# NOTE ON THE EARTHQUAKE OF MARCH 11TH, 1882.

By Prof. J. A. EWING.

[*Read March 23rd, 1882.*]

The "Astatic Horizontal Lever Seismograph" which I had the honour to exhibit to the Society more than a year ago has now been in continuous use in the University of Tokio since October 1880, and has given records of a large number of earthquakes. In previous communications to this Society and to the Asiatic Society of Japan I have described the general features which some of the earliest of these records presented. The conclusions as to the character of earthquake motion which were then, for the first time, enunciated, have received ample confirmation in my more recent observations. A shock which occurred a few minutes before 8 p.m. on March 11th, 1882, was, however, so remarkable for the extent of its motion compared with the earthquakes usually experienced here, that a brief notice of it may perhaps be interesting.

The record was in this instance obtained by means of a newly constructed instrument which has been made at the desire of the Government of Manila for use there, and

which, while it is in all essential respects the same as my earliest form of horizontal lever, embodies several improvements which the experience of more than a year's use has shown to be desirable. It differs too from the one hitherto used here, in multiplying the actual motion of the earth only three times instead of six—a change which seemed proper in view of the more violent shocks to which the Philippine Islands are liable. As far as the earthquake of March 11th is concerned, this change was a fortunate one, for the motion was then so large that a ratio of six to one would have been excessive. As usual, the two marking pointers were placed so that one showed N.S. motion and the other E.W. motion.

The earthquake began with a series of very slight oscillations, not exceeding one millimeter in amplitude This lasted for eight seconds. Then came a sudden lurch in a direction nearly S.E., the actual amplitude of which was no less than 6 mm. [The record shows a movement E. of 12 mm., and a simultaneous movement S. of 14 mm.: the resultant of these divided by three, gives the motion just mentioned.] This was followed by two or three vigorous back and forth displacements in the same plane S.E. nearly; the greatest amplitude of actual movement of the ground from one side to the other being 8 millimeters.

During the remainder of the disturbance this motion was not exceeded or even equalled, but there were scores of oscillations whose extent was as much as three or four millimeters.

After the first great displacements it becomes difficult to trace the phase relation of the two components. In the large waves which have been described as coming about 8 seconds after the beginning of visible motion, the displacements toward E. and S. were clearly simultaneous, and also the opposite displacements towards W. and N.

After that, the record shows the same irregularity in direction, as well as in period and amplitude, which I have commented on in describing to the society, a year ago, the earthquake of March 8th, 1881.

The record can be distinctly traced over a little more than three complete revolutions of the plate, which was making one turn in 88 seconds. Its duration was therefore not less than four and a half minutes.

The largest wave had a period of 0.7 seconds. If we take it to have been simple harmonic motion, the greatest velocity of the earth's surface must have been 36 mm. per second and the greatest rate of acceleration 320 mm. per second, or one-thirtieth of the value of gravity.

## Discussion.

At the conclusion of Professor Ewing's Note, Dr. Divers asked whether the author had full confidence in the fixed points of his machine—whether from the length of the earthquake the bobs ought not to have swung?

Mr. Milne remarked that it was his intention at a future period to give some notes on this earthquake to the society himself. Last year at and near his house he had placed a number of similar earthquake machines to determine the effects of differences in topography and geology in altering the character of a shock. In this particular shock the records as obtained by similar machines placed in different positions were very different. Whilst at the University Professor Ewing had recorded a motion lasting over 4½ minutes with a maximum amplitude of 6 mm., Mr. Milne said that with him, as recorded by a machine very similar to that employed by Professor Ewing, the motion had only lasted about 1½ minutes and the maximum amplitude had perhaps been 2 or 3 mm. His house appeared to be in a very safe locality. The unsafe localities in Tokio were on the flat ground, in fact one yashiki

which he mentioned had such a bad reputation for earthquakes that it was difficult to sell. In the great earthquake of 1854 it was also shewn that the flat ground in Tokio was more severely moved than the hills. In Yokohama the rule appeared to be the reverse. Certainly in this shock, and in the severe shock of February 22nd, 1880, the houses on the hills suffered more than those in the plains. Whether these rules apply to *all* earthquakes Mr. Milne was not prepared to say. The earthquake originated to the S. E. of Tokio but at no great distance. It reached to about Sendai in the North, and to Shidzuoka and Iida in the South. It formed one member of a very large series of earthquakes all probably coming up from the sea, which had taken place since the 1st of March. From that date up to the present time Mr. Milne had collected records of probably over 50 earthquakes. This particular earthquake was, in fact, only one gust in a seismic storm about which it would be possible to write an interesting volume. In concluding, Mr. Milne asked Prof. Ewing whether his instrument was carried on two posts or on one; because from experiments which he had been making he could not be altogether sure that the heads of two posts, even if they were only situated 2 feet from each other, synchronized in their motion—and if they did not sychronize, the records obtained from an instrument like that employed by Prof. Ewing would be of but little value.

Mr. Mayet enquired whether it was possible to make comparisons of relative intensity, and whether the ratio of the intensities of a shock as recorded at two localities remained constant?

Mr. Milne remarked that the greatest movement during the last earthquake was about equal to that produced by 2 lbs. of dynamite fired in a ten foot bore hole at the distance of 100 feet. About relative intensity at

different localities we know a little, but whether the *ratio* of these intensities was constant had yet to be investigated.

In reply to Dr. Divers, Mr. Ewing explained that it was not possible for his horizontal lever seismograph to acquire any motion of its own which would give an effect of the kind observed. Unlike an ordinary pendulum seismometer, it had no power of being set into a state of oscillation by a prolonged disturbance. It was certain that the actual motion of the ground continued as long as any record was given. With reference to a remark by Mr. Milne, he added that the instrumental error, which, so far as it existed at all, was due to friction, would tend to make the record too small rather than too large. In a badly made or badly adjusted instrument this error might be very considerable, but he believed it to have been insignificantly small in the observations now described to the Society.