HOW THE EARTH'S MOVEMENTS ARE NOTED.

The land on which we live and build our houses—the land, which the sea-writers of the early part of last century confidently and almost affectionately termed *terra firma*—is well nigh restless as the ocean which washes its shores. In England at least seventy unfelt earthquakes, each of which has a duration varying from twenty minutes to several hours, may be recorded yearly. Our buildings rock and sway, if we could but see them, as the masts of a ship on a heaving sea. To be sure, the incessant rising and falling of the waters is more violent than the motion of the land. But the difference between the two is largely a difference of effect—the difference between a billow and a ripple.

We, who live far north of the equator, never perceive the feeble tremors of the earth beneath our feet. But the man who spends his life in studying the movements of the land, great and small—seismologist he calls himself—knows better.

The seismologist knows that the earth throbs, not because he has better eyes than other people, but because he has devised wonderfully ingenious instruments, so highly sensitive that they tremble as the earth trembles, and thus enable him, as it were, to feel the earth's pulse. And with the help of these delicate instruments, he can tell us how large, or rather how small, are the ripples that play over the earth's surface. Some day when more seismological stations are established throughout the world, when more seismological records have been gathered, and when some master mind will burst forth whose grasp is so broad that it can embrace many isolated scientific facts that now apparently have no connection, we may even know what earthquakes really are and by what they are caused. When that scientific millennium comes, the earthquake-prophet will appear in the land and tell us when and where we may expect the next volcanic eruption or upheaval of the earth.

It must be confessed that the theories of the origin of volcanic eruptions and of earthquakes, with which science has so far furnished us, are more picturesque than useful. About one hundred and fifty years ago a Cambridge professor, John Michell, advanced the remarkable theory that the earth's crust constituted but a shell, the interior of which was a liquid body. He thought that this interior liquid was in some inexplicable way lashed into waves, just as a carpet becomes a billowy mass when shaken by one corner; and that such waves shook the earth's crust and produced earthquakes. For a century and more that theory, modified slightly to suit newly-discovered facts, has been paraded in every school and college that professed to teach anything at all of geology. Modern physicists, however, have contumeliously knocked Michell's theory on the head. We are almost ashamed now that we ever believed it. With the fate of Michell's doctrine before them, scientists have been loath to advance new ideas. Nevertheless, an English geologist of note had the courage to believe that earthquakes were due to "the snap and jar occasioned by the sudden and violent rupture of solid rock masses, and perhaps the instantaneous injection into them of intumescent molten matter from beneath." That seems bewildering enough to be true. But the "intumescent molten matter" theory has also been laid at rest. Well aware of the enormous expansive force of steam, some students of earthquakes, have not hesitated to attribute such violent eruptions as we have recently witnessed in Martinique, to water which has found its way down into the earth and come into contact with highly heated masses of rock. The theory is at least plausible. But it has been sharply assailed by well-informed critics.

After all this indiscriminate theorizing, it must be confessed that but little progress has been made in furnishing an adequate explanation of the origin of earthquakes and volcanic disturbances. Seismologists have succeeded in establishing simply the fact that the occasional displacements of the earth's crust are due to the sliding, crumpling, bending, and cracking of rocks. The origin of such a disturbance may be best described as a wrench, which, when analyzed, is found to consist of a pull and a twist. This wrench both compresses and distorts. It gives rise to two waves—a wave of compression and a wave of distortion—which travel with different velocities. Rock, like most bodies, tends to return to its original volume, after compression, by virtue of its elasticity. To the forcing together and springing apart of the rock molecules is due a wave of longitudinal displacements—one of the two waves mentioned. The rigidity of the rock gives rise to a wave of transverse displacement—the other of the two waves.

If an earthquake be simply the result of wave motion, an inquiring man might ask: How comes it that only certain places experience the shock, and not all those along the line of the wave.

A distinction must be drawn between the movement of the wave and the movement of the molecules of rock through which the wave travels. The pulse of the wave may be propagated to a vast distance; and yet the excursions of the rock molecules are confined within narrow bounds. Imagine a long row of marbles, placed on a table, the one touching the other. If a shock be imparted to the marble at one end of the row, the marble at the opposite end will leap out of its place; but the intermediate marbles will scarcely move at all. The wave was transmitted through its entire row, but only where it broke, was the shock felt. Thus is the shore battered by sea-waves; thus is the earth heated by the breaking of light-waves sent by the sun; and thus it happens that such rock-molecules during an earthquake may move only through a few inches, while the undulation may travel for hundreds of miles. The distance through which the individual molecules oscillate is called the "amplitude" of the wave.

With the effect of a seismical wrench determined, the next step is to invent some means of detecting and recording the waves, felt and unfelt, to which that wrench gives rise. Such means are primarily of importance for the purpose of determining the path of the wave. Naturally, the waves that can be felt are those most easily recorded. Every object that has been visibly affected by a seismic disturbance is a recorder, to a certain extent. Fractures and fissures in walls rent by an earthquake are of inestimable value to the seismologist, because they often indicate the direction in which the waves emerge at the surface and the manner in which they break. The simplest of all recorders, one which has been used in Japan for over twelve hundred years, is a lamp, which, when overthrown, is extinguished. Still another form of recorder, simple as it is rude, consists of a vessel containing some syrup-like liquid, which rocks as the earth rocks, and leaves its mark—a rough indication of the direction and extent of seismic motion. A device much used in Italy comprises a tray, formed in its sides with recesses which are filled to the brim with mercury. When the earth trembles, the mercury is spilled into small cups, hung beneath the recesses. By measuring the amount of mercury retained by the cups, the intensity of the shock can be roughly gaged.

Such recorders are too crude for the modern scientist; they can never reveal those finer perturbations, which play so important a part in the study of earthquakes. For that reason the seismologist has been compelled to devise ingenious self-registering instruments which furnish us with permanent records of tremors, so exceedingly feeble in their effects that the particles of earth-molecules are not displaced more than a very small fraction of an inch in the transmission of the pulse.

The instruments in question are called seismoscopes and seismographs, and may be roughly divided into two classes. In the one class, the earth's motion is translated into diagrams written on stationary plates; and from these diagrams it is possible to ascertain with wonderful accuracy the extent and the direction of the principal vibration in a shock. In the other class, the movement of the earth is recorded on a surface traveling at a known rate; and from the tracing thus made the seismologist can deduce the period or the rapidity with which the earth's undulations follow one another. These latter diagrams are of extreme importance. They are the means of calculating the acceleration or suddenness of movements; in the hands of the engineer they are factors that enable him to erect structures capable of resisting known forces, and not structures simply strong enough to withstand an earthquake. To the man who knows an earthquake merely as a destroyer of towns, the diagrams written by the earth seem a tangled, hieroglyphic script. To the seismologist, they are as unmistakable in their meaning as printed words; they are autographs, as it were, written by the quivering earth at a time of great, internal violence.

In order to obtain a complete record of every detail of a seismic disturbance, the movement of the earth, in one of the most approved forms of instrument, is resolved into three components, the one vertical, the other two horizontal, and all at right angles to each other. These three component movements are registered by three distinct pointers on a sheet of smoked glass, which is made to rotate at constant speed by clockwork. A single earthquake always consists of many successive displacements of the ground; hence the mark traced by each pointer on the moving plate is a line comprising many undulations, usually very irregular in character. The amplitude, period, and form of each of these tracings are measured; and by compounding the three the seismologist obtains full information of the direction, extent, velocity, and rate of acceleration of the movement at any epoch in the disturbance.

Instead of using a smoked disk of glass, a drum can be employed, the record being made on a band of smoked paper. The diagram is less difficult to interpret than that of a plate, because it is written on either side of a straight line, and not around a circle. In order to avoid the trouble of handling smoked paper, the diagram is sometimes written along a straight line with a pen or pencil. When the shock has passed, the drum stops. But if a second or third shock should occur, which is often the case, the drum is again automatically set in motion.

In order to record slight earth tremors, an instrument called a tronometer is used. Every five minutes, by clockwork contacts and an induction coil, sparks are discharged from the end of a long pointer, and perforate bands of paper. If the pointer be at rest holes are pierced, following one another in a straight line; but if the pointer be in motion, the bands of paper are perforated in all directions. The earth movements which cause these so-called tremors are apparently long surface undulations of the earth's crust, resembling very much the swell of the ocean. A more satisfactory record of this swell is made by a continuous photograph of a ray of light reflected from a small mirror attached to an extremely light horizontal pendulum.

Electrical seismoscopes are among the most delicate devices yet invented for the measuring of earthquakes. They are of such construction that they cannot be here described for lack of space. So sensitive are they, that the slightest disturbance closes an electric circuit, thereby actuating electro-magnets and liberating the driving mechanism of the recording surfaces on which the earth's signature is written.

In some Japanese observatories the time of an earthquake is recorded by a curious form of clock. When the ground trembles, the dial moves quickly back and forth and receives on its surface three dots from ink pads on the hands. Thus the earth is made to stamp on the dial the exact hour, minute and second when it trembled.

The list of the instruments might be tediously multiplied. Enough have been mentioned, though, to show through what means our knowledge of the movements of the ground has been increased, and how we are investing earthquakes with a significance which they certainly did not possess for our forefathers.

Future Application for Radium.

The Anglo-Indian Review summarizes an interesting account of the possible future applications of radium. The area where success is practically assured is at present not very large, but in the medical field it is already fairly extensive. In the working of X-rays and in the marvelous results achieved in the treatment of cancer and blindness we have every hope for great and universally benefiting results. In its industrial application we are somewhat restricted by the extremely limited supply of radium available, but it is stated that a small fraction of an ounce, properly employed, would probably provide a good light sufficient for several rooms and would not require renewal during the present century. It has been calculated that the energy stored up in 1 gramme of radium is sufficient to raise 500 tons weight a mile high. An ounce would, therefore, suffice to drive a 50-horsepower motor car at the rate of 30 miles an hour round the world.

A Test With Radium to Restore Eyesight.

The New York Sun publishes an account of an experiment conducted by William J. Hammer and Dr. Amon Jenkins for the purpose of ascertaining the effect of radium rays on a blind girl. From the account published, it cannot be gleaned exactly what degree of success was attained. Still it would seem that some favorable results were obtained by the combined effect of an X-ray tube with radium. Some change in the patient has taken place; but just what that change is has not been given out.

It is said that London has no less than 313 parks and open spaces, while in 1884 their number was only 103. They are reckoned to have cost $10,995,000. On a rough calculation there is an acre to 752 persons, reckoning to London a little more than 4,500,000 souls. New York, on the other hand, has in the Borough of Manhattan public parks covering an area of 1,415 acres, in Richmond 2¾ acres, in Brooklyn 1,026 acres, in Queens 550 acres, and in the Bronx 3,866 acres, a total of about 6,862¼ acres. In the boroughs of Manhattan, Brooklyn, Queens, and the Bronx there are 321,561 feet of parkways, streets, avenues, etc., under the jurisdiction of the department. The vast playground for coming generations in the Bronx is made up principally by Bronx Park, 661 acres, against Central Park's 843 acres, Pelham Bay Park, 1,756 acres, and Van Cortlandt Park, 1,132 acres.

In "The Mineralogy of the Chicago Area" Prof. Crook, of the Northwestern University, states that diamonds are deposited between Chicago and Milwaukee. Some seventeen specimens, weighing together about 70 carats, have been found. The largest weighed 21¼ carats. They are commonly white or faintly green or yellow in color. They were found in the sand and gravel of the kettle moraines or in the beds of streams.