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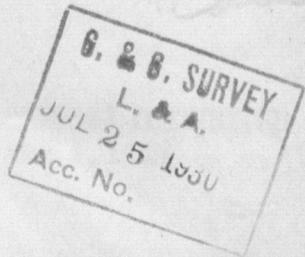
U. S. DEPARTMENT OF COMMERCE

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COAST AND GEODETIC SURVEY

R. S. PATTON, Director

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PROGRESS  
OF SEISMOLOGICAL INVESTIGATIONS  
IN THE UNITED STATES

July 1, 1927, to January 1, 1930

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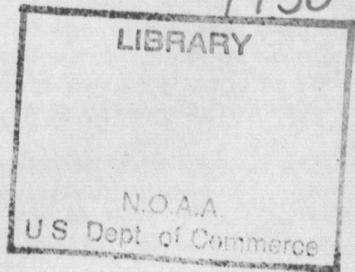
(Report to the Section of Seismology of the International Geodetic and Geophysical Union, International Research Council)

BY

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# National Oceanic and Atmospheric Administration

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# PROGRESS OF SEISMOLOGICAL INVESTIGATIONS IN THE UNITED STATES, JULY 1, 1927, TO JANUARY 1, 1930

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By N. H. HECK, *Chief, Division of Terrestrial Magnetism and Seismology*

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## INTRODUCTION

The period covered by this report has been an important one in the development of seismology in the United States. It has been one of installation of high-grade instruments either at new stations or as replacements at existing stations; of development and perfecting of new types of instruments; of expansion of programs of local investigations in regions more frequently subject to earthquake; of expansion of programs of teleseismic investigation; of attack on the engineering, insurance, and other practical phases of the problem; and of unprecedented public interest in the subject.

This is the work of many organizations. The function of the Coast and Geodetic Survey, which is charged with seismological investigations on behalf of the Government, has been one of coordination and cooperation with the various organizations, including the encouragement and assistance of institutions desiring to enter the field but not fully able to function without such assistance; of carrying on work in regions not otherwise provided for; and the collection, publication, and dissemination of information. Since all this work is intimately associated with all the activity in this subject of other Government organizations and many others, this publication will deal first with the work of the Coast and Geodetic Survey in seismology and then a summary will be given of all other known activity in the subject. Every effort has been made to avoid omissions, but the interest in the subject is developing so rapidly that this may not have been possible.

Especial attention is called to the cooperation with Canada in this work. The practice of exchange of information in regard to earthquakes occurring near the border and felt in both countries, with complete report by the country which contains the epicenter, has been continued.

## Part I.—WORK OF THE COAST AND GEODETIC SURVEY

### PRESENT AND PLANNED EQUIPMENT OF STATIONS

The station at San Juan, P. R., was forced to suspend operations in seismology as a result of the hurricane of September, 1928, which destroyed several buildings and did other damage. Present plans include the early installation of two horizontal components of the Wenner seismometer and later a vertical component instrument of similar type and also two horizontal components of an instrument to record strong shocks for which the Wenner instrument is too sensitive. The loss of this station for more than a year and a half has been severely felt both as regards the important seismic region of the West Indies and because of the geographical position of the station with regard to more distant earthquakes.

At Cheltenham, Md., the operation of the Bosch Omori instrument has been discontinued because the first-class station at Georgetown University is not far away. However, though there has been no continuous operation of any instrument, the station has been used to very good advantage for test and development work.

The station at the University of Chicago, Chicago, Ill., has been kept in operation. The two horizontal components of the Milne Shaw seismograph have been provided with electrical illumination.

The station at Tucson, Ariz., has two horizontal components of the Wood Anderson type. In addition to recording distant earthquakes these give useful records of earthquakes in southern California and Mexico in connection with the special investigations in that region.

The station at Sitka, Alaska, will soon have two horizontal components of the Wenner seismometer in operation. The same additions are contemplated as in the case of Porto Rico.

The station at Honolulu, Hawaii, is a cooperative one, the two horizontal components of the Milne Shaw seismograph being installed at the University of Hawaii. Contemplated changes include new recording apparatus with more open time scale (to overcome partially effects of frequent microseismic activity) and a vertical component instrument.

A definite plan has been made for the installation of a seismograph at the Alaska Agricultural College and School of Mines, at Fairbanks, Alaska, to be operated on a cooperative basis. Such a station is urgently needed.

Other cooperative stations are under consideration, but plans have not yet been developed. There is every indication, however, that before many years there will be sufficient stations to meet most of the needs of seismological investigation.

## REPORTS OF VISIBLE AND FELT EFFECTS OF EARTHQUAKES

The value of reports of visible and felt effects of earthquakes has long been debatable, and there has been recent consideration of this subject in the United States. Owing to the fact that there will never be enough instruments to make it possible to draw isoseismal lines from instrumental records alone or to find out exactly what happened throughout the epicentral region of a great earthquake, it is certain that we will always be dependent on these reports. Since they are indispensable, an effort should be made to have them as accurate as possible, and it is very desirable, in so far as practicable, to select in each region a number of persons who may be relied on to make satisfactory reports. This does not mean that in the case of an important earthquake reports should not be received from everyone possible, but that there should be a nucleus of persons who may be relied upon not to be unduly affected by the conditions accompanying the earthquake and to be reasonably skilled in setting down accurate impressions.

The plan of collection is now rather elaborate, since it varies not only with earthquake types and intensities which are different in different parts of the country, but also with the density of population. Of the entire 48 States, only 3 are not known to have had earthquakes of force 5, Rossi-Forel scale, or over. Service of fundamental importance is performed by the Weather Bureau, which with its large force of cooperative observers has continued the reporting of earthquakes for the entire country. For many regions these reports have been the sole source of information. The interest has become so great, however, that there is now need for additional reporters in most parts of the country.

For the eastern half of the United States the National Research Council through its division of geology and geography is investigating the geological relations of earthquakes, especially the association of surface geology with minor earthquakes. Various cooperating agencies are assisting in this work, and as a result information is collected with regard to all earthquakes of moderate extent.

In case of major earthquakes or any that, without great intensity, affect a wide area the Coast and Geodetic Survey uses its facilities for obtaining information from many sources.

For the western half of the country and Alaska the Coast and Geodetic Survey organizes the collection from all sources outside the Weather Bureau. In the States adjoining the Pacific Ocean the collection is carried on through the field station of the Coast and Geodetic Survey in San Francisco, Calif., with the cooperation of the organizations engaged in regional studies and primarily for their use.

The essential feature of all these plans is that the work is done with minimum effort and without duplication, and under no circumstances is the same person asked by different agencies to make reports.

The problem of field investigations of earthquakes has not yet been fully worked out, but suitable arrangements exist to meet emergencies.

## SEISMOLOGICAL REPORTS

The Quarterly Seismological Report, which began with 1925 (through a supplement with July, 1924), was continued through 1927. This combined instrumental reports, abstracts of reports of visible and felt effects of earthquakes, and lists of earthquakes occurring within or near the United States and the regions under its jurisdiction or recorded by instruments within this area.

Beginning with 1928 the quarterly report has been replaced by two annual publications. The first gives complete information, except for details of instrumental recording, regarding each earthquake or tells where it may be found, and is in convenient form for all users. It is sufficiently complete to serve as an earthquake catalogue. The second publication is chiefly for the use of the seismologist, and it gives the instrumental results and their interpretation for the stations of the Coast and Geodetic Survey and such cooperative stations as have no arrangement for printing their results. From the viewpoint of the seismologist, earthquakes may be studied in great numbers in order to determine the seismicity of a region or to find the velocity of earthquake waves, or single earthquakes may be studied in detail, using original records. The publication serves both purposes and, while omitting no essential information for the former purpose, it gives in general terms some information heretofore given in great detail, so that the seismologist can decide whether or not the particular record will be of use in his study.

### EARTHQUAKE HISTORY OF THE UNITED STATES

Earthquakes have been going on for countless ages, and even the longest recorded history is short in comparison, and that of the United States is very short compared to that of Europe or parts of Asia. Even for the period of occupation of the country by white men, it is only for the past few years that reports have had the accuracy required by the seismologist. However, we can not make progress without some knowledge of the past, and even scanty records are of value. One of the accomplishments of the period has been the collection in a single volume of information regarding all earthquakes in the United States, exclusive of the Pacific region, of force 5 or over, Rossi Forel scale. (See list of publications, p. 6.) This information has been compiled from many volumes, many of which are out of print, and from sources which have never been published. There still remain to be published the lesser earthquakes for the same region and a catalogue for the Pacific coast. The latter work is now in progress as cooperative work of a number of interested institutions.

### IMMEDIATE DETERMINATION OF EPICENTER

When first undertaken in the United States it was thought that immediate determination of epicenters of earthquakes would have news value only. It has developed, however, that seismologists are finding the information of value in the interpretation of records, especially when they are complex or when obscured by microseisms. As a result there has been a steady increase in the number of stations

cooperating, and combined with similar activity in Europe, a large part of the earth is covered and telegraphic or radio reports come from all continents except South America.

Seismological stations in the United States, Canada, Alaska, Hawaii, Samoa, New Zealand, Philippine Islands, and China send telegraphic messages in code to Washington. Cost of commercial messages is paid by Science Service and others are sent through official channels by the United States Navy Department. All messages are received by the Coast and Geodetic Survey, where a preliminary determination of epicenter is made. This is at once given to Science Service for issue to the press. In the meantime the same information goes to the headquarters of the Jesuit Seismological Association at St. Louis, Mo., where an independent determination is made. The joint determination is then sent out by card, except for the western and southern Pacific stations, whose cards are sent out from Honolulu and Manila on receipt of telegraphic information.

Since January 1, 1929, information from the records of important earthquakes has been added to the meteorological messages broadcasted by the United States Weather Bureau through the naval station at Arlington, in accordance with a plan which is fully described in the Report of the French National Committee of Geodesy and Geophysics for the General Assembly of March 27, 1929.

In Europe information from various stations in Europe and Africa is collected by the central bureau at Strasbourg and broadcasted from Eiffel Tower. This has not as yet been regularly received in the United States, through difficulties in radio reception, but it is hoped that this can soon be accomplished. There are unsolved problems in the coding of earthquake messages, and it is hoped that something may be accomplished toward their solution at the Stockholm meeting of the International Geodetic and Geophysical Union.

#### OTHER ACTIVITIES OF THE COAST AND GEODETIC SURVEY IN SEISMOLOGY

Important geodetic work in California is described as part of the program of the local investigation, since it is intimately related to that work, and is also reported to the section of geodesy of the International Geodetic and Geophysical Union.

All tidal records are examined as a routine matter for indications of seismic sea waves.

Completed hydrographic and topographic surveys of the coast are invaluable in the case of an important earthquake, as they make it possible to determine accurately whether changes of elevation have occurred. In most of the coastal regions of the United States and the regions under its jurisdiction the surveys are satisfactory for this purpose or good progress has been made in making them so, and this statement applies to all regions except Alaska.

#### INFORMATION TO THE PUBLIC

There has been a strong and growing demand for information regarding earthquakes, which has been enhanced by the occurrence of several earthquakes which were felt in the densely populated east-

ern part of the country, one of which was destructive over a limited area. The demand has been met by correspondence, articles, and furnishing information to news agencies as well as by publication. There has been some demand for advice in regard to engineering problems connected with earthquakes.

**BIBLIOGRAPHY OF ARTICLES BY MEMBERS OF THE UNITED STATES COAST AND GEODETIC SURVEY**

1. U. S. Coast and Geodetic Survey Quarterly Seismological Reports. Serial Nos. 388, 395, 405, 424, 431, 463, 468, each covering a quarter of a year from the last quarter of 1925 to the second quarter of 1927; by Frank Neumann.
2. Earthquake History of the United States (exclusive of the Pacific region). U. S. Coast and Geodetic Survey Special Publication No. 149, by N. H. Heck.
3. Earthquake Investigations in the United States (revised edition, 1929). Serial No. 456, by N. H. Heck.
4. Transmission of Earthquake Waves Across the Pacific Ocean. Third Pacific Science Congress (Tokyo), 1926, by N. H. Heck.
5. Report on Network of Earthquake Observations of Countries Bordering the Pacific. (Same as 4.)
6. Some Joint Needs of Oceanography and Seismology in the Pacific Region. (Same as 4.)
7. Velocity of Seismic Surface Waves Across the Pacific. Bulletin of Seismological Society of America, June, 1929, by Frank Neumann.
8. Southern Appalachian Earthquake of November 2, 1928. Bulletin of Seismological Society of America, December, 1928, by Frank Neumann.

## Part II.—SUMMARY OF EARTHQUAKE INVESTIGATIONS IN THE UNITED STATES

### UNITED STATES COAST AND GEODETIC SURVEY

*Seismograph stations.*—The United States Coast and Geodetic Survey now operates seismographs at six stations—San Juan, P. R. (after lapse on account of hurricane damage); Cheltenham, Md.; Chicago, Ill.; Tucson, Ariz.; Sitka, Alaska; and Honolulu, Hawaii. All have or will soon have modern instruments except Cheltenham, where, on account of the proximity of Georgetown University, seismological work is confined to experiment and test.

*Collection of data on observed and felt earthquakes.*—The Weather Bureau, National Research Council, and many other organizations are cooperating with the Coast and Geodetic Survey in securing accurate reports in regard to the visible and felt effects of earthquakes on a much more intensive basis than ever before. This type of information has been found to be indispensable.

*Record of earthquakes.*—The Quarterly Seismological Report was discontinued with 1927, and thereafter reports will consist of two annuals—one of a descriptive and the other of an instrumental nature. These are expected to meet the needs more effectively.

*Earthquake history of the United States.*—Important progress was made in collecting and publishing information which was contained in volumes no longer in print, unpublished catalogues, magazine and newspaper files, and elsewhere.

*Determination of epicenter.*—Through cooperation of many agencies immediate determination of epicenter is now made for all important earthquakes and made available for the public and also, after a delay for revision, to seismologists, who find them useful in the interpretation of seismograms. International broadcasting is now part of the plan.

*Information to the public.*—Special effort is made to meet the public demand for information regarding earthquakes, which has been enhanced by occurrence of earthquakes, especially in the eastern part of the country.

*Other activities.*—Geodetic determination of position and elevation in regions subject to earthquake has become an important part of the investigation. Tidal records are searched for indications of seismic sea waves. Hydrographic and topographic surveys are for a considerable part of the coast becoming competent for use in determining changes due to earthquakes, should such changes occur.

### OTHER GOVERNMENT ACTIVITIES

The Bureau of Standards has, with the cooperation of the Coast and Geodetic Survey and the Carnegie Institution of Washington, made an important contribution to seismology in the Wenner seis-

meter developed by Dr. Frank Wenner, of its staff. While the instrument is not yet in permanent operation at any station, it has received rigid test in installation and operation with satisfactory results. This instrument has been fully described in publications of the Bureau of Standards.

The Weather Bureau has continued to furnish, through its observers, valuable information regarding visible and felt effects of earthquakes and has for some parts of the country been the sole source of such information.

The Geological Survey has recorded and studied earthquakes of volcanic origin in the Hawaiian Islands and Alaska and is interested in the investigation under the auspices of the National Research Council.

The National Research Council is closely associated with the Government but cooperates with many other activities. Through its division of geology and geography it is studying earthquakes with especial relation to association with surface geology and in this connection collects much valuable information which is made available to all cooperators. The American Geophysical Union through its section of seismology acts as a coordinating agency and is especially concerned with keeping in touch with progress and indorsing new projects.

#### JESUIT SEISMOLOGICAL ASSOCIATION

During the period July 1, 1927, to January 1, 1930, the following stations belonging to the Jesuit Seismological Association were in continuous operation: Buffalo, Chicago, Cincinnati, Denver, Florissant, Fordham, Georgetown, Milwaukee, New Orleans, Santa Clara, Spokane, and St. Louis.

Cleveland, Mobile, and Worcester were in partial operation but published no reports during this time.

The stations at Cincinnati and Florissant are entirely new.

The station at Cincinnati is equipped with a Galitzin-Wilip vertical-component, two long-period horizontal-component torsion seismometers of the Wood-Anderson type, and two short-period horizontal-component seismometers of the same type. A short-period vertical-component torsion seismometer was purchased but proved unsatisfactory.

The stations at Buffalo, Chicago, Denver, Milwaukee, Mobile, Worcester, and Spokane were equipped only with an 80-kilogram horizontal-component Weichert seismograph. However, the station at Canisius College, Buffalo, has since placed an order for a Wilip-Galitzin vertical-component seismometer.

The stations at New Orleans and Santa Clara were equipped with an 80-kilogram horizontal-component and an 80-kilogram vertical-component Weichert seismograph. The University of Santa Clara has since constructed a new subterranean vault and has purchased and installed two short-period horizontal-component torsion seismometers of the Wood-Anderson type, two horizontal-component Galitzin-Wilip electromagnetic seismometers, and a Galitzin-Wilip vertical-component of the same type.

The station at Fordham University has been entirely reconstructed. A new subterranean vault was excavated into the Fordham gneiss

and the former granite building of the station placed over but not in contact with the entrance to the vault. The Weichert horizontal-component seismograph was installed in the superstructure to serve as an indicator and visible writing seismograph for the inspection of the public who might be interested, whereas there were installed in the underground vault the two horizontal-component Milne-Shaw seismographs which had been in use, the one since the autumn of 1924, the other since 1925. In addition to these there were purchased and installed in the same vault two horizontal-component Galitzin-Wilip seismometers and one vertical-component of the same type. All of this expansion was made possible by the generous gift of William Spain, of New York.

At Georgetown University there were in continuous operation throughout the entire period a 2-component horizontal Mainka seismograph, a 200-kilogram 2-horizontal-component Weichert seismograph, and a Galitzin vertical-component seismograph of the Cambridge type. There have also been installed two horizontal-component Galitzin seismographs of the Cambridge type.

The equipment of the St. Louis station consists of one 80-kilogram horizontal-component Weichert seismograph and two long-period horizontal-component torsion seismometers of the Wood-Anderson type. The latter instruments are installed on a pier which rests directly on the massive St. Louis limestone of Mississippian age.

The Florissant station is an underground vault about 3 by 12 meters, inside dimensions, in which are installed two short-period Wood-Anderson torsion seismometers, two horizontal-component Galitzin-Wilip seismometers, and one vertical-component Galitzin-Wilip seismometer. The time is kept at this station by a Shortt synchrochrome master and slave clock.

The association has continued the program of cooperation with Science Service of Washington whereby the data of the important earthquakes are telegraphed to the United States Coast and Geodetic Survey from selected Jesuit stations and communicated, together with the data from the Government and from other independent stations, to the central station of the association at St. Louis. The reports of western stations are also telegraphed directly to St. Louis, the central station, and the United States Coast and Geodetic Survey. Each makes a preliminary determination of the position of the epicenter and exchange the results. Should there be disagreement a further determination is made as soon as additional data are available.

During the period in question the central station determined in this way the epicenters of 52 earthquakes.

The data assembled from all the stations by telegram through the courtesy of Science Service, by radiogram through the cooperation of the United States Coast and Geodetic Survey and the Navy wireless stations, together with reports sent to St. Louis by mail, are interpreted and published within a few days after the respective earthquake in the form of a mimeographed preliminary bulletin. During this period 44 such bulletins were issued and sent to more than 250 institutions in all parts of the world.

In addition St. Louis University, with the cooperation of the National Research Council, which provided the funds, is establishing two stations in the New Madrid region—one at Little Rock, Ark.,

at Little Rock College, and the other in western Kentucky. These will be of the greatest importance in the investigation of the seismic region of the Mississippi Valley. They will be equipped with short-period Wood-Anderson seismometers. Plans have been studied for precise triangulation and leveling in the region which it is hoped can eventually be accomplished by the Coast and Geodetic Survey.

#### CARNEGIE INSTITUTION AND COOPERATING INSTITUTION IN SPECIAL EARTHQUAKE INVESTIGATION IN CALIFORNIA

The California program has made excellent progress. The following statement is in part an abstract from annual reports of the advisory committee in seismology of the Carnegie Institution of Washington and additional information from other sources. Other institutions concerned in the program include the Coast and Geodetic Survey, the California Institute of Technology, Leland Stanford University, University of California, and others, with local support of various kinds, especially in providing funds.

The accurate determination of positions and elevations of fixed points marked by monuments has always been considered as a fundamental activity both for the purpose of determining changes accompanying earthquakes and crustal creep in the intervals between them. The program has included a precise triangulation scheme which covers most of California and which at north and south ends and in the middle is connected with the more stable seismic regions to the east, readjustment of the triangulation of the entire western half of the country by methods which reduce effects of unavoidable errors to a minimum, and the determination of positions of many monuments close together in a specially selected region so that relative movements at varying distances from fault traces may be studied. The program for precise leveling is similar. In both cases the plan includes redetermination from time to time so as to detect changes.

Determination of epicenters and their association with fault lines has been an important part of the program. The number of recording stations has increased, and the methods of interpreting results have been given much study. The situation regarding operating stations is not yet as satisfactory in the San Francisco Bay region as in southern California. However, new instruments had been received for Santa Clara University and University of California seismological stations, though they had not been installed at the close of the period.

The instrumental results have proved very fruitful, as have also the reports of volunteer observers of visible and felt effects which have been collected through the plan that has already been described.

Special additional work at the seismological laboratory at Pasadena has included the improvement of the details of the Wood-Anderson seismometer, development of vertical-component instruments with results not yet entirely satisfactory, and improvement of time control of recording drum and absolute time control for all stations. Though the desired control from a master clock at Pasadena has not yet become a possibility, the adopted plan of recording time signals three times a day at all stations and of the same code message at the beginning of each hour has proved a fairly satisfactory substitute.

During the autumn of 1929 a conference of seismologists was held at Pasadena to study the program and suggest improvements and additions.

#### OTHER INSTITUTIONS

Harvard University, Cambridge, Mass., has installed two components of the Milne Shaw seismograph.

Massachusetts Institute of Technology, Cambridge, Mass., will soon have two Wenner seismometers in operation at its new station near Machias, Me. This may be expected to be of great value in recording earthquakes in New England and Canada, especially in view of the Grand Banks earthquake of November 18, 1929.

The University of Pittsburgh, Pa., will soon have two components of the Wenner seismometer in operation either at the new Cathedral of Learning or at Alleghany Astronomical Observatory.

A cooperative station of the Montana State College at Bozeman, Mont., and the Coast and Geodetic Survey has been planned. This is of special interest as being in the region of the severe Montana earthquake of 1925.

Serious interest which is likely to result in the establishment of stations exists in New York, North and South Carolina, Minnesota, New Mexico, and Oregon.

While engineering phases of the earthquake problem can not be included under geophysics, the fields overlap, and a brief statement of present and prospective accomplishment is desirable. The American Society of Civil Engineers has had a committee on earthquake problems, and their investigations have included studies of structures which have passed through earthquakes and development of principles of design for all types of structure, including large dams, bridges, and factory buildings, all of which have special problems. Visits by prominent engineers to the International Engineering Congress held in Tokyo, Japan, during 1929, stimulated interest in this subject; and the prospects of development of this work, which will eventually come into close touch and may help in the solution of some of the problems of the seismologist, are excellent. There has been in operation in an experimental way a large shaking platform at Leland Stanford University on which all types of structures may be tested. During the period the chief attention was given to simulating earthquake movements as closely as possible and to studying theory of resulting movement of the platform. The California Institute of Technology has also given serious attention to design of buildings and structures. Thus, while the pressure for results is not so great as in Japan, the prospects of treatment adequate to the needs of the United States are very good.

The Seismological Society of America, with headquarters at San Francisco, Calif., and its eastern section have had important influence in stimulating interest in seismology from every viewpoint and in bringing together those interested. In addition to holding annual meetings the society publishes the Bulletin of Seismology, and the section issues Earthquake Notes, a quarterly, which presents notes of interest. The section, in cooperation with the Dominion Observatory of Ottawa, Canada, started the Bibliography of Seismology, which has since become a publication of the Dominion Observatory.

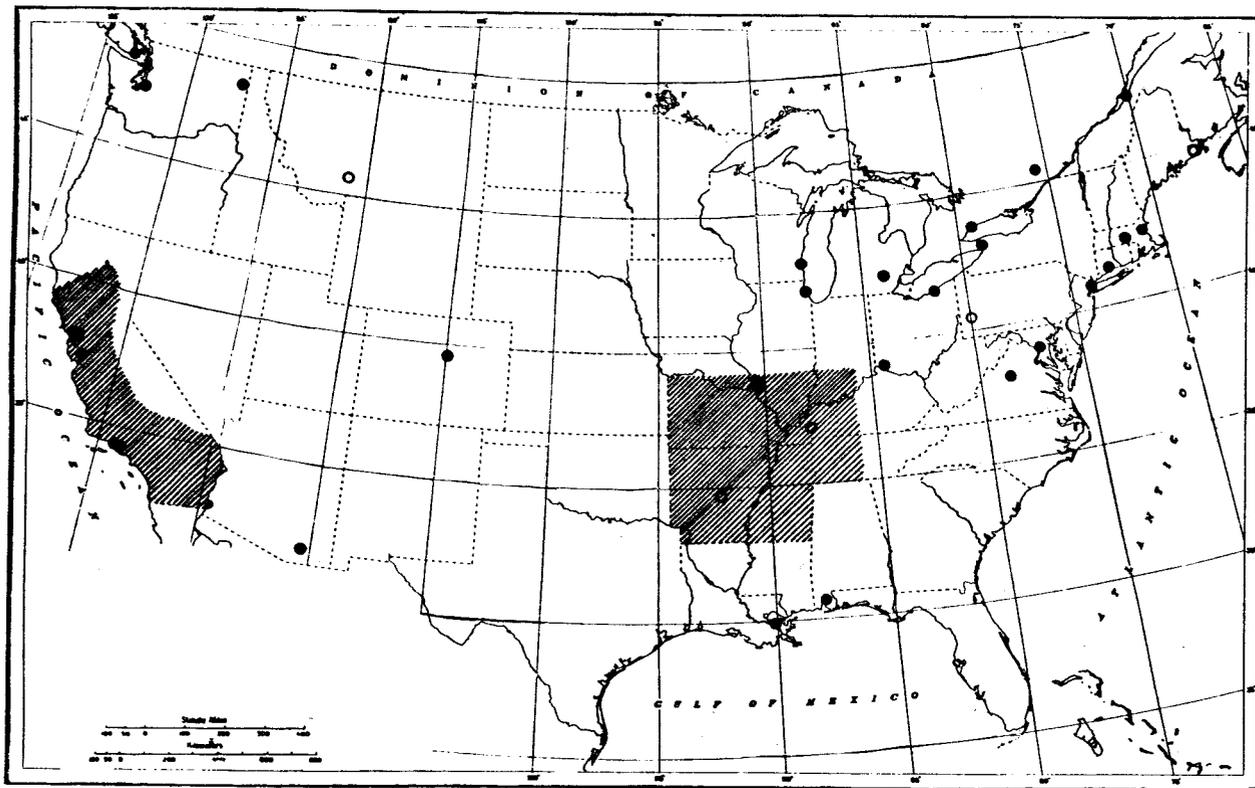


FIGURE 1.—Seismological stations of the United States and adjacent Canada. Crosshatching indicates areas of special investigations of seismic regions

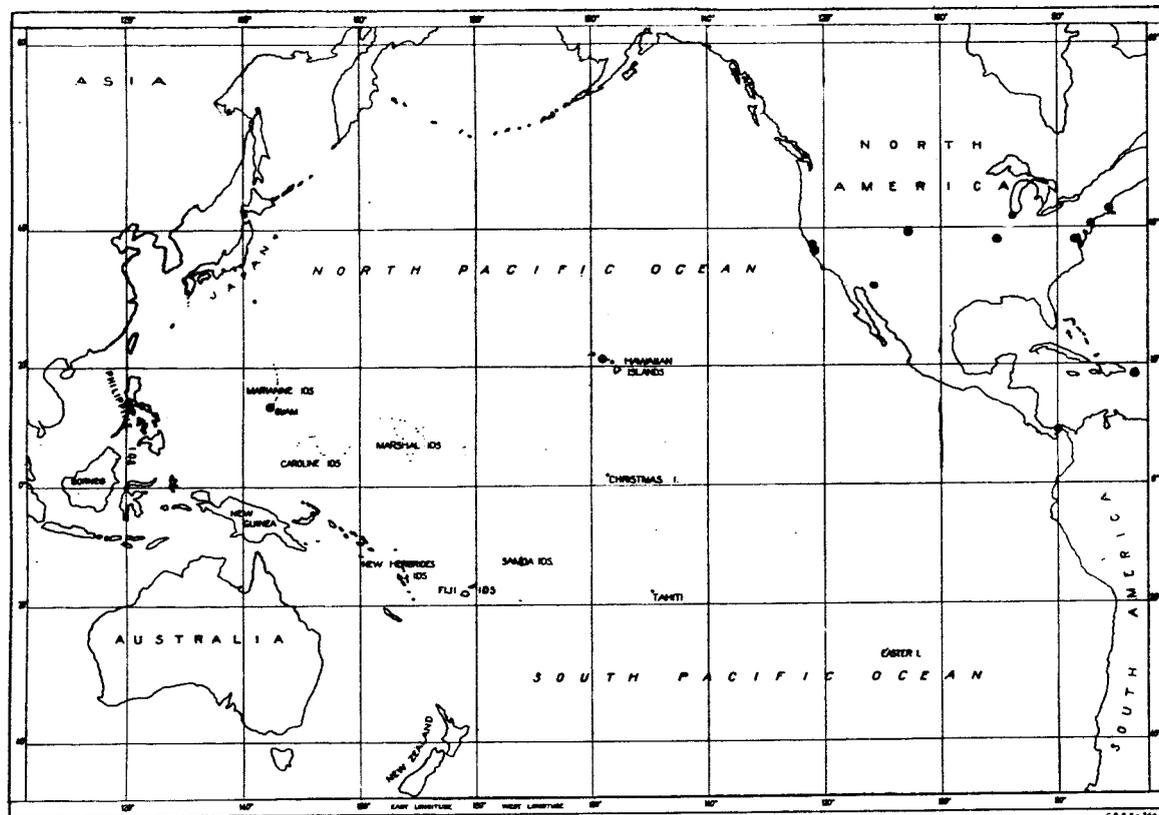


FIGURE 2.—Important seismological stations in the United States and regions under its jurisdiction

## EARTHQUAKES OF IMPORTANCE

The following earthquakes of importance occurred in or near the United States or the region under its jurisdiction:

Date	Locality	Remarks
May 7, 1927	Missouri.....	Felt over 5 States.
June 1, 1927	New Jersey.....	Near Long Branch.
Oct. 24, 1927	Alaska, southeastern.....	Cables broke.
Nov. 4, 1927	Southern California.....	Near Point Concepcion.
June 21, 1928	Alaska.....	Prince William Sound.
Nov. 2, 1928	North Carolina.....	Near Asheville.
Aug. 12, 1929	New York.....	Severe east of Buffalo.
Nov. 18, 1929	Newfoundland.....	At sea, near Grand Banks; cables broke; tidal wave felt throughout New England.

The following is a list of seismological stations with indication where new or improved instruments have been installed or will be in the near future. (See figs. 1 and 2.)

## LIST OF TELESEISMIC STATIONS

Ann Arbor, Mich.....	Astronomical Observatory, University of Michigan.
Balboa, Panama Canal Zone....	Chief Hydrographer.
Berkeley, Calif. <sup>1</sup> .....	University of California.
Bozeman, Mont.....	University of Montana.
Buffalo, N. Y. <sup>1</sup> .....	Canisius College (Jesuit).
Cambridge, Mass. <sup>1</sup> .....	Harvard University.
Charlottesville, Va. <sup>1</sup> .....	University of Virginia.
Chicago, Ill. <sup>1</sup> .....	Chicago University, Coast and Geodetic Survey (U. S. Weather Bureau).
Do.....	Loyola University (Jesuit).
Cincinnati, Ohio <sup>1</sup> .....	St. Xavier College (Jesuit).
Cleveland, Ohio.....	St. Ignatius College (Jesuit).
Denver, Colo.....	Sacred Heart College (Jesuit).
Fairbanks, Alaska <sup>1</sup> .....	A. A. C. & S. of M., Coast and Geodetic Survey.
Guam, Marianas Island.....	Weather Bureau, Philippine Islands.
Honolulu, Hawaii <sup>1</sup> .....	University of Hawaii, Coast and Geodetic Survey.
Machias, Me. <sup>1</sup> .....	Massachusetts Institute of Technology.
Manila, P. I. <sup>1</sup> .....	Weather Bureau, Philippine Islands.
Milwaukee, Wis.....	Marquette University.
Mobile, Ala.....	Spring Hill College (Jesuit).
Mount Hamilton.....	Lick Observatory.
New Haven, Conn.....	Yale University.
New Orleans, La.....	Loyola University (Jesuit).
New York, N. Y. <sup>1</sup> .....	Fordham University (Jesuit).
Pasadena, Calif. <sup>1</sup> .....	Carnegie Institution of Washington and California Institute of Technology.
Pittsburgh, Pa. <sup>1</sup> .....	University of Pittsburgh.
Santa Clara, Calif. <sup>1</sup> .....	University of Santa Clara (Jesuit).
St. Louis and Florissant, Mo. <sup>1</sup> .....	St. Louis University (Jesuit).
San Juan, P. R. <sup>1</sup> .....	Coast and Geodetic Survey.
Seattle, Wash.....	Department of Geology, University of Washington.
Sitka, Alaska <sup>1</sup> .....	Coast and Geodetic Survey.
Spokane, Wash.....	Gonzaga University.
Tucson, Ariz. <sup>1</sup> .....	Coast and Geodetic Survey.
Washington, D. C. <sup>1</sup> .....	Georgetown University.
Worcester, Mass.....	Holy Cross College (Jesuit).

<sup>1</sup> New or improved installations have been made or have been ordered.