one

Photography and Observation

> Nothing is real unless it is observed.
>
> John Gribbin[1]

Part of the enthusiasm for photography in 1839 was engendered by its claim to fulfil so many of the criteria deemed necessary for good scientific observation. It was mechanical, and so indefatigable. It was indiscriminate, and therefore objective. It was optical, and consequently reliable. Or so went the rhetoric. Through the eighteenth century the use and reputation of observation, as opposed to theory, in the sciences had been steadily on the rise. Observing was considered an art, reserved for those exceptional, diligent and above all sharp-eyed devotees of the natural world and the heavens. To name oneself an artistic or scientific observer in the first, pre-photographic decades of the nineteenth century was to aspire either to the nearly mythical fame of enlightenment observers like Senebier or Linneaus, or to emulate the extraordinary (possibly less attainable) Renaissance observers of nature and the human form, Leonardo and Michelangelo.

Nineteenth-century cultures of observation were powerfully pervasive, and they left a clear signature on the development and use of photography, not to mention its rhetoric. The inventions and innovations of photography, in their turn, influenced the way scientists observed, and restructured the hierarchy of observations scientists held to be valuable. Pre-photographic scientific observation required not only years of painstaking acquisition of skill, but an innate genius for concentration and attention to detail. Photography promised these skills to those who lacked such training, while at the same time upholding the high standards that had been set by able observers of the past. It also temptingly collapsed the separate processes of the act of observing into the reliable recording of observations. This eliminated the aggravating need to momentarily take one's eyes off the subject while jotting down notes or sketches. Photography 'recorded as it looked', and scientific photographs can be seen as consisting largely of these sorts of recordings. But perhaps photography's two most seductive claims, and those most often associated with observation, were the promise of passivity and the extension of the realm of the visibly observable.

Complete passivity, the damping down or elision of subjective decisions by scientists in the illustration of an observation, became so desirable to those striving for objectivity in their representations of science that it was (and for many decades remained) a powerfully active metaphor even in the face of significant evidence to the contrary. The notion that photography was inherently passive was quite likely the single greatest stumbling block for advocates of art photography in the second half of the nineteenth century. It was also the key to George Eastman's wildly successful advertising campaign for the first Kodak camera, 'You press the button, we do the rest'. In science, it was the foundation on which photography was based, and any threat to that foundation revealed a coincident threat to the paired notion of objectivity, especially mechanical objectivity.[2] As pervasive as the notion of passivity was and is, photography's real calling card is its reputation for widening the scope of what could be observed by the eye. Ultraviolet radiation, called variously the chemical spectrum and the actinic spectrum, formed the basis of nineteenth-century photography. When it was found that photography was also sensitive to a whole host of other 'invisible' radiation in the 1890s, the discovery did no more than reinforce Talbot's opinion, written in 1844, that 'the eye of the camera would see plainly where the human eye would find nothing but darkness'.[3]

To the consternation of scientists, the practicalities of photography in the real world deviated, sometimes uncomfortably far, from the theoretical ideal. It was often the case in the nineteenth century that professional or amateur photographers were hired to work side by side with astronomers, microscopists and surveyors, adapting their knowledge to specialist instruments. In each instance, the record produced by photographic observing needed consequently to be understood against the background of the technical parameters of photographic capability, the operational setup and the ability of humans to interpret what they saw on the photographic negative or positive. With so many variables, it is hardly a wonder that photography was not quite the unqualified success it was often hailed to be. Nonetheless, scientists and photographers persisted in their attempts to wrest ideal, objective and clearly legible images from the photographic medium.

Emulsions, Emulsions, Emulsions

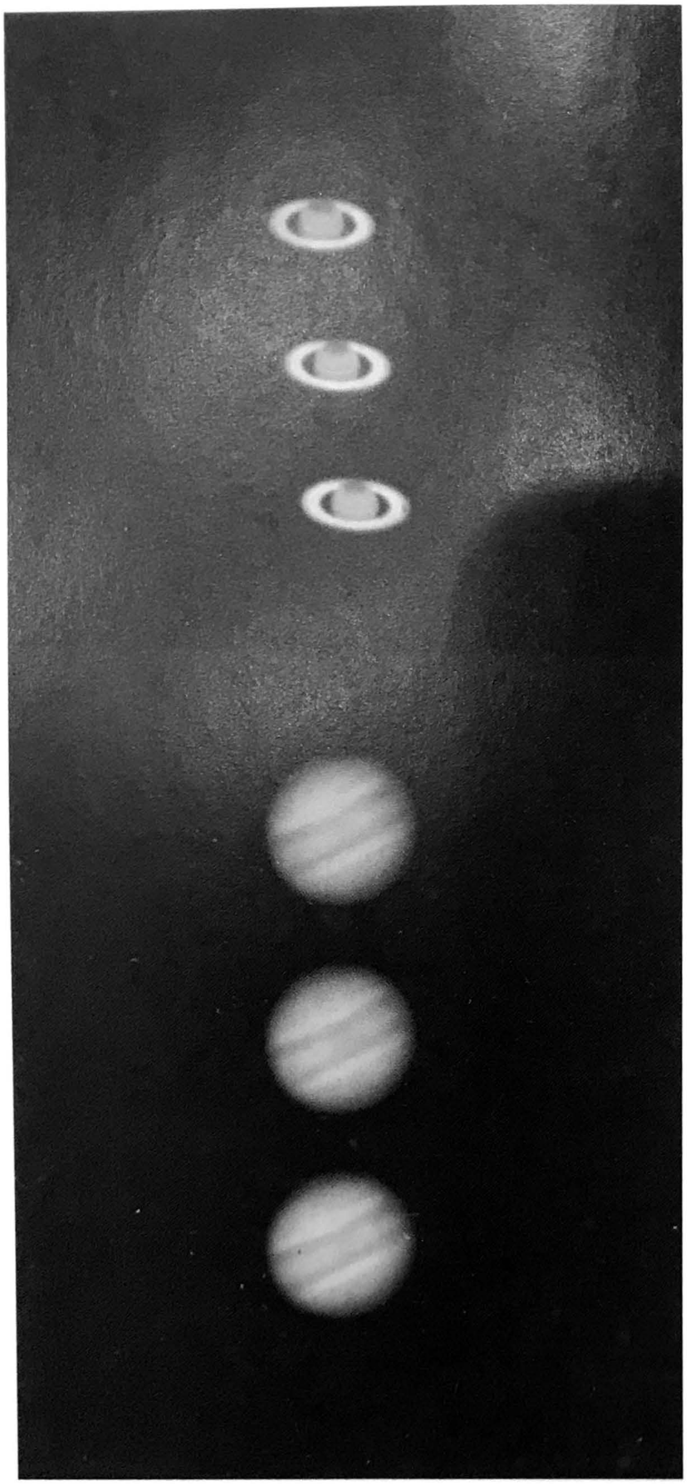
> Some gentlemen apparently seem to find this albumen-beer process not [the] answer, and lay the blame on the beer . . . One thing, I think, may affect sensitiveness, and that is the collodion. I make mine rotten with water and then add the same unwatered collodion to it till all 'crappiness' disappears from the film. I lay great stress upon this point, as I believe the constitution of the pyroxyline is altered by it, and certainly the film becomes more porous.[4]

Experimental emulsions are not confined to the nineteenth century. At a stretch, one could count the work done by Elizabeth Fulhame and others in the latter half of the eighteenth century as emulsion research, and could certainly include the development of nuclear, x-ray and other specialized films in the early and mid-twentieth century.[5] The specially-devised, hand-made, specific emulsion remained an important component of scientific photography long after the three largest companies, Kodak, Agfa, and Ilford, had succeeded in standardizing most day-to-day film use. Many of the most specialized emulsions were made to order by these same companies.[6] With new emulsions came adjustments in the evaluation of observations, and many conflicts about the 'success' of a given observation when it was conducted photographically. This is why there often seem to be conflicting opinions about the usefulness of photography in the sciences. 'It is a success', say some, 'It is a failure', contradict others. The true measure appears to lie somewhere in the middle. Often an enterprise was a photographic success story even while it failed to produce the desired scientific data.

Some of the earliest debates on the subject of emulsions and emulsion speeds (here used interchangeably with 'sensitivity'), and consequently success and failure, appeared in the context of astronomy. A great many household names in the history of photography have been associated with astronomical images: William de Wivelselie Abney, E. E. Barnard, William Crookes, L.J.M. Daguerre, John Draper, Paul and Prosper Henry, Jules Janssen, Hermann Krone, Adolphe Neyt, Warren de la Rue, Lewis Morris Rutherfurd, Hermann Wilhelm Vogel and John Adams Whipple, to name a handful. Much of their work revolved around adapting emulsions and photographic instruments to astronomical observation, and they produced everything from spectra of starlight, to photometric readings, to iconic images of the heavens (illus. 10).

In the 1870s and '80s photographers' theories and innovations, which had been published and discussed in scientific and photographic journals for several decades, were brought together in one of the most prominent international debates about photographic observation – the discussion about the use of photography in observing the two transits of Venus of 1874 and 1882. The collective observations were massive undertakings, underwritten by each respective government, in which hundreds of individuals dispersed around the globe in search of the perfect viewing station. In 1874 alone, expeditions were sent by the British, French, Russians, Italians, Americans, Germans and Dutch. Partly because the expeditions were so public, and partly because they were so contentious, they provide an excellent record of the sorts of photographic concerns that astronomers felt were the most pressing. Much of the debate centred on the viability of measuring the resulting photographic plates to extract an accurate indication of parallax, giving the scientists the tools with which to mathematize distances in space. In the end, it was the contentious issue of exactly how to measure the plates that led to astronomers' dismissal of the photographic results.

In 1874, one could either observe the transit or photograph it, but one could not do both at the same time. The photography was so complex,

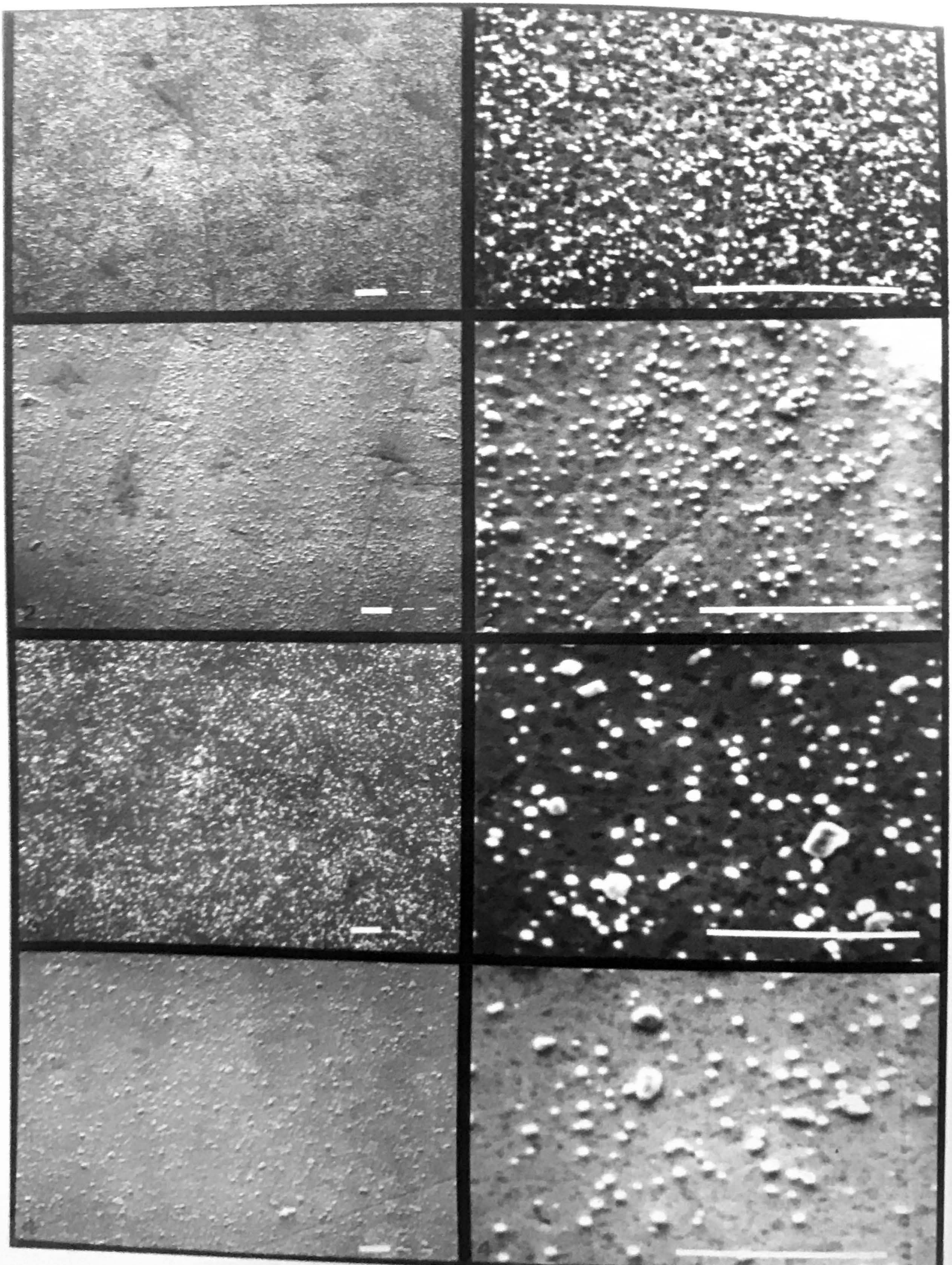


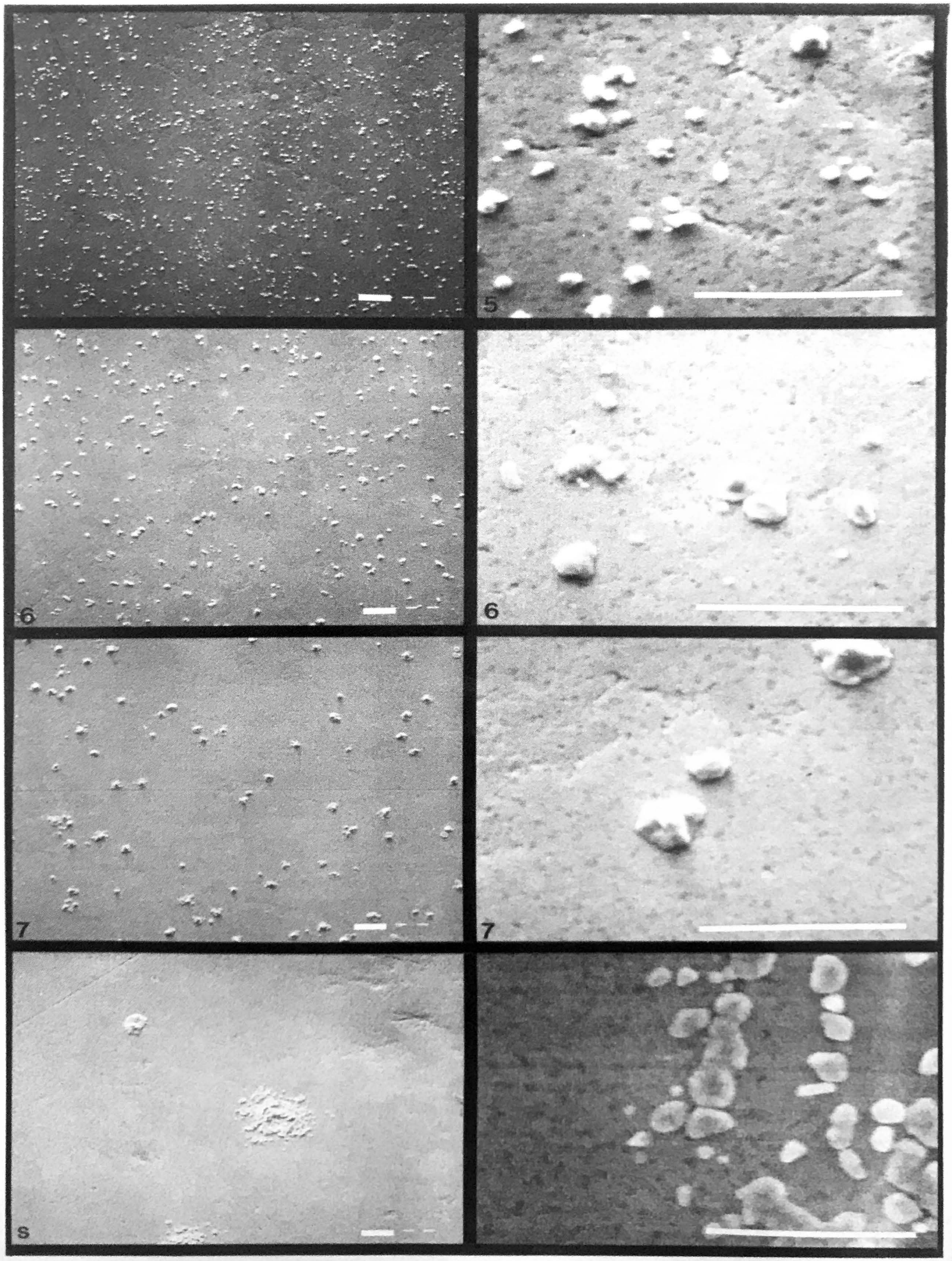
10 Paul and Prosper Henry, *Photographs of Saturn and Jupiter*, 1886, albumen print.

and needed such careful supervision, that the photographer's attention was trained mostly on the photographic task and only partly on the transit itself. A decision had to be met, not only about who would make the photographs if the observers were busy with their own instruments, but also whether or not it was worth the effort of training and equipping photographers to accompany the observers at all. The resulting photographic record would also need to be standardized across viewing stations so as to make them comparable, and standardization was not one of photography's strong points.

Consider the problem. What would it take to create an effectively measurable photographic plate in 1874? Commercially made, standardized, gelatin dry plates were still some decades off. Daguerreotypes, although considered somewhat old-fashioned by photographers of the 1870s, were nonetheless very practical for science. The silver-coated copper plates could be rough-polished and transported in cases. The necessary chemicals, iodine and bromine crystals and mercury and gold solution were half crystalline, so the darkroom procedure could be conducted with relatively little water. Fresh, clean water was always a problem on expeditionary travels, certainly no less so if it was needed to prepare uncontaminated developers and fixing baths. One particular advantage of the daguerreotype lay in the opacity of the plate. There could be no internal reflection in a metal plate. This problem of internal reflection, and the lack of clarity it might cause in the resulting images, was of more concern to scientists than any question of sensitivity or dimensional stability, although those were factors as well. In the end, it was the daguerreotype's huge power of resolving fine details that ensured its usefulness for creating measurable records. When in the late 1970s and early '80s scanning electron microscopes were turned on daguerreotype images, they revealed some secrets of this fine detail. (Before this time, daguerreotype emulsions had been investigated, but the image particles were smaller than the resolution of the strongest available microscopes). The analysis of the silver-mercury and – in the case of gilded daguerreotypes – silver-mercury-gold amalgams creating the emulsions revealed that chemically and physically, the micro-structure of the image surface differs from one part of the image to another. This together with the minute size of the image particles lends the perception of near-magical, endless detail that so captured the public's imagination in 1839 (illus. 11).[7] Measurements of these details could be trusted, or so believed the French in the nineteenth century, who largely employed the daguerreotype in their transit expeditions.[8]

overleaf: 11 Dr Susan Barger, *micro-structure of a gilded, mercury-developed daguerreotype step tablet, with high and low magnifications*, c. 1991, photograph of a daguerreotype emulsion made with a scanning electron microscope.

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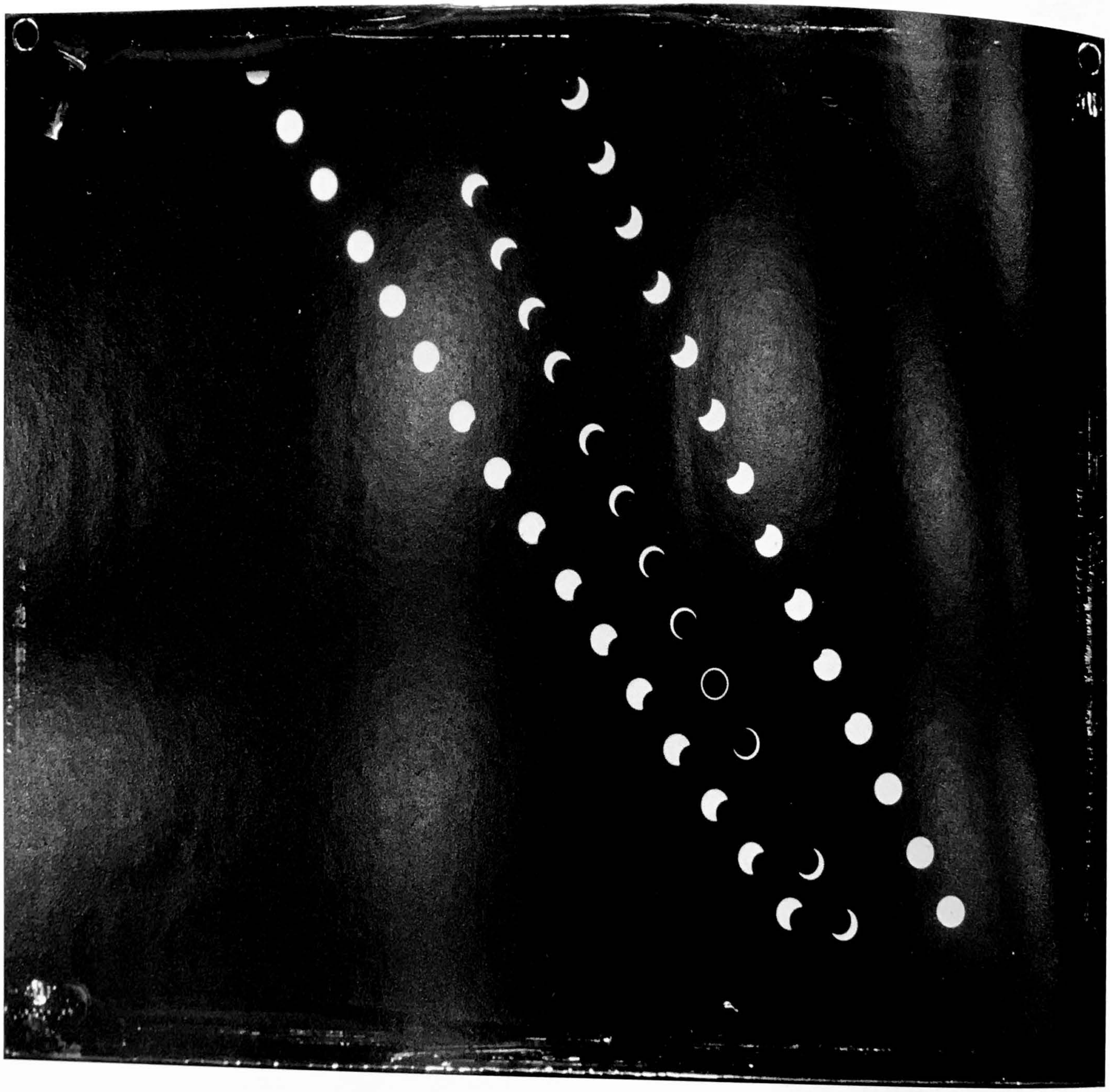
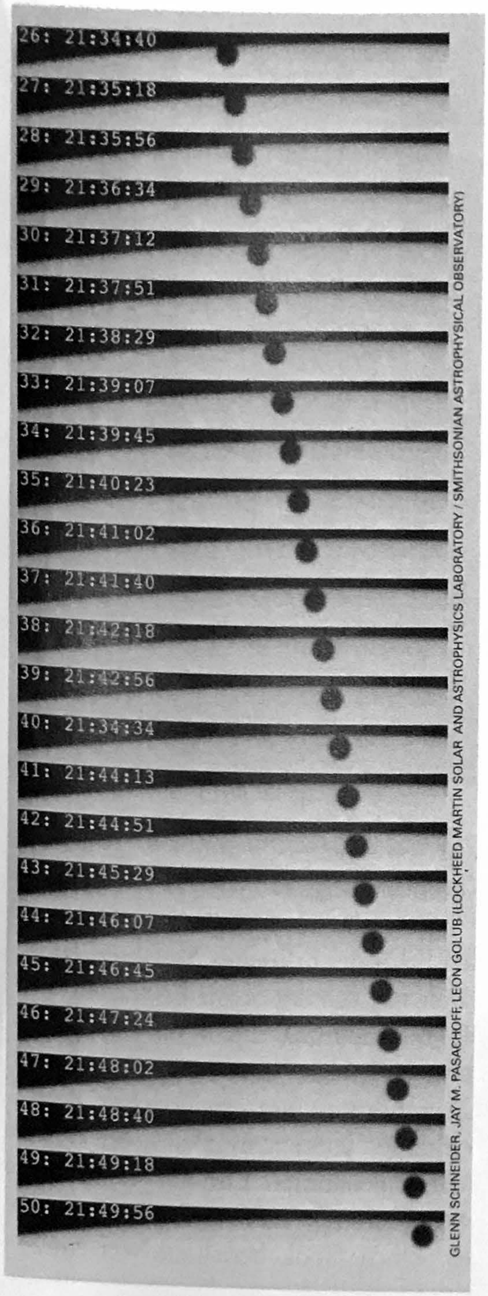


12 Robert Schlaer, *Annual Solar Eclipse from Santa Teresa, New Mexico*, 5 October 1994, multiple exposure daguerreotype, taken at five-minute intervals, 4 x 5 inches. Although this plate was not made with a Jansen instrument, it shows the advantage of multiple exposure images of astronomical events.

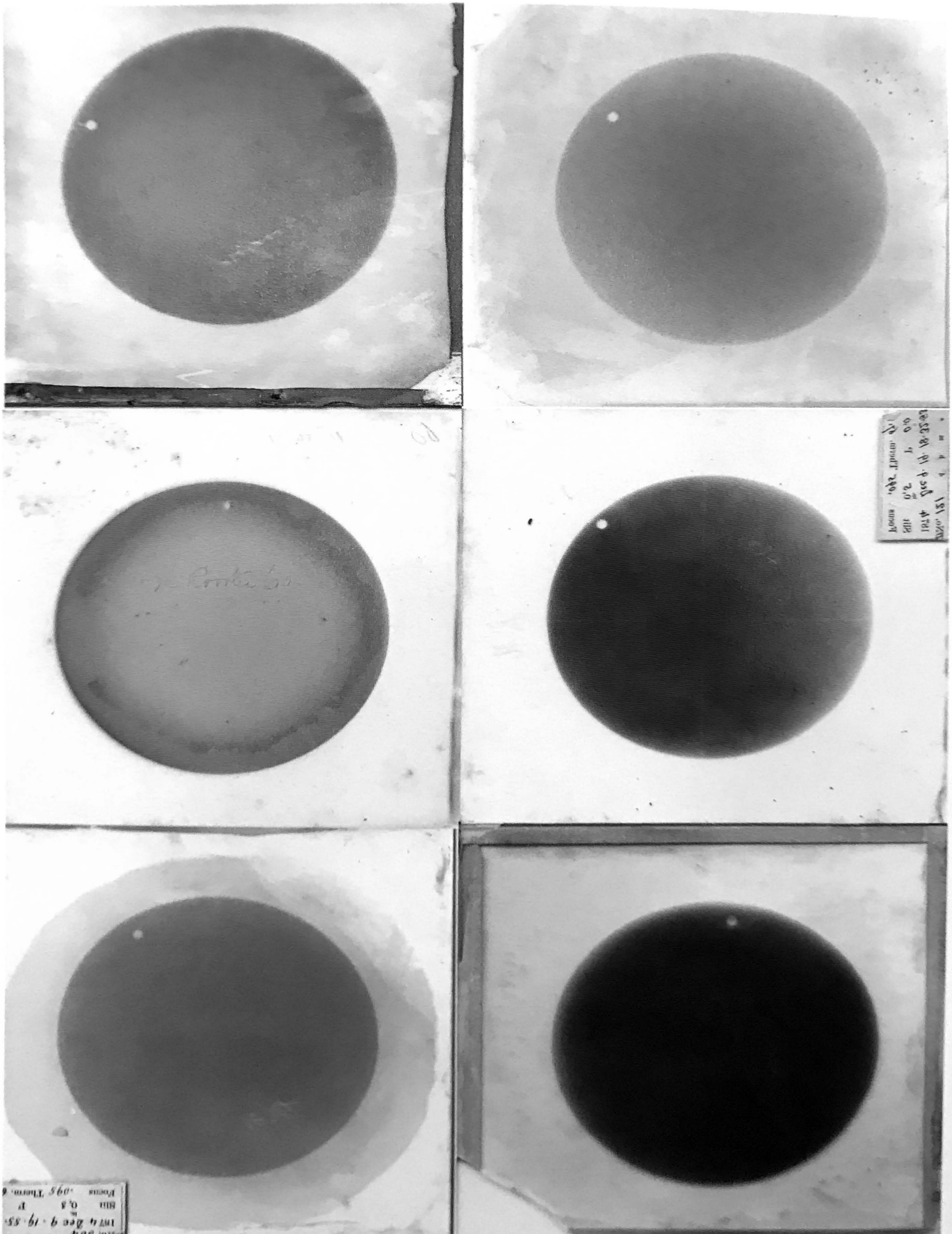
The more sensitive but rather unpredictable 'dry' collodion method also had its advantages. Chief among them was the speed of the emulsion. Although wet collodion plates could produce some very fast emulsions, it was obvious that photographing the transit on a still-wet emulsion, one that would then be developed, fixed and dried, would not render scientifically viable measurements. Dry collodion plates were considered more stable dimensionally, and could be prepared at home for use on the transit a month or more later. The British expedition photographers were all



13 Glenn Schneider, Jay M. Pasachoff and Leon Golub, *Transit of Mercury*, TRACE image, 1999.

trained in the dry collodion technique. This was not the end of the debate, however. Once the emulsion type had been chosen, there were three possible methods of exposure. There was the so-called 'Janssen' plate, where as many as 50 exposures could be made on one plate (illus. 12). This method, often considered a forerunner to cinema, was eventually developed into instruments like TRACE, the white light optical telescope used to make images from space of, among other things, the transit of Mercury in 1999 (illus. 13).[9] Images could also be made in stereo, or one exposure per plate could be made serially and the measurements could be reduced along with other eye-observations (illus. 14).[10] Each of these methods has its advantages, but by far the most prevalent was the one-exposure-per-plate method. The six negatives here, taken by different photographers at different stations, exhibit a range of both colours and densities, although they were made after the same method and intended to be uniform. They testify to the extreme difficulty of photographing any astronomical event.

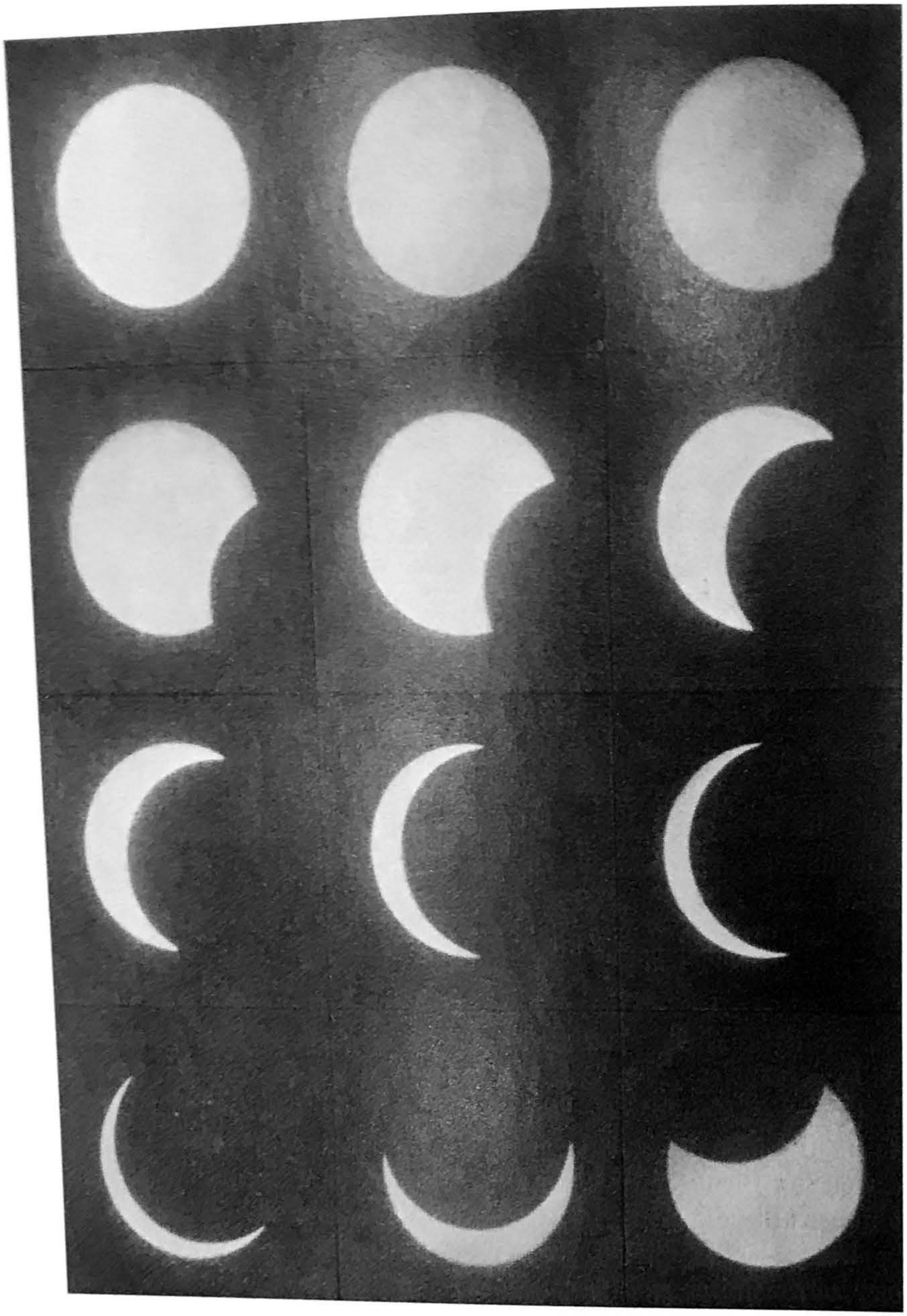
William de Wiveleslie Abney was stationed in Egypt for the 1874 transit.[11] He brought with him two types of dry plates, collodio-albumen (the albumen beer process) and a form of collodio-gelatin plates, as well as the chemicals to make both on site. Recipes varied among daguerreotypists, but not as widely as they varied for dry collodion. Because collodion becomes impervious to liquids when dry, 'dry' collodion wasn't any such thing. It was a collodion emulsion that was treated with honey, sherry, syrup, beer or any number of sticky substances. These humectants retained moisture, preventing the emulsion from drying out completely. Different photographic recipes delivered different results, and this meant different colours and sometimes quite different sensitivities. Pure collodion emulsions were faster than pure albumen emulsions, but when collodion and albumen were used together, usually the result was faster than either used separately. The unknown quantity with the use of each colloid, whether it was albumen, collodion or later gelatin, was its effect on the sensitivity of the entire emulsion. It was a problem that baffled photographers and scientists until well into the twentith century. Gelatin turned out to be not only practical, because it could be dried and later wet again, but also faster, because gelatin positively affects the sensitivity of silver halides.



14 Six glass plate negatives of the 1874 Venus transit made by British photographers on various expeditions, 1874, glass plate negatives.

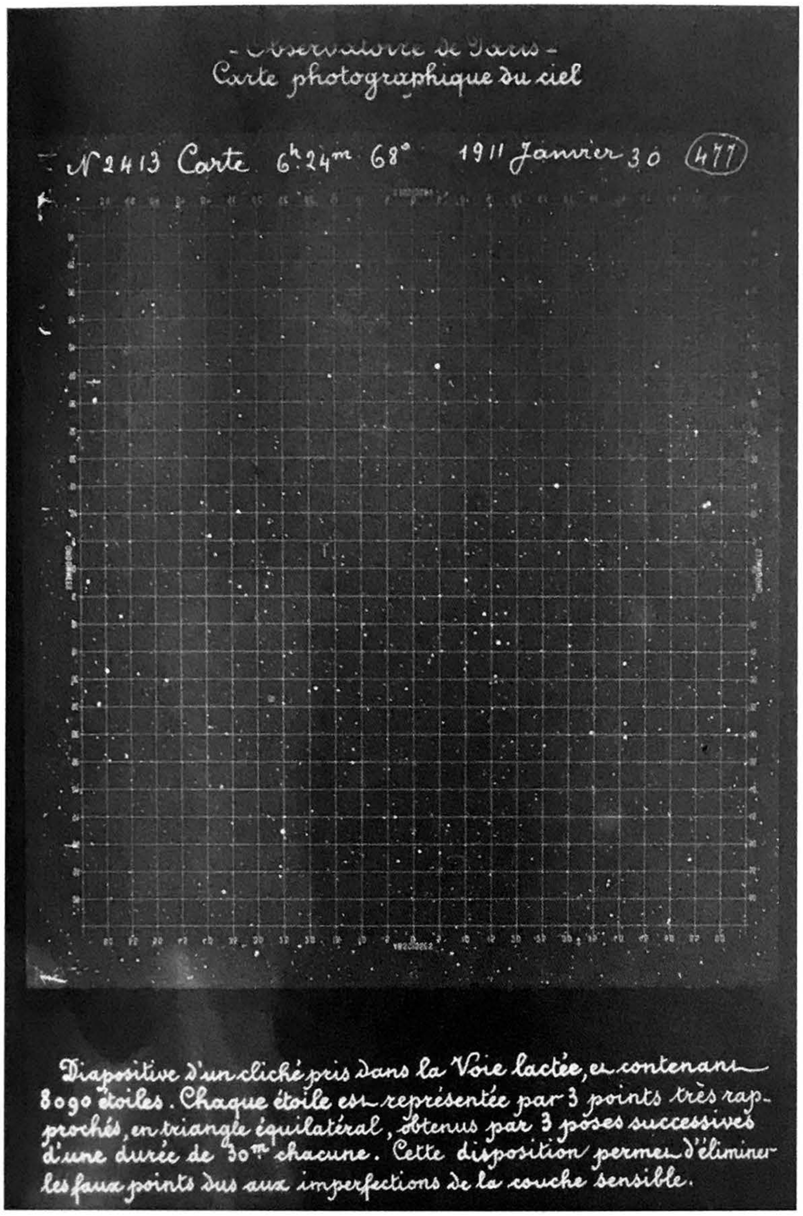
Speed did not mean a sacrifice of quality or greyscale, at least not in the case of Abney's recipe. The collodio-albumen emulsions were favoured for their tonal scale by many landscape photographers in Britain from the late 1850s onwards. The albumen-beer process, a variant of collodio-albumen, was Abney's own invention, developed some time in 1873 and taught to all of the British expedition photographers of 1874.[12] His defence of the emulsion, cited above, reveals a deep-seated anxiety about the level of standardization that could be effectively achieved. Abney trained the British photographers, who were then dispatched with similar equipment, similar observatories and similar chemistry, right down to the Tennents. The photographers were militarized, even if they weren't paid members of the military. They were taught at the School of Military Engineering at Chatham and sent with military assistants who recorded the transit with military timing, preparation, exposure, storage and later development of the plates.

Even with all this British military prowess, they still had no control over the weather. Abney despaired when his developing baths, 'which suited daywork, were too weak for the cold of the night, and it was too hot to prepare the plates during the day', and 'the dust interfered, and we were obliged to wait for the dew to lay it before we dared venture on preparing a large batch. We had trial after trial. As fast as one difficulty vanished another made its appearance.'[13] Abney counted the expedition a success. He and his military team exposed 45 plates, several of them Janssen plates with 50 exposures each. The *London Illustrated News* also hailed the transit photography (collectively) as a success.[14] The astronomers, however, deemed the photographs failures. In spite of all attempts at standardizing the effort and orchestrating the photographic training, the reliable data set they hoped to create was not forthcoming. After lengthy discussions at Greenwich (where G. B. Airy, as the Astronomer Royal, was in charge of the observation reductions) about how to measure the plates, and with what instrument, the results revealed a parallax measurement significantly different from that achieved by the other observations. They were then measured again, using a different method, again with unsatisfactory results. The anomalies were put down to everything from irradiation to atmospheric distortion, but the real cause was never ascertained. The fact remained that the planetary definition was far



15 August Hagenbach, *Solar Eclipse of 1912*, made using Agfa Chromo-Isolar plates with a yellow filter, 1912.

too soft for accurate measurement. In one early exposure, Venus appeared to be 'square with rounded corners'.[15] In total, the British transit photographers made hundreds of images of the transit, but these images were not considered in the final result of the transit project.[16] The measurement of photographs of astronomical events remained difficult even when it appeared that the theories of measuring had been resolved. In 1912,



16 Photographer unknown, *Carte photographique du Ciel, No. 2413, Carte 477, 30 January 1911*, print made from a negative taken in the Milky Way, containing 8,090 stars. Each star is represented by three points very close to one another, forming an equilateral triangle, which were obtained by three successive exposures of a duration of 30 minutes each. This method allows for the elimination of phantom points arising from imperfections in the emulsion.

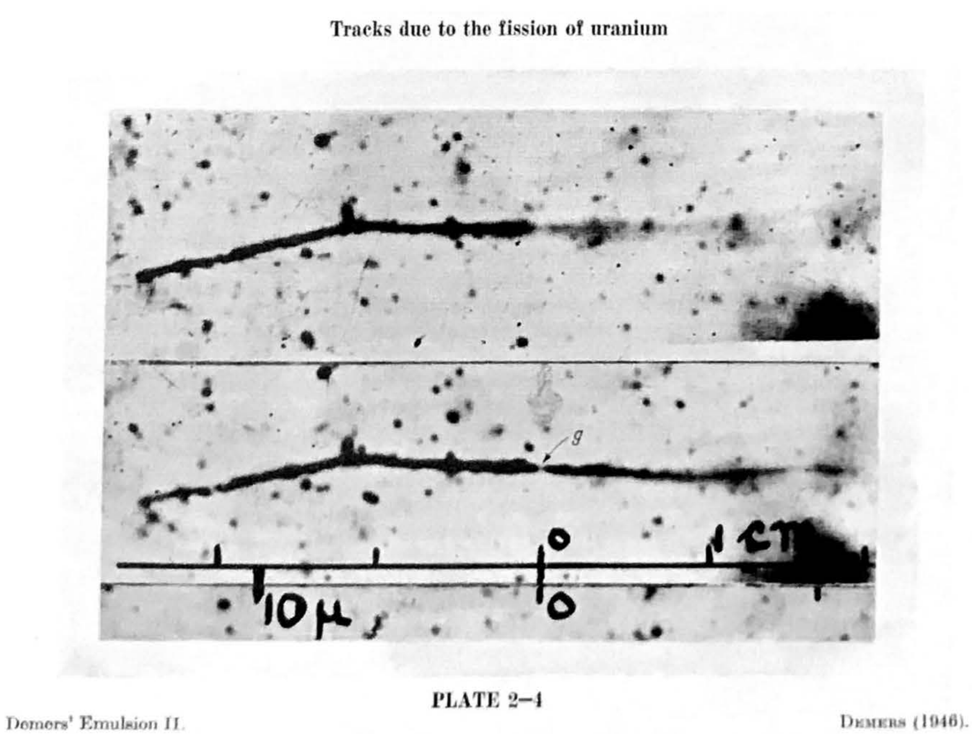
August Hagenbach photographed the solar eclipse with an eye toward generating exact measurements of the moment the moon began to slide in front of the sun (the moment of contact) (illus. 15). Although he developed a means by which the measurements could be made, his own images were, like the transit images, insufficiently sharp – a fault he put down to a loose camera mount but which could have been due to any number of factors.[17]

This failure of photography in the transit of 1874 did not signal the death knell for photographic observation in astronomy. Nor did it seem a great impairment to the general impression that reliable, measurable photographic observations could be made, both in astronomy and elsewhere. It would only be a matter of how and when. Only 13 years later, in 1887, a group of scientists met in Paris to form the Carte du Ciel, one of the most influential photographic observation projects in astronomy. This project to measure and map the heavens continued for nearly a century, providing an astrographic catalogue of millions of stars used to the present day. Carte du Ciel images begin their existence as individual observations, and carry on their working lives as part of an enormous observation archive. The photographic plates, once observations themselves, are observed again and again, always with different questions in mind (illus. 16). What is most striking about the Carte du Ciel is not just the idea of picturing millions of stellar objects, but the initial purpose, which was to observe and measure all stars over the eleventh magnitude. In this particular case, measurement was two-fold. Not only were stars compared to one another to determine their brightness, after which they were classified into magnitudes, but each star was also located in relation to its neighbours. Measurement, as we have seen in the story of the transits, often goes hand in hand with photographic observation.

The Impulse to Measure

From the moment photographs arrived on the scene, there has been an impulse to measure them in one way or another (illus. 17). This impulse is perhaps a by-product of the sometimes overwhelming specificity of photographs. A photograph like C. F. Powell's image of tracks of fission of uranium is not only a record of a specific event that occurred at a specific time, but also a record of the capability of one film emulsion (in this case Demers' Emulsion II, a diluted emulsion) to record a track with greater specificity than an emulsion of regular strength. The image represents a particular event – the collision of a fission fragment (at the left) with a nucleus in the emulsion at *g*.[18] It is the particularity that makes it possible to 'observe' the distance of the forked track to the right, through 1 cm of air, as shown at the scale at the bottom of the image. Curiously, the photograph is able to do this *even though* it shows how much variation occurs from one emulsion to the next. As we will see in the next chapter, it might be able to do this *because* it shows the variation between emulsions.

Scientific images have not always been made to measure. In the eighteenth century and before, the majority of scientific images were 'ideal' or

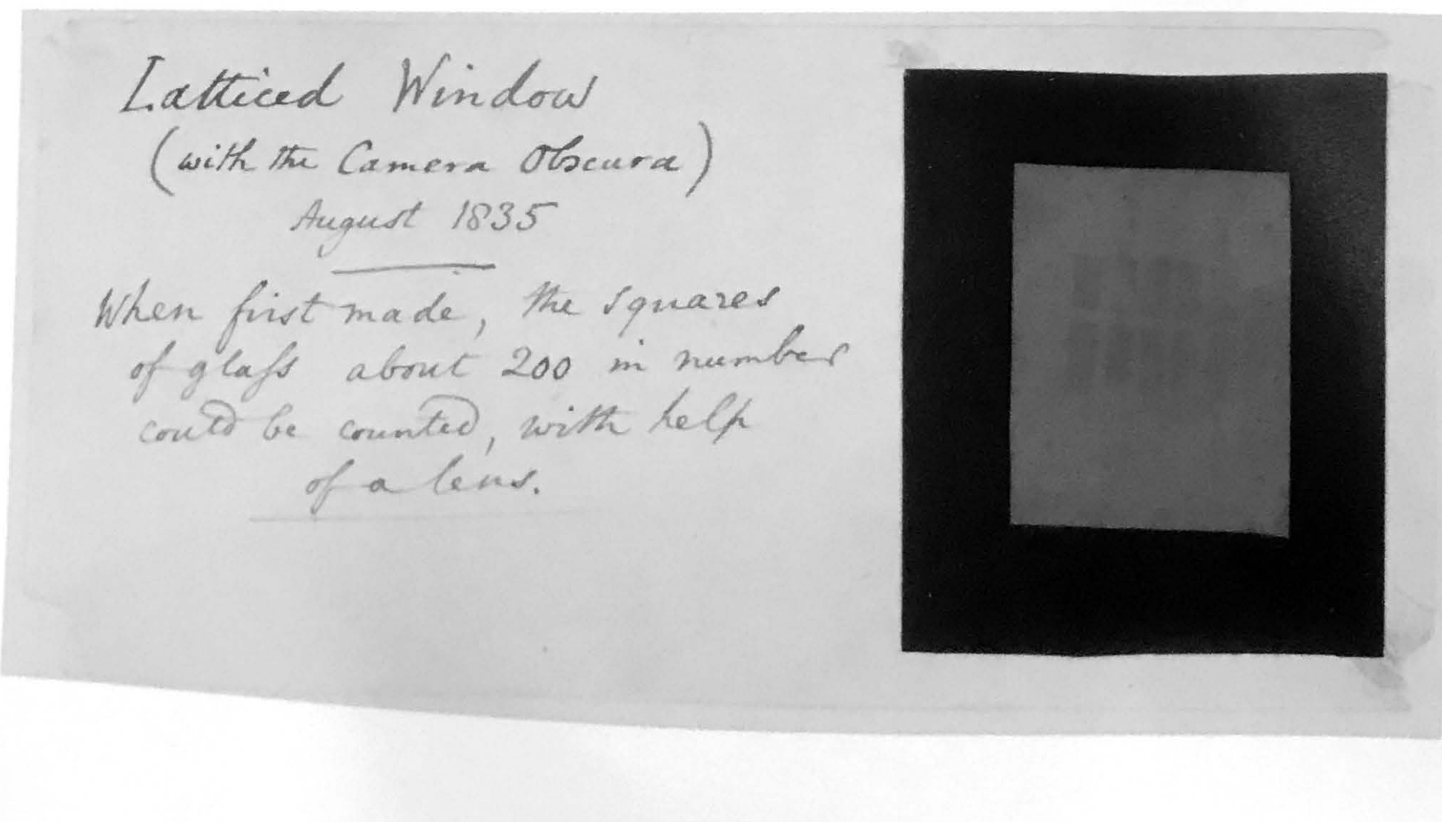


17 C. F. Powell, *Tracks due to the fission of Uranium*, Demers' Emulsion II, 1946. To achieve this, Demers 'sandwiched' layers of ammonium uranate between emulsions.

18 Maria Sibylla Merian, *Peach and Oak Egger*, after 1705, watercolour and gouache on parchment.

'reasoned'.[19] These images were true and scientific representations of nature, just like photographs, but they relied on an entirely different understanding of the truth claims. Maria Sibylla Merian's drawings of botanical and zoological specimens in the eighteenth century are an example of these sorts of images. Here she has drawn the various stages of an oak egger moth in its habitat (illus. 18). Botanical specimens were also often drawn as one plant with buds, flowers and leaves as seen throughout the growing season. Scientists of the day felt that only by examining many examples could they recreate a representation that was true to nature. True, that is, to the underlying nature of the specimen.

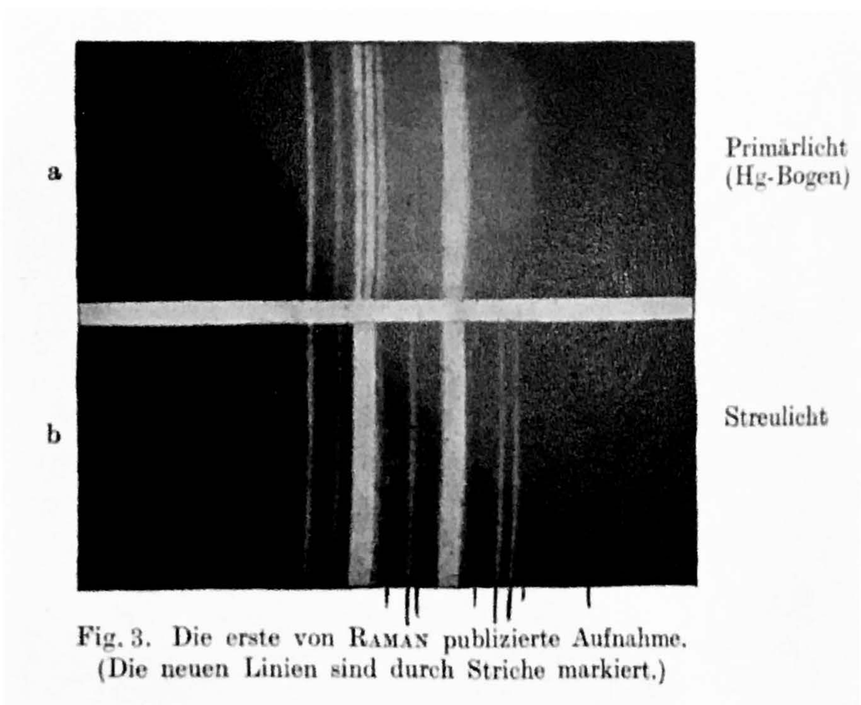
Photographs have the knack of doing quite the opposite. They depict the specific object at a specific time and in a specific place. That is not to say that ideal photographs don't exist; they surely did and do, in both art and science. (For instance, in Francis Galton's or Henri Becquerel's work; see illus. 31 and 41). But the impulse to measure photographs rests on the premise that a particular object has been depicted, and that measuring it will tell you something about that object. Sometimes, like Talbot's counting 'about 200' panes of glass in his negative the *Latticed Window*, the ability to measure appears to be a useful but unintended byproduct of a photographic image made for other reasons (illus. 19). Often, however, photographs were produced specifically to be measured, like the Venus transit plates, or the star charts of the Carte du Ciel. The very notion that photographs could possibly be measured forms the foundations of various types of scientific photography, such as Raman spectroscopy and photogrammetry, two methods that bent photographic observation to mathematization. Surveying, for instance, is heavily dependent on the idea of measurable photographs, as is cataloguing museum objects by photographing them, and documenting archaeological sites. In the late



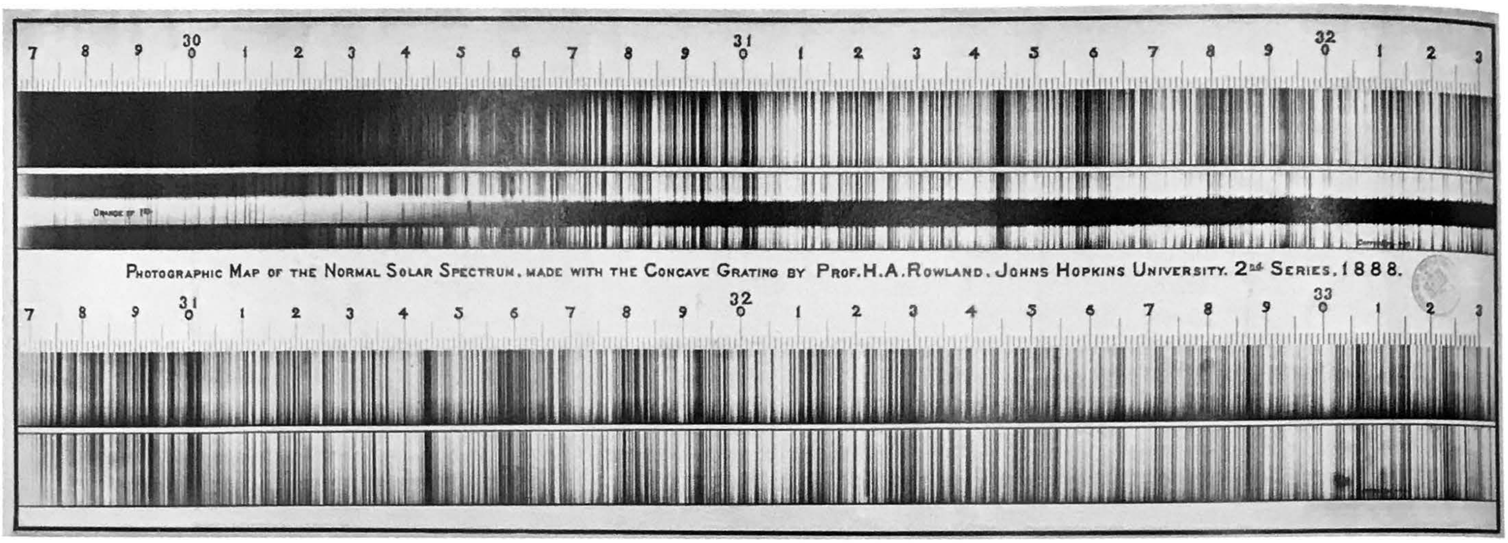
19 William Henry Fox Talbot, *Latticed Window* (with the camera obscura), 1835, photogenic drawing negative.

nineteenth and early twentieth centuries, people of all sorts were photographed and measured (see illus. 57). Microscopically, photography has often been used to produce an exact measure of its own particles (see illus. 11); or a nuclear event (see illus. 17); earthquake tremors; or the human pulse (see illus. 4). Often images made to be measured, like earthquake tremors or spectrograms, aren't considered photography at all. They use photography, but produce images that don't appear to depict anything recognizable. Even when they are recognizable as pictures, the images are often strangely distorted. Both Raman spectroscopy and photogrammetry created successfully measurable photographs, one producing extremely unconventional records, the other much more pictorial images.

In the early part of the twentieth century, C. V. Raman began publishing his results on obliquity factors of diffraction, measured photometrically (illus. 20). Measuring diffraction in this way, using both solar light and x-rays, became a dominant practice in spectroscopy, and led to notable studies of objects at the structural level as well as the molecular level (illus. 72). Raman photometric images resemble the stripy maps of the spectrum, or in the words of one spectroscopist, a supermarket bar code (illus. 21).[20] Unlike spectral maps, however, the information in Raman images was contained in the diffraction measurements, not in the visual



20 Chandrasekhara Venkata Raman, Raman's first published image, 1928, photomechanical reproduction.

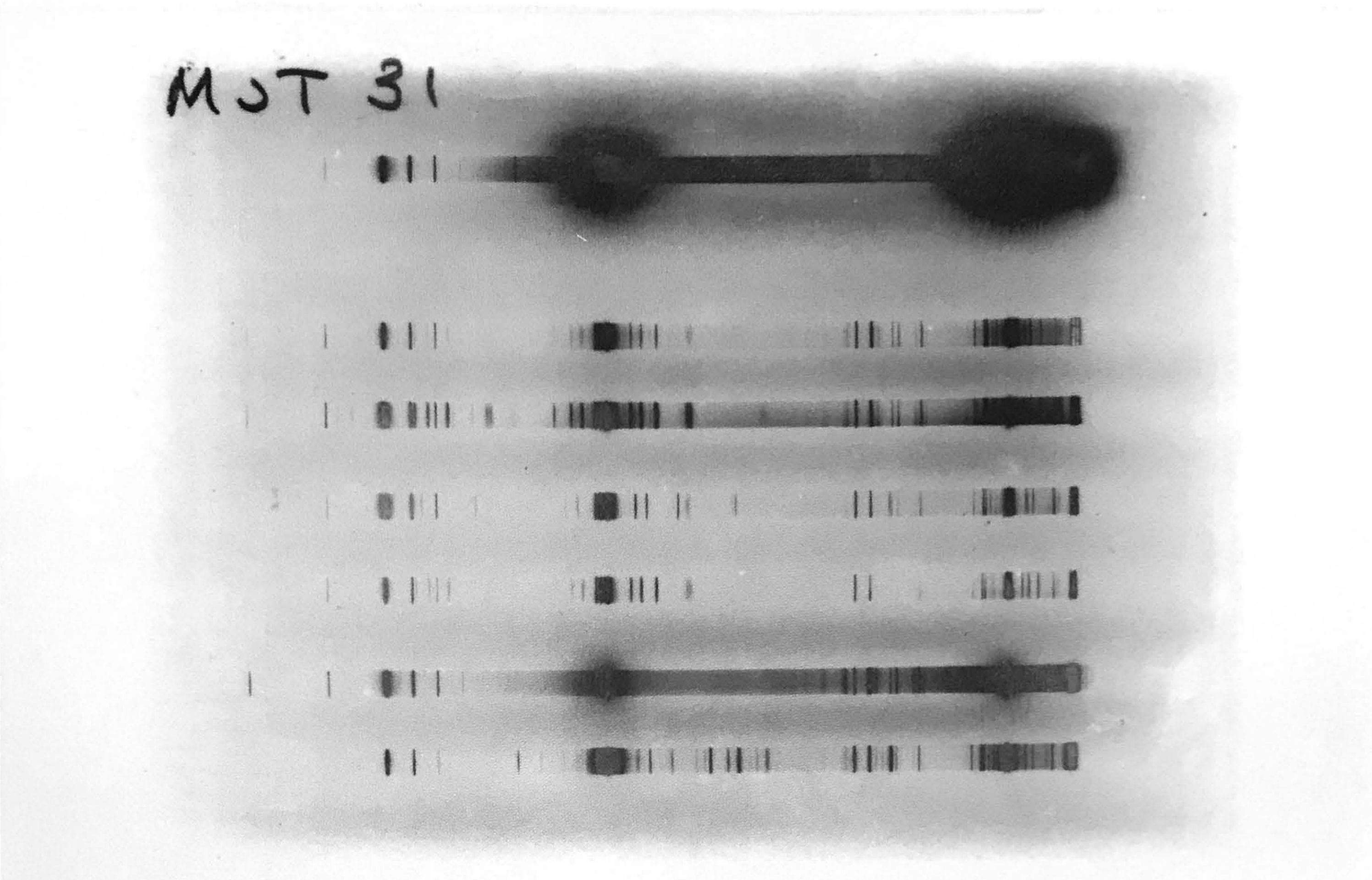


form (illus. 22). These Raman plates were exposed over extremely long periods of time, utilizing the invaluable quality of photographic emulsions to gather light over periods of hours or even days. In this respect the discussion of emulsion speeds can be highly deceiving – giving the impression that 'fast' or 'sensitive' plates are always associated with short exposure times. In some sense they are, but even short exposures for some types of scientific photographs can still take hours or days rather than 1,000ths of a second. William Crookes took two days to expose his piece of pitch blend on a photographic plate (see illus. 38) and one image from the Carte du Ciel (see illus. 16), comprises in total a 90-minute exposure – three different exposures of 30 minutes each.

Raman plates are formed when monochromatic light is scattered over a molecule. Most of the light continues in its same wavelength, but a small amount is scattered sideways in different wavelengths, producing a spectrum that can be fixed with a photographic plate. It is then measured and calculated in different ways to ascertain the molecule size, shape and bond characteristics (illus. 23). These measurements are only applicable to that particular molecule, with that particular molecular bond, although they differ from many observations of singular events in that the Raman spectrum can be recreated if necessary, using another molecule of the same compound. While conclusions in the form of broader chemical theories can be extrapolated from the Raman technique, the emphasis is on the specific and the numerical. The spectrogram images are converted to a set

21 Henry A. Rowland, *Photographic Map of the Normal Solar Spectrum, Made with the Concave Grating*, 2nd series, 1888.

opposite: 22–23 Dr. Michael J. Taylor, *Raman Spectra of Some Liquids*, made using Hilger equipment in the chemistry department, University of Auckland, 1968, glass plate.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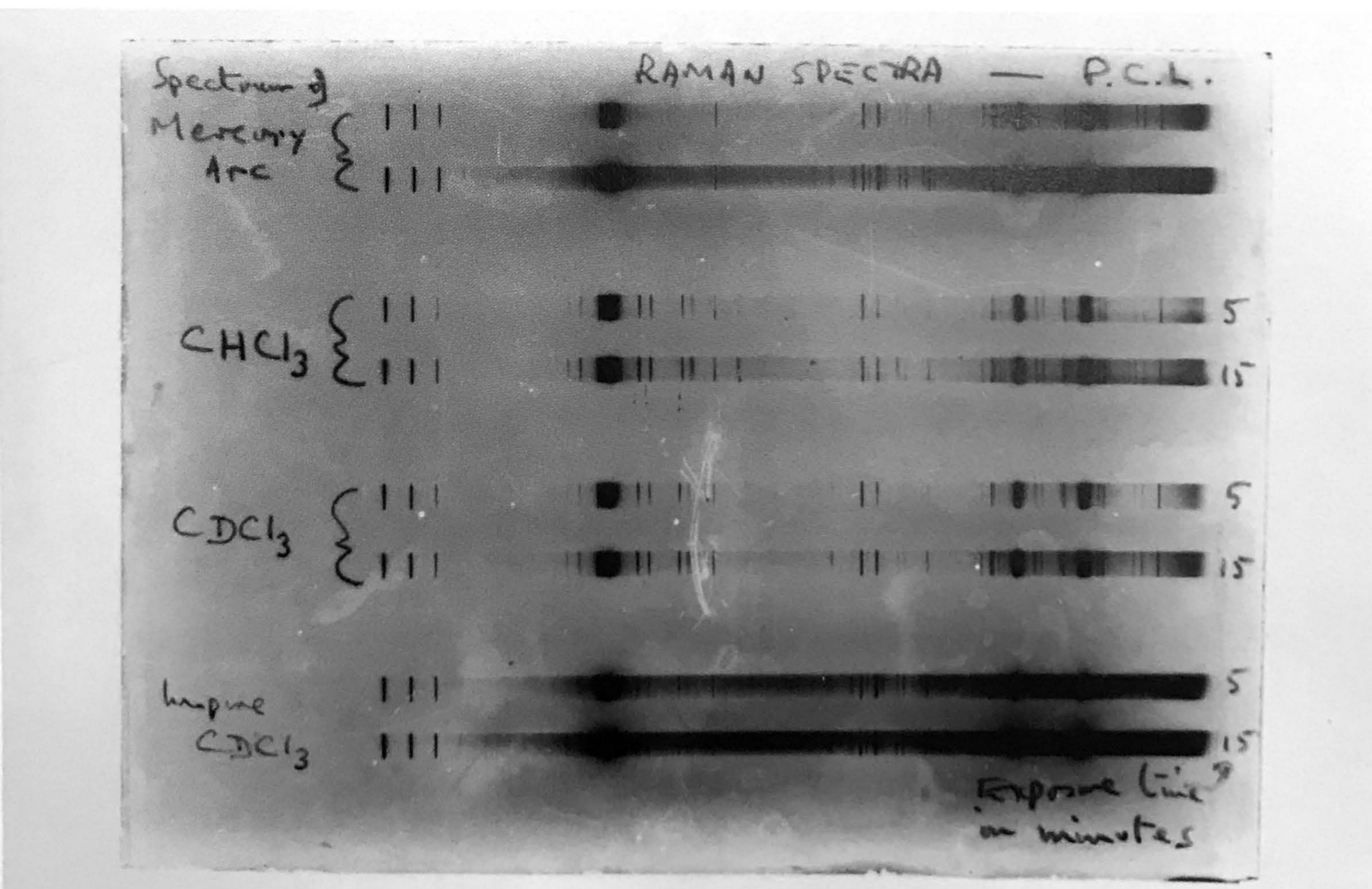
RAMAN SPECTRA — P.C.L.
Spectrum of Mercury Arc
$CHCl_3$
5
15
$CDCl_3$
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15
Impure $CDCl_3$
5
15
Exposure time in minutes

24 Albrecht Meydenbauer, *Elisabethkirche in Marburg*, 1883, photogrammetric image, silver gelatin.

of numbers by various algorithms. The physical objects, the glass plates, are often subsequently discarded. Raman spectroscopy on glass plates, like those shown here, was adopted in the 1920s, using first solar light and later the mercury arc. The photographic emulsions were generally those adapted for astronomical photography, the so-called 'fast' emulsions. The technique has been used in chemistry, condensed matter physics and sometimes even in medicine and museum conservation throughout the twentieth century. Scientists made Raman spectrograms in analogue form (usually on glass plates) up to the 1970s. Now these images are made digitally.

The story of photography in observational sciences often resembles that of Raman spectroscopy. Photography, the eye analogy notwithstanding, does here what the eye cannot in allowing the collection of light over time. It produces images of spectra that are essentially not there. The extra lines are scatterings of light, leavings normally discarded to the side. They are nonetheless quantifiable, and correspond according to the laws of physics to the molecules that produce them. They are, for the lay person, impossible to read as any sort of image. Spectroscopists can 'read' these images, but the information is no use in pictorial form. It has to be converted into mathematics to generate useful data.

Processes that centred on measurement did not always have to dispense with the pictorial in this way. Photogrammetry is an excellent example of a photographic process that coincided in history with Raman spectroscopy, and that also relies on measurement. But photogrammetric images can contain visual information alongside the mathematical. Phototopography, iconometry, metrophotography and photographic surveying have all become loosely associated under the title photogrammetry, which began as a method for documenting buildings or landscapes by photographing them from carefully regulated points of view. In the 1850s and '60s, Albrecht Meydenbauer in Germany and Aimé Laussedat in France developed photogrammetric methods for the recording of buildings and landscapes respectively (illus. 24). In Berlin this led to the creation of the Königlich Preussische Messbildanstalt (the Royal Prussian Institute for Photogrammetry) where nearly 20,000 images still reside.[21] In France, Laussedat's *métrophotographie* had less tangible results, but his methods were adapted by Alphonse Bertillon to analyze crime scenes


AFFAIRE Assassinat et cambriolage
au bureau de poste de Bezons
PHOTOGRAPHIE MÉTRIQUE
Tirage focal 0m15
Orientation de l'axe optique N.E. 45°
DISTANCES
HORIZON
RÉDUCTIONS
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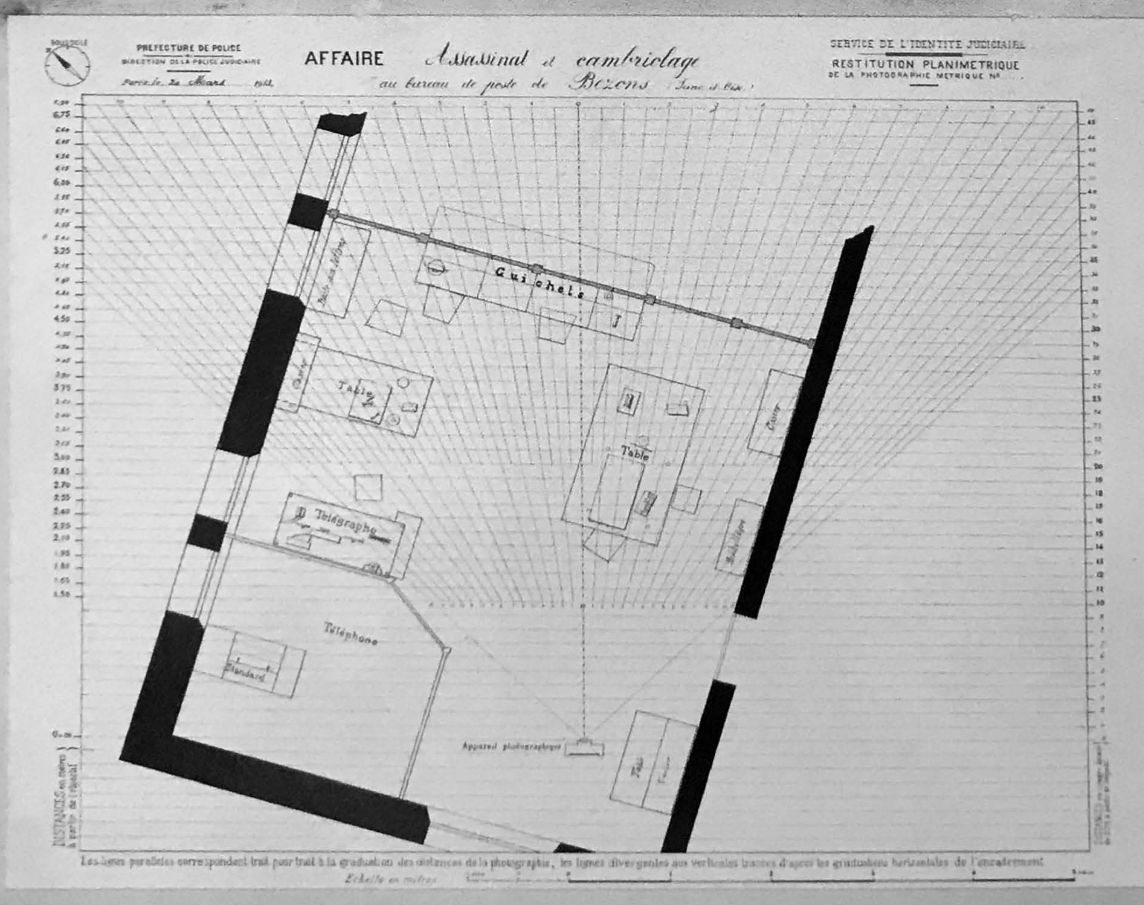

PREFECTURE DE POLICE
DIRECTION DE LA POLICE JUDICIAIRE
AFFAIRE Assassinat et cambriolage
au bureau de poste de Bezons (Seine et Oise)
SERVICE DE L'IDENTITE JUDICIAIRE
RESTITUTION PLANIMETRIQUE
DE LA PHOTOGRAPHIE METRIQUE No
Guichets
Table
Table
Télégraphe
Téléphone
Standard
Appareil photographique
Echelle en mètres

25 Alphonse Bertillon, *Photogrammetric Crime Scene*, 20 March 1913: 'Murder and break-in at Bezons' post-office'. The notes top-right give the height of the lens (1.5 metres), the focal length (15 metres), and the compass orientation of the optical axis (N.E. 45°). Albumen print mounted on card.

(illus. 25). Photogrammetry is in all respects as tricky as most other distance surveying. The successful measurement of the plates requires images with strict vertical orientation and at least one known control point. Although photogrammetric images look quite different – some, like Bertillon's, employ a visible grid, and others, like Meydenbauer's, do not – they all require this painstaking precision of camera placement and note-taking on the scene. In the schematic of Bertillion's photogrammetric crime scene, the placement of the camera is clearly marked within the grid. Without the orientation or control points, these images cannot be measured. Photography did not therefore obviate manual work on surveys, but it promised to shorten the time it took, and removed some of the danger inherent in clambering along building facades.

The popularity of photogrammetry in the nineteenth century was largely confined to the Continent. Many British authors were quite dismissive of the idea that such a survey of monuments could be useful or scientific, adjudging it 'more akin to an amusing game than to a useful art'.[22] But photogrammetry expanded slowly, first into archaeology, and then into aerial surveying, biometrics, geology and mechanical and civil engineering. The images, first as single photographs, then as stereo and sequential sets, are extensively used in archaeology. The extensive use of photogrammetry in archaeology in the twentieth century has even led to its introduction in underwater surveying of archaeological sites. The introduction of mapping in 3D by sequential photogrammetric imaging has made it an increasingly valuable tool. The Sesimbra Trial is part of a project to bring this sort of mapping photogrammetry not only to underwater archaeology, but to the general public. As part of the VENUS (Virtual ExploratioN of Underwater Sites) project, the Sesimbra Trial measures cargo from a presumed shipwreck near the mouth of the Sado River, off the coast of Portugal.[23] The three sequential images taken by Jean-Luc Verdier show industrial ceramic tiles photographed at a depth of approximately 56 metres. The resulting 3D map of the site allows archaeologists an overview that would be impossible in a dive situation (illus. 26).

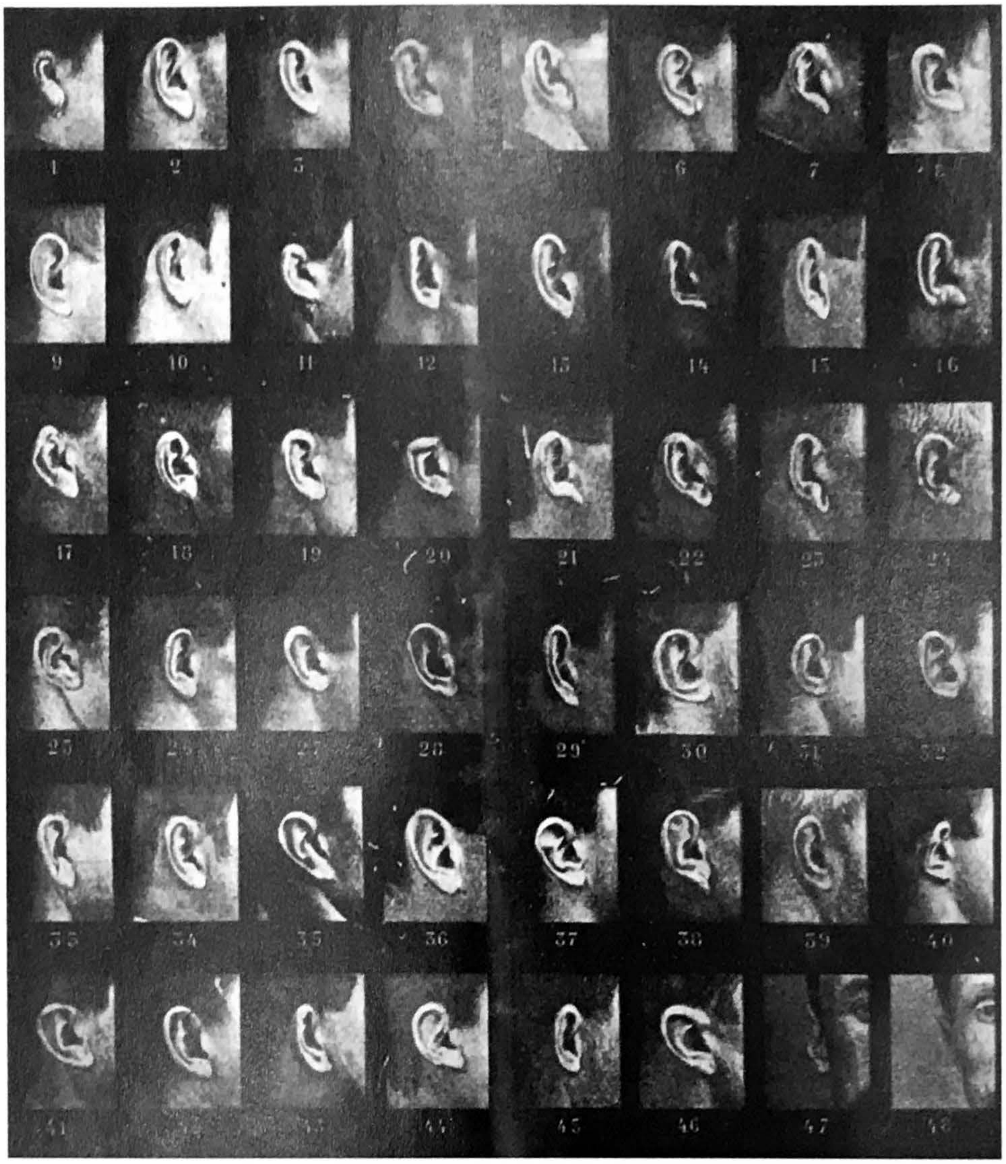
Unlike the Raman spectrograms, photogrammetric photographs provide a picture we can recognise as a photograph. The ladder at the base of the church steps and the fish swimming through the Sesimbra images

26 Jean-Luc Verdier, *Sesimbra sea trial*, photogrammetric strip, excerpt of three images, 25 October 2007, made with a Nikon D200, 20mm lens, embedded in a housing Sea and Sea DXS5 with two flashes Ikelite SB125 at a depth of 56 metres. In the framework of the VENUS Project, Mission in Sesimbra, Portugal.

are just the sort of accidental pictorial details lacking in Raman spectrograms. Although Meydenbauer's Marburg church has an other-worldly flatness about the roof, it is still recognizable as a roof. The Raman images generate very specific information and not much of the accidental. Therefore, when the mathematical information is harvested and published, it is often the case that the physical photographs have little to offer, and most of them have been discarded. Measuring photographs that also offer accidental pictorial details are, on the other hand, more likely to survive in archives. Thus it is the case that the vestiges of the vast majority of these sorts of measurement photographs are only visible in the pages of professional science journals. The Meydenbauer archive and archives like that of the Cartes du Ciel are the exception.

Generating Observables

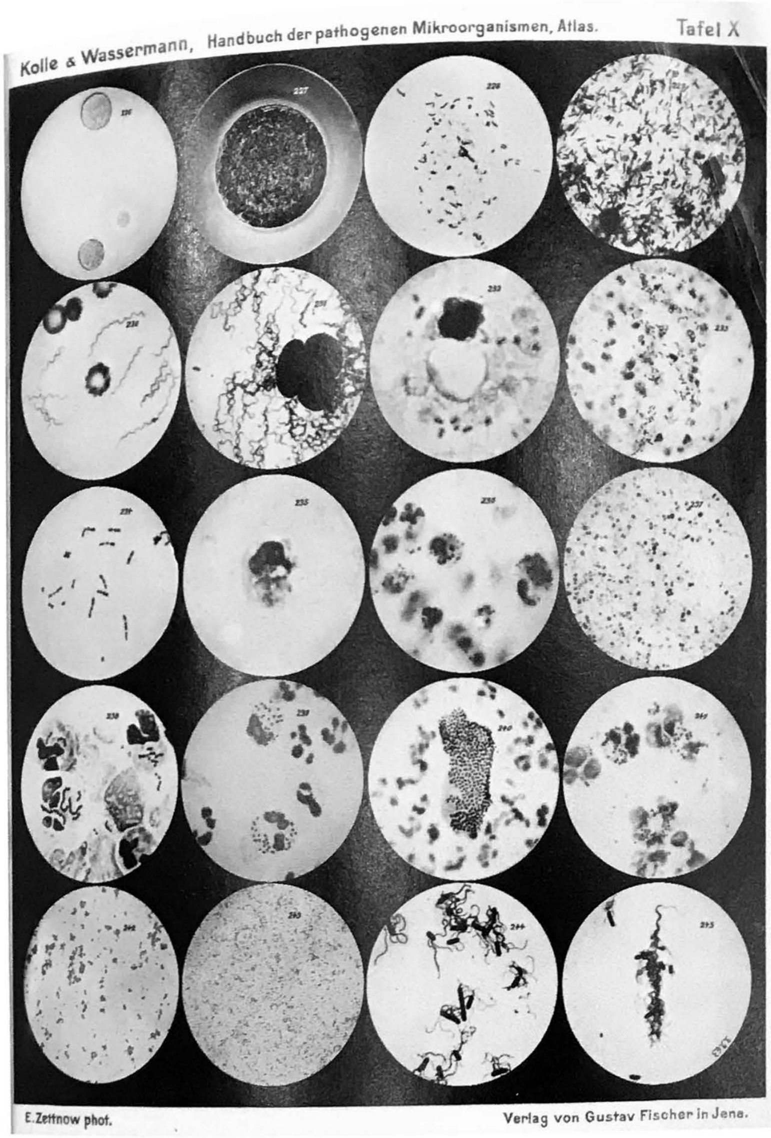
'Photography makes the invisible visible!' is the usual sort of headline we encounter when talking about photography and observation. This way of speaking lumps together very generally some of photography's most complex effects – effects that are quite widely varied in scope, scale and presentation. First is the registration of incidental, numerous and often minute details in objects visible to the human eye (illus. 27). There is also the effect of rendering the very small larger – for instance, photographs made under the microscope (illus. 28) – and rendering the very large smaller, for instance, making hand-sized images of swathes of the Milky Way (illus. 29). It might mean slowing action down by means of the stroboscope, as E. J. Marey, Eadweard Muybridge, Harold Edgerton and Ernst Mach did (illus. 30, 55). Or it might mean speeding up a process, like films of plant cycles on the Nature channel. If we refer back again to Talbot's assertion that the eye of the camera can see where the human eye sees nothing but darkness, one could say most photography relies at its very simplest on 'invisible', ultraviolet rays. The various functions listed above, however, are more than just the making of invisible things visible, they are entirely new methods of observing. There are two ways photography generates observable things: first by singling out a moment of

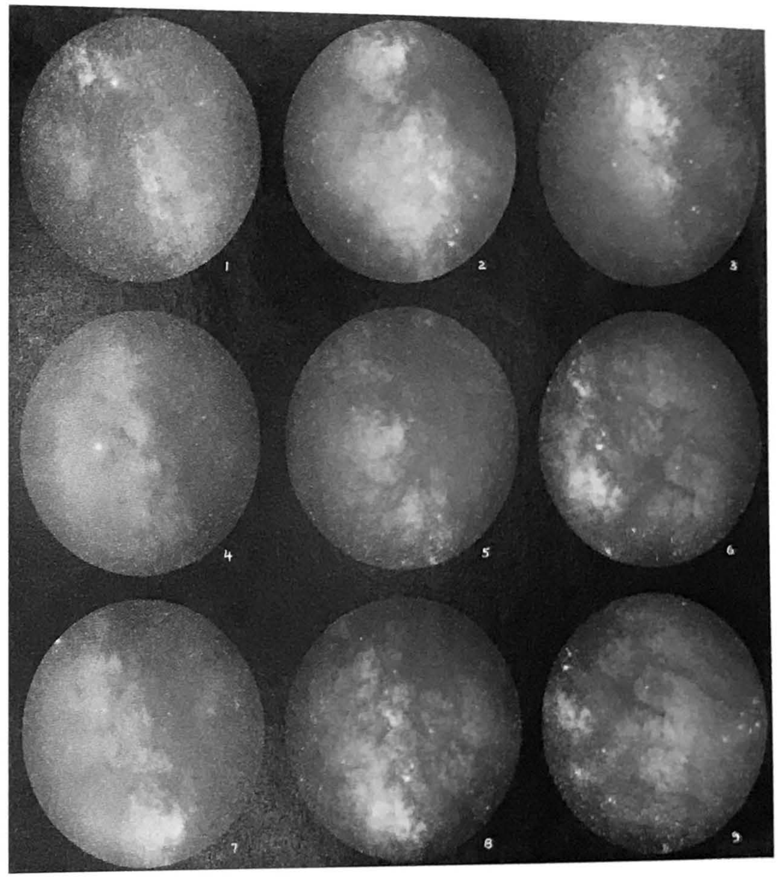


27 Photographer unknown, *Ears: Illustrating certain types of ears referred to in the text*, 1901, photomechanical reproduction.

time usually too small for human perception to register; second, gathering up light over a number of seconds, minutes, hours or even days and presenting it as one image. This last also includes the hybrid multiple-exposure – that is, short exposures made individually but then combined to create a new image.

The use of the strobe or spark, for instance, when applied to photography (it was used independently of photography for eye observations as well) is a powerful tool for the isolation of single elements in the stages of motion. The motion can refer to human bodies, projectiles, splashes, smoke or any number of ambulant objects. This high-speed photography, as it became known, differs greatly from human observations of the same activities. In physiology, the use of the stroboscopic, or graphic, method (as

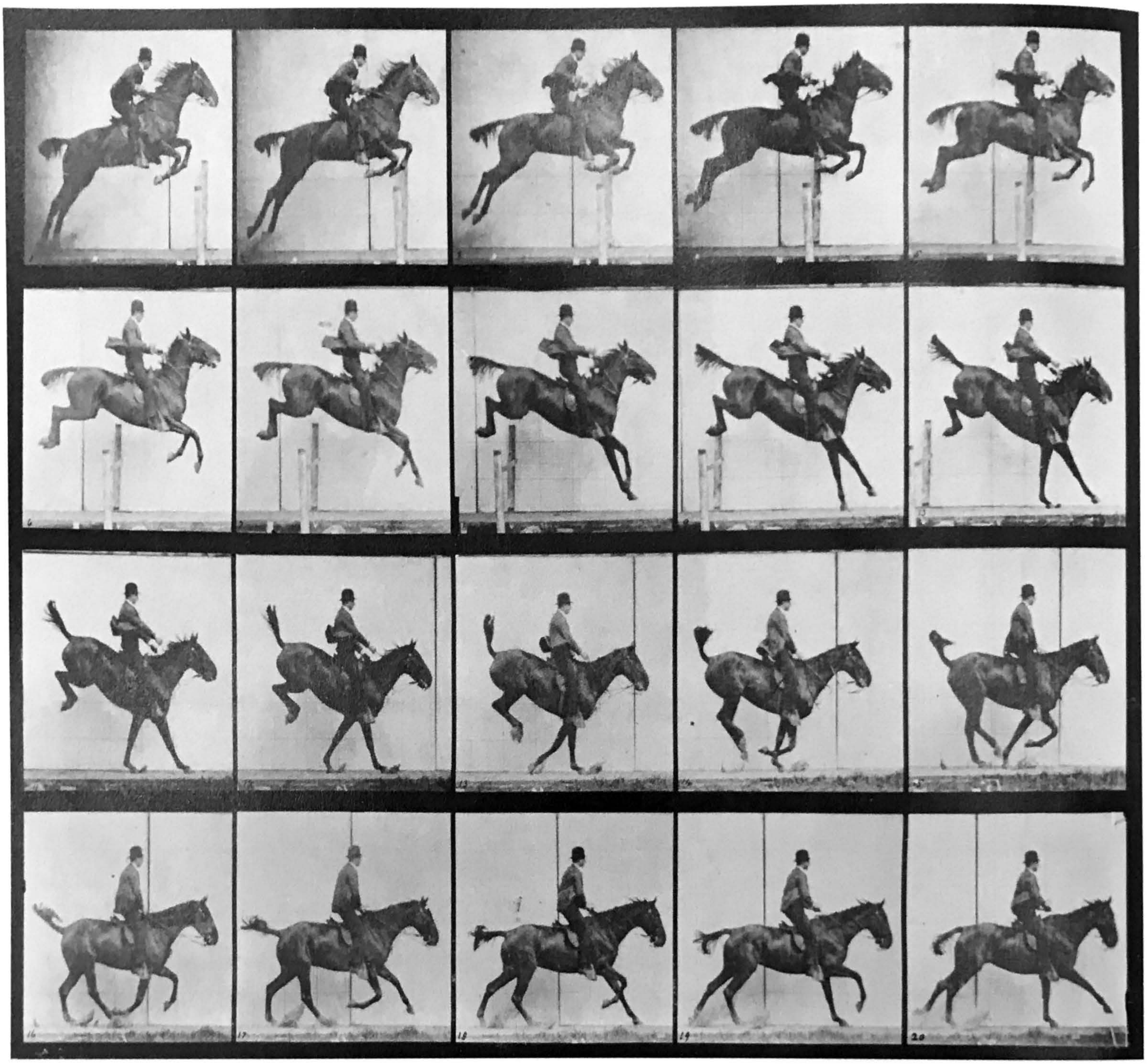




28 Emil Zettnow, *Microorganism Plate X*, c. 1902, silver gelatin.

29 Edward E. Barnard, *Nine selected areas of the Milky Way photographed on a small scale*, plate 51, 1927, albumen print.

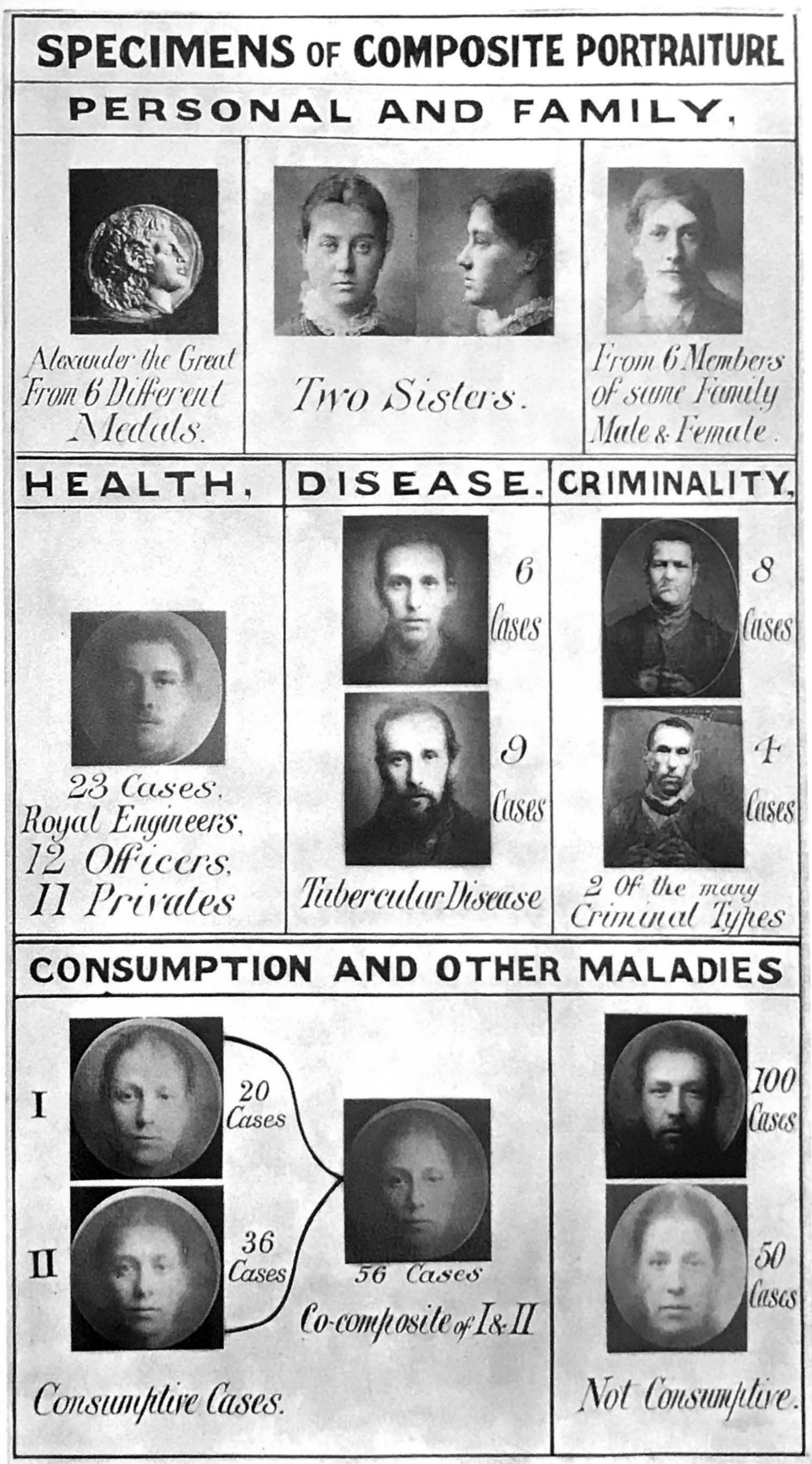
Marey named it) broke human and animal motion down into finely distinguished moments (see illus. 64). It allowed gait analysis by disregarding the whole and concentrating on the pieces. The whole, in this case motion, could be recombined as a moving image, but the trend was there to see motion as a series of individual discrete movements strung together, rather than as a continuous whole. In the Raman method, or in Francis Galton's analytic photography, the process was one of collecting and combining rather than separating. Raman images combine photon activity over many hours, the Carte du Ciel negatives combine three different exposures and Francis Galton layered many negatives to achieve his composite human 'types' (illus. 31). These composite images belong in many ways to the tradition of the ideal scientific drawings of the eighteenth century.



30 Eadweard Muybridge, *Animal Locomotion*, 1887, collotype.

In the 1890s photographic observation was transformed. Although it had always revealed objects too small, too fast, too complex, too slow and too far away to be seen with the eye, the discoveries of x-rays and radiation broadened the scope of photographic observation and led to a great many photographic experiments, as we will see in the following chapter. It began with Wilhelm Röntgen's 1895 announcement on what we now call x-rays, which were long referred to as Röntgen Rays (illus. 32). Like the ultraviolet spectrum, these rays were invisible to the human eye, but worked, as light

1 Francis Galton, *Specimens of Composite Portraiture*, c. 1883.



overleaf:
(left) 32 Wilhelm Konrad Röntgen, *Magnetnadel in Metalldose* (Magnetic compass in metal tin), 1895, silver gelatin print.

(right) 33 Collection of Louis Westenra Sambon, *Victim of Elephantitus* [Elephantiasis], 1919, autochrome.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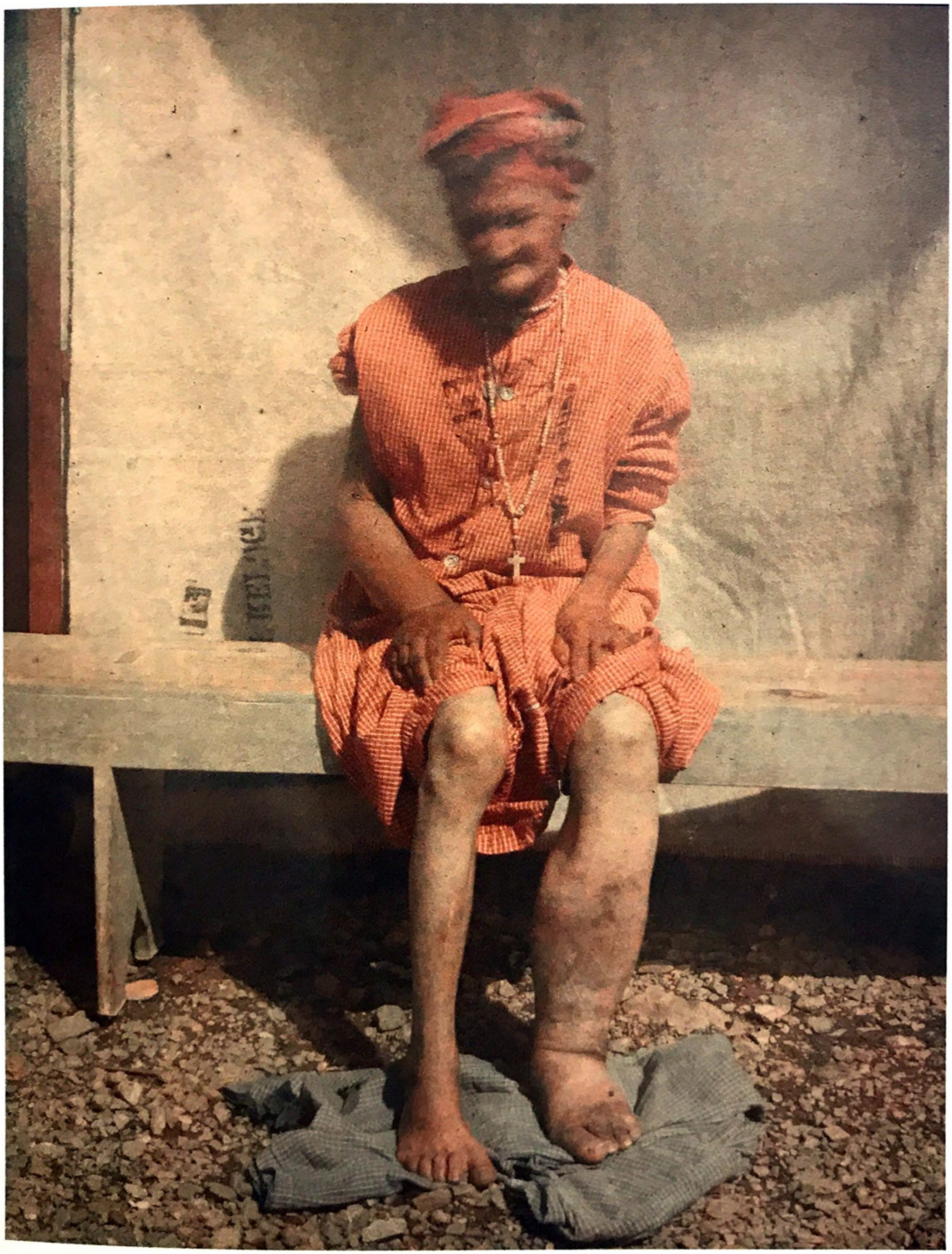

did, on the photographic emulsion. Again, unlike any part of the human anatomy x-ray photography allowed for a sort of observation heretofore unknown; penetrative observation. The sensational nature of the reception of x-rays can hardly be overstated. It was as if photography had been born again, more powerful and more omniscient than before. Images made with x-rays were published widely in the daily press as well as in photographic and specialist scientific journals.

Medical practitioners immediately began to test their usefulness for diagnostics and physicists began experiments searching for other 'invisible' but photogenic 'rays', all of which were soon gathered under the general title 'radiation'. Until this time, photography had not been overly successful as an observational method in the sciences of medicine and anatomy. It had been used with some success in the case of skin or deformative conditions, but photographing anatomical specimens successfully was difficult (illus. 33). This was in part due to the overall similar colouration of dead tissue, but also to the undifferentiated tissue abnormalities that occurred between one specimen and another. As teaching tools, photographs were much more vague than good anatomical drawings. x-ray photography soon changed all that. It took a leading diagnostic role in medicine, starting a century-long tradition of medical observation (illus. 34).

X-ray photography arrived at a time when the reliability of photography was acutely questioned in both scientific and popular cultures.[24] The rhetoric of replacing the error-ridden, limited, fatigable human eye with photography, which appeared to be as indiscriminate as it was infallible, was beginning to wear thin under the weight of incompetent portraitists and photographic confidence men (and women). Photographs of spirits and faked events, heavily retouched portraits and landscapes, all added to the notion that photography was a malleable medium, and malleable media are not the stuff of objective, passive observation. In the face of scepticism about the medium of photography, experiments on photographic emulsions were of crucial importance if scientists were to employ photography with authority. These sorts of experiments worked together with photographic observation to bolster the faltering reputation of photographs, establishing them as sufficiently scientific.

34 Josef Maria Eder and Edward Valenta, *Hand eines 4 jährigen Kindes* (Hand of 4-year-old child), 1896, photogravure from an x-ray, 19.9 x 8.2 cm, image on 48.8 x 34.1 cm, album page.