also the mean daily curve of temperature in the sun for forty-two days at Midsummer. The latitude at Point Barrow is 71° 21′ North, longitude 156° 17′ West.

On the Grand Currents of Atmospheric Circulation.

By JAMES THOMSON, *C.E., &c.*

In this paper Mr. Thomson brought under the notice of the Section a theory of the grand currents of atmospheric circulation, which had occurred to him. It has been ascertained as a matter of observation, that in latitudes extending from about 30° to the poles, the winds, while prevailing from west to east, prevail also in directions from the equator towards the poles. Now this motion towards the poles appears not to have been hitherto satisfactorily explained. In fact, it is the contrary motion to what is naturally to be expected when the theory of Halley, which was given about the year 1686, and which appears to afford the true key to the explanation of the trade-winds, is followed up with respect to the circulation of the air in other latitudes than those in which the trade-winds occur. According to this theory so applied, it would naturally be expected that the air, having risen to the upper regions of the atmosphere in a hot zone at the equator, should float towards the north and south polar regions in two grand upper currents, retaining, as they pass to higher latitudes, some remains, not abstracted by friction and admixture with the currents below, of the rapid equatorial motion of about 1000 miles per hour from west to east, which they had in moving with the earth's surface at the equator. Also, it would be expected that the air in the polar regions should have a prevailing tendency to sink towards the surface of the earth, in consequence of its increased density caused by cold; and that it should tend to flow from the polar regions along the surface of the earth, towards the equator, with a prevailing motion from west to east in advance of the earth, until, by friction and impulsès on the earth's surface, the motion in advance of the earth, brought from above by the air in its descent, and communicated further to it by friction and admixture from above, as it passes to lower latitudes than its places of descent, is exhausted; or, in other words, until it reaches the latitude in which the trade-winds commence to blow from the east; and until it has communicated, in blowing from west to east on the earth's surface, a torsional force to the earth, just sufficient to balance the opposite torsional force communicated to the earth by the trade-winds blowing from east to west. Now this theory, obvious as it appears in the form just adduced, is found in one essential point to be controverted by observations. This point is what was stated in the outset of the present article, namely, that the prevailing winds on the surface of the earth in latitudes higher than 30°, are, while blowing from the west, as should be expected, found to blow more towards the poles than from the poles; and thus do not move as if impellēd along the surface of the earth from polar to equatorial regions by an augmented pressure due to condensation by cold in polar regions, and a diminished pressure due to rarefaction in the equatorial regions. Observations being thus at variance with the only obvious theory proposed, the circumstance in question has been commonly regarded as rather paradoxical: and Lieut. Maury, one of the most recent writers on the subject, has, in his much-valued treatise on the Physical Geography of the Sea, found himself forced into supposing an entire reversal in latitudes above 30°, of the great circulation just described.

Mr. Thomson regards Lieut. Maury's supposition as being entirely unsupported by the known physical causes of the atmospheric motions. He, on the contrary, maintains that the great circulation already described does actually occur, but occurs subject to this modification, that a thin stratum of air on the surface of the earth in the latitudes higher than 30°—a stratum in which the inhabitants of those latitudes have their existence, and of which the movements constitute the observed winds of those latitudes—being, by friction and impulses on the surface of the earth, retarded with reference to the rapid whirl or vortex motion from west to east of the great mass of air above it, tends to flow towards the pole, and actually does so flow to supply the partial void in the central parts of that vortex, due to the centrifugal force of its revolution. Thus it appears that, in temperate latitudes, there are three currents at different heights:—that the uppermost moves towards the pole, and is part of a grand primary circulation between equatorial and polar regions;—that the lowermost moves

also towards the pole, but is only a thin stratum forming part of a secondary circulation;—that the middle current moves from the pole, and constitutes the return current for both the preceding;—and that all these three currents have a prevailing motion from west to east in advance of the earth. This is the substance of Mr. Thomson's theory; and he gives, as an illustration, the following simple experiment:—If a shallow circular vessel with flat bottom, be filled to a moderate depth with water, and if a few small objects, very little heavier than water, and suitable for indicating to the eye the motions of the water in the bottom*, be put in, and if the water be set to revolve by being stirred round, then, on the process of stirring being terminated, and the water being left to itself, the small particles in the bottom will be seen to collect in the centre. They are evidently carried there by a current determined towards the centre along the bottom in consequence of the centrifugal force of the lowest stratum of the water being diminished in reference to the strata above through a diminution of velocity of rotation in the lowest stratum by friction on the bottom. The particles being heavier than the water, must, in respect of their density, have more centrifugal force than the water immediately in contact with them; and must therefore in this respect have a tendency to fly outwards from the centre, but the flow of water towards the centre overcomes this tendency and carries them inwards; and thus is the flow of water towards the centre in the stratum in contact with the bottom palpably manifested.

On the Plasticity of Ice. *By* JAMES THOMSON, *C.E. &c.*

Mr. Thomson commenced by stating, that to Prof. James Forbes is to be attributed the discovery that the motion of glaciers down their valleys depends on a plastic or viscous quality of the ice. He (Mr. Thomson) had formed a theory to explain the nature of this plasticity, and the manner in which it originates. He had been led to his speculations on this subject from a previous theoretical deduction at which he had arrived, namely, that the freezing-point of water, or the melting-point of ice, must vary with the pressure to which the water or the ice is subjected, the temperature of the freezing-point being lowered as the pressure is increased. His theory on that matter† led to the conclusion that the lowering of the freezing-point for one additional atmosphere of pressure must be 0°·0075 Centigrade, and that the lowering of the freezing-point corresponding to other pressures must be proportional to the additional pressure above one atmosphere. The phenomena which he thus predicted, in anticipation of direct observations, were afterwards fully established by experiments made by his brother, Prof. William Thomson, of which an account was published in the 'Proceedings of the Royal Society of Edinburgh for February 1850.' Having thus laid down as a basis the principle of the lowering of the freezing-point of water by pressure, Mr. Thomson proceeded to offer his explanation, derived from it, of the plasticity of ice at the freezing-point, as follows:—If to a mass of ice at 0° Centigrade, which may be supposed, for the present, to be slightly porous, and to contain small quantities of liquid water diffused through its substance, forces tending to change its form be applied, whatever portions of it may thereby be subjected to compression will instantly have their melting-point lowered so as to be below their existing temperature of 0° Centigrade. Melting of those portions will therefore set in throughout their substance, and this will be accompanied by a fall of temperature in them, on account of the cold evolved in the liquefaction. The liquefied portions being subject to squeezing of the compressed mass in which they originate, will spread themselves out through the pores of the general mass, by dispersion from the regions of greatest to those of least fluid pressure. Thus the fluid pressure is relieved in those portions in which the compression and liquefaction of the ice had set in, accompanied by the lowering of temperature. On the removal of this cause of liquidity, the fluid pressure, namely, the cold, which had been evolved in the compressed parts

* A few tea-leaves taken from a teapot will suit the purpose well.

† This theory is to be found in a paper by the author, entitled "Theoretical Considerations on the Effect of Pressure in lowering the Freezing-point of Water," published in the Transactions of the Royal Society of Edinburgh, vol. xiv. part 5, *1849*, and also re-published in the Cambridge and Dublin Mathematical Journal for Nov. 1850, vol. v. p. 248.