Letters to the Editor.

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Dutch Pendulum Observations in Submarines.

DR. F. A. VENING MEINESZ, commissioned by the Dutch Geodetic Committee to make pendulum observations on board the Submarine K II of the Royal Dutch Navy during the voyage from Holland to Java (see NATURE of September 15, p. 393), has sent particulars of his observations from Gibraltar, Tunis, and Alexandria.

The beginning of the voyage was extremely disappointing because of the bad weather. For the first five days the sea was continually very rough. The rolling of the ship amounted to 30° to each side, and the pitching to 8 metres; the nights had to be spent strapped to the berths. It was a very rough experience for the first stay on board a seagoing vessel.

After passing Portland Bill in the English Channel, an attempt was made to take observations. Submerged to a depth of 20 metres, the rolling still amounted to $\frac{3}{4}$° to each side, which made observations impracticable. At length, off the Portuguese coast, the weather cleared and it became calmer, but the long swell continued. On September 24 an inquiry was made again into the movements of the submerged ship. The greatest angle of inclination caused by the pitching amounted at the sea-surface to 1°, the rolling to 6° to each side. At a depth of 30 metres, and while the vessel was going in the direction of the swell, the inclination caused by the pitching was at most $\frac{3}{4}$°, which by the use of the horizontal rudder could be reduced to less than $\frac{1}{4}$°; but as the rolling was still $1\frac{1}{4}$° to each side, observations were practically impossible.

Notwithstanding the considerable rolling of the ship, the amplitudes of the pendulums appeared to vary fairly regularly. The principal impediment was the circumstance that the rays from the electric lamp, reflected by the mirrors of the pendulums, went beyond the edge of the film. The actual trouble was therefore of an incidental nature. This induced Dr. Vening Meinesz to devise an arrangement for suspending the whole apparatus from a horizontal axis to be placed lengthwise in the ship in order to neutralise the rolling. He supposed that it would be possible to get this constructed at the workshops of the Royal Navy at Gibraltar.

On September 26, between Cape St. Vincent and Cadiz, the sea was very smooth, and for the first time observations were crowned with success, as at a depth of 25 metres the movements were very small. The first observation was made in a place where the sea was 110 metres deep, the second where it was 480 metres deep. During the second observation the direction of the course was taken successively W.E. and E.W., to test the effect of the speed of the ship on the intensity of gravity, first mentioned by Eötvös.

On the afternoon of September 28, Gibraltar was reached, and immediately Dr. Vening Meinesz took steps for the construction of the suspension apparatus. All the assistance desired was kindly given by the British authorities. The time being very limited, it was necessary to carry on the work day and night without intermission.

During the stay at Gibraltar the observations were worked out, and they proved to be very successful. The discrepancies of the observations showed the accuracy to be greater than was expected from the preliminary observations at the Helder. The effect of the speed of the ship was clearly indicated by the diagrams; the speed could even be derived from these with a difference of but $\frac{1}{2}$ mile from the true value.

On October 3, a few hours before leaving Gibraltar, the suspension apparatus was fitted up on board the submarine. I am glad to express thanks to the British authorities at Gibraltar, who so readily contributed to the realisation of Dr. Vening Meinesz's project.

During the passage between Gibraltar and Tunis, the arrangement proved to be satisfactory in every respect. Although the rolling amounted to 2° to each side, observations were easily practicable. A stay at Tunis, where the submarine arrived on October 7, was again used by Dr. Vening Meinesz for the preliminary computation of his observations. One of these gave the value of g for a sea-depth of 2500 metres with a difference of only 0·003 cm. sec.$^{-2}$ from the theoretical value, which indicates complete isostasy.

Tunis was left on October 13, and Alexandria was reached on October 18; the sea being generally very smooth, observations were made without any difficulty. The Eötvös effect was tested again; the deduced speed of the ship differed only 0·3 mile from the true value.

It appears from the diagrams that the accuracy of the deduced period of oscillation in favourable circumstances may be about 1/1,000,000, and that in a rough sea there is little fear of the divergences exceeding 1/100,000. We must wait, however, for the complete computations before a positive statement will be possible.

It should also be mentioned that the rate of the chronometer was controlled by using the rhythmic time-signals of the Eiffel Tower.

On October 31 the squadron, consisting of the mother ship *Pelikaan* and the three submarines, left Suez; it will touch at the ports of Aden, Colombo, and Sabang, and arrive at Batavia about the middle of December. Dr. Vening Meinesz will carry out observations in the Red Sea and the Indian Ocean, and will ultimately determine, with the invar pendulums, the intensity of gravity at a few stations in Java.

From the results already obtained it may be concluded that, by the method of Dr. Vening Meinesz, investigations of the intensity of gravity by pendulum observations can be realised on the parts of the earth covered by the ocean with almost the same accuracy as on continents and islands. For the study of isostasy, and of Wegener's hypothesis of floating continents, observations in submarines, especially between the coast and the deep sea, will be of the greatest value.

J. J. A. MULLER.
Zeist, November 7.

The True Relation of Einstein's to Newton's Equations of Motion.

THE equations of a space-time geodesic or Einstein's general equations of motion of a free particle are, in usual symbols,

$$\frac{d^2x_\iota}{ds^2} + \left\{ \begin{matrix} \alpha\beta \\ \iota \end{matrix} \right\} \frac{dx^\alpha}{ds}\frac{dx_\beta}{ds} = 0, \quad \iota = 1, 2, 3, 4. \qquad (1)$$

In order to show their relation to Newton's equations of motion, which may be written

$$\frac{d^2\xi_i}{dt^2} = \frac{\partial\Omega}{\partial\xi_i}, \quad i = 1, 2, 3, \qquad (N)$$