ON THE MOVEMENTS OF HORIZONTAL PENDULUMS.

AN ABSTRACT WITH NOTES ON OBSERVATIONS MADE BY DR. E. VON REBEUR-PASCHWITZ.

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The following notes are abstracted from three papers, by Dr. E. von Rebeur-Paschwitz (see Astronomische Nachrichten Nos. 2809, 3001—02, and No. 3109—10. These papers summarize a series of observations made by Dr. Rebeur-Paschwitz in Potsdam, Wilhelmshaven, and in Teneriffe, on the movements of particularly sensitive and well constructed horizontal pendulums.

Any one of these instruments is practically identical with apparatus used in Japan to record earth pulsations, which in turn are modifications of a bracket or conical pendulum seismograph. The first instrument of this class was Zöllner's pendulum (see Kgl. Sächs. Ges. d. Wiss, 1869 and 1871). In Dr. Paschwitz's arrangement the distance between the pivots was about 74 mm. whilst the length of the frame, at the end of which there was a small weight, was about 188 mm. The frame which is made of light brass tubing, carried a mirror which reflected a beam of light from a slit to a receiving drum carrying a sheet of sensitised paper. The distance between the mirror and the drum was 4½ metres. The pendulums were installed in the plane of the meridian, and therefore movements in a N. and S. direction were not recorded, the only movements fully recorded being those exactly at right angles to the plane of the instrument. In Japan the writer has usually employed two such pieces of apparatus swinging in planes at right angles to each other. Every precaution was taken to isolate the apparatus from artificial disturbances, as for example change of temperature, air currents, artificially produced vibrations, &c. As in Japan, it was found that the latter disturbances only cause a slight tremor in the instrument and do not alter the position of the pendulum.

The following are a few of the results obtained in 1889 :—

1.—At Wilhelmshaven the movement of the mean position of the pendulum seemed to follow barometrical changes. With a rise of the barometer the zero point moves eastward. A change of 1/4″ in the vertical corresponded to a change of 1 mm. in pressure. In fact, the pendulum, with but occasional exceptions, worked with the barometer. This, however, which may be due to the soft or marshy ground near Wilhelmshaven, was not so marked at Potsdam.

2.—A second class of movements are periodical, and apparently depend upon the position of the sun.—For example, the pendulum usually goes farthest E. about 2 p.m. and farthest W. about 4 a.m. closely following the curve for declination—the pendulum going E. when the magnet goes west. More accurately the Easterly movement is completed at Wilhelmshaven at 2 p.m. whilst at Potsdam it is at 3½ p.m. The most Westerly excursion is reached at Wilhelmshaven at 4 a.m. and at Potsdam at 8 a.m.

The Amplitude of motion at the two places is

Wilhelmshaven	from 1.″44 to 4.″32
Potsdam	from 0.″14 to 1.″13

It would be interesting to know if the Wilhelmshaven and Potsdam instruments were installed side by side, whether they could be calibrated with sufficient accuracy to yield indications of practically equal amounts of deflection.

In Japan the author has often had similar instruments on the same columns in parallel positions, but although the distance of the mirror from the scale was only 3 feet, owing to the coarseness of the levelling screws and other causes he has always had difficulty with accurate calibration.

The movements in Tokio, however, appear to be as follows:—The westerly excursion of the pendulum commences about 7 or 8 p.m. and reaches a limit of as much as 5″ at about 7 a.m. At 11 a.m. it is back in its normal position and remains fairly steady until 7 p.m. Now and then there may be an easterly excursion during the day. These have been the movements recorded in January and December. On some days movements are hardly perceptible.

3.—Irregular movements are of three kinds.

a. In Wilhelmshaven especially, movements take place which remind one of magnetic storms—they are very irregular in period and in amplitude.

b. Microseismic motions which may continue for more than one day.

c. Disturbances due to earthquakes, of which 30 have been noted; some of them lasting several hours.

When considering the influence of the moon on the horizontal pendulum the most certain results that have been reached are:—

1.—At Wilhelmshaven there is a change in the vertical of 0.″28, which must be taken into account when making astronomical observations.

2.—This change cannot be entirely due to tidal load, although the observatory is near high water mark. The easterly motion of the pendulum is completed one hour before high water.

The movements may be due either to a change in level or to a deflection in the vertical, but the results are too great for the latter, therefore in Wilhelmshaven the movements are most likely due to a change in the level of the ground. At Potsdam the movements are smaller, but may be put down at 0.″01.

In his third paper Dr. Rebeur-Paschwitz adds an account of his observations in Teneriffe extending from December 26th, 1890, to April 27th, 1891. Here the instrument was not in a cellar.

The reduction constants were.

Wilhelmshaven	0.″2904
Potsdam	0.″2000
Puerto Orotava	0.″1465

These numbers represent, in seconds, the change in the vertical for a displacement of the spot of light through 5 mm.

The movements of the instruments are equivalent to the movement of the style of a pendulum 1m. long multipled :—

3,552	times
5,156	times
7,040	times

The first discussion refers to the possible influence of the moon in producing elastic tides, which, if they have been detected, are extremely small and different at Potsdam and Teneriffe.

The daily changes observed at these places agree very closely with each other and also with the declination curve. About 9 a.m. they are farthest West and from 3 to 4 p.m. they are farthest East.

In his first paper, Dr. Rebeur-Paschwitz describes daily movements, when at 6 hours the movements are farthest S. and at 18 hours farthest North, the amplitude being 0.″5.

In relation to meteorological changes Dr. Rebeur-Paschwitz observes :—1. That at all these stations a temperature effect is observable which agree with each other. 2. Atmospheric pressure acts sometimes in one direction sometimes in another, and sometimes appears to be without effect. Local conditions no doubt play an important rôle. 3. Geological conditions are connected with irregularities of movements.

In many cases the effect of strong winds confirm the observations in Tokio. The present writer, however, finds that there is a closer correspondence with steepness of barometric gradients which are not always proportional to winds.

Eight earthquake shocks have been observed near Wilhelmshaven and Potsdam, six of which were common to both places. Six were observed in Teneriffe. In eleven months 14 shocks were recorded. In Tokio sometimes six or seven disturbances not recorded by seismographs at Observatories are noted. The second class of movements may be the so-called miscroseismic motions which the present writer regarded as surface waves produced by fluctuations in barometric pressure. Three of these disturbances, however, might be the result of distant earthquakes. One of these, which is of interest to residents in Japan, is as follows:—

On April 17th, 1889, the curves at Wilhelmshaven and Potsdam were greatly disturbed (but without a sharp beginning), at 17h. 51m. and 17h. 54m. M.G.T. At 16h. 48.4m. there was an earthquake in Tokio. The distance is 9,000 km. and the difference in time 64m.3. The resultant velocity is 2.33 km. per sec.

A third class of disturbances have only been observed in Teneriffe where sometimes there are repeated movements of the pendulum without swinging. On the assumption of a velocity of 2km. then the lengths of these waves varied between 180 and 1080 km., whilst the heights from crest to sinus were between 20.5 and 83.4 mm.

As the velocity of surface waves is so variable, at times not being more than from 50 to a few hundred feet per second, although the writer has often endeavoured to give dimensions to earth waves, (see paper in this volume on Earth Pulsations in relation to various Phenomena), for the present he regards his own results as tentative. In all probability their length is nearer Dr. Rebeur-Paschwitz's minima rather than to his maxima. No doubt they vary with the soil and the intensity of the producing cause, while they flatten, become longer, and increase in period as they radiate.

In conclusion, the writer wishes it to be understood that these notes have no pretension to be a translation of Dr. Paschwitz's work, and therefore may here and there possibly fail in accurately expressing his meaning. It is, however, hoped that they give at least an outline of what is an exceedingly valuable contribution to a certain branch of Earth Physics.

In Japan, the writer's work has been chiefly to define the nature and to study the laws governing earth pulsations (earth tremors or microseismic disturbances). Dr. Rebeur-Paschwitz has chiefly devoted his attention to changes in the vertical.