By Dr. W. H. ECCLES, F.R.S.

Preceding speakers having marshalled the available evidence for the Heaviside layer, it may be most useful for me, while agreeing broadly with the conclusions drawn from that evidence, to refer to some other points of view and other agencies. For example, in connexion with wireless phenomena at short distances from the transmitting station, the diminution of the density of the air with increase of height, which causes the lower atmosphere to act as a prism with its base on the ground, taken together with diffraction, must be remembered. Consider a source from which electric waves of length 20 metres, 600 metres, and 20,000 metres are being simultaneously emitted, and consider especially the rays emitted horizontally. Up to distances of 100 kilometres, all these waves can be detected by an ordinary aerial—beyond that distance the 20-metre waves vanish but the others remain perceptible. This, I suggest, indicates diffraction of the longer waves, as is supported by the fact that an aerial on a high mast or hill can detect short waves passing overhead like the beam of a searchlight. I want to suggest also that variations of signal strength at these short distances may be due to variations in or movements of the lower atmosphere. (The well-known vertical oscillations of pilot balloons at a height of 10 kilometres suggest movements of the air.)

Beyond 100 kilometres, in daylight, the 20-metre signals are completely lost, the others are continuously perceptible. It has been found (*e.g.* by Hollingworth) that after falling off with distance, the long wave signals increase up to a distance of 400 kilometres. Here it seems that the ionised atmosphere is aiding diffraction and the prismatic action. At 700 kilometres the lost 20-metre signals reappear, though the tangent plane through the source passes 100 kilometres above. This suggests that the horizontal rays from the source have followed a trajectory perhaps only 30 kilometres in height at its apex and now graze the ground again. Rays starting with an upward angle from the source would, on this view, descend to earth at greater distances and perhaps at grazing incidence. These possibilities have caused me to remain unconvinced by Prof. Appleton's use of the 'skip' of short waves to deduce the maximum electron density at a sharply defined Heaviside surface nearly 100 kilometres high. This possible explanation by the aid of non-intersecting and gradually bending trajectories of varying height demands considerable thickness in the Heaviside layer. It is perhaps in disaccord with Sir Joseph Larmor's recent review of an old theory; for he appears to deny the possibility of bending in the lower atmosphere and also supports the 'whispering gallery' view, which assumes the formation of a thin caustic layer of radiation in the sky.

The preceding remarks refer to daytime propagation. At night the 20-metre waves make a larger skip, say 4000 miles, and are picked up at all distances beyond; the 600-metre waves are picked up at all distances to 5000 miles, and the 20,000-metre waves go everywhere. Measurements are available on the medium wavelengths and show that in the great fluctuations of strength beyond 2000 miles, the maximum may exceed the strength calculated for a perfectly conducting flat earth with a non-absorbing atmosphere. This seems one of the best proofs of the existence of the Heaviside layer, for otherwise we must believe that the earth is flat.

The Glaciers of Savoy.

AN important and unusually interesting report, of more than two hundred pages, on the glaciers of Savoy, especially those of the Mont Blanc "massif," the Tarantaise Alps, and those of Haut Maurienne, has been recently issued by the Ministère de l'Agriculture, Département (Direction Générale) des Eaux et Forêts. It is entitled "Études glaciologiques," and represents most valuable results, from the beginning of the century down to the year 1920, obtained by a special "Commission glaciaire de Savoie," composed of high officers of the Département des Eaux et Forêts, aided by specially appointed geologists, geodesy experts, M. Tairraz, the well-known Alpine photographer of Chamonix, and the late M. Joseph Vallot of the Mont Blanc observatory. In spite of the unavoidable reduction of the staff during the War, several members indeed being among the fatal casualties, the work was continued throughout the terrible four years 1914–1918.

The results achieved consist in annual, and in some important cases monthly, measurements of the lengths of the glaciers, determinations of their relative movements at the sides, snouts, upper surfaces, beds, and various parts of their width, estimations of their depths, total volumes, amounts of water they discharge at their lower ends, their gain by snowfalls, and their loss by solar fusion. In addition, a careful record has been compiled of all catastrophic occurrences, such as exceptional avalanches, bursts of lakes and water pockets, earth-quakes and -tremors which have resulted in avalanches or alterations of beds and configurations; and to render this portion of the report still more interesting, historical data have been added concerning all known happenings of this character since the year 1800.

During the last ten years (1910–1920) of the period dealt with, the glaciers on the Savoy side of the chain of Mont Blanc have in general been advancing. For example, the Glacier du Tour reached its minimum length and showed a tendency to grow in 1909, and although there was a slight set-back in 1910 due to special solar activity, in 1911 a distinct move forwards was made, and has continued without interruption up to the end of the report period, 1920. The progressive movement was only communicated to the Argentière glacier four years later, in 1913, as regards maximum length, but even from 1911 there was a growth of several metres a year on the right flank of the snout, until the total length became at last affected in 1913, and the elongation became more and more marked until in 1920 the glacier end moved forwards 40 metres.

The Mer de Glace was difficult to investigate, as its end had been hidden, by its retrogression, in an inaccessible ravine. But from such observations as could be got of the snout, and especially from those on the glacier proper above the Montanvert, it is clear

that there has been a forward movement occurring, ever since 1916 with certainty, and probably from 1914. From further observations of the higher portions known as the Glacier du Géant, and of its tributaries, the Glaciers de Leschaux and Talèfre, it is shown that there has been a very considerable increase in the bulk of the glacier, an augmentation of thickness having been observed ever since 1913.

The Glacier des Bossons, the central glacier of Mont Blanc itself, offers the most interesting results, for owing to the snout being so readily accessible by the exceptional advance of the glacier on to the very meadows of the valley of Chamonix, it has been found possible since March 1917 to obtain monthly records of progress. They show that the glacier does not advance *en bloc*, but with a waddling motion, sometimes one side, sometimes the other, and sometimes the middle of the front, moving most during the month, like a heavy man walking in such a manner as to advance each shoulder alternately. Moreover, in summer the left of the front moved, on the whole, the more rapidly, and in spring and winter the right; the former is due to greater melting of the ice on the side showing least motion, and the latter to the form of the glacier bed, the line of maximum movement of a sinuous glacier being, as is well known, on the convex side of the central line of the glacier, that is, nearer to the concave border. Since the year 1910 the annual march of this glacier has varied from 33 metres during the first year (July 1910–July 1911) to 51 metres in 1917, from which it slowed down to 23 metres in 1920. The advance was greatest in spring, then next in summer, then in winter, and slowest in autumn. The mean values for the four years 1917–1920 were 11 metres in spring, 5·2 metres in summer, 5·1 metres in winter, and 1·7 metres in autumn. In spring there is extra pressure from above, owing to accretions from the névé of the higher snowfields, undiminished by melting, as the spring sun has first to melt the fresh winter snow. But in summer the movement is diminished by real fusion and thereby loss of solid ice, combined with reduced pressure from above, the weight of the winter snow having been removed by melting.

The Glacier de Bionnassay has been advancing since the year 1916 with certainty, and probably since 1914. The last measurements had been in 1913, and between then and 1916 the front of the glacier had advanced 30 metres. It continued at this rate more or less steadily down to the report period 1920.

Thus it is clear that the glaciers of the French Savoy side of the chain of Mont Blanc have all advanced, the amount being accentuated in the cases of the steeper glaciers, Le Tour, Argentière, and Les Bossons. In the more slowly moving cases, the Mer de Glace and the Trélatête glacier, the increase has been chiefly one of bulk and of thickness.

The glaciers of the Tarantaise, and other Savoy Alps, which are much influenced by the Lombardian winds of the valley of the Po, have either advanced to a less amount than those of Mont Blanc, or have retrogressed. The latter, for example, has been the case with the Glacier de la Vache (Source de l'Isère).

Special reference should be made to the particularly interesting determinations of the thickness of certain glaciers. The late M. Joseph Vallot obtained results on the Mer de Glace, at widely different positions in its course, which varied from one hundred to two hundred metres of solid ice; and he came to the conclusion that the latter figure represents the maximum depth. This estimate is almost exactly confirmed by these later measurements and estimations by the Department des Eaux et Forêts, the opinion being that, if not quite accurate, it errs on the low side.

The observations conclude with some remarkable estimates of the volume of additional ice represented by the advance of these glaciers. The Glacier du Tour has increased per annum between 1911 and 1920 by the amount of eight and a half million cubic metres. The glacier of Argentière has increased in volume by one to three million cubic metres per annum of solid ice; and the Mer de Glace has shown a similar amount of swelling, until in 1920 the exceptional heat caused a slight net loss. The Bossons glacier has enlarged by amounts varying from one-sixth to one-half million cubic metres a year. The glaciers of Bionnassay and Trélatête have gained in volume of solid ice between 1912 and 1920 more than five million and seventeen million cubic metres, corresponding to an increase of thickness of the glaciers of seventeen and six metres respectively.

The French Department des Eaux et Forêts is to be most sincerely congratulated on this magnificent piece of accurate work. It is to be hoped that the observations have been carried on beyond the year 1920 in an equally satisfactory manner, and that they will be continued. It would appear that this is being done, for the writer has several times come on the officers of the department at work during his recent summer visits to the Savoy mountains, both Mont Blanc and the Tarantaise Alps, including one paid this last summer, and has had personal experience of the admirable way in which the measurements are being carried out.

A. E. H. TUTTON.

Obituary.

SIR PHILIP WATTS, K.C.B., F.R.S.

SIR PHILIP WATTS, who died on March 15, was born in May 1846, being thus nearly eighty years of age when he died. He was educated at the Dockyard School at Portsmouth and the Royal School of Naval Architecture, South Kensington, completing his education in 1870. Until 1885 he spent most of his time at the Admiralty on the Naval Constructor's staff, which afterwards became the Royal Corps of Naval Constructors.

During this time Sir Philip was engaged in the design work of the office which then produced such original designs as the *Inflexible* with 24 in. of armour and four 16-in. 80-ton guns; the *Iris and Mercury*, the first all-steel ship and the fastest then produced; the *Polyphemus*, an armoured ram which was almost submerged; and many other original designs. He assisted Mr. Wm. Froude in the classic observations on the behaviour of the battleship *Devastation*, one of the first of the mastless turret ships in H.M. Navy. He took a leading part in the investigations of the *Inflexible* Committee, which was created as the result of doubts expressed as