THE ANEROID BAROMETER.

THE following letter has been forwarded to us for publication :—

DEAR WHYMPER,—It is with diffidence that I venture to criticise an expert, but I know you will not take amiss a few remarks on your 'Use of the Aneroid Barometer,' which I have read with attention, as well as the interesting stories of the ascents.

There is no doubt that an aneroid barometer cannot be considered as an instrument of absolute precision. In comparing it with a mercurial barometer it has the same defects, only more complicated, as a spring balance compared with an accurate pair of scales. In the aneroid there is, first, the elasticity of the metal vacuum-box, which is liable to be fatigued by the changing pressure; and, next, there is the chance of derangement of either of the levers by which the index is worked, with the further possibility of an imperfect adjustment of the spring, which professes to compensate for temperature. Hence we have the irregular variations in the index error, which you have endeavoured to systematise in your carefully-worked experiments; but, from the construction of the instrument, they can never be entirely accounted for, and when the changes of pressure are excessive they are liable to become considerable.

I have frequently worked, though I have never observed, with the aneroid at heights much above 11,000 feet, and up to that elevation have been astonished at its accuracy. I have never noted an error reaching three millimetres (say, one-tenth of an inch) in either of the three instruments I possess; but the elasticity of the vacuum-box will scarcely admit of the expansion required for lower pressures. My instruments consist of one full-sized, one three inches in diameter, and one watch-size. This last, though it was specially made for me with the greatest care, is, I find, the least trustworthy. I doubt whether an aneroid, with face less than three inches in diameter, can be scaled accurately for a height above 5,000 feet.

With your remarks on this point I entirely agree, as also on the inadvisability of trusting to the scale of feet, as marked on some aneroids, which at most can give an approximate height.

It would be rash for anyone, taking original altitudes, to do so, when depending solely on the aneroid. Without doubt, in portability and facility of observation without loss of time, the aneroid has a great advantage over any instrument for taking the pressure of the atmosphere, and for measuring the difference of level of contiguous stations it is especially convenient; but the index error should be ascertained and allowed for from time to time, and under various pressures. This can only be done by comparison with the mercurial barometer or the boiling-point thermometer, which, in my judgment, serves equally well, and is unduly depreciated by you.

It is only indirectly that the height is given by the barometer, being deduced from the atmospheric pressure. So, too, with the boiling-point, the height is calculated from the tension of the vapour—that is, from the temperature at which the force of the steam becomes equal

to the superincumbent atmospheric pressure. The same errors in the computation will affect both, the two most inevitable being the difficulty of ascertaining the temperature of the intervening column of air, and also the amount of moisture contained in it. The mean of the upper and lower thermometer readings is usually taken to give an estimate of the first; but I think a better result is got by assuming a fall of 1° Fahr. for every 320 feet of rise.

To ascertain the amount of moisture, hygrometric observations are necessary; but, even with these, the distribution and transmission of vapour in the air is too uncertain to make it worth while to use the somewhat complicated formula which professes to give this small correction.

In order to attain accuracy with a boiling-point observation more than one thermometer should be used, and more than one boiling should be made with each thermometer. For myself, I use, first, two thermometers with the degrees over-lapping in sequence. The degrees (Fahrenheit) are divided into tenths, nearly a millimetre in length, and these, with the eye and a lens, I can readily divide again into ten parts, so as to read to a hundredth of a degree Fahr. I also use, at the same time, a second thermometer, which has the degrees divided into fifths, which I am able again to divide with the eye. The thermometer, when new, will have a small and varying index error, owing to the dilatation of the glass bulb. This will settle permanently with time and use. The index corrections of my thermometer, made by Casella, are—for the two in sequence, + 0°·04 and — 0°·16, and for the other — 0°·06. If the two boils do not coincide, at least within 0°·02, I discard the observation. It is, of course, essential to take care that the bulbs are placed in the steam, not in the water, and that only just sufficient to reach of the thermometer stem projects above the rubber-stopper, also that the steam freely escapes by the hole in the chimney. It is only while vapour is free to expand indefinitely, as in an open vessel, that the temperature can never exceed ebullition. In a closed vessel, or even when the pressure of the rubber-stopper holding the tube is considerable, so that the vapour cannot escape freely, the temperature may be higher.

You say that you boiled water at seventeen stations, but always found the temperature too high. This may have been owing to the last-mentioned cause, or possibly there may have been impurities in the water to raise its temperature Care must also be taken that the flame does not unduly heat the metal vessel, and that the thermometer bulb is not in contact with the metal. It seems to me probable that if the air is moist, especially to the degree of saturation, the vapour would linger, as if unwilling to contribute to the already over-charged atmosphere, and this cause might fractionally raise the boiling-point. Perhaps you have considered this. Lastly, care must be taken in the reading to avoid parallax, by keeping the eye exactly on the level of the mercury surface when the column becomes stationary.

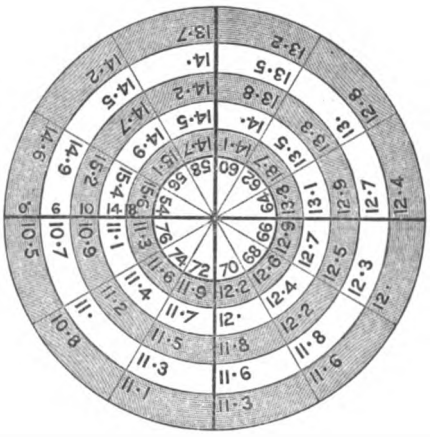
The mercurial barometer, in addition to its cumbrous form and liability to fracture, has its own weak points, the principal one being the not improbable admission of a bleb of air above the mercury

column, as a consequence of the bumping and rough usage to which it is exposed.

I entirely agree with you that everyone who has had much experience of the boiling-point thermometer on the top of a mountain will have often had to curse the expenditure of time and lucifers which has failed to procure a satisfactory result; but as an adjunct to correct the reading of the aneroid I have found it invaluable. The comparison may be made leisurely and carefully in a room at the lower station, or, when the circumstances are favourable, on an elevated mountain.

Years ago, in the Pyrenees, I had frequent occasion to compare the aneroid, zeometer, and mercurial barometer, and always found the results to tally fairly well. The aneroid was full size (4½ inches diameter), by Bianchi, of Toulouse. The scale was divided, of course, in millimetres, descending to 520 mm. (= 20·55 inches).

I much regret that you have not found yourself at liberty to adopt the metrical system, which I suppose was in vogue in Ecuador. You would have found it much more convenient and have saved yourself a world of trouble. At or about the sea level, at the mean temperature of, say, 12° C., a fall of 1 mm. in the barometer may be taken to denote a rise of 14 m. For a speedy estimate of the height, I find the annexed diagram, which fits into the lid of the aneroid case, very convenient.



The figures nearest the centre represent the height of the barometer, and the figures in the section under it give the equivalent in metres, answering to that height, on the ring nearest coinciding with the temperature, which is given along the horizontal radius in degrees centigrade. Multiply the number of metres so obtained by the interval in millimetres, and tenths of the barometer, as shown between the two stations, to obtain the height of rise or fall.

I appreciate your notice of the gentleman in the Midland counties, though I hope in your barometer observations you were more strict to the truth. You seem to have strung several facts together, and hung

them upon one peg to make a pretty tale; as, though my dogs did once dismount a curate, I was never in England had up before the 'beaks' on account of them. However, you see I have taken my revenge in inflicting this upon you. I am, yours truly,

CHARLES PACKE.

PROCEEDINGS OF THE ALPINE CLUB.

A GENERAL MEETING of the Club was held at the Club Rooms on the evening of Tuesday, February 2, 1892, Mr. HORACE WALKER, *President*, in the chair.

Messrs. Arthur Bird, E. A. Fitzgerald, A. F. de Fonblanque, A. P. Harper, J. E. Koecher, Major-General H. C. N. Blanckley, Lieut. Hon. C. G. Bruce, and Conte F. Lurani were balloted for, and elected members of the Club.

The Hon. Secretary and Treasurer presented the accounts for the year 1891, which were unanimously passed.

Mr. J. H. GIBSON read a paper, 'The Eastern Arête of the Meije.' A short discussion followed in which the President, Messrs. Morse, Mathews, and Conway took part, and the proceedings terminated with a cordial vote of thanks.

A General Meeting of the Club was held at the Club Rooms on the evening of Tuesday, March 1, Mr. HORACE WALKER, *President*, in the chair.

Messrs. P. Fletcher and C. B. Heberden were balloted for and elected members of the Club.

The PRESIDENT referred to the loss sustained by the Club through the death of Mr. E. L. Ames, one of the founders of the Club, and a contributor to 'Peaks, Passes, and Glaciers.'

The Rev. GEORGE BROKE read a paper, 'A Fortnight round Saas,' for which an unanimous vote of thanks was accorded to him.

A General Meeting of the Club was held at the Club Rooms on Tuesday evening, April 5, Mr. HORACE WALKER, *President*, in the chair.

One candidate, Dr. Ludwig Darmstaedter, was balloted for, and elected a member of the Club.

The PRESIDENT announced the death of another distinguished member, Mr. John Murray, who had belonged to the Club since 1858, and had always taken a keen interest in Alpine matters, and whose loss would be much regretted. He was the publisher of many Alpine books, and all who had seen the last edition of his Guide to the Alps would agree that it was a most valuable work.

With regard to his remarks made at the General Meeting in December, in reference to the base of the Club Rooms, the President mentioned that negotiations with the landlord had taken place, and that it had been decided to continue the tenancy at the same rental as before for two years (with the option of a third year) from September 1, 1892.