Counting dust and domesticating clouds:

inside the 'outdoor physics' of John Aitken (1839–1919)

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Abstract
This paper takes the work of John Aitken, physicist and meteorologist, to illustrate one facet of nature on display in late nineteenth-century Scotland. Commentators on Aitken from the early twentieth century classified him as a devotee of 'outdoor physics'. They recognised his profound spiritual engagement with everyday environmental phenomena, understanding that his explanations of dew or clouds according to scientific canons did not diminish his wonder at nature. Here, I re-consider Aitken's programme of reducing complex phenomena on the largest natural scale, whether a beautifully coloured sky or a vast weather system, to the scope of his domestic workshop laboratory. Trained as an engineer, Aitken used mechanical skills to manufacture models of glaciers or anti-cyclones at home. In a process of small-scale 'mimicry', models provided suggestive analogies to natural phenomena, from which scientifically useful inferences could be made. It was a scientific style intermediate between the reductive, analytical practices of the physical laboratory and the observation of untamed natural phenomena. In an age of 'Big Science', with international involvement and costs beyond the reach of the individual, Aitken prided himself on what he called a 'test-tube kind of work', devoid of mathematical complication; he nevertheless won a prestigious Royal Medal from the Royal Society of London. For Aitken, glaciers and clouds alike could be reduced to homely demonstrations fit for gentlemanly entertainment.

Keywords
John Aitken (1839–1919), nineteenth-century physics, nineteenth-century meterology

Introduction
My article focuses on the nineteenth- and early twentieth-century Scottish physicist and meteorologist John Aitken (1839–1919) (Marsden 2008; Knott 1923). Amongst historians of science, Aitken is primarily known for his work on the origins of dew, and the role of particles (subsequently named 'Aitken nuclei') in the condensation of clouds. More recently his studies of precise thermometry have attracted investigated (Chang 2004:35–39). Yet paradoxically Aitken is alluded to most often in connection with someone else's work: he is 'known' for physicist C.T. R. Wilson's so-called 'cloud chamber', a

particle detector at the centre of the new atomic physics of the 1890s (Galison and Assmus 1989; Galison 1997:81–96). In a manner still unclear to historians Wilson's 'cloud chamber', central to the new physics, derived from Aitken's on-the-face-of-it less exciting 'dust detective', a device which estimated the number of particles in a sample of air. Although I will touch on that connection, here I speculate primarily on Aitken's idiosyncratic attempts, as an amateur gentlemanly physicist, to display nature in her 'everyday moods'. The general ambition of this nascent man of science was this: to make manifest, often by magnifying through simple apparatus, the everyday phenomena, and powers, of nature.

At first sight, he looks like an anachronism: a lingering example of the gentlemanly amateur specialist in science, pushed to the margins in early twentieth-century Britain. He practised no profession, and held no position at any university. He dallied with government only during the First World War. He was constitutionally remote from the displays of mental and physical athleticism typical of the Cambridge University mathematical students, or 'wranglers', who came to dominate British physics (Warwick 2003). He left others to network, internationalize and divide their experimental labours in 'Big Science': no complex collaboration, and few esoterica or exotica for him (Hughes 2003). Aitken resembles more closely the amateur gentlemanly scientific specialist of the 1830s than the typical scientific practitioners of the later nineteenth century: the public servant, the professional, the polemicist worried about British economic 'decline' relative to other nations, the tub-thumping empire-building scientific naturalist (Morrell and Thackray 1981; Barton 2003).

Why, then, immediately after the First World War, did Britain's premier scientific body, the Royal Society of London, reward Aitken with one of its highest honours? I would like here to move Aitken out of Wilson's shadow and to try to explain that Royal Medal; but to do that means looking at Aitken's curiously domestic brand of 'outdoor physics'. The journey takes us from Edinburgh to Ben Nevis, via the Eiffel Tower – but we start in Falkirk, in the central belt of Scotland.

From marine engineering to meteorology: taming and displaying nature

Aitken's original career choice was marine engineering, rather than physics or meteorology (Marsden 2008). The legal firm of 'Russel & Aitken' melded lawyers, bankers, accountants and industrialists, the last of whom had substantial interests in mining, shipping and railways.[1] John Aitken and his brothers were trained up to meet the strategic needs of the business. The eldest, James, studied law. John went to Glasgow, and to its University, where he imbibed an unusual blend of engineering theory and practice. William Thomson, later Britain's first scientific peer Lord Kelvin, trained him in theoretical and experimental natural philosophy, or what we would call physics (Smith and Wise 1989). The elite firm of Robert Napier & Sons gave him practical experience in marine engineering and ship design. Also, during the university session of 1856–57, a new appointee at Glasgow, William John Macquorn Rankine, provided the bridge between 'theory and practice' at his class in civil engineering and mechanics.[2] Aitken excelled in his university studies; and exquisite surviving drawings of engines for the Napiers augured a bright future in the profession of marine engineering where he might, according to the terms of the charter of the Institution of Civil Engineers, tame the great forces of nature.[3]

He was a prize-winning student but never the scientific engineer Rankine might have hoped. His parents died in quick succession in 1860; and his own health, never strong, showed signs of failing. His father's will, however, provided for the completion of his sons' professional tutelage and, quite explicitly, stated that should any of his progeny become ill, rather than merely idle, the family home 'Darroch' would remain open to him throughout his life.[4] From the early 1850s, the capacious Aitken home in Falkirk thus became the unlikely domicile of numerous Aitken brothers: these men were unmarried, ailing, or both.[5] The precise nature of John Aitken's illness remains mysterious. His letters complain of colds, influenza, sciatica, a damaged leg, a broken hand, shingles, and depression; tellingly, they report a 'feeble constitution' from birth which had put Aitken 'out of the running with the able bodied'.[6] Late in life Aitken joked: 'If I wanted to improve the [human] breed I would aim at something better than Aitkens.'[7] Yet illness and domestic seclusion might easily be conducive to a productive life in gentlemanly science: we know this well from the case of that most famous scientific invalid Charles Darwin (Browne 1998). So it would be with Aitken.

In transition, or in a process of re-fashioning his identity, this marine engineer *manqué* dabbled in the gentlemanly pursuits of angling, gardening, ornithology and philanthropy. But through the 1860s and 1870s it was the then fashionable, yet serious, leisure pursuit of photography that eased him into the role of what historians of science Morrell and Thackray have termed the 'gentleman of science' (Tucker 2005; Morrell and Thackray 1981); it also allowed him to dally with institutions for science. The Royal Scottish Society of Arts (RSSA), based conveniently for Aitken in nearby Edinburgh, provided a socially diverse and thus unintimidating stage for photographic spinoffs like Aitken's forays into colour chemistry; and through the RSSA, Aitken came into contact with local stars and rising celebrities in physics, like the Scottish electromagnetic theorist James Clerk Maxwell.[8] They met when the peripatetic British Association for the Advancement of Science (BAAS) held its annual meeting in Edinburgh in 1871; a correspondence began.[9] Around this time Maxwell had extracted himself from country pursuits at his Glenlair estate and was embarking on a programme of experimental physics teaching at the new Cavendish Laboratory in Cambridge.[10] He wanted apparatus to entertain and inform his classroom students – and Aitken responded with simple kit for illustrating, in this case, the peculiarities of colour perception.

As Aitken toyed with scientific activity, his personal style emerged. It had several distinctive characteristics, adopted from the broader scientific culture he inhabited, yet given particular prominence and emphasis. In Aitken's work there was a particular style of reporting, especially in the writing of scientific notes and papers; a particular attitude towards apparatus; views of the place of home and travel in his scientific practice; and, ultimately, a profound and holistic engagement with what we would call the environment – and what contemporaries like the Edinburgh physicist C. G. Knott thought of as nature at large, or indeed, 'nature in her everyday moods'.[11] These attitudes towards scientific endeavour, we shall see, invested Aitken's practice with certain moral virtues.

As the originator of scientific ideas but especially as the agent of literary expression of those ideas, Aitken learnt, self-consciously, from at least two iconic predecessors: both were famous in his time for displaying, in different ways, nature's powers. He owned, and we presume read, tracts by the seventeenth-century experimental virtuoso Robert Boyle, a key figure of the early Royal Society of London. He also owned the works of the nineteenth-century luminary Michael Faraday, 'discoverer' of electromagnetic induction and a hugely popular lecturer at London's fashionable Royal Institution.[12] Steven Shapin reminds us of Boyle's prolixity, his direct and circumstantial manner of writing or 'plain style', his consensus building, and his avoidance of uncivil, provocatively over-precise, technical mathematical statement. For Shapin, that writing style was coherent with a theologically voluntarist posture in which Boyle worshipped nature as it had been fashioned by God, according to His choices, and not according to intellectual or rational constraints imposed by humanity (Shapin 1984; Shapin 1994:310–54). Working a century and a half later than Boyle, Faraday related his experimental researches in protracted numbered series; his style too was plain and circumstantial, deliberately stripped of what he considered to be unnecessarily theoretical, dogmatic and exclusive language (Gooding and James 1985; Gooding 1985). In particular Faraday avoided the abstruse mathematics of the elite Cambridge University wranglers he knew so well, amongst them Aitken's teacher William Thomson and his correspondent James Clerk Maxwell.

Aitken's style, like Boyle's and to a lesser extent like Faraday's, was circumstantial: it provided extensive and particular detail rather than abstraction; it was quite pointedly and deliberately anti-hypothetical. In notes, letters and papers submitted from the early 1870s Aitken rigorously excluded mathematical symbolism. The astronomer and reformer of science education Norman Lockyer provided in his journal *Nature* a forum for practitioners across the spectrum: contributions came from occasional dabblers to university professionals alike (Gooday 1991). In *Nature*, Aitken could talk in plain, non-technical language on whatever caught his attention, from butterflies to heat engines.[13] The phenomena of nature should, under Aitken's pen, be comprehensible to those untutored both in science and mathematics, amongst whom he liked, somewhat disingenuously, to position himself. He had won prizes in Glasgow University science classes and survived Macquorn Rankine's famously challenging engineering classes and textbooks; his large personal library certainly contained mathematical works.[14] Somehow, perhaps because of those experiences, Aitken had come to see mathematics as just so much obfuscation. Aitken avoided the mathematical register of new generations of British physicists trained up by mathematical coaches, or 'wrangler makers' in the reformed Cambridge University (Warwick 2003). Nature should be left to speak for herself or, if not quite for herself, through the actions of the experimental demonstrator who could appear as a transparent vessel. For Boyle, Faraday, and now for Aitken, art concealed art: nature spoke with apparent directness to her human admirers.

One thing that made this allegedly direct communication possible was the construction of scientific apparatus designed to magnify particular natural effects. Both as a student of William

Thomson and as a marine engineer *manqué*, Aitken was trained to make, manufacture and measure. Thomson's thrifty laboratory students in Glasgow constructed much of their own apparatus: they were coached to believe that to understand natural phenomena one most model them mechanically and then subject them to measurement. Rarely, then, were the scientific instruments they used bought 'off the shelf' (Smith 1998). After leaving Thomson's class, Aitken had collaborated with his old professor on experiments concerning centrifugal force. But also, after giving up any thought of a marine engineering career, ensconced in the domestic arena of Darroch, in Falkirk, Aitken continued to practise his mechanical skills, making useful objects of 'beauty, delicacy, and finish', not to mention decorative 'turned' metal objects using the kind of lathe that the London company of Holtzapffel routinely supplied to gentleman amateur mechanics. This 'bric-a-brac' apparently possessed the 'charm and grace of a Phidias [the Greek sculptor]'; some of the objects 'privately sold for charitable purposes, realised big prices'.[15] Thus did Aitken fulfil his philanthropic duties.

But what kind of experimental style or 'experimental life', to borrow physics historian Iwan Morus's phrase, would Aitken have? What was his manner with, and attitude towards, the apparatus which he had so painstakingly constructed in his home? Was he a Faraday: the philosopher, concealing human artifice and conspicuous apparatus in his demonstrations through careful practised lecturing art? Or was he more like Faraday's rival and contemporary William Sturgeon: the craftsman, tradesman and electrician, for whom apparatus in all its gaudiness was the route to eye-catching display spectacle (Morus 1992)? Probably the former: with covert ambitions to teach, and to entertain, Aitken invented and constructed new instruments fitted equally for the classroom or for the polite entertainment of a domestic space. Indeed, the so-called 'democratic intellect' of Scotland's university system, with its broad social mixing and its discursive lecture style, meant that the classroom and the entertaining show-space were not so far apart (Golinski 1992:11–37). Thus, Aitken's 'chromomictor', to take only one example, facilitated the separation and mixing of colours. That was something useful for domestic consumption, popular lecturers, and more formal class-room teacher alike.

Through such devices for the display of nature, Aitken indicated that, despite his withdrawal from active masculine work and university life, he could contribute to the practice and pedagogy of natural philosophy at home, in his local Falkirk community. Experiments, and apparatus-building, happened in the amply stocked domestic workshops tolerated by Aitken's brothers and connected to the larger household economy run primarily by paid female servants. We should not be too surprised to find this overlapping of the homely and the experimental: William Thomson used his own 'home from home', the yacht *Lallah Rookh*, as a floating laboratory (Smith and Wise 1989:733–40). And, as Simon Schaffer reminds us, country house laboratories were not rare in late nineteenth-century British physics, at least amongst those who could afford the considerable expense (Schaffer 1998; see also, for some Oxford examples, Fox and Gooday 2005:162–164). Domesticity was almost a necessary option for the invalid, but for 'scientific invalids', like Aitken and Darwin, it erected a tough boundary which screened and filtered unwanted scientific encounters, or excused a shyness to act publicly and accept an institutional office. What is, perhaps, surprising is the way in which Aitken combined these virtues of life-saving domestic retirement with frequent travel abroad.

Finding 'good' air: an advocate for dust

Holidays were for recuperation and also, Aitken hinted, for science. Annually he headed for Italy, or for Cannes, to find a matrimonial mate, to take the air, and more particularly to escape the pollution of industry and agriculture. Cannes delivered copious curative winter sun and the 'good' air which came in stimulating, tonic, and calming varieties. All this was an ideal combination for anaemia, rickets, neurosis, rheumatism, and of course pulmonary sufferers as, perhaps, Aitken was. Imagine then John Aitken, amid the winter sun, breathing deeply, blockaded by scientific books and surrounded by the meteorological instruments which he had knocked up at home. Travel for his health facilitated a science of environment 'in the large'. Bored with Cannes, Aitken journeyed to Paris. The proprietors of the Eiffel Tower afforded him, or more likely his assistants, early access, before the public opening – for the salutary purposes of scientific measurement, of course.

Finding and defining 'good' air was not new: the eighteenth-century chemist and radical preacher Joseph Priestley had tried to do this a century earlier (Schaffer 1990). Nineteenth-century Britain, obsessed by its own steam-driven, coal-powered, industrialization, grappled with and re-invented the idea of 'pollution' (Thorsheim 2006). For Aitken, working in that age, the quest for good air was a kind of heuristic 'glue' which bound together his scientific, therapeutic and peripatetic explorations. Was good air to be found in the Scottish mountains and glens? Was it in Paris at the top of the new Eiffel Tower, way above the industrial pollution of the city? Few sought it in the smog of London, or the grime of Grimsby – yet, obtusely, Aitken claimed that smoke might be deodorizing and antiseptic, beneficial to human health (Thorsheim 2006:22). These were the kinds of questions that occupied him.

Air, as a vector for dust, dew, and light, figured prominently in the set-piece experiments that had made Aitken an unlikely celebrity by the 1880s. When not writing, in a plain and direct style, in Lockyer's journal *Nature* about nature's doings, Aitken performed with the demonstrators' skill before the Royal Society of Edinburgh (RSE). There, and at non-specialist and popular *conversaziones* in London open even to ladies,[16] he domesticated, by demonstrating, the physics of the great outdoors: the phenomena of the skies – sunsets, sky colour, cloud formations. His forte was not the formal paper but rather the virtuosic display. Contemporary audiences gaped, jaws wide, at chains of practical experiments which quietly compelled them to apprehend familiar outdoor phenomena. In a revealing example of the every-day in Aitken's homely natural world, 'dew' revealed its properties with the help of minute observations of a supremely unchallenging and non-technical vegetable: garden broccoli.[17]

'Clouds', too, delivered the secrets of their formation. Giving the answer of the 'feeble-bodied', concerned with his own and with the public's health, Aitken demonstrated that we get clouds when we have particles, without which there can be no condensation of vapour. So 'good' was, surprisingly, not necessarily air that was entirely 'clean'. Once again Aitken performed a structured chain of experiments made credible by his unassuming gestural rhetoric. He showed that dusty air that was cooled rapidly by the process of expansion underwent what was called 'cloudy condensation'; yet air first deprived of its dust and then expanded failed to produce the same cloudy effect. Journalists in *Nature* and in the London *Times* reported these demonstrations, and their subsequent ramifications, with joyous enthusiasm.[18] Dust was rehabilitated as a natural, and indeed vital, additive of common air, without which there would be no rain.

Domesticating and disciplining outdoor physics

For Aitken, fame followed and a research programme began. It was one which used the precise measurement instruments constructed at home to measure the dust to be found in air, whether in the domestic arena, in the gardens of a country-house, or in the great outdoors. On the one hand, then, it used the products of the domestic workshop to comprehend outdoor physics, at the garden gate or much further afield; on the other, as we shall see, that programme brought nature, or a simulacrum of nature, into the living room in the form of homely and easily understood models. In the late nineteenth and early twentieth centuries, as distinctions between the laboratory spaces, domestic venues, and nature at large were becoming firmer, Aitken instead insisted on their permeability.

Two dust-detecting instruments formed a vital part of his programme, in part by emphasising the importance of discipline in scientific action: here, standardized, routine behaviour leading to simple numerical records. The instruments served two human constituencies and two purposes. Aitken's pocket dust counter was made and marketed in bulk for the numerous class of trustworthy gentlemanly observers and indeed for a more select group of travellers, whether of the middle class or in various public and private services. Aitken worked with an Edinburgh instrument maker and manufacturer of class-room apparatus, William Hume, to market the pocket dust counter (Clarke et al. 1989:133–136). These so-called 'dust detectives' and their carriers were soon sampling air in the Sahara and monitoring quality in round-the-world voyages; soon they had been renamed with morality in mind as 'sanitary detectives'.[19] The observing power of philosophically inclined gentlemen at home and in their normal walks of life was similarly recruited, harnessed, even disciplined, just as it had been in the sciences of geology, by the Geological Society of London, and meteorology, by the BAAS (Morrell and Thackray 1981:517–23). Factions within the BAAS favoured the creation of focused centres of meteorological practice, including observatories at key sites in Britain, notably at Aberdeen. But there was the opportunity also to harvest the local and dispersed products of gentlemanly amateur meteorologists; one of the best ways to do that was to distribute approved standardized instruments which, by proxy, disciplined their scientific practice (Anderson 2005:86-94). Aitken himself kept extensive reports over many years of temperature, pressure, and wind-speed as sampled in his Falkirk garden, but no less valuable for that.[20] The pocket dust-counter, when not a 'sanitary detective', was a new weapon in the amateur scientific armoury – destined, one could but hope, to ground inductively a science of the weather.

The second of Aitken's dust counters was a much larger, more robust, and, allegedly, more accurate instrument. It was designed to supplement the meteorological equipment improbably placed on the top of Scotland's highest mountain: Ben Nevis. Originally, a thirst for meteorological data led one athlete to make the demanding ascent every day. Later, the Scottish Meteorological Society and the RSE milked national pride and individual largess to fund a permanent, if inhospitable, Ben Nevis Meteorological Observatory (Anon 1893; Roy 2004). There, the dust counter had its place. The hope, at least, was that comparing data at the peak with data taken at the foot of the mountain would bring vital insights about large-scale air movements. Sadly, money ran out and the Observatory closed in 1903. In 1894, however, the Observatory had received one C. T. R. Wilson, a talented student physicist then 'between jobs' but, as it turned out, destined to return to the Cavendish Laboratory (Crowther 1974:134–36). Wilson was understandably fascinated, even awe-struck, by the vivid phenomena of 'glories' and 'coronas' manifested at the summit; as a volunteer observer he also encountered Aitken's dust counter which, of course, functioned essentially by creating small-scale clouds, or cloudy condensation. Later, attempting to reproduce these phenomena in the apparently more tranquil, yet in many senses more artificial, environment of the laboratory, he used Aitken's techniques. 'Dust counter' or 'sanitary detective' thus morphed, for a new group of practitioners, into 'cloud chamber'; and, to abbreviate, Wilson had the apparatus he, and his colleagues in and beyond Cambridge, wanted in order to monitor tiny particles, especially charged particles, in the laboratory.

Much has been made of Wilson's attempt to reproduce in miniature large-scale meteorological phenomena and of the initially surprising consequences of such attempts for physics more generally (Galison and Assmus 1989; Galison 1997:81–96); but long before, others had laboured to 'bring nature down to size', *mimicking*, rather than directly *reproducing*, natural effects. For example, a young William Stanley Jevons, later well-known as an economist, manipulated chemical precipitations to mimic the formation of clouds (Maas 2005:72–94). Without a cloud, or at least a cloud of water vapour, things about common clouds might still be learned. In one of many other examples, engineering professor Lewis Gordon claimed to the Alpinist and natural philosopher James David Forbes that he could mimic and explain aspects of the glacier motion which he had earlier experienced when lowered into a glacial crevasse. Gordon fabricated his explanation not out of ice but instead by recording his observations of the contents of a barrel of a kind of tar known as Stockholm pitch.[21] Without a glacier, or at least a glacier of ice, things might be learned about common glaciers.

As an acolyte of 'scientist of energy' William Thomson, Aitken too had produced a table-top glacier with blocks of ice, heat-conducting metal coins, and strings: all this mimicked the passage of a real glacier around a large 'erratic' block in a manner consistent with Thomson's science (Aitken 1872; Smith 1998a). Undaunted by the vast scale of meteorological phenomena, Aitken later attempted to build an anti-cyclone 'at home', in his Falkirk laboratory, his understanding guided, as Thomson so often advised, by making a human-scale mechanical model. Vertical tubes, heaters, and chemical air colorants did the trick. This apparatus analogue, once subjected to experimental investigation, was set to reveal the structure of weather systems. Thus were some of the grandest phenomena of everyday nature captured in the domestic arena; thus did Aitken respond to merely symbolic mathematical accounts which he dismissed as utterly artificial (Knott 1920–21:180).

'My test tube kind of work': putting the whole of nature on display

Aitken's view of the natural world was holistic, religiously inspired, and activated by a domesticating agenda. In a world shy of mathematical theory, the leap from air, to dust, to dew, to the robin in his garden was not so great. His frighteningly close scrutiny of divinely given everyday phenomena extended from the 'robin' returning over many seasons to his country garden, just beyond the workshop, to a curiously stubborn anomaly in the dust count at his holiday spot Kingairloch on Loch Linnhe. The real or pretended spiritualist phenomena of figures like Houdini and Daniel Home likewise came under his gaze, to be explained, or explained away, like the habits of the robin, the density of dust, the wind or the rain, by his homely scrutiny strengthened by the psychophysical insights of a Sigmund Freud or William James.[22]

Towards the end of his life, nevertheless, Aitken wryly remarked to his friend, the chemist Arthur Smithells: 'I am very pleased to hear you are still interested in my test tube kind of work which is rather unattractive to most mathematical workers, & has a disagreeable way of discrediting some of their fundamental assumptions'.[23] He meant, of course, the kind of science that could be done without expensive collective action or the brokered government involvement more typical of 'Big Science': the science focused in universities, from which he had excluded himself; or that servicing the military for which, even during the First World War, he could do little. By then he was recipient of the Royal Society's Royal Medal. That prize came as a response to his years of work on meteorology and to 'cloudy condensations', certainly. Yet, somewhat paradoxically, it came because of a re-evaluation of the central significance of his work – a re-evaluation with which he seems not to have fully approved. His dust counter, or 'sanitary detective', had been designed to clutch at nature 'in the large', in her everyday moods; it was rebranded as a central tool for a new laboratory-based physics of the very small, in forced circumstances.[24] Aitken had lectured, and written, for decades, on dust in all its ubiquitous variety. Visitors to Ben Nevis, like C. T. R. Wilson, captured dust at the top of this highest peak. Yet Wilson's cloud chambers would track phenomena which were artificial and for Aitken quite simply unnatural. Tiny charged particles, if such they were, were never, according to Aitken, revealed by his dust detective in nature's normal moods: they were thus unworthy of his study, and perhaps any study.

For Aitken's biographers their subject was less a man of specialist apparatus, even of the simplest portable test-tube variety, and more a devotee of the great outdoors. Their Aitken was to be found, in spirit at least, engaged in what H. J. Humphreys playfully called, in his review of Aitken's edited papers, 'outdoor physics' (Humphreys 1924). These evaluations point to Aitken's values. Informed by readings of the New England sage Henry Thoreau's *Walden*, Aitken saw the natural world as a place of glory and unity. It was a place comprehensible, with patience, by the little-tutored senses. The Ben Nevis observatory showed that a physical laboratory need not capture, torture, or pervert nature: rather, a mountain-top observatory – unsustainable, soon ruined – engendered humility as humanity wrestled with protean forces. For Aitken, nature was a living, un-dissected, totality to be properly witnessed in her 'everyday moods'. His nature was one coaxed to speak by patient and encouraging listening and observation by venturing out from living room to garden. It was not nature confronted and outgunned by laboratory apparatus, or strangled by wrangler makers.

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Notes

1. The firm's history is best explored through the Russel & Aitken Collection, Falkirk Council Archives.
2. See "Rankine, William John Macquorn (1820-1872), *Oxford Dictionary of National Biography*.
3. Box 16 (engineering drawings), Russel & Aitken Collection.
4. Inventory of Henry Aitken, SC67/36/42, National Archives of Scotland.
5. See return for Falkirk, Census 1861.
6. See, for example, Aitken to Smithells 14 July 1917, MS 416 267/11917, University of Leeds.
7. Aitken to Smithells, 23 October 1916, MS 416/260/1-2, University of Leeds.
8. See "Maxwell, James Clerk (1831-1879)", *Oxford Dictionary of National Biography*.
9. Aitken to Maxwell, 6 March 1873, Add. 7655, II, 70, Cambridge University Library.
10. See "Maxwell, James Clerk (1831-1879)", *Oxford Dictionary of National Biography*.
11. *Nature* 27 November 1919: 338.
12. 'Catalogue of Books, J. A., Darroch, May 1873' in Russel & Aitken Collection, Box 16. This key reference details the contents of Aitken's library and thus his probable readings.
13. See Knott 1923 for a bibliography and for a selection of Aitken's papers; topical references have been excised from the papers.
14. See 'Catalogue of Books'.
15. *Falkirk Herald* 22 November 1919: 5.
16. For example, *Times* 20 June 1889: 9.
17. *Falkirk Herald* 22 November 1919: 5.
18. For example, 'Lucifer', in *Times* 6 January 1892: 4.
19. *Scotsman* 18 October 1892: 6.
20. Notebooks B, C, D, E and F in John Aitken Papers, Russel & Aitken Collection, Falkirk Council Archives.
21. Lewis Gordon to James David Forbes, Glasgow, 5 February 1845, Forbes Papers, St Andrews University Library. Gordon was Rankine's predecessor in Glasgow University's engineering chair; Forbes had taught them both natural philosophy at Edinburgh University.
22. Aitken owned books by these authors. See 'Catalogue of Books'.
23. Aitken to Smithells, 14 July 1917, MS 416 267/1, University of Leeds.
24. Arthur Schuster, President of the RSL, to Aitken, 1 November 1917, in John Aitken papers, Falkirk Council Archives.

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