THE BAROMETRICAL DETERMINATION OF HEIGHTS: A PRACTICAL METHOD OF BAROMETRICAL LEVELLING AND HYPSOMETRY, FOR SURVEYORS AND MOUNTAIN CLIMBERS

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Trieste

THE BAROMETRICAL DETERMINATION OF HEIGHTS

A PRACTICAL METHOD

OF

BAROMETRICAL LEVELLING AND HYPSOMETRY

FOR

SURVEYORS AND MOUNTAIN CLIMBERS

BY

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PREFACE.

THE discrepancies arising in the calculation of mountain heights by the barometrical formulæ which have hitherto been in use have brought this valuable and in many cases only applicable method into disrepute. The fault has lain in the formulæ, not in the method, which is one susceptible of great accuracy. These formulæ have either been based upon unwarrantable assumptions or have failed to take account of all the conditions obtaining in the problem.

The present essay was originally entered in the Hodgkin Prize Competition, held under the auspices of the Smithsonian Institution, and was awarded honorable mention. In it the important problem of Barometrical Hypsometry, which has not been touched upon since 1851, when it was discussed by Guyot, has been gone over anew and brought up to date. Important errors in the older formulæ have been detected and a new method has been furnished which is rigidly accurate in theory and which in practice will give reliable results under all conditions.

F. J. B. C.

THE BAROMETRICAL DETERMINATION OF HEIGHTS.

One of the most important applications of the known properties of air has been a deduction from them of a means of finding the vertical height between any two points, and the problem of measuring the vertical distances between any two levels is one that has engaged the attention of a number of mathematicians and physicists for many years.

Laplace, in the "Mécanique Céleste," gave what at the time was considered a complete solution of the problem; but as it was based upon several unwarrantable assumptions, and took no account of the aqueous vapor in the atmosphere, it was at best an approximation.

The complete formulæ as given by him is

$$Z = \log \frac{h}{H} 18336 \begin{cases} (1 + 2 \frac{(t + t')}{1000} \\ (1 + .0028371 \cos. 2 L \\ (1 + \frac{(\log \frac{h}{H} + .868589) \frac{Z}{a}}{\log \frac{h}{H}} \end{cases}$$

where Z = the difference of level in metres;
a = Earth's mean radius = 6,366,200 metres;
L = mean latitude of the two stations.

And further

At station:

- Lower
  - h = height of barometer;
  - T = temperature of barometer;
  - t = temperature of air;
- Upper
  - h' = height of barometer;
  - T' = temperature of barometer;
  - t' = temperature of air;

$$\text{and } H = h + h'\left(\frac{T - T'}{6196}\right).$$

The first parenthesis in the terminal factor is the correction for the difference of temperature of the two levels. It assumes that the problem would be the same if the air between the two levels were of a uniform temperature—the mean of what is observed at the two levels. As a matter of fact, if the two stations are remote, a large range of temperatures may be found at intervening points.

The second parenthesis is the correction for the change of gravity with the latitude. It assumes that gravity increases regularly according to a law as we go from the equator to the poles—a supposition which we now know to be true only in a general way. The third parenthesis is the correction for the decrease of gravity in a vertical direction. It is based upon the Newtonian law that externally to the earth's surface gravity decreases inversely as the square of the distance from the centre of mass. From careful pendulum experiments we know that such a law does not hold near the earth's surface, large masses of matter in different localities causing variations that are not to be accounted for by any simple law.

Baily, in his "Astronomical Tables and Formulæ," gives the following formula:

$$x = 60345.51 \left\{ 1 + .0011111 \, (t + t' - 64^\circ) \right\}$$

$$\times \log \left\{ \frac{\beta}{\beta'} \times \frac{1}{1 \ \times .0001 \, (\tau - \tau')} \right\} \times \left\{ 1 + .002695 \cos. \, 2\phi \right\}$$

where ϕ = latitude;

β = height of barometer;
τ = temperature of mercury;
t = temperature of air; } at lower station.

β' = height of barometer;
τ' = temperature of mercury;
t' = temperature of air; } at upper station.

Feet, inches, and the Fahrenheit scale are here used. Here the same assumption is made in re-