



Figure 1 Fountainhall House, Aberdeen, around 1880, before Blenheim Place was built.

THE HEIGHTS OF THE CAIRNGORMS AND FOUNTAINHALL HOUSE

JAMES FRIEND

Fountainhall House, built in about 1752, is an unusual house tucked into Blenheim Place near Queen's Cross, Aberdeen. Originally built in the country, it was engulfed by the city of Aberdeen in the late 1890s as West Aberdeen was built around it. One of its most distinguished inhabitants was Professor Patrick Copland (1749-1822), who was Professor of Natural Philosophy at Marischal College from 1775 until his death. Patrick Copland bought the house in 1803, by which time he had already acquired wide renown as a teacher, aided by a remarkable collection of working models, many of which still exist in the Physics Department in the University. He was also responsible for setting up the first Astronomical Observatory on the Castlehill in 1781, and with Robert Hamilton, (after whom Hamilton Place was named), devised much needed improvements to Aberdeen's water supply.

The link between Fountainhall House and the Cairngorms may not appear obvious so far, but it is a real one. For in 1810, George Skene Keith (1752-1823) Minister at Keith Hall, cooperated with Patrick Copland in the first attempt at measuring the heights of the Deeside hills and Cairngorms. Patrick Copland himself had already had an interest in mapping, and in 1808 had assisted with a topographical survey of Aberdeen and Banff, nine years before the Ordnance Survey reached this part of Scotland. Skene Keith, on the other hand, had an interest in agriculture, and particularly in distillation, in which he made a number of experiments for the commissioners of excise in Scotland. Sharing between them an interest in things scientific and in measurement, it is understandable that two active scientific workers in the Age of Enlightenment should set themselves the task of measuring the heights of the hills, of which up till then only Mount Battock had been measured, by a William Garden, as being 3465 feet above sea-level.

Skene Keith published an account of his two expeditions as an appendix to his major work, *A General View of the Agriculture of Aberdeenshire*, published in Aberdeen in 1811. Extracts of his article were published in the *Cairngorm Club Journal*, (1968) Vol 93, p238-242, but the whole account makes such fascinating reading that Members might like to have an opportunity to learn more of these pioneering expeditions and the techniques used in the measurements.

"Before I set out, on my first survey, I got a mountain-barometer, made by that excellent artist Mr Thomas Jones, formerly of Mount Street, now of Kenton Street, London. I also got a very good spirit level, made for me by James Cassie, a very ingenious mechanic in my own parish, whose snuff boxes, and other neat trinkets, find a ready sale in all parts of the country, and even in the city of London. And what was of the utmost consequence,

Fig. 11.



Fig. 12.

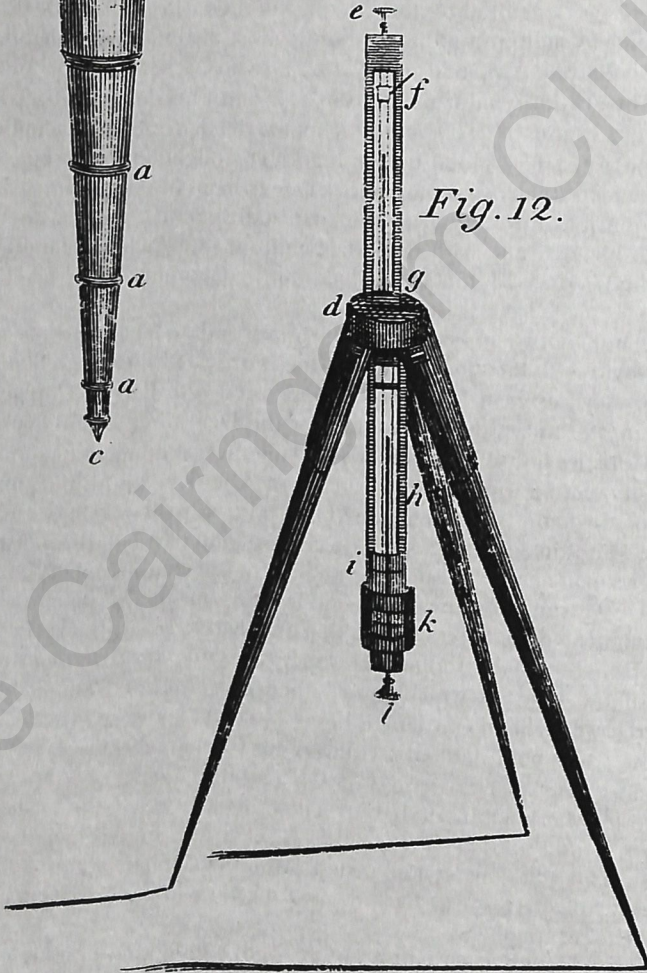


Figure 2

A typical portable mountain barometer of Keith's day, shown in (fig. 11) and open (fig. 12) position. (from *The Philosophical and Mathematical Dictionary*, Charles Hutton, London, 1815.)

Mr Patrick Copland, of Marischal College, had, in the most friendly manner, given me his best advice for carrying on my operations on the mountains, and had very kindly undertaken to mark the heights of the barometer at his house at Fountainhall, by Aberdeen, which is 160 feet above the level of the sea, at half-flood. It is, by comparing the different heights of the barometer at two places, taken at the same hour, that the heights of mountains are calculated, after making allowance for the difference of the temperature of the air, and the expansion of the mercury, indicated by the heat of the attached and detached thermometers”.

Contemporary texts of the time give us more details of the methods which Skene Keith probably used. In Charles Hutton's *Philosophical and Mathematical Dictionary* (London, 1815), the method is attributed to Sir George Shuckburgh-Evelyn and General William Roy. Sir George, M.P. for Warwick, gentleman and scientist, first reported in 1777 on work done with General Roy to the Royal Society as 'Observations made in Savoy to ascertain the Height of Mountains by the Barometer'. In the following year General Roy, originally from Carlisle, an engineer responsible for extending General Wade's roads, reported to the Royal Society on 'Experiments and Observations made in Britain in order to obtain a Rule for measuring Heights with the Barometer'. Using mercury filled barometers, with the mercury contained in a pigskin bag at the base of the glass column, a detached thermometer was used to measure the ambient temperature, and thus compensate for changes of air pressure with temperature. A second thermometer attached to the barometer was used to measure the temperature of the mercury itself, so that correction could be made for the expansion and contraction of the mercury at different temperatures. The formula deduced by Sir George and General Roy is as follows:- 'The difference of the logarithms of the heights of mercury in the barometer, at two stations, when multiplied by 10000, is equal to the altitude in English fathoms, of the one place above the other. That is, when the temperature of the air is about 31 or 32 degrees of Fahrenheit's thermometer'. Further details of the calculations and corrections for temperature are given in Hutton's Dictionary, and summarised in Appendix 1. It seems likely that the type of barometer made by Jones and used by Skene Keith was from a design of Sir Henry Englefield, a member of the Linnean Society, with an attached folding tripod, shown in the accompanying illustration.

We shall continue in Skene Keith's words. "July 9, 1810. - Set out on my first survey of the mountains, and arrived at my friend, the Rev. James Gregory's at Banchory Ternan, where I staid all night. Found, by a medium of three observations taken this evening, and at two subsequent periods, that the surface of the Dee, at this time very low, was only 12 feet higher than Fountainhall, or 172 feet above the level of the sea.....July 12. - Set out for Mount Battock; ascended the mountain and staid an hour on the top of it. Quite disappointed in finding it only 2600 feet. This was verified by an

observation made some months after. (I had formerly suspected that Mr. Garden, who was a most accurate man, had committed some error, when he measured this mountain; and I can account for so great an error no other way, than by supposing that he had either mistaken, or *put a wrong figure in his field book*, for the *angle* which marked the elevation of the Grampians above the flat land called the *How of the Mearns*). Returned to Finzean at 6 o'clock.....left my good friends after breakfast, and rode to Ballater-house, the residence of William Farquharson, Esq., of Monaltry. Found the elevation of the Dee, below the Bridge of Ballater, to be 780 feet. The top of the Craigs of Ballater, a romantic hill close by the house, 1340 feet. After dining, and spending three hours with the hospitable Mr. and Mrs. Farquharson, my public spirited landlord accompanied me to the Manse of Crathie, where we arrived at a late hour, and were kindly received by Mr. and Mrs. McHardy.

July 14. - Breakfasted at 7 o'clock, and set out with Mess. Farquharson and McHardy. On our way we were joined by Mr. Alexander Warren, a very ingenious man, who had measured the estate of Invercauld, consisting of nearly 10,000 Scotch acres, and to whom I was much indebted in my subsequent operations. Three guides took care of our horses, and conducted us in safety to the mountain top, which on the medium of three measures taken on this, and another visit on the 20th, was found to be elevated above the sea almost exactly 3800 feet. Laid my spirit level on the Ca Cuirn, or highest top (of Lochnagar), in order to compare its elevation with the mountains near the source of the Dee. Found, that after making allowance for the curvature, they were considerably higher. Dined, and staid three hours on this interesting mountain, from whence the German Sea, from the Firth of Forth to the Murray Firth, and a great extent of country was distinctly seen for about two hours. The varied scenery would have detained us much longer, had not a thick fog, and every appearance of a great fall of rain, obliged us to descend as quickly as possible. Our descent was accompanied with a number of awkward tumbles, and one of the gentlemen was rolled nearly 100 feet; but no accident happened to any of us, except the loss of my spirit level. After 12 hours absence, we returned to the Manse of Crathie, completely drenched with rain; but we soon got dry clothes, and most hospitable entertainment.

July 15. - Preached at Crathie for my friend Mr. McHardy, but felt a considerable inflammation in the pleura from the great rains, and exertion of yesterday. Dr. Stuart took from me about eight ounces of blood, which gave me relief.

July 16. - Rose at 5 o'clock. Rode ... to Mr. Stuart's at Allanquoich. Here we breakfasted, and our hospitable landlord accompanied us to the mountains of Ben-a-bourd and Benavon. The former ... is an immense mass, without beauty or fertility, extending about three miles in length, and almost flat on the top; and was found to be elevated above the sea 3940 feet. The

latter was more interesting, having greater variety of surface. Its highest peak was 3920 feet, or 20 feet lower than Ben-a-bourd. But the mountain in general was 100 feet lower than the other. Several Scotch topazes and beryls are found in Lochnagar, and in both these mountains. We returned to Allanquoich at 5 o'clock at night, where we were entertained most hospitably, and had a sound sleep after the labours of the day".

On the following day, the party again rose at 5 o'clock, called at Mar Lodge, and set out up the River Dee to the junction of the Guisachan and the Garchary, which they followed 4 miles to the Lairig. "Here we took a luncheon, and as neither my hospitable landlord, nor our guide had ever been at the source of the Dee, we were doubtful what course to pursue, when, fortunately, a man going with provisions from Badenoch to the shealing, came up to us, and pointed out the line that we should follow; for we had no road, nor even a foot-path.

At 2 o'clock, P.M. we set out to climb the mountain, still keeping in sight of the river. In a few minutes we came to the foot of a cataract, whose height we found to be above 1000 feet; and which contained about a fourth part of the water of which the Garchary was now composed. In about half an hour after, we perceived that this cataract came from a lake in the ridge of the mountain of Cairntoul, and, that the summit of the mountain was another 1000 feet above the loch, which is called Loch-na-youn, or the blue lake. A short time after, we saw the Dee, here called the Garchary...tumbling in great majesty over the mountain, down another cataract; or, as we afterwards found it, a chain of natural cascades, above 1300 feet high. It was in flood at this time, from the melting of the snow, and the late rains; and, what was most remarkable, an arch of snow covered the narrow glen from which it tumbled over the rocks. Here our landlord and our guide ascended the mountain by an easier though more circuitous course; but I was determined not to lose sight of the river, and Mr. Warren kindly accompanied me. We approached so near to the cataract as to know that there was no other lake or stream; and then we had to climb among huge rocks, varying from one to ten tons, and to catch hold of the stones of fragments that projected, while we ascended in an angle of 70 or 80 degrees. A little before 4 o'clock, we got to the top of the mountain, which, (by information given me, before I set out, by George Skene, Esq. of Skene,) I knew to be Briiach, or the speckled mountain. Here we found the highest well, which we afterwards learned was called Well Dee, and other five copious fountains, which make a considerable stream, before they fall over the precipice. We sat down, completely exhausted, at 4 o'clock, P.M. and drank of the highest well, which we found to be 4060 feet above the level of the sea; and whose fountain was only 35 degrees of heat, on the 17th of July, or 3 degrees above the freezing point. We mixed some good whisky with this water, and recruited our strength. Then we poured, as a libation, into the fountain, a little of the excellent whisky which our landlord had brought

along with him. After resting half an hour, we ascended to the top of Breriach, at 5 P.M. and found it to be 4280 feet above the level of the sea. We then descended amidst a thick fog, which suddenly overwhelmed us, and attempted next to get to the top of Cairntoul, on the other side of the Garchary. We could not see an object at above 100 yards distance; and at last ascended one of the inferior peaks, but afterwards climbed up the rocks to the highest summit of Cairntoul, which we found to be only 5 feet higher than Breriach, and that *apparent* difference was only occasioned by *the weight of the atmosphere*. On this summit the rain poured out in such torrents, and the wind battered us so much, that two gentlemen, holding umbrellas over my head, could not protect me while I marked the height of the barometer in my journal. We were obliged to leave the index, then draw on the brass cover, and inverting the barometer, to descend the mountain. Unfortunately we had no pocket compass, and afraid of falling over the huge rocks of Poten Duon, which are nearly 1600 feet high, we turned too much to the right hand, and completely lost our way. It was 9 o'clock at night before we found, that a small river, whose course we happily followed, was the Guisachan, or the other source of the Dee. And it was half an hour past 9, when we arrived at the junction of the two streams, and the shealing which we passed at noon. We were now completely exhausted with hunger and exertion; and the shepherds had neither ale, milk, whisky, nor anything, except oatmeal, and bannocks baked of oatmeal, and nearly two inches thick. But hunger gives a better relish for food than the best sauces can do. And the butter, which we had untouched, spread on these bannocks, appeared to me the best meat I had ever tasted; while the stream of the Dee allayed our thirst. Our horses joined us at 10 o'clock, and we mounted, retraced our steps homeward, and arrived at Allanquoich, about half an hour past 1 next morning. There we received the kindest treatment, and afterwards enjoyed a sound sleep, after nearly 19 hours of fatigue".

The next day, Skene Keith returned to Crathie, and then travelled by Abergeldie to 'Altguisach' by Loch Muick, and on July 20th he climbed Lochnagar again, and the White Mounth, taking measurements at several points on the route. With remarkable energy, (he was aged 58 at the time) he tackled Mount Keen the very next day, and as he arrived back at Ballater at 4 P.M., he was able to persuade a guide to escort him to Morven, reaching the top at 6 P.M. It is clear that the lower level parts of this expedition were accomplished on horseback, but not the ascents and descents. That evening he recruited his strength with birch wine at House of Ballater, preached at Glenmuick the following morning, and returned to Aberdeen on July 22nd, measuring the elevations of the Dee at a number of points on the way. Finally, he went to the Quay at Aberdeen at half-flood, to check the Barometric pressure, and then to Fountainhall, where Professor Copland gave him all the recordings from his barometer. He returned home, to make his calculations, with the following reflections - "...concluded my first

expedition to the mountains of Marr; which had taken up two weeks, during which time I had travelled above 330 miles. But though I had left Aberdeen in rather bad health, the pure air, and the kind hospitality which I met with everywhere, not only enabled me to bear the fatigue which I had undergone, but gave me a degree of health and strength, which I had not enjoyed for some months preceding. - At the same time I must remark, that the man must have good stamina, who expects to regain health by measuring mountains”.

Keith still felt the urge to make further measurements, and particularly of Ben Macdui, which he had been unable to measure from Cairntoul because of the fog and rain, and the loss of his spirit level. His Jones Barometer had been sent to London for repair, and unfortunately, on the return journey the master of the ship had forgotten to leave the barometer in Aberdeen, and had returned to London with it! Undaunted, he was able to borrow two barometers from friends, and on September 10th 1810 he left Aberdeen again, and by the 14th he was again on top of Breriach and Cairntoul, from which he decided that, using a new spirit level, the top of Cairngorm was considerably lower, and the top of Ben Macdui considerably higher than Cairntoul. Having set out from Mar Lodge at 7 o'clock that morning, they descended to Aviemore by 10 o'clock that night. For this expedition he also had the help of the Duke of Gordon, who lent him a compass, and arranged to have the low level barometric recordings made at Gordon Castle, by a Mr. Hoy, since Professor Copland was away from home. On September 21st, having met with his son who had just returned from Ben Nevis, which he had found to be 4350 feet, Keith climbed 'Breriach', crossed the Lairig to 'Ben Macdouie', and returned to Glenmore over Cairngorm. He returned to Aberdeen over the next few days by way of Tomintoul, Corgarff, and the valley of the Don, taking measurements as he went. During this journey he had travelled 400 miles, and his son 440 miles, at a time when there were no railways and only the most rudimentary maps and roads. In Appendix 2 some of Keith's measurements are detailed, in comparison with more modern measurements, and it will be seen that they were remarkably accurate. After Keith's time, mercury barometers were replaced by aneroid barometers for mountain use, and later, levelling and trigonometric methods became the norm. Since the 1970's, aerial photography, using stereoscopic pairs, has given heights to an accuracy of about one metre. But George Skene Keith can be credited with a remarkable achievement, in making such accurate first measurements of the heights of the Cairngorms, and perhaps laying some of the foundations for the establishment of the Cairngorm Club some 77 years later. There is little evidence, from his account, that the pleasures and vagaries of walking the hills have changed significantly over the last 178 years!

Acknowledgments: I was encouraged to write this article by the Editor, who discovered on a Cairngorm Club weekend meet of the link between Fountainhall House, in which I live, and these early measurements of the heights of the Cairngorms. I am particularly grateful to Dr. John Reid, of the University Dept. of Physics, and Dr. Jeffrey Stone, of the University Dept. of Geography, for much helpful advice, and to the University and Central Public Libraries for access to books and documents.

APPENDIX 1. An example calculation of height from barometric measurements, from Charles Hutton's *Philosophical and Mathematical Dictionary*, London, 1815.

If D = density of the air in one place, and d = the density of the air in another place, measured by the mercury barometer, then the difference in altitude a = a constant $\times \log D/d$. If the mercury columns are measured in feet, the constant is 63551, or if in fathoms, the constant is 10000 at 55 degrees Fahrenheit. But the altitude will vary by $1/435$ for every degree change in temperature.

Example;	Thermometer readings, degrees F.		Barometer readings, inches.	
	Detached	Attached		
	35	41	29.45	lower
	31	38	26.82	higher
	mean 33	difference 3		

As 9600	:	3	29.45	0.01
Mean 33			0.01	
standard $\frac{31}{2}$			$D=29.44$	$\log 4689378$
difference 2			$d=26.82$	$\log 4284588$
		As 435 : 2,	404.790	: 1.86
		correction added	<u>1.86</u>	
		so the altitude sought is -	406.65 fathoms,	
			or <u>2439.90</u> feet.	

APPENDIX 2. Heights of the mountains as estimated by George Skene Keith.

Name of Mountain	Date climbed	Height estimated	Modern estimate
Mount Battock	12 July 1810	2600 feet	2555 feet
Lochnagar	14 July 1810	3800 feet	3786 feet
Lochnagar	20 July 1810	3800 feet	3786 feet
Ben-a-Bourd	16 July 1810	3940 feet	3924 feet
Ben avon	16 July 1810	3920 feet	3843 feet
Brieriach	17 July 1810	4280 feet	4248 feet

Breriach	14 Sept. 1810	4220 feet	4248 feet
Breriach	21 Sept. 1810	4220 feet	4248 feet
Cairntoul	17 July 1810	4285 feet	4241 feet
Cairntoul	14 Sept. 1810	4220 feet	4241 feet
Ben Macdui	21 Sept. 1810	4300 feet	4296 feet
Cairngorm	21 Sept. 1810	4050 feet	4084 feet

