VELOCITIES OF THE EARTH WAVES.

A Letter by the Right Honourable Lord Kelvin, President of the Royal Society, &c., &c.

The University, Glasgow.

December 13th, 1893.

Dear Professor Milne,—

I have to-day received your letter of the 7th November, and I am much interested in what you tell me of "earth waves which apparently go round the world." I am surprised to learn that you have found such small velocities as 2·2 or 2·3 kilometres per second, but the results if thoroughly confirmed are of great importance, and I earnestly hope that the Japanese Authorities will do all that can be done to promote your work and to allow you all possible opportunities for carrying it on. It is very important to have trustworthy results as to velocities of propagation of disturbances within such an area as Japan affords, besides the apparent velocities of propagation of disturbances to great distances such as those to Potsdam and Wilhelmshaven of which you tell me. The velocities of distortional waves and condensational waves in glass are respectively 2·8 and 2·9 kils. per sec. From the experiments by yourself and Thomas Gray on granite, giving Young's modulus about 425×10^3 dynes* per. sq. cm., the velocity of a pulse in a free rod of granite is 3·95 kils. per sec. From

* I regret to say that certain errors crept into the calculations made by Mr. Gray and myself, and as our original notes were lost these have not been corrected. Prof. Yamagawa, of the Imperial University, has made preparations for the redetermination of these constants.—J.M.

this it is probable that a condensational rarefactional wave in continuous rock may be about 4·5, and that of a distortional wave not very different from 2·2 or 2·3 kils. per sec. But I should have expected that the influence of gravity would have caused the velocity of propagation to be very much greater than this.

Yours very truly, KELVIN.

Since receiving the above letter from Lord Kelvin, I have received a paper from Dr. Adolfo Cancani, "Sulle ondulazeoni Provenienti da Centri Sismici Lontani" (*Annali dele' Ufficio centrale di Meteorologia e Geodianamica*, Vol. XV. Part I. 1893). From a translation kindly made by my friend M. Nembrini Gonzaga, I made the following abstract:—

TABLE OF VELOCITIES OF PROPAGATION OF EARTH WAVES OVER GREAT DISTANCES.

		Distance in Kilometers.	Velocity in Kilos. per sec.
1	From Kumamoto (Japan) to Potsdam...	31140	2.3
2	From Iquique to Pulkova	12257	2.8
3	From Tokio to Potsdam.....	9000	2.3
4	From Kumamoto to Potsdam	8860	2.2
5	From Wjernoje to Berlin	4800	3.0
6	From Malta to Pulkova.....	2945	3.7
7	From Andalusia to Wilhelmshaven.....	2000	2.8
8	From Andalusia to Greenwich	1620	3.6
9	From Andalusia to Parc de S. Maur ...	1350	3.2
10	From Andalusia to Lisbon	530	4.2

From the first 5 of these cases it is assumed that only the transversal waves were recorded, while the second five cases when the distances are shorter it is supposed that the velocities represent a mean value for transversal and longitudinal waves.

In the apparatus put up by the author and D. Agamemone at Rocca di Papa and at Rome, we are told that the arrival of the longitudinal waves can sometimes be distinguished from the arrival of the transversal waves which come later, and as a result of these observations it is seen that the velocity of one is about double that of the other.

The high velocity of 5 kiloms. per sec. determined over long distances for the Charleston shock of 1886 is explained on the assumption that persons only observed the longitudinal waves.

Experiment has shown us that the velocity increases with the intensity of the initial disturbance, and that it decreases as a disturbance radiates. Velocities of 5 kilometers per second are equal to that at which a sound wave could be transmitted through pianoforte steel wire (Tomlinson). The earthquakes of 1891 reached Tokyo from Gifu (150 miles) at rates of 6,000 to 8,000 feet per second; the main disturbance reached Shanghai, 1,000 miles, at 5,104 feet per second, and Berlin at 9,841 feet per second. In this instance, which is exceptional, velocity has increased with radiation.

High rates of propagation evidently mean that elastic waves are being transmitted, and these are announced to us as short sharp shocks which do not disturb exceedingly delicate horizontal pendulums. These instruments which have recorded motion transmitted round the world are only disturbed by actual tilting, and this occurs with surface undulations the maximum slopes of which have been measured.

I therefore imagine that the velocities of 2 or 3 kiloms. per second refer to the propagation of a motion not unlike the swell upon an ocean.

JOHN MILNE.