81				0.5	13
7	00	23	37.5*	52.1	178.3 E.	Rat Islands	136	4.5			0.7	24
8	01	23	30.5*	59.6	153.6	Southern Alaska	95	4.3			0.8	13
8	09	48	55.9	60.1	152.4	....do	89	3.4			0.6	15
8	19	17	11.0	50.6	172.4	Andreanof Islands	15	5.0			0.9	36
9	01	56	21.3*	44.6	112.4	Eastern Idaho	N				0.7	6
9	11	53	44.9*	64.6	154 5	Central Alaska	81				0.9	12
9	16	00	44.9	35.8	120.3	Central California	3				1.1	14
9	16	29	47.0	59.8	152.4	Southern Alaska	98				0.5	13
11	03	15	37.6*	64.2	147.5	Central Alaska	120	3.6			0.5	13
11	19	15	00.0A	37.2	116.2	Southern Nevada. Nevada Test Site. Mag. 4.8, P; 4.5, B	0	4.6			0.0	23
12	13	23	58.5	36.6	116.3	California-Nevada border region	3				0.0	10
14	15	44	56.4*	36.2	120.5	Central California	1				0.7	11
18	12	56	00.0	52.1	175.5 E.	Rat Islands	59	5.0			0.9	60
20	17	56	04.7*	51.8	177.9 E.	....do	80	4.5			0.6	19
21	06	13	45.9	39.4	110.6	Utah. Coal bump	0 G	4.1			1.0	7
21	09	57	35.0*	52.7	167.7	Fox Islands	21	3.7			0.6	8
22	20	53	55.8*	59.7	153.1	Southern Alaska	121	3.5			0.9	13
23	07	25	18.2	51.3	177.4	Andreanof Islands	44	4.1			0.8	16
23	07	52	11.9	34.5	121.8	Off coast of California. Mag. 3.8, B	10 G	4.3			0.0	19

24	08	05	39.6	59.6	143.9	Gulf of Alaska. Mag. 5¾–6, Gol	15	5.0	5.6	5.4	1.3	47
24	17	31	55.7	53.8	163.1	Unimak Island region	25	4.4			0.7	24
25	14	28	38.0A	37.0	116.0	Southern Nevada. Nevada Test Site	0	5.2			0.0	57
25	18	59	40.7	59.8	148.5	Kenai Peninsula	7				0.2	8
26	05	58	18.5	51.2	170.0	Fox Islands	N	4.4			0.8	25
26	08	36	47.4	37.3	118.1	California-Nevada border region	11				0.9	9
26	09	01	05.3	37.2	118.2	....do	10 G				0.9	10
26	15	30	00.0A	37.1	116.1	Southern Nevada. Nevada Test Site. Mag. 5.2, P; 4.8, B	0	5.3			0.0	70
27	07	17	51.7	50.1	179.8	Andreanof Islands	25	5.0			0.7	28
27	07	49	33.4	50.1	179.6	....do	38	4.2			0.9	24
27	07	50	28.7	50.0	179.7	....do	35	4.8			0.9	22
27	08	18	02.0	50.1	179.6	....do	18	4.6			0.7	44
27	08	54	25.4	50.2	179.7	....do	N	4.8			0.7	37
27	10	05	45.7	50.0	179.8	....do	24	4.5			0.6	38
27	18	52	05.6	50.1	179.9	....do	24	4.2			0.7	23
28	00	19	02.6	51.5	178.9	....do	45	4.9			0.9	16
28	01	49	31.6*	50.1	179.8	....do	33	4.1			0.9	12
28	02	44	42.5*	50.1	179 6	....do	9	4.0			0.7	11
28	03	55	58.6*	50.0	179.8	....do	N	4.0			0.8	12
28	05	55	52.0*	50.1	179.8	....do	N	4.0			0.5	10
28	06	56	49.9	63.1	150.6	Central Alaska	120	4.1			0.7	17
Mar. 1	04	14	15.2	35.9	118.1	Central California	5				0.4	11
1	15	08	42.5	60.3	148.2	Kenai Peninsula	N	3.8		3.9	1.0	16
2	02	38	53.1	59.8	144.5	Gulf of Alaska	N	4.0		4.1	0.6	12
2	03	03	41.1*	50.1	179.7	Andreanof Islands	N	4.1			0.8	12
2	04	57	42.4	52.8	167.4	Fox Islands	N	4.3			0.8	20
6	14	24	00.9A	37.2	116.1	Southern Nevada. Nevada Test Site. Mag. 4.8, P; 4.2, B	0	4.5			0.0	18
6	15	00	00.2A	37.1	116.0	Southern Nevada. Nevada Test Site, Mag. 4.3, P; 4.1, B	0	4.3			0.0	12
6	17	57	28.2*	50.5	179.9	Andreanof Islands	35	4.0			0.4	9
7	21	50	46.5	59.8	144.5	Gulf of Alaska	N	4.2		4.3	0.9	16
8	01	01	10.6*	50.2	179.7	Andreanof Islands	N	4.0			0.8	6
8	01	11	40.3*	50.1	179.7	....do	26	4.2			0.6	10
8	17	09	58.2	59.8	144.4	Gulf of Alaska	24	4.0		4.3	1.0	12
8	19	00	31.0	52.2	169.7	Fox Islands	32	4.4			0.9	18
9	11	49	13.7	62.5	149.4	Central Alaska	70	3.3			0.9	20
10	00	17	18.4	59.8	144.3	Gulf of Alaska	N	3.9		4.1	1.0	19
10	10	21	58.1*	50.1	180.0	Andreanof Islands	25	3.3			0.2	8
10	10	57	34.6*	67.5	157.1	Alaska	N	3.5			0.6	13

See footnotes at end of table.

TABLE 1.—*Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Mar. 10	20	58	14.4P	35.8	118.1	Central California. 35°47.6′ N., 118°03.9′ W. Mag. 3.3, P	10				0.0	18
11	07	18	53.4*	59.4	144.0	Gulf of Alaska	N	4.0		3.7	1.2	8
11	10	22	46.3	50.2	179.6	Andreanof Islands	37	4.2			0.5	18
12	22	01	13.3*	50.1	179.6	....do	N	4.1			0.7	12
13	17	28	25.0	51.7	175.3 E.	Rat Islands	57	4.6			0.8	34
13	19	33	29.2*	40.2	123.1	Northern California	N	3.8			0.8	8
13	21	03	13.2	59.8	144.1	Gulf of Alaska	21	3.8			0.8	21
14	08	51	03.1*	57.6	153.5	Kodiak Island region	42	3.7			0.7	13
14	13	09	26.5*	57.6	153.5	....do	57	3.6			1.0	15
14	14	11	48.9*	52.0	178.8	Andreanof Islands	98	4.3			0.7	16
14	16	11	14.6*	57.6	153.5	Kodiak Island region	25	3.5		3.1	0.9	8
14	17	55	57.6*	58.5	154.9	Alaska Peninsula	38	4.6			1.0	17
15	07	28	02.0*	63.0	149.4	Central Alaska	93				0.3	13
15	12	58	24.9*	62.8	150.8	.....do	100	4.0			0.9	27
15	15	01	23.3*	65.5	149.9	Alaska	56				1.1	14
17	15	25	04.7*	57.8	153.4	Kodiak Island region	N	3.5		3.4	0.4	12
17	16	42	13.9*	58.6	153.6	....do	N	3.8		4.1	1.1	13
17	21	36	51.1*	50.0	179.8	Andreanof Islands	18	4.3			0.4	13
18	01	19	54.2*	58.4	152.7	Kodiak Island region	N	4.5		3.8	1.4	10
18	16	38	48.5	36.3	118.3	Central California. Mag. 3.1, P	10 G				1.0	13
18	17	00	44.1*	36.2	118.3	Central California	10 G				0.0	10
19	02	00	54.3*	51.8	169.1	Fox Islands	N	4.4			1.1	12
19	14	03	30.0A	37.0	116.0	Southern Nevada. Nevada Test Site	0	4.1			0.0	31
19	15	20	54.6	50.0	179.7	Andreanof Islands	15	5.4			0.8	79
20	00	25	17.5*	51.2	173.7 E.	Near Islands	14	4.7			0.8	28
20	10	18	44.4	36.9	118.1	Central California	10 G				0.9	9
21	05	53	33.3	56.7	151.7	Kodiak Island region	18	4.4			0.9	30
22	15	36	50.7*	44.7	110.4	Yellowstone National Park, Wyo	N				1.0	7
22	18	08	25.7*	44.9	110.8	....do	N	3.4			1.6	6
23	21	55	39.1	39.6	118.1	Nevada	5 G	4.2			0.8	10
23	22	14	46.2	51.2	179.2	Andreanof Islands	47	4.2			0.5	18

	23	23	05	00.0A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 5, P; 5.4, B	0	5.5			0.0	97
	24	02	18	13.2	51.4	173.9 E.	Near Islands	12	4.9	5.0		0.8	47
	24	05	14	41.6	39.6	118.1	Nevada. Mag. 4.3, B	10 G	4.2			0.7	11
	25	12	21	11.7	56.7	152 1	Kodiak Island region	11	4.9		4.5	1.1	39
	26	15	20	53.7	50 7	175.0	Andreanof Islands	4	4.7			0.7	38
	26	16	18	30.4	38.8	119.5	California-Nevada border region. Mag. 3.4, B	5 G				1.2	8
	26	19	00	00.2A	37.3	116.5	Southern Nevada. Nevada Test Site. Mag. 6.2, P; 6.3, B	0	6.5	5.3		0.0	149
	27	06	56	52.9	36.8	121.6	Central California. Mag. 3.2, B	10				0.9	12
	28	09	38	43.2	38.9	116.4	Nevada	5	4.5			1.0	39
	28	10	53	38.9	38.9	116.4	....do	2				1.5	6
	28	11	44	11.1	59.7	144.9	Gulf of Alaska	N	3.7			1.1	10
	28	17	49	10.2	53.7	163.6	Unimak Island region	23	4.5			0.6	22
	29	02	45	21.9*	51.4	174 1 E.	Near Islands	39	4.3			0.5	16
	29	11	18	09.3	61.2	151.0	Southern Alaska	68	3.8			1.5	10
	31	05	42	04.5	51.2	179.2	Andreanof Islands	42	4.1			0.4	12
	31	12	58	30.6	51.9	176.0	....do	76	5.0			1.0	53
Apr.	1	03	20	57.0	59.4	144.7	Gulf of Alaska	N	4.2			1.2	21
	3	08	40	59.9*	51.6	177.0	Andreanof Islands	52	4.0			0.5	10
	3	13	59	02.3	51.8	175.3	....do	57	5.0			1.0	63
	3	17	05	14.1	61.4	150.1	Southern Alaska	52	3.4			0.4	14
	4	03	27	39.7	63.2	150.4	Central Alaska	129				0.4	12
	4	14	08	36.4	59.7	152.5	Southern Alaska	95				0.5	13
	5	17	22	11.6	63.5	150.9	Central Alaska	67				0.9	13
	6	16	57	01.7	59.6	153.4	Southern Alaska	118	3.7			0.7	18
	7	15	15	27.9	63.1	150.6	Central Alaska	122				0.3	15
	7	16	13	30.9*	56.7	155.0	Alaska Peninsula	56	4.4			1.2	19
	8	09	08	19.5	63.4	149.7	Central Alaska	119	3.1			0.8	17
	8	19	51	31.1	56.2	156.6	Alaska Peninsula	23	5.0			0.9	42
	9	03	06	24.4*	50.1	179.7	Andreanof Islands	33	4.0			0.5	11
	11	09	59	46.3	59.5	142.7	Gulf of Alaska	N	4.6		4.6	1.0	36
	11	10	45	07.8*	51.4	178.5	Andreanof Islands	43	4.6			0.5	16
	11	12	55	37.9	59.8	142.7	Gulf of Alaska	N	4.5		4.3	1.1	29
	12	02	10	36.0	51.5	178.5	Andreanof Islands	47	5.2			0.8	66
	12	06	41	23.5	37.2	116.6	Southern Nevada	13	3.2			1.1	7
	12	20	07	49.1	59.5	143.0	Gulf of Alaska	N	3.9		4.0	1.2	14
	13	12	53	51.4*	59.7	142.6	....do	N	3.7			1.0	11
	14	10	40	54.2	39.7	110.8	Utah	13	4.2			1.0	10
	15	09	45	57.9*	58.0	154.2	Alaska Peninsula	61	4.1			1.1	10

See footnotes at end of table.

TABLE 1.--*Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Apr. 16	05	59	44.2	59.7	142.7	Gulf of Alaska	N	4.0		4.5	1.1	10
16	06	25	36.1*	60.0	142.4	Southern Alaska	N	4.1		4.4	1.0	15
16	06	40	21.9	59.8	142.6	Gulf of Alaska	N	3.8		4.6	1.2	12
17	15	31	47.3	59.6	142.7	....do	15	4.3			0.7	23
18	10	42	11.9	37.9	111.6	Utah	10 G	4.4			1.4	10
18	17	53	13.8	58.5	154.6	Alaska Peninsula	23	3.9		4.7	1.3	15
18	19	23	01.2	53.6	166.1	Fox Islands	50 G	4.7			1.0	50
20	21	16	48.6	37.3	116.6	Southern Nevada	4				0.5	9
21	06	44	24.8	59.6	142 6	Gulf of Alaska	1	4.9			0.9	50
21	06	52	42.6	59 4	142.7	....do	N	4.0			1.1	8
21	11	59	25.7	54.2	163.4	Unimak Island region	27	4.8			1.1	27
21	14	30	00.0A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 4.4, P; 4.6, B	0	4.6			0.0	26
21	15	00	00.0A	37.1	116.1	Southern Nevada. Nevada Test Site. Mag. 4.4, P; 4.8, B	0	4.8			0.0	33
22	09	24	14.2	60.0	153.1	Southern Alaska	145				0.5	15
22	22	32	25.6*	40.4	124.7	Near coast of northern California	24	4.4			0.7	9
24	01	13	46.6*	58.4	154.8	Alaska Peninsula	54	3.6			0.7	15
24	13	40	25.0	61.2	151.7	Southern Alaska	96	3.1			0.8	18
25	08	25	50.1	36.0	114.7	Southern Nevada	5 G			3.0	0.9	10
26	02	29	36.1*	36.0	114.7	....do	5 G			2.7	1.9	6
26	14	20	30.6	53.0	171.5 E.	Near Islands. Mag. 6, P	41	5.8	5.7		0.9	122
27	07	56	22.6	60.0	153.4	Southern Alaska	148	3.9			0.7	20
28	21	53	25.7	60.2	151.3	Kenai Peninsula	85				0.7	15
29	00	35	01.9	52.5	173.4	Andreanof Islands	91	5.1			0.9	46
29	10	52	13.2*	50.1	179.5	....do	16	4.1			0.5	9
29	12	00	39.5	51.8	177.0 E.	Rat Islands	52	5.0			1.0	71
30	15	44	49.0	63.1	151.0	Central Alaska	125	3.3			0.7	14
May 1	04	42	57.0*	63.6	150.2	....do	7	3.7		3.9	0.6	10
1	14	13	00.0A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 3.8, P; 4.0, B	0	4.2			0.0	24
1	14	40	00.2A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 3.9, P	0	4.5			0.0	30
2	21	41	33.6*	66.0	150.6	Alaska	N			3.4	0.9	15
4	07	07	08.0	51.4	179.2	Andreanof Islands	44	5.2			0.8	64

5	15	30	00.2A	37 2	116 2	Southern Nevada. Nevada Test Site. Mag. 4.3, P; 4.7, B	0	5 2			0 0	55
7	07	23	02 0	61 0	146 6	Southern Alaska	N	3 7			1 0	17
7	20	28	32 9	62 6	151 3	Central Alaska	N			3.3	1 0	15
8	10	59	55 9	36 6	120.3	Central California. Mag. 3.3, B	10 G	4 2		3.5	0 8	23
8	17	16	53 7	61 8	151 5	Southern Alaska	106	3.9			0.6	22
8	17	41	29 0	19 6	64.7	Virgin Islands	N	4.6			1 3	27
9	04	38	05 1*	60 1	152 5	Southern Alaska	110				0.7	14
9	11	04	44 8	49 9	180 0	Aleutian Islands region	12	4 9			0 7	17
9	11	20	19 2	64 9	149 4	Central Alaska	23				0 7	12
11	10	10	01 1	52 5	173 4 E.	Near Islands	59	4 8			0 7	51
11	23	26	45.7	63 5	150 1	Central Alaska	6			3.3	1 4	11
13	09	45	16 1	58 8	152 9	Kodiak Island region	126				0.8	15
13	20	56	54 9*	51.6	176 8	Andreanof Islands	54	3 9			0 9	11
14	08	01	32 0	63.3	150.0	Central Alaska	122				0 5	15
14	13	33	02 6	60.2	153.0	Southern Alaska	124	3 6			1.0	13
14	18	50	19 9*	41 0	117.4	Nevada	5 G				1 1	10
15	10	12	33 8	51 5	176 7	Andreanof Islands	55	4 0			1 2	14
15	13	30	00 0A	37 2	116 0	Southern Nevada. Nevada Test Site. Mag. 4.8, P; 5.0, B	0	5 3			0 0	63
17	22	55	23.2	53.1	171.0 E.	Near Islands	38	4 6			0 8	39
18	19	10	52.1	51 3	170.8	Fox Islands	N	4.3			1 2	14
18	20	10	41.5	36 4	117 9	California-Nevada border region	10 G	3.7			1 2	19
20	05	18	48 5	36 6	120 3	Central California	10 G	4.1		3.0	0.8	26
20	20	30	54.7	51 5	178 5	Andreanof Islands	48	5 7			0 9	96
20	23	48	16.3	57.3	151.4	Kodiak Island region	N	4.5			1.9	13
21	14	00	00.4A	37.0	116.0	Southern Nevada. Nevada Test Site. Mag. 3.5, P	0	3.5			0.0	9
21	14	15	00.0A	37 1	116 0	Southern Nevada. Nevada Test Site. Mag. 4.6, P; 4.8, B	0	5.1			0 0	65
22	09	01	04.0*	59.9	152.8	Southern Alaska	121				0.5	11
23	22	55	22.4	38.1	112.4	Utah	3	4 6		3.6	1 1	21
23	23	59	24 5	38.0	112.4	. . do.	6			2.7	1.4	11
24	01	54	32.7*	37.9	112.4	....do	5 G			2.2	1.1	7
24	01	56	05.9	38.1	112.4	. . do.	6			2.5	1.9	10
24	02	09	53.4	38.0	112.4	....do	5			2.8	1.6	9
24	09	58	09.3	63.7	150.3	Central Alaska	131	3.1			1.0	10
26	09	53	31.0	54.2	164.7	Unimak Island region	36	5.2			0.9	65
26	14	16	00.2A	37.2	116.2	Southern Nevada. Nevada Test Site. Mag. 4.3, P; 4.2, B	0	5.0			0.0	22
26	15	00	00.0A	37.1	116.1	Southern Nevada. Nevada Test Site. Mag. 5.1, P	0	5.6			0 0	120
27	09	08	57.7	58.1	139.3	Off coast of southeastern Alaska	N	3 8		3 7	0.7	10
27	17	59	42.8	39.7	78.2	Virginia. Probable blast	0 G				2.3	5

See footnotes at end of table

TABLE 1.—*Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			S D [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
May 28	00	50	51.4	51.4	177.0	Andreanof Islands	54	4.5			0.9	25
28	12	00	03.3*	37.2	116.0	Southern Nevada	N	4.2			1.0	9
29	17	45	59.1	59.5	147.7	Gulf of Alaska	17	4.3		3.9	1.3	10
30	18	42	57.3	62.8	147.8	Central Alaska	35	3.8		3.5	1.1	9
30	23	19	37.4	53.7	164.1	Unimak Island region	N	4.9			1.2	50
31	02	50	58.5*	53.6	164.5	....do	N	4.4			1.0	29
June 1	02	06	38.8*	63.4	145.4	Central Alaska	2			3.1	0.6	10
1	04	12	12.2	51.5	178.8	Andreanof Islands	55	4.8			0.8	23
2	20	11	27.0*	62.6	150.0	Central Alaska	96				0.7	11
5	13	28	44.4	63.0	148.7	....do	1	3.2			0.3	11
5	13	54	44.7	52.2	170.5	Fox Islands	45	4.4			0.8	31
5	20	58	50.7	63.0	148.7	Central Alaska	3	3.3			0.2	11
6	15	57	17.4	62.9	151.0	....do	87				0.5	12
7	20	48	06.5*	65.5	150.0	Alaska	N	4.0		4.3	0.5	12
8	10	39	09.3	51.4	179.5 E.	Rat Islands	53	4.3			0.5	17
8	10	48	56.3	61.5	151.9	Southern Alaska	124				0.7	15
9	15	31	16.3	61.6	151.8	....do	118				0.5	14
10	04	15	16.8	61.3	151.1	....do	64	4.0			0.8	25
12	04	54	31.4	56.6	152.1	Kodiak Island region. Mag. 4.9, B	N	5.2	5.3	5.2	1.1	67
13	05	27	54.4	51.6	178.3	Andreanof Islands	55	5.5			0.9	68
13	08	43	00.6*	19.3	65.2	Puerto Rico region	52	4.8			0.9	12
19	01	42	11.1	63.5	150.9	Central Alaska	N	4.2		4.1	0.8	13
19	09	40	16.6*	57.6	151.9	Kodiak Island region	N	3.9		3.2	0.3	8
23	02	34	44.8	44.8	110.9	Yellowstone National Park, Wyo	N	4.4			1.3	12
25	16	08	54.6E	39.6	71.0	Off east coast of United States. Mag. 4.7, Pal	0	5.0			0.0	65
26	13	00	00.0A	37.1	116.1	Southern Nevada. Nevada Test Site. Mag. 4.6, B	0	4.3			0.0	16
July 1	12	46	31.9	60.6	150.9	Kenai Peninsula	48	3.9			0.9	18
2	06	10	01.3	51.3	179.2	Andreanof Islands	43	4.5			0.8	24
2	12	11	40.8*	60.3	147.9	Southern Alaska	40				1.0	12
5	06	14	22.3*	61.5	146.7	....do	N			3.0	0.7	10
6	10	51	28.5	54.7	164.5	Unimak Island region	90	4.6			1.1	26

6	11	52	29.7*	39.2	122.4	Northern California. Mag. 3.0, B	22				1.2	5
6	23	42	04.0	52.4	180.0	Rat Islands	231	4.4			0.9	22
7	09	16	57.2*	47.5	114.0	Montana	N				1.0	5
7	09	38	43.4	60.6	146.8	Southern Alaska	64				1.3	13
7	10	48	33.4	36.0	117.7	California-Nevada border region. Mag. 3.3, B	5	3.4			0.4	8
8	19	47	53.8	52.5	176.1	Andreanof Islands	172	4.7			0.9	34
10	09	16	44.2	61.5	146.5	Southern Alaska	35	4.2		4.7	1.3	36
11	03	21	12.0*	50.7	179.4 E.	Rat Islands	43	3.8			0.8	9
11	05	26	55.4*	51.2	179.2	Andreanof Islands	37	4.1			0.7	9
14	01	15	36.3	35.0	119.1	Central California. Mag. 3.4, P; 3.7, B	10 G	4.2			1 2	11
14	18	48	34.4*	51.5	174.4 E.	Near Islands	39	4.9			0.8	28
17	07	32	10.1	51.0	171.3	Fox Islands	N	4.9			1.0	45
19	03	40	42.5*	51.1	178.2	Andreanof Islands	30 G	4.3			1.2	12
21	10	48	21.7	53.0	168.2	Fox Islands	54	4.7			0.8	41
21	23	05	03.0*	53.7	164.9	Unimak Islands region	N	4.4			0 8	27
24	08	02	23.6	52.1	171.5 E.	Near Islands. Mag. 4.7, B	N	5.0	4.1		1.1	71
25	14	37	14.1	40.3	124.9	Near coast of northern California	24	4.8			1.0	7
25	15	19	50.3*	57.3	137.6	Off coast of southeastern Alaska	N	3.2			1.7	8
26	21	57	58.9*	39.3	115.0	Nevada	5 G	3.7			1.1	5
27	08	44	00.2	39.0	118.0	....do	15				0.8	8
27	10	59	35.2	34.3	121.7	Off coast of California	10 G	3.7			1.1	12
28	17	02	09.2	37.0	114.9	Southern Nevada	5 G				1.0	8
28	19	28	13.8	54.1	165.9	Fox Islands	92	4.8			1.0	47
29	01	23	16.7	36.0	117.7	California-Nevada border region. Mag. 3.0, P	10 G	3.5			1.7	9
29	14	23	16.7*	34.0	122.3	Off coast of California. Mag. 3.3, P	10 G				1.5	11
29	18	10	57.6	37.3	116.6	Southern Nevada	5 G				0.9	8
30	08	48	51.5M	37.0	82.2	West Virginia	0	3.8			0.0	9
30	09	57	12.1	37.7	118.8	California-Nevada border region. Mag. 3.2, P	10 G				0.8	16
30	15	15	16.3M	37.0	82.2	West Virginia	0	4.0			0.0	9
30	20	16	36.1	37.3	116.5	Southern Nevada	7	4.1			0.6	13
Aug. 3	19	24	17.8E	34.3	110.5	Eastern Arizona	0 G				0.6	5
4	11	29	59.6	53.3	166.9	Fox Islands	46	4.8			0.9	28
5	04	10	17.5*	39.2	122.7	Northern California. Mag. 3.5, B	11	4.3			0.7	10
5	22	54	10.8*	51.1	179.5	Andreanof Islands	30	4.3			0.5	10
8	12	02	14.1	60.2	147.2	Southern Alaska	17	4.2		4.0	1.1	15
11	06	55	26.5*	59.0	137.5	Southeastern Alaska	N	3.3			0.7	7
13	05	06	16.8	36.1	121.8	Central California. Mag. 3.7, B	5 G				0.9	16
13	08	03	03.2	59.9	147.6	Gulf of Alaska	24	3.6		3.5	0.9	8

See footnotes at end of table.

TABLE 1.- *Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Aug. 15	02	39	47.4*	51.9	176.7	Rat Islands	30 G	4.4			1.4	22
15	16	55	51.5*	63.6	147.0	Central Alaska	N	4.3		4.0	0.7	8
16	08	33	18.5	19.1	65.1	Puerto Rico region	40 G	4.7			0.9	24
16	09	44	04.8*	53.0	174.6	Andreanof Islands	190	4.3			0.6	24
20	16	34	15.0E	38.9	72.4	Off east coast of United States	0	4.2			0.0	19
21	11	58	50.0	60.8	142.5	Southern Alaska	14	4.5		4.7	0.9	31
23	07	47	38.6*	51.8	173.9	Andreanof Islands	40 G	4.0			0.8	15
24	20	30	28.0P	32.8	118.3	Off coast of California	10	4.6			0.0	16
28	14	30	22.0	55.2	157.4	Alaska Peninsula	39	3.8			0.6	14
28	23	50	48.3	59.0	152.5	Southern Alaska	103				0.9	10
30	00	16	36.5	52.0	179.7	Andreanof Islands	84	5.0			0.7	32
30	20	47	07.6	52.8	177.7	....do	227	4.6			0.8	34
31	03	05	50.5	38.2	112.3	Utah	5 G			3.0	1.2	6
Sept. 1	11	52	17.0	37.5	113.8	....do	5 G	4.1		3.1	1.1	7
1	12	19	41.6*	37.4	113.8	....do	5 G				0.8	5
2	02	40	14.0*	19.4	65.5	Puerto Rico region	N	3.9			1.2	11
3	07	32	53.7	63.1	150.0	Central Alaska	105				0.7	17
4	06	02	24.4	60.6	145.6	Southern Alaska	33	3.6		3.7	1.0	15
5	07	12	09.3	62.8	149.5	Central Alaska	113				0.2	9
6	01	55	03.2*	61.6	147.5	Southern Alaska	30			3.0	0.4	11
6	15	43	18.2	60.1	141.2	Southeastern Alaska	5	4.7		4.6	1.0	26
7	05	28	54.1	51.8	168.2	Fox Islands	N	4.1			0.6	21
7	18	06	28.1*	19.2	65.1	Puerto Rico region	35	4.6			1.2	6
12	16	12	20.3*	53.1	172.1 E.	Near Islands	29	4.5			0.6	18
13	01	45	08.6*	62.7	151.3	Central Alaska	44				0.4	10
13	21	29	37.0P	35.3	118.5	Central California. 35°20.3'N., 118°32.4' W. Mag. 3.2, P	8				0.0	19
15	06	20	45.7*	44.9	111.4	Hebgen Lake region	15 G				1.2	5
16	17	20	15.1*	59.0	136.7	Southeastern Alaska	N	3.4			0.7	5
19	02	21	07.2*	51.6	167.6	Fox Islands	N	4.5			1.3	22
19	05	03	28.1*	63.3	151.0	Central Alaska	N	3.9		3.5	0.8	7
19	16	27	27.7	37.0	117.9	California-Nevada border region. Mag. 3.8, B	10 G				1.0	13

19	16	43	37.2	51.7	176.5 E.	Rat Islands	45	4.3			0.7	24
20	06	34	57.3*	44.7	110.4	Yellowstone National Park, Wyo	10 G	4.2			1.4	8
20	06	40	50.0*	44.6	110.4	....do	15 G				1.7	5
20	07	36	13.6*	44.6	110.6	....do	15 G	4.0			1.0	7
20	08	37	21.5*	40.3	121.3	Northern California	8	3.9			1.1	11
20	17	49	21.6*	51.5	176.2 E.	Rat Islands	16	4.2			1.2	26
21	01	01	25.7	19.4	65.0	Puerto Rico region	45 G	4.4			1.0	19
21	07	04	36.9	43.2	110.8	Wyoming	15 G	4.4			1.0	19
21	14	59	40.9	37.3	116.6	Southern Nevada	5 G				1.1	11
22	22	35	49.8	52.4	169.5	Fox Islands	N	4.6			0.9	24
23	12	06	39.6	58.4	155.4	Alaska Peninsula	100 D	4.6			1.0	59
26	08	05	40.3	47.9	114.4	Montana	10				0.9	8
27	03	37	03.9	41.6	123.8	Northern California. Mag. 3.6, B	19	4.3			0.9	9
27	18	24	33.8	40.5	120.9	Northern California. Mag. 3.7, B	10 G	4.3			1.3	15
28	04	21	49.8	54.5	164.5	Unimak Island region	77 D	5.0			1.1	66
30	18	14	35.9	58.4	155.3	Alaska Peninsula	101	4.5			0.8	28
Oct. 2	05	55	40.9*	62.4	151.6	Central Alaska	84	4.1			0.5	17
2	09	34	27.4*	52.9	173.2	Andreanof Islands	127	4.3			0.9	13
3	08	12	20.8	58.4	150.5	Gulf of Alaska. Mag. 4.7, B	25 D	5.0	4.7	5.1	0.8	52
4	06	55	25.9*	60.0	152.8	Southern Alaska	90	4.0			0.7	12
5	19	07	30.4*	58.1	156.7	Alaska Peninsula	127	4.6			0.6	18
6	13	30	01.0G	37.9	119.0	Central California. Seismic experiment. 37°56.8′ N., 119°01.2′ W.	0				0.0	23
7	16	01	10.3	50.5	177.7 E.	Rat Islands	41	4.9			0.9	54
8	04	49	59.0	34.6	121.5	Off coast of California. Mag. 3.6, P	10 G	4.6			0.5	46
8	13	02	04.7	50.4	176.2	Andreanof Islands	38 D	5.1			0.9	72
10	00	16	49.1	50.2	178.6	....do	N	4.6			0.8	34
12	18	04	36.4*	51.9	175.4	....do	68	4.2			0.7	10
13	06	40	19.2*	59.2	138.0	Southeastern Alaska	N	3.7			0.9	9
14	03	51	53.4*	51.2	178.2	Andreanof Islands	31 D	4.0			0.8	12
14	14	30	00.0A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 5.2, P; 5.3, B	0	5.5			0.0	161
16	02	32	24.3*	58.3	151.5	Kodiak Island region	N				1.2	8
16	16	11	50.5	53.0	167.7	Fox Islands	45	4.2			0.9	31
17	05	04	43.8*	60.8	150.8	Kenai Peninsula	84				0.8	9
17	08	06	33.3	42.7	111.1	Eastern Idaho	15 G	4.3			1.6	6
18	11	03	45.0	37.3	117.3	California-Nevada border region	8				0.5	11
20	13	08	59.7	51.3	178.5	Andreanof Islands	49	4.7			0.9	33
20	16	17	12.2*	59.7	145.9	Gulf of Alaska	N	3.9			1.1	11
21	12	35	43.7	51.4	174.3	Andreanof Islands	21	5.1			1.0	51

See footnotes at end of table.

TABLE 1.—*Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Oct. 22	03	09	05.2	54.2	165.3	Fox Islands	65 D	4.8			1.1	7_0
23	10	40	16.7	52.4	176.0	Andreanof Islands	163	4.5			0.7	2_3
23	15	28	32.4*	60.1	152.5	Southern Alaska	105				0.4	7
24	00	09	46.3	56.1	158.1	Alaska Peninsula	N	4.6			1.3	2_8
25	02	13	51.6	37.9	112.3	Utah	5 G			2.3	1.4	9
25	07	46	42.1*	39.2	111.4	....do	5 G	4.3		3.0	1.7	1_4
27	06	11	51.5	39.1	111.4	....do	5 G			2.6	1.3	9
29	00	57	42.8	54.2	164.6	Unimak Island region	27	5.3			1.0	12_4
31	14	56	20.3	56.5	153.0	Kodiak Island region	44	4.6			0.8	2_5
Nov. 1	12	59	41.5*	52.0	174.7	Andreanof Islands	86	4.5			0.7	1_7
1	14	21	15.6*	61.2	151.6	Southern Alaska	43				0.8	1_2
2	02	05	19.0*	61.3	148.7	....do	32			3.4	0.7	1_1
2	17	45	52.2*	52.4	174.6	Andreanof Islands	159	3.8			0.2	1_0
3	03	17	05.7P	34.0	116.6	Southern California. 33°58.2'N., 116°37.4'W. Mag. 3.0, P	8	4.3			0.0	1_6
3	16	41	16.9	37.3	115.0	Southern Nevada	7				0.4	1_3
5	06	52	57.9*	60.7	148.7	Kenai Peninsula	16			3.5	1.1	1_1
5	07	22	48.7	51.5	179.3	Andreanof Islands	36	4.7			0.9	3_2
5	12	53	11.6	61.7	150.8	Southern Alaska	53				0.8	1_4
5	15	00	00.0A	37.0	116.0	Southern Nevada. Nevada Test Site. Mag. 4.7, B	0	4.9			0.0	4_5
6	22	27	26.2*	51.7	176.2 E.	Rat Islands	47	4.2			0.9	1_5
7	12	00	45.2*	51.8	175.4	Andreanof Islands	69	4.1			0.5	1_1
7	23	15	12.2	63.2	150.6	Central Alaska	127				0.6	1_3
8	08	08	11.0*	44.4	115.6	Western Idaho	N	3.8			1.3	6
9	02	05	29.9*	51.8	176.2 E.	Rat Islands	49	3.9			0.8	2_1
10	00	24	21.3*	61.1	147.8	Southern Alaska	85				1.6	1_1
12	16	16	24.4	62.5	150.1	Central Alaska	48				1.1	1_5
13	00	45	45.1*	44.0	110.4	Yellowstone National Park, Wyo	N	3.9			1.4	1_0
13	19	02	19.2	51.8	176.8 E.	Rat Islands	66	4.5			0.6	2_2
14	18	03	58.6B	36.6	121.2	Central California. 36°33.9'N., 121°12.3'W. Mag. 3.3, B	5				0.0	1_1
14	18	53	30.6*	58.8	149.7	Gulf of Alaska	N	3.9		3.9	0.9	1_0
15	02	39	27.8*	46.9	113.3	Montana	15 G				0.8	5

	15	09	19	03.5	19.0	66.8	Puerto Rico region	50	4.7		0.9	47
	17	01	14	54.0P	33.8	115.5	Southern California. 33°46.8′N., 115°32.3′W. Mag. 3.1, P	8	4.1		0.0	17
	20	04	33	02.6	51.3	179.9	Andreanof Islands	40	5.1		1.1	67
	21	17	23	29.4	39.2	118.1	Nevada. Mag. 3.8, B	9	4.2		0.5	16
	21	19	26	28.0	57.0	157.0	Alaska Peninsula	90 D	4.6		1.0	42
	21	19	32	47.8*	52.3	178.6	Andreanof Islands	170	3.8		0.4	19
	23	01	13	57.8	61.5	149.9	Southern Alaska	49	3.9		1.0	11
	24	16	47	56.0	36.4	112.3	Western Arizona	6		3.0	1.5	7
	25	08	32	28.4	51.5	179.3 E.	Rat Islands	69			0.3	7
	25	21	49	27.3	37.8	116.0	Southern Nevada	5 G			1.0	11
	27	07	02	43.2	60.9	147.1	Southern Alaska	N	3.6	4.0	1.4	10
	27	11	18	45.0*	44.5	115.6	Western Idaho	N	3.5		2.1	6
Dec.	1	13	43	15.1	63.2	151.1	Central Alaska	31		3.0	0.9	14
	1	19	29	16.6	52.4	169.1	Fox Islands	60	5.2		1.0	69
	1	21	29	54.8	51.4	175.3	Andreanof Islands	46	4.6		0.9	17
	2	03	34	17.7	51.4	175.2	....do	46	4.3		1.0	18
	2	04	56	55.3*	51.3	175.0	....do	38	4.1		1.0	13
	2	08	11	37.2	51.4	175.3	....do	49	4.3		1.0	13
	2	10	41	34.2*	51.2	175.3	....do	59	4.3		0.7	13
	2	12	23	33.8*	36.0	114.8	Southern Nevada	2		3.4	1.3	13
	3	03	47	24.6*	35.9	111.9	Eastern Arizona	5 G		2.8	1.4	7
	3	15	54	50.4*	19.0	64.9	Virgin Islands	57	4.5		0.7	16
	4	21	58	26.8	61.0	151.2	Southern Alaska	89			0.8	18
	5	02	16	30.9	44.5	115.4	Western Idaho	N	3.9		0.7	9
	5	02	54	16.9	44.3	115.5	....do	N	4.3		0.9	14
	5	03	53	21.6P	35.5	118.3	Central California. 35°29.1′N., 118°18.9′W. Mag. 3.4, P	8			0.0	32
	5	08	17	46.0	44.5	115.5	Western Idaho	N	3.7		0.8	7
	6	00	53	01.8*	51.4	175.4	Andreanof Islands	65	4.1		0.9	12
	6	09	33	47.5	44.5	115.4	Western Idaho	N	4.3		0.7	8
	7	02	48	44.5*	50.8	179.2	Andreanof Islands	23	3.9		0.5	10
	7	06	07	38.1	60.1	152.8	Southern Alaska	124	3.8		0.7	20
	9	23	56	01.0*	44.8	111.0	Hebgen Lake, Mont., region	10 G			1.2	7
	10	09	46	29.0	63.1	151.4	Central Alaska	118	4.3		0.8	21
	10	10	15	07.2	53.1	169.8	Fox Islands	48	5.5	5.3	1.0	77
	12	15	57	19.1	44.0	107.5	Wyoming	15 G	4.9		0.8	16
	12	20	08	24.9	62.5	151.2	Central Alaska	85			0.5	13
	14	14	48	11.8	53.0	169.9	Fox Islands	50	5.3		0.9	69
	14	19	14	19.4P	34.3	115.7	Southern California. 34°19.0′N., 115°43.8′W. Mag. 4.0, P	8	4.6		0.0	34

See footnotes at end of table.

TABLE 1.--*Instrumentally located earthquakes and related phenomena recorded in the United States during 1970*—Continued

Date 1970	Origin time [1] G.M.T.			Geographic coordinates		Region and comments [2]	Depth [3]	Magnitude [4]			SD [5]	No. of stations
				N. Lat.	W. Long.							
	hr.	*min.*	*sec.*	*degrees*	*degrees*		*km.*	m_b	M_S	M_L		
Dec. 14	21	11	39.1	53.0	170.0	Fox Islands	54	5.2			1.0	67
15	03	51	29.3P	34.5	116.5	Southern California. 34°28.6'N., 116°28.6'W. Mag. 3.1, P	8				0.0	19
15	17	02	00.7*	53.1	170.1	Fox Islands	72	4.5			1.0	27
16	02	36	30.9	48.4	113.2	Montana	15 G	4.8			0.5	8
16	13	44	19.2*	36.8	113.7	Western Arizona	5 G			2.6	1.1	7
16	13	46	47.3*	36.7	113.7	....do	5 G			2.2	0.4	5
16	16	00	00.1A	37.1	116.0	Southern Nevada. Nevada Test Site. Mag. 5.1, B	0	5.1			0.0	78
16	16	24	34.8	51.3	174.9	Andreanof Islands	37	4.9			1.0	43
17	16	05	00.2A	37.1	116.1	Southern Nevada. Nevada Test Site. Mag. 5.7, B	0	5.7			0.0	149
18	04	01	25.0	36.0	114.8	Southern Nevada	3			2.6	0.5	6
18	08	21	30.6	36.0	114.8	....do	7			3.0	0.5	8
18	09	18	33.4	36.0	114.8	....do	7	3.7		3.1	0.5	8
18	11	00	52.6	36.0	114.8	....do	3			2.3	0.5	5
18	15	30	00.2A	37.2	116.1	Southern Nevada. Nevada Test Site. Mag. 4.9, B	0	5.2			0.0	63
20	19	13	44.8*	61.3	147.2	Southern Alaska	N	3.2			1.4	8
21	08	00	27.6	53.0	174.7	Andreanof Islands	223	4.1			0.7	26
21	12	04	45.8*	61.1	147.5	Southern Alaska	21			2.6	0.9	9
22	09	19	49.0*	45.3	113.2	Montana	10 G				1.5	6
22	17	59	40.9	62.5	149.1	Central Alaska	44	3.5			0.2	8
23	07	11	15.7*	63.0	149.4	....do	114				0.4	10
24	03	17	15.1	62.0	152.3	....do	125	3.5			1.0	13
29	10	24	31.4	51.2	168.4	Fox Islands	9	5.0			1.0	44
29	17	17	51.4	51.6	177.7 E.	Rat Islands	58	4.4			0.9	31
30	06	40	34.9*	59.9	153.9	Southern Alaska	187	3.8			1.0	9
31	14	56	34.9	36.9	120.9	Central California. Mag. 3.0, B	8				0.4	16

[1] Symbols following the origin time are as follows:

* The epicenter has been determined from incomplete, or less reliable data and is not considered so accurate as the computed solution appears to indicate.

A Underground explosion under the direction of the U.S. Atomic Energy Commission.

B Parameters of hypocenter in "Region and comments" column were furnished by the University of California, Berkeley.

E Explosion or suspected explosion.

P Parameters of hypocenter in "Region and comments" column were furnished by the California Institute of Technology, Pasadena.

G Parameters of hypocenter in "Region and comments" column were furnished by the U.S. Geological Survey.
M Hypocenter was based on information from mining area where rockbursts are common.
J Parameters of hypocenter in "Region and comments" column were supplied by the St. Louis University, St. Louis, Mo.

[2] Abbreviations following magnitudes are as follows:
B University of California, Berkeley.
P California Institute of Technology, Pasadena.
Gol Colorado School of Mines, Golden.
Pal Columbia University, Lamont-Doherty Geological Observatory, Palisades, N.Y.

[3] Abbreviations in this column are as follows:
N Indicates the depth was restrained at 33 km. for earthquakes whose character on seismograms indicates a shallow focus, but whose depth is not determined satisfactorily by the data.
D Indicates the depth was restrained by the computer program based on two or more compatible pP phase arrival times.
G Indicates the depth was restrained, based on evidence from available seismograms, by an ERL geophysicist.

[4] Magnitudes computed by ERL (Environmental Research Laboratories, NEIC) are as follows:
m_b Computed from body wave on seismogram.
M_S Computed from surface wave on seismogram.
M_L Computed only for local earthquakes.

[5] A standard deviation of seismic stations used in computing hypocenter.

[6] Number of stations reporting P or P' phases used in computation.

TABLE 2.—*Principal earthquakes of the world during 1970*

Listed in this section are (1) earthquakes of magnitude greater than 6¾, and those of smaller magnitude which were locally destructive and caused casualties; (2) earthquakes of unusual interest.

Date	Origin time G.M.T.			Region	Geographic coordinates		Remarks*
					Lat.	Long.	
	hr.	*min.*	*sec.*		*degrees*	*degrees*	
Jan. 4	17	00	40.2	Yunnan Province, China.	24.1 N.	102.5 E.	Probable heavy damage. Felt at Hanoi. Depth 31 (D) km. Mag. 7.5 (M_s).
Jan. 8	17	12	39.1	South of Kermadec Islands.	34.7 S.	178.6 E.	Felt on North Island, New Zealand. Depth 179 km. Mag. 7, P.
Jan. 10	12	07	08.6	Mindanao, Philippine Islands.	6.8 N.	126.7 E.	Felt on Mindanao, Samar, and Cebu Islands. Depth 73 km. Mag. 7.3, P.
Jan. 20	07	19	51.2	South of Fiji Islands....	25.8 S.	177.3 W.	Felt at Apia, Western Samoa. Depth 80 km. Mag. 7.3, P.
Jan. 20	17	33	05.4	Hokkaido, Japan, region.	42.5 N.	143.0 E.	1 killed, 38 injured, and slight property damage on Hokkaido. Also felt on Honshu and Kyushu Islands. Depth 46 km. Mag. 6.4 (M_s).
Feb. 5	22	05	58.3	Luzon, Philippine Islands.	12.6 N.	122.1 E.	3 killed, several injured, moderate damage on Romblon Island. Depth 11 km. Mag. 6.6 (M_s).
Feb. 14	11	17	16.1	Peru.....	9.9 S.	75.6 W.	6 killed, extensive property damage in northeastern part of State of Huanuco. Depth 35 km. Mag. 5.4 (M_s).
Mar. 14	01	51	44.4	Turkey-Iran border region.	38.6 N.	44.7 E.	5 killed at Baulan. Two other villages destroyed, 300 homeless. Depth 23 km. Mag. 4.8 (M_s).
Mar. 23	01	52	59.3	India.....	21.7 N.	73.0 E.	26 killed, 200 injured,and heavy property damage at Broach. Felt widely in southern Gujarat and at Bombay. Depth 3 km. Mag. 5.4 (m_b).
Mar. 28	21	02	23.4	Turkey.....	39.2 N.	29.5 E.	1,086 killed, 1,174 injured, 8,229 buildings destroyed, 5,586 buildings damaged at Gediz and surrounding area by this earthquake and major aftershocks. Felt throughout Anatolia, at Istanbul, and on Chios and Lesbos Islands. Depth 20 km. Mag. 7.1 (M_s).

*See footnotes 2, 3, and 4 at bottom of table 1. When no authority is given for magnitude, it has been computed by the ERL National Earthquake Information Center.

TABLE 2.—*Principal earthquakes of the world during 1970*—Continued

Date	Origin time G.M.T.			Region	Geographic coordinates		Remarks*
					Lat.	Long.	
	hr.	*min.*	*sec.*		*degrees*	*degrees*	
Mar. 30	16	46	45.6	Mindanao, Philippine Islands.	6.8 N.	126.7 E.	Felt on Mindanao. Depth 76 km. Mag. 6.9, P.
Apr. 7	05	34	05.6	Luzon, Philippine Islands.	15.8 N.	121.7 E.	15 killed, more than 200 injured; major damage in Manila area. Felt throughout Luzon Island. Depth 37 km. Mag. 7.3 (M_s).
Apr. 12	04	01	44.0	Philippine Islands region.	15.1 N.	122.1 E.	At least 18 injured, minor damage in Manila. Felt widely on Luzon Island. Depth 24 km. Mag. 7.0 (M_s).
Apr. 16	05	33	17.5	Gulf of Alaska.....	59.8 N.	142.6 W.	Felt at Yakataga, Yakutat, and Cordova. Depth 7 km. Mag. 6.8 (M_s).
Apr. 20	10	39	12.5	New Hebrides Islands...	18.8 S.	169.3 E.	Felt at Port Vila. Depth 246 km. Mag. 6.8, P.
Apr. 29	14	01	32.8	Near coast of Chiapas, Mexico.	14.5 N.	92.6 W.	Slight damage in Tapachula. Felt in southern Mexico, Guatemala, and at San Salvador, El Salvador. Depth N. Mag. 7.3 (M_s).
May 14	18	12	28.0	Eastern Caucasus.....	43.0 N.	47.1 E.	This quake and the foreshock at 0920 caused heavy casualties and extensive damage in Dagestan Republic, U.S.S.R. Depth 44 km. Mag. 6.5 (M_s).
May 27	12	05	06.0	Bonin Islands region....	27.2 N.	140.1 E.	Depth 382 km. Mag. 7.1, P.
May 31	20	23	27.3	Near coast of northern Peru.	9.2 S.	78.8 W.	66,794 killed or missing. At least 1 million homeless. $250 million in damage. Yungay buried by land- and mudslide (*huayco*) triggered by icefall. Caras, Huaras, and Casma nearly destroyed. Chimbote heavily damaged. *Huaycos* occurred throughout the Callejon de Huaylas. Depth 43 (G) km. Mag. 7.8 (M_s).
June 5	04	53	06.4	Region of Alma Ata, U.S.S.R.	42.5 N.	78.8 E.	20,000 homeless, 5,000 buildings destroyed. No casualty report. Depth 20 km. Mag. 6.6 (M_s).
June 11	06	02	54.9	Chile-Argentina border region.	24.5 S.	68.5 W.	Depth 112 (D) km. Mag. 6.8, P.

*See footnotes 2, 3, and 4 at bottom of table 1. When no authority is given for magnitude, it has been computed by the ERL National Earthquake Information Center.

TABLE 2.—*Principal earthquakes of the world during 1970*—Continued

Date	Origin time G.M.T.			Region	Geographic coordinates		Remarks*
					Lat.	Long.	
	hr.	*min.*	*sec.*		*degrees*	*degrees*	
June 11	16	46	38.3	Macquarie Islands region.	59.1 S.	157.8 E.	Appears to be a complex multiple event. Depth N. Mag. 7.2 (M_s).
June 24	13	09	08.3	Queen Charlotte Islands region.	51.8 N.	131.0 W.	Felt on Queen Charlotte Islands and in western British Columbia. Depth 12 km. Mag. 7.0 (M_s).
July 2	02	24	35.7	Turkey.....	38.8 N.	36.7 E.	1 killed and 150 houses destroyed in Sivas Province. Depth 27 km. Mag. 4.8 (m_b).
July 25	22	41	10.7	Kyushu, Japan.....	32.2 N.	131.7 E.	Slight damage at and near Miyazaki. Felt throughout Kyushu, on southern Shikoku, and in the northern Ryukyu Islands. Tsunami generated. Depth 34 km. Mag. 7.0 (M_s).
July 30	00	52	19.5	Iran-USSR border region.	37.8 N.	55.9 E.	176 killed, 483 injured, 10,000 homeless, and extensive property damage in cities of northwestern Khorasan Province, Iran. Depth 19 km. Mag. 6.6 (M_s).
July 31	17	08	05.4	Colombia.....	1.5 S.	72.6 W.	1 killed, several injured, and property damage reported in Peru. Felt from Buenos Aires, Argentina, to Mexico City, Mexico, and throughout the Caribbean. Depth 651 km. Mag. 7.1 (M_s).
Aug. 11	10	22	20.0	New Hebrides Islands...	14.1 S.	166.7 E.	Felt on Banks Islands and at Luganville. Depth N. Mag. 7.0 (M_s).
Aug. 30	17	46	09.0	Sea of Okhotsk.....	52.4 N.	151.6 E.	Felt at Morioka and Kushiro, Japan. Depth 645 km. Mag. 7.2, P.
Sept. 26	12	02	29.3	Near west coast of Colombia.	6.2 N.	77.6 W.	Two injured and 104 houses destroyed at Bahia Solano. Felt at San Cristobal and Merida, Venezuela. Depth 8 km. Mag. 6.6 (M_s).
Sept. 30	09	52	22.7	Philippine Islands region.	20.6 N.	122.0 E.	2 buildings collapsed and 60% of houses damaged at Basco, Batan Islands. Minor local tsunami generated. Depth N. Mag. 5.3 (M_s).

*See footnotes 2, 3, and 4 at bottom of table 1. When no authority is given for magnitude, it has been computed by the ERL National Earthquake Information Center.

page 57 follows

TABLE 2.—*Principal earthquakes of the world during 1970*—Continued

Date	Origin time G.M.T.			Region	Geographic coordinates		Remarks*
					Lat.	Long.	
	hr.	*min.*	*sec.*		*degrees*	*degrees*	
Oct. 31	17	53	09.3	Near north coast of New Guinea.	4.9 S.	145.5 E.	At least 5 killed. Considerable damage at Mandang. Felt throughout mainland of New Guinea. Depth 42 km. Mag. 7.0 (M_s).
Nov. 8	22	35	46.7	West New Guinea region.	3.4 S.	135.6 E.	Depth N. Mag. 6.8 (M_s).
Nov. 14	07	58	19.8	Taiwan region.....	22.7 N.	121.3 E.	2 killed. 2 injured at T'aitung. Also felt at Yonaguni-jima, Ryukyu Islands. Depth 28 km. Mag. 6.1 (M_s).
Nov. 28	07	40	11.6	New Mexico.....	35.0 N.	106.7 W.	Minor damage at Albuquerque. Depth 9 km. Mag. 4.5 (m_b).
Dec. 2	15	54	19.9	Solomon Islands.....	11.0 S.	163.3 E.	Depth N. Mag. 7.0 (M_s).
Dec. 10	04	34	38.8	Peru-Ecuador border region.	4.0 S.	80.7 W.	81 killed, many injured, and property damage in southern Equador and northern Peru. Depth 25 (D) km. Mag. 7.6 (M_s).

*See footnotes 2, 3, and 4 at bottom of table 1. When no authority is given for magnitude, it has been computed by the ERL National Earthquake Information Center.

Miscellaneous Activities

HORIZONTAL CONTROL SURVEYS FOR CRUSTAL MOVEMENT STUDIES [1]

In 1970, surveys for the study of horizontal movements in the earth's crust were made by NOAA's National Ocean Survey in the following areas of Alaska and California.

Alaska

Denali Fault.—Two quadrilaterals, with sides 5 to 9 km. long, crossing this fault were first observed in 1941. Triangulation and trilateration measurements were made in September 1970. This small selected net is located in the vicinity of the proposed Trans-Alaska Pipeline route, about 48 km. north of Paxson, and about midway between Glennallen and Delta Junction in the Third Judicial Division. Results of the resurvey indicate right-lateral movement on the order of 25 cm. during the 29-year interval between surveys.

California

San Francisco Bay Area.—A resurvey of a small fault-crossing net in the Bay area was made in February 1970. At Mira Vista (MAR site), measurements and direction to reference marks show some instability at two stations in the net. The rotation in astronomic azimuths produces changes in position vectors, but there is no clear indication of right-lateral movement.

Imperial Valley.—*Operational Data Report C&GS DR–10,* September 1970, available from the National Ocean Survey, gives a complete analysis of the results from the 1969 survey.

Aqueduct Surveys.—The cooperative project with the California State Department of Water Resources was continued during 1970. Resurveys were accomplished at seven sites along the aqueduct route. At three of the sites, CAST, BARREL, and DEVIL, the results did not indicate any significant changes from the previous surveys. The right-lateral shift at the COLT site, located on the San Jacinto Fault, was about 1 cm. during the interval 1964–70. However, relative movement between stations in the net amounted to as much as 2 cm. At the RIALTO site there was small, but systematic, right-lateral movement of about 2 mm. per year during the 1964–68 interval. From 1968 to 1970, relative movements between stations in the net were about 2 cm. Most of the stations at the TEJON site were destroyed during this reporting period. A new site was established over the same general area, and the station spacing was increased to extend the net farther away from the fault. At the time of that survey, the RANCH site was connected to the new TEJON site. A resurvey of the VERAS site, straddling the Calaveras Fault, showed right-lateral movement of about 12 mm. for the 5-year interval 1965–70.

TSUNAMIS [2]

Seven tsunamis were reported to the Environmental Research Laboratories (ERL) during 1970, including one that was recorded

[1] Prepared by B. K. Meade, Geodesy Division, National Ocean Survey, National Oceanic and Atmospheric Administration, Rockville, Md

[2] Prepared by M. G. Spaeth, Earth Sciences Laboratories, Environmental Research Laboratories, National Oceanic and Atmospheric Administration, Rockville, Md.

on a tide gage of NOAA's National Ocean Survey.

An earthquake in Mindanao, Philippine Islands, on January 10 (6.8° N., 126.7° E.) caused a minor tsunami that was recorded at the Malakal, Palau Island, Caroline Islands, tide station with an amplitude of 6 cm.

Following an earthquake on April 7 in Luzon, Philippine Islands (15.8° N., 121.7° E.), local wave activity was recorded at Dingalan Bay. Several huts along the shore were inundated. One witness reported the incoming waves were "taller than a man."

Press reports stated that on May 14, a series of shocks in the eastern Caucasus region of the USSR (43.0° N., 47.1° E.) caused a tsunami which submerged sand dunes along the Caspian seacoast.

Following the disastrous earthquake in Peru (9.2° S., 78.8° W.) on May 31, a minor tsunami was observed along the Peruvian coast. Waves of 76 cm. were recorded at Chimbote; La Punta tide station recorded 61-cm. waves.

An earthquake near Kyushu, Japan, on July 25 (32.2° N., 131.7° E.) caused a small tsunami which was recorded on Shikoku and Kyushu Islands. Maximum wave heights recorded were 52 cm. at Tosa-Shimizu, 42 cm. at Aburatsu, and 10 cm. at Murotomisaki.

Press reports indicated that a minor local tsunami was generated by the September 30 Philippine Islands earthquake (20.6° N., 122.0° E.).

An earthquake near the north coast of New Guinea (4.9° S., 145.5° E.) on October 31 generated a local tsunami which caused the only tsunami-related fatalities during 1970. Three people drowned when the waves upset their canoe. Maximum wave height reported from Madang was 1.2 meters.

Fluctuations in Well-Water Levels[1]

INTRODUCTION

In 1943, the Coast and Geodetic Survey (now the National Ocean Survey) first published the section on well-water fluctuations in its annual *United States Earthquakes* series. Data for the years 1944–49 appeared in the 1949 issue. From 1950 to the present, the material has been published annually.

The section on well descriptions lists only the new wells reported to the Water Resources Division of the U.S. Geological Survey during the year. Table 3 lists fluctuations in well water caused by various sources, such as blasts, earthquakes, and rockbursts. Table 4 lists the date, time, and location of specific events that may have been associated with the fluctuations noted in table 3. Also included are the States recording the fluctuations.

Complete information on earthquakes possibly associated with tabulations in table 3 may be obtained from the biweekly *Preliminary Determination of Epicenters* listings, published by the National Earthquake Information Center, Environmental Research Laboratories, National Oceanic and Atmospheric Administration, Boulder, Colo. 80302.

[1] Prepared by H. P. Eisenhuth, Water Data, Water Resources Division, Geological Survey, U.S. Dept. of the Interior, Denver, Colo.

WELL DESCRIPTIONS

Alaska

Well No. AK1022. Owner, U.S. Geological Survey, 61°10′33″ N., 149°43′01″ W., North Fork Campbell Creek fan (test no. 1). Drilled observation water-table well in sand and gravel of Pleistocene age. Depth, 112 feet; diameter, 6 inches; perforated 61.5 to 64.5 feet, open end at 75 feet, bedrock at 93 feet.

Georgia

Well No. 9F520. Owner, Graham Bolton, 30°36′00″ N., 84°57′30″ W., Bainbridge. Drilled observation artesian well in Ocala Limestone. Depth, 251 feet; diameter, 10 inches; cased to 130 feet.

Idaho

Well No. 9S–39E–2cbcl. Owner, Don Rigby, 42°27′13″ N., 111°51′58″ W. Drilled observation water-table well in Snake River Group, Quaternary age. Depth, 96 feet; diameter, 6 inches.

TABLE 3.—*Fluctuations in well-water levels during 1970*

County and/or well number	Date (Greenwich mean time)	Time at recorder (Greenwich mean time)	Depth to water before disturbance	Water-level fluctuations: From prequake level: Upward	Water-level fluctuations: From prequake level: Downward	Water-level fluctuations: Double amplitude
				feet	*feet*	*feet*
ALASKA						
AK590 (Formerly 12-4-1-1)	Apr. 18	0900	9.115	0.010	0.030	0.040
AK316b	June 2	0300	8.375	.020	.005	.025
AK17	June 24	1330	60.76	.06	.06	.12
AK1022 (Formerly AK818)	June 24	1330	41.39	.04	.03	.07
Do	Aug. 18	1830	40.45	.005	.035	.040
AK17	Aug. 18	1900	58.91	.02	.03	.05
AK1022	Nov. 3	0230	38.98	.000	.015	.015
AK316b	Nov. 3	0300	7.955	.005	.005	.010
GEORGIA						
Charlton 27E2	Jan. 4	1700	63.31	0.01	0.01	0.02
Decatur 9F520	Jan. 4	1700	48.01	.03	.03	.06
Dougherty 13L3	Jan. 4	1700	43.52	.04	.05	.09
Thomas 14E15	Jan. 4	1700	198.28	.09	.06	.15
Charlton 27E2	Apr. 16	0533	60.70	.02	.07	.09
Decatur 9F520	Apr. 16	0533	44.69	.22	.22	.44
Dougherty 13L3	Apr. 16	0533	35.22	.08	.12	.20
Long 33M4	Apr. 16	0533	39.09	.01	.01	.02
McIntosh 35M13	Apr. 16	0533	9.73	.03	.02	.05
Charlton 27E2	Apr. 29	1122	60.54	.025	.025	.050
Decatur 9F520	Apr. 29	1122	43.62	.01	.04	.05
Dougherty 13L3	Apr. 29	1122	35.82	.03	.03	.06
Thomas 14E15	Apr. 29	1122	197.67	.12	.13	.25
Charlton 27E2	Apr. 29	1401	60.58	.14	.18	.32
Decatur 9F520	Apr. 29	1401	43.66	.26	.31	.57
Dougherty 13L3	Apr. 29	1401	35.87	.24	.24	.48
Long 33M4	Apr. 29	1401	38.73	.07	.05	.12
McIntosh 35M13	Apr. 29	1401	10.09	.08	.09	.17
Thomas 14E15	Apr. 29	1401	197.65	.75	.80	1.55
Charlton 27E2	Apr. 30	0832	60.57	.015	.025	.040
Decatur 9F520	Apr. 30	0832	43.65	.06	.03	.09
Dougherty 13L3	Apr. 30	0832	35.86	.06	.04	.10
Long 33M4	Apr. 30	0832	38.72	.001	.009	.010
McIntosh 35M13	Apr. 30	0832	9.12	.01	.02	.03
Thomas 14E15	Apr. 30	0832	197.69	.09	.08	.17
Charlton 27E2	May 31	2023	62.10	.05	.07	.12
Decatur 9F520	May 31	2023	45.23	.04	.04	.08
Dougherty 13L3	May 31	2023	36.27	.06	.06	.12
Long 33M4	May 31	2023	39.08	.02	.04	.06
McIntosh 35M13	May 31	2023	9.50	.04	.04	.08
Thomas 14E15	May 31	2023	197.85	.18	.15	.33
Decatur 9F520	June 24	1309	45.83	.02	.04	.06
Dougherty 13L3	June 24	1309	33.33	.02	.02	.04
Decatur 9F520	July 31	1708	46.50	.03	.03	.06
Dougherty 13L3	July 31	1708	34.70	.02	.04	.06

TABLE 3.—*Fluctuations in well-water levels during 1970*—Continued

County and/or well number	Date	Time at recorder (Greenwich mean time)	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
GEORGIA—Continued						
			feet	*feet*	*feet*	*feet*
Long 33M4	July 31	1708	39.23	0.01	0.01	0.02
McIntosh 35M13	July 31	1708	10.63	.015	.015	.030
Dougherty 13L3	Sept. 26	1202	34.47	.01	.02	.03
Thomas 14E15	Sept. 26	1202	197.98	.05	.07	.12
Dougherty 13L3	Sept. 27	0338	34.49	.01	.02	.03
Thomas 14E15	Sept. 27	0338	198.17	.04	.04	.08
Charlton 27E2	Dec. 10	0434	63.46	.04	.06	.10
Decatur 9F520	Dec. 10	0434	48.00	.09	.09	.18
Dougherty 13L3	Dec. 10	0434	37.71	.10	.14	.24
Long 33M4	Dec. 10	0434	39.71	.05	.06	.11
McIntosh 35M13	Dec. 10	0434	11.13	.04	.07	.11
Thomas 14E15	Dec. 10	0434	197.86	.47	.45	.92
IDAHO						
Madison 7N–38E–23dbal	Jan. 4	1715	40.70	0.09	0.11	0.20
Butte 5N–31E–28cccl	Jan. 10	1330	257.92	.05	.05	.10
Do	Jan. 20	0815	258.32	.04	.03	.07
Teton 4N–45E–13adal	Feb. 4	0515	199.28	.01	.03	.04
Madison 7N–38E–23dbal	Feb. 4	0520	41.52	.09	.09	.18
Butte 4N–30E–7adbl	Feb. 4	0545	315.17	.05	.08	.13
Butte 5N–31E–28cccl	Feb. 4	0615	258.40	.03	.05	.08
Caribou 9S–39E–2cbcl	Mar. 23	0040	81.02	.15	.27	.42
Blaine 8S–26E–33bcbl	Mar. 26	1400–1600 [1]	107.68	.07	.06	.13
Blaine 1S–19E–3ccb2	Mar. 26	1600–1800 [1]	16.93	.03	.03	.06
Teton 4N–45E–13adal	Mar. 26	1840	201.10	.02	.02	.04
Elmore 2S–5E–36bbbl	Mar. 26	1845	285.12	.03	.05	.08
Canyon 5N–5W–24dbbl	Mar. 26	1900	10.84	.03	.03	.06
Butte 5N–29E–23cdal	Mar. 26	1900	260.83	.01	.03	.04
Madison 7N–38E–23dbal	Mar. 26	1910	42.74	.04	.05	.09
Butte 4N–30E–7adbl	Mar. 26	1915	315.47	.05	.08	.13
Jefferson 7N–34E–4cdcl	Mar. 26	1920	5.17	.05	.05	.10
Butte 3N–29E–14adbl	Mar. 26	1925	452.16	.10	.13	.23
Cassia 13S–21E–18bbcl	Mar. 26	1930	551.97	.02	.05	.07
Butte 4N–30E–7adbl	Mar. 28	2150	315.39	.02	.03	.05
Madison 7N–38E–23dbal	Mar. 28	2200	42.79	.04	.04	.08
Butte 5N–31E–28cccl	Mar. 28	2300	258.98	.02	.03	.05
Teton 4N–45E–13adal	Apr. 11	0415	201.43	.03	.01	.04
Madison 7N–38E–23dbal	Apr. 11	0430	42.99	.08	.10	.18
Butte 4N–30E–7adbl	Apr. 11	0445	315.28	.01	.04	.05
Teton 4N–45E–13adal	Apr. 16	0545	201.67	.11	.09	.20
Butte 6N–25E–3aaal	Apr. 16	0600	73.26	.02	.04	.06
Madison 7N–38E–23dbal	Apr. 16	0600	43.13	.49	.47	.96
Elmore 2S–5E–36bbbl	Apr. 16	0605	285.24	.03	.05	.08
Butte 3N–29E–14adbl	Apr. 16	0645	452.28	.06	.07	.13

[1] See footnote at end of table.

TABLE 3.—*Fluctuations in well-water levels during 1970*—Continued

County and/or well number	Date	Time at recorder (Greenwich mean time)	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
IDAHO—Continued						
			feet	*feet*	*feet*	*feet*
Butte 4N–30E–7adbl	Apr. 16	0700	315.37	0.10	0.13	0.23
Butte 5N–31E–28cccl	Apr. 16	0700	259.38	.10	.10	.20
Blaine 1S–19E–3ccb2	Apr. 29	1100–1300 [1]	17.52	.02	.02	.04
Madison 7N–38E–23dbal	Apr. 29	1320	43.09	.20	.20	.40
Teton 4N–45E–13adal	Apr. 29	1320	201.84	.02	.03	.05
Elmore 2S–5E–36bbbl	Apr. 29	1325	285.33	.05	.05	.10
Madison 7N–38E–23dbal	Apr. 29	1330	43.69	.06	.06	.12
Butte 6N–25E–3aaal	Apr. 29	1330	73.30	.02	.03	.05
Cassia 13S–21E–18bbcl	Apr. 29	1400	551.82	.05	.04	.09
Twin Falls 14S–15E–28bad2	Apr. 29	1440	104.45	.03	.04	.07
Butte 3N–29E–14adbl	Apr. 29	1445	452.06	.03	.03	.06
Madison 7N–38E–23dbal	Apr. 30	0740	43.09	.03	.02	.05
Cassia 13S–21E–18bbcl	May 31	2030	553.63	.02	.02	.04
Elmore 2S–5E–36bbbl	May 31	2045	285.44	.01	.02	.03
Teton 4N–45E–13adal	May 31	2050	185.54	.02	.03	.05
Madison 7N–38E–23dbal	May 31	2100	42.50	.07	.08	.15
Do	June 11	1745	41.87	.04	.02	.06
Do	June 15	1200	41.65	.02	.02	.04
Do	June 24	1250	41.24	.09	.09	.18
Elmore 2S–5E–36bbbl	June 24	1300	285.32	.03	.03	.06
Madison 7N–38E–23dbal	June 24	1315	41.24	.06	.07	.13
Teton 4N–45E–13adal	June 24	1315	158.11	.05	.06	.11
Cassia 13S–21E–18bbcl	June 24	1330	554.15	.02	.02	.04
Jefferson 7N–34E–4cdcl	June 24	1330	13.35	.03	.02	.05
Madison 7N–38E–23dbal	July 31	1720	39.76	.04	.03	.07
Do	July 31	1740	39.75	.02	.03	.05
Butte 5N–31E–28cccl	July 31	1745	262.00	.03	.03	.06
Madison 7N–38E–23dbal	Aug. 11	1115	39.42	.02	.02	.04
Butte 7N–31E–34bdcl (Formerly 7N–31E–34bdl)	Sept. 12	1945	267.53	.03	.01	.04
Teton 4N–45E–13adal	Dec. 10	0415	193.08	.02	.02	.04
Elmore 2S–5E–36bbbl	Dec. 10	0530	285.47	.02	.01	.03
Madison 7N–38E–23dbal	Dec. 10	0545	40.05	.22	.12	.34
INDIANA						
Sh 2	Jan. 4	1725–1735	19.16	0	0.01	0.01
Ma 32	Jan. 4	1735–1800	10.33	.04	.03	.07
Do	Jan. 10	1300–1330	10.40	.01	.01	.02
Do	Jan. 20	0740–0750	10.67	.01	0	.01
Do	Jan. 21	1730–1740	10.77	.01	.01	.02
Do	Mar. 19	2355–2400	10.81	.01	.01	.02
Do	Mar. 26	1900–1905	10.70	.01	.01	.02
Do	Mar. 28	2240–2300	10.47	.01	.03	.04
Do	Apr. 7	0545–0605	10.33	.02	0	.02
Fu 7	Apr. 16	0530–0535	7.83	0	.01	.01

[1] See footnote at end of table.

TABLE 3.—*Fluctuations in well-water levels during 1970*—Continued

County and/or well number	Date	Time at recorder (Greenwich mean time)	Depth to water before disturbance	Water-level fluctuations		
				From prequake level		Double amplitude
				Upward	Downward	
INDIANA—Continued						
			feet	*feet*	*feet*	*feet*
Pu 6	Apr. 16	0530–0550	8.225	0.065	0.063	0.128
Dw 4	Apr. 16	0540–0550	48.17	.01	.02	.03
Sh 2	Apr. 16	0550–0600	18.33	.03	.01	.04
Md 8	Apr. 16	0600–0610	17.67	.01	0	.01
Ma 32	Apr. 16	0600–0630	10.29	.19	.19	.38
Do	Apr. 29	1140–1150	9.36	.01	.01	.02
Dw 4	Apr. 29	1350–1400	48.10	.01	.01	.02
Ma 32	Apr. 29	1350–1415	9.37	.13	.20	.33
Pu 6	Apr. 29	1420–1435	6.775	.033	.025	.058
Ma 32	Apr. 30	0830–0840	9.97	.12	.09	.21
Do	May 31	2015–2100	10.98	.07	.09	.16
Sh 2	May 31	2020–2030	18.93	.11	.09	.20
Pu 6	May 31	2045–2100	7.96	.018	.018	.036
Dw 4	May 31	2050–2100	48.35	.01	0	.01
Ma 32	June 11	1740–1800	11.69	0	.02	.02
Dw 4	June 24	1300–1305	48.53	.01	.01	.02
Ma 32	June 24	1300–1350	11.75	.05	.09	.14
Sh 2	June 24	1330–1340	19.58	.01	.01	.02
Pu 6	June 24	1330–1340	8.629	.053	.017	.070
Ma 32	July 31	1640–1705	11.87	.03	.06	.09
Sh 2	July 31	1730–1740	20.06	0	.01	.01
Md 8	July 31	1800–1810	18.18	.03	.02	.05
Ma 32	Sept. 26	1115–1130	11.41	.02	.02	.04
Do	Sept. 27	0350–0400	11.39	.01	.02	.03
Pu 6	Dec. 10	0425–0515	9.735	.027	.016	.043
Sh 2	Dec. 10	0440–0450	21.27	.02	.01	.03
Dw 4	Dec. 10	0450–0455	49.12	.01	0	.01
Ma 32	Dec. 10	0450–0515	10.54	.11	.09	.20
Md 8	Dec. 10	0600–0610	19.93	.01	0	.01
NEVADA						
S17/50-36-bcdl	Feb. 24	0810	1.20	0.02	0.02	0.04
Do	Feb. 25	1430	1.27	0	.01	.01
Do	Feb. 26	1530	1.33	.01	.02	.03
Do	Feb. 28	1050	1.38	.02	.03	.05
Do	Mar. 10	2100±	1.27	.02	.02	.04
Do	Mar. 11	2250	1.19	.02	.03	.05
Do	Mar. 26	1900	1.38	.39	.34	.73
Do	Mar. 28	2145	1.28	.04	.05	.09
Do	Apr. 11	0420	1.43	.08	.07	.15
Do	Apr. 16	0600	1.17	.28	.42	.70
Do	Apr. 19	0115	1.23	.04	.03	.07
Do	Apr. 29	1200	1.05	.12	.11	.23
Do	Apr. 30	0900	1.07	.23	.83	1.06
Do	May 1	0830	1.01	.03	.02	.05

TABLE 3.—*Fluctuations in well-water levels during 1970*—Continued

County and/or well number	Date (Greenwich mean time)	Time at recorder (Greenwich mean time)	Depth to water before disturbance	Water-level fluctuations: From prequake level, Upward	Water-level fluctuations: From prequake level, Downward	Water-level fluctuations: Double amplitude
			feet	*feet*	*feet*	*feet*
NEVADA—Continued						
S17/50-36-bcd1	May 1	2000	0.96	0.02	0.03	0.05
Do	May 2	0230	.98	.02	.01	.03
Do	May 26	1500	.90	.02	0	.02
Do	May 31	2030	.85	.11	.14	.25
Do	June 24	0730	2.32	.02	.03	.05
Do	June 24	1305	2.42	.15	.08	.23
Do	July 10	1330	2.52	.01	.01	.02
Do	Aug. 28	1750	2.85	.02	.01	.03
Do	Sept. 12	1430	2.78	.03	.03	.06
Do	Sept. 27	0420	2.84	.01	.01	.02
Do	Dec. 16	1515	2.69	.04	.04	.08
Do	Dec. 17	1520	2.69	.19	.19	.38
Do	Dec. 18	1445	2.81	.02	0	.02
WISCONSIN						
M1-120	Jan. 4	1815	96.500	0.025	0.025	0.050
Do	Jan. 10	1355	96.675	.020	.005	.025
Lf-57	Feb. 24	0810	111.83	.04	0	.04
Do	Feb. 28	1100	112.17	.01	.01	.02
Do	Mar. 26	1845	111.60	.05	.04	.09
Do	Mar. 28	2115	111.88	.03	.01	.04
M1-120	Mar. 28	2200	94.730	.014	.006	.020
Lf-57	Apr. 7	0630	111.87	.02	.03	.05
M1-120	Apr. 7	0700	94.290	.009	.012	.021
Lf-57	Apr. 11	0330	111.65	.07	.03	.10
M1-120	Apr. 11	0500	94.263	.014	.013	.027
Lf-57	Apr. 16	0500	111.73	.66	.36	1.02
M1-120	Apr. 16	0630	94.180	.161	.226	.387
Lf-57	Apr. 19	0030	111.61	.04	.03	.07
Do	Apr. 29	1020	111.63	.01	.04	.05
M1-120	Apr. 29	1150	93.724	.005	.014	.019
Lf-57	Apr. 29	1300	111.65	.17	.17	.34
M1-120	Apr. 29	1445	93.750	.050	.071	.121
Lf-57	Apr. 30	0730	111.66	.01	.02	.03
M1-120	Apr. 30	0900	93.750	.007	.009	.016
Do	May 31	2100	94.320	.081	.052	.133
Lf-57	June 11	1515	111.52	.04	.04	.08
Do	June 24	1315	111.40	.27	.35	.62
M1-120	June 24	1320	95.032	.052	.038	.090
Do	July 25	2345	94.440	.003	.005	.008
Do	July 31	1715	94.102	.020	.018	.038
Lf-57	July 31	1715	111.34	.06	.03	.09
Do	Aug. 11	1100	111.48	.02	.05	.07
M1-120	Aug. 11	1100	94.100	.001	.016	.017
Do	Sept. 26	1230	94.910	.002	.023	.025

TABLE 3.—*Fluctuations in well-water levels during 1970*—Continued

County and/or well number	Date	Time at recorder (Greenwich mean time)	Depth to water before disturbance	Water-level fluctuations: From prequake level, Upward	From prequake level, Downward	Double amplitude
				WISCONSIN—Continued		
			feet	*feet*	*feet*	*feet*
Lf–57	Sept. 26	1230	111.45	0.03	0.04	0.07
M1–120	Sept. 27	0410	95.017	.006	.013	.019
Lf–57	Dec. 10	0450	111.26	.06	.09	.15

[1] Time of occurrence for monthly gage believed to be accurate to ±1 hour. Time for all other gages believed to be accurate to ±3 minutes.

TABLE 4.—*Earthquakes in 1970 believed to have caused fluctuations in well-water levels*

Date	Origin time G.M.T.	Location	States recording fluctuations
	hr. min. sec.		
Jan. 4	17 00 40.2	Yunnan Province, China	Georgia, Idaho, Indiana, Wisconsin.
Jan. 10	12 07 08.6	Mindanao, Philippine Islands (and aftershocks)	Idaho, Indiana, Wisconsin.
Jan. 20	07 19 51.2	South of Fiji Islands	Idaho, Indiana.
Jan. 21	17 51 38.5	Off coast of Mexico	Indiana.
Feb. 4	05 08 48.0	Off coast of Guerrero, Mexico	Idaho.
Feb. 24	08 05 39.6	Gulf of Alaska	Nevada, Wisconsin.
Feb. 25	14 28 38.0	Southern Nevada (Nevada Test Site)	Nevada.
Feb. 26	15 30 00.0	.....do	Do.
Feb. 28	10 52 31.2	Andreanof Islands, Aleutian Islands	Nevada, Wisconsin.
Mar. 10	20 58 14.4	Central California	Nevada.
Mar. 11	22 38 34.6	Kodiak Island region	Do.
Mar. 19	23 33 29.1	Near Islands, Aleutian Islands	Indiana.
Mar. 23	00 20 54.7	Honshu, Japan	Idaho.
Mar. 26	19 00 00.2	Southern Nevada (Nevada Test Site)	Idaho, Indiana, Nevada, Wisconsin.
Mar. 28	21 02 23.4	Turkey	Do.
Apr. 7	05 34 05.6	Luzon, Philippine Islands (and aftershocks)	Indiana, Wisconsin.
Apr. 11	04 05 41.1	Gulf of Alaska	Idaho, Nevada, Wisconsin.
Apr. 16	05 33 17.5	.....do	Georgia, Idaho, Indiana, Nevada, Wisconsin.
Apr. 16	06 40 21.9	.....do	Idaho, Wisconsin.
Apr. 18	08 50 40.5	Southern Alaska	Alaska.
Apr. 19	01 15 46.8	Gulf of Alaska	Nevada, Wisconsin.
Apr. 29	11 22 36.4	Near coast of Chiapas, Mexico	Georgia, Idaho, Indiana, Nevada, Wisconsin.
Apr. 29	14 01 32.8	.....do	Georgia, Idaho, Indiana, Wisconsin.
Apr. 30	08 32 59.1	.....do	Georgia, Idaho, Indiana, Nevada, Wisconsin.
May 1	08 35 24.2	.....do	Nevada.
May 1	20 03 27.9	.....do	Do.

TABLE 4.—*Earthquakes in 1970 believed to have caused fluctuations in well-water levels*—Continued

Date	Origin time G.M.T.	Location	States recording fluctuations
May 2	02 06 56.3	Near coast of Chiapas, Mexico	Nevada.
May 26	15 00 00.0	Southern Nevada (Nevada Test Site)	Do.
May 31	20 23 27.3	Near coast of northern Peru	Georgia, Idaho, Indiana, Nevada, Wisconsin.
June 2	02 59 31.3	Southern Alaska	Alaska.
June 11	16 46 38.3	Macquarie Islands region	Idaho, Indiana, Wisconsin.
June 15	11 14 52.4	Falkland Islands region	Idaho.
June 24	07 30 30.8	Queen Charlotte Islands region	Nevada.
June 24	13 09 08.3	.....do	Alabama, Georgia, Idaho, Indiana, Nevada, Wisconsin.
July 10	13 14 50.9	Near coast of Guerrero, Mexico	Nevada.
July 25	22 41 10.7	Kyushu, Japan	Indiana, Nevada, Wisconsin.
July 31	17 08 05.4	Colombia	Georgia, Idaho, Indiana, Wisconsin.
Aug. 11	10 22 20.0	New Hebrides Islands	Idaho, Wisconsin.
Aug. 18	17 52 06.3	Southern Alaska	Alaska.
Aug. 28	17 39 44.7	Central Mexico	Nevada.
Sept. 12	14 30 51.9	Southern California	Do.
Sept. 12	18 26 28.0	.....do	Idaho.
Sept. 26	12 02 29.3	Near west coast of Colombia	Georgia, Indiana, Wisconsin.
Sept. 27	03 38 36.2	.....do	Georgia, Indiana, Nevada, Wisconsin.
Nov. 3	02 30 11.4	Central Alaska	Alaska.
Dec. 10	04 34 38.8	Peru-Ecuador border region	Georgia, Idaho, Wisconsin.
Dec. 16	16 00 00.1	Southern Nevada (Nevada Test Site)	Nevada.
Dec. 17	16 05 00.2	.....do	Do.
Dec. 18	15 30 00.2	.....do	Do.

Strong-Motion Seismograph Data[1]

INTRODUCTION

The NOAA National Ocean Survey (previously the Coast and Geodetic Survey) has conducted an engineering seismology program in the United States and Latin America since 1932. The Survey, with the cooperation of state and municipal governments, private industry, and state and private educational institutions, has installed and maintained strong-motion seismographs and analyzed the seismograms. The results of the analysis have been published in Government bulletins and scientific journals, and the records, either originals or copies, have been made available to research scientists.

A list of strong-motion stations in the United States and Central and South America is available from the Seismological Field Survey, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, 390 Main Street, San Francisco, Calif. 94105. Entitled *Strong-Motion Station Instrumental Data* (with an addendum for installations during the year 1970), the report gives the geographic location of each station, instrumental constants, and lists of new stations and those removed during 1969 and 1970. In addition, it lists seismoscope sites in Alaska, Arizona, and California for those years.

The number of strong-motion accelerographs in the United States and Central and South America has risen from 75 in 1963 to 455 in December 1970, with a net increase of 93 instruments from 1969. The rapid growth in the network is attributable largely to the development of modern accelerographs, the subsequent cooperative program instituted with the State of California Department of Water Resources, Army Corps of Engineers, and California Institute of Technology, and to numerous cities that have adopted building code provisions that require three accelerographs in most structures taller than six stories. Seismoscope installations also increased from 377 in 1969 to 382 in December 1970.

Figure 6 shows the locations of strong-motion sites in the network operated by the Seismological Field Survey. Table 5 lists earthquakes recorded and records obtained on strong-motion instruments in 1970.

Notes pertinent to this engineering seismology program may be found in preceding issues of the *United States Earthquakes* series, and in *Publication 41–2, Earthquake Investigations in the Western United States, 1931–1964*, U.S. Department of Commerce, Coast and Geodetic Survey, 1965 (out of print). The latter is much broader in scope, containing data on structural and ground vibrations and detailed descriptions of the many activities which constitute the seismological program as a whole.

INTERPRETATION OF RECORDS

The accelerations and displacements shown in tables 6 and 7 are values derived from direct scaling of maximum amplitudes from the original records. Periods are approximated by assuming simple harmonic motion, as most accelerograph records are irregular in character. All accelerograms recorded in 1970 are listed by date in table 6, but only those

[1] Prepared by V. Perez and C. F. Knudson, Seismological Field Survey, Environmental Research Laboratories, National Oceanic and Atmospheric Administration, San Francisco, Calif.

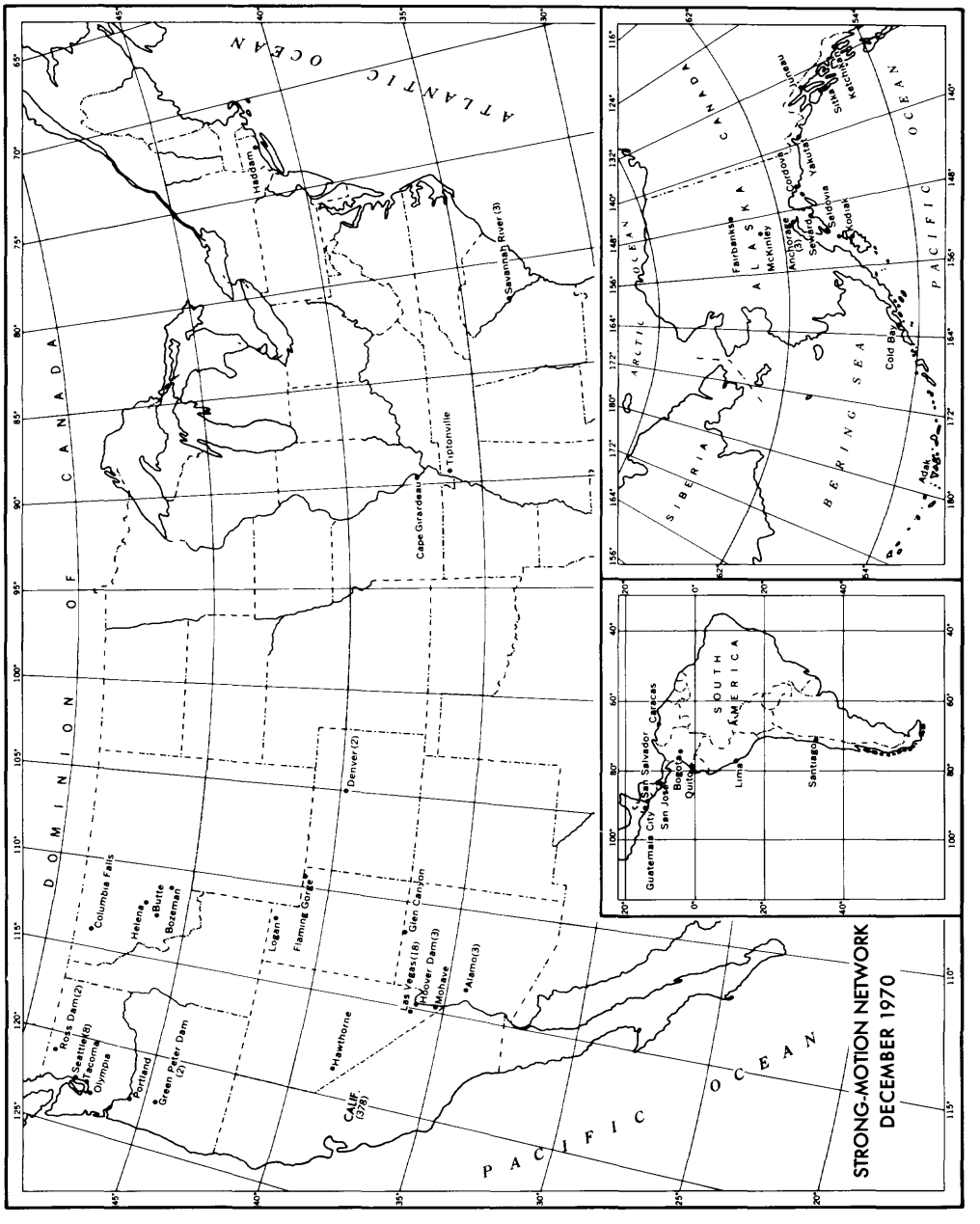

FIGURE 6.—Strong-motion station locations in the United States and Central and South America.

that had 10 cm/sec² in amplitude or more are shown in table 7.

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/sec². For practical purposes, point off three decimal places to the left to convert cm/sec² to an approximation of g.

Table 8 lists five different accelerograph models now incorporated in the strong-motion network. Although a large number of the instruments in column 1 have been installed, only the Kinemetrics SMA–1 and Teledyne-Geotech RFT–250 are in production at the present time. All of the instruments are 1–g models, i.e., they have the capability of recording acceleration pulses as large as 1 g without going off scale.

Sensitivity of the accelerographs, as shown in table 7, is expressed as the deflection of the trace in centimeters for a constant acceleration of 1 g. Damping ratio of the pendulum is the ratio between successive amplitudes when the pendulum oscillates.

TABLE 5.—*List of shocks recorded and records obtained on strong-motion seismographs in 1970*

Date	Region and recording station	Number of records		
		Accelero-graph	Survey displacement meter	Carder displacement meter
Between Aug. 9, 1969, and Feb. 11, 1970	*California-Nevada border region*			
	Bishop (probably Oct. 3, 1969, 05:10:11 PST)	1		
Mar. 11	*Alaska*			
	Kodiak	1*		
Mar. 30	*Central California*			
	Hollister, City Hall	1		1
	.....do	1**		
	Hollister, Sago East	1***		
Mar. 31	*Central California*			
	Hollister, Sago East	1***		
Apr. 4	*Central California*			
	Hollister, Sago (Harris Ranch)	1***		
Apr. 18	*Alaska*			
	Seldovia	1*		
	Seward	1*		
June 2	*Alaska*			
	Anchorage, Alaska Methodist University	1*		
	Anchorage, Government Hospital	1*		
Aug. 13	*Northern California*			
	Ferndale	1	1	
Aug. 18	*Alaska*			
	Cordova	1*		
Sept. 12	*Southern California*			
	Anza Post Office	1**		
	Arcadia, Santa Anita Reservoir	1*		
	Borrego Springs	1**		
	Carbon Canyon Dam	1**		
	Castaic, Castaic Dam	1**		

TABLE 5.—*List of shocks recorded and records obtained on strong-motion seismographs in 1970*—Continued

Date	Region and recording station	Number of records		
		Accelero-graph	Survey displacement meter	Carder displacement meter
Sept. 12	*Southern California*—Continued			
	Castaic, Old Ridge Route	1*		
	Cedar Springs, Allen Ranch	1*		
	Cedar Springs, right abutment	1*		
	Colton	1	1	
	Hemet, Fire Station	1**		
	Lake Hughes, Array No. 1	1*		
	Lake Hughes, Array No. 4	1**		
	Loma Linda Hospital	1**		
	Long Beach State College	1**		
	Los Angeles:			
	800 W. First St., 1st floor	1***		
	16th floor	1***		
	Roof	1***		
	750 S. Garland, basement	1**		
	2d floor	1**		
	6th floor	1**		
	Griffith Observatory	1**		
	Hollywood Storage, basement	1		
	Penthouse	1		
	Pacific Electric Lot	1		
	1640 Marengo, basement	1*		
	4th floor	1*		
	Penthouse	1*		
	808 S. Olive, basement	1*		
	4th level	1*		
	Roof	1*		
	3440 University, basement	1***		
	5th floor	1***		
	Water and Power, basement	1*		
	7th floor	1*		
	15 floor	1*		
	3710 Wilshire Blvd., basement	1*		
	5th floor	1*		
	11th floor	1*		
	Palmdale, Fire Station	1**		
	Pasadena, Cal Tech:			
	Jet Propulsion Lab., basement	1**		
	Roof	1**		
	Millikan Library, basement	1**		
	Roof	1**		
	Seismological Lab	1**		
	San Bernardino, Devils Canyon	1*		
	Hall of Records	1**		
	San Dimas, Puddingstone Reservoir	1*		
	Upland, San Antonio Dam	1**		
	Whittier Narrows Dam	1**		
Sept. 13	*Northern California*			
	Ferndale	1	1	

*Instrument is AR–240.
**Instrument is RFT–250.
***Instrument is MO–2.

TABLE 6.—*Summary of outstanding instrumental and noninstrumental data for 1970*

Epicenter	Recording station and distance	Location of instrument	Intensity**	Acceleration *cm./sec.*^{2}
San Bernardino, Calif., Earthquake of Sept. 12 (06:30:53.0 PST)				
34°16.2′ N., 117°32.4′ W., southern California, VII*. Mag. 5.4, P.	San Bernardino, Devils Canyon, 17½ km.	One-story reinforced concrete block building, 8 by 7 meters, resting on a reinforced concrete foundation.	VI	174

*An asterisk following the intensity designation in the epicenter column indicates the maximum reported intensity of the earthquake. See Modified Mercalli Intensity Scale, page 4.

**The nearest intensity reported was intensity VI in San Bernardino, about 13 km. southeast of Devils Canyon Station.

TABLE 7.—*Composite of strong-motion instrumental data for 1970* [1]

Station and component	Instrument no.	Period (T_0) sec.	Magnification (V)	Sensitivity cm./g.	Damping ratio (ε)	Maximum				Remarks
						Acceleration		Displacement		
						Period sec.	Amplitude cm./sec.^{2}	Period sec.	Amplitude cm.	
California-Nevada Border Region Earthquake Between Aug 9, 1969, and Feb. 11, 1970										
Bishop:										
Up	241	0.066	118.0	13.1	10.0	0.85	5	.....	.....	
East	242	0.066	116.0	12.6	10.0	1.18	5	.....	.....	
South	243	0.064	119.0	12.3	9.0	1.28	12	.....	.....	
Alaska Earthquake of Mar. 11										
Kodiak:										
Down	367	0.054	107.0	7.8	10.0	0.86	4	.....	.....	
S 10° E	187	0.052	113.0	7.5	9.5	0.70	18	.....	.....	
N 80° E	155	0.053	111.0	7.6	9.5	0.63	45	.....	.....	
Central California Earthquake of Mar. 30										
Hollister, City Hall:										
Up	239	0.068	123.0	13.5	9.0	0.12	15	.....	.....	
						0.21	9	.....	.....	
S 1° W	238	0.066	123.0	14.2	10.0	0.24	31	.....	.....	
						0.28	25	.....	.....	
N 89° W	240	0.066	122.0	13.3	10.0	0.25	15	.....	.....	
						0.30	17	.....	.....	
N 1° E	6	2.1	1.0	.....	11.0	.....	.....	0.83	0.10	
N 89° W	5	2.2	1.0	.....	11.0	.....	.....	0.50	0.18	
Hollister, City Hall:										
Down	Prototype	0.048	.....	1.9	10.0	0.20	15	.....	.....	Factory instrument
North	RFT–250	0.048	.....	1.9	10.0	0.42	36	.....	.....	constants.
West		0.048	.....	1.9	10.0	0.51	18	.....	.....	

[1] Accelerograms with acceleration amplitudes less than 10 cm./sec.^{2} were not measured.

Hollister, Sago East:										
Up		0.030		2.40	10.0	0.12	32			Portions of film are too dark to read.
South		0.030		1.66	10.0	0.14	125			
West		0.030		1.65	10.0	0.13	100			
Central California Earthquake of Mar. 31										
Hollister, Sago East:										
Up		0.030		2.40	10.0	0.11	9			
South		0.030		1.66	10.0	0.13	12			
West		0.030		1.65	10.0	0.10	19			
Alaska Earthquake of Apr. 18										
Seldovia:										
Down	217	0.063	78.0	7.6	11.0	0.18	2			
West	255	0.062	112.0	7.6	11.0	0.30	11			
South	227	0.061	81.0	7.6	10.0	0.35	11			
Seward:										
Down	213	0.058	91.0	7.6	11.0	0.32	10			
West	205	0.056	97.0	7.6	9.0	0.33	13			
South	148	0.058	91.0	7.6	10.0	0.29	18			
Alaska Earthquake of June 2										
Anchorage, Government Hospital:										
Down	222	0.051	116.0	7.6	10.0	0.31	8			
South	212	0.058	90.0	7.6	12.0	0.25	11			
East	249	0.059	88.0	7.6	12.0	0.28	20			
Alaska Earthquake of Aug. 18										
Cordova:										
Down	161	0.051	118.0	7.6	12.0	0.40	7			
South	196	0.051	118.0	7.6	12.0	0.69	20			
East	147	0.051	117.0	7.6	12.0	0.72	15			

TABLE 7.—*Composite of strong-motion instrumental data for 1970*—Continued

Station and component	Instrument no.	Period (T_0) sec.	Magnification (V)	Sensitivity cm./g.	Damping ratio (ε)	Maximum				Remarks
						Acceleration		Displacement		
						Period sec.	Amplitude cm./sec.^{2}	Period sec.	Amplitude cm.	
Southern California Earthquake of Sept. 12										
Anza Post Office:										
Down	217	0.048	34.0	1.9	10.0	0.11	5	.....	.....	
N 45° E	180	0.048	34.0	1.9	10.0	0.15	10	.....	.....	
N 45° W	204	0.048	34.0	1.9	10.0	0.12	20	.....	.....	
Arcadia, Santa Anita Reservoir:										
Down	297	0.052	119.0	7.6	9.0	0.12	18	.....	.....	
N 03° E	389	0.051	110.0	7.6	10.0	0.14	54	.....	.....	
						0.11	23	.....	.....	
N 87° W	266	0.051	117.0	7.6	10.0	0.09	27	.....	.....	
						0.11	22	.....	.....	
Carbon Canyon Dam:										
Down	102	0.048	34.0	1.9	10.0	0.10	13	.....	.....	
S 40° W	101	0.048	34.0	1.9	10.0	0.25	20	.....	.....	
						0.15	20	.....	.....	
S 50° E	104	0.048	34.0	1.9	10.0	0.24	38	.....	.....	
						0.26	24	.....	.....	
Castaic, Old Ridge Route:										
Down	159	0.050	123.0	7.9	8.0	0.11	8	.....	.....	
						0.21	6	.....	.....	
N 21° E	165	0.050	123.0	8.1	10.0	0.15	19	.....	.....	
						0.13	20	.....	.....	
N 69° W	172	0.050	123.0	7.6	13.0	0.50	23	.....	.....	
						0.52	20	.....	.....	
Cedar Springs, Allen Ranch:										
Down	288	0.061	81.0	7.6	10.0	0.10	98	.....	.....	
						0.08	47	.....	.....	
S 5° W	250	0.058	92.0	7.6	10.0	0.12	58	.....	.....	
						0.17	56	.....	.....	

S 85° E		231	0.057	94.0	7.6	10.0	0.10	83	.....	.....	
							0.13	83	.....	.....	
Cedar Springs, right abutment:											
Down		484	0.055	101.0	7.6	11.0	0.10	43	.....	.....	
							0.09	24	.....	.....	
S 36° W		501	0.055	101.0	7.6	10.0	0.09	46	.....	.....	
							0.28	71	.....	.....	
S 54° E		312	0.051	119.0	7.6	11.0	0.20	61	.....	.....	
							0.16	58	.....	.....	
Colton:											
Up		253	0.066	120.0	13.1	10.0	0.15	43	.....	.....	
							0.16	38	.....	.....	
East		254	0.066	125.0	14.0	10.0	0.21	40	.....	.....	
							0.31	31	.....	.....	
South		255	0.065	124.0	13.4	10.0	0.19	46	.....	.....	
							0.18	44	.....	.....	
West	RDM		9.78	1.0	.....	10.0	.....	.....	1.50	0.26	
North	LDM		9.75	1.0	.....	10.0	.....	.....	0.80	0.23	
Loma Linda Hospital:											
Down		265	0.048	34.0	1.9	10.0	0.24	9	.....	.....	
East		246	0.048	34.0	1.9	10.0	.....	.....	.....	.....	Too faint to read.
North		287	0.048	34.0	1.9	10.0	0.28	19	.....	.....	
Los Angeles, 445 Figueroa, 19th floor:											
Down		502	0.055	102.0	7.6	10.0	0.12	9	.....	.....	
							0.27	11			
N 52° W		403	0.055	102.0	7.6	10.0	0.23	16	.....	.....	
							0.18	15			
S 38° W		433	0.053	111.0	7.6	10.0	0.21	16	.....	.....	
							0.24	16			
Los Angeles, 445 Figueroa, 39th floor:											
Down		505	0.050	123.0	7.6	12.0	0.27	20	.....	.....	
							0.41	20			
N 38° E		507	0.050	123.0	7.6	11.0	0.41	11	.....	.....	
							0.73	9	.....	.....	
N 52° W		438	0.050	123.0	7.6	10.0	0.49	13	.....	.....	
							0.31	13	.....	.....	

TABLE 7.—*Composite of strong-motion instrumental data for 1970*—Continued

Station and component	Instrument no.	Period (T_0) sec.	Magnification (V)	Sensitivity cm./g.	Damping ratio (ε)	Maximum				Remarks
						Acceleration		Displacement		
						Period sec.	Amplitude cm./sec.^{2}	Period sec.	Amplitude cm.	
Los Angeles, 800 W. First Street, 1st floor:										
Up		0.030		2.36	10.0		5			Film faded and blurry at beginning; no time marks.
N 53° W		0.030		1.60	10.0		7			
N 37° E		0.030		1.59	10.0		10			
Los Angeles, 800 W. First Street, 16th floor:										
Up		0.030		2.39	10.0		17			Film faded and blurry at beginning; no time marks.
N 53° W		0.030		1.59	10.0		11			
N 37° E		0.030		1.57	10.0		9			Vertical accel. largest?
Los Angeles, 800 W. First Street, roof:										
Up		0.030		2.36	10.0		33			Film faded and blurry at beginning; no time marks.
N 53° W		0.030		1.56	10.0		12			
N 37° E		0.030		1.61	10.0		12			Vertical accel. largest?
Los Angeles, 750 S. Garland, basement:										
Down		0.048	34.0	1.9	10.0	0.14	5			
S 30° W		0.048	34.0	1.9	10.0	0.21	11			
N 60° W		0.048	34.0	1.9	10.0	0.25	12			
Los Angeles, 750 S. Garland, 2d floor:										
Down		0.048	34.0	1.9	10.0	0.10	10			
S 30° W		0.048	34.0	1.9	10.0	0.15	20			
N 60° W		0.048	34.0	1.9	10.0	0.20	15			
Los Angeles, 750 S. Garland, 6th floor:										
Down		0.048	34.0	1.9	10.0	0.10	12			

S 30° W		0.048	34.0	1.9	10.0	0.45	36			
N 60° W		0.048	34.0	1.9	10.0	0.37	19			
Los Angeles, Hollywood Storage, basement:										
Up	217	0.065	121.0	12.8	10.0	0.19	4			
East	216	0.066	122.2	13.3	10.0	0.24	12			
South	215	0.064	122.0	12.4	7.0	0.30	9			
Los Angeles, Hollywood Storage, penthouse:										
Up	193	0.045	121.0	6.3	8.0		11			No time marks.
South	192	0.046	123.0	6.7	8.0		15			No time marks.
West	191	0.045	125.0	6.5	8.0		23			No time marks.
Los Angeles, Hollywood Storage, Pacific Electric Lot:										
Up	214	0.065	122.0	12.9	9.0	0.11	5			
East	213	0.065	121.0	12.1	8.0	0.22	15			
South	212	0.066	120.0	13.2	10.0	0.10	17			
Los Angeles, 1640 Marengo, basement:										
Down	419	0.048	126.0	7.6	9.0	0.13	10			
N 38° W	420	0.051	119.0	7.6	9.0	0.16	23			
S 52° W	434	0.053	111.0	7.6	9.0	0.13	18			
Los Angeles, 1640 Marengo, 4th floor:										
Down	427	0.051	119.0	7.6	10.0	0.12	24			
						0.14	14			
N 38° W	440	0.055	101.0	7.6	8.0	0.17	43			
						0.20	28			
S 52° W	448	0.051	119.0	7.6	9.0	0.21	24			
						0.16	24			
Los Angeles, 1640 Marengo, penthouse:										
Down	449	0.054	106.0	7.6	10.0	0.16	20			
						0.18	13			
N 38° W	471	0.052	112.0	7.6	10.0	0.16	55			
						0.22	27			
S 52°W	447	0.052	112.0	7.6	10.0	0.21	36			
						0.23	37			

TABLE 7.—*Composite of strong-motion instrumental data for 1970*—Continued

Station and component	Instrument no.	Period (T_0) sec.	Magnification (V)	Sensitivity cm./g.	Damping ratio (ε)	Maximum				Remarks
						Acceleration		Displacement		
						Period sec.	Amplitude cm./sec.^{2}	Period sec.	Amplitude cm.	
Los Angeles, 808 S. Olive, basement										
Down	445	0.055	101.0	7.6	10.0	0.09	6	.....	.....	
S 37° W	429	0.054	105.0	7.6	10.0	0.20	6	.....	.....	
S 53° E	466	0.054	105.0	7.6	10.0	0.17	10	.....	.....	
Los Angeles, 808 S. Olive, 4th level:										
Down	430	0.055	101.0	7.6	11.0	0.28	9	.....	.....	
S 53° E	293	0.052	112.0	7.6	10.0	0.26	14	.....	.....	
N 37° E	443	0.055	101.0	7.6	10.0	0.47	10	.....	.....	
Los Angeles, 808 S. Olive, roof:										
Down	457	0.059	87.0	7.6	11.0	0.17	10	.....	.....	
S 37° E	403	0.054	106.0	7.6	10.0	0.42	13	.....	.....	
S 53° E	410	0.056	97.0	7.6	10.0	0.30	28	.....	.....	
Los Angeles, Water and Power, basement:										
Down	346	0.053	108.0	7.5	11.0	0.12	5	.....	.....	
N 50° W	323	0.052	115.0	7.7	11.0	0.12	6	.....	.....	
S 40° W	288	0.053	106.0	7.3	10.0	0.13	13	.....	.....	
Los Angeles, Water and Power, 7th floor:										
Down	233	0.057	99.0	7.9	9.0	0.21	9	.....	.....	
N 50° W	242	0.058	95.7	7.9	10.0	0.20	10	.....	.....	
S 40° W	316	0.052	117.0	7.8	11.0	0.18	10	.....	.....	
Los Angeles, Water and Power, 15th floor:										
Down	290	0.052	111.0	7.4	8.0	0.28	13	.....	.....	
N 50° W	285	0.052	113.0	7.5	9.0	0.28	8	.....	.....	

S 40° W	310	0.052	113.0	7.5	9.0	0.21	6	.....	.....
Pasadena, Cal Tech., Jet Propulsion Lab., basement:									
Down	274	0.050	34.0	1.9	10.0	0.22	15	.....	.....
S 8° W	255	0.050	34.0	1.9	10.0	0.17	18	.....	.....
S 82° E	271	0.050	34.0	1.9	10.0	0.30	12	.....	.....
Pasadena, Cal Tech., Jet Propulsion Lab., roof:									
Down	189	0.050	34.0	1.9	10.0	0.19	33	.....	.....
S 8° W	181	0.050	34.0	1.9	10.0	0.43	25	.....	.....
S 82° E	203	0.050	34.0	1.9	10.0	0.31	20	.....	.....
Pasadena, Cal Tech, Millikan Library, basement:									
Down	308	0.050	34.0	1.9	10.0	0.15	10	.....	.....
East	235	0.050	34.0	1.9	10.0	0.25	15	.....	.....
North	290	0.050	34.0	1.9	10.0	0.30	15	.....	.....
Pasadena, Cal Tech., Millikan Library, roof:									
Down	212	0.050	34.0	1.9	10.0	0.11	12	.....	.....
East	194	0.050	34.0	1.9	10.0	1.40	25	.....	.....
North	187	0.050	34.0	1.9	10.0	0.50	46	.....	.....
Pasadena, Cal Tech., Seismology Lab.:									
Down	282	0.050	34.0	1.9	10.0	0.20	10	.....	.....
South	250	0.050	34.0	1.9	10.0	0.19	12	.....	.....
East	276	0.050	34.0	1.9	10.0	0.25	15	.....	.....
San Bernardino, Devils Canyon:									
Down	137	0.051	114.0	7.4	9.0	0.07	95	.....	.....
						0.12	63	.....	.....
South	136	0.051	123.0	8.1	9.0	0.19	163	.....	.....
						0.18	148	.....	.....
East	186	0.053	114.0	8.1	9.5	0.13	174	.....	.....
						0.12	145	.....	.....
San Bernardino, Hall of Records:									
Down	128	0.051	30.0	1.9	10.0	0.18	51	.....	.....
East	129	0.052	28.0	1.9	9.0	0.30	54	.....	.....
						0.23	46	.....	.....
North	130	0.051	30.0	1.9	11.0	0.26	118	.....	.....
						0.27	95	.....	.....

TABLE 7.—*Composite of strong-motion instrumental data for 1970*—Continued

Station and component	Instrument no.	Period (T_0) *sec.*	Magnification (V)	Sensitivity *cm./g.*	Damping ratio (ε)	Maximum				Remarks
						Acceleration		Displacement		
						Period *sec.*	Amplitude *cm./sec.*^{2}	Period *sec.*	Amplitude *cm.*	
San Dimas, Puddingstone Reservoir:										
Down	321	0.051	117.0	7.6	10.0	0.09	13	.....	.....	
N 55° E	351	0.052	110.0	7.6	10.0	0.11	16	.....	.....	
N 34° W	268	0.052	114.0	7.6	10.0	0.13	15	.....	.....	
Upland, San Antonio Dam:										
Down	96	0.045	38.0	1.9	10.0	0.07	30	.....	.....	
N 75° W	98	0.046	36.0	1.9	10.0	0.17	116	.....	.....	
						0.23	92	.....	.....	
N 15° E	94	0.044	41.0	2.0	11.0	0.13	90	.....	.....	
						0.27	70	.....	.....	
Whittier Narrows Dam:										
Down	95	0.048	34.0	1.9	10.0	0.14	5	.....	.....	
S 53° W	97	0.048	34.0	1.9	10.0	0.11	10	.....	.....	
S 37° E	99	0.048	34.0	1.9	10.0	0.11	7	.....	.....	

TABLE 8.—*Accelerograph models in the strong-motion network*

Instrument	Sensitivity	Period	Recording medium	Manufacturer
	cm./g.	*sec.*		
C&GS Standard	6–17	0.04–0.08	6- or 12-inch photo paper	Coast and Geodetic Survey*
AR–240	7.5	0.06	12-inch photo paper	Teledyne-Geotech, Inc.
RFT–250	1.9	0.05	70-mm. film	Teledyne-Geotech, Inc.
MO–2	1.5 (horizontal) 2.2 (vertical)	0.03	35-mm. film	Victoria Engineering, Ltd., New Zealand
SMA–1	1.9	0.04	70-mm. film	Kinemetrics, Inc.

*Now the National Ocean Survey (NOAA).

☆ U.S. GOVERNMENT PRINTING OFFICE: 1972 O—455-929