Volume 42 | Annual Issue

Article 53

1935

Teleseismic Recording in Iowa

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TELESEISMIC RECORDING IN IOWA

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The Des Moines Seismograph Station started operation December 20, 1934, using a single component to record east-west motion. On March 15, 1935, a second instrument was placed in operation to record north-south motion.

The establishment of this station was undertaken with a view to contributing to the knowledge of travel time in the middle west and making available additional data on earthquakes, generally. It should have especial value in recording those originating in the New Madrid, Missouri, district, and the Great Basin district in Utah.

Seismological research requires access to the grams of stations with as wide a range as possible in distance and direction from earthquake epicenters, and with a number of different types of instruments. The Pacific Coast area and the Atlantic Coast have been well-covered, but the middle west has had little to offer in the way of seismological data. A number of stations have been abanded since the beginning of the depression because of expense of operation. Seismological data from Iowa is now being furnished by the Des Moines Station.

A modified Bosch-Omori type of instrument was decided on after two years of study and investigation of different types of teleseismic instruments, i.e., instruments used for long distance earthquakes rather than local shocks. Thereafter a year was spent in developing the instruments to secure greater precision and sensitivity with a minimum of friction. For valuable advice and coöperation in the establishment of the Station and the design of the instruments the writer is indebted to Dr. Frank Neumann, Chief of the Division of Seismology of the United States Coast and Geodetic Survey.

A horizonal pendulum is used. The pendulum is pivoted on an upright set in a re-inforced concrete pier which extends three feet below the floor of the basement seisemograph room into the compact Kansan drift. The upper suspension consists of fine piano wire attached to bolts in each side of the heavy mass, and extending from the top of the upright. The heavy mass, a 24 kilogram lead cylinder, is adjustable along the boom of the pendulum. The wire suspension at the top of the upright is adjustable from right to left so that the position of the pendulum may be shifted to correct the tilt which accumulates with marked temperature changes, such as sub-zero weather. The angle of the pendulum may be changed by adjusting the length of the wire supports by means of the turnbuckle at the back of the upright. The period is controlled by (1) the length of the boom from the pivot to the center of oscillation and (2) the inclination of the axis of rotation.

A 9-second period of the pendulum is used because this is an average period for teleseismic instruments. From 6 to 15 second periods are used for such instruments. Instruments designed for the recording of local shocks are operated on very short periods, usually .5 of a second, and are more sturdily built. A strong local shock would dismantle a teleseismic instrument.

By means of the magnifying device attached to the end of the boom the earth's movement is magnified and recorded by a platinum tipped stylus on smoked paper wound about a clock-driven drum which revolves once an hour, with a travel speed of 11 mm. per minute. A lead screw at the end of the shaft governs the travel. The drum, like the upright, is rigidly attached to a re-inforced concrete pier extending three feet below the floor of the basement room.

When a shock occurs the uprights and drum move with the earth, but the pendulum with its heavy mass remains momentarily at rest, because of its inertia, later picking up the earth movement. The magnifying arm, ending in the stylus, magnifies the difference between the earth vibration and the pendulum movement. The magnification in the Des Moines instruments is 15.

The magnifying system used is a new device, designed to reduce friction, which is the great problem in lever magnification. A steel rod, attached to the end of the boom by a three-way adjusting device, ends in a U-shaped fork, having a needle eye at the end of each tine. The fork moves in the same plane as a clock wheel, mounted on a pinion, working in polished bearings in a frame, the wheel being mounted between the two ends of the fork. A groove is cut in the rim of the wheel. A fine silk thread, knotted at one needle eye, passes around the groove in the wheel, thence through the other needle eye and back to the steel rod, where it is kept at unvarying tension by a tiny weight.

A 17 cm. recording arm of .006 aluminum is riveted to the wheel ending in a fork with an arbor set in polished bearings. The arbor carries the balanced stylus which has just enough weight to remain on the smoked paper. When a movement occurs the fork with the silk thread turns the wheel oscillating the recording arm, and resulting in a variation from the straight line which the stylus has been recording.

Time control is provided by a regulator clock which closes a circuit every minute, operating an electro-magnet extending above the drum and lifting the stylus from the paper for four seconds, and leaving a gap in the record. These minute marks enable the record to be quickly and accurately interpreted. The utmost accuracy in timing is necessary if correct travel time is to be determined from the records of the stations of the world. For this reason every American station is expected to obtain at least one radio time check from the Naval Observatory daily, the time correction being marked on the gram. We mark time corrections down to one-fourth of a second.

Damping of the pendulum is necessary to prevent too great harmonic magnification. Without damping the amplitude of the trace on the gram would be out of proportion on movements of certain periods. In the Des Moines station the damping is provided by two adjustable vanes attached to the end of the boom and moving in cylinder oil. A damping ratio of 3:1 is used at present, i.e., the overswing of any pendulum movement is approximately one-third of the original movement.

The two components are set at right angles to each other but record on opposite ends of the same drum, thus making it possible to keep the travel time on both grams equal. Two instruments are necessary to give azimuth as well as distance. This is determined by a comparison of the onset of the first waves on the two components. Direction can be determined by combining the trace amplitudes in accordance with the laws of kinetics. There is a possible 180 degrees error in this result.

Period, magnification, solid friction and damping must be exactly equal on both instruments. Reduction of friction is a never-ending problem and unceasing vigilance is needed to keep the mechanism in perfect adjustment.

The records in the Des Moines station are changed every 20 hours, time corrections and other data marked on the gram, which is then passed through a bath of shellac and alcohol and hung up to dry before it can be studied. The record is placed over a light box and studied through a magnifying glass, every deviation which is an indicator of earth movement is listed, with the interpretation of phases when a shock occurs. The record is then sent in to the office of the Geodetic Survey, Seismology Division, at Washington, D. C., where it is compared with the records of the other stations reporting to the Geodetic Survey. From these records the epicenters of earthquakes are determined and studies of travel time prepared.

When an earthquake occurs several different kinds of waves are set in motion. The first preliminary, or P waves, longitudinal or compressional in type, travel a direct course through the earth. These are the only waves which penetrate the core of the earth on their way to distant stations. These waves, however, are refracted when they enter and leave the core, causing a change in travel time. The P waves arrive first at the station and make a small trace on the gram.

The second preliminary, or S waves, travel a transverse course, do not penetrate the core of the earth without being transformed into compressional waves as they enter the core and back to S as they emerge. They reach the station secondly and make a larger trace on the gram.

The surface waves follow a longer course and arrive last but usually write the largest traces on the gram. The preliminary waves, both P and S, may be reflected, once, twice, or three times, on their way to the station, each reflection making it's characteristic record on the gram.

The estimate of the distance of the epicenter of the earthquake from the station depends upon the difference in arrival times of the first P phase and the first S phase. Having computed the time interval between various phases these are applied to travel time charts which give the approximate distance in miles, kilometers and degrees. Travel times differ due to local geological structure, distance, and the depth of focus of the quake, thus complicating the task of the interpreter and frequently making revision necessary. Roughly speaking, the P waves travel at 5 miles per second, the S waves at 3 miles per second and the L or surface waves at $2\frac{1}{2}$ miles per second.

In addition to the records of earthquakes on the grams are the microseisms — small movements occurring for hours or days at a time on all sensitive instruments. These are not fully understood as yet, but are claimed by Dr. B. Gutenberg of California Institute of Technology, and other authorities, to be the result of storms on the rocky coasts of the North Atlantic (1). Tilt arising from temperature, daily or seasonal, widens or narrows the lines. Any one standing in the room where the instruments are located causes sufficient tilt of the earth to depress the line. Wind tremors transmitted from the house foundations can be detected. Traffic vibration makes very little disturbance, and such as it is is readily distinguishable from earth movements.

The first component at the Des Moines station had been in operation just ten days, when the Lower California, quake of Decemberber 30 occurred, registering nicely and giving the operator of the new station the thrill of a lifetime. This quake is estimated to be comparable to the Long Beach earthquake in intensity. The following day, 60 kms. further south, occurred the second Lower California movement, writing a record more than twice the size of the first. These originated 2260 and 2320 kilometers respectively from the Des Moines station.

On January 23 a quake at 52.2° N. Lat., 168° W. Long. in the Aleutian Arc, 5700 km. distant, was recorded. On February 22, a larger quake at 51.2° N. Lat., 175.8° E. Long. in the Aleutian Arc, 6610 km. from Des Moines, was recorded.

Our next recording was the Middle West earthquake of March 1, 1935, which was felt over approximately 50,000 square miles. The epicenter of this earthquake has been located by the Geodetic Survey as approximately 40° 20′ N. Lat. and 96° 12′ W. Long. near Tecumseh, Johnson County, Nebr. The only place reporting damage was Tecumseh, where some chimneys were cracked and windows broken. This would correspond to Intensity VI in the modified Mercalli Scale, which lists twelve grades of intensity. In the area enclosed in the loop on the map sleepers were generally awakened, clocks were stopped, suspended objects swayed and some dishes crashed. This is listed as Intensity V. With diminished intensity the shock was felt in Iowa as far as Dunlap, Des Moines and Chariton.

Only five seismograph stations registered this earthquake, the Des Moines station being the closest to the epicenter. The earth displacement at Des Moines was .15 mm, and the acceleration 2 cm/sec^2.

Iowa and the western part of Missouri are seismically inactive, but an earthquake zone crosses eastern Nebraska and Kansas about 125 miles west of the Iowa-Nebraska boundary and parallel to it. Earthquakes occurred along this zone, but farther northwest on November 15, 1877 and July 28, 1902 (2). No earthquakes have occurred along the Wilson-Thurman fault in Iowa since the coming of the white man. Since March 1, no shocks have been completely recorded at this station.

REFERENCES

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DES MOINES SEISMOGRAPH STATION,
DES MOINES, IOWA.

A NIPISSING FLORA OF THE APOSTLE ISLANDS REGION OF WISCONSIN

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Materials from buried peat beds in Lake Superior near the Apostle Islands in Wisconsin have been critically studied for plant fossils. The deposits are considered as contemporaneous with the one-outlet stage of Glacial Lake Nipissing. Twenty-five species of plants are recorded. These belong to the flora of the Canadian Zone and occur in the region today. A spectrum of the microfossils was also determined.

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