simultaneously along a parallel of latitude, and, if possible, to combine these with regular series of ascents at places distributed as nearly as possible along a meridian. When this has been done a firm foundation for a survey of the atmosphere will have been laid.

There is a certain lack of coherence about the present work, so that although each individual contribution is excellent, the collection does not reach the same standard. Something of this kind is perhaps inevitable where different authors, separated from each other by the Atlantic, undertake to write different sections of a scientific report which are closely related to each other, and require to be published without undue delay.

E. GOLD.

PRECISION OF LEVELLING OPERATIONS.[1]

THE volume referred to below, containing the account and discussion of the precise levelling operations in India from 1858 to 1909, is published at an opportune time. The revision of the main lines of levels in this country and the establishment of really permanent bench marks is, we understand, a task that our Ordnance Survey intends to take up at an early date. The experience gained in the Indian work as recorded in this volume cannot fail to be of great value.

As with any other physical measurement, we find in the case of levelling that increased precision means that problems unimportant or often unthought of in earlier days rise to prominence and demand solution. Thus at the very outset of the subject we are confronted by a question of definition; what do we mean when we say that two points are at the same level? Do we mean that the distance of each point from the surface which would correspond with the mean sea surface, assuming the land to be removed, measured along the normal is identical, or do we mean that our two points lie on the same equipotential surface? The former definition gives us the so-called "orthometric" height, while the latter gives what has, perhaps not very happily, been called the "dynamic" height.

Thus consider the case of a lake. The dynamic height of every point on the water surface is evidently the same, but the actual vertical distance above sea-level varies from point to point, the rate of variation being a maximum along a north and south line and zero, if we exclude second-order distortions of the spheroid, along an east and west line.

Authorities vary as to which system is on the whole the more convenient for practical use, so that the Indian Survey has followed the safe plan of printing both values. We may, however, venture the remark that a convention which assigns different "levels" to different points upon the surface of still water is repugnant to a very large class of practical men, namely, the engineers. The difference between the heights of a station, measured on the two systems, amounts to a maximum of nearly two feet in the case of Bangalore, 3000 feet above the sea, a figure which would obviously be largely exceeded if the levelling were extended to regions of great elevation, and if the mean latitude were differently selected. It is not quite clear in choosing a mean latitude of 24° for the zero of their dynamic heights, and thereby making the system valid only for India, that the Survey experts have adopted the best course. It is an arguable question, which we merely mention here without, be it understood, expressing any definite opinion, whether, if dynamic heights are to be used at all, they should not be based upon a universal datum, and therefore referred to a mean latitude of 45°.

The discussion of the level errors is of great interest and importance. The conclusion arrived at is that for the Indian work the error of a circuit varies neither directly as the length nor as the square root of the length, but in accordance with an intermediate formula :—

$$\text{Error in feet} = \sqrt{(0{\cdot}004)^2 M + (0{\cdot}00034)^2 M^2},$$

where M is the distance in miles.

This gives one-tenth of a foot for a line of 235 miles, and one foot for about 2800 miles, a very satisfactory degree of precision.

The importance of both accurate and permanent bench marks is rightly insisted upon. Many cases have been found where the marks have moved, and obviously no deductions can be drawn as to elevations or subsidences in the earth's crust unless the stability of the bench marks is beyond suspicion.

E. H. H.

[1] "Account of the Operations of the Great Trigonometrical Survey of India." Vol. xix., Levelling of Precision in India (1858–1909). By Colonel S. G. Burrard, R.E., F.R.S. Pp. xiii+484+xviii plates. (Dehra-Dun: Office of the Trigonometrical Survey of India, 1910.) Price 10.8 rupees.

DR. HENRY TAYLOR BOVEY, F.R.S.

WE announced with regret last week the death of Dr. H. T. Bovey, late rector of the Imperial College of Science and Technology, and formerly dean of the faculty of applied science in McGill University, Montreal, which occurred at his residence in Eastbourne on February 2. The funeral service was held at St. John's Church, Eastbourne, on February 6, and his remains were interred in Eastbourne Cemetery.

Dr. Bovey was born at Torquay in 1852, and after being educated in a local school, entered Queens' College, Cambridge, in 1870. He graduated in 1873 as twelfth wrangler, and was elected a fellow of his college in 1876. He entered the profession of engineering, and joined the staff of the Mersey Docks and Harbour Board. Whilst at Liverpool he took part in founding the Liverpool Society of Civil Engineers, and he had every reason to look forward to a prosperous professional life in England. But an accident occurred which gave his life a new bent, and afforded opportunity for a brilliant career elsewhere. Like the best type of Cambridge honours man, Dr. Bovey was a keen supporter of athletics. Whilst taking part in a game of football, he was thrown down and had several ribs broken. He made a good recovery, but one lung had been slightly injured, and he was advised to spend the next winter in a dry climate, lest the wound should become a focus for pulmonary disease. He therefore accepted from Sir William Dawson, principal of McGill University, the offer of a chair in civil engineering and applied mechanics, but declined to bind himself to hold this post for longer than a year.

When Dr. Bovey arrived in Montreal in 1881, he found that his post was indeed a sinecure. Not only was there no laboratory of any description, but his chair was attached to the "Arts" faculty, and his subject had to compete with literary subjects as an option for a degree. At that time in McGill the principal qualification for the success of an optional subject was constituted by its claims to be considered a "soft snap," *i.e.* by demanding light work and having easy terminal examinations. The mathematical teaching provided by the University was quite unsuited to engineering students, and Dr. Bovey's efforts to have it modified met with no success. Next year, therefore, Dr. Bovey resigned his chair, and was about to return to England, but he was pressed by