

the reflector to the heater. Yet we find that an increase of the number of reflecting plates increases proportionably the power of the motor. Considering that the parallelism of the rays absolutely prevents augmentation of temperature during the transmission, it will be asked: What causes the observed increase of mechanical power? Obviously, the energy produced by the increased density of the rays acting on the heater. The truth of the Newtonian doctrine, that the energy increases as the density of the rays, has thus been verified by a practical test which cannot be questioned. It is scarcely necessary to observe that our computation of temperature—1,303,640° Fahr.—does not show maximum solar intensity, the following points, besides atmospheric absorption, not having been considered:—(1) The diminution of energy attending the passage of the heat rays through the substance of the reflecting plates; (2) the diminution consequent on the great amount of heat radiated by the blackened surface of the heater; (3) the diminution of temperature in the heater caused by convection.

J. ERICSSON

#### A CHRISTMAS VISIT TO BEN NEVIS OBSERVATORY

ALTHOUGH I have no tale of perilous adventure or hair-breadth escape to tell the readers of NATURE, yet I think that they will be interested to hear of the progress that is being made in the first British attempt at the cultivation of high-level meteorology. This interest will be all the greater that the hearty encouragement and support that the Ben Nevis experiment has received from all parts of the United Kingdom has given it the character of a national undertaking.

As most of the readers of NATURE doubtless know, the observatory is at present in the experimental stage. A good road to the top with bridges and waterways has been made, and a part of the building erected sufficient to shelter the observers. It was judged wise to build as little as possible, until experience should have taught us the peculiar difficulties to be contended with in the somewhat novel circumstances presented by the summit of Ben Nevis in winter time. For, although several high level meteorological observatories, and indeed many other human habitations, already exist at much greater heights above the sea, yet there is probably no spot at present inhabited all the year round that presents climatic vicissitudes so remarkable. When winter is over, the directors will have a full report, with practical suggestions from the superintendent, Mr. Omond, to guide them in their further operations. Still it was thought well that some of the governing body should see with their own eyes the state of the observatory, and the work of the observers during the cold season. Accordingly two of them (Mr. John Murray and myself) made a visit of inspection on December 26th, of which I propose to give a few particulars.

Accompanied by Mr. Maclean, the contractor for the road and observatory buildings, we started from Fort William about 9.30 on Wednesday morning. At first the sky was dark and gloomy, and it was thought that Ben Nevis was to give a specimen of his worst weather. It was not cold however; in fact it was oppressively warm during the first thousand feet of the ascent from the farm of Achantie where the new road begins. This, coupled with the fact that the pony which one of the party rode up the first 2500 feet of the hill somewhat forced the pace, made it a little uncomfortable for the two pedestrians. The newly made road, loosened by the frost, and sodden by the rain and melting snow, was in places very heavy. Up as far as the little lake (Loch an Meall aut Suidhe), however, the roadway had suffered no substantial damage, except that the fall of a large stone had carried away a small piece of the margin; and all the bridges and waterways were found in excellent condition. This is very satisfactory, for the snow has already been down to Fort

William; and recently a very rapid thaw has carried it so completely away, that on the 26th very little was met with under 3000 feet. The test has thus been tolerably severe and yet up to 2600 feet or so the road on the 26th was in far better condition than it was on the day of the opening ceremony. About the altitude just mentioned, a part of the road had been badly ploughed up by a spate of water from the melting snow; higher up still, the damage seemed to be less, but it was not so easy to judge, as the roadway was there gradually lost in the overlying snow.

As the party rose in height, the temperature of the air and the ardour of the pony alike fell, and then the walkers were left to the full enjoyment of their climb. During the latter part of the first 3000 feet, the mist had been so thick that the pony and its rider could scarcely be discerned a few yards off; but several hundred feet higher, after the road had been finally lost sight of in the snow, and all the party were on foot, we suddenly emerged about noon from the gloom of the mist into the brightest of daylight. Overhead the sky was blue, a fresh light breeze was blowing, and the reflected sunlight was shining in silvery masses on the undulating surface of the frozen snow. We soon reached Buchan's Well, the position of which had been marked by a wooden pole; but the well itself was completely hidden by a deep snow-drift, which filled the hollow in which it lies. From this spot to the top, the ascent was made almost straight over the snow. At times it was steep and slippery, but the surface was so hard that we rarely sank over the ankles. Two of us were rough shod, one having a few cricketer's spikes screwed to the soles of his boots, the other a pair of *steigeisen* (climbing irons), the use of which he had learned several years ago during some excursions in the Tyrolean Alps. Mr. Maclean, who had not taken these precautions, fell once or twice, but fortunately without being hurt in any way. When near the last slope we desisted Mr. Omond hacking away most assiduously with an ice-axe to prepare a way for us, a needless precaution as far as the rough-shod members of the party were concerned.

The view from the plateau on the summit was magnificent. All round there floated a billowy ocean of white mist, from which rose masses of the same, piled up in places like mountain ranges, and through which rose here and there black mountain peaks (prominent among these Schiehallion). A way towards Fort William was stretched a black curtain of mist in striking contrast with the snow-whiteness of the upper layer. Down in Glen Nevis a similar mass was seen, rolled and twisted by the air-currents into the most fantastic shapes. So grand was the spectacle that one of our party insisted that we had before us the model from which Dante had drawn his vision of the entrance to hell.

The summit reached, the directors naturally looked around for the building, whose site they had chosen some five months before, and upon whose construction they had expended so much anxious thought. There was, however, nothing to be seen but two small dark-looking stumps rising a little over the surrounding snow flat, and alongside of these a little mound of snow. The stumps turned out to be the chimney and ventilator on the roof of the observatory, and the mound was a portico built by the observers with blocks of frozen snow to protect a snow staircase which had been carried down the side of the house to the doorway. After descending under the translucent canopy and stumbling for a little in the unfamiliar darkness of the passage, we entered the main room of the observatory, which for the present serves as sitting-room, kitchen, and office combined. Here we found the table laid for our lunch; and very soon we were comforting ourselves with hot coffee, cabin biscuits, and excellent Danish butter from the stores of the establishment. The whole ascent had occupied a little over three hours and a half.

The little room in which we sat contained the American

stove which heats the whole observatory, and on which the snow melting and all the cooking is done by John Duncan, the second assistant observer and housemaid. On one of the walls is the combined sideboard and crockery and instrument cupboard; against another stands a small bench with a vice; and on a third is the telegraph instrument, Mr. Omond's desk and book-case, and the drawers in which are kept the records of the observatory. Out of the sitting-room open the three bedrooms for the observers, which resemble very closely the cabins on board a ship; indeed the whole establishment has an intensely nautical air about it, and the visitor steadies himself instinctively now and then, and wonders that the roll never comes.

The rest of the building is occupied with a coal and oil store, and a storeroom in which are kept the cabin biscuits, dried potatoes, tinned soups, meat, and vegetables, lime juice, and medicine chest; which Mr. Omond calculates will support the three observers till June.

The afternoon and evening we spent in watching the observers at work, in dining (which we did very comfortably off the Christmas cheer, viz. roast turkey and plum pudding, provided for the inhabitants of Ben Nevis by a thoughtful friend), and in eager discussion of plans for the present and future work of the Observatory. The routine of the observatory at present consists in hourly observations of the barometer, protected thermometers, dry and wet bulb and maximum and minimum, wind-direction and pressure, rain, snow, sleet or hail, mist, fog or haze, clouds lower and upper, amount, species, and direction, sunshine recorder, miscellaneous, thunder, lightning, haloes, auroræ, meteors, &c., nature and precise time of occurrence of. The self-registering barograph and thermograph now added to the collection of instruments are working very well, and will be invaluable for the record of sudden changes. The protected thermometers and the thermograph are attached to a ladder fixed in the snow. As the level of the snow rises and falls, they are moved from step to step, so as to keep them as nearly as possible to the regulation distance of four feet from the surface. A measurement from the top of the ladder to the surface gives the depth of the snow, which at present varies from six to ten feet at different parts of the summit of the mountain.

Any detailed account of the winter climate of Ben Nevis would be premature and out of place in this notice; but Mr. Buchan has kindly furnished me with an analysis of the meteorological phenomena on Christmas and the following day which were in several respects remarkable.

At 1 A.M. of Christmas day, temperature was 37° 0 from which it steadily fell to 31° 5 at 11 A.M., the air all the time being quite saturated and loaded with dark, gloomy mist, with a barometer steadily rising. The wind was moderate from north-west till 3 A.M., when it changed to west-south-west. About noon the mist pall cleared away and the sun shone out with great splendour. From this hour to midnight, the following most remarkable observations were made (see table).

Except a few cirrus clouds which appeared about one, three, four, and ten o'clock, the sky was cloudless throughout, and during the evening the stars sparkled with unwonted brightness in the dark blue sky.

These remarkable atmospheric conditions were strictly confined to the higher region of Ben Nevis. Fog or cloud covered the lower hills and filled the valleys all the afternoon; it rose sometimes as high as the "plateau of storms," but was mostly below 3000 feet on Ben Nevis, and during the time no other hill showed itself through the sea of cloud. The sunset of the 25th, as well as the sunrise of the 26th, was very beautiful. On the 26th pressure remained high and steady, wind south-westerly, sky generally clear, and temperature and humidity equally

	BAROM.	THERM.		HUMIDITY.	
	Inches.	Dry.	Wet.	Calculated.	Air Hygrometer.
Noon	25·822	33° 0	31° 9	88	—
1 P.M.	·834	36° 9	33° 4	70	86
2 "	·824	37° 6	33° 1	66	76
3 "	·823	40° 9	31° 8	45	64
4 "	·819	37° 7	30° 8	50	71
5 "	·818	39° 8	31° 8	47	60
6 "	·817	40° 0	32° 8	50	56
7 "	·811	39° 3	32° 2	51	57
8 "	·813	38° 4	32° 1	53	64
9 "	·812	32° 8	31° 7	87	77
10 "	·813	38° 8	34° 7	69	63
11 "	·804	37° 0	36° 1	92	65
Midnight	·809	38° 9	38° 5	97	62

remarkable as on the preceding day. Indeed at 2 P.M. the relative humidity, which was lower than could be calculated from Glaisher's Tables, was only 34. At 3 P.M. temperature had fallen 6° 9, humidity risen to 96°, and a light fog prevailed for the next four hours, the wind having shifted from south-west to west-north-west. About 7 P.M. the sky again cleared, temperature steady, rose from 28° 0 to 36° 0 at midnight, and a humidity as low as 67 was observed. The great significance of these observations on Ben Nevis will be more apparent when compared with the anticyclone which overspread so large a part of north-western Europe at the time, to which, being situated on its west side, we owed the mild weather of Christmas, 1883.

In addition to the hourly observations, the observers have had for some time back to conduct a constant warfare with the rapidly-accumulating snow. Every now and then all hands had to be turned out to clear the doors and windows of the observatory; and it sometimes happened that, when they went out for this purpose, the snow drifted in so rapidly that it was almost impossible to shut the door again. The device of the snow staircase got over the difficulty to a large extent as regards the door, and it is proposed to build tubes with short lengths of rectangular wooden framework, passing from the windows up to the surface of the snow. At the upper end of these will be placed, at night or during heavy snowfalls, light canvas doors, which can be afterwards removed and additional lengths of framework added according to necessity. The chimney will be lengthened in a similar way by means of iron tubes, which have been sent up for the purpose. In this way the difficulties of the present winter will be met. For the future it is proposed to get over the difficulty of the accumulating snow by building an observing tower at some little distance from the living-rooms. In this tower there will be several stories with doors to the four cardinal points of the compass, so that the observers may use for exit and entrance that story which is nearest the snow level, and that door which happens to be on the lee-side of the tower. In the ground-floor of this tower it is proposed to place a seismometer and self-registering magnetic instruments. On the roof will be placed an anemometer for measuring the direction and strength of the wind. It is proposed so to arrange this instrument that its indications can be read inside the tower. This appears to be essential, for during the storm on the 12th ult. it was found impossible to go outside the observatory, so that wind observations are wanting in the daily sheet on that very interesting occasion. The observing-tower will be connected with the rest of the buildings by a covered way of some length fitted with doors to cut off the hot air; and in all probability the accommodation of the observatory will be increased by the addition of an office, or experimenting room, and one or more small

bedrooms for the use of inspectors or others on temporary business, and for the convenience of scientific men who may wish to make a visit to the observatory for the purposes of scientific research.

For reasons sufficiently explained, the staff has scarcely had time as yet to go beyond the mere routine of observations above mentioned; but none of the valuable suggestions which Mr. Omond and the directors have received have been lost sight of. A beginning has already been made in the collection of meteoric dust; in fact Mr. Murray carried down with him a portion of the residue obtained by melting considerable quantities of surface snow. This is now being examined, and we shall doubtless hear by and by whether it is all of purely local, or partly of volcanic or cosmic origin.

It is intended, as soon as proper arrangements can be made, and the concurrence of the Post Office authorities obtained, to commence a series of simultaneous observations on earth currents along the cable from the summit of Ben Nevis to Fort William, and along a telegraph line from Fort William to some other station not far above sea-level. By means of this horizontal and vertical exploration we hope to obtain some interesting data (either positive or negative) regarding the origin of the variations of terrestrial magnetism, auroræ, &c. The cable will also be turned to account for observations on atmospheric electricity. These plans are mentioned partly to show that the directors are fully alive to the manifold uses to be made of their stronghold upon Ben Nevis, partly to incite scientific men generally to favour us with their suggestions for the full utilisation of the observatory, not only for meteorology, but for physical science in general.

It would take too long to dwell at length on all the interesting casual observations recorded in Mr. Omond's log, a detailed account of which will probably be given hereafter by Mr. Omond himself. It may be interesting, however, to allude to the frequently occurring phenomenon which he calls "Glories." The shadow of the head or hands of the observer is frequently seen on the clouds in the valley to the north-east surrounded by a halo of colour. The phenomenon appears to be akin to, or identical with, the mist phantom so well known under the name of the "Brocken Spectre." The occurrence of this phenomenon is by no means so rare in this country as many suppose. The writer of this notice saw it to perfection three years ago in Skye. A party of four or five of us were standing on Sgur-na-Panachtich, or e of the Cuchullin peaks; we were looking down on the dark rock basin of Coruisk, in which was floating a cloud of mist. The sun was low behind us; and, projected on the mist, we saw what appeared to be gigantic dark shadows of ourselves completely outlined with a glory of rainbow colours. Each could see his own spectre best, but also those of his neighbours more or less distinctly. The figures imitated every motion we made, and, when we whirled our alpenstocks over our heads, the antics of the phantoms were most weird and awe-inspiring.

We spent the night of the 26th at the Observatory. During the first watch, that is, up to about one o'clock in the morning, we sat up, and went out with the observer when he made his hourly observations. The air felt quite mild, although the temperature was about the freezing point; the sky was perfectly clear, and the stars shone brilliantly. Mr. Omond brought out his telescope, and we lay down on the snow and examined Jupiter and his satellites, filled our eyes with the beauties of the Pleiades, and exhausted our little stocks of astronomical knowledge by naming such constellations as we happened to know.

The staff had insisted on providing each of us with a bed; we thus had good opportunity of testing their sleeping accommodation, which turned out to be excellent. Next morning we rose to see the sun rise, and were richly rewarded. About eight o'clock a ribbon of

bright crimson appeared behind Schiehallion, which developed a gorgeous succession of tints ending in copper colour and brick red, under the gradually rising sun; to right and left appeared the peculiar green colours so marked in the recent remarkable sunsets, to which the Ben Nevis sunrise showed a great resemblance. The greater part of the horizon was clear, and we had a view of the surrounding mountains seldom, if ever, equalled in summer time for beauty of colour. Ben More, the range of Glencoe, the Perthshire Hills, the whole length of the Caledonian Canal, the Cuchullin Hills, could all be seen with perfect distinctness. The white snow on the black-blue hilltops, and the bright red of the withered heather and bracken lower down, afforded contrasts of colour to be seen at no other season. Some of the hillsides shone in the sunlight like bronze. Others glowed like the richest velvet, and the valleys were filled with the subtle blue haze that gives such a charm to the scenery of the west of Scotland.

We naturally congratulated Mr. Omond on the weather he enjoyed on Ben Nevis; but it appeared that the treat was as great for him as for us. Since he began his seclusion on November 11, there had been just three fine days—the day on which he went up, Christmas day, and the day following, all the rest of the time the most he had seen was an occasional glimpse of a snow-covered mountain-peak through a hole in the mist. Our good fortune had been great; and, although it might have suited the main purpose of our visit better to have been detained by mist and sleet, or to have seen the observatory in the process of being buried in a snow-drift, we resigned ourselves with a very good grace to what the Fates had sent us.

After sharing the regulation breakfast of tinned mutton and coffee, we went out once more to see the observers at work. We then had an opportunity of seeing the precautions which they find it necessary to take in tempestuous weather when they have occasion to go near the edge of the narrow plateau on which they live. For sanitary reasons it is necessary to carry all the refuse of the observatory to a considerable distance, where it is thrown over a cliff. In winter, when this cliff is covered with a treacherous cornice of slippery snow, and the wind blows so hard that the head of a meat tin thrown to windward is often carried right back to leeward of the mountain, the footing at the edge is anything but secure. On such occasions two of the observers go abreast with the pail of rubbish between them, and each is roped to one who goes behind with an ice-axe to steady him in case of accident.

By 11 o'clock the barometer had begun to fall, and the humidity of the air had greatly increased. Mr. Omond therefore warned us that, unless we were prepared to incur the risk of detention, we had better depart. Accordingly we packed up our trophies, consisting of the residue above mentioned, pregnant with the potentiality of cosmic and volcanic dust, a bundle of Mr. Omond's daily sheets, and a little shrew that had been killed on the previous evening, the first of a colony of these animals who, with several weasels, had taken up their abode in the outer dry stone wall of the observatory. As might be expected, animal life is very scarce in winter on the top of Ben Nevis. No deer or ptarmigan had been seen, only the tracks of foxes, which abound in certain parts of the hill. The only living things we had seen in the snow-covered part of the hill were large numbers of a dipterous fly, which we found every now and then crawling on the surface of the snow.

Having bidden farewell to Mr. Omond and his companions, and wished them good luck and a continuance of their present good health and spirits during the rest of the winter, we commenced our descent at 11.30. The bottom was reached, after several halts to enjoy the magnificent view, in about the same time as it had taken us to ascend.

In such weather as we had the ascent of Ben Nevis is decidedly more pleasant and less fatiguing than in summer. It is well, however, to warn the readers of NATURE that our case was exceptional, and that under adverse circumstances such an enterprise is likely to be both unpleasant and dangerous. G. CHRYSAL

#### THE REMARKABLE SUNSETS

INFORMATION with regard to these beautiful phenomena and their cause is rapidly being collected, and at the same time the opinions of those who have given most attention to them are being stated, both here and on the Continent. Among the latter we may refer to a memoir presented by Prof. Forel to the Société Vaudoise des Sciences Naturelles, on the 19th of December. At the beginning of the displays in Switzerland, M. Forel ascribed them to those causes which produce the ordinary after-glow so beautifully visible in mountainous countries, and at first he considered that the meteorological conditions were such as to favour this view. Further inquiry, however, he now states has made this hypothesis absolutely untenable. One of his arguments is that the glows which first appeared in November and then decreased to 3rd December, regained a maximum on the 24th and 25th. Now from the 22nd to 26th December, Switzerland was the centre of a maximum of atmospheric pressure, the barometer being higher there than in any of the surrounding countries. Exactly the opposite held in November, and this confirms him in the idea that meteorological factors alone do not suffice to explain the glows. He also describes the dates and tracts of the chromatic phenomena observed, and considers that their origination in Krakatoa is a simple and sufficient explanation. *La Nature* for the 29th ult. contains an interesting communication from M. Van Sandick, an Engineer des Ponts et Chaussées, at Pedang, who was an eye witness of the later stage of the eruption. He was on board the *Governor-General Loudin*, and was close to Krakatoa on August 26th. His communication is accompanied by a very detailed map, showing the changes which have supervened not only in the Straits themselves, but also on the neighbouring coasts of Java and Sumatra, but we shall return to this important letter.

The new observatory on the summit of Ben Nevis has been utilised for the collection of snow, with a view of determining whether or not it contains any dust particles. This has been forwarded to Mr. John Murray of the *Challenger* Commission by Mr. Omond the superintendent of the observatory. We may hope to hear soon whether the results are positive or negative on this special point of inquiry. We have to call attention to the important letter of Mr. Macpherson published below. We learn from the *Weekly British Colonist*, published at Victoria, British Columbia, that the sunsets made their appearance there on November 27th. Long after sunset the light in the sky became more fervent in colour, till at last the waters in the harbour and straits borrowed the splendid crimson. Darting and rapidly moving blood-red rays of light were seen shooting far into the sky, suggesting an aurora. A letter from St. Raphael, on the shores of the bay of San Francisco, dated December 4th, refers to the magnificent sunrises and sunsets. The date of their commencement is not stated. From Kiakhita, on the Mongolian frontier, we learn that the glows there began on December 11th, and terminated on the 25th.

The glows were seen some time before November 6th at Kalim Pong, twenty miles north-west of Darjeeling.

We have received the following further communications on this subject:—

THE body of evidence now brought in from all parts of the world must, I think, by this time have convinced Mr. Piazzi Smyth that the late sunrises and sunsets do need

some explanation, more particular than he was willing to give them. With your leave I should like to point out from my own observations and those of others that, "given a clear sky" and the other conditions put by Mr. Smyth, the sunrises and sunsets of other days, however bright and beautiful, have *not* given any such effects as were witnessed, to take an instance, here on Sunday night, December 16th. I shall speak chiefly of the sunsets.

(1) *These sunsets differ from others, first in their time and their place or quarter.* Sunset proper is, I suppose, the few minutes between the first dipping and the last disappearance of the sun's disk below the true horizon; the pageant or phenomena we call sunset, however, includes a great deal that goes on before and after this. The remarkable and specific features of the late sunsets have not been before or at sunset proper; they have been after-glows, and have lasted long, very long, after. To take instances from your number of the 13th ult., Mr. F. A. R. Russell notices that on November 28th, the sun having set at 3.55, one after-glow lasted till 5.10, and was then succeeded by another "reaching high above the horizon." The day before he mentions the after-glow as lasting to 5.20. On the 29th a "foreglow" is reported as seen in London from 5.30 to 7.30, that is more than two hours before sunrise, which was at 7.43. On December 1st, sunset being at 3.53, Mr. Russell observed an after-glow till 5.35; on December 4th the first dawn at 6.5, the sun rising at 7.50; the next day dawn at the same time, sunrise 7.51; that evening, sunset being at 3.50, he observed not a glow only but "spokes of rays from the glowing bank" at 4.45, that is to say, sunbeams, visible in the shape of sunbeams, 55 minutes after sunset. Mr. Johnston-Lavis speaks of the after-glow at Naples as *at a maximum* an hour after sunset. Here at Stonyhurst on December 16th, the sun having set at 3.49, the glow was observed till 5.50. Now winter dawns and after-glows do not last from an hour to two hours, and still less so day after day, as these have done. The recent sunrises and sunsets then differ from others in duration.

They differ also in the quarter of the heavens where they are seen. The after-glows are not low lingering slips of light skirting the horizon, but high up in the sky, sometimes in the zenith.

I have further remarked that the deepest of the after-glow is in the south, whereas the sun below the horizon is then northing. I see that other observers take notice of the same.

(2) *They differ in their periodic action or behaviour.* The flushes of crimson and other colours after ordinary sunsets are irregular, not the same nor at the same time for two days together; for they depend upon the accidental shapes and sizes and densities of the cloud-banks or vapour-banks the sun is entering or freeing himself from, which vary and can never be alike from day to day. But these glows or flushes are noticed to be periodic before sunrise and after sunset. Mr. Russell furnishes exact estimates of the intervals of time, which he finds to be the same day after day.

(3) *They differ in the nature of the glow, which is both intense and lustreless,* and that both in the sky and on the earth. The glow is intense, this is what strikes every one; it has prolonged the daylight, and optically changed the season; it bathes the whole sky, it is mistaken for the reflection of a great fire; at the sundown itself and southwards from that on December 4, I took a note of it as more like inflamed flesh than the lucid reds of ordinary sunsets. On the same evening the fields facing west glowed as if overlaid with yellow wax.

But it is also lustreless. A bright sunset lines the clouds so that their brims look like gold, brass, bronze, or steel. It fetches out those dazzling flecks and spangles which people call fish-scales. It gives to a mackerel or dappled cloudrack the appearance of quilted crimson