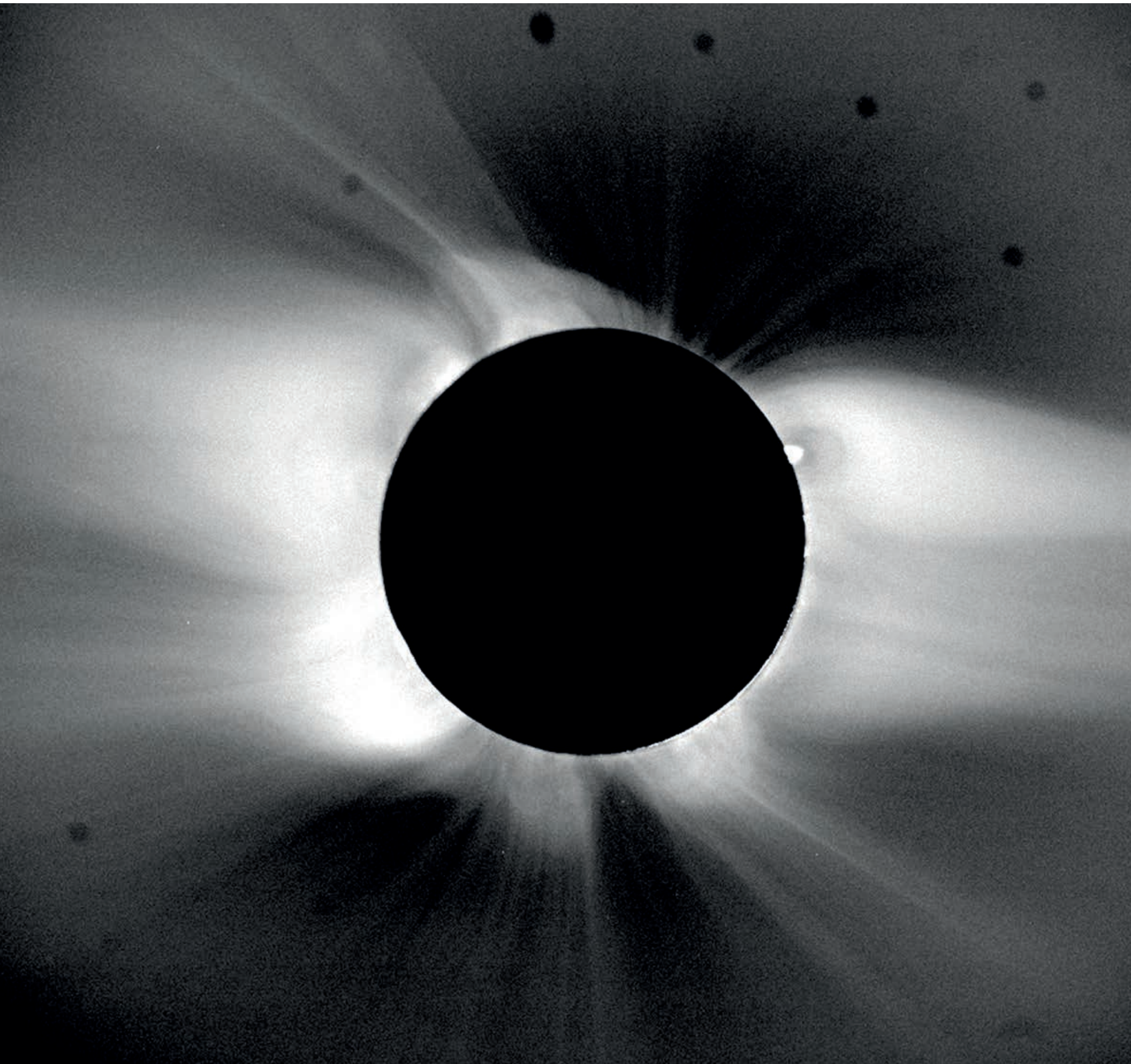
UMĚNÍ 3 ART

LXX 2022

ČASOPIS ÚSTAVU DĚJIN UMĚNÍ
AKADEMIE VĚD ČESKÉ REPUBLIKY

JOURNAL OF THE INSTITUTE OF ART HISTORY
CZECH ACADEMY OF SCIENCES



EDITOVANÉ ČÍSLO O FOTOGRAFII A VĚDĚ / SPECIAL ISSUE ON PHOTOGRAPHY IN SCIENCE
EDITORKY / EDITORS: BARBORA KUNDRAČÍKOVÁ, FEDORA PARKMANN

ÚVOD EDITOREK / EDITORS' INTRODUCTION

ČLÁNKY / ARTICLES

ZPRÁVY / REPORTS

RECENZE / REVIEWS

PŘEDNÍ STRANA OBÁLKY / FRONT COVER:
Katarína Poliačiková, The Way Geologists Liberated in Time, She Thought, Astronomers are Freed by Space, 2013/2021
fotografická instalace, archivní digitální tisk / photographic installation, archival digital print

KELLEY WILDER
PHOTOGRAPHIC HISTORY RESEARCH CENTRE (PHRC), DE MONTFORT UNIVERSITY

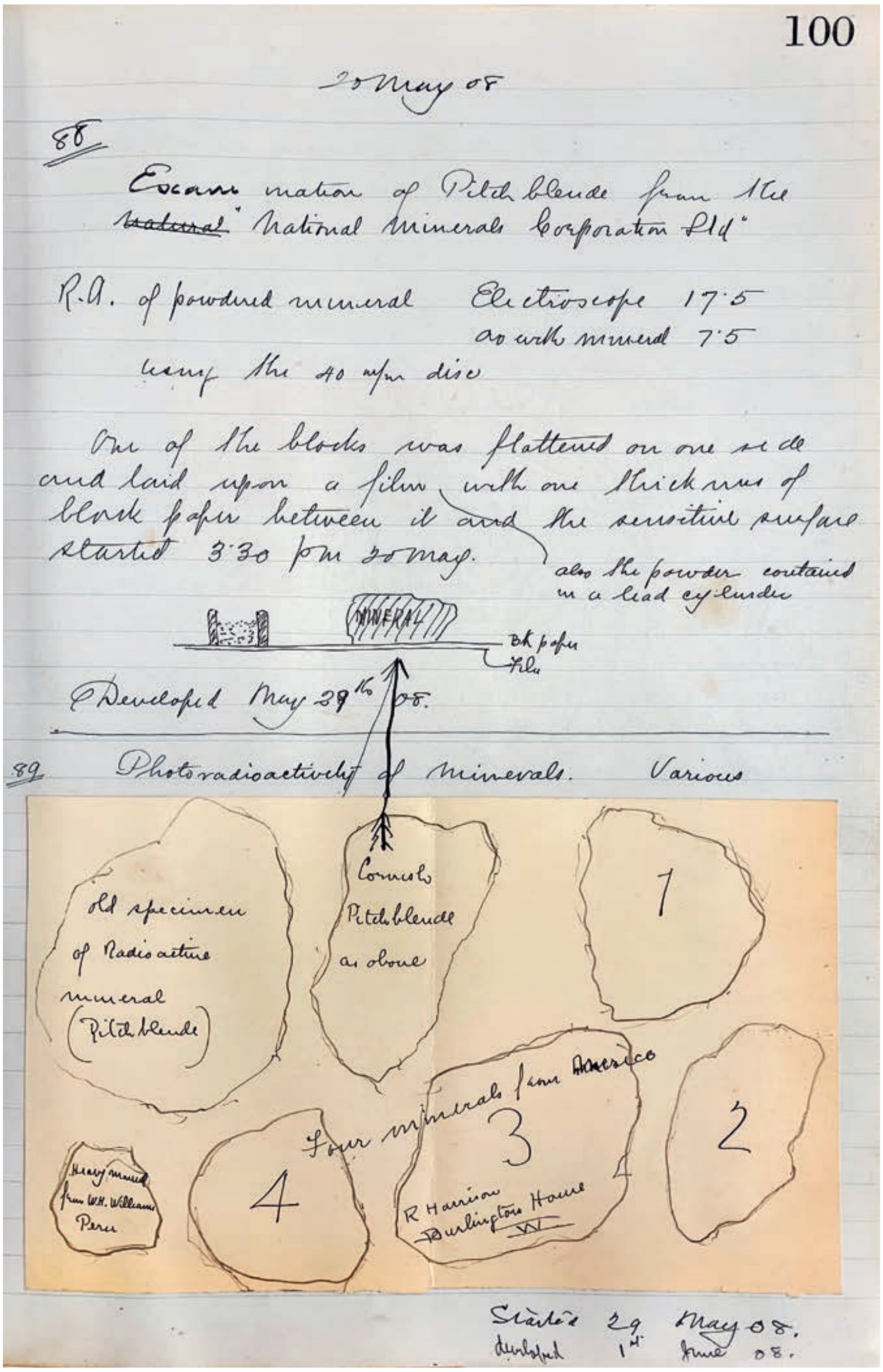
Photographs, Science, and the Expanded Notebook

Notebooks are a critical part of observational and experimental practices in the lab and the field, and they appear in all disciplines of science, humanities, and the arts. In photographic history, notebooks by well-known experimenters like William Henry Fox Talbot and John Frederick William Herschel have been critical to understanding how photography was developed. But in spite of their ubiquitous presence and critical place in photographic history, very little attention has been given to understanding the effects of photography on the notebooks, or to the photographic patterning of scientific notetaking. This article is about photographic notebooks and the way in which photography insinuated itself into the working practice of a few scientists, creating a new and hybrid 'expanded notebook'. These expanded notebooks are full of what Omar Nasim calls 'working images', that is, those images that are made pre-publication, that require interpretation and training to read, that are used to learn things by, or to make decisions over. Nasim's emphasis on learning how to 'see' rather than how to 'reason' also applies in these working photographs and the notetaking that accompanies them.[1] There is much to be gained by trying to understand what photographic practices brought to scientists in the working phase of their research through their notebooks, not least, a sense of the way in which photography began to create visible patterns in some scientific practices.

Unfortunately, to get to the pre-publication images, you have to find them first. If the published photographs, (the so-called iconic ones), are *'brown specky things'* as Jon Darius once called them, and have been thrown away in droves, well, the working photographs, the ones that did not make it into print, have suffered even more severely.[2] In part, it is because photographs fit only awkwardly into notetaking, which was a highly developed practice already when photography came along. For that reason, I take a broad definition of 'notebook', and call it the 'expanded notebook' because the material of photographs, and the insertion of photographic practices into notetaking practices, caused the expansion of notebooks both physically and conceptually. In part, they were expanded into spaces and places not normally inhabited by notebooks. They were also expanded through the insertion of purely photographic concerns of making, cataloguing, collecting, and experimenting with photographic materials in parallel with whichever scientific enquiry was at hand. This essay leans especially heavily on concepts by three authors: Nasim in his notion of working images; Jennifer Tucker, with her insights into the way in which groups of disparate photographs come together to make evidence, and her substantial writing about photography and communities, be they science, the law, or as she has recently written, industry; and Anke te Heesen for her thought-provoking writing about expanded places and spaces of learning as they occur in scrapbooks and cabinets of science.[3] In addition to these, there are three concepts that are important when considering the expansion photography caused in science notebooks: the physically expanded notebook, the photographic catalogue, and photographic experiments.[4] To look at this phenomenon in notebooks across the disciplines of science, I organize this essay around two examples: the notebooks of British chemist Sir William Crookes and those of American geologist Herman LeRoy Fairchild.

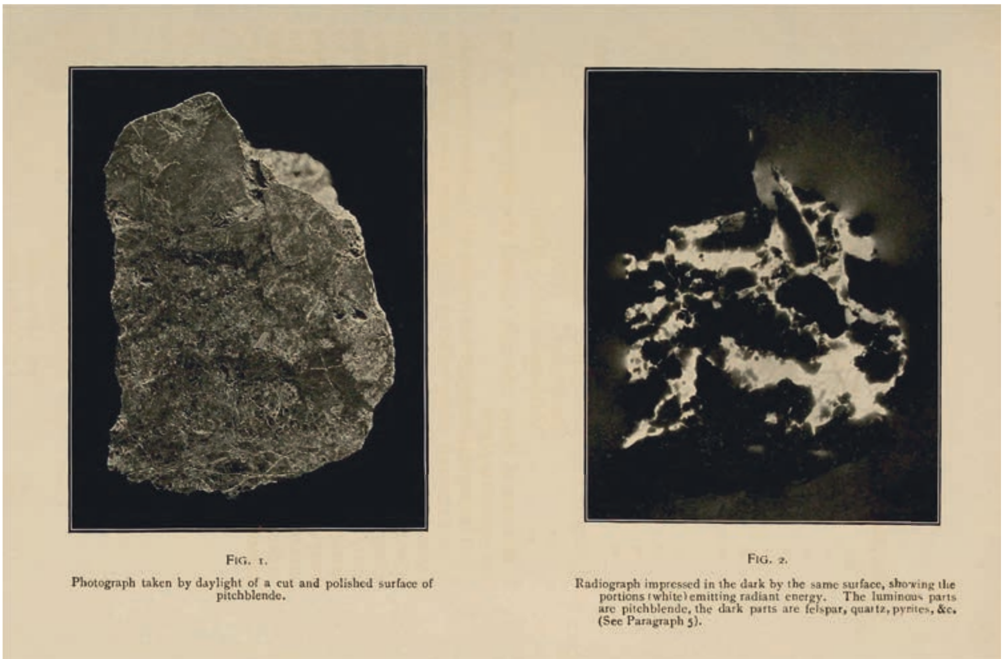
To begin with the expanded notebook, it is important to acknowledge that one of the problems of studying photographs that did not make it into print is that they are often separated from the notebooks in which they play

HTTPS://DOI.ORG/10.54759/ART-2022-0303



1 / **Sir William Crookes, notebook**, 1908
Notes detailing two photoradioactivity experiments on pitch blende
Royal Institution, London, Special Collections
Photo: Kelley Wilder — with permission of the Royal Institution

a critical part. Sir William Crookes's notebooks are a good example of the kind of dispersion that creates an expanded notebook. Crookes is likely best known for his invention of the Crookes tube in 1875, or his discovery of thallium in 1861, or quite possibly as a champion of spiritualism as the President of the Society for Psychical Research.[5] Many people do not know that he was also deeply involved in photography from its very beginnings. He was a close friend of Henry Talbot's, served as the first editor of *The Photographic News* (1858–1860), and he was a prolific photographer. Unfortunately, most of his photographs are dispersed, some to institutions with whom he worked, some to the private market, and only half of his notebooks are available to the public, from the Royal Institution. The other half of the notebooks are in the Science Museum, but are quarantined in the radioactive store, and not due to be accessed for a number of years.[6] This fragmented archive means that most of the record of Crookes' photographic activity is found in his notebooks and letters, even though comparatively few of these images have been found so far. Figure 1 shows a notebook page from 20 May 1908 with a typical Crookes experiment on photoradioactivity.



2 / **Photomechanical illustrations of pitchblende and resulting 'radiograph'**, 1900
Reproduction: William Crookes, Radio-activity of uranium, London 1900

This page, like many of the pages of several volumes of the notebooks, is all about photography, although it has no photographs in it. It is representative of Crookes's notebooks in this collection, as well as representative of other science notebooks by scientists who used photography. Commonly, photographs were collected in another space, even a separate notebook, book, or box. The extended spaces of knowledge in science take in these physical spaces as well as cupboards, cabinets, and closets.[7] Photography in particular seems to accrue in such places, even when the scientists' notes are ordered and kept. Although it might be tempting to think that this is because the materials were difficult to integrate, for instance, photographs on glass, it seems to have been common even when photographs were on more amenable supports like paper or flexible film. The notebook in Figure 1 is page 100 of Crookes' notebook, dated 20 May 1908, although the experiments in it range from May to June of that year. It shows two related experiments numbered 88 and 89, on pitch blende and other radioactive materials. The experiments derive from Crookes' ongoing investigations of what he called 'rare earths', in this case various ores and several examples of pitch blende, from the National Mineral Corporation Ltd. The setup of this sort of photographic experiment was quite common and had been used frequently since the earliest experiments on photographic surfaces. Objects were placed on the photographic film or plate and they formed an impression, or outline, directly on the photographic substance. While many such experiments used light as the radiant source, resulting in a silhouette of the object, in the case of radioactive minerals, the ore itself is the source of the exposure. The entry in Figure 1, from 1908, is a direct repetition, or one could call it a replication, of experiments, made some 12 years earlier by Henri Becquerel in Paris, in his first investigations of radioactive material.[8] Repetition or re-use of the experimental setup is commonly found in photography in science notebooks and Crookes' experiments represent a fairly normalized practice among scientists studying radioactivity at the time. The notebook page represents not just one but two photographs, and two distinct experiments, or perhaps they might even qualify as observations. Number 88 constituted an examination of pitch blende received from the National Mineral Corporation Ltd. The drawing is explained in the following way:

The description of the pitchblende in number 88 allows us to imagine the shape of the ores in number 89, on the bottom half of the page; that is, flat on one side. Both experiments demonstrate a good deal about how photography exerted pressure on the experimental setup. The most obvious is the shaping of the ores to accommodate the flat plane of the photographic surface. All the minerals that have been photographed now have one flat and often polished plane, incorporating, or one could even say, imposing the shape of photography on the objects. This adjustment to the shape of the specimens is evident in the *'old specimen'* pitch blende indicated on the top left corner of 89, as it is very likely to be the one that Crookes had been using for several years, and which can be seen in the Science Museum collection.[9] The flattening of specimens and printing them photographically was a practice that Crookes had been using for years to examine radioactive ore, and on which he had already published in 1900.[10] The illustrations to that paper (Figure 2) demonstrate clearly the indicative correlation between the flattened side of the pitch blende and the resulting exposure.

The second, more subtle, insertion of photography is in the photographic notation pertaining to the image entered in the notebook. In the case of experiments 88 and 89, it is the exposure time, written below each drawing and the drawing of the composition of the image, a photographic practice that became common in science notebooks. Photographic notations like these exposures vary, and might also take the form of a written description of the photographs taken, type of film or plates, time of day, situation of the camera (if there was one), weather, and development. They are notations that are shared with photographers, who also carried various forms of notebooks on photography expeditions to make notes about their exposures.[11] Sketching the photograph was also a common practice, and Crookes used sketches frequently in the study of rare earths as well as other experiments. For Crookes, the drawings serve two functions — they help him identify the components of the image, after development, and they stand in, in the experimental notebook, for photographs filed elsewhere.

Because notebooks are frequently separated from their photographs, they often necessitated separate but complimentary numerical arrangement. Crookes acknowledged this in an entry from 11 July 1894: *'There is a little inconvenience in numbering if a running number is used for chemistry and photographic pictures. It will cause gaps in the negative albums, perhaps it will be better to use two numbers one for pictures only.'*[12]

Unfortunately, Crookes's 'negative albums' have not surfaced, unless they are in the Science Museum collection, so it requires some imagination to conceive of what they might be. There is evidence enough, though, that he did continue to number and file his photographs separately. Crookes' insistence that his photographs be collected elsewhere may be an indication of how integral the working images were to his scientific experiments. Although he could have printed his photographs and incorporated them into his notebook, he only seldom did so. It may have been a matter of habit — Crookes began photographing with glass plates — but it also could have been his use of photographs for publication and exhibition at a later date. Some scientists, like Charles Piazzi Smyth in his Cloud Atlases, had stationers print special albums that incorporated photographic prints, bringing the photographs and notes together.[13] Emphasis on photographic prints might have to do with the nature of studying such transient objects as clouds, but there is little doubt that the prints could be inserted easier into the physical notebook, in a uniform size that accommodated the stationer, rather than adhering to sizes dictated by photographic companies and conventions. Crookes, though, used his negatives as working tools, marking them up, turning them, and annotating them in various ways, to make notes and draw conclusions on or about various experiments.

It is important to note that although photographs were often physically separated from Crookes' notebooks, photographic concerns were not. The notebooks frequently contain recipes for the treatment or development or other handling and preparation of photographic plates. Sometimes, Crookes would repeat the experiment or observation, developed in two different ways — for instance with pyrogallol and then with amidol.[14] On the same day in 1894 that Crookes was contemplating the numbering system for negatives, he also noted his method for sensitizing with aniline dye:

'Process for staining Gelatine Plates

For red { *Cyanine in Alcohol 1/10 gr to 100 cc*
1 drm (1/8 oz) in 3 ozs water
Green { *1 Phosphine N (quinoline) in 1000 alcohol*
one drm of this with above if green is required

Soak 3 minutes in winter and 2 minutes in summer and rock drain rapidly flood under tap to wash off solution pour off mixed cyanine and phosphine from dish fill [dr?] *with tap water slightly.'*[15]

Sensitizing your own plates in the 1890s might seem odd to the photographic historian. After all, it is a decade after Wilhelm Vogel's ground-breaking publications, and when many others had joined in researching spectral sensitization of plates.[16] It might be even more surprising considering the proliferation of ready-made plates by commercial manufacturers. By many photographic history accounts, 1890s photography was more straightforward, and less artisanal. However, Crookes' notebooks demonstrate that scientists were still regularly customizing their plates, even when they bought them from commercial manufacturers. Notebook XIV, in which these notes are found, has an advertisement for Edwards's Isochromatic and ordinary plates and films as well as a flyer for Wellington & Ward's platino matt bromine paper pasted into the front flap. Although this is evidence that Crookes was buying his plates and films commercially, he was also using his own aniline dying system to create plates of varying sensitivity to different wavelengths of light or of radiation. The dyes Crookes used are dyes that were discovered in the aniline dye industry and were very quickly brought into use for colouring gelatin plates, making them sensitive to different wavelengths. Dry plates came on the market in the early 1870s, and ten years later, dyed plates were also available commercially. Even ten years after such dyed photographic plates were being manufactured, scientists' practice of dying their own plates persisted. Crookes used cyanine in this example, which was also known as quinoline blue. Crookes referred to the plates as azuline plates but more commonly such plates are called orthochromatic. It is important to note that Crookes manipulates his commercial photographic materials both before exposure, with dying, and after, with development. The working photograph here is a nonstandard, highly specialized object, tailored to specific experiments.

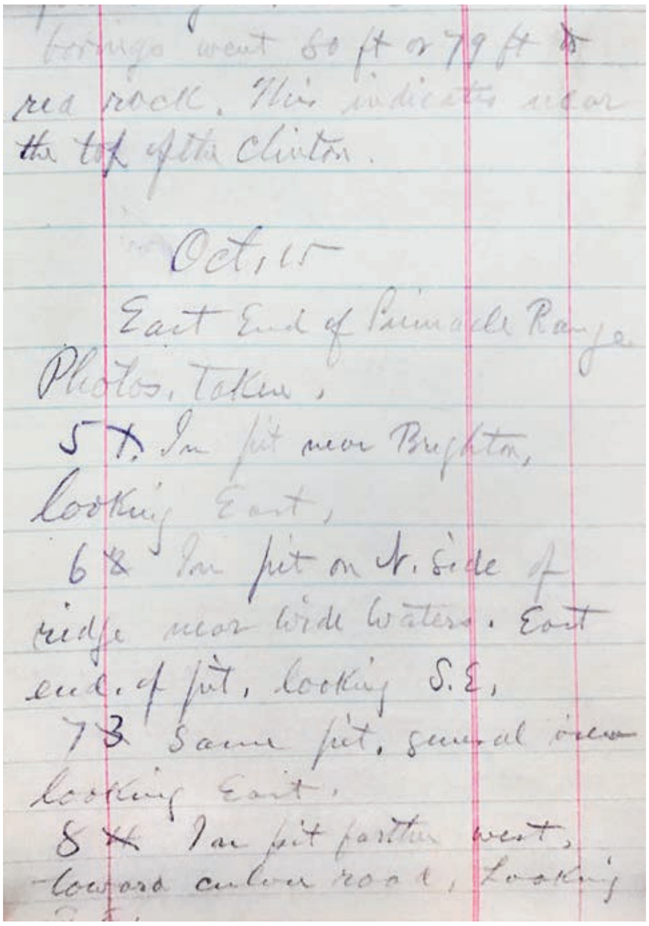
Klaus Hentschel writes eloquently about the problems of standardization or rather non-standardization in photographic manipulations in the 1870s–1900.[17] Hentschel goes so far as to describe some of the accounts (about Abney with infra-red) as '*pre-scientific* […] *artisanal practice*'.[18] The experiments in photographic chemistry and aniline dyes he describes as '*chaotic*'. This might be perhaps because of the number of people with different backgrounds, funded mightily by the Aniline Dye industry, jumping into these experiments with both feet. But these 'chaotic' experiments engendered a scientific community in the way that Jennifer Tucker has taught us to see, that sprang up around the validation of photography as an experimental tool.[19] Its reliability hinged on coordination of opinion achieved often by sharing photographs and recreating experiments.

Crookes' notebooks are not entirely devoid of photographs, and some can be found either attached to a page in the context of an experiment, or inserted between pages. But these few examples are not at all indicative of the number of photographs made by Crookes in the course of his experiments. In an example from 1906, two spectra, printed in a single platinum print mounted on board and attached are the only images present of 6 photographs taken on two days, 25 May and 18 September. The page can give us a rough estimate of the large number of photographs Crookes was making. Counting conservatively, we could imagine that only half the pages indicate the use of photographic materials. At page number 136 of about 200, if half the pages have this number of photographs it indicates that about 500 photographs were produced for this set of experiments, in this volume of the notebooks. It demonstrates a clear picture of a coordinated set of experiments patterned continuously by photographic activity. With Crookes, the analysis is quite incomplete. How it patterned his research and what the consequences are for how he understood or learned from his photographic practice can only be finalized when the notebooks of the two collections can be reunited. What Crookes' expanded notebooks might look like if reunited with the negative albums and photographs can be seen by comparing it to a more intact collection by Herman LeRoy Fairchild, a geologist working at roughly the same time in Upstate New York.

Fairchild was a professor of Geology and Natural History at the University of Rochester, New York from 1888 to 1920, and one of the founders of the Geological Society of America. He was a hugely prolific author, with 246 publications listed in his archive. At various times, though, he also worked for the State of New York and Ward's Scientific of Rochester. In what seems to be an active side-business he also sold many of his own photographs and bought many photographs from others. While Fairchild was nowhere near the first geologist to use photography extensively — Aimé Civiale and Frederich Simony among others were accomplished photographers and applied their photographic talents to geographical study decades before Fairchild was active — he makes a good example of the routinized use of photography throughout his geological practice.[20] Fairchild's 'expanded notebooks' and working images help to show how the routine making and maintaining of a catalogue of self-authored photographs, and a collection of photographs authored by others formed an integral part of scientific research when photography was fully embedded in the scientific enterprise. The formation of a catalogue on Fairchild's work binds the disparate parts of the expanded notebook, confirming Crookes' indication that cataloguing is an integral component of the making and use of photographs in science.

It is not clear when Fairchild began photographing, but by 1885, he was embarking on a working tour of Mexican railways with his camera. Whether it was taking photographs of the railroad and engineering works that was his main occupation, or geological observation, is not entirely clear. To discuss the expanded notebook, however, and show the role of cataloguing in creating it, one particular group of his photographs exemplifies Fairchild's photographic and notetaking practice. This is a group of photographs and notes made between about 1890 and 1906 of what Fairchild called the Pinnacle Range. 'Range' sounds rather grandiose for what is in fact a collection of hills that run through the centre of Rochester, NY from what is now Cobb's Hill Park to Mt. Hope Cemetery, just behind the University of Rochester. Although the location is now composed largely of city parks, at the time it was a series of quarries, like the one shown in Figure 3. The quarries provided access to cuttings that showed the internal structure of the hills far better than any conventional landscape could. In other projects, Fairchild took advantage of new road cuttings and in particular the Erie Canal cuttings so prevalent in Rochester and its surrounding area. Fairchild chronicled the Pinnacle Range over a number of years and from a number of views, putting together a series of photographs that not only cover the whole of the Range but also that chronicle the industrialization that occurred in and along it in the rapid expansion of the city. It was of interest to him because Rochester sits on a glacial moraine, and glaciers were Fairchild's particular area of study. Its industrial importance lies in the Range's composition of glacial soil, largely sand and gravel, and these are highly commodified substances used in construction and building in the expanding city of Rochester. Part of Rochester's expansion was due to its strategic location and landscape. The Genesee River, home to powerful waterfalls used to generate electricity for the flour mills, also spawned a number of canals running through the city, picking up goods from factory warehouses like that of Eastman Kodak's, which changed its name from the Eastman Dry Plate and Film Company

3 / **Herman LeRoy Fairchild, 636. Oct. 15, 1904. Cobb's Hill near Monroe Ave. Looking S. 60 E.**, 1904
University of Rochester, River Campus Libraries, Rare Books, Special Collections, and Preservation Herman LeRoy Fairchild papers, A.F16
Photo: Kelley Wilder



borings went 80 ft or 79 ft to
red rock. This indicates near
the top of the Clinton.

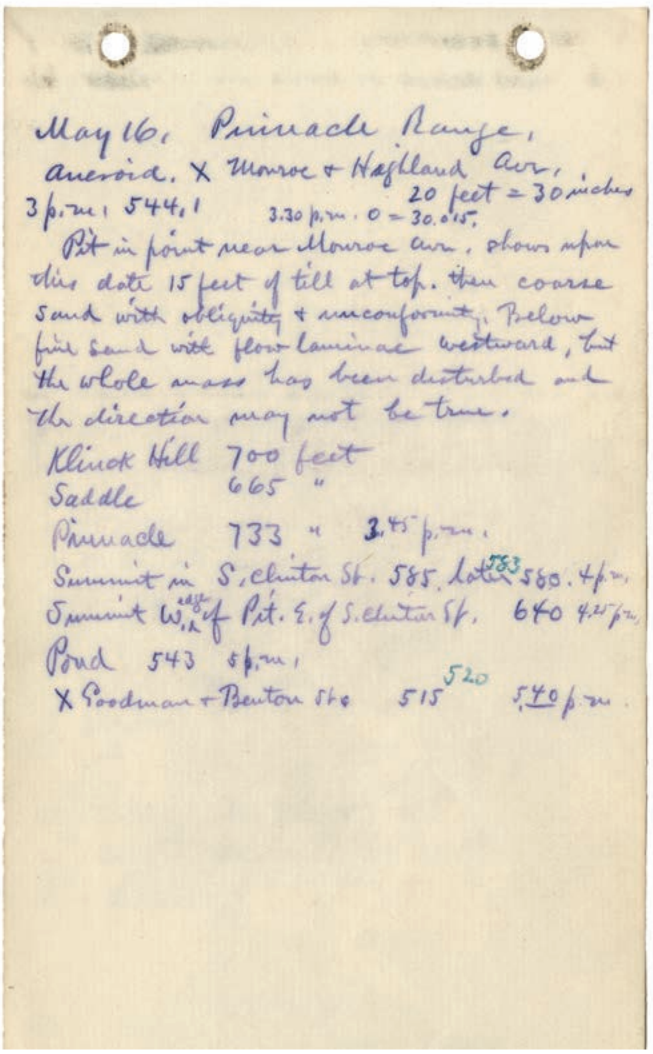
Oct. 15
East End of Pinnacle Range
Photos. Taken,
5 X. In pit near Brighton,
looking East,
6 & In pit on N. side of
ridge near Wide Waters. East
end of pit, looking S.E.
7 B Same pit, general view
looking East.
8 X In pit farther west,
toward culver road, Looking

4 / **Herman LeRoy Fairchild, Notebook**, October 15, 1904
University of Rochester, River Campus Libraries, Rare Books, Special Collections, and Preservation Herman LeRoy Fairchild papers, A.F16
Photo: Kelley Wilder

in 1892. Its intersection with the Erie Canal ensured easy access to markets in both Canada and New York. Expansion of enterprises like Kodak and Bausch & Lomb, and a thriving garment industry caused the population to more than double between 1880 and 1910. With such rapid changes, Fairchild's urge to note the native landscape is understandable, even as road building and quarrying ensured that he gained unprecedented access to the many layers of glacial deposits around the city.

Fairchild's combined expanded notebook takes in photographic notebooks, geological notebooks, and photographs to form a scientific space, in this case a geological formation, over time.[21] To organize his photographs, Fairchild put together several numbering series, very much like Crookes' proposed numbering system. The catalogue gathered together subjects in series, while the caption represented a photograph number, possibly relating to the negative number in a separate numbering series. When taken together, Fairchild's field notebooks and the photographs as well as the photographic catalogue, which brought together his notes and the photographs, constitute an expanded notebook of working images about the Pinnacle Range extending over a decade, from 1891 to 1906, and stretching the length and breadth of the physical range, focussing in for details, and telescoping out for wider views. Fairchild published his findings in 1923, as the hills were slowly developed and Rochester grew significantly. In particular, he intended that *'the photographs taken during the last 30 years should be published as a permanent record of the form, composition, structure and origin of the Pinnacle Range'.*[22] In addition to his sense that he was recreating not just the outward form, but also the structure and composition,

5 / **Herman LeRoy Fairchild, 76. Pinnacle Range, Cobb's Hill**, April 17, 1895
University of Rochester, River Campus Libraries, Rare Books, Special Collections, and Preservation Herman LeRoy Fairchild papers, A.F16
Photo: University of Rochester, Special Collections


May 16. Pinnacle Range,
aneroid. X Monroe & Highland Av.
3 p.m. 544.1 3.30 p.m. 0 = 30.015. 20 feet = 30 inches
Pit in point near Monroe Av. shows upon this date 15 feet of till at top. then coarse sand with obliquity & unconformity. Below fine sand with flow laminae westward, but the whole mass has been disturbed and the direction may not be true.
Klinck Hill 700 feet
Saddle 665 "
Pinnacle 733 " 3.45 p.m.
Summit in S. Clinton St. 585 later 583 580. 4 p.m.
Summit W. edge of Pit. E. of S. Clinton St. 640 4.20 p.m.
Pond 543 5 p.m.
X Goodman & Benton Sts 515 520 5.40 p.m.

Fairchild also clearly indicated that his activities gathered up the history of the industrial and residential growth of the area as well.

Fairchild's notebooks combine geological field notes with photographic notes, that is, notes of the photographs made, the orientation and location. It is this parallel notetaking that illuminates a critical part of the expanded notebook, and also demonstrates the importance of cataloguing. Figure 3 shows one of 4 exposures made on October 15, 1904. The corresponding notebook page in Figure 4 for October 15, 1904, titled *'East End of Pinnacle Range'*, details the following photographs:

'5 1. In pit near Brighton, looking East.

6 2 In pit on N. Side of ridge near wide waters. East end of pit, looking S. E.

7 3 Same pit, general view looking East.

8 4 In pit further west toward Culver Rd Looking S. E.'

Just as in the example of Crookes' notation and his drawings of rare earth photographs, Fairchild's notebook serves the function of identifying the plates after development. It is a type of photographic notetaking that was common for photographers of the time who worked with glass plate photography in the field. The plates were loaded into plate holders at home in the darkroom, and packed into a carrying case, along with the camera, tripod, dark cloth, and any other necessary accessories. Some expeditions carried

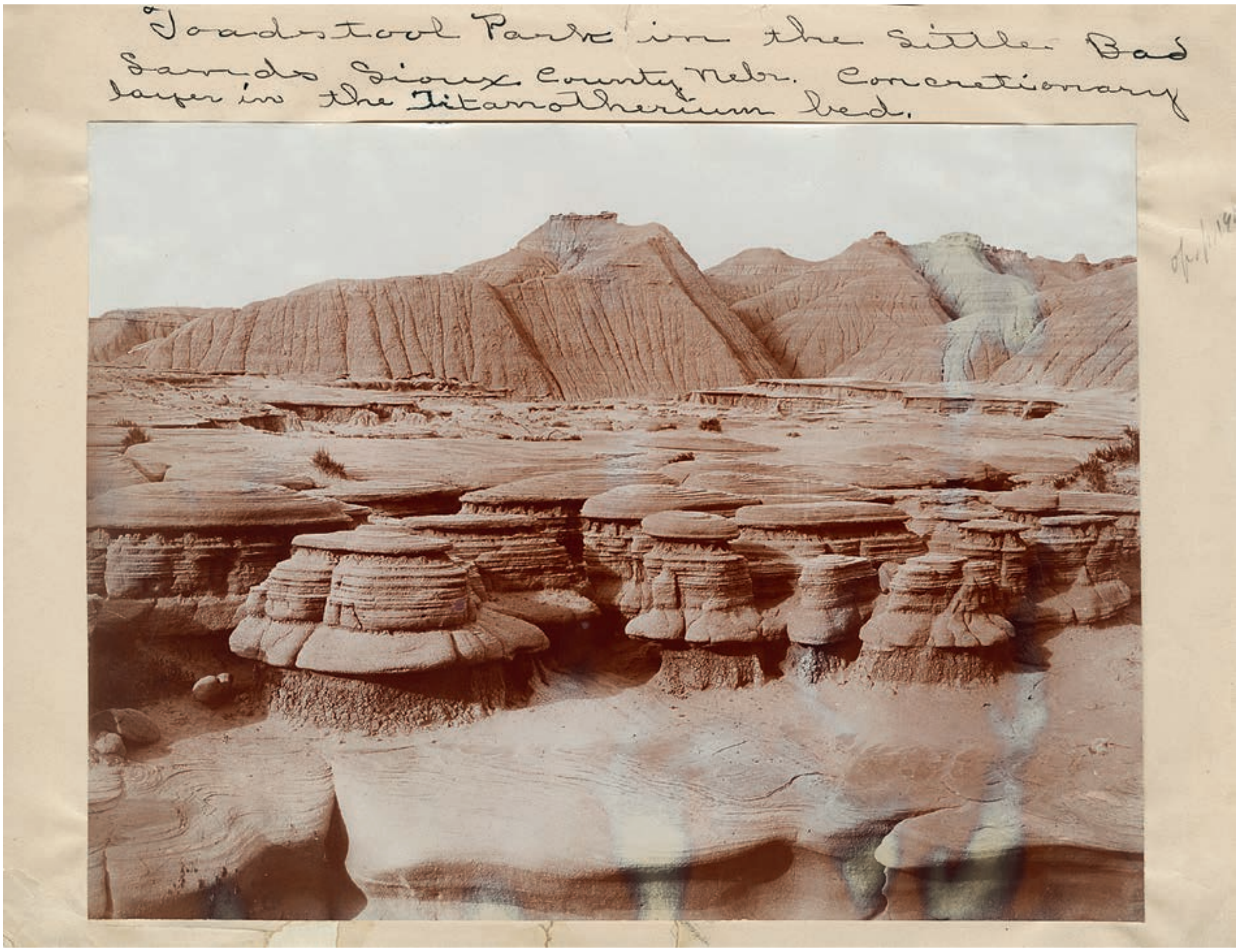
6 / **Herman LeRoy Fairchild, Field Notebook on Pinnacle Range,** May 16, 1895
University of Rochester, River Campus Libraries, Rare Books, Special Collections, and Preservation Herman LeRoy Fairchild papers, A.F16
Photo: University of Rochester, Special Collections

7 / **Herman LeRoy Fairchild, 78. Photograph from Klink Hill**, April 18, 1895
University of Rochester, River Campus Libraries, Rare Books, Special Collections, and Preservation Herman LeRoy Fairchild papers, A.F16
Photo: University of Rochester, Special Collections

a portable changing bag to refill the plate holder, but Fairchild never travelled very far for these photographs and seems to have taken only a handful of exposures on any given day.[23] The four exposures of 15 October are quite typical of Fairchild's practice. Each plate holder was numbered, and the numbers were used to match the list of exposures. It is clear that this list notes the numbers corresponding to plate holders, because the eventual negative number 636 can be seen on the lower left-hand side of the print. As with Crookes' notebook, this is an example of photographic notetaking, one of the many common photographic practices that were incorporated into the expanded science notebook.

The re-numbering in the notebook indicates also that there was an iterative process occurring between the photographs, the cataloguing, and the notebook. The relationship or pattern created by negative numbering and the subsequent catalogue numbering of the prints is not yet entirely clear and requires more investigation, but some of the processes are apparent. Fairchild made a silver gelatin (usually bromide) print from each negative, mounted it on thick green board, and attached a label, deriving details for the label from his field notebooks. The extensive catalogue, running numerically to nearly 800, brings the photographic and written notes and observations together, forming a systematic working catalogue of all his geological observations, from an extensive number of research projects. The notes from the photographic notebooks about orientation and location were incorporated, as one would expect, into the catalogue descriptions, and the dates were crucial for bringing together a series of photographs like the Pinnacle Range series, for discussions of the changing landscape as it was utilized. The catalogue effectively combines numbering processes, notes, and photographs in a single system organized eventually in a photographic catalogue.

Fairchild appears to have interspersed his photographic activities with days of purely geological observation. Figure 6 shows just such a typical day, where Fairchild made height measurements from Klink Hill,



8 / **Erwin Hinkley Barbour, Toadstool Park, Little Badlands, Nebraska**, 1896
albumen print mounted on paper, notation also on verso
University of Rochester, River Campus Libraries, Rare Books, Special Collections, and Preservation Herman LeRoy Fairchild papers, A.F16
Photo: University of Rochester, Special Collections

in the Pinnacle Range, looking across to the Cobb's Hill pit of Figure 5. He may have been standing on the spot from which Figure 7, was taken on 18 April, just four weeks earlier. The notebook is not only about measurement of Klink Hill, though. It also includes a lengthy description of the 15 feet of till at the top of the pit *'on this day'*. It reminds us that Fairchild was capturing a constantly moving and changing landscape in a quarry, subject to immense change from one day to the next. '[B]*ut the whole mass,'* he writes in his notebook, *'has been disturbed and the direction may not be true'.* Nonetheless, Fairchild benefitted from his relationship with the quarry owners, sometimes even photographing them in situ. The changing nature of the landscape both forced him and allowed him to photograph and re-photograph the land in certain locations, creating a time-lapse set of images.[24] His field notes and photographic notes were carefully combined in the photographic catalogue, on the prints, where the labels served as useful areas to cross reference similar observations. In Figures 5 and 7, Fairchild's admonition to 'see' other numbers indicate his habit of creating a cross referencing system.

The catalogue serves as a method of producing images in a certain way, producing a vision, as Nasim puts it, *'bit by bit'*, enhancing *'what was seen, might be seen, would be seen and should be seen'* in this geological landscape.[25] The Pinnacle Range research formed a core of Fairchild's understanding of the glacial effects on the landscape of Upstate New York. With this knowledge, with the vision of the landscape from the inside, he was able to form theories and tell histories of landscape in dozens of papers during his career. His research was highly influential not only at the national level, but also in the form of public history and education. Fairchild worked for the New York Department of Education, taking photographs of important geological morphology. His photographic catalogue shows evidence that he occasionally also sold it his negatives. Thus the catalogue has far-reaching consequences as a part of an expanded notebook for Fairchild's work, bringing together disparate and numerous data into a single holding to allow the parsing of the information.

Fairchild did not confine his research to photographs only he made. He also formed a wide-ranging collection of photographs by others, complete with notes, often made on the photographs themselves. This collection, unlike his catalogue of photographs, is arranged thematically, and includes photographs he commissioned, photographs he collected, and photographs he took. In the collection there are folders on glaciers, geysers, collections of ice crystals and volcanos, and numerous collections of interesting features of the American landscape.

One particular group of albumen prints mounted on paper, from the Morrill Geological Expeditions, brings together photographs by E.H. Barbour and Ulysseys Cornell of the University of Nebraska and shows how Fairchild collected photographs that fit well with his own photographic practices. The notes on Figure 8 focus the readers' attention on the layers and type of geology in Toadstool Park, now Toadstool Geologic Park in the Ogala National Grasslands in North-western Nebraska. That Fairchild collected these images, and not the many photographs made of fossil excavation, indicates his interest in Badlands geology. While it is not yet clear how he used these images, it is fair to guess that Fairchild's interest in the stratification and the inner composition of the landscape was most important. In more than a dozen photographs collected from these expeditions, all the images exhibit such stratification and most of the captions emphasizes it. The Morrill Expeditions, headed by E. H. Barbour, Professor of Geology at the University of Nebraska and financed by John Morrill, collected numbers of fossils for the Nebraska State Museum from expeditions running from 1891 through at least 1903. Although much of the Barbour collection appears to be dispersed (more work remains to be done on this), a large part of it found its way into Fairchild's collection. The examples mirror his own photographs of the Pinnacle Range in composition, attention to stratification and use as carriers for extensive observations about the landscape.

The Cornell and Barbour photographs are clearly working images. They are heavily annotated, mounted on paper carrying two punch holes at the top (just visible in Figure 8), for clipping into a notebook. Some have clearly been prepared for publication and have editorial and cropping marks. Together they form a picture of the Badlands geology of the American West. They cover two areas of Badlands, one in Nebraska referred to as the 'little' or the 'bad' Badlands in the captions, and the other, more famous Badlands of South Dakota. It is typical of the collection photographs, as opposed to the catalogue photographs, that they are heavily annotated. Here the paper qualities of photography are useful carriers for extra notes, drawn lines, marks for emphasis, and added annotation. Fairchild's own photographs, when in this collection, appear mostly unmounted and often heavily annotated.

Fairchild's collection and use of geological photographs is evidence that the expanded notebook should consider the collection of science photographs, as well as the making of them. Jennifer Tucker has argued quite effectively that the massing of photographs together, even when they are made in disparate places and circumstances, achieves a systematic nature that can also be taken as evidence in certain ways. She is equally persuasive in establishing that the sort of use of photographs produced for one purpose, in her case, portraits, and used for another, in a court of law, '*required new social conditions of knowledge*'.[26] Fairchild's use of the catalogue, for his own photographs, numbered sequentially, and the collection, unnumbered and grouped thematically for his and others' photographs, are more than just a publication aid, they are a type of visual notetaking that supplements the field and photographic notes, and creates a new condition of knowledge based on the pattern of photographic practices.

The notebooks and photographs of Crookes and Fairchild together suggest that we should consider the working photographs and their dispersed archives as a sort of 'expanded notebook' and that we should see the use of photographs as not illustrations, but as working practices of experiment and observation, and sites of new practices of making knowledge. Understanding what happens when these working photographs get plucked from the notebooks and used as illustrations in finished and published work, and the relationship between the two, is a matter for consideration elsewhere.

NOTES

1 Omar Nasim, *Observing by Hand: Sketching the Nebulae in the Nineteenth Century*, Chicago 2013, pp. 10–11.

2 Jon Darius, *Beyond Vision: One Hundred Historic Scientific Photographs*, Oxford 1984. For a description of iconic science images see Peter Galison, *Image and Logic: A Material Culture of Microphysics*, Chicago 1997.

3 Jennifer Tucker, 'Moving Pictures: Photographs on Trial in the Sir Roger Tichborne Affair', in Gregg Mitman and Kelley Wilder (eds), *Documenting the World: Film, Photography and the Photographic Record*, Chicago 2016. See also Jennifer Tucker, *Nature Exposed: Photography as Eyewitness in Victorian Science*, Baltimore, 2014. For Anke te Heesen's work see especially Anke te Heesen, *Der Zeitungsausschnitt: Ein Papierobjekt der Moderne*, Frankfurt am Main 2006; and eadem, 'The Notebook: A Paper technology', in Bruno Latour and Peter Weibel (eds), *Making things Public: Atmospheres of Democracy*, Cambridge, MA 2005, pp. 582–590.

4 Acknowledgements. To place at the beginning of the footnotes. I am deeply indebted to Melissa Mead, at the University of Rochester Special Collections, for bringing the Fairchild photographs in this paper to my attention some years ago, and for supplying me with photographs of Fairchild's archive and producing a number of crucial scans even during closure in the pandemic.

5 The most helpful overview of Crookes' many avenues of research is William Brock, *William Crookes (1832–1919) and the Commercialization of Science*, New York 2016.

6 A brief description of the 5 notebooks can be found at https://collection.sciencemuseumgroup.org.uk/documents/aa110067393/laboratory-notebooks-of-william-crookes.

7 Anke te Heesen and Anette Michels (eds), *Auf/Zu: Der Schrank in den Wissenschaften*, Berlin 2007.

8 It is not clear here whether Crookes was working with glass plates or flexible film. For a more extensive discussion of radioactivity and photographic experiment in the 1890s see Kelley Wilder, 'Visualizing Radiation: The Photographs of Henri Becquerel', in Elizabeth Lunbeck and Lorraine Daston (eds), *Histories of Scientific Observation*, Chicago 2011, pp. 349–368.

9 The Science Museum also retains the glass plate, marked up and labelled here.

10 Sir William Crookes, *Radio-activity of Uranium*, London 1900.

11 This form of notetaking of each exposure was so widespread that Kodak thought they might make money by building it into their Autographic cameras manufactured from 1914 onwards.

12 William Crookes, *Notebook* XIV. Royal Institution, 11 July 1894, p. 31.

13 Five albums are split between the Royal Society and the National Science and Media Museum, Bradford.

14 Crookes (note 12), p. 31.

15 Ibidem.

16 One of the best overviews of the early period still remains: William West, 'The First Hundred Years of Spectral Sensitization', *Photographic Science and Engineering* XVIII, 1974, pp. 35–48.

17 Klaus Hentschel, *Mapping the Spectrum*, Oxford, 2009, pp. 250–260.

18 Ibidem, p. 255.

19 Jennifer Tucker, *Nature Exposed: Photography as Eyewitness in Victorian Science*, Baltimore 2006, esp. Chapters 1 and 5.

20 See Magdalena Vukovic, *Von wunderbarer Klarheit*, Wien 2019; and Jan van Brevern, *Blicke von Nirgendwo: Geologie in Bildern bei Ruskin, Viollet-le-Duc und Civiale*, München 2021.

21 Vestburg conjures up the sort of space created by both making and assembling photographs in Nina Lager Vestburg, 'A Photographic Archive of Physics, or a Physical Archive of Photography', in Anna Dahlgren, Dag Petersson and Nina Lager Vestberg (eds), *Representational Machines: Photography and the Production of Space*, Aarhus 2013, pp. 171–192.

22 Herman LeRoy Fairchild, 'The Pinnacle Hills or the Rochester Kame Moraine', *Proceedings of the Rochester Academy of Science* VI, November 1923, No. 5, pp. 141–194, p. 144.

23 Cobb's Hill is only about 3 miles from the University Campus.

24 It is an early example of the repetitive photography of landscape over time that is so common now with satellite missions like LANDSAT.

25 Nasim (note 1), p. 10.

26 Tucker, 'Moving Pictures'(note 3), p. 16.