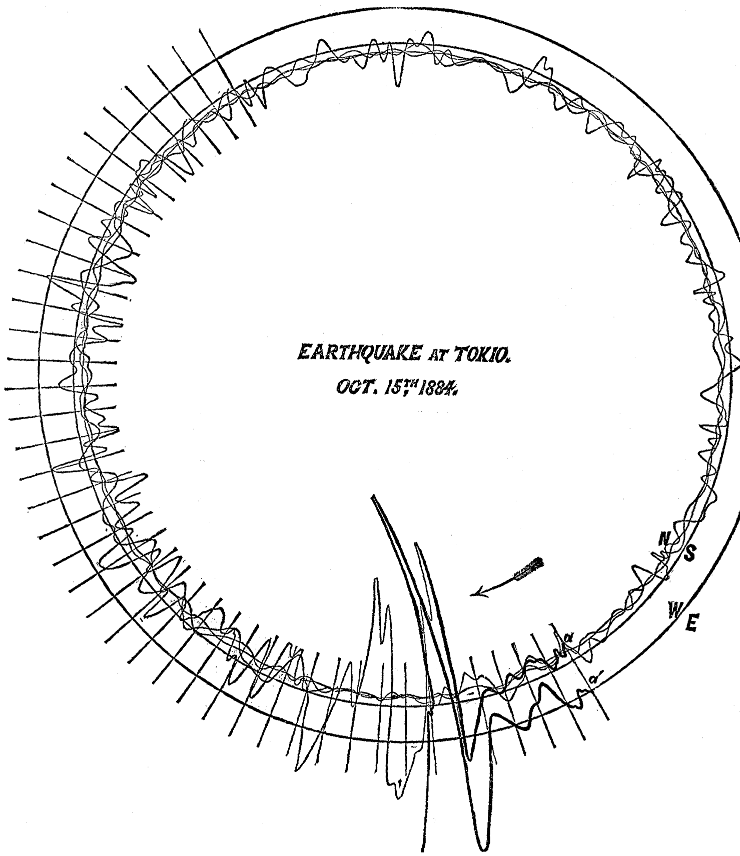
A RECENT JAPANESE EARTHQUAKE.[1]

AN unusually great earthquake was felt in and about Tokio on Oct. 15, 1884. The annexed autographic record of it comes, with the following particulars, from my former assistant, Mr. K. Sekiya, who is now in charge of the seismological observatory of the University of Tokio. It was given by a horizontal pendulum seismograph of the kind recently described in *Science* (iv. 516), and it has many features in common with the examples of records shown on p. 517 of the same volume. But in the present case the amplitude of the earth's horizontal movement far exceeds any thing that has been recorded since observations of this kind were instituted, in 1880.



The figure shows the record reduced to about one-third its actual size. The undulations on the inner circle have been traced by a pointer which registered the north to south component of motion, and those on the other circle by another pointer, which registered east to west motion. The pointers are prolongations of horizontal pendulums, and trace their records on a revolving sheet of smoked glass, which in this example was started into motion by the earthquake itself, through the agency of a delicate electric contact-maker. The plate is driven by a clock-work train, which, after starting, quickly reaches a steady rate under the control of a fluid friction governor. The speed of rotation was one revolution in eighty-two seconds. The short radial lines mark seconds during the first part of the disturbance. The record on the outer, or east to west, circle, has been turned round so as to bring it into synchronism with the inner, or north to south, record; and the earliest motions are distinguished in the cut by the use of a somewhat heavy line. The records begin at *a* and *a'*, and are traced in the direction of the arrow, which is opposite to the direction of motion of the glass plate. At *b* the east to west record comes to an abrupt stop, owing to the displacement there having been so great as to carry that pointer off the plate altogether. The inner record extends over nearly four complete revolutions, showing that visible motions of the ground lasted for about five minutes. During the first half-dozen seconds, while both components were being registered, there is a tolerably close agreement of phase between the two, showing that the displacements were then not very far from rectilinear. The greatest motion in this part of the disturbance took place five seconds from the start. At that point the actual motion of the ground was 3.7 centimetres from east to west, and 2.2 centimetres from south to north. The displacement of the ground is multiplied four times in the original record, or about one and a third times in the reduced copy given here. The two components taken together represent a movement of the ground, from one side to the other, of no less than 4.3 *centimetres*, — a quantity which is in striking contrast to the '5 or even 7 *millimetres*' which, after three years' experience, I named as the amplitude to which in a Yedo earthquake the displacement from the mean position 'occasionally rises.'

So far as can be judged from the north to south component alone, the most violent motions were over in about ten seconds; but for some minutes afterwards, the oscillations, though very much re-

[1] From *Nature*, April 23.

duced, continued to exceed in amplitude almost any that I have recorded.

Fortunately, however, this earthquake was prevented from being excessively destructive by the unusual slowness of the oscillations. The period of the principal movements appears to have been not far short of two seconds. For a rough estimate of the greatest velocity and acceleration, we may treat the 4.3 centimetres movement as simply harmonic; and we find for the greatest velocity 6.8 centimetres per second, and, for the greatest acceleration, 21 centimetres per second, or $\frac{1}{47}$ of g. If the amplitude of motion which was recorded here had occurred in conjunction with the more usual period of three-quarters of a second or so, the destruction would have been immense. The earthquake appears to have been felt over an area of about twenty thousand square miles.

Mr. Sekiya writes, "We are going to exhibit your seismograph in the exhibition in London, to be held next May. I am sure we will get a first-prize medal."

Whether Mr. Sekiya and the Tokio university authorities get their medal or not, they should at least excite admiration for the zeal and success with which they are pursuing the study of seismology.

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ELECTRIC LIGHTING ON SHIPBOARD.

A PAPER recently presented to the British institution of civil engineers by Mr. Andrew Jamieson gave rise to an exceedingly interesting and instructive discussion. The author of the paper considered the advantages of the electric light on board ship to be summed up in the following points: its healthfulness; freedom from heat, odor, or gaseous products; its general agreeableness; its freedom from danger of setting fire to combustible material; removal of the danger of storage of inflammable illuminants; avoidance of the nuisance of cleaning and refilling lamps; reduction of space occupied by total plant; and a fair competition in cost of illumination.

The dynamo should be placed with its axis in the fore and aft line, in order to reduce the gyrostatic effect caused by rolling, and thus to lessen the heating of its bearings. It should be capable of developing the required electromotive force at its regular speed; should be self-regulating; should not 'spark;' should not heat the conductors when running light; should contain, either in its own coils or in the conducting system, not less than ninety-six per cent pure copper; and the system should have an insulation resistance of not less than ten thousand ohms per volt, generated at the regular speed of working. The speed is generally preferred to be under six hundred or six hundred and fifty revolutions per minute. Higher speeds demand more careful supervision, give rise to danger of heated bearings and sometimes of bursting the armature, cause objectionable gyrostatic action in uneasy ships, and make it difficult to drive by direct connection.

The engine should be capable of driving continuously and indefinitely as to time, without danger of heating or break-down. Its governor should control the speed within five per cent,[1] with variation of steam-pressure of ten pounds or more per square inch, and a variation of load of ninety per cent, i.e., with full load, or with nothing on but the dynamo. A tachometer, or continuous speed-indicator, is a valuable adjunct to the engine as exhibiting all variations of speed. An electrical governor acting upon the throttle-valve is thought to be a desirable instrument.

When not driven directly, the dynamo is, as a rule, connected to its engine by cotton rope, the steel-wire coiled belting coming into use in the United States not apparently having been introduced into Great Britain. The Westinghouse engine is reported to be doing excellent work. Brotherhood's 'three-cylinder engines,' and the Tower 'spherical engine,' are also working satisfactorily. Friction pulleys have been used, in some cases, instead of belting, for indirect connection.

The system of distribution is usually one of two principal kinds: in the one method, a set of return wires is used; in the other, the hull of the ship takes the return currents. The latter system is the less costly and more easily fitted, and gives rise to less resistance: but it has the disadvantages that a fault in the leading wire has more effect than in the other, a contact with the hull short-circuiting the current; it is more likely to be injured by leakage of salt water upon the conductor, in which event corrosion goes on with serious rapidity; but care in protecting the wires, and in placing them, reduces the danger from these causes to a very small quantity.

It is of great importance that the junctions of wires should be very carefully and thoroughly soldered; and the size of wire should be such that it should give at least a square centimetre area per fifty ampères, according to the rule of Sir William Thomson. But the author of the paper would adopt the rule: Make the conductivity of the wire not less than ninety-five per cent that of pure copper, and give it a cross-section of a square millimetre for an ampère and a half of current, or about a square inch to a thousand ampères; the insulation resistance of the whole circuit, including switches, etc., to be not less than a thousand ohms per volt of electromotive force of the dynamo. Failures are usually due to neglect of the precaution of testing the insulation when the plant is put in place. Safety-wires, to prevent the overheating of any part in case of wires crossing, should always be introduced.

The size of lamp should be ten-candle power for staterooms or 'cabins,' twenty-candle power for the saloons and larger rooms, and fifty to a hundred candle power for above-deck illumination. Arc-lamps of ten thousand to twenty thousand candle power are used on men-of-war for illuminating the surroundings of the ship, and for protection against the unobserved approach of torpedoes.

[1] In the United States, a variation of two per cent is considered too great.