the ether in the other. The responsive power is due to structure, which in the one case is on the large, and in the other on the molecular scale. J. D. EVERETT.

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Gravé par F. Borremans, 5, rue Hautefeuille_Paris

FIG. 1.—Triangulation at Spitsbergen, for the measurement of an Arc of Meridian.

MEASUREMENT OF AN ARC OF MERIDIAN IN SPITSBERGEN.

THE *Revue générale des Sciences* for December 15 and 30, 1902, publishes an account of the measurement of a meridian-arc in Spitsbergen from the pen of M. A. Hansky. Other accounts of the same enterprise have appeared in various journals, and some of them are before me.[1] The history of the undertaking is as follows:—In the year 1823 Sir Edward Sabine was sent to Spitsbergen and Greenland to make "experiments to determine the figure of the earth by means of the pen-

[1] Carlheim Gyllensköld in *Ymer*, 1900, h. 2; O. Backlund in *La Géographie*, April 15, 1901, p. 287, and later numbers; Rapport till Kongl. Kommitten för gradmätning på Spetsbergen (Stockholm, 1900, &c.).

dulum vibrating seconds in different latitudes." Sabine's experiences in Spitsbergen led him to conclude that that country, and that alone in the Arctic regions, owing to its exceptionally mild climate for so high a latitude, was suited for the actual measurement of a meridian-arc of any valuable length. Accordingly he wrote a memorandum advocating the undertaking, which will be found in the *Quarterly Journal of Science and the Arts* for 1826 (pp. 101-8). Nothing was done in the matter, but the proposition was not lost sight of. When the Swedes, in and after 1858, made their remarkable series of scientific expeditions to Spitsbergen, they set before themselves as one of their objects a preliminary survey and the choice of stations for an arc-measurement, and as long as Sabine lived they kept him informed of their interest in his proposal.[1] The detailed proposal, with a map of the net, was published by Dunér and Nordenskiöld in a paper presented to the Swedish Academy on September 27, 1866.[2]

It was hoped for a long time that England would join Sweden in carrying out this work, but nothing was ever done, and the years passed. At length, all hope of English cooperation being abandoned, the Swedes turned to Russia, and, in or about 1897, an agreement was come to by the two Governments for a series of joint expeditions to perform the measurement. The work was actually begun in 1898, and concluded in 1902. The observations are now being reduced, and the result will probably be published in 1904.

The southern extremity of the arc is Mount Keilhau, near the South Cape; the northern is Little Table Island (Fig. 1). The difference in latitude between the two is 4° 10′. The Russians undertook the southern and easier part of the arc, from Mount Keilhau to Thumb Point, at the south end of the Hinloopen Strait. The Swedes took the northern part. Both nations established winter stations—the Russians in Horn Sound, on the site of the old whaling station of the London Muscovy Company; the Swedes in Treurenberg Bay, close to the harbour, where Parry's station was established in 1827. Horn Sound is always easily accessible. Treurenberg Bay is not accessible at all in many seasons. The Swedes had bad luck in this respect, and the best part of two seasons had to be wasted in painful efforts to reach their base station.

FIG. 2.—Whales Point, where the Russian base was measured.

The year 1898 was devoted to a preliminary expedition by the Swedes. The Russians began work in 1899, and spent the following winter at Horn Sound. They likewise devoted the summer seasons of 1900 and 1901 to their share of the work. The Swedes were not able to finish in 1901, so they returned for one more long and arduous season in 1902, by which the whole undertaking was finally carried to a successful issue. M. A. Hansky's articles only describe the Russian expeditions. They are admirably illustrated by photographs, but, unfortunately, it is not always stated what is the exact subject of the view. Thus, Fig. 1 is entitled "Montagnes et Glacier au Spitzberg," a ridiculous title for any scientific journal to accept. I believe the view

[1] *Vide* Dr. Otto Torrell's letter to General Sabine, December 12, 1863, in *Proc.* Roy. Soc., xiii pp. 83, 84; and Capt. Skogman's letter to the same, November 21, 1864, announcing the completion of the preliminary survey, in *Proc.* Roy. Soc., xiii. pp. 551-553.

[2] K. S. Vet. Akad. Handl. Bd. 6, No. 8.

was taken in Fair Haven, the great bay at the north-west angle of the main island, but it may be in Magdalena Bay. Incidentally, I may also mention that the geographical nomenclature employed is very inaccurate, thus the name Mount Hedgehog, which belongs to Hornsundstind, is given to a hill on the east coast, and other names are likewise misapplied. Mr. Arnold Pike is called Mr. Pikes.

The Swedes measured their base at Treurenberg Bay, the Russians theirs near Whales Point (Fig. 2). For this purpose they used the Jäderine apparatus, in which a wire consisting of Guillaume metal (a steel and nickel alloy), about 25 metres long and 1.7 mm. thick, is supported at a fixed tension on a series of tripods, used in pairs successively. By this means the base was measured in four days, each measurement being repeated four times with two different wires. The limit of error is stated to be not more than 1 in 400,000.

At the beginning of the season of 1899 the Russians went up to Horn Sound, and began establishing their winter station close to a spot where Garwood and I spent a week in 1897, so that it was not, as they imagined, "a spot where for more than two centuries no human being has lived." Here, in fact, throughout the eighteenth and part of the nineteenth centuries the Russians themselves had a trappers' winter establishment. While the houses were building, the observers went for a trip to the north, but the weather was very bad. Then they went round to Wybe Jans Water (which they call Storfiord) to commence the observation of their ten triangles, one of which had a side 130 kilometres long. They found the sea free of ice—an unusual condition to the eastward—and were able to land anywhere with ease. They were astonished by the relatively rich vegetation on Anderson Island. Not until August 6 could they actually begin observations from the signal point at Cape Lee, where they spent twenty days and could only work on three. They had to abandon the place before their work was done. The wintering party settled in whilst the others returned home. The winterers next spring made overland expeditions to Mount Keilhau, and began work there. In June, 1900, the other observers returned from Europe. It was several weeks later before the Keilhau observations were complete. Meanwhile, others were exploring the interior of the ice-sheet from Klaas Billen Bay, to find a junction signal-point for the Swedes and Russians. They succeeded after forty-five days, and built a pyramid on Mount Tchernycheff, a point first discovered by me in 1897. At Whales Head the observations were very protracted, and ice cut the observers off, so that it was long before they could get away. An expedition went overland to relieve them from Low Sound (wrongly called Van Mijen Bay). This was about all that was accomplished that season.

In 1901 the weather was much more favourable. The Russian base was measured near Whales Point. The remaining stations were occupied as far as Thumb Point, and the work completed. A final visit was paid to the abandoned winter station, and the expedition returned home in safety and content.

MARTIN CONWAY.

SEISMOMETRY AND GĒITE.

OBSERVATIONS on earthquakes which have transmitted vibrations to all points upon the surface of our globe apparently lead to conclusions respecting the physical nature of its interior. The following notes indicate the character of these conclusions, and at the same time suggest directions in which these may be harmonised with astronomical and other requirements.

Within a radius of 10° or 20° of a centrum, the velocity of transmission of the larger earthquake waves varies between 1·8 and a little more than 3 km. per second, such variations being usually attributed to the nature of the medium through which the waves have passed. Beyond these limits, and up to 165°—that is, to near the antipodes of an origin—speeds which are practically constant prevail.

The large waves have a velocity which, if regarded as "arcual," is constant at about 3 km. per second, whilst the preliminary tremors, if it is assumed that they travel along paths approximating to chords, quickly attain a velocity exceeding 9 km. per second.

The constant velocity for the large waves and the high velocity for their precursors preclude the idea that either of them were transmitted through the heterogeneous quasi-elastic crust.

If the large waves are regarded as the outcroppings of mass waves, then as pointed out by Dr. C. G. Knott the law which would govern their transmission so that their apparent arcual velocity should be constant would be "most complicated and improbable." Considering this uniformity of speed in conjunction with observations which indicate that as they pass beneath country after country they give rise to tilting phenomena on the surface, and that the amounts of tilting recorded at different stations in areas like Great Britain are, at least for the smaller disturbances, practically equal, the conclusion arrived at is, that the large waves of earthquakes are transmitted through a comparatively homogeneous medium beneath the crust, which, as they pass, is forced to rise and fall like a raft upon an ocean swell.

If the preliminary tremors followed the same path as the large waves, then their velocity would not be constant, but would vary from 3 km. per second in the vicinity of their origin to 15 km. per second as they approached the antipodes. On the contrary, if it is assumed that the paths approximate to chords, then for chords of 10°, 20°, 30°, 40°, 50°, 60°, 80°, 90° and 150° the corresponding average velocities in kms. per second are from 3 to about 5, 7·3, 8·1, 8·5, 8·5, 8·8, 9·0, 9·3 and 9·3—these being minimum rather than maximum values.

The lower of these velocities, all of which are average values deduced from observations dating back to 1889, may be due to the fact that they refer to the shorter chords, a considerable portion of which lie within and near what is assumed to be the crust of the earth.

But even accepting as appears to be necessary an increase in average velocity along paths as they are taken nearer and nearer to the centre of the earth, the above figures show that this increase is not very great. The inference is that not only has the world a high rigidity, but also that its interior is probably fairly uniform so far as those properties are concerned which determine the rate at which it transmits vibrations. Possibly, therefore, it may have a density throughout its nucleus which is nearly uniform. Unless we assume that as we descend in the earth elasticity and density increase in about the same ratio, to which hypothesis there are objections, it seems likely that the nucleus of the earth has a density that is more nearly uniform than is generally assumed. Prof. Wiechert has shown that such a nucleus made of iron, density 8·2, and four-fifths of the earth's radius, covered by a shell of density 3·2, satisfies the astronomer. Such a world, however, does not comply with what appear to be the requirements of seismology. Iron or steel do not transmit vibrations at the observed rates, whilst chordal velocities within the assumed shell would closely approach those observed along chords which are largely within the core. If a homogeneous nucleus