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E. LESTER JONES, DIRECTOR

PROGRESS OF SEISMOLOGICAL INVESTIGATIONS IN THE UNITED STATES

JANUARY 1, 1925, to JUNE 30, 1927

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

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

INTRODUCTORY

The period covered by this publication has been important in the growth of interest in seismology in the United States. Prior to this period there was considerable activity, but very little in the way of concentrated attack on the many problems. To-day, although full development of a suitable program is not yet at hand, a number of events indicate that such full development is imminent.

In 1925 seismological investigation by the Government was transferred from the Weather Bureau to the United States Coast and Geodetic Survey. Among the reasons leading to this transfer were: Operation of seismographs by the Coast and Geodetic Survey at its magnetic observatories for more than 20 years as an adjunct to magnetic work; special geodetic surveys during recent years in regions subject to earthquakes to study crustal creep; practice of studying tidal records for evidences of seismic sea waves; accurate hydrographic surveys of coastal waters, which make it easy to determine with accuracy submarine changes accompanying earthquakes; and last and, perhaps, most important, the desirability of applying the precise methods used in the work of the United States Coast and Geodetic Survey to instrumental seismological work.

In taking up this work the Coast and Geodetic Survey realized that it was neither practicable nor desirable for the Government to undertake a very large part of the great amount of work to be accomplished. The survey has made special efforts to establish cooperation with other organizations and the encouragement by advice and assistance of small institutions desiring to enter the field but not fully able to function without such assistance.

A valuable contribution to seismology in the United States is that of the Jesuit Seismological Association, organized in 1925 under the direction of Rev. James B. Macelwane, S. J., head of the department of geophysics, St. Louis University, St. Louis, Mo. The association's work includes the coordination of the work of 11 stations, with a definite program of improvement of instruments and methods and interpretation of results.

An activity, local in extent but of international importance, is the earthquake investigation being carried on in California under the direction of the advisory committee in seismology of the Carnegie Institution of Washington, of which Dr. Arthur F. Day,

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Director, Geophysical Laboratory, Washington, D. C., is chairman. This work is carried on with the cooperation of the United States Coast and Geodetic Survey, United States Geological Survey, several universities in California, as well as commercial organizations. The work includes geological studies, study of crustal creep, instrumental seismological observations from permanent stations, and other operations.

A number of universities not included in the above groups are operating seismographs, chiefly of the teleseismic type. In some cases their records are being interpreted by the Coast and Geodetic Survey. Commercial organizations are using seismic methods for study of geological formation, and while the operations are being held secret for business reasons, it is expected that results will eventually be made available for scientific study.

Other organizations are studying earthquakes with a view to protection from disaster. This includes design of structures and actual tests of materials and structures.

Progress has been made in instrumental design, and a new instrument, the Wood-Anderson torsion seismometer, has been put into use for investigation of both near and distant earthquakes. Work is being done on a simpler and less expensive, yet more reliable, device for recording the maximum acceleration of an earthquake, with a view to placing a number of such instruments in regions subject to earthquake.

The study of wave transmission is being prosecuted actively. The work of Macelwane is outstanding, and Byerly (of the University of California) and Neumann (of the Coast and Geodetic Survey) are giving considerable attention to this subject. Practically all organizations in the United States engaged in the interpretation of seismograms are using all possible phases, recording those which can not be interpreted at this time.

There is excellent cooperation with Canadian seismological stations. Whenever an important earthquake occurs in either Canada or the United States, if it is felt across the border, the country in which the epicenter occurs receives from the other all reports for its own publication. This program was in effect for the St. Lawrence earthquake of February 28, 1925, and the Montana earthquake of June 28, 1925.

Figure 1 shows the location of seismological stations in the United States and the adjacent parts of Canada which contribute information regarding earthquakes occurring or felt within the United States.

Part 1 contains the detailed report of the seismological work of the United States Coast and Geodetic Survey and other Government organizations cooperating.

A composite picture of all the activities in the United States is given in Part II. In the cases of the Jesuit Seismological Association and the Carnegie Institution of Washington complete reports of their activities are given elsewhere, and only a brief summary will appear here.

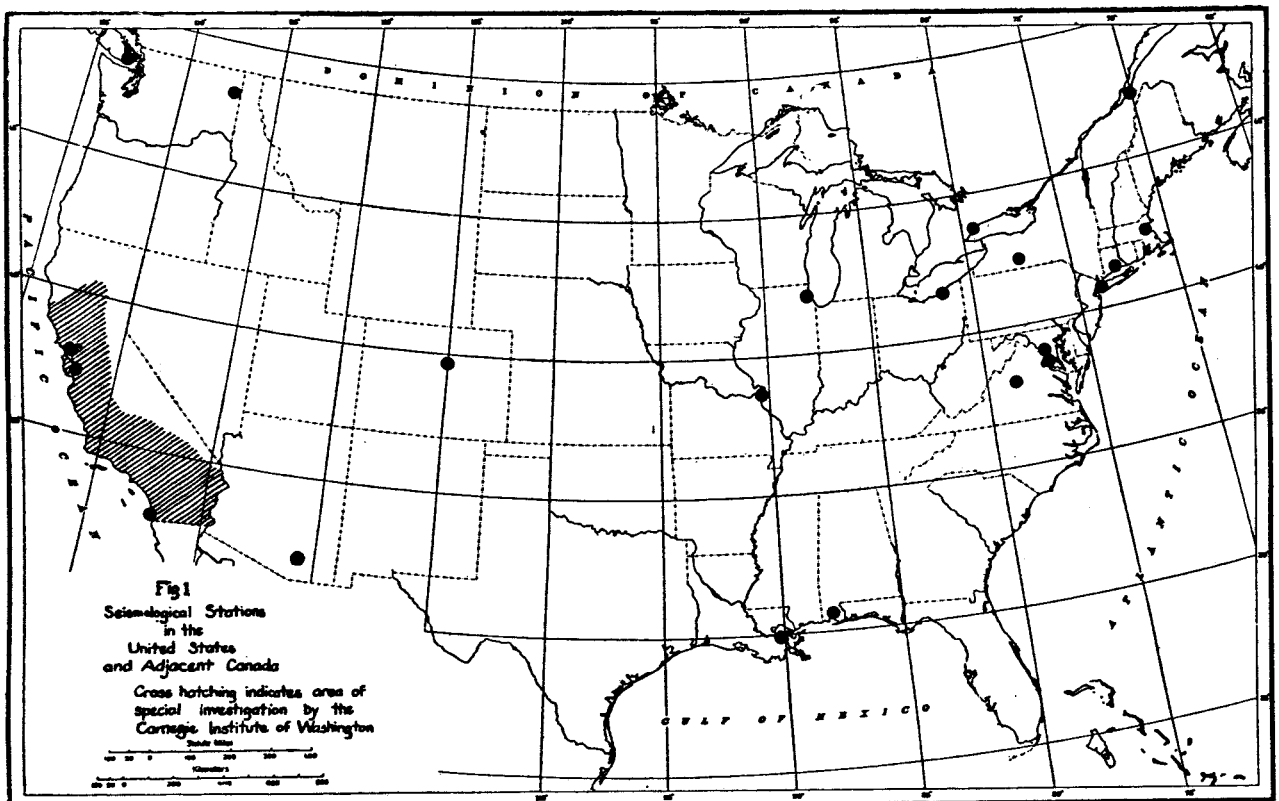

Fig 1
Seismological Stations
in the
United States
and Adjacent Canada

Cross hatching indicates area of special investigation by the Carnegie Institute of Washington

PART I. WORK OF THE COAST AND GEODETIC SURVEY

PRESENT AND PLANNED EQUIPMENT OF STATIONS

The station at San Juan, P. R., has a Bosch-Omori seismograph at present. The important position of this station with regard to the Caribbean region makes it important to install a more modern and accurate instrument here, and this will be done as soon as practicable.

The station at Cheltenham, Md., has a Bosch-Omori seismograph. This will not be replaced for the present because the first-class station of Georgetown University, Washington, D. C., is only 18 miles away.

The station at Tucson, Ariz., has a Wood-Anderson torsion seismograph of the teleseismic type. This instrument has been in use for a year under good conditions. Study of the results is not yet sufficiently complete, however, to make a report. A large number of shocks in the Imperial Valley of California were recorded by this station in January, 1927.

The station at Sitka, Alaska, has a Bosch-Omori seismograph, which will be replaced with another instrument as soon as practicable.

The station at Honolulu, Hawaii, has operated a Milne-Shaw seismograph for five years. This was recently moved to the University of Hawaii, where a joint station is being operated, thus affording opportunity for special studies. At all times, but especially at certain seasons of the year, microseisms are recorded at Honolulu. At times these are so great as to interfere with interpretation of the preliminary phases of the records. This affords an unusual opportunity for the study of microseisms, and it is hoped to make such a study in the near future.

The station at Chicago University, formerly operated by the Weather Bureau, is being continued by the Coast and Geodetic Survey. This station has a Milne-Shaw seismograph whose recording apparatus has been remodeled, so that excellent results are being obtained.

No vertical-component instruments have as yet been installed at any of these stations, and this is one of the outstanding needs.

REPORTS OF VISIBLE AND FELT EFFECTS OF EARTHQUAKES

It has always been difficult to secure adequate information of earthquakes from the observations of eyewitnesses. However, in regions of large extent with comparatively few seismographs, as will always be the case in parts of the United States and elsewhere, a certain dependence must be placed on such reports. The plan now being followed is to have responsible observers of high type. The Weather Bureau, with its large staff of cooperative observers, is cooperating by continuing the service which it had previously organized, thus making it unnecessary to organize a special arrange-

ment for the country as a whole. In regions subject to earthquakes the reporting service is considerably expanded, and an attempt is made to secure adequate reports of each earthquake. The form adopted for such reports is a modification of previously existing forms, with special effort toward simplicity. The observer is not asked to estimate the intensity of the earthquake, but only to give observed facts. The intensity is appraised by those reviewing the reports, so that all reports receive uniform treatment.

It is hoped that an entirely satisfactory device will soon be forthcoming for giving the maximum intensity. None of those heretofore developed are entirely reliable, and a device sufficiently inexpensive to be used in large numbers would be most valuable.

Special investigations of regions where important earthquakes have occurred are made for various reasons. When the investigation is geological the work is done by the United States Geological Survey. The Coast and Geodetic Survey makes special investigations to determine intensity and also to appraise damage to engineering structures. In the case of the California regions various local organizations are prepared to make special investigations.

SEISMOLOGICAL REPORT

All earthquakes occurring within the United States and the regions under its jurisdiction, with certain exceptions, are included in the Quarterly Seismological Report published by the United States Coast and Geodetic Survey. This publication also contains data on all earthquakes recorded by stations within the area named, provided the epicenter can be determined. Complete summaries by date and by region appear at the end of each quarterly report, and at the end of each year summaries for the year and maps showing the position of epicenters are given. Volcanic earthquakes in the Hawaiian Islands are not given, since they are recorded in the Bulletin of the Volcano Research Association. Numerous minor earthquakes in the United States and the Philippine Islands are also omitted.

The publication includes the records of the observatories under the jurisdiction of the Coast and Geodetic Survey, one at Guam under the Navy Department, one in the Panama Canal Zone, and those of other stations which do not publish their results. In determining the epicenters all available reports are used, and for this reason the publication will normally be sent to the printer about six months after the close of the period. At present the interval is considerably longer, but it is hoped to rectify this condition soon.

IMMEDIATE DETERMINATION OF EPICENTERS

Immediate determination of epicenters is sometimes considered useful merely as a matter of publicity and a means of arousing public interest in seismology. This is not, however, the entire function of this work, as carried on by the Coast and Geodetic Survey and cooperating organizations. To make this point clear, it may be well to outline the cooperative method employed. When an earthquake occurs messages are sent in code either to Science Serv-

ice, an organization under the auspices of the National Academy of Sciences and the American Association for the Advancement of Science, at their expense, or through official channels to the Coast and Geodetic Survey from its own stations. The best possible immediate interpretation from the reports first arriving is then given to the press.

These determinations of epicenter are usually made with insufficient data and, while usually accurate enough to meet the needs of publicity, are often considerably in error from the viewpoint of correct interpretation. Accordingly, on receipt of reports from all stations contributing for a given earthquake, another and more accurate determination is made. Information is exchanged with the Jesuit Seismological Association, and, if possible, agreement is obtained on the interpretation. The adopted time of origin and epicenter are then sent, within 10 days of the earthquake, to all contributing stations. In the case of Pacific stations the information is sent by radio to Honolulu and distributed from there.

The value of this arrangement is particularly great for those observatories which attempt to interpret all possible phases. The area covered is so great that in practically all cases the earthquake will be relatively near to some and distant from the others. The position obtained from the nearer stations aids the distant stations in interpreting their phases. The experience of the Coast and Geodetic Survey is that the time saved in interpretation of seismograms of distant earthquakes more than compensates for the time and effort necessary for carrying out the cooperative plan. Special care is used to avoid duplicating the functions of any other organization, and as a result it is believed that the reports of the Jesuit Seismological Association and of the Central Bureau at Strasburg, as well as the final report (The International Seismological Summary), prepared under the direction of Prof. H. H. Turner, at Oxford, is strengthened rather than duplicated.

Figure 2 shows the contribution which the stations in the United States and regions under its jurisdiction are making to determination of earthquake epicenters in the Pacific.

INFORMATION TO THE PUBLIC

Special effort is made to keep the public informed in regard to earthquakes. This is done by correspondence, published articles, and furnishing information to the press. Science Service is particularly active in this respect. The Seismological Society of America, an international organization, publishes the Seismological Bulletin, which gives information on every subject relating to earthquakes. An eastern section, recently formed, issues a bibliographical bulletin, the work being done by Mr. Ernest Hodgson, seismologist, Dominion Observatory, Ottawa, Canada, with the cooperation of various organizations and individuals in the United States who are members of the society.

OTHER WORK

The United States Geological Survey has made special geological investigations and published reports of the St. Lawrence earthquake of 1925 and the Montana earthquake of the same year.

Additional work of the Coast and Geodetic Survey includes the highly important geodetic work in California reported as part of the program of the Carnegie Institution and also reported to the section of geodesy of the International Geodetic and Geophysical Union. Somewhat related work, though primarily volcanological,

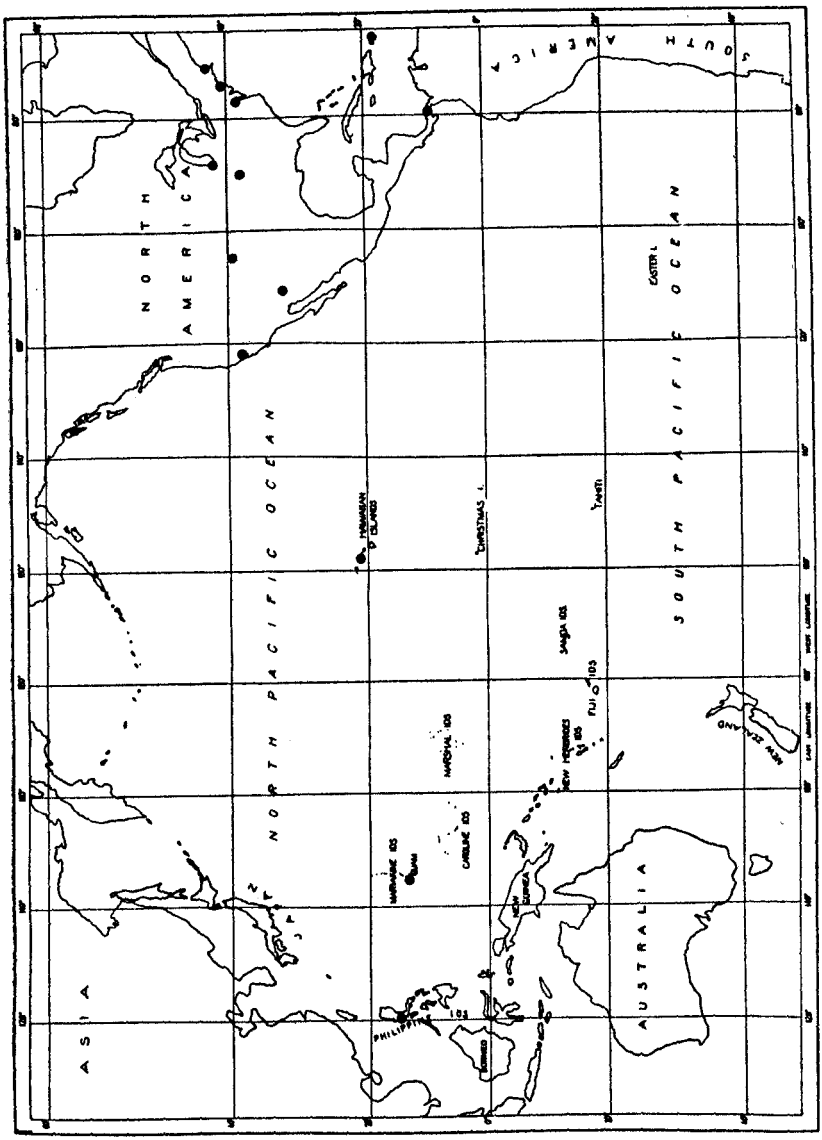

FIG. 2.—Important seismological stations in the United States and regions under its jurisdiction

is the running of precise levels on the Island of Hawaii, to be repeated from time to time to detect changes in elevation.

All tidal records received by the Coast and Geodetic Survey are examined, as a routine matter, for indications of seismic sea waves.

Completed hydrographic and topographic surveys of the coast are invaluable in case of an important earthquake, as they make it

possible to determine accurately whether changes have occurred. In all the waters under the jurisdiction of the United States, and adjoining waters, rapid progress is being made in such surveys. The present status of surveys complete for the purpose is indicated in the following table:

Completed hydrographic and topographic work	Per cent completed
Atlantic and Gulf coasts of the United States	90
Pacific coast of the United States	50
South coast of continental Alaska, Dixon entrance to Alaska Peninsula	40
Remainder of Alaska	Very small
Hawaiian Islands	40
Philippine Islands	90
Porto Rico and Virgin Islands	100

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

Seismological Report, Jan., Feb., Mar., 1925, U. S. Coast and Geodetic Survey, by Frank Neumann. Serial No. 328.
Seismological Report, Apr., May, June, 1925, U. S. Coast and Geodetic Survey, by Frank Neumann and Jerry Service. Serial No. 337.
Seismological Report, July, Aug., Sept., 1925, U. S. Coast and Geodetic Survey, by Frank Neumann. Serial No. 363.
Earthquake Investigation in the United States, by E. Lester Jones, U. S. Coast and Geodetic Survey. Serial No. 304.
Science and the Earthquake Peril, by E. Lester Jones, U. S. Coast and Geodetic Survey. (Reprint from the Journal of the Franklin Institute, May, 1926.)
Earthquakes in 1925, N. H. Heck, U. S. Coast and Geodetic Survey. Bulletin of the Seismological Society of America, June, 1925.
Some Remarks on Certain Earthquakes of 1925, by Frank Neumann, U. S. Coast and Geodetic Survey. Bulletin of the Seismological Society of America, June, 1925.
Earthquake Epicenters in the North Pacific, by N. H. Heck, U. S. Coast and Geodetic Survey. Bulletin of the Seismological Society of America, Sept., 1926.

PRINTED INSTRUMENTAL SEISMOLOGICAL REPORTS IN THE UNITED STATES

Quarterly Seismological Report, Coast and Geodetic Survey, July, 1924, to March, 1926.
U. S. Weather Review, Monthly Reports from 1915 to June, 1924.
Georgetown University Seismological Station, Annual Report, latest, 1924.
University of California, Annual Report, latest, March 31, 1926.
Beginning with 1926 the Jesuit Seismological Association expects to publish reports of 11 stations in the United States.

PART II. SUMMARY OF EARTHQUAKE INVESTIGATION 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.; Cheltenham, Md.; Chicago, Ill.; Tucson, Ariz.; Sitka, Alaska; and Honolulu, Hawaii. Three of these have modern instruments, Milne-Shaw at Chicago and Honolulu, and Wood-Anderson (teleseismic type) at Tucson. The others have Bosch-Omori instruments which it is planned to replace in the near future.

Collection of data on observed and felt earthquakes.—The Weather Bureau is giving active support to this part of the work, and additional reports are being obtained in regions of frequent earthquakes. Although such reports are not scientifically equal to instrumental reports, the inadequate number of instruments for the great area involved will continue to make such reports of importance. An improved special form for making reports has been adopted.

Record of earthquakes.—The most complete record possible, from information available, is published for earthquakes occurring within the United States, or regions under its jurisdiction, or earthquakes occurring outside of these areas but recorded by instruments within them. This information is published quarterly as the Quarterly Seismological Report of the Coast and Geodetic Survey. At the end of each year an annual summary with maps is given. All epicenters are determined from information available, it being understood that the determinations are preliminary. The publication includes the records of the six observatories of the Coast and Geodetic Survey and those of five or more universities.

Determination of epicenter.—Preliminary determination of epicenter is made within 24 hours, especially of those earthquakes occurring in North America or the Pacific region. This is accomplished through the cooperation of several organizations and numerous seismological stations within the United States and throughout the world. The cooperative method is described in detail in Part II. A more accurate determination of epicenter, from all reports received, is made within 10 days and transmitted by radio or mail to all contributing stations.

Information to the public.—Special effort is made to inform the public regarding matters of interest and importance relating to earthquakes.

Other Government activities include: Special geological investigations of regions where earthquakes have occurred are made for the more important earthquakes by the United States Geological Survey; the United States Navy Department reports seismic sea waves felt by its vessels or those of the merchant marine reported to it; the United States Bureau of Standards is at work on seismograph

design and is also concerned with tests of materials and structures to resist earthquakes.

JESUIT SEISMOLOGICAL ASSOCIATION

The Jesuit seismographic stations in the United States date back to the organization in 1909 of a Jesuit seismological service by the Rev. Frederick L. Odenbach, S. J., of the John Carroll University, Cleveland, Ohio. Under his direction 18 seismographs of the small Wiechert type were imported and set up in the following places: Brooklyn, Buffalo, and Fordham, N. Y.; Cleveland, Ohio; Chicago, Ill.; Denver, Colo.; Georgetown, D. C.; Milwaukee, Wis.; Mobile, Ala.; New Orleans, La.; Santa Clara, Calif.; Spokane, Wash.; St. Boniface, Manitoba, Canada; St. Marys, Kans.; St. Louis, Mo.; and Worcester, Mass. Three of these—Georgetown, New Orleans, and Santa Clara—installed both vertical and horizontal components.

Two years later unfortunate circumstances caused the disruption of the established seismological service. The number of stations in full operation gradually decreased, until in 1924 the only Jesuit stations in the United States still publishing earthquake data were Georgetown, Fordham, and Spring Hill. Georgetown had installed in the meantime a pair of photographic Bosch seismographs, a Mainka bifilar pendulum, a 200-kilogram Wiechert horizontal seismograph, and finally a Galitzin vertical. Fordham also had been equipped with two seismographs of the Milne-Shaw type. Rev. Francis C. Tondorf, S. J., of Georgetown, was very active in keeping alive popular interest in seismology.

The stations at Santa Clara, Spokane, and St. Louis continued in operation but without publishing their results. In the summer of 1925 an exchange of views between the Jesuit colleges and universities in possession of seismographs resulted in a meeting which took steps to reorganize the stations. The Jesuit Seismological Association was formed and a central station established at St. Louis.

During the past months there have been 10 stations in operation: Buffalo, Denver, Fordham, Georgetown, Mobile, New Orleans, St. Louis, Santa Clara, Spokane, and Chicago. A new station is being established at Cincinnati equipped with a Galitzin vertical, two long-period, horizontal-component, torsion seismometers of the Wood-Anderson type, and three short-period components of the same type.

The station at St. Louis is installing the same equipment as Cincinnati, but with two horizontal components of the Galitzin type in addition. Part of the equipment will be placed in a subterranean room in the university building on a pier of concrete built into massive St. Louis limestone of Mississippian age. The balance of the equipment will be located outside the city in a large vault completely under ground and separated from all buildings. The time service will be furnished by a Shortt synchronome checked by wireless time signals.

The association has arranged a program of cooperation whereby the data of important earthquakes are telegraphed to the United States Coast and Geodetic Survey from selected Jesuit stations and relayed, together with the data from the Government and other

stations, to the central station in St. Louis, some of the reports being telegraphed direct to St. Louis. The central station has made determinations of epicenters and issued preliminary bulletins by mail, giving the tentative location of the epicenter and an interpretation of the reports of the stations in each case a few hours after the earthquake. These preliminary bulletins are sent to about 170 stations and individuals throughout the world.

Plans for the future include further expansion of the equipment at Fordham and at Georgetown and a continuation of the program of research that has been undertaken.

CARNEGIE INSTITUTION OF WASHINGTON

Part of the work of the advisory committee of seismology of the Carnegie Institution of Washington is in cooperation with the Coast and Geodetic Survey. The chairman of the committee has made the following statement in regard to this work:

"One major task, jointly elaborated at the outset between the institution and the United States Coast and Geodetic Survey, contemplated fixing the position both in horizontal and vertical dimensions of the significant landmarks throughout the entire zone of earth movement in California. The obvious purpose of these, which has often been alluded to before, was two-fold—(1) to fix with precision the actual displacement occuring during earthquakes, (2) the much more novel and, eventually, perhaps more useful purpose of attempting to evaluate indications of accumulating stress or 'creep.'

"The purpose of this object has made necessary a new primary triangulation extending southward from Ukiah to the Mexican boundary, and east and west across the State to suitable points beyond the Sierra Nevada range which are believed to be nearly free from movement. This triangulation is now nearly completed, north and south, and three lines have been finished in the east-west direction, namely, at San Francisco Bay, San Luis Obispo, and the Mexican boundary.

"For the detection of vertical movements, lines of precise leveling have been undertaken in the southern portion of the State, chiefly with reference to known fault zones. The leveling is still in progress. Eventually it is hoped to extend it over substantially all the region covered by the recent triangulation."

The other activities are fully described in the Report of the Advisory Committee in Seismology of the Carnegie Institution of Washington for 1925–26, and a brief résumé follows:

The geological history of the San Andreas Rift and other active faults have been studied in detail. In eastern California several vertical faults have been found, while the others are chiefly horizontal. The rock is badly crushed in the fault zone.

Development of special instruments has progressed in a satisfactory manner, especially the Wood-Anderson seismometer, and this has also been modified for teleseismic use.

An artificial explosion of 62.5 tons of dynamite at a distance of 70 miles has been recorded.

The research laboratory at Pasadena and some of the substations are equipped with instruments and are in operation. Five stations will eventually be in operation.

Plans for a similar group of stations around San Francisco Bay are being worked out.

MISCELLANEOUS ACTIVITY

Harvard, Yale, Cornell, and Virginia Universities operate seismographs, their records being interpreted by the Coast and Geodetic Survey. The University of California, Lick Observatory, and several other organizations in California operate seismographs and print their results.

EARTHQUAKES OCCURRING DURING PERIOD 1925–1927

The year 1925 was an unusually active one in the United States. The eastern section was shaken by the St. Lawrence earthquake of February 28, 1925. The western section had the Montana earthquake of June 28, the Santa Barbara, Calif., earthquake of June 29, and an earthquake in Texas on July 30. An earthquake occurred in Alaska on February 23. Five others were felt over an appreciable area.

The year 1926 was relatively inactive. One earthquake occurred in San Francisco on October 14 and one in Idaho on November 28. All others were minor, though scattered over a considerable area.

On January 1, 1927, an earthquake at Calexico, Calif., was felt both in Mexico and the Imperial Valley of California.

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