

ing mantle or "jacket" of such enormous density and altitude as to contain (as its main constituents) (a) the greater part of the water of the present hydrosphere in the vapour state; (b) the CO_2 locked up in the limestones and other carbonates of the lithosphere, as well as that represented by the coal and the living vegetation of the globe; (c) the hydrocarbons possibly represented by Archæan graphite, together with (d) the halogens (if atomic evolution had reached that stage), including the Cl_2 of the 73 per cent. of the NaCl of the salts of the present ocean. It is conceivable that a vast convection system existed, as the outer zones of the primordial atmosphere underwent cooling with consequent condensation, and descended towards the molten globe; but there could scarcely be contact generally between such cooler portions and the heated molten mass. The conditions would be rather such as are partly illustrated by what a student of physics is familiar with as the "spheroidal state" of a liquid floating on a cushion of steam above a hot plate of metal. Under the enormous pressure prevailing at the surface of the globe in that pre-oceanic stage of its history great quantities of superheated steam and other gases must have been mechanically included, and in some cases, perhaps, occluded, in the hot crust in the inceptive stages of its development by congelation; and in such circumstances, as I suggested seventeen years ago, superheated water in traces would probably enter into the composition of such silicates as *hornblende* and *mica*, the two most characteristic of the minerals of the heavier metals of the Archæan gneisses and schists. A year or two later that hypothesis received demonstration from the splendid work of de Kroustchoff (see *NATURE*, vol. xliii. p. 545, also *Bulletin de l'Académie des Sciences de St. Petersburg*, tome xiii., "Über künstliche Hornblende," by K. von Chrustschoff). So, I take it, we can understand how such a crust could float on a magma of molten rock material, just as air-charged fragments of pumice or of charcoal float on water, yet sink quickly to the bottom under the exhausted receiver of an air-pump; or as even a coil of platinum foil (sp. gr. 21.5) can be made to float in water inside a good air pump, as it is pontooned by innumerable bubbles of distended atmospheric gases previously condensed upon its surface; or, again, as masses of lava slag of large dimensions are seen to float for a time upon the vast lake of liquid rock material in the crater of Kilauea. With tidal action in the magma greater when the moon was nearer the earth than at present, such a thin crust would easily undergo disruption, while portions of it would float off and be engulfed in the magma. This view, which I propounded some seventeen years ago, had been anticipated partly by Zöllner, and was adopted by the distinguished American geologist, Dr. A. C. Lawson, to explain the phenomena presented by the enormous inclusions of more basic rock masses in the gneiss of the Rainy Lake region, which excited great interest among our leading British geologists at the International Geological Congress in London in 1888, though it seems at the time to have been very imperfectly perceived by most of them. So far the evidence we have goes to support Dr. See's contention that the descent of such masses into the magma would be arrested long before they even approached the centre of the sphere; but one feels great difficulty in following his argument based on "Laplace's law," for reasons given in my former letter (*NATURE*, May 4).

By a slip I wrote, it appears, "impossibility" for possibility in the top line of p. 8 in my last letter.

Bishop's Stortford, May 17.

A. IRVING.

The Spirit-level as a Seismoscope.

A MISCONCEPTION seems to prevail among seismologists as to the behaviour of a spirit-level. A displacement of the bubble is regarded as conclusive evidence of the tilting of the instrument. It should be pointed out, however, that this is far from being the case. For a second cause, equally effective in producing displacement of the bubble, is a horizontal acceleration of the instrument in the direction of the tube. The position of the bubble should be taken as indicating, not the normal statical vertical, but

the dynamical residual vertical obtained by subtracting the acceleration of the instrument (as a vector) from that of gravity. (I disregard, in this statement, the slight lag due to viscosity.)

A couple of simple experiments, serving to emphasise this, may be suggested. A spirit-level is suspended in a horizontal position by two equal strings attached one to each end. In one case the strings hang vertically from two hooks; in the other case they are attached both to one hook. If the level is set swinging in the plane of the strings, then in the first case the bubble will be found to have an oscillatory movement relatively to the tube, the tube having linear acceleration but no tilting movement. In the second case the tube has both movements, but their effects exactly neutralise each other, and the bubble remains stationary in the tube. The expert waiter (may it be added?) who hurries about with plates of soup has a very effective empirical knowledge of this last case of compensation.

The motion of the bubble of a level has been brought forward as evidence in favour of the undulatory character of the disturbance producing the motion; but if the above suggestions are to be accepted, the motion might as reasonably be urged as evidence of a horizontal disturbance; the truth being that the instrument is sensitive to both disturbances, and is quite ineffective as a means of discriminating between them.

The evidence referred to is contained in the British Association report, 1902 (seismological committee report, p. 72). The view finds acceptance in some recent and authoritative works,¹ and seems, so far, to have passed unchallenged.

G. T. BENNETT.

Emmanuel College, Cambridge.

A Feather-like Form of Frost.

THE accompanying photograph shows a form of frost not, I believe, usually seen except at a comparatively high altitude and unsheltered position. This photograph was



FIG. 1.—Frost "feathers" on windward side of rock.

taken on April 22 near the summit of Carnedd Llewelyn, N. Wales (3484 feet above sea-level). These delicate frost "feathers" appear gradually to grow outwards from the rock face on the windward side, and the delicacy of their form is, no doubt, modified in some degree with the varying rate of the wind and the temperature. I have found, in the same district, these "feathers" 9 inches from root to tip; those shown are about 6 inches long. They form a comparatively solid mass where they touch, but the tips keep distinct, and the whole mass is in reality very brittle, and easily breaks up into small pieces.

H. M. WARNER.

44 Highbury Park, N., May 16.

¹ Dutton, "Earthquakes in the Light of the New Seismology," p. 137; Davison, "A Study of Recent Earthquakes," p. 280.