



Gabriel Lippmann's Colour Photography

Science, Media, Museums

Amsterdam
University
Press

Edited by
Hanin Hannouch

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Gabriel Lippmann's Colour Photography: A Critical Introduction

Hanin Hannouch

Abstract

This introduction, in lieu of a streamlined biography of physicist Gabriel Lippmann (1845–1921), complicates photography historian Georges Pottonniée's three canonical predicates about Lippmann's interferential colour photography. These predicates, which have shaped most studies about him so far, are: Lippmann's association with France, his position as the sole inventor of interferential colour photography, and the myth of the "non-use" of this medium. After presenting the state of the art, the introduction offers readers interdisciplinary methods and considerations that embrace the complexity of the interferential image, positioning it at the interplay between science, media, and museums.

Keywords: Gabriel Lippmann, interferential colour photography, Wilhelm Zenker, media history, history of photography, history of science

Who made any money out of colour photography by the interference method? No one. Nevertheless, would anyone dare to challenge the right of [Gabriel] Lippmann to be called an inventor? (Pottonniée 1936, 126).

In his seminal *Histoire de la découverte de la photographie* (1925, translated in 1936 by Edward Epstein), photography historian Georges Pottonniée mentions physicist and photographer Gabriel Lippmann (1845–1921) in passing as he charts the claims of both Louis-Jacques-Mandé Daguerre (1787–1851) and Joseph-Nicéphore Niépce (1765–1833) to the first photograph. The commercial success of the daguerreotype long overshadowed the scientific contribution of Daguerre's collaborator Niépce. To stake a larger claim than what has been attributed to Niépce in the history of photography, Pottonniée bolsters his argument by referring to Gabriel Lippmann whose own input, though

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significant to colour photography, has been consigned to oblivion since it proved to be financially unviable. Yet, for Pottonnée, its commercial failure does not diminish the scientific achievement underpinning it, nor does it, as this book contends, justify its marginalisation in the history of photography.

Lippmann disclosed a colour photograph on glass featuring the spectrum of light on February 2, 1891 at the French Académie des sciences in Paris. The photographic process Lippmann used is called “interferential colour photography,” since the colours visible in the image are the result of light waves “interfering” with their own reflection. This interference principle allows us to see rainbow colours in soap bubbles or in seashell nacre. Lippmann had thus succeeded in recording these optical standing waves in a single-layer, ultra-fine-grain emulsion made from silver iodide and/or silver bromide in albumen. His work differs from the application of pigments or dyestuff unto its photographic surface also known as hand-colouring, and from the reliance on three-colour photography whose separation processes split light into three primary colours which can then be reconstructed through projection, the use of viewers or printing (Hannouch 2022).

The year 2021 marks the centenary of Lippmann’s death. *Gabriel Lippmann’s Colour Photography: Science, Media, Museums* uses this as an opportunity to reflect on Lippmann’s legacy and reconsider his colourful endeavour. This book seeks to enrich the debates about his life, his work, and his international reception in order to enable scholars to approach him from a variety of vantage points. It hopes to furnish readers with interdisciplinary methods and considerations to navigate colour photography; ones that embrace the complexity of its image, thus operating at the interplay between science, media, and museums. These three forces, which shaped the emergence of Lippmann photography, likewise constitute this book’s three sections: in the first section, the authors provide nuanced answers and a clear orientation to elemental questions surrounding the science of colour, light waves, and photography. In the second section, writers complicate Lippmann photography’s position in media history, delve into the aesthetic appreciation for the colour image, and pluralise its ties to cultural history and to neighbouring technologies. The third part of this volume surveys the renewed enthusiasm and material care for Lippmann plates, both in museums and exhibition spaces today, as well as among contemporary analogue photographers. Readers of *Gabriel Lippmann’s Colour Photography: Science, Media, Museums* will immerse themselves in colour photography as its own field of inquiry. They will explore the questions contouring it, pertaining to the nature of scientific knowledge, its interdependence on other media, and the impact politics and culture have had on it. Moreover, archivists,



conservators, curators, and photographers tending to interferential colour photographs in their museum or personal collections will gain knowledge on how to address their materiality, preservation, and exhibition.

Researching Colour Photography

This introduction begins with a state of the art meant to help readers situate Gabriel Lippmann and colour photography in the history of photography as such. In lieu of a streamlined biography of the scientist, this introduction also investigates Potonniée's three predicates about Lippmann, which are embedded in his rhetorical question cited above to help the audience orient themselves in the topic's various historical, cultural, and medial entanglements: Lippmann's association with France, his position as the sole inventor of the interferential colour process, and the myth of the "non-use" of his colour photography. The Lippmann process was internationally discussed for almost two decades (from 1891 until around 1910), Lippmann even won the Nobel Prize for Physics in 1908 against quantum physicist Max Planck (1858–1947), and the aesthetic quality of the photographs he and practitioners of his method produced was well-received. Nevertheless, there is no book-length history of interferential photography or a published biography of Lippmann so far. Moreover, researching his life and work today is arduous since writers have to grapple with the historiographic vacuum around colour photography at the turn of the last century. In fact, throughout the nineteenth century, the absence of colour was constantly bemoaned as a "problem" across a steady stream of publications, such as Ducos de Hauron's 1869 *Les Couleurs en photographie: solution du problem*, Paul Liesegang's 1884 edited volume *Die Heliochromie: das Problem des Photographirens in natürlichen Farben*, and Hermann Krone's 1893 *Über das Problem, in natürlichen Farben zu photographiren*. With this in mind, it is surprising how little scholarly attention photographers' solutions to this predicament have received during the emergence of the grand narratives about the medium in the 1920s (Brunet 2017). The current literature on photographic histories continues to exclude colour, except for the autochrome. The "autochrome turn," which is the increased investigation of the Lumière brothers' colour process over the last two decades, has bestowed upon it the honorary and exceptional title of the "first" commercial colour technology (Bjorli and Jakobsen 2020, Fuchs 2017, Lavédrine 2009, Boulouch 2008, Amad 2007, Boulouch 1995, Wood 1993). While this approach has fruitfully directed research to colour photographs produced before or during World War I, it



has rarely led to the study of the multitude of colour media that were coeval to the autochrome. It has also ignored the numerous debates about colour processes in the nineteenth century that shaped public sensitivities to and expectations of colour images, such as interferential colour photography.

The fragmentary nature of the secondary literature about this photographic process and its uneven weight in favour of the history of science and the under-representation of photographic or media history compounds the difficulties scholars face. Beyond a handful of writers, engagements with the Lippmann process and the scientist whose name it bears are as sporadic as they are significant. They have emanated more from science historians and practitioners and less from photography theorists and artists, arguably because interferential colour photography stems from the French scientific milieu. Daniel Jon Mitchell's unpublished doctoral thesis "Gabriel Lippmann's Approach to Late-Nineteenth Century French Physics" (2010) sketches Lippmann's intellectual biography beyond his investigation of colour, including Lippmann's study of electrical standardisation. In doing so, the dissertation is unique in its scope, being the only research about the scientist's life. Klaus Hentschel's 2002 book *Mapping the Spectrum: Techniques of Visual Representation in Research and Teaching* positions Lippmann's success in colourfully recording electric and solar arc spectra within spectroscopy's broader imaging techniques and their interpretation. Also, Pierre Connes's 1987 foundational article "Silver Salts and Standing Waves: The History of Interference Colour Photography" traces the circulation of knowledge about standing waves across Europe, with a focus on Lippmann's theoretical formulation.

The subsequent use of Lippmann photography's emulsion for holograms has garnered interest for Lippmann among holography enthusiasts. Historian of science and artist Susan Gamble's doctoral dissertation "The Hologram and Its Antecedents 1891–1965: The Illusory History of a Three-Dimensional Illusion" (2004) surveys Lippmann photography's emergence and reception and its relationship to Dennis Gabor's (1900–1979) discovery of the hologram in 1948 and to other scientists. Gamble's creative work as part of the artist duo Wenyon & Gamble combines art, optics, and colour. Also, Sean Johnston's book *Holographic Visions: A History of New Science* (2006), which explores holography as a distinct field of inquiry, its past and its present, shows Soviet physicist Yuri Denisuyuck's (1927–2006) reliance on Lippmann's conceptualisation of three-dimensional images for the technology he produced.

Among contemporary optical engineers and scientists, Hans I. Bjelkhagen is a key figure in the revival of Lippmann's method. The multiple primary sources about it, which he made available online for free, are tremendously



helpful. So, too, are his studies of its relationship to holography in articles such as “Lippmann Photography” (1999) and “Silver Halide Emulsions for Lippmann Photography and Holography” (1996), and in his book *Ultra-Realistic Imaging: Advanced Techniques in Analogue and Digital Colour Holography* (2013). William R. Alschuler’s international, decades-long survey of over four hundred Lippmann plates in private and public collections, as well as his studies of their materiality, of process history, and of their connection to holography, combines his multifaceted and interdisciplinary scholarship with connoisseurship, clarifying both the theory and the physicality of Lippmann plates. Must-read articles by Alschuler include “Physical and Visual State of 100-year-old Lippman Color Photographs” (1998) and “Lippmann Photography and the Glory of Frozen Light: Eternal Photographic Color Real and False” (2003). Jean-Marc Fournier likewise delved into interferential images’ past and holographic connection by analysing their microstructure, the results of which he published in articles such as “An Investigation on Lippmann Photographs: Materials, Processes, and Color Rendition” (1994).

Despite the keenness of the scientific community about Lippmann, contemporary photography historians have paid little attention to him. A notable exception is Kim Timby’s monograph *3D and Animated Lenticular Photography* (2015), focusing on Lippmann’s preoccupation with lenticular photography modelled on insect eyes, which emerged out of his colour research “in the hopes of creating images as realistic as a view out a window” (Timby 2015, 13).

To integrate Lippmann further in the history of (colour) photography, unpacking Potonniée’s undertones are key, starting with his association of Lippmann to France, a relationship that Potonniée takes for granted.

Gabriel Lippmann and France

Potonniée includes Lippmann in a conversation about Daguerre and Niépce, two photographers whose productions helped position France as the giver of the medium to humankind (Brunet 2011, 2017). Yet, Lippmann was born in Luxembourg, where his family had been living for generations (Wagener 2013, 40). Due to antisemitism in Luxembourg, the Lippmanns struggled with naturalisation and voting rights (Wagener 2016, 158–9) and their efforts to settle there were thwarted. Gabriel’s father, Isaïe Lippmann, was excluded from the electoral roll to vote in his community of Hollerich in 1845 (Wagener 2013, 39), despite his best efforts, because he was Jewish.



Therefore, the Lippmanns moved to France, where the introduction of the Code Napoléon allowed them to remain, and they took their leather glove manufacturing company with them. France, however, was hardly free from discrimination. Lippmann's disclosure of the colour spectrum at the Académie des sciences in Paris in 1891, and his subsequent research about interferential colour photography, unfolded in light of a major political scandal in the Third Republic. Starting in 1894, the Dreyfus affair tore apart the fabric of French society. The scandal lasted for over a decade, during which, due to antisemitism and a spectacular miscarriage of justice, Captain Alfred Dreyfus (1859–1935) was sentenced to life imprisonment for treason, having allegedly divulged French military secrets to the German Empire. This event polarised the French public at the time, and several scientists in Paris positioned themselves in relation to the Dreyfus affair. Lippmann considered himself a *dreyfusard* and asserted Dreyfus's innocence (Noronha-DiVanna 2010, 45), despite the continuous rise of the French far right and its xenophobic, misogynistic, and antisemitic overtones.

Also, since Lippmann had been elected member of the Académie des sciences in 1886, he presented the research of non-member scholars, such as Marie Skłodowska and Pierre Curie's first paper on radioactivity, titled "Rayons émis par les composés de l'uranium et du thorium" (1898), thus beginning a long cooperation with Skłodowska. Lippmann amiably worked with her, was her doctoral advisor, and was part of the defence committee for her thesis (which is why his exclusion of her in a petition nominating Pierre Curie and Henri Becquerel for the 1903 Nobel Prize in Physics is disappointing) (Lestel 2007, 112). This cooperation did little to better their social positions. Skłodowska was wrongly considered Jewish, and she was vilified for being a homewrecker due to her clandestine love affair with physicist Paul Langevin (1872–1946) after Pierre Curie's death, which had detrimentally reached the press. Lippmann refused to publicly condemn her private life, and along with mathematician Henri Poincaré (1854–1912) and other scientists, he openly supported her ambition of being elected into the Académie des sciences, which rejected her nomination in 1911.

In his support for Skłodowska, combined with his status as a *dreyfusard*, Lippmann became the target of *La France profonde*, a protofascist set of ideas (Weissmann 2010, 4) underscoring the importance of rural life away from the centrality of Paris. Monarchist journalist and editor-in-chief of the nationalist newspaper *L'Action Française* Léon Daudet (1867–1942) championed this conservative movement (Weissmann 2018, 166). He repeatedly attacked both Skłodowska and Lippmann in writing, referring to Lippmann as "the Jew of colour photography" (Daudet 1911), among numerous insults. Yet, Lippmann's



Nobel Prize win in 1908 against Planck was heralded in France as a national and nationalist victory against the German Empire, while newspapers in Luxembourg appropriated his academic success and hailed his local origins (Pier and Massard 1997). Not much critical reflection on the reasons for his troubles in France or on his family's departure from Luxembourg (Wagener 2013, 40) took place in light of his win. Following Lippmann's death a mere decade after these events, scientist and photochemist Daniel Berthelot (1865–1927) published a lengthy obituary of him in the conservative journal *La Revue des deux mondes*, which had previously been “prudently reserved” about the Dreyfus affair. In it, Berthelot refers to the “sentiment of grandeur of loss” that French science experienced with Lippmann's demise (Berthelot 1922, 19). He indicates the religion of Lippmann's parents as “Israelite” (Berthelot 1922, 43) and that he was interested in the “the ironic and malevolent gaze of the foreigner” Albert Einstein's (1879–1955) relativity theory. Unsurprisingly, Berthelot silences the extent to which Lippmann's stance on Dreyfus and on Marie Skłodowska fuelled the hateful discrimination they both faced.

Read in this light, Potonniée's brief evocation of Lippmann in the same breath as two other major French photographers is significant, because it obfuscates the historical conditions under which Lippmann and his family grappled with antisemitism both in Luxembourg and in France. It also flattens Lippmann's ambiguous position: he was the *French* Nobel Prize winner seen from the outside, but the Jewish scientist seen from within French society. Potonniée also absorbs him into a French photographic memory in which he occupies the uncertain place of a local inventor whose genius nobody doubted, but whose work nobody implemented.

For scholars today, bringing interferential photography out of its marginalisation in the history of colour photography has to begin by historicising the scientist and by placing his research within broader cultural, political, and aesthetic trajectories.

Gabriel Lippmann as Sole Inventor

Photography's foundational dates – 1891, the year of Lippmann's presentation at the Académie des sciences, being one of them – are the crux of the hierarchy of knowledge around which practitioners and historians articulate both the medium's prehistory and its “general” and often nationalistic historiographies. Potonniée's assertion that nobody doubted Lippmann as the sole inventor of the colour process turns his history of photography



written from a French vantage point into an overarching and universal narrative. Lippmann's success propelled him into the disputed terrain of the first colour photograph between the French and the German Empires. It led authors on both banks of the Rhine to produce compelling accounts of national success and to domesticate larger epistemological and cultural divergences between themselves as exclusive Western European contenders. The variety of terminologies used in reference to interferential photography, such as "direct colour photography," "the Lippmann process," and "the Zenker-Lippmann process," reveal this much. They all describe the same photographic process and its complicated relationship to standing light waves. They differ, however, in relation to the positionality of the history of colour photography, as in the stance from which historians understood and located its technical genesis, both geographically and epistemologically. Doubt about Lippmann as the sole inventor was palpable, and nowhere was his reception more heated or contentious than in the German Empire.

Gabriel Lippmann had numerous biographical ties to his neighbouring country. His multilingualism (he spoke French, German, and English) opened up several avenues for him within local and international academic exchange, which Daniel Jon Mitchell extensively explored. After being admitted to the Parisian *École Normale Supérieure* in 1868, Lippmann worked with Pierre-Augustin Bertin (1818–1884), who tasked him with the translation and analysis of German and English scientific publications, which were widely discussed among department members. Lippmann's initial interest in electrical phenomena and his inquiry into the discharge of condensers emerged out of Bertin's preoccupation with electricity and galvanism (Mitchell 2010b, 37–38). Yet, the eruption of the Franco-Prussian War (1870–71) and the ensuing violence during the Paris Commune drew Lippmann away from the *agrégation*, to which he became inadmissible in 1872. This qualification could have secured him a junior laboratory position, later a doctorate, and could have facilitated his career in French academia. By that time, the Ministry of Public Instruction considered the rise of German laboratories and universities a possible threat to French science, whose marginalisation within the international research landscape was deemed a major culprit in France's military defeat (Mitchell 2010b, 39). Therefore, the ministry commissioned numerous French scientists to report on the state of research in disciplines such as chemistry, physiology, anatomy, and pathology practised across the border. At its behest in 1872, and to avoid becoming a secondary school teacher without the *agrégation*, Lippmann could continue his research about electricity at his laboratory of choice in the German Empire, provided that he represented French science, whose



rehabilitation facing its neighbouring country became “a patriotic duty of government associated with the extraction of revenge” (Mitchell 2010b, 40). At the University of Heidelberg, Lippmann worked at Wilhelm Kühne’s (1837–1900) physiology laboratory and Gustav Kirchhoff’s (1824–87) physics laboratory. With Kirchhoff’s encouragement, he passed his examination for the title of Doctor of Philosophy with distinction in 1875, with a thesis on the change in the surface tension of a liquid when electrically charged, titled “Relations entre les phénomènes électriques et capillaires” (Fechete 2016, 1). Both Hermann von Helmholtz (1821–94) and Kühne served, respectively, as doctoral and academic advisors to Lippmann. He wished to continue reporting on German institutions (Mitchell 2010b, 86–87) and moved to Berlin to work alongside Helmholtz, whose theory of the electrical double layer was widely discussed and whose notion of three-colour vision was instrumental to three-colour photography, but was recalled back to Paris. There, Lippmann successively held the chairs of mathematical physics (1883) and of physics (1886), presiding over the prestigious *Laboratoire des Recherches Physiques de la Sorbonne*. Hence, Lippmann was known in some scientific circles in the German Empire and was himself familiar with some of the ongoing research there. This set the ground for the antagonistic reception of his colour process across the Rhine, especially the claim to priority by German scientist Wilhelm Zenker (1829–99).

The supposed theoretical precedent set by Wilhelm Zenker long haunted interferential colour photography’s historiography. It can be exemplified by this question: Did Gabriel Lippmann invent colour photography in 1891 (as Potonniée asserted), or was Lippmann merely proving the theories that Zenker initially expressed in 1868?

Lippmann’s colourful 1891 session took place right after physicist Marie Alfred Cornu (1841–1902) presented Otto Wiener’s (1862–1927) research about the orientation of the polarisation plane of light rays in relation to their propagation direction at the Academy (Mitchell 2010b, 190), based on Wiener’s initial article “Stehenden Lichtwellen und die Schwingungsrichtung polarisirten Lichtes” of 1889. In his text, Wiener briefly cites scientist Wilhelm Zenker’s self-published (1829–90) *Lehrbuch der Photochromie – Photographie der Natürlichen Farben* of 1868, a mention which Cornu reiterates. In *Lehrbuch*, Zenker uses standing waves to explain the genesis of colour in the images produced by Becquerel, Sir John Herschel, and Johann Seebeck. The book’s reception was virtually non-existent among scientists (Connes 1987, 152), and it only began in the German-speaking photographic circles starting in 1891 – after Lippmann disclosed his interferential method. Wiener’s reference to Zenker brought him back from photographic oblivion,



and the latter published an article, “Die Entstehung der Farben in der Photochromie” about the wave theory in the 1891 edition of Josef Maria Eder’s *Jahrbuch für Photographie und Reproduktionstechnik*. In it, Zenker posits that a “general interest in the photographic reproduction of colour” (Zenker 1891, 294–95) can be sensed, and that while it is “possible” that accidents lead to progress, it is “particularly advantageous” (*von besonderem Vortheil*) that one inquires deeper into pre-existing scholarship, since it offers guidance for one’s own research. The author explained the emergence of colour in Becquerel’s plates, cited Wiener’s work, and made no mention of Lippmann at all, if indeed the article was published after February 2, 1891. In parallel to Zenker, just four days after Lippmann’s presentation in Paris, his colleague and promoter physicist Alphonse Berget (1860–1933) publicised his discovery as entirely autonomous of German or British (Lord Rayleigh’s) scholarship, underlining its exclusive French origin. He reaffirmed this stance in his 1901 treatise, writing that “it has nothing in common with the photochromatic essays attempted until this day. It is so ingenious, so elegant in its genius simplicity that it is certainly a scientific oeuvre more beautiful than the actual result” (Berget 1901, VII). In doing so, he rebutted the hegemonic narrative in the German Empire, where Lippmann was thought to have merely confirmed a pre-existing theory through a novel research method: colour photography. Furthermore, as early as April 10, 1891, at the Physikalische Gesellschaft zu Berlin, which hosted regular meetings about new colour technologies and theories of vision, and which was still presided over by Hermann von Helmholtz (Schreier, Frankeunter, and Fiedler 1995, 41–42), Hermann Wilhelm Vogel (1834–98) presented the interference theory of light and colour photographs of spectra made by Lippmann. Vogel, who was the first professor of photochemistry at the Technical University of Berlin and who was known for his sensitisation of the orthochromatic plate, by which he added “aniline dyes to his emulsions to stretch its sensitivity well into the green, and eventually he extended his films to orange sensitivity” (Wilder 2009b, 166), was an authority on photographic matters. He added fuel to the fire and solidified the German claim to priority over Lippmann by anchoring the latter’s work in Zenker’s *Lehrbuch der Photochromie* from 1868 and by refuting any British claim to Lord Rayleigh’s priority (Vogel 1892, 34–35). Also, in a survey of the year 1892’s progress in photography and reproduction technologies in Eder’s *Jahrbuch*, Lippmann’s colour photography and Wiener’s inquiry were considered as confirmations (*bestätigen*) of Zenker’s theory, stressing how the silver salts in the emulsion are stored in both irregular layers as Lippmann predicated as well as in regular ones as Zenker “stipulated” (*verlangt*) (Anonymous 1892,



331). In his 1893 article “*Ueber die Entstehung der Farben im Lippmann’schen Spectrum*,” Zenker himself began referring to the “Lippmann-Zenker’sche Theorie” (Zenker 1893, 115), hyphenating his name to that of the French physicist whose images he deemed a mere method (*Methode*) validating his own concepts (Zenker 1893, 114). Anthropologist and doctor of medicine Richard Neuhauss, who was a key Lippmann photographer in Berlin, also emphasised how the Lippmann process, in making images fixable, actually *applies* Zenker’s notions (Neuhauss 1894, 296). With this much recognition, in 1895, Zenker became an honorary member of the Deutsche Gesellschaft von Freunden der Photographie in Berlin, which considered him the founder (*Begründer*) of photography in natural colours, as announced in the journal *Photographische Rundschau* that year. *Lehrbuch der Photochromie* was republished posthumously in 1900, and Neuhauss reviewed it along the German nationalist line, heralding it as the work in which Lippmann’s foundational theory is expressed *avant la lettre* (Neuhauss 1900, 148). Nevertheless, around that time in Paris, A. Berthier’s introduction to his *Manuel de Photochromie Interferentielle* subtly but clearly maintains Lippmann as “the creator himself” (*le createur lui-même*) (Berthier 1895, 2) of the photographic technology.

Nobody attempted to explain the two-decade gap between *Lehrbuch*’s release in the German Empire and the 1891 announcement in Paris or why Zenker never tried colour photography himself to prove his own theory and gain broader recognition for his work at the time of its initial publication. The “Zenker before Lippmann” historiographic paradigm, which began as early as 1891 and continued until ca. 1910, thus countered its coeval “Lippmann as sole inventor” narrative in France, broached by Potonniée.

The relationship between Lippmann and Zenker, whether real or imagined, along with the fact that the presentation of Lippmann’s colour spectrum in 1891 sits somewhat awkwardly in the panorama of his work at the time, has led to various claims to priority in France, along with contemporary speculations about colour photography’s relation to Lippmann’s previous research, which Alschuler’s chapter in this book surveys. The note Lippmann read to the Academy that year was accompanied by little detail. It also contained no references to other scholars and no clarification about prior experiments, and nothing in Lippmann’s lectures at La Sorbonne alludes to any investigation of standing waves before 1891 (Connes 1987, 157). Therefore, the date which scholars consider to be the starting point of Lippmann’s research is equally pivotal for grasping his relationship to Zenker. Alschuler states in his chapter that Lippmann’s 1889 attempts to expand the sensitivity of orthochromatic emulsions and his previous work on three-colour photography informed

his research on the interferential image. He also agrees with historian of science Pierre Connes that the emergence of Lippmann's optical standing wave theory (and, by extension, his photographic practice) can be linked to his previous research on acoustic waves (Connes 1987, 151), thus rebutting the possibility that he relied on Zenker's work since their starting points were different. Connes insists that Lippmann maintained the starting date of his research to be 1886 (Connes 1987, 153), while Alschuler's text points to Lippmann lodging the start of his research even earlier than that – in 1879 – thus strengthening the argument that his work on acoustics predates his possible knowledge of Wiener (and, by extension, the possibility of him knowing Zenker via Wiener, in both cases). Also, as Klaus Hentschel points out in his contribution to this volume, Lippmann's overall mastery of physics gave him enough empirical and theoretical knowledge to undertake the research he saw fit without needing to rely on a scientist as obscure as Zenker. This marks “the acoustic to optical wave” trajectory as a plausible explanation.

The unclarity about the origins of interferential colour photography persisted during the first years after its presentation in 1891. Daniel Jon Mitchell (2010b) asserts that Lippmann suppressed the extent of his chemical research during and before interferential photography's disclosure in order to highlight its theoretical elegance, for which he won the Nobel Prize for Physics. And if Lippmann's starting point was purely theoretical, as he declared, then it is surprising that he only revealed the photographic process's Fourier transform; as in the mathematical rendition of the theory underpinning it, three years after the image's revelation (Mitchell 2010b, 326). This marks the “chemistry VS physics” contention. Yet, as Alschuler claims, “any chemistry with sufficient resolution to resolve the interference pattern to a 10th of the wavelength will succeed in recording it in satisfactory detail” (W. R. Alschuler, 2021, personal communication, March 2021). This means that any silver halide-based photographic material (be it albumen, gelatin, or collodion, etc.) will manage to resolve light – provided it is fine and consistent enough. For this reason, Lippmann did not need to elaborate on his chemistry because all emulsions worked. Hence, the interplay between chemistry and physics in interferential photography and the establishment of disciplinary boundaries between these two fields should fuel future considerations of Lippmann photography.

Potonniée, in his brief but crucial mention of Lippmann, suppresses these contentions to Lippmann being the sole scientist behind interferential colour photography, although his colleagues at the time were clearly aware that Zenker set a theoretical precedent to Lippmann's disclosure,



one powerful enough to alter the geographic location of the medium's emergence. Zenker risked dimming the lustre of interferential photography as a French achievement by inadvertently aligning Lippmann with the German research tradition on optical waves. And in the German Empire, it did just that, becoming a drawn-out chauvinistic battle for the first colour photograph and of the precedence a theory about colour photography can take over the image.

Nevertheless, disputes about Lippmann's merits and limitations have unfolded at the expense of the multiple ways in which colour photography and the wave theory of light came into being in various parts of the world. Chapters in this volume evoke colour photography's numerous practitioners in the German Empire, such as Richard Neuhauss, Hermann Krone, and Hans Lehmann; in Spain, through the photography of science by Santiago Ramón y Cajal; in Austria, through the writings of Edward Steichen and Josef-Maria Eder; and in the United States, with the work of Herbert and Frederic Ives. Knowing this, this book acknowledges its focus on the Global North. It recognises that the handful of countries it mentions cannot account for the international fascination with the medium, and it asserts that remaining within this geographic epistemology can only propel research about the history of this neglected medium up to a point. Readers are encouraged to pursue the fundamental disparity at the heart of *all* "beginnings" as historiographic constructions in order to dispel the chimera of their (Northern) unifying origin. Future scholars are called upon to transregionally examine colour photography's "first" images and to activate future discussions about its manifold outsets and numerous histories beyond Western Europe and the United States. In this book, Alschuler opens up fascinating avenues for this kind of work: Lippmann was read and reviewed in Argentina as early as 1893, which means that interferential photography was known there. Also, in the Russian Empire, physicist Ivan Filippovich Usagin (1855–1919) published "Practical Techniques of Photographing by Lippmann's Method Used for Making Photos of Solids and Vapours Spectrums" in the 1903 edition of the journal *News of Russian Association of Photography Amateurs*. He also demonstrated a colour image of the light spectrum at the world fair in Paris in 1900, which marks his reception there (Sogreshilin 1966, 36). Additional scholarship is needed to extend the history of interferential colour photography to these countries and to many more.

Moreover, expanding the state of the art about Lippmann has to account for another parameter that shapes historical inquiry and writing: gender. "In order to create a richer, truer history of photography, we need to identify the 'masculine' bias that distorted photography's early history" (Hudgins 2020,



1). This book is aware that it mentions exclusively White male scientists who practised interferential photography but still contends that their history is not universal and must be rebalanced by other genders. The various chapters presented here merely hope to provide enough questions about a historically marginalised practice for future scholarship to overcome the narrative of the “great male scientist,” especially since the spread of photography throughout the nineteenth century “coincided with feminist challenges to prevailing gender relations” (Latimer and Riches 2006). As authors Pauline Martin and Carole Sandrin mention, little is known about Laurence Cherbuliez (1857–1934), Lippmann’s laboratory assistant and spouse, beyond these two roles she assumed. Still, there is enough to indicate that she played a more substantial role in his scientific and photographic practice ca. 1900 than previously assumed, which future scholarship should be attuned to. Also, women were a crucial part of Lippmann’s audience at the Royal Society in London. Their appreciation of the material quality of his photographs; whose brilliance and their “jewel-like quality” persisted as an observation category throughout the twentieth century (Gamble 2004, 39) and needs further scrutiny. In Berlin, the Lette-Verein founded in 1866 played a key role in women’s professionalisation in the photographic industry ca. 1900. Since “technical developments, new processes from abroad and requirements from industry and science shaped the curricula, teaching methods and the time required for the various branches of education” (Vitten 2018), and given the three interferential colour photographs made by Richard Neuhauss which I located in the Verein’s collection, it is highly probable that women learned interferential photography and were more than just passive recipients, so their contributions must be mapped as well. That this research about Lippmann photography and women has not yet been undertaken only means that the absence of evidence is not evidence of absence, and there is still a learning curve ahead.

Beside repositioning Lippmann within the political history of France, deconstructing Eurocentric approaches to him, and using gender to criticise and renew the history of colour photography, assumptions about colour also require an update. The uselessness of interferential colour photography reiterated by Potonniée is a key notion precluding further inquiries.

The Myth of the “Non-Use” of Interferential Photography

A long-reiterated myth about the Lippmann process that Potonniée notes is its purely theoretical nature. Scholars on both sides of the Atlantic have

maintained that, as a “direct” colour photography, the Lippmann process succeeded in transcribing the shades of light, but due to its technical difficulty, it remained unused. For this reason, it was quickly upended by “indirect” methods, such as three-colour photography and the autochrome, methods that reconstitute the perception of colour based on the recombination of its three primary hues. Thus, historians have often conflated the commercial viability of a medium with the various manners in which its practitioners implemented it. In doing so, they have inadvertently blurred the line between the actual and unique uses of interferential colour photography and the historiographic constructions that led to the omission of these practices.

This book is sensitive to the implementations that interferential photography *did* have, instead of lingering on the ones it did not, thereby connecting it with the various scientific, medial, and institutional frameworks that gave rise to it and without which it could not have thrived as long as it did. It addresses the mechanism of the exclusion of the Lippmann process to help rewrite its history by criticising its dominant understanding as a theoretical exercise at the expense of the materiality of its images. The understanding of interferential photography as an abstraction rather than as a material object has several reasons. First, it emerged due to the overall unreliability of the process, resulting in the failure of many photographs to show any colour to the point where the belief in its experimental viability stood on shaky grounds. Second, the Lippmann plate, as a direct positive on glass, is irreproducible which means that opportunities for the spectators to connect with the physical object hinged on the one photograph and were thus scarce. Third, its visibility is such that the surface reflection, which is the unwanted light reflected from the top surface of the emulsion, interferes with viewing the image – even at the best angle. The best angle and its range are restricted by the angle sensitivity of the interference process. The surface reflection issue was dealt with by cementing a wedge prism on the image. When beholding a Lippmann plate, however, even with a prism, there are special conditions under which the colours may be seen at their best, and viewers must take their time to find the right angle from which its shades will reveal themselves. This means that even when an interferential colour photograph is a successful experiment, seeing it remains a task all on its own. Hence, these material conditions underpinning the Lippmann plate have widened the gap between it as object and as colour theory. This distinction was visible during the early as well as modern formation of the history of colour photography, and has become a standard narrative, one which this book deconstructs.

British photography historians wrote in 1900 that “unfortunately there seems at present but *faint hope of carrying out in practice* that which appears



simple in theory, but M. Lippmann appears to hope almost against hope” (Bolas, Tallent, and Senior 1900, 59, my emphasis). Beaumont Newhall’s *Photography 1839–1937* (1937) picked up this rift, dedicating one paragraph to Lippmann’s “direct” photography, deeming it “remarkably true to nature” and its image “marvelously brilliant,” although it was “never a practical technique” (Newhall 1937, 82). In the German Empire, Erich Stenger’s *Geschichte der Photographie* (1929) and his *Die Photographie in Kultur und Technik* (1938) restate interferential photography’s “difficult implementation” – (*schwierige Ausführbarkeit*) (Stenger 1929, 31 and Stenger 1938, 154) – and stopping at that.

In a more modern canonical narrative about colour photography, *Colour Photography: The First Hundred Years 1840–1940*, the author Brian Coe starts his chapter with the “hope – even expectation – that soon a way would be found to record the colours of Nature directly, and in a manner as simple as that of recording light and shade in a monochrome photograph” (Coe 1978, 20). The chapter is then concluded with the brick wall of the “long-hoped-for fully practical method of direct colour photography [that] has never been found; instead, successful colour photographs have been produced by indirect methods of analysing and reproducing colour” (Coe 1978, 25). Moreover, as François Brunet has pointed out, when Potonniée employed the term “photograph” in his *Histoire*, he did so in reference primarily to a monochrome image on paper that is neither in colour nor on glass (Brunet 2017, 182–83). From this vantage point, he is indifferent to the Lippmann plate, because his focus was on a different kind of photographic materiality altogether. Potonniée only paid attention to glass slides used in projection when writing the history of cinema and of modern visual communication, briefly mentioning interferential photography in his subsequent books.¹

Over time, the existence of the interferential colour photograph as material object became almost impossible to imagine. It turned into a mere horizon, an expectation, and a theory, which was quickly thwarted by other technologies and then forgotten. Yet, the physical photograph did exist and continues to do so, thereby negating the purely conceptual nature of the medium on a fundamental level: several photographers produced Lippmann plates – and did not merely theorise about interference – and these photographs are part of museum and private collections. This book is an invitation to reconnect with the Lippmann plate as a material object, one that is also a conduit for various forms of knowledge which have structured

1 Over a decade after *Histoire*, in *Cent ans de photographie: 1839–1939*, Lippmann re-emerges as an “illustrious scientist” and is accompanied by a short description of his colour photographic process (Potonniée 1940, 85).

its historical implementations and continue to configure its current uses, implementations that the authors centre on.

They dispel the myth of the “non-use” of interferential photography by exploring its “symbiotic relationship” with science (Wilder 2009b, 163), its use in commercial entertainment through projection sessions ca. 1900, and today, its importance as a museum object and as a medium of artistic expression by contemporary practitioners exploring its creative dimension.

The first part of this volume positions the Lippmann plate as both a scientific photograph representing physical phenomena (such as the wave nature of light) and as the object of scientific inquiry (Wilder 2009a, 12). William R. Alschuler's chapter introduces the history of the Lippmann process, as in the Lippmann plate and the knowledge about light waves embedded in it, as revealed by Lippmann himself in France, as well as in the context of its international reception among scientists and photographers. Furthermore, as Klaus Hentschel asserts, interferential colour photography operates at the crossroads of the rise and institutionalisation of scientific photography at the turn of the last century as well as spectrographers' visual practice of documenting and mapping the solar spectrum. Lazaros C. Triarhou and Manuel del Cerro investigate the inquiry of Spanish scientist Santiago Ramón y Cajal into the genesis of interferential colour. They present how Cajal transmitted practices from histology and microscopy to colour photography and the ties that bind these two fields. Susan Gamble studies Lippmann photography and the scientific theories underpinning it as the object of transatlantic competition and of textual translation from French to English by Frederick and Herbert Ives. In doing so, she sheds light on all that was lost in translation during this transmission, thus highlighting the misunderstanding of Lippmann in the United States.

Beyond its centrality to scientific knowledge, the second part of this book aims to help readers straddle the technical and discursive complexity of the Lippmann process by grounding it in a matrix of media, art, and cultural history. Just as interferential colour photography is marginalised by photography historians, contemporary historians of vision have fared no better. Jens Schröter's article in this volume criticises historian of vision Jonathan Crary's “rhetoric of ruptures,” which posits a shift between the seventeenth century's geometrical optics and the eighteenth century's physiological optics, accounting for the disappearance of the camera obscura and the increasing importance of stereoscopic vision. Given Crary's focus on physiological optics around 1820, he excludes several photographic media. Schröter favours an approach he terms “layering replacing succession,” as



in the sedimentation of various layers of optical knowledge in media over time, rather than considering how one indefinitely replaces the other. Concretely, Lippmann photography did not vanish with the rise of three-colour technologies or the autochrome; it merely acquired another place in the landscape of media. Lippmann photography's position among media should interest photography historians attuned to the "synchronic plurality and [the] heterogeneity of regimes of vision" in order to overtake the teleological history of colour photography. My article highlights how anthropologist Richard Neuhaus's use of interferential photography was connected to and entangled with an assortment of media that were foundational to its genesis in an imperial context: taxidermy allowed Neuhaus to work consistently with the same test object – a stuffed parrot. The use of various optical media, including projection, helped the Lippmann plate's high-resolution colours reach individuals as well as collective spectators ca. 1900. And, thanks to the hype around it, Lippmann photography rivalled Hermann Wilhelm Vogel's three-colour printing method, all of which consolidated its presence along other technologies. Moreover, as Elizabeth Cronin points out, interferential photographs were exhibited in world fairs and made headlines in the photographic literature. They were seen as jewel-like objects and admired just as much for their beauty and their brilliance as for the complicated science behind them. The aesthetic framing of Lippmann plates proves that they were more than the results of "difficult science". Rolf Sachsse's article reflects upon the cultural history of Lippmann photography and the motivations for its exclusion from the iconic exhibition "Farbe im Foto" in Germany. Sachsse also connects the scientist with his surroundings, and most importantly with his family situation by proposing that his use of liquid mercury in the photographic process could have stemmed from his family business in leather manufacturing, thereby linking colour photography to craftsmanship.

The third section of this book presents interferential photography as used today by scientists, museums, and artists who together reconfigure and expand the limit of its implementation. Jens Gold's article points out how researching the materiality of colour plates made by Richard Neuhaus and Hans Lehmann is central to Preus Museum: Norway's Museum for Photography. Gold positions the collection as worthy of conservation care and of protection from degradation to make sure that, through the preservation of their material, knowledge is safeguarded for future generations. As Pauline Martin and Carole Sandrin propose, the extensive collection of interferential plates made by Gabriel Lippmann at the Musée de L'Élysée in Lausanne (Switzerland) challenges and enlarges the very concept of the



museum and the future of its interdisciplinarity in research and in cooperation. Also, Hans Bjelkhagen not only explores its past but also highlights its steady attraction for contemporary photographers and holographers, which has been increasing since the 1980s. The colour image's allure has led them to reconfigure its emulsion and update the process, ascertaining its continuity in the second half of twentieth century. Last, my interview with contemporary Lippmann photographer Filipe Alves underscores the joys and frustrations of practising this kind of colour photography today – both as a hands-on practice and as a way to empirically connect to its history.

Therefore, readers of *Gabriel Lippmann's Colour Photography: Science, Media, Museums* are invited to take part of a wave of interest in interferential photographs as objects of scientific knowledge, as an anchor in the sea of media, culture, and art, and as material museum objects that are appreciated by scientists, conservators, and curators. All of these are functions Potonniée did not predict.

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Works Cited

- "Die Fortschritte der Photographie und der Reproduktionstechnik in den Jahren 1890 und 1891." 1892. *Jahrbuch für Photographie und Reproduktionstechnik* 6: 287–487.
- Alschuler, William R. 1998. "On the physical and visual state of 100 year old Lippmann color photographs." In *Sixth International Symposium on Display Holography, 21–25 July 1997, Lake Forest, Illinois*, edited by T. H. Jeong and H. I. Bjelkhagen, 84–94. Bellingham: SPIE.
- Alschuler, William R. 2002. "Lippmann Photography and the Glory of Frozen Light: Eternal Photographic Color Real and False." In *Proceedings of the 31st Applied Imagery Pattern Recognition Workshop, Washington, DC, October 16–18, 2002*, edited by David Schaefer and IEEE Computer Society. doi:10.1109/AIPR.2002.1182248.
- Amad, Paula. 2010. *Counter-archive film, the everyday, and Albert Kahn's Archives de la Planète*. New York: Columbia University Press.
- Berthelot, Daniel. 1922. "La vie d'un savant: Gabriel Lippmann." *Revue Des Deux Mondes (1829–1971)* 10, no. 1: 19–46.



- Berthier, A. 1895. *Manuel de Photochromie Interférentielle. Procédés de reproduction Directe des Couleurs*. Paris: Gauthier-Villars et Fils Imprimeurs-Libraire.
- Bjelkhagen, H. I. 1996. "Silver halide emulsions for Lippmann photography and holography." *SPIE Milestone Series* 130: 102.
- Bjelkhagen, Hans I. 1999. "Lippmann Photography: Reviving an Early Colour Process." *History of Photography* 23, no. 3: 274–80.
- Bjelkhagen, Hans I., and David Brotherton-Ratcliffe. 2013. *Ultra-Realistic Imaging Advanced Techniques in Analogue and Digital Colour Holography*. Boca Raton: CRC Press, Taylor & Francis Group.
- Bjorli, Trond, and Kjetil Jakobsen. 2020. *Cosmopolitics of the Camera: Albert Kahn's Archives of the Planet*. Bristol: Intellect Books.
- Bolas, Thomas, Alexander A. K. Tallent, and Edgar Senior. 1900. *A Handbook of Photography in Colors*. New York: E. & H.T. Anthony & Co.
- Boulouch, Nathalie, and José Vovelle. 1995. *La photographie autochrome en France (1904–1931)*. Lille: Atelier national de reproduction des thèses.
- Brunet, François. 2011. "Nationalities and universalism in the early historiography of photography: (1843–1857)." *History of Photography* 35: 98–110.
- Brunet, François. 2017. *La photographie: histoire et contre-histoire*. Paris: Presses Universitaires de France.
- Coe, Brian. 1978. *Colour photography: the first hundred years, 1840–1940*. London: Ash & Grant.
- Connes, P. 1987. "Silver Salts and Standing Waves: The History of Interference Colour Photography." *Journal of Optics* 18, no. 4: 147–66.
- Fechete, Ioana. 2016. "Jonas Ferdinand Gabriel Lippmann: The pioneer of color photography or primus inter pares." *C. R. Chimie* 19: 903–8.
- Fournier, Jean-Marc. 1994. "An investigation on Lippmann photographs: materials, processes, and color rendition." In *Practical Holography VII*, edited by S. A. Benton. Proceedings SPIE International Symposium on Electronic Imaging: Science and Technology 2176: 144–52.
- Fuchs, Caroline. 2017. *Das Autochrom in Großbritannien: Revolution der Farb fotografie*. Berlin: De Gruyter.
- Gamble, Susan A. 2005. *The Hologram and its Antecedents 1891–1965: The Illusory History of a Three-Dimensional Illusion*. Cambridge: University of Cambridge Press.
- Goldsmith, Barbara. 2008. *Obsessive Genius The Inner World of Marie Curie*. New York: Paw Prints.
- Hentschel, Klaus. 2002a. *Mapping the Spectrum. Techniques of Visual Representation in Research and Teaching*. Oxford: Oxford University Press.
- Hudgins, Nicole. 2020. *The Gender of Photography: How Masculine and Feminine Values Shaped the History of Nineteenth-Century Photography*. Abingdon and New York: Routledge.



- Johnston, Sean F. 2009. *Holographic visions: a History of New Science*. Oxford: Oxford University Press.
- Latimer, Tirza, and Harriet Riches. 2006. *Women and Photography*. Oxford: Oxford University Press.
- Lavédrine, Bertrand. 2009. *Photographs of the Past: Process and Preservation*. Los Angeles: Getty Conservation Institute.
- Lestel, Laurence. 2008. *Itinéraires de chimistes, 1857–2007: 150 ans de chimie en France avec les présidents de la SFC*. Les Ulis: EDP sciences.
- Mitchell, Daniel Jon. 2010a. *Gabriel Lippmann's Approach to Late-Nineteenth Century French Physics*. PhD diss., Oxford University.
- Mitchell, Daniel Jon. 2010b. "Reflecting Nature: Chemistry and Comprehensibility in Gabriel Lippmann's 'Physical' Method of Photographing Colours", *Notes and Records of the Royal Society of London* 64 (4), 319–337.
- Neuhauss, Richard. 1894b. "Die Photographie in natürlichen Farben." *Photographische Rundschau* 8, no. 10: 295–302; 11: 327–29; 12: 359–64.
- Neuhauss, Richard. 1900. "Bücherschau". *Photographische Rundschau*. 14: 148.
- Newhall, Beaumont. 1937. *Photography: 1839–1937*. New York: The Museum of Modern Art. Exhibition catalogue.
- Noronha-DiVanna, Isabel. 2010. *Writing History in the Third Republic*. Newcastle upon Tyne: Cambridge Scholars.
- Pier, J.P, and J. A. Massard (eds). 1997. *Gabriel Lippmann, Commémoration par la Section des Sciences Naturelles, Physiques et Mathématiques de l'Institut Grand Ducal de Luxembourg du 150^e Anniversaire du Savant né au Luxembourg Lauréat du Prix Nobel en 1908*, Luxembourg: Jean-Paul Pier & Jos. A. Massard.
- Potonniée, Georges. 1925. *Histoire de la Découverte de la Photographie*. Paris: Montel.
- Schreier, Wolfgang, Martin Frankeunter, and Annett Fiedler. 1995. "Geschichte der Physikalischen Gesellschaft zu Berlin 1845–1900". *Physik Journal*. 51 (1): F-9–F-59.
- Schröter, Jens. 2014. *3D: History, Theory and Aesthetics of the Transplane Image*. London: Bloomsbury Academic.
- Sogreshilin, V. I. 1966. *Usagin Ivan Filippovich*. Moskva: Izd-vo Prosveshchenie.
- Stenger, Erich. 1929. *Geschichte der Photographie*. Berlin: VDI Verlag.
- Stenger, Erich. 1938. *Die Photographie in Kultur und Technik Ihre Geschichte während 100 Jahren*. Leipzig: E.A Seemann.
- Timby, Kim. 2015. *3D and Animated Lenticular Photography*. Berlin: De Gruyter.
- Vitten, Anne. 2018. "Professionalisierung und Vernetzung. Berufsfotografinnen im 19. und 20. Jahrhundert". *Fotogeschichte* 149. <http://www.fotogeschichte.info/bisher-erschienen/hefte-126-149/149/anne-vitten-berufsfotografinnen/> Accessed March 30, 2021.

- Vogel, H.W. 1892. "Ueber Lippmann's Photographien des Spektrums in natürlichen Farben". *Verhandlungen der Physikalischen Gesellschaft zu Berlin im Jahre 1891*. 10: 33–35.
- Wagener, Renée. 2016. "Verspätete Verbürgerlichung. Politische Partizipation Luxemburger Juden im 19. Jahrhundert." In *Identitätsbildung und Partizipation im 19. und 20. Jahrhundert: Luxemburg im europäischen Kontext*, edited by Thorsten Fuchshuber, Université du Luxembourg, Jean-Paul Lehnens, Renée Wagener, Sonja Kmec, Norbert Franz, and Michel Pauly, 147–74. Frankfurt: Peter Lang Publishing Group.
- Wagener, Renée. 2016. "Gabriel Lippmann, ein Moderner Wissenschaftler." *Ons Stad* 113: 38–40.
- Weissmann, Gerald. 2010. "Radium, Telomeres, and Ribosomes: Glass Ceilings Break in Stockholm". *The FASEB Journal: Official Publication of the Federation of American Societies for Experimental Biology*. 139 (1): 1–5.
- Wilder, Kelley. 2009a. *Photography and Science*. London: Reaktion Books.
- Wilder, Kelley. 2009b. "Photography and the art of science", *Visual Studies* 24 (2), 163–168.
- Wood, John. 1993. *The Art of the Autochrome the Birth of Color Photography*. Iowa: University of Iowa Press.
- Zenker, Wilhelm. 1891. "Die Entstehung der Farben in der Photochromie." *Jahrbuch für Photographie und Reproduktionstechnik* 5: 294–303.
- Zenker, Wilhelm. 1893. "Ueber die Entstehung der Farben im Lippmann'schen Spectrum." *Jahrbuch für Photographie und Reproduktionstechnik* 7: 114–121.

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