side, thence through in a straight line to Modano, a small village of Savoy.

Of course they went but slowly on at first, the Italian Government having to bear all the expense, but soon after, when Savoy had been ceded to France and Napoleon commenced to bore at the Modano terminus, the work went more rapidly forward. For thirteen years, night and day, the work progressed and the opposite gangs were steadily approaching each other. For the first five years, the work moved forward tardily enough—being at the rate of 1,643 feet per annum. The rock is of the hardest species of gneiss, and hand-drilling was consequently exceedingly arduous. 1862, however, marks a new era in the history of this entreprise, for Sommeiller, a French savant, invented one of the most wonderful machines of modern times. It is especially adapted for the purpose, for, being put into action by pneumatic power, the dangerous boiler and the air destroying fire, were rendered useless. Immediately the work took a fresh start and was pushed forward at the rate of 4,200 feet per year.

This gigantic drilling apparatus was worked entirely by compressed air which was forced through pipes by a series of turbine wheels, driven by steam power at the entrance of the tunnel. The wonderful adaptability of this style of machines for working in close confined quarters, is shown in the fact, that the same air, after serving as the motive power, passed into the atmosphere and afforded breathing material for the working men. Water to clean the drills was also forced into the machine by pumps erected in the valleys at either end of the tunnel, and as the tunnel lengthened, a new section of the pipes was inserted, to keep pace. To render moving the drill easy, the connecting pipes were of flexible India-rubber.

When the holes had been drilled about thirty inches deep, the machine was drawn back upon the tracks, which were laid as rapidly as the work progressed, not only for this purpose, but also for the transportation of the detached rock. Now the blasters filled each drill with a pound, more or less, of powder; the men drew back, and soon a thunder-like noise would resound, scattering the rock and shaking the mountain to the summit. To those who dwelt near the opening of the tunnel the sound would resemble distant cannon. Immediately the air valves are opened, and soon all the smoke and dust is blown out of the tunnel into the open air. Soon all the detached stone is cleared away and the work proceeds as before.

Sommeiller lived to see his invention accomplish the work in about half the time it had been calculated at the outset would have been required. The most sanguine had removed the completion twenty-four years ahead, but the inventor finished the work within thirteen years. He was amongst the first to pass through the tunnel, end to end, by rail, but did not long survive the severe exposure he had undergone during the work. He died the following summer.

The tunnel is a fraction less than eight miles in length, 41,815 feet. And to give an idea of the labor it required, we will give a few figures. For every foot of stone taken out it was necessary to drill from thirty-five to forty holes, and to loosen the stone from thirty to thirty-five pounds of powder were used; thus making in all something like 1,580,970 holes drilled, and requiring no less than 1,489,892 pounds of powder.

From the entrance, on the French side, the bore ascends at the rate of sixty feet to the 1,000, until about half way, then level to the other end. So exact had been the calculation, that when the workmen met, four miles from the starting point, they found that there had not been an inch of deviation from the straight line. What wondrous skill so to guide, that two lines shall exactly meet at the centre of a mountain nearly 10,000 feet in height!

We can hardly imagine the moment of intense joy that thrilled the workmen on the 28th December, when at early dawn they heard, though dimly, each other working on either side of the fast waning rocky partition.

How they must have redoubled their energy and with what strong enthusiasm, they, flushed with the expectant victory, pressed on with their work. Never did men feel more filled with the importance of their work than they. For many long and laborious years they had gradually worked toward one another, and now their labours were soon to terminate in perfect success.

Quickly a messenger was sent from the Italian workmen, to go over the mountain and tell their French co-workers to prepare a huge blast, and touch it off at exactly twelve, noon, and the Italians would do the same.

The hour came, and with it a tremendous blast which shattered the last remaining rock, and united the ends of this stupendous master work.—*Cal. Ill Press.*

ON AN IMPROVED FORM OF ANEROID FOR DETERMINING HEIGHTS, &c.*

By [illegible] ROGERS FIELD, B.A., C.E.

The author begins by stating that the object aimed at in designing this improved form of aneroid was to simplify the correct determination of altitudes in cases such as ordinarily occur in England, and that the instrument is therefore arranged to suit moderate elevations, say of 2,000 ft. and under, and is not intended for considerable elevations.

Before proceeding to describe this instrument he briefly recapitulates the general principles on which the measurement of heights by a mercurial barometer depends, and for this purpose he refers to the mercurial barometer as the original source from which the graduations on the aneroid are obtained. If an observation taken at one station is compared with that taken at a higher one the difference of the readings of the barometer will give the height of mercury which balances the column of air between the two stations, so that knowing the relative weight of air and mercury we can determine the height of the column of air, or in other words, the vertical height between the two stations. The relative weights of air and of mercury are variable, being affected by the gradual reduction of the pressure of the air as we ascend, and also by variations of temperature; the accurate determination of their relative weights is the principle which lies at the basis of the various formulæ that have been proposed for barometrical measurement of altitudes, although the problem cannot be stated in such a simple form as this.

The preceding general principles apply to the aneroid equally with a mercurial barometer. A good aneroid is always graduated by direct comparison with a standard mercurial barometer, so that the readings of the aneroid represent those of a mercurial barometer, and the better the aneroid the more accurate this representation will be. A well constructed aneroid, however, differs from a mercurial barometer by being compensated to a certain extent for the effect of the temperature on the instrument itself, so that this need not be taken into account, more especially as the effect of temperature on the instrument only becomes important when the temperatures of the stations differ considerably, which they will not do in moderate elevations.

The conditions, therefore, which have to be taken into account in the present case, are, (1) the pressure of the atmosphere, and (2) the temperature of the air.

Various formulæ are given by different authorities for determining the altitude readings of the barometer, but they do not differ much for small altitudes, though this is far from being the case with great altitudes. The table which is adopted in graduating the present aneroid is that given by the Astronomer Royal in the "Proceedings of the Meteorological Society," vol. iii., page 406, and gives results which lie between those of the other authorities.

Aneroids constructed for the determination of elevation by readings from an altitude scale consist of two classes, one in which the altitude scale is fixed, and the other in which it is movable at random. The first class of aneroid with a fixed scale is accurate in principle, but the scale only allows for one of the conditions which have to be taken into account, viz., the varying pressure of the atmosphere, and the other condition, or temperature of the atmosphere has to be allowed for by calculation. The second class of aneroid, that with a movable scale, is radically wrong in principle as ordinarily used, inasmuch as the movable scale must be graduated from one fixed position of the zero, and when the zero is shifted at random according to the position of the hand of the instrument, the scale necessarily becomes inaccurate.

In the improved aneroid the scale of altitudes is movable, but instead of being shifted at random according to the position of the hand of the instrument, it is moved into certain fixed

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* British Association, Section G.