ON THE FIVE MILE WATER LEVEL.

BY DR. PAUL MAYET.

The reviewer of the *Seismological Journal of Japan* (*Japan Mail*, April 10th, 1893) seems to think that special mechanical skill would be needed to construct a five mile level, that mechanical science would not be able to devise an instrument of such a kind worthy of complete confidence. He pronounces on Professor Milne's scheme, the judgment that the latter proposes to measure a supposititious cause by a contrivance subject to mechanical inaccuracies incomparably greater than the probable changes it is intended to record. But such an instrument is of the very simplest kind imaginable, because it is not the intention to measure the variation of the ground at every point of the five mile level, but only at the end stations, or at intermediary points.

If there are only stations for observation at the two ends of the five mile tube, very little is needed. Science teaches that freely rising water in a tube with vertically bending ends, will at both ends always be on the same level, *the shape of the tube being whatever it may be*. There is not at all needed a rigidly straight line tube, its direction may deviate to the left or right; it may dive under ground; it may pass streams crossing its path under the river bed; always the water at the two ends will and must be at the same level. The only two conditions are that the tube be *full* of water and that no point of the five mile tube be placed higher than the water level mark at the end.

If, for instance, iron were used and at one intermediate point of the length of the tube a constant water supply pouring into the iron tube were provided, the water at the two ends of the five mile tube would be exactly at the same level with the source of the water supply, a tank into which water from a constant source of supply flows and whose edges allow the water to overflow freely.

But what is it that would be measured by such a level?—*Nothing concerning the circumstances of the ground between the end stations.* Nevertheless, it would measure something worthy of knowing. The two connected vertical glass standards at the ends, are each supported by a column of concrete such as is used to bear astronomical instruments. These vertical glass standards show a scale with exactly equal divisions. They are observed *at the same time* by the observers at the two end stations. Now, if to-day at noon the water-mark is standard glass A is at division 15 and in B at 20, we have for to-day at noon a difference of 5. The next day the water-mark in A may be at 12 and in B at 21, the difference being 9, and the difference between the differences will be 4. Then there are only three explanations possible; either the column A remained immovable and the column B moved in comparison to it, or the column B remained steady and the column of station A was moved by 4 degrees, or both columns moved—how much is unascertainable—but the diffence of their variation must certainly be 4 degrees.

If the zero of the scale is at the surface of the supporting column, the end that shows on the second day the lower reading must have risen more, comparatively to the other.

Nothing will be changed by the circumstance that the water supply is inserted at a certain point between the two stations. If the column supporting the water tank is raised by the action of the ground, say 10 divisions of the scale, the water in both standard glasses will each equally be raised 10 divisions and the *difference* between readings uninfluenced. If the column bearing the tank is lowered by the action of the ground, say 11 divisions, the water will be lowered exactly for the same amount in both ends of the tube. If the proposed leveling instrument would require a rigidly straight and unbending pipe of 5 miles in length, mechanical science and skill might indeed be insufficient to provide such a thing. But just the contrary is required. The tube, be it of iron or lead, must not be allowed to bend, or *push* by its expansion during bad weather, or by mechanical displacement during an earthquake, the instruments at its ends. The water pipe in order to be allowed to move freely will therefore be connected with the vertical glass standard at each end *by means of a flexible tube.*

I thing nothing can be simpler, and hope that Prof. Milne's ingenious suggestion will be executed. Such an instrument would at least show if there exists a difference in motion *of the two columns* carrying the measuring instruments and the amount of that difference. Both instruments might be continually observed by photographic arrangements. It would show if there exists any periodicity or regularity in movements, if, for instance, the one column be raised continually in comparison to the other. In case an alternate raising and lowering of the two points be shown by the reading of the scales, it would be of great moment for science to learn if such motion is a periodical one, and, if so, whether the periodicity of such movements of the earth is connected with other known phenomenon (barometrical changes, tides, earthquakes, warming and cooling of the surface of the earth by the sun, variations in magnetic force, &c.).

In the interest of science, I hope to see Professor Milne's suggestion acted upon, be it in Japan or any other country.

[NOTE.—With a five mile water level and assuming that we could read differences in the water columns of $\frac{1}{16}$ inch we might measure changes in level of about 0.06 seconds of arc. Such changes may, however, be easily recorded by horizontal pendulums which are much quicker in action thán water in a long tubes. Two stations provided with such pendulums would therefore be equivalent to the long level with two standards.—ED.]