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Summary of Recent Pendulum Observations in Russia

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of Settah Mountains, which run nearly north and south, losing their distinct character in the hills surrounding Arba al Ouf, a large village on the Wad Ardat, a tributary of the Wergha. I reached Wazan that day, passing Arba al Ouf and crossing the Wad Ardat, then following the borders of the Beni M'Sara country to Sidi Rahou-Rahou, where I witnessed earlier in the year an attack upon the Arabs by the above-named tribe, which ended in a complete victory for a handful—perhaps three hundred—mountaineers over ten times their number of Arabs, who were, too, better armed and mounted, while the Sari were on foot. A great quantity of spoil—women, jewellery, animals such as horses, mules, donkeys, &c.—was carried away by the successful mountaineers, who left only two dead, while some seventeen of the Arabs were killed.

There is no reason why Europeans should not travel over this road from Wazan to Fez. I found the natives most hospitable, but on account of their, in most cases, never having seen Europeans, great care must be taken not to give offence in any way. The country is pretty and there is plenty of sport, but the road is impracticable in winter, on account of the mud and flooded state of the river. However, in summer it is one of the most enjoyable districts in Morocco.

Summary of Recent Pendulum Observations in Russia.

By E. DELMAR MORGAN.

IN 1884 the Russian Geographical Society decided on taking in hand a series of pendulum observations at a great number of stations, in order to investigate the distribution of gravity in Russia. The necessary pendulums were ordered of Repsold, at Hamburg, and the clock of Messrs. Hohwü, at Amsterdam. With these, preliminary observations were made by M. Lenz, at Berlin and Pulkova, in order to establish a connection with those hitherto made in Europe and Asia, notably by Bessel, Savitch, Lenz, Smyslof, Basevi, Heaviside, Tsinger, Stebnitzky, and Kuhlberg. By the end of 1886 matters were so far advanced as to allow of the projected scheme being begun, and Lieut. Wilkitzky, of the Imperial Navy, undertook the difficult task of making the necessary observations in Nova Zembla, the most advanced station towards the north, and at Archangel. Having familiarised himself with the use of the instruments at Pulkova, under the direction of M. Lenz, M. Wilkitzky started on the 18th (30th) June, 1887, for his destination. A schooner was placed at his disposal by the Minister of Marine, to transport him and his instruments from Suma, on the White Sea, to

Nova Zembla. In a fascicule * recently issued by the Society, the first of a new series on the Distribution of Gravity in Russia, the results of his work are published.

The apparatus consists of three pendulums oscillating $\frac{3}{4}$ second, and furnished with agate knife-edges. Two of them, Nos. I. and II., weigh respectively 1958 and 2053 grammes; the third, No. III., only 1055 grammes. Each pendulum consists of a copper cylindrical tube, to both ends of which are attached similar cylinders—one solid, the other hollow—enabling the reduction to a vacuum to be almost entirely eliminated, though the pendulum is swung in the air. A full series of oscillations comprises observations of the pendulums in four positions:—

1. Heavy end below, face in front.
2. „ „ above, „ „
3. „ „ above, „ behind.
4. „ „ below, „ „

In each of these positions eight coincidences with the clock were observed; but since, when the heavy weight is above, the diminution of the amplitudes is twice as rapid as with the heavy weight below, an initial amplitude is again given to the pendulums in the former of these positions after the first four coincidences. Thermometer readings were taken at the beginning, middle, and end, those of the barometer only at the beginning and end, of each series: the amplitudes were noted in the middle between two consecutive coincidences. The length of the pendulum was observed at Nova Zembla and Archangel.

But, although M. Wilkitzky's determinations are absolute in character, they are only relative in reality; before and after his expedition he made two complete determinations at Pulkova of the length of the seconds' pendulum. Here the rate of the clock was deduced by comparison with Kessels' star clock at the observatory, showing an infinitesimally small probable error.

The observing station on Nova Zembla is in lat. $72^{\circ} 22' 33'' \cdot 3$, and long. 3 hrs. 30 m. $50 \cdot 1$ sec. east of Greenwich; that at Archangel is in lat. $64^{\circ} 34' 16'' \cdot 5$, and long. 2 hrs. 42 m. 4 sec. The observatory at Pulkova is in lat. $59^{\circ} 46' 18''$, long. 2 hrs. 1 m. $18 \cdot 8$ secs.

At the first of these stations four complete series of oscillations, at the second three, were observed. The rate of the clock by Hohwü was deduced by comparison with nine chronometers, and these were rated by observations for time with a transit instrument; independent observations to find the time by the sun were also taken by means of Repsold's vertical circle. The height of the observing station at Nova

* "Materialy dlia izuchéniya raspredélénia sily tiajesti v Rossii. Nabliudeniya nad kachaniyami povorotnykh mayatnikov Repsolda proizvedénniya na Novoi Zemlé i ov Arkhangelské," by A. Wilkitzky. Published in the 'Zapiski,' vol. xxiv. No. 1.

Zembla is 7·3 metres (23·95 feet), that of Archangel 5·5 metres (18 feet), and Pulkova 247·6 feet above mean sea-level.

The results are as follows:—

The definite value of a single infinitely small oscillation, T , is for the two pendulums:—

	No. II.	No. III.
At Pulkova (initial)	$0''\cdot7499441 \pm 14\cdot8$	$0''\cdot7499169 \pm 23\cdot4$
„ Nova Zembla	$0''\cdot7496136 \pm 26\cdot1$	$0''\cdot7495878 \pm 33\cdot8$
„ Archangel	$0''\cdot7497935 \pm 11\cdot8$	$0''\cdot7497689 \pm 14\cdot6$
„ Pulkova (terminal)	$0''\cdot7499447 \pm 18\cdot2$	$0''\cdot7499140 \pm 23\cdot4$

Starting with these numbers, Wilkitzky finds the following values of the differences in length of the seconds pendulum:—

	No. II.	No. III.	Mean.
Nova Zembla — Pulkova ..	$+ 0\cdot8632$ mm.	$+ 0\cdot8549$ mm.	$0\cdot8591 \pm 63$
Archangel — Pulkova ..	$+ 0\cdot3856$ „	$+ 0\cdot3739$ „	$0\cdot3797 \pm 36$

And adopting for the length of the seconds pendulum at Pulkova the value determined by Stebnitzky, 994·8384 mm., he obtains the following:—For Nova Zembla, 995·6975 mm.; Archangel, 995·2185 mm.

These results give the following values of the length of the seconds pendulum in English measure:—

Pulkova	(lat. 59° 46')	39·1672 inches.
Archangel	(„ 64° 34')	39·1822 „
Nova Zembla	(„ 72° 23')	39·2010 „

In the preparation of this brief note I have been kindly assisted by General J. T. Walker, late Chief of the Trigonometrical Survey of India, who has given an account of the pendulum observations in India with two differential pendulums, the property of the Royal Society, and also with two Repsold pendulums, obtained on loan from the Russian Imperial Academy of Sciences for the purpose of connecting the Indian with the Russian operations; see vol. v. of the ‘Account of the Operations of the Great Trigonometrical Survey of India.’ He has also given an account of recent pendulum observations to connect the observatories at Kew and Greenwich, which is published in the ‘Transactions of the Royal Society,’ vol. clxxxi. (1890), A., pp. 537–558). I also desire to call attention to an able treatise on the same subject by Commandant Defforges, entitled “Sur l’intensité absolue de la Pesanteur,” published in the ‘Journal de Physique’ (June, August, and October 1888).