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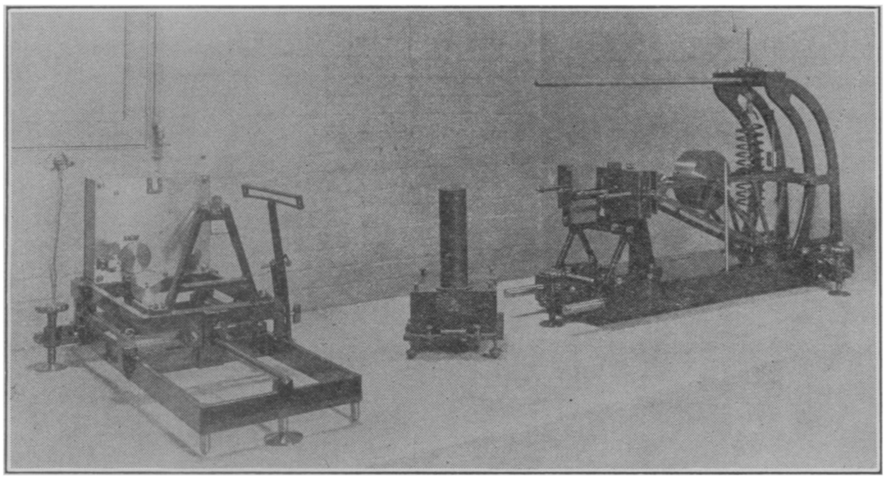
SEISMOLOGY

Earthquakes Send Their Own Telegrams



GALITZIN SEISMOGRAPH at Georgetown University, Washington. The round weight, in the instrument to the right, remains stationary during an earthquake, while the other parts move up and down around it. Attached to the weight are small coils of wire connected to the galvanometer in the center. The coils are between the poles of the magnet and their motion relative to the magnetic field produces a minute electric current which is detected by the galvanometer and recorded photographically in the apparatus to the left.

Last Monday, October 24, there was an earthquake at 10:59½ A. M., Eastern Standard Time. At 4 o'clock on Monday afternoon Science Service announced that the U. S. Coast and Geodetic Survey, which cooperates with it in locating earthquakes, had found that the quake centered at 61 degrees north latitude and 140 degrees west longitude. This is on the Alaska-Canadian boundary, about 75 miles north of Yakutat Bay. But not until the next day did any reports of it reach the United States from Alaska, while it will probably be some time still before full accounts are received from the affected area.

Long before telegraphic dispatches from the region of a quake reach distant points, scientists are able to tell that it occurred and even to locate definitely the center of the disturbance. The earthquake has sent its own dispatch to those who have the instruments, and the experience, to read the message. The seismograph, which is the machine that detects these tremors, even when occurring in the opposite parts of the earth, is based on a very simple principle. Lay a piece of paper on a table, and place a coin on it. Then suddenly pull the paper away. If you do it quickly enough, the coin will not move, but will drop to the table immediately under the place that it occupied on the paper.

How the Seismograph Works

The seismograph works in precisely the same way. The reason that the coin did not move with the paper, was that it possessed what the physicist calls inertia, or resistance to motion when it is standing still. The seismograph has a heavy weight, often hundreds of pounds, corresponding to the coin. It is suspended like a pendulum, so that it can move freely. But when the earthquake occurs, it does not move. The vibrations are transmitted through the earth, and the earth vibrates slightly even at points far away from the region of greatest activity. Just as the coin kept still when the paper was moved, the pendulum remains stationary and the earth moves under it.

Fastened to the pendulum is a small needle which is in contact with a sheet of smoked paper on a drum that is set firmly on the ground, so that when the vibration comes the drum with the smoked paper moves under the needle and a record is obtained. Actually there is usually a system of levers which magnifies the relative motion of the drum and the pendulum, and sometimes the needle and smoked paper is replaced by a beam of light reflected from a

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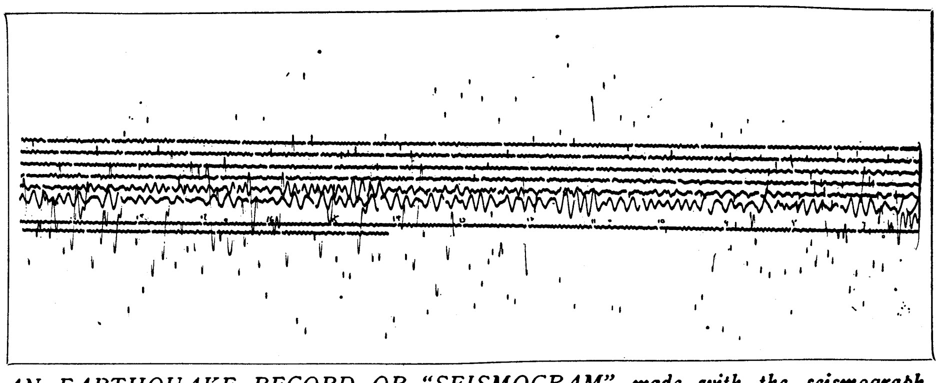

AN EARTHQUAKE RECORD OR "SEISMOGRAM" made with the seismograph shown above. This is the autograph of the Santa Barbara earthquake.

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tiny mirror on the pendulum and a photographic film, but the principle is the same.

But even when the record is obtained, to the average citizen, it would simply indicate that an earthquake has happened some place. The important question is "where is it?" Far from the usual notion, an earthquake is not a promiscuous shaking, but follows definite laws. The typical quake consists of several parts, first the preliminary phase, then the secondary and finally the third or long phase. At the "epicenter" or the center of the disturbance these three phases occur so closely after each other that it would be almost impossible to distinguish them, but the waves do not travel with the same velocity. The preliminary phase of the recent quake in Santa Barbara was felt in Washington about seven minutes after it occurred, while the secondary phase arrived about five and a half minutes later. The greater the distance, the greater the difference between the two phases, and from this difference as measured by the seismograph, seismologists may find the distance of the quake.

Their job is complicated by the fact that a large mass at the center of the earth is apparently made of iron. At least it is different from the ordinary rock-substance of the earth's crust, for it acts in many ways more like a mass of rigid steel; and it does queer tricks with the earthquake waves, reflecting some of them and bending others from their course. But the principle remains the same; the iron center of the earth only makes the seismologists use a little more arithmetic to get their results.

The Direction of a Quake

The estimating of the direction of an earthquake center is a more difficult matter. It depends on the fact that the pendulum of a seismograph is "pointed" in a certain direction, and will behave differently if an earthquake wave hits it parallel or transversely, just as a straw floating on a pond bobs in one way if the ripples catch it lengthwise, and in another if they take it crosswise. Most well-equipped seismological stations have several instruments, with their pendulums "pointed" in various directions, so that their results can be compared and checked against each other. At best, it is difficult to tell the exact direction of an earthquake center from the observations of a single station, and sometimes even good observers will have the distance quite right, and the violence properly estimated, but be "off" on the direction by 180 degrees of a circle, stating that the quake was in the southeast instead of the northwest.

This, then, locates the epicenter on a circle a certain distance from the station where the seismograph is located, and approximately in a certain direction. As there are certain regions of the earth where earthquakes are most likely to occur, when the seismologist sees that this circle crosses one of these earthquake zones, it is probable that it is the source of the tremor.

Several Reports Needed

An earthquake may, however, take place in any part of the world, and so this method is a bit of a gamble. But if two separate stations, some distance apart, both get records, we have circles around each. Unless the epicenter is directly between the two stations, these circles intersect at two places, one of which is the place where the quake occurred. Then, if a third, and a fourth, station report, three or four circles to intersect each other and help to determine the exact location.

For years there have been a number of seismograph observatories in

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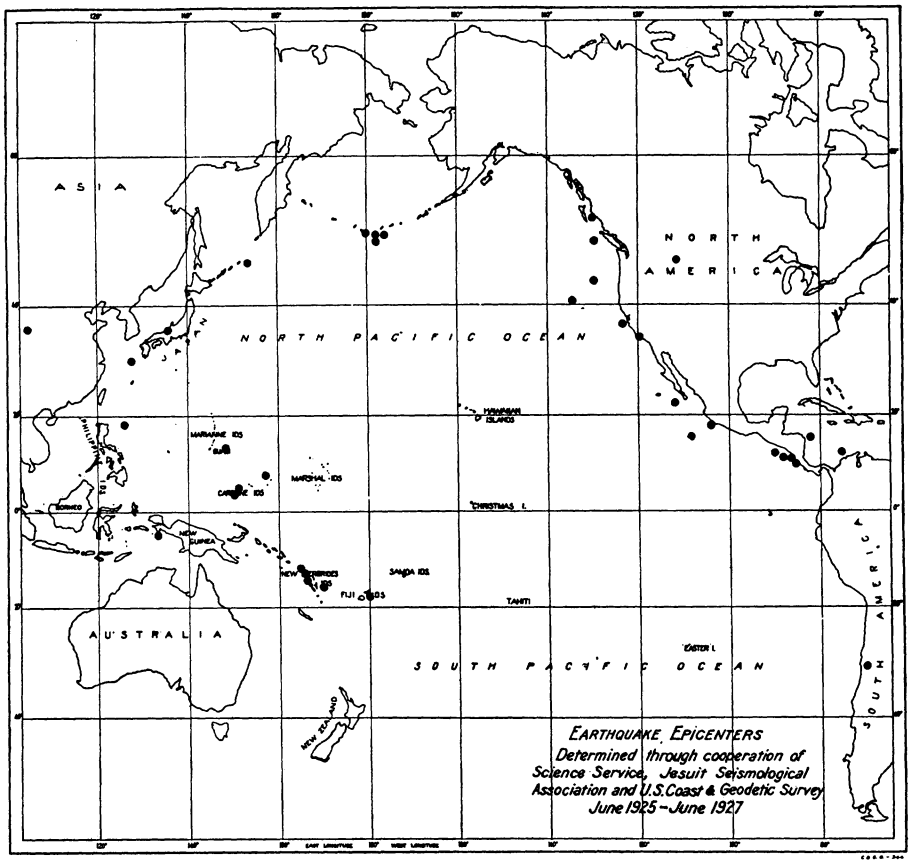
various parts of the United States, but only comparatively recentlv have their efforts been coordinated so that their records would be most useful. A few years ago all the earthquake investigations of the U. S. Government were placed in the Coast and Geodetic Survey, in charge of Commander N. H. Heck. This division began to gather earthquake reports from various universities, as well as its own observatories, and publish the results.

But many months were sometimes required to determine a quake, and still are required for a final determination. In order that the location of an earthquake might be determined within a few hours after it happened, and with considerable accuracy, Science Service, in June, 1925, started to cooperate with the Survey. By this arrangement the seismograph observatories of the Survey, as well as at various universities, and a few in foreign countries, telegraph or cable the data to Science Service in Washington immediately after the record of a quake is obtained. For this purpose a special code is used, so that the message may look something like this:

ENBAIPUXEN BAENOTFIOT
AMENFIDEFI ENDEUXKUEN
FIOTENBABA IPDEEOTBAIP
VYVYVYBAAM KUBAENOTBA.

When decoded this gives practically all the data that the seismogram —the record taken off the instrument —does. This data is given to the experts at the Survey, and a determination of the epicenter of the quake is usually made within a few hours after it occurred. The location of the quake is then made public by Science Service through the daily press.

A few months after this scheme of cooperation was put into effect the Jesuit Seismological Association was organized. For many years, the Jesuit colleges of the United States have operated many of the principal seismograph observatories, one of the chief of which is that at Georgetown University, Washington, in charge of Rev. F. A. Tondorf, S. J. This association was intended to coordinate their work, just as the Coast and Geodetic Survey had coordinated the Government's work. The scheme of cooperation then became a triple one, between Science Service, the Jesuit Seismological Association and



MAP SHOWING LOCATION OF EARTHQUAKES located during first two years of Science Service's cooperation with the Coast and Geodetic Survey and the Jesuit Seismological Association

the Survey. The data obtained from the earthquake stations is also telegraphed on to the headquarters of the Jesuit Association in St. Louis, under the direction of Rev. James B. Macelwane, S. J. Here an independent determination of the quake is made and telegraphed back to Washington, as a further check on accuracy.

A striking illustration of the value of this cooperation was obtained last spring when a very severe earthquake occurred on May 22 in the Kan-Su province of China. The following day Science Service announced its location, but not until July did reports reach civilization from the devastated region, which confirmed the first announcement.

The Cause of an Earthquake

The ultimate cause of an earthquake is the transfer of material from one part of the earth to another. By the process of erosion, whole mountains may be moved, and vast canyons, like that of the Colorado River in Arizona, may be cut. The most important agency of erosion is water. Rain falls on a mountain and each drop washes away a small part, which is carried down to the valley below. Infinitesimal as the effect of a single drop is, when the process is carried over a period of thousands of years the effect is enormous. This changes the loading of the earth's surface. A vast amount of material may have been carried into a valley, thus increasing the weight there, while the neighboring mountain may have been reduced in size. The result is a slipping of the heavier part to readjust itself, and it slips along a definite line which geologists call a "fault".

When a fault is once established, other slips may occur along it in the future. To determine the places where quakes are most likely, maps have been made showing the principal faults which are known to exist. California has been most completely studied in this way and a fault map, issued by the Seismological Society of America, in cooperation with various government agencies, shows hundreds of them. But probably other parts of the country would also show a large number if studied as completely.

A Quake in a Layer Cake

Faults need not be open fissures in the rock; in fact, they seldom are. Most faults are detected simply by the fact that the layers or strata of

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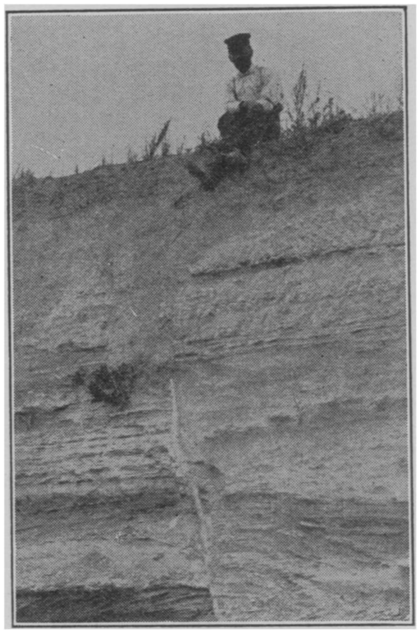
rock fail to match up along a certain line. Such a line is a "fault line," and marks the place where, under great stress from above or below or from one side the solid rock cracked and slipped. You can produce a fault on a small scale in a layer cake, by slipping a knife under it and lifting until it breaks. When you take the knife away, the chances are that the layers in the cake will no longer match up evenly. After a while, perhaps, the heaved-up part will settle back into position a little; the fault is readjusting itself. If an ant happens to be walking on top of the cake at the time, he will get a bit of a jolt: the readjustment of the fault has caused an earthquake.

As in the little world, so in the big. This round, cosmic layer-cake on which we humans live is full of places where the layers are pushed and twisted out of place. Every time a new push causes another slip, we get an earthquake. Every time the dislocated parts readjust themselves a little, we get another jar.

These movements of dislocation and readjustment may take place either up, down, or sideways, and sometimes they are of quite considerable extent. Dr. Bailey Willis, a prominent seismologist who happened to be in Santa Barbara at the time of the earthquake, noted that the trail of an old cannon in front of the postoffice left a scar on its stone pedestal sixteen inches in length, running from north to south, thus indicating a movement of nearly a foot and a half. But the Santa Barbara earthquake was a comparatively mild one. Roads that crossed the great San Andreas fault, which caused the San Francisco disaster twenty-one years ago, were dislocated by as much as their full width, so that the right-hand edge on one side of the line met the left-hand edge on the other. Similarly, fences that ran across this fault were broken, the offset between the ends being wide enough for a good, generous-sized farm gate.

Seismologists and geologists point out that man can profit by his costly experiences with these earthquake-causing slips of rock faults. The San Franciscan's claim that "it wasn't the earthquake, but the fire, that caused most of the damage" is true. But when the fire started, the aqueducts that should have supplied water to fight it were broken in two at the fault line, just like the roads and the fences. And in too many



"FAULT" AS SHOWN ON THE SIDE OF A CLIFF. The different layers of rock were originally continuous, but the part to the right slipped down. Filling in of dirt later made the top level again. (*Photo courtesy U. S. Geological Survey.*)

instances, the water mains of earthquake-scourged cities have been rebuilt exactly as they were before, right across the fault lines; so that when another quake comes they will break again in exactly the same places. Similarly, railwav tracks that might carry relief can be cut off. Sources of danger, like high-tension electric wires, and pipes conveying inflammable oil and natural gas, in many places stand ready for the wrecking wrench of the earthquake to add their share of death and destruction.

Measures are already being taken in California to gain a more intimate knowledge of the earthquake situation in general, so that a newer generation of engineers may be able to avoid the costly mistakes of their predecessors, and even so that scientists may predict the coming of a quake with something like accuracy. Prof. Willis tells of the initial steps in this movement.

"The Carnegie Institution of Washington is now engaged in establishing stations at Pasadena, Riverside, La Jolla, and other points in southern California," he says, "where instruments designed to record local earth tremors are being set up. All of the stations will operate in unison under the central control of the principal station at Pasadena and the records which they will yield will enable us to fix the focus of even the slightest tremors within fifty or sixty miles of the stations. As the records are continuous we shall know exactly where the earthquake strain is gathering and how it increases or diminishes from day to day or month to month.

"In the course of time a chain of stations of this character will no doubt be established from San Diego to the Oregon line. But it will have to be done through the cooperation of the communities interested and will not be accomplished until public opinion is educated to an understanding of the advantage of knowing all that we can about earthquakes and the methods of protecting ourselves against their effects."

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Region of Past Quakes

The earthquake last Monday was not the first that has visited the region in Alaska. One of the most severe earthquakes of the earth's history occurred in Yakutat Bay in 1899. This disturbace is listed as "the earthquake of the century." Another severe earthquake shook the region on February 21, 1925.

It may take weeks for the news of the quake to be transmitted from the region to the outside world. The Alaskan coast in this locality is only sparsely settled with natives. One native village and a federal school is located at Yakutat Bay, but this is sufficiently far from the zone of greatest disturbance to arouse no fears as to its safety. Communication is limited to a coast-wise steamer that plies as far as Steward on a monthly schedule, but weather conditions at this time of year make even this meager contact unreliable.

A seismographic station of the Coast and Geodetic Survey is located at Sitka, some 300 miles away, and probably felt the shock.

The great Yakutat shock of 1899 caused vertical displacements of the earth of as much as 40 feet. While changes of the earth's surface of this extent are not likely as a result of the present shock, the configuration of the ocean bottom in that region may have been changed, causing navigation to be menaced.

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A German chemical company reports that it has perfected a method of producing 100 per cent. pure tin.

Indians of the Seneca Nation in New York State passed their own law to control the corn borer two years ago.