ation of the mesethmoid, rises above the plane of the top of the skull, and extends forward beyond the jaw. A bilateral expansion of its base in front forms a firm supporting pad, resting upon the pre-maxillary bones. The two remaining cartilages are paired.

Since returning from the seal-fishery, I have examined the accessible works that would be likely to mention this curious appendage, but have failed to discover any thing approaching an accurate or complete description of it. That given by Fabricius more than a century ago is one of the best All writers whose accounts I have seen, including the most recent, agree in failing to express the chief characteristic of the animal, which is, that the so-called 'hood' of the male is an inflatable proboscis, protruding considerably beyond the mouth, which it overhangs.

C. HART MERRIAM, M.D.

MEASURING EARTHQUAKES.[1]

IN VIEW of the recent earthquake in England, and the still more recent shakings which parts of this country have experienced, a notice of the above work will be of especial interest. Professor Ewing's long residence in Japan as professor of mechanical engineering in the University of Tokio, and his active labors in connection with the Seismological society there, of which he was vice-president, entitle him to speak with authority on this subject. Indeed, in this matter of the exact measurement of the motion of the ground during an earthquake, seismologists the world over must look for enlightenment to young Japan, whose Seismological society, under the guidance of the foreign professors in her university and her college of engineering, has in this particular branch far outstripped European seismologists.

In chapter i. Professor Ewing gives a *résumé* of the theory of waves in an elastic solid, as applied by Hopkins, in the British association report for 1847, to the case of terrestrial disturbances; "since it both teaches the earthquake-observer what to look for, and guides him in the interpretation of his results." This shows how, from a single sudden disturbance, two series of waves will set out in all directions,— the first or normal waves consisting of compression and expansion of the material in the direction of transit; the second or transverse waves travelling more slowly, and consisting of motion of distortion at right angles to the line of transit, — also how these waves may be reflected or refracted at the bounding-surfaces between different strata, and thus by successive reflections be reduplicated; so that, at a distant point, the vibrations will probably be far different from (in number, order, phase, and period), and generally much more complicated than, those at the origin. Add to this the effect of imperfect elasticity, and the condition that the original disturbance may be a series of slips along a whole line or 'fault,' and nothing further could be desired to give confusion to the vibrations.

Chapters ii. and iii. deal with instruments for measuring the horizontal motion of the ground. At the outset Professor Ewing notes the difficulties in the way of getting a steady point, or something 'to tie to,' while every thing around is being shaken; and the characteristic feature of every seismometer is its method of supporting a heavy mass so that it will remain steady, receiving no impulse (save what is unavoidable through friction) while the system that supports it is being shaken. As the 'horizontal pendulum' seismograph in one of its forms is considered the best, and has given the greater part of the records obtained, its essential feature is here shown in fig. 1. Popularly it might be termed a heavy weight, swinging on a gate. It is a heavy mass, pivoted upon a vertical axis through d, upon a frame free to move about the vertical axis bc. The long light reed multiplies the motion, and records it upon a rotating smoked-glass plate by the steel pointer on its end. This reed is pivoted at d, with most of its weight taken up by the coil-spring, whose tension is adjustable at e. The parts of this supporting lever and long reed are so proportioned that in the vertical axis through d lies the centre of percussion relative to the axis bc: hence, if this is shaken through bc at right

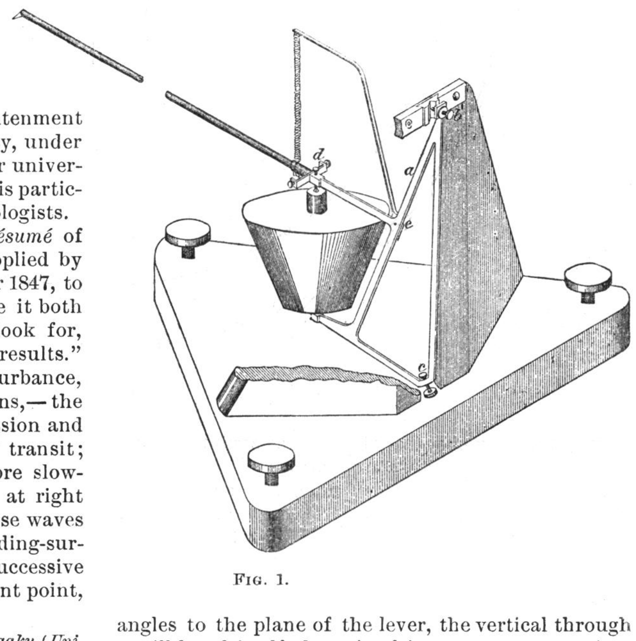

FIG. 1.

angles to the plane of the lever, the vertical through d will be of itself the axis of instantaneous rotation, independent of the heavy mass pivoted there; hence the latter will receive no impulse at right angles to

[1] *Memoirs of the science department, Tôkiô Daigaku (University of Tôkiô), No. 9. Earthquake measurement.* By J. A. EWING, B.Sc., F.R.S.E. Tôkiô, *Tôkiô Daigaku,* 1883. 12+92 p., 23 large plates. 4°.

the plane of the lever, save that due to the very slight friction at *b* and *c* and at the marking-point; and the purpose of the heavy mass is chiefly to furnish, by its inertia, the necessary fulcrum upon which to overcome this slight friction. These principles, as regards centre of percussion, and axis of instantaneous rotation relative to the axis of support, are especially insisted on by Professor Ewing as essential features of a reliable seismometer. Two of these horizontal pendulums at right angles record the two already obtained. Fig. 2 shows this record, made by a pair of horizontal pendulums multiplying the motion six times. As here reproduced, it is about twice the actual motion of the ground. The inner circle gives the N–S, and the outer the E–W components. At *d* and *d′* are two cross marks, showing where the pointers rested when the plate was stopped; and their angular distance is that to be used in connecting the two circles to obtain the simultaneous motion of the two points. The motion began on the outer,

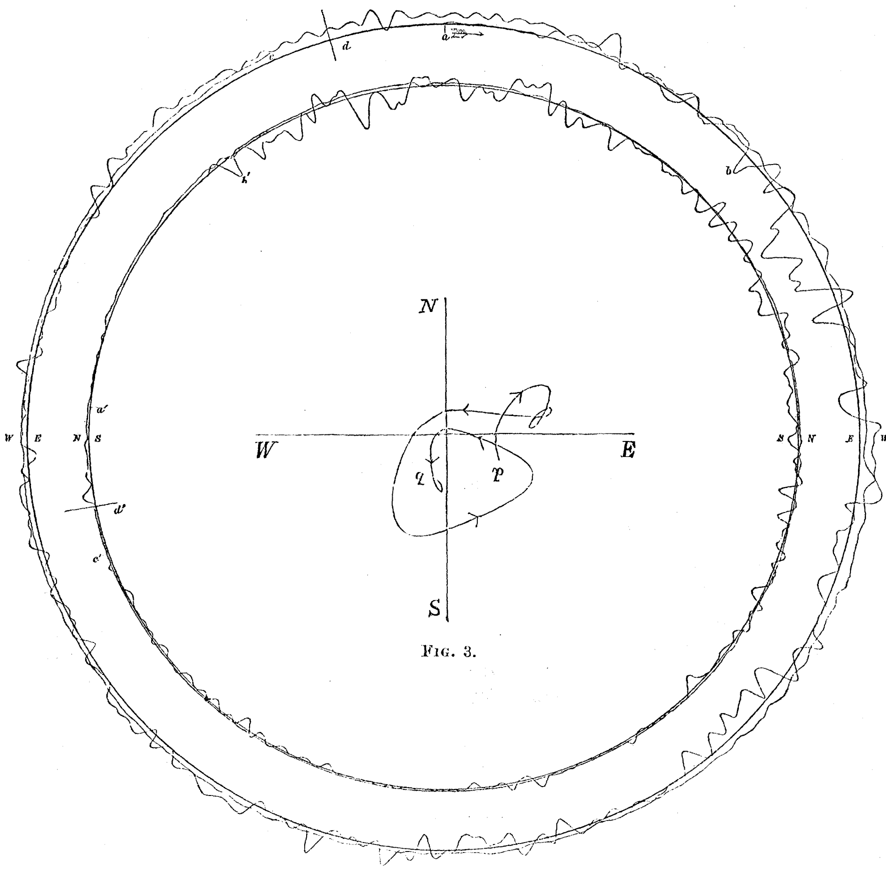

FIG. 3.

FIG. 2.

rectangular components of the horizontal motion upon a rotating smoked-glass plate.

Many other ingenious and novel forms of apparatus for registering the horizontal motion of the earth are described in chapters ii. and iii., and various devices are described in chapter iv. for measuring the vertical component of the motion.

We reproduce the trace of the earthquake of 1881, March 8. Fortunately, Professor Ewing was present during its occurrence, and, as it drew to a close, lifted the marking-levers from the plate, so that their subsequent trace should not obliterate at all the record E–W, circle at *a* (corresponding to *a′* on the inner), and thence can be easily traced nearly twice round the circle to *c*, where the pointer was lifted (corresponding to *c′* on the inner circle). There was no appreciable motion in a N–S direction till about ten seconds after it began at *a*, E–W; but it began quite suddenly just before *b′*, and can be traced twice round to where the plate stopped at *d′*. The rotation time was about eighty seconds, and the earthquake had lasted about two minutes and a half when the plate was stopped. Feeble movements were observed some time longer.

In fig. 3, Professor Ewing has carefully combined the motion of the two components so as to give the actual path of a point of the earth's surface for a short interval. From p to q, following the arrowheads, it shows that motion (magnified six times) during an interval of three seconds.

This same characteristic wriggling motion is shown in fig. 4, which is the entire record, magnified three and a half times, upon a stationary plate, of an earthquake which occurred on April 23, 1883, and lasted four minutes and a half. It is quite likely that the earthquakes which recently shook up our middle and western states would have given a somewhat similar record.

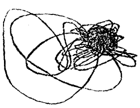

FIG. 4.

The principal characteristics of the average earthquake in the plain of Tokio are: 1°. The motion of the ground begins very gradually. 2°. An earthquake consists of many successive movements, and there is almost always no single large one which stands out prominently from the rest. 3°. The disturbance ends even more gradually than it begins. 4°. The range, the period, and the direction of movement, are exceedingly and irregularly variable during any one earthquake. 5°. The duration of disturbance of the ground is rarely less than one minute, and often several minutes. 6°. Even in somewhat destructive earthquakes, the greatest displacement of a point on the surface of the soil is only a few millimetres. 7°. The vertical motion is generally much less than the horizontal. 8°. A mass shaken back and forth in the most severe earthquakes of Tokio, would, if it did not slide, be urged by a horizontal force, which, at its maximum, would equal about one thirty-third of its weight. This, regularly repeated, is sufficient to crack brick walls, and sometimes throw down chimneys.

To the many readers who have had no experience of earthquakes, but are accustomed to think of them as a sudden violent thrust, accomplishing at a blow, as it were, all their disastrous work, the preceding descriptions will be a somewhat new revelation.

Professor Ewing plainly shows that as seismometers, the instruments in use by Palmieri and others are worthless; for not one of them can be depended upon to give a reliable measure of the direction, period, or amplitude of the vibrations of the ground, most of them being designed to record a single violent thrust in one direction, and nothing subsequent, and the greater part of them being some form of stable pendulum which is almost certain to be set swinging in an earthquake through amplitudes far greater than the earth itself, and thus to mask entirely the motion of the latter.

One novel 'time-taker,' the invention of Professor Milne, whose work in Japan is so well known, is worthy of note. A clock has its hour, minute, and seconds hands all on the centre of the face, and of different lengths, with their ends turned up into the same plane, and tipped with cork smeared with printer's ink. In front is a track upon which, when a seismoscope closes a circuit, a carriage travels up and presents a disk to the face, and then backs off again, carrying an impression of the instantaneous position of the three hands, and leaving the clock to go on undisturbed.

The closing chapter treats of the constructive details and requirements of a seismological observatory; and a series of experiments by Professors Milne and Gray are noticed, in which it was sought to determine, by a series of artificial earthquakes (dropping heavy weights in a foundery, and exploding buried cartridges of dynamite) in connection with time-recording seismometers, the velocity of transmission through the ground. These gave 438 feet per second for normal, and 357 feet per second for transverse, waves. This was through hardened mud. Mallet's earlier experiments gave for sand 825 feet, for jointed granite 1,306 feet, and for solid granite 1,665 feet, per second. The last, Professor Ewing remarks, is probably very much too low.

This element of earthquake motion, the velocity of transmission through the earth's crust, is very inexactly known; and the author notes the desirability of extending the observation of earthquakes over a considerable region of such a country as Japan by means of many stations connected by telegraph, to which simultaneous time-signals can be sent, and at which the same earthquake may be recorded on rotating plates, together with a record of the absolute time. These, if sufficiently widely distributed and numerous enough, would give us valuable data regarding the latitude, longitude, depth, and time of the origin of the disturbance, and the velocity of its transmission to the surface in all directions, supposing it rectilinear and uniform. Regarding the possibility of this, Professor Ewing, in the article referred to above (*Nature*, June 19, 1884), speaks as follows: "But all this depends upon our being able to recognize at the various stations, some one wave out of the complex records deposited at each; and, especially in view of the curvilinear nature of the motion, it would be hazardous to say, without trial, whether this can be done."

In conclusion it may be said, that the whole work is exceedingly interesting and valuable; and Professor Ewing is to be highly commended for thus bringing together the best results of modern methods in exact seismometry, and for showing the sources of error and the fallacies in older methods and theories. The work should receive as wide a distribution as possible by the University of Tokio.

H. M. PAUL.

EXCURSION MAP OF THE VICINITY OF BALTIMORE.

THE need has long been felt, among those students of the Johns Hopkins university who are especially interested in the study of natural history, of a reliable map of the adjoining country, on a suitable scale, and so mounted as to be adapted for convenient pocket use. It is believed that a few words regarding the method by which the want of it has been recently