"The Fatal Blemish"
Purity, Consistency and Chemical Engineers at the Origin of a New Visual Order, 1890–1930

Emmet von Stackelberg
Harvard University
emmetvonstackelberg@fas.harvard.edu

This article has been published in Enterprise & Society: doi.org/10.1017/eso.2024.39.

Some time in the early 1890s, the newly-renamed Eastman Kodak Company published a pamphlet called *The Home of The Kodak*. It introduced readers to the recently established Kodak Park, a fourteen-acre campus with a handful of buildings, all gleaming and new: "Unconsciously the visitor takes a look at his shoes to see that they are clean before he steps upon the highly polished floor."[1] But to enter the film building, with its "labyrinth of dark rooms," the pamphlet suggests, "one feels as if in enchanted fairy land." Not just the place but the people, "dimly seen as they move silently about the room, seem ghostly in this weird chamber."[2] The company elected to display a brand new factory in terms magical, exotic and mysterious—in fact, some mysteries were too closely guarded to even be described. Only one sentence described the "region of Egyptian darkness" of the emulsion building, telling readers that "its secrets are as closely guarded as…those of the alchemists of old."[3] In 1929, Eastman Kodak published a pamphlet called *The Home of Kodak* to show the world the immensity of Kodak Park, now over four hundred acres and more than 120 buildings. But in place of mystery, Kodak offered precision and clarity. "The nature of the sensitized products manufactured at Kodak Park…" the pamphlet read, "require that they shall be manufactured and handled under exacting conditions imposed on few other products."[4] The buildings where film was made were no longer dim fairy worlds, but rigidly controlled interiors, closed to the rhythms of the outside world, "kept at uniform temperature and humidity the year round."[5] Even darkness itself had

---

[1] *The Home of The Kodak*, 14.

[2] Ibid., 16.

[3] Ibid., 16.

[4] *The Home of Kodak*, 15.

[5] Ibid., 15.

been banished: “so-called ‘dark’ rooms” were now “well illuminated [by] a system of diffused lighting, in safe colors.”[6]

The Home of The Kodak and *The Home of Kodak* feel as if they were written in different worlds—or with an eye to different worlds. In the forty years between pamphlets, Kodak had grown and diversified. It wasn’t just making “the Kodak,” it was making a Kodak version of everything: papers, lenses, chemicals, and the raw material of an entirely new medium, motion pictures. Cinema by the close of the 1920s was a global phenomenon, led by a US film industry fueled by finance capital.[7] Cinema emerged at the tail end of a communications revolution—telegraphic worldwide connectivity—and at the beginning of industrial speedup that created the conditions for a new kind of consumer capitalism. Intensive, ecology-destroying factories produced goods for an increasingly worldwide market, and financialized large-scale agriculture was continually pushing rural young men toward resettling in cities, joining a new urbanized consumer base. Nowhere was this happening more profoundly than in the developing nation of the United States.[8] The story of Kodak’s rise in this period is not merely a case study but a focal point of the transformation of the US economy, because Kodak’s rise made possible the cinematic dreamworld that, in turn, helped drive consumer appetites and introduce the US’s culture abroad.[9]

The emergence of motion pictures was facilitated by a transparent flexible film substance called celluloid, which Eastman first put to market.[10] Raw celluloid film is a thin layered translucent substrate upon which images are embedded. As a translucent yet flexible and thin material, it was something radically new. As a means of placing images in mo-

---

[6] Ibid., 19.

[7] For the spread of American cinema abroad, see Thompson, *Exporting Entertainment*. For the financialization of cinema production, see Grieveson, *Cinema and the Wealth of Nations*, ch. 11.

[8] On applying a developmental framework to the late-19th-century United States, see Link and Maggor, “The United States as a Developing Nation.”

[9] For the importance of cinema to the entrenchment of the capitalist world system of the 20th century, see Grieveson, *Cinema and the Wealth of Nations*.

[10] Historically, the term celluloid described a plastic made of cellulose used for all kinds of imitation products. Celluloid was once a trademarked term, belonging to John Wesley Hyatt’s Celluloid Manufacturing Company. Friedel, *Pioneer Plastic*, 16. I use the term here in its now most common usage, to describe celluloid film stock used for motion pictures.

tion and expanding them to fill a screen, it was something astonishing.[11] But Eastman Kodak found its manufacture troublesome and trying. Highly flammable and sensitive to temperature and humidity, celluloid film was a vibrant substance that refused to be rendered fully inert—handling it and manufacturing it remained hazardous for as long as it was in production.[12] Its chemical composition was little understood, and the chemical workings of its emulsion were a mystery. In nitrate film Kodak faced a host of difficulties that challenged makers of "new" materials.

This article traces how the struggle over these difficulties transformed the Eastman Kodak Company into a chemical company, managed by experts in chemistry. In becoming a chemical company, Kodak in turn made it possible to disseminate moving images on an unbelievably wide scale.[13] The struggle to make film stock behave consistently and produce images predictably was at the heart of Kodak's chemical engineering approach. Though innovation through research was one clear goal for Kodak beginning in the 1890s, the single greatest consequence of the firm's empowerment of technically trained chemists and engineers was in consistency of manufacture of a volatile and novel material.[14] Kodak's new generation of chemical experts, lacking fundamental knowledge of the temperamental substance they were tasked with producing, turned to practices and testing methods centered on the goal of *purity*. The standardized film resulting from this approach made possible the effacement of film stock itself from the minds of film viewers.

The origin story of celluloid manufacture adds a new account to the history of knowledge production within manufacturing firms. Historians have focused much attention on industrial research and the emergence of what came to be called "fundamental research,"

[11] While the technological history of cinema optics, projection, and sound has been more thoroughly explored, the story of celluloid has been largely left out of film history. The work of Alice Lovejoy and Pansy Duncan is helping to fill in this lacuna, as part of a broader eco-material turn in media studies. See Lovejoy, "Celluloid Geopolitics" and Duncan, "Celluloid™". See also Bustamente, "Agfa, Kullmann, Singer & Co. and Early Cine-Film Stock." Film archivists have given nitrate film more attention. See Smither and Surowiec, *This Film is Dangerous*.

[12] I draw the term "vibrant" from Jane Bennett, whose concept of *vibrant matter* provides one way of considering the possibility of the latent potential for action within supposedly static, nonliving substances. Bennett, *Vibrant Matter.*

[13] On the economic history of cinema's growth to become mass entertainment, see Bakker, "How Motion Pictures Industrialized Entertainment."

[14] On George Eastman and Kodak's turn to a strategy of technological innovation, see Jenkins, *Images and Enterprise*, 179–87.

especially through close studies of laboratories like Kodak's own Research Laboratory.[15] At Kodak, however, another laboratory preceded the Research Laboratory by decades—it was established as a research and an analytical laboratory in one, a space not only for testing raw materials, but for experiments as well. This essay recovers the story of this earliest laboratory, which was put to work in an early legal dispute between Kodak and one of its original chemical suppliers. The story of this first lab demonstrates that Kodak did not prioritize knowledge of *why* celluloid film possessed the properties it did, or why certain processes to manufacture it succeeded while others failed, as acquiring such knowledge did not meet the imperatives of manufacture itself. Far from a research-oriented company in its early decades, Eastman Kodak first built a formidable monopoly around a substance that it only partially understood. Regardless of whether Kodak's chemists could determine from first principles what caused celluloid to act the way it did, the firm could make sure that the ingredients of celluloid met the standards of purity that chemists determined would produce a standardized finished product. For Kodak, purity was a substitute for fundamental knowledge.

Purity—along with its enemy, dirt—was an animating feature of early 20th century life, a signal idea guiding the work of sanitarians, moralists, and reformers.[16] Yet many of the standard accounts of the cultural and political life of purity at the turn of last century cast these figures against private enterprises and whole industries that cared little about purity or contamination. The standard histories of food regulation suggest that private firms sought to profit from a *lack* of purity, through adulteration and a lack of sanitation.[17] The historiography of industrial firms in this period has thus largely left unconsidered the ideological work of purity *within* firms themselves.[18] We know much about the chemists who worked to establish robust governmental regulation of pure goods, especially of food, and surprisingly little about how chemical experts were applying principles of purity inside

---

[15] On Kodak's Research Laboratory over a long dureé, see Sturchio, "Experimenting with Research." On the history of industrial research, see Hounshell, "The Evolution of Industrial Research in the United States." Alfred D. Chandler provides a key account of research as one important emergent structural feature of the large business corporation, analyzing the embedding of research laboratories into the managerial structures of large firms including DuPont and General Electric. Chandler, *The Visible Hand*, ch. 13. DuPont's research activities have perhaps received the most sustained attention. See Hounshell and Smith, *Science and Corporate Strategy*.

[16] Burnstein, *Next to Godliness*; Cohen, *Filth*. On the centrality of water purity to these political currents, see Melosi, *The Sanitary City*, 134–43 and Smith, *City Water, City Life*, ch. 5.

[17] Young, *Pure Food*; Thomas, *In Food We Trust*, ch. 1.

[18] The work of David Roth Singerman, still centered on food, provides a crucial intervention in this historiography. Singerman, "Inventing Purity in the Atlantic Sugar World."

of firms themselves.[19] In Kodak's case, testing for purity provided the answer not to the political dilemmas of discerning and disgusted customers, but to the material problems of manufacturing a difficult "new" chemical material. In time, a politics of public health emerged surrounding cinema precisely centered on the dangers posed by this new, flammable substance, celluloid.[20] But Kodak's issues with celluloid were problems not of adulteration or lack of sanitation threatening consumer health but of a vibrant material itself resisting efforts to control its volatility—both its ability to replicate images and its tendency to burst into flame.[21] The question of control within capitalist firms in the 19th and 20th centuries has never been far removed from the question of labor discipline.[22] But before firms could harness self-consciously technical expertise toward controlling their workers, they first had to control the things they produced. Kodak's work to manage the specific technological problems and risks created by celluloid was thus itself constitutive of the new industrial shape the firm took.

Importantly, Kodak recruited not primarily chemists but chemical engineers, and it was these experts who took the most prominent management roles. At the apex of this trend was Frank William Lovejoy, the company's first chemical engineer, who served as head of Kodak Park, then head of all manufacturing, and finally general manager of the entire firm, all during its period of most rapid early 20th century growth. This article takes up the call recently made in these pages by Israel G. Solares and Edward Beatty to examine the consequences of the fact that "engineers played a significant and enduring role in the managerial revolution."[23] At Kodak, chemical engineers, as they became managers, spread the ethos of purity that came to define how the company approached manufacturing its photosensitive goods, and ultimately how it marketed those goods.

The firm's shift toward empowering chemists emerged out of business catastrophe. George Eastman, Kodak's founder, joined the photographic trade when it was guided by

---

[19] On Harvey Washington Wiley, the chemist crusader for food safety and key architect of the Pure Food and Drug Act of 1906, see Coppin and High, *The Politics of Purity* and Blum, *The Poison Squad*.

[20] For the politics of public health and their relationship to early cinema regulation, see Grieveson, *Policing Cinema*, ch. 3.

[21] On explosiveness and fire and their key roles in Gilded Age capitalism, see Immerwahr, "All That Is Solid Bursts into Flame."

[22] For an elaboration of this perspective, see Braverman, *Labor and Monopoly Capital.* For a history of control of not only workers or material, but of information itself, see James R. Beniger, *The Control Revolution.*

[23] Solares and Beatty, "Engineers and Corporate Management," 506.

sensuous and intimate knowledge practices. His young company faced two crises, ten years apart, in its ability to make material that could produce clear images. In the first, in 1882, Eastman could not produce glass plates, at the time his only real product. But worse was the second, in 1892, which arrested celluloid production and plate production alike. These crises demonstrated to Eastman the necessity of maintaining consistency in raw materials to ensure the product they combined to create had any value at all. While emulsion failures drove Eastman to rely more and more on chemical experts, those chemical experts did not, in the end, take control of emulsion making itself. This most important work of the company, the work of making blank material into the stuff that could render images, continued to use methods and knowledge practices that echoed the experimental, empirical, artisanal photographic approach of Eastman and his contemporaries prior to Kodak's transformation.[24]

From the mid-1890s through the 1920s, Kodak's new cohort of scientifically trained employees developed standards of purity as a way to maintain consistency while accommodating the volatility of this new film, which they only partially understood. This history of industrial purity demonstrates that celluloid had a pivotal role to play in the development of the industrial practices—around standardization and testing—of the largest photographic firm in the world, while it simultaneously played an equally crucial role in the creation of the new massively popular medium of motion pictures. This story concerns less how Kodak made celluloid than how celluloid made Kodak.

---

[24] Though Michael Pritchard claims that beginning in the 1880s in the United Kingdom "the move towards the mechanisation of manufacture and a more scientific approach to emulsion making which the largest manufacturers adopted introduced a consistency to manufacture and formulae," the story of Kodak's emulsion manufacture presents a different story, one more aligned with Reese Jenkins's claim that emulsion making "remained an empirical art" well beyond the 1890s. Pritchard, "The Development and Growth of British Photographic Manufacturing," 171. Jenkins, *Images and Enterprise*, 80. Kodak's own reliance on an artisanal model of emulsion production and its associated knowledge practices stands in stark contrast to the approach taken by the Aktiengesellschaft für Anilinfabrikation (Agfa), which employed a number of doctorate-holding chemists and relied on technically trained staff to develop its film business beginning at the turn of the 20th century. (By 1904, the company had abandoned film production because of a host of manufacturing defects, including with emulsion. Even after it began in 1909 a massive project to make large quantities of photosensitive film at a new purpose-built factory in Wolfen, near one of its existing dye plants, Agfa still struggled to make motion picture film with the consistency, durability, and sensitivity of Kodak film for many years.) Agfa Jahresbericht 1904, pp. 77–79, R 8128/15761, Bundesarchiv, Lichterfelde, Berlin, Germany; Löhnert and Mustroph, *Der Aufbau und die ersten Jahre der Filmfabrik Wolfen*, 39; Jenkins, *Images and Enterprise*, 278.

Emulsion, Chance, and Crisis

George Eastman was born in 1854 in Waterville, New York, a few hundred miles south of Rochester, where his father had founded the Eastman Commercial College, one of the first business colleges in the country. Students attended year-round to learn accounting and penmanship through practical instruction. Their textbook was Eastman father's own 1851 guide to bookkeeping, a standard of the field through the end of the century.[25] Rochester was a boomtown at the convergence of the Eerie canal and multiple railroads, an outlet to the agricultural land of the Midwest, as well as the financial centers of the east. In 1857, however, a financial panic struck, the first global financial crisis. The Panic of 1857 emerged out of overextended credit from undercapitalized banks, financing a land speculation bubble in the West. It was as dramatic an encapsulation of the hand of Fortuna in the making and unmaking of wealth in the market society of 19th century America.[26] Just as the financial crisis struck, Eastman's father fell ill. He died in 1862, at the age of 47, leaving behind a wife and three children.[27] George Eastman was seven. Though his father founded a college, Eastman did not attend one. He was still a teenager when he took his first job, at an insurance firm. A few years later he left insurance and became a bank clerk.

Eastman bought his first set of photographic equipment on a lark, with no idea how to use it. In its earliest days, photography depended upon the intimacy of the photographer and their chemical tools. Achieving this intimacy required collaboration and support from other photographers: Eastman could only understand how to take photographs after paying for lessons from another local photographer.[28] This intimacy was distinct from a scientific understanding of the chemical processes upon which photography depended. Knowledge of how chemicals reacted, why sensitized material acted the way it did, even the chemical structure of certain ingredients, was decades from development. Instead, this intimacy more closely resembled the 18th century scientific regime that Lissa Roberts has called "sensuous chemistry," in which the chemist's most important tool was their body.[29] Chemists of the 18th century tasted, touched, and smelled their way through their exper-

---

[25] Fulton and Eastman, *A Practical System of Book-keeping.*

[26] For more on chance, risk, and the 19th century American political economy, see Levy, *Freaks of Fortune* and Sandage, *Born Losers*. On the Panic of 1857, see Calomaris and Schweikart, "The Panic of 1857" and Sandage, *Born Losers*, 92–98.

[27] Brayer, *George Eastman*, 19.

[28] Ackerman, *George Eastman*, 15.

[29] Roberts, "The Death of the Sensuous Chemist."

iments, rather than relying on the precision of instruments of measurement and observation that would later come to reconfigure the sciences. Following historians of science Peter Galison and Lorraine Daston, we can see their scientific selves as consciously intervening in their scientific practice: they were "geniuses of observation," rather than self-effacing calculators.[30] This approach of the tinkerer, utilizing the tacit and embodied knowledge familiar to artisans of all kinds, gradually eroded as standardization and measurement became more and more important to the epistemic claims chemists could make.

Eastman quickly became obsessed with photography, experimenting with the "wet" collodion process that involved taking glass plates, coating them in a thick solution of nitrated cotton combined with silver salts, and then quickly inserting them into a camera and exposing them to light. After he built his skills, he began making and selling glass plates that were already sensitized with gelatin and silver, a newer technology called "dry" plates, to other photographers. This plate business began in an attic, while he was still working as a bank clerk. He experimented and fiddled, ruddying his hands and staining his clothes. With the help of Monroe and others, Eastman built his tacit knowledge, learning to trust his senses in the making of emulsion. "After long experience," Eastman bragged decades later, "I found that I could tell by the color of the substance" when the emulsion was "cooked enough." Sometimes, if the emulsion wasn't ready, "I would lie down and sleep for an hour or two hours and would always wake up at the proper time without the aid of an alarm clock."[31]

In spite of his later boasts, Eastman never distinguished himself as an emulsion-maker. His earliest attempt at innovation lay not in the wizardry of photochemistry but in eliminating human labor from the making of glass plates. Dry plates had already transferred the work of coating plates from the photographer to the dry plate manufacturer. Eastman envisioned shifting this labor again from the human to the machine. After filing patents for a plate-coating machine, he licensed its sale in Great Britain through a London dealer. Eastman promised much and delivered little. The machine broke constantly, and most of the time it produced plates with an uneven coating. Eastman himself paid workers to coat his company's plates by hand.[32] But it introduced to photography the tantalizing possibili-

---

[30] Daston and Galison, *Objectivity*, 203. For the relationship of instruments and the scientific episteme, see Daston and Galison, *Objectivity*, ch. 1–3.

[31] Recollection of George Eastman, Will H. Hays, March 10, 1942, George Eastman Papers, D.138, Rare Books, Special Collections, and Preservation, River Campus Libraries, University of Rochester.

[32] Brayer, *George Eastman*, 96.

ty of something that the field had yet to enjoy: machine standardization. Mechanization could reduce labor and create consistency.

The confounding dilemma at the heart of photography was in the apparent inability of rational or standardized practice to reliably produce clarity. In the nascent photography industry, a glass plate provider was expected above all else to produce clear images. This was exceedingly difficult in photography's early years, for largely mysterious reasons. The long duration of exposure of photographic material to light was an obvious cause of blurriness. Daguerrotype portraiture famously required living subjects to sit motionless for minutes at a time while their images were being exposed inside of the camera's darkness.[33] The proliferation of other photography methods created new challenges to clarity. A flaw in the emulsion would either obscure the image in a gauzy fog or produce no image at all. If a photographer found their images to be cloudy, and once issues of optics and camera mechanics could be ruled out, it was the maker of the sensitized material who was to blame. But if finding fault in the emulsion proved easy, finding the reason for the emulsion's failure proved terrifically hard, like searching for the source of an insect infestation months after they've settled in.[34]

In 1882, George Eastman's emulsion started failing. The timing was horrible. He had quit his job only a handful of months before and was having an entire new factory for his glass plates built. The economy was entering a depression that would last until the middle of the decade. He experimented with hundreds of variations on his emulsion formula, with all producing some "fog" or "veil." In desperation he traveled to London, where his raw materials came from. There he was generously helped by other dry plate makers, his ostensible competitors, as he puzzled over what could be causing the issue. After many inquiries, he found it: without telling any of his clients, Eastman's English gelatin supplier had changed his source of gelatin. It came down to the cows, whose flesh was boiled to make gelatin. After surviving the fogging of his plates, Eastman newly appreciated the necessity of control. Wherever possible, he needed to control his raw materials to ensure their consistency. Consistency, at first, meant not altering the methods of extraction or the

[33] Taft, *Photography and the American Scene*, 32.

[34] For an overview of the first fifty years of photography in the United States, see Taft, *Photography and the American Scene*. For an accounting of the role of artisanal experiment in creating a distinctive American photographic community, see Smiley, "'An American Sun Shines Brighter.'"

provenance of materials in any way. Workers at Kodak Park would years later claim that Kodak's gelatin could only come from herds of cattle grazing in specific fields in Europe.[35]

It is worth dwelling for a moment on what this incident revealed about how the photographic trade operated. Materials were defined by their provenance, rather than their inherent qualities, and most materials were channeled through London-based supply networks. The photographic community, still small, was built on arrangements of reciprocity and friendship, through which technological and practical problems could be resolved through groups of supposed competitors. After young Eastman discovered that gelatin was the problem, his English dry plate counterparts taught him how to test gelatin for photographic suitability before applying it to emulsion, and helped him find a new, more reliable supplier. Nobody on either side of the Atlantic had any clue as to why some gelatin ruined emulsions and other gelatin did not. They knew only how to empirically work through problems with raw materials as they arose.

Eastman's aim, from his earliest days as a dry plate manufacturer, was to transform this small photographic community into a much larger base of customers. To make a camera that more people could use and would want to use, Eastman sought a flexible film that could hold many images rather than the single image of a glass plate, and that could be rolled on a spool. He debuted the first rolled film strips in 1885, but could only accomplish the feat by making them with an opaque paper backing. Eastman was looking to do away with the opaque paper layer, which made images look grainy when enlarged.[36] For this he felt needed a chemist. In 1886, he hired Henry M. Reichenbach, just graduated from the University of Rochester's newly established chemistry program. "He knows nothing about photography," wrote Eastman—he was to devote "his time entirely to experiments."[37] The most important experiment was in how to make transparent film using a nitrocellulose plastic, now commonly known as celluloid.

Nitrocellulose, or cellulose nitrate, is made by reacting cellulose with nitric acid. Cotton linters, leftover fibers after the longer strands had been ginned from the seed, was among the most readily available sources of cellulose. When reacted with nitric acid, cotton becomes dissolvable in a host of different solvents. Heavily nitrated cotton was enormously flammable, and was usually called guncotton. Cotton nitrated only enough to be

---

[35] Company legend from Roger Loveland, "A History of Chemistry in Kodak," 1985, Folder 15, Box 101, Kodak Historical Collection #003, D.319, Rare Books, Special Collections, and Preservation, River Campus Libraries, University of Rochester (hereafter, KHC). See also accounts in Brayer, *George Eastman*, 40–41; Ackerman, *George Eastman*, 42–44.

[36] *United States v. Eastman Kodak Company*, pg. 500.

[37] Quoted in Ackerman, *George Eastman*, 57.

dissolved was called soluble cotton or pyroxylin, and when it was combined with some sort of solvent, it made a sticky, gooey substance that could dry into hardened forms.[38] Eastman was familiar with a very similar nitrocellulose product, collodion, composed of nitrated cotton dissolved in ether alcohol and used as part of the gelatin emulsions that were poured onto wet plates of the kind Eastman used when he first made photographs. Reichenbach worked to develop a nitrocellulose film with a consistency much like collodion: the sought-after liquid form could first be poured in a thin layer and then dried and coated in emulsion to make a flexible, rollable film. This would be the "support" on which the emulsion would then be spread.

Reichenbach proceeded empirically, following a process of trial and error to find a substance with such properties. Eastman and Reichenbach were clearly still operating more like tinkerers than research scientists.[39] Their concern was for thrift rather than for purity: in January of 1889 Eastman cast out looking for soluble cotton by writing one firm, "Can you inform us where we can get papyroxylin [sic] or nitro-cellulose such as used in making celluloid? We want something cheap."[40] Reichenbach's eventual material, nitrocellulose dissolved in wood alcohol and combined with a small amount of camphor, flowed in a thick, viscous trail. The company built a new factory floor for film manufacture, with special vats for mixing the substance and fifty-foot tables covered in glass, sourced from France. Upon these tables workers spread the gummy liquid to dry in the thinnest possible layer. The earliest batches were plagued with problems that would have marred the tiny images the film was designed to capture—the celluloid dried with bubbles in it and the emulsion contained black spots. Celluloid was a much more reactive sub-

---

38 Friedel, *Pioneer Plastic,* 1–23.

39 The empirical and artisanal nature of knowledge production in the firm was a transatlantic one, as demonstrated by the surviving recollections of F.W. Thomas Krohn, Kodak Limited's Works Chemist in England, who trained with Reichenbach (referred to by Krohn as "genius") at Kodak Park. As Nicholas Le Guern points out in his survey of Kodak's research practices in Europe, in hiring Krohn the young firm made clear "the great importance of keeping the production in good working order rather than undertaking experiments to develop innovative products." In fact, Le Guern argues, "The possibility that Krohn might make some inventions during his routine work was therefore seen more as a threat than a benefit." Le Guern, "Contribution of the European Kodak Research Laboratories," 96–97. Le Guern argues that Krohn's suggestions around improving manufacturing and his push for acquisitions of more precise equipment—along with the early career of the Experimental and Testing Department that is discussed later in this essay—constitute scientific progenitors to the fundamental research approach of the Kodak Research Laboratory before 1912. But these ad hoc and informal maneuvers by Kodak's earliest scientists constitute only further evidence of the extent to which manufacturing difficulties and the search for consistency continued to take great primacy over any desire for innovation during the firm's early history.

40 *EKC v. Kleinhans, et. al.*, p. 539.

stance than glass, and getting emulsion to stick to it consistently, without streaking or spotting, was a difficult task. It took months to make sellable film.[41]

When rolled film was introduced widely in 1889 it became a fast success. Eastman credited his chemist for the invention, going so far as to have the patent for the chemical formula be granted in Reichenbach's name.[42] "It will not be long before your concern will need a practical chemist," Eastman wrote a counterpart in England in 1890, "If he is any good he will be the most profitable man you can hire."[43] An assistant of Thomas Edison, William Kennedy-Laurie Dickson, placed his first order in September of 1889 for the most sensitive and thickest and longest strips of celluloid film Kodak could provide.[44]

At the beginning of 1892, Eastman discovered that Reichenbach, the chemist's assistant, and the company's head of sales had been conspiring to launch a competitor film manufacturer with the help of the Celluloid Company. He fired them immediately. Reichenbach had been in charge of all film production and, most importantly, all emulsion manufacture. Scrambling to find a new emulsion-maker, Eastman hired George Monroe, the photographer who first taught him how to take pictures. Monroe's emulsion started failing only months later, and Eastman fired him. Monroe was followed by Walter Butler, a longtime employee, and after Butler met no success, a local professor and photographer took over, and also failed. For part of 1892, the Eastman Kodak Company suspended all film sales.[45] Like in 1882, Eastman's emulsion failed at the same time the national economy faltered, as the Panic of 1893 caused a massive banking crisis. Eastman believed a sellable, decent film would soon eclipse any other material for making photos.[46] "All that we have got to do now," he wrote in a letter, "is to get rid of the spots and streaks."[47] While Eastman floundered without film, Dickson and Edison debuted the Kinetoscope publicly using film coated by the rival Blair Camera Company and manufactured by the Celluloid Company.[48]

---

[41] For one account of this period, see Jenkins, *Images and Enterprise*, 127–33.

[42] Ackerman, *George Eastman*, 62–63.

[43] Eastman to Walker, October 28, 1890, quoted in Ackerman, *George Eastman*, 63.

[44] Spehr, "Unaltered to Date," 7; Reproduction of letter in Folder 19, Box 186, KHC.

[45] An account of this succession of failed emulsion attempts is in Brayer, *George Eastman*, 94–95.

[46] George Eastman to James B. B. Wellington, April 18, 1892, George Eastman Legacy Collection, George Eastman Museum, Rochester, NY (hereafter, GELC).

[47] Ibid.

[48] Spehr, "Unaltered to Date," 14.

A key problem was that the celluloid "support" more readily chemically altered the emulsion than the much more inert glass plates did—another part of the temperamental nature of celluloid. At first, Eastman blamed the specific supplier of soluble cotton in solution.[49] (He had agreed to switch from one supplier to a Celluloid Company subsidiary as part of a legal settlement with the Celluloid Company.)[50] But when he returned to his original supplier, the troubles only persisted. Different issues required added solutions: nitrate salts to correct mottling caused by static electricity, chalk rubbed on the glass tables to keep the film from sticking to them after drying. Solutions would be tried, declared a success, and then later declared a failure and discarded.[51] The issue was not merely failing film but *inconsistently* failing film—same soluble cotton base, same nitrate salts, but with some batches deteriorating or developing poorly while other batches "retained their quality perfectly," as Eastman put it.[52] Temperamental celluloid, it seemed, required a strange combination of rigid perfectionism and blunt luck.

Film was a radically "new material," a substance that produced visual delight through an unlikely combination of qualities: strength, thinness, flexibility, and transparency. To fuse these features into one material required that Kodak sacrifice stability—film was volatile, flammable, prone to spontaneous eruption of flame. As Amy Slaton has noted, manufacturers of things often chased consistency in both its forms: seeking to understand the sensuous and measured qualities of a substance while also seeking to assure conformity of the substance to tight standards across time.[53] This was the project for Reichenbach and his successors in making rolled film. But these two senses of consistency were achieved unevenly. Chemical engineers were able to rapidly introduce processes to make film consistently, but its consistency as a substance—what it was made of and how its constituent parts interacted—was largely unknown. Stabilizing film, a project that required the operationalization of both senses of consistency, was the hardest thing to manage of all.

Given that coating celluloid with emulsion seemed to be a process immune to full standardization, it is perhaps fitting that Eastman's solution to this crisis could not be

---

[49] He suggested this soluble cotton solution may have been too acidic. George Eastman to George Dickman, February 16, 1893, GELC.

[50] Ackerman, *George Eastman*, 94.

[51] The company switched to greasing glass tables instead of chalk, then switched right back months later. Brayer, *George Eastman*, 98.

[52] George Eastman to George Dickman, February 16, 1893, GELC.

[53] Slaton, introduction to *New Materials*, 9.

hired out of a chemistry program or a technical college. It took until 1894 for Eastman to find an emulsions expert to fix the company's film, a photographer named William G. Stuber, who had just finished training with an emulsion specialist in Switzerland. The Panic of 1893 had left Stuber with little money, and Eastman was able to lure him from Louisville, Kentucky, where he was born and raised.[54] When Eastman asked him what mattered most in photographic goods, Stuber pointed to "uniformity—the importance of a stabilized, uniform product."[55] The photographer, whose only education was grammar school in the 1870s, conducted his experiments in secret.[56] Nobody, not even Eastman, was allowed to observe him or his department, and this secrecy was a feature of the emulsions division for years after.[57] Eastman was only too happy to accommodate such secrecy to protect Kodak from competitors stealing the firm's emulsion recipes, something Reichenbach had reportedly tried to do after his resignation. After diligent and cloistered experiment, Stuber arrived at a proprietary formula and special method that improved upon Reichenbach and Monroe's emulsions. By the end of 1894, Kodak was steadily producing film again.[58]

The Emulsion Department run by Stuber took a different path than the rest of the company, relying not on engineers but on the very forms of artisanal knowledge production that had defined the photographic community in the previous century. Emulsion remained a finicky thing, prone to fits of fogging. Surrendering to chance remained the only viable way forward when emulsion misbehaved. Even ten years into his tenure, Stuber still found new difficulties. Around 1903, emulsion trouble seized Kodak's facilities, leaving only a small trickle of usable material to send to customers. Stuber, at wit's end, went to Eastman's residence and offered his resignation. "I'm making four batches a day," he had said, and "I'm getting one good batch a day and I don't know why." Eastman offered no engineering support, nor did he ask his chemists to assist Stuber. Instead, he offered a simple remedy: make sixteen batches a day, so that four would come out right.[59]

---

[54] Interview with Adolph Stuber, June 22, 1976, pg. 5, Folder 1, Box 1, AS.

[55] Ibid., 6.

[56] Ibid., 3.

[57] One account of Eastman being banned from emulsion rooms comes from "Excerpts from Interviews with Henry Busch, George Cannan, John Herring, Frank Meyering and Charles Ras," 7, Folder 1, Box 49, KHC.

[58] For accounts of this crisis, see Brayer, *George Eastman*, 94–98; Jenkins, *Images and Enterprise*, 153–56.

[59] Interview with Adolph Stuber, June 11, 1976, pg. 10, Folder 1, Box 1, AS.

The Emulsion Department held to its secretive, top-down, empirical approach for the next half-century. At a time when the rest of Kodak Park had been made into a rigorously standardized and highly engineered zone of chemical purification, emulsion-making remained a far less rigidly mechanized and far more artisanal process. Though Stuber brought on a chemist named Charles Hutchison as his right-hand man in 1899, the department didn't hire a university-trained chemist as a worker until 1926.[60] When Stuber was promoted to President of the company, Hutchison took over the department. Stuber continued to inspect products until his retirement in 1934, and Hutchison supervised the department until he retired in 1952. Stuber and Hutchinson were secretive enough that few records survive of their processes. A recollection transcribed in the 1970s of the process in the 1930s, however, shows that even then—long after Stuber had left the emulsion department—the process was guided by experiential knowledge, bespoke tools, and artisanal processes. The people who mixed the batches of emulsion out of raw ingredients were called "makers." They did so by hand, using twenty-gallon ceramic jars and special silver-lined kettles. The silver lining had been handmade by Mennonites in Pennsylvania, and company lore was that these were the only non-employees allowed to enter the emulsion department, in order to make repairs. "To become a maker was the ambition of just about all of the production workers," claimed one emulsion worker. New makers were trained through an apprenticeship system, by being assigned a maker to shadow. Different emulsion formulas were needed for different products. At the end of every batch, makers washed their own kettles and jars.[61] Ultimately, emulsion making at Kodak was the one part of the company's photomaterials business that did not transform through supervision by chemical experts—an irony, given the centrality of emulsion failure to the firm's broader transformation. Artisanal processes maintained a quality of emulsion that could keep Kodak's film usable, but to reliably make that film in the first place, the company needed to make its base celluloid consistently. To accomplish this, Eastman and his firm turned to chemists and chemical engineers.

Engineering, Purity, and Kodak as Chemical Company

The difficulties of making a cellulose-based film rapidly transformed the priorities of Eastman's manufacturing operations. While creating the first film may have largely been a process of tinkering and iterating, manufacturing it introduced challenges that required

---

[60] Brayer, *George Eastman*, 180. Earl Arnold Interview, May 4, 1971, Folder 1, Box 1, Lawrence Bachmann papers, D.137, Rare Books, Special Collections, and Preservation, River Campus Libraries, University of Rochester.

[61] "Forty Years in the Film Emulsion Department," Folder 2, Box 97a, KHC.

more standardized solutions. How could Kodak make film consistently, so that it would deviate as little as possible in thickness and in performance? How could Kodak make film safely, without causing a factory catastrophe as a result of the flammability of nitrated cellulose? How could Kodak make film that did not degrade under different conditions—that did not have emulsion separating from the backing, that did not tear when run through projectors, and that did not stop performing when weather conditions changed? After entrusting temperamental emulsion to the artisan Stuber, Eastman turned to chemical experts to address these other quandaries of making the cellulose-based film backing. And as Eastman hired chemists and engineers in this struggle to make consistent, reliable film, these specialists instilled a corporate ethos that Kodak could master contingency through rigid application of standardized technical processes. In 1890, Eastman hired his first Massachusetts Institute of Technology (MIT) graduate, Darragh de Lancey, to plan and manage a new manufacturing complex outside of Rochester.

Cheap rural land made for easy expansion, allowing Eastman to realize his dream of expanding the photographic business. The Boulevard Plant was first opened in 1891, immediately ballooning Kodak's film production capacity. A new film production building, purpose-built, could make film at longer lengths using longer tables. By 1893 the company had already doubled the capacity of the new campus.[62] Three years after that, the plant had already added another five acres.[63] At the beginning of the new century, the plant, now served by its own trolley line, had nineteen buildings.[64] Kodak Park helped constitute the remit of purity that drove the company forward. Its location outside of town was only secondarily about provisioning for growth—the foremost reason for making film further from town was to avoid contamination from soot, dust, and the grime of the city.[65]

The plant was from its beginnings designed not only as a manufacturing facility, but as a workspace of scientists. One of the four buildings open at the plant's debut was a new laboratory, of which Reichenbach was the director. Called the Experimental and Testing Department (ETD), this laboratory was established for experiments with new materials and for testing raw materials—maintaining the control over ingredients that Eastman saw as essential after the gelatin mishap of his first emulsion disaster.[66] No mere analytical laboratory, the facility was the source of a number of important research developments,

---

[62] Jenkins, *Images and Enterprise*, 148.

[63] Kodak Park Timeline, Folder 16, Box 99, KHC.

[64] Ibid.

[65] Kodak Park History, Folder 1, Box 38, KHC.

[66] Jenkins, *Images and Enterprise*, 185.

including, in the first decade of the 20th century, non-curling film and the company's first non-flammable film.[67] Though the Kodak Research Laboratory, started by Charles Edward Kenneth Mees in 1911, has received much attention for being one of the earliest examples of the fundamental research laboratories that many American firms launched in the early 20th century, the ETD had the longer history, remaining a distinct department within the company for the next century.[68] The Experimental and Testing Department's name itself contained a dilemma between experimentation with new and different ways of controlling unstable celluloid and the imperative of not changing the source and composition of materials, to maintain the consistency that prevented incidents like the two emulsion failures. The chemists found a resolution in the form of a clear chemical goal: purity.

The laboratory developed standard procedures for testing the purity of raw materials.[69] The ETD, eventually renamed the Industrial Laboratory (in contrast to the Research Laboratory), was led not by theoretical researchers but by a succession of practical chemists. After Reichenbach's firing, the ETD was headed by a chemist newly graduated from MIT named Harriet Gallup. When she shortly left to marry, Albert F. Sulzer, another MIT graduate, took it up. He soon moved to department making developing solutions, and the company then hired David E. Reid, a trained pharmacist, to run the laboratory. The laboratory's remit of purity soon animated the ethos of the entire organization, as the Experimental and Testing Department steadily produced the future managers of Kodak Park—it was christened by one Kodak lifer "the Superintendents' Proving Ground."[70]

Eastman staffed his testing laboratory not only with chemists but with a new category of practical chemistry expert, the chemical engineer. MIT had recently launched a new program it called "Course X" to provide a kind of chemistry training according to the needs of industrial workplaces.[71] This was the first of a wave of programs that would be

---

[67] Jenkins, *Images and Enterprise*, 185, 302.

[68] For an account of the Research Laboratory's development, see Reese Jenkins, *Images and Enterprise,* 305–16.

[69] Darragh de Lancey testified during anti-trust proceedings in 1915, "The laboratory was intended for the systematic testing of raw materials used in the other departments. It was made a practice of the plant that no consignment of raw material was accepted and paid for until it had the O. K. from the laboratory testing department." *US v. EKC*, p. 769.

[70] Wyatt Brumitt, "The Other Labs," Folder 16, Box 99, 8, KHC. This is notably different from how other internal testing laboratories tended to be viewed by early 20th century chemists, who often regarded the analytical work of such laboratories as relatively low status. See Reynolds, "Defining Professional Boundaries," 701.

[71] Ndiaye, *Nylon and Bombs*, 16; Haynes, *Background and Beginnings*, 394–95.

created in the 1890s designed to prepare students for immediate practical work in the American chemicals industry.[72] The first hire from MIT's new program in chemical engineering was a man named Frank William Lovejoy, who arrived at Kodak Park after holding two other chemistry jobs, at a sugar company and at a soap-maker.

Lovejoy's first job as Louisiana sugar chemist placed him at the center of a transformation in how sugarcane was processed into "pure" sugar. The idea of achieving a "pure" sugar, measurable and equivalent across harvests and regions, only arose once chemists determined the chemical composition of sugar. Before the arrival of the science of chemistry into the sugar factory, cane sugar production depended upon the artisanal skill of plantation laborers, including enslaved people.[73] As David Roth Singerman describes it, when determining the readiness of boiled cane for crystallization, the typically Black enslaved sugar master of the 18th and early 19th century plantation "stretched the scalding syrup between his fingers to test its elasticity, tasted it, inhaled its odors, and listened for its crackle."[74] Refining a sugar with the proper "character," the ideal crystal grains to fill a sugar bowl in a tea service, required the steady hands, eyes, ears, and noses of skilled plantation laborers. But by the late 19th century, planters and the owners of sugar capital saw chemistry as a means of finally disempowering the skilled sugar artisan. Chemists, once they entered the industry, worked to impose a new kind of labor discipline on every element of sugar production, insisting on standardized quality checks and quantified measurements of everything from the cane to the boiling vessels to the sacks of finished sugar. The industry termed this new way of doing things *chemical control*. Where once human skill was the key determinant of the quality of refined sugar, now human error was the only thing standing in the way of perfection. This laborious transformation of the power relations of the sugar plantation helped to render invisible the messiness of sugar and the prior indeterminacy of its refinement.[75]

After six months working on a sugar plantation, Lovejoy left purification of cane behind to return to Boston and work on the chemistry of bodily hygiene. Curtis Davis & Company, the soapmaker which would later be purchased by Lever Brothers when they first entered the United States, hired Lovejoy as a draftsman and chemist. The company's central product was a bar of soap, named Welcome. The company's newspaper advertise-

---

72 For the rise of chemical engineering, see Ndiaye, *Nylon and Bombs*, ch. 1.

73 Singerman, "The Limits of Chemical Control in the Caribbean Sugar Factory."

74 Singerman, "The Limits of Chemical Control in the Caribbean Sugar Factory," 43.

75 For more on sugar, purity, and chemical control, see Singerman, "Inventing Purity in the Atlantic Sugar World."

ments stressed that while the soap had many imitators, the "pure and sweet materials" in Welcome Soap were what set it apart over other "soaps of doubtful character."[76] As an MIT-trained chemical engineer, Lovejoy likely worked with and in the soap company's chemical laboratory. There, reported the *American Soap Journal*, "all raw materials are carefully tested to see that no impure or noxious matter finds its way into the various products."[77] The discourse of purity, one that animated social fury over contamination and adulteration in food and in the unregulated world of patent medicines, crossed freely between the realm of advertising and the space of the chemist's laboratory itself. The work of analysis, the most widely available job of the trained chemist at the end of the 19th century, encouraged a cultural embrace of purity in the public sphere while advancing a practice of purification within industrial laboratories.[78]

Lovejoy was enticed to join Kodak not from love of photography (he'd never tried it), but by the promise of a higher paycheck. Though he had no experience with celluloid or with photochemistry, Lovejoy was quickly placed in charge of the film support department. Film's base layer was a gummy, viscous nitrocellulose liquid—cotton treated with acid and dissolved in wood alcohol. Kodak had this liquid made for it by Charles Cooper & Company, a chemical manufacturer in Newark. Everyone at Kodak called this liquid "dope," a term derived from the Dutch term for a dipping sauce, doop. This term had become a stand-in for all kinds of thick, glob-forming liquids, but had been taken up by the chemical industry, especially explosives manufacturers like Hercules Powder Company. It was the common term for the liquid stabilizer that nitroglycerine was mixed with to make commercial dynamite, and for nitrocellulose in wobbly liquid form.[79] The name implied viscosity, but also uniformity—the things chemists described as dope were spreadable and smooth. Consistency within the liquid and across batches was crucial to successful manufacture. When poured, the liquid needed to spread to a precise and even thickness, but not drip off of the long glass tables where it dried.

It was a problem, then, when Cooper's dope stopped flowing right. In 1898, workers in the film department began dealing with dope that was inconsistent in two senses. Firstly, it did not flow the same way across batches. Secondly, it was not homogenous: it some-

---

76 *The Cambridge Tribune*, September 22, 1888, 3.

77 "Among the Soap Factories #3," *American Soap Journal & Manufacturing Chemist* 13 no. 4 (December 1, 1902), 101.

78 Terry S. Reynolds argues analytical chemists were "by far the most numerous" of all kinds of employed chemist at the turn of the century. Reynolds, "Defining Professional Boundaries," 700.

79 Eissler, *A Handbook on Modern Explosives*, 49.

times had lumps, undissolved cotton floating amongst the goo. This problem of flow could be summarized as an issue of inconsistent viscosity.[80] It was viscosity that determined how thick the final film would be, and thickness had to remain uniform across time. The foreman of the film plant found himself needing to create a new "formula" for each batch of dope he mixed to spread on glass tables, trying things out until he achieved a dope of the right viscosity.[81] Kodak sued Cooper, arguing that the company had not put a sufficient amount of cotton into the barrels of dope it supplied to Kodak. They arrived at this conclusion after rigorous testing to determine the dope's cotton content, conducted by the ETD over a series of months. Yet as the lawyers for Cooper complained, Kodak had no standard of measuring viscosity, and presented none to the court. It was done by eye. Eastman and others at Kodak complained that the issue was that Cooper had changed its procedure for making Kodak's dope without notifying Kodak—specifically, chemists there had begun using machines to produce the cotton. Before, Cooper's workers had, in the "dipping plant," dipped the cotton into a nitric acid bath by hand.[82] At the time of this crisis, regimes of rationalization and regimes of personal knowledge were colliding. Dope, whose most important feature, viscosity, was determined through sense impressions of skilled practitioners, was subjected to careful testing to determine its pure ingredients in a scientific manner. Kodak's managers then used this testing in order to demonstrate the inferiority of machine processes over techniques of handiwork, with the aim of ensuring that a critical ingredient for their film would not be changed in any way.

Cooper turned to its own chemical expert to assert a different narrative of purity, one that at once questioned Kodak's testing methods and placed the blame for defective dope elsewhere. As an expert witness it called a PhD-holding analytical chemist trained in Germany, who asserted that Kodak's method of sampling was faulty: testers didn't take enough samples, they only took them from the tops of cans, and they tested them at the wrong temperature.[83] Worse, their scientific reasoning was all wrong. The dope's viscosity varied not because of cotton content, he claimed, but because of the "purity" of the wood alcohol, which, in quantities large enough and cheap enough for use in Kodak's dope, always contained a small proportion of acetone.[84] Unfortunately, Cooper's superintendent himself put in writing that he never used "anything else but pure 97–98 per cent wood al-

[80] *EKC v. Kleinhans et. al.*, 186.

[81] Ibid., 174.

[82] Ibid., 122.

[83] Ibid., 299–301.

[84] Ibid., 310, 316.

cohol," so variation in acetone could not have been the culprit.[85] But on both sides of the suit, purity set the parameters for determining whether the inconsistency of Cooper's dope was its own fault. The case illustrates how legal frameworks dovetailed with analytical chemistry's techniques to fashion purity as a form of attainable knowledge and demonstrable evidence, knowledge that could at once adjudicate disputes and insulate firms from allegations of misconduct.

The experience with Cooper's seemingly defective dope underscored for Eastman that control ultimately meant manufacturing raw materials at Kodak's own plant. From 1899 until the mid-1900s, the company transitioned to manufacturing its own nitrated cotton, silver nitrate, and nitric acid. The firm would begin by developing a pilot process, before commissioning high capacity equipment and building new plants for the manufacture of these ingredients. To staff these new plants, the company needed more chemical experts, and Eastman sent letters directly to technical colleges, including, of course, MIT, seeking to fill openings for "chemists or chemical engineers, preferably the latter."[86]

Eastman's push for greater and greater control of the company's raw materials made film cheaper over time, with ultimately great consequence for cinema. Beginning in 1896, Kodak began selling what it called "Cine film," cut to 35mm size and available in a more sensitized version for use as camera negative and a less sensitized version for projection. In its first years, this cine film product created reliable profits, but not growth, its sales seesawing up and down.[87] Darragh de Lancey, having gone immediately from graduating MIT to running a rapidly expanding chemical manufacturing campus, suffered a nervous breakdown in 1898, and Lovejoy took his place as head of Kodak Park. By 1906, he was general manager of all manufacturing. During Lovejoy's rapid rise in management, Kodak successfully transitioned to producing its own nitrated cotton and silver nitrate, using washed cotton scrap and pure silver bars. This transition, however, was fraught with danger created by the volatility of celluloid.

Purity was a remit meant to ensure not only consistency, but also stability. Stability might be a matter of life and death. In 1898, a fire broke out in the storage facility for nitrocellulose scraps. De Lancey reported a "rapidly increasing flame, which, in a few sec-

---

[85] Ibid., 525.

[86] George Eastman to Massachusetts Institute of Technology, June 5, 1899, GELC.

[87] Sales of cine film between 1897 and 1902 fluctuated between a low of under $72,546 to a high of over $134,654, while the portion of total sales (including not only film, but cameras and paper) taken by cine film never rose above 8%. (By 1912, cine film made up 31% of all sales.) Government Exhibit 210: "'Dissection of Sales' of Eastman Kodak Co., from 1892 through 1912," *US v. EKC*.

onds, reached a height of about 100 ft., accompanied by a loud roar." The cotton shed then caught fire. "The heat was so intense during the combustion of the dope," the manager wrote, "that it was difficult to stand 300 ft. away from the building."[88] Kodak Park had only just formed a fire department the year before, and the first people to aim hoses at the fire were workers in other departments.[89] "As to the cause of the fire," speculated de Lancey, "I can only attribute it to the spontaneous decomposition induced by the prolonged heat which we have had this summer."[90] If Kodak were to make its own nitrated cotton, it had to contain any fires that might start from it. More fires followed. On June 1st, 1900, an explosion caused by an electric heater igniting some dope killed a 27-year-old chemist.[91] In 1904, the storage facility for film scrap caught fire and then exploded, likely due, the plant manager reported, to "spontaneous combustion of the dope."[92] Guncotton, a slightly more nitrated form of the cotton in Kodak's dope, was long seen as so deadly it could not be safely manufactured—at one point, Russia even banned all manufacture or use of it.[93] Only after decades of struggle and deadly accidents did ballistics makers arrive at a working procedure: purification, typically through boiling.[94] Purity was the key element of a regime of control that made safe manipulation of explosive substance possible.

The development of Kodak's methods of nitrating cotton and silver was led by another MIT alumnus, James Haste, who would go on to become the next head of Kodak Park after Lovejoy. Haste was overseeing a constant flux of separation and purification. He developed and maintained new ways of processing filmic waste, with the aim of recovering silver from the byproducts of nitration and emulsion-making. To nitrate silver, he needed pure silver bars and pure acid, which combined would create pure silver salts. The leftover solution, the waste, could then be processed, along with film scrap, to yield more pure silver. This was the interpellation of waste and pure ingredient at the center of industrial chemistry, now transposed to the manufacture of clear images. Calculations supported the

---

[88] Darragh de Lancey to George Eastman, September 3, 1898, GELC.

[89] The Kodak Park Fire Department, Folder 8, Box 97, 1, KHC.

[90] Darragh de Lancey to George Eastman, September 3, 1898, GELC.

[91] The Kodak Park Fire Department, 4, KHC.

[92] "FIRE IN SCRAP HOUSE," June 22, 1904, Lovejoy manuscript, Folder 10, Box 31, KHC.

[93] Haynes, *Cellulose*, 18.

[94] Eissler, *Handbook on Modern Explosives*, 56.

value of processing waste: 15,207 ounces of silver per ton of waste as assayed in 1902.[95] By 1905, Haste and Lovejoy had begun distilling their own nitric acid, as well, using saltpetre—potassium nitrate—from Chile. Haste's efforts even yielded small amounts of gold that could be assayed in the ETD. After a few years of operation, Lovejoy wrote to Eastman that the nitrating plant had produced about $675 worth of gold.[96]

The circulation of waste and pure good, implicating every industrial chemist in the act of separation and extraction, was also a practice of repeatable commoditization. Nitre cake, film scrap, and cotton linters all changed hands through monetary transactions, according to repeatable principles of pricing and measuring. Through these transactions, waste was transformed back into a commodity, carrying a market value that could be traced over time. Key to commoditization was a process of grading, in which material is sorted into different varieties that are distinguished by physical qualities and by market value. Grading commodities was a project of purity and of abstraction: it made possible the ascribing of different values to commodities based not on their physical origin (cows in certain fields), but on their adherence to particular measurements and tests.[97] Kodak increasingly relied on grading, and increasingly demanded the highest grade of its raw materials. It came to be widely accepted that only the choicest grades were suitable at all for photosensitive usage: one representative of a gelatin supplier claimed only the best 30% of each boiling of gelatin "could be used for photographic" purposes, with the rest having "to be run into inferior grades."[98] Kodak's English subsidiary once rejected $25,000 worth of gelatin as being not suitable for photographic work.[99]

The single most important grading dilemma for Kodak emerged once they began nitrating silver out of silver bullion, a substance that had been assayed for its purity for centuries. Kodak first acquired silver bars off of the commercial exchange, from Handy & Harman, a prominent New York dealer. When Haste ran into difficulties with the nitration process, he began blaming the silver. In 1902, he wrote Eastman that the department had switched to ordering government assay bars, up to the standards of the US Mint, because "the commercial brand suddenly fell below the standard," which he determined by ob-

---

[95] Frank Lovejoy to George Eastman, September 30, 1902, GELC.

[96] Frank Lovejoy to George Eastman, February 17, 1902, GELC.

[97] For more on the technological and intellectual history of grading and abstraction, see Cronon, *Nature's Metropolis*, ch. 3.

[98] Lovejoy manuscript, April 12, 1904, Folder 8, Box 31, KHC.

[99] Lovejoy manuscript, September 13, 1905, Folder 9, Box 31, KHC.

serving that the dissolved silver solution became discolored with their use.[100] Eastman felt differently, seeing commercial bars—already priced 3/8¢ per ounce less than assay bars—as instead a waste of money when Kodak could be buying the bars directly from a smelter.[101] Silver served as scapegoat when problems arose anywhere in production. When in 1905 the emulsion started showing issues, Haste blamed it on unexpected lead content in their supply of silver bars. He found "this impurity is apparently confined to the silver of Handy & Harman," not bars sold by a competitor, Zimmermann & Forshay.[102] A few months later, Haste began ordering more refined silver. Haste's continued quibbles with Handy & Harman led the dealers to send a representative to Kodak, where they met with Haste and "proved to him that the specially refined silver" that he had been using "was no better than if as good as the commercial silver which we formerly used."[103]

The work of purification within Kodak's factory also reinforced gendered hierarchies of labor. It exclusively placed men in leadership roles while exiling from the workplace certain forms of sensory experience and tacit knowledge common to early photography—and which Eastman himself had formerly embraced—that scientists broadly considered feminine. Purity as a production and research goal was tied to the work of making practical chemistry a masculine enterprise, freed from the domestic spaces like kitchens and attics where formerly photographic innovations were first tested. The masculine environment of Kodak's chemical plants conditioned the male gaze for the broader world: the standards to which Kodak's film were held were applied through the use of "Shirley Cards," images of young white women posing for the camera, and "China Girls," leader images on motion picture film strips used to calibrate the development of film into positive prints for projection.[104]

The solidification of exclusionary gendered divisions of industrial labor, and the role of practices of purity in this solidification, was clearly exposed during Kodak's wartime development of a pure chemicals business. Beginning in World War I, Kodak became one of the earliest US manufacturers of organic chemicals. With the entrance of the US into the war, supply of most organic chemicals to American firms was cut off. Many were manufactured in Germany almost exclusively, by the large chemical firms that had begun

---

[100] James Haste to George Eastman, August 12, 1902, GELC.

[101] George Eastman to Harris Hayden, August 21, 1901, GELC.

[102] Lovejoy manuscript, January 18, 1905, Folder 9, Box 31, KHC.

[103] Lovejoy manuscript, June 29, 1905, Folder 9, Box 31, KHC.

[104] Roth, "Looking at Shirley, the Ultimate Norm"; Yue, "The China Girl on the Margins of Film."

there as dye manufacturers.[105] Putting together a makeshift laboratory out of one portion of a building at Kodak Park, the company entered the market for organic chemicals in the fall of 1918. It manufactured three grades of chemicals. The least pure were "technical" and the slightly impure named "practical." The very purest chemicals were labeled "Eastman" chemicals. The laboratory employed mostly women at first, as men graduating from chemical programs tended to either join the military or work for explosives manufacturers. But under the new regime of purity governed by chemical engineers, tacit knowledge and the forms of attention associated with it had been thoroughly discouraged anywhere outside of the Emulsion Department. Instead, company supervisors gendered such attentional forms as feminine, rendering them as degraded habits unsuitable for the laboratory. Young women, research laboratory head C.E.K. Mees lamented, "required more careful supervision in…the setting up of their apparatus," as they were liable to forget about things, their "attention turned to some other matter, which, if it went well became the girl's only joy."[106] Mees believed "the mental attitude of the majority of girl chemists" was akin to "that of a good cook."[107] At the war's conclusion, they decided to replace all chemists who left the laboratory with men.[108]

The same year Kodak began selling chemicals, a reporter from *Motion Picture News* visited Kodak Park. "Multitudinous Processes, Repeated Tests and Unusual Cleanliness Features of Eastman Plant Where Motion Picture Film Is Made," read the headline of his story. As this headline made clear, *purity* of material was increasingly joined with *cleanliness* of space. "How important this factor of cleanliness is," read the article, "one can well imagine by considering the fact that any fleck of dirt lodged on the surface of the film will be enlarged on the screen many times."[109] While in 1892, dirt had served only as a fanciful contrast with the brilliant novelty and majesty of Kodak Park's equipment, by the 1920s it

---

[105] Metol, a crucial developer, was among the chemicals that American companies found themselves needing to stockpile. In 1918 Kodak compiled a list of moving picture companies current supply of metol. Metol Situation in Chicago, August 1918, Folder 5, Box 189, KHC.

[106] H.T. Clarke and C.E.K. Mees, "The Production and Supply of Synthetic Organic Chemicals," 19 March 1920, 7, Box 77a, KHC.

[107] Ibid., 7.

[108] This did not remain the case across time. As Joris Mercelis has recently argued, following this nadir moment around WWI, women chemists in consequent decades were ultimately able to secure greater recognition and promotion in the photographic industry than in most other chemical industries, though most women who worked as chemists in the photochemical industry did so in what amounted to sex-segregated laboratory spaces well into the middle of the 20th century. Mercelis, "'Men Don't Like to Work Under a Woman.'"

[109] "Sidelights on Manufacture of Motion Picture Film," 271.

had become a central villain within the story Kodak told of its manufacturing prowess. By the time Kodak published its second *The Home of Kodak* in 1929, cinema was now big business, and so dust could be costly: "Fortunes may have been spent" on a moving picture production, "and half the globe traversed in pursuit of the picture before the fatal blemish is discovered."[110] And so, dust was exterminated and banished:

> In the construction of all buildings and treatments of interior surfaces—wall, ceilings and floors—materials that will disintegrate and cause dust are scrupulously avoided. The air fed to various departments is washed and filtered to trap the elusive dust particles. Vacuum cleaners in the hands of cleaning squads go over every inch of exposed surface many times daily. "Round" corners leave no hiding place for dirt and make easy the cleaners' task.[111]

This was the immaculate space from which almost every motion picture materially originated. It existed at once as a material place out of which raw film stock emerged and a mental space cultivated by ongoing publicity that stressed Kodak's meticulous commitment to purity.

Though part of an industry known for its trade secrets, Kodak was seemingly eager to tout the "everlasting search for purity" that defined its manufacturing process.[112] "The campaign for an absolutely pure product," the article explained, "commences with the selection and treatment of the raw materials."[113] It described the intense stages of cotton washing necessary for nitration, and about silver it reported: "The proverbial slogan, '99.9 per cent pure' just about fills the bill here."[114] The emulsion rooms, no longer sites of magic, were by now sites of careful atmospheric control, "dark rooms which are kept at a

[110] *The Home of Kodak* (1929), 15.

[111] Ibid., 15.

[112] "Sidelights on Manufacture of Motion Picture Film," 271.

[113] "Sidelights on Manufacture of Motion Picture Film," 271.

[114] Ibid., 271. By the 1940s, Kodak began publicizing a new standard for its silver, asserting that it required a purity even greater than required by the US Treasury. An article titled "The Story of Silver" in the company's house magazine *Kodakery* in 1945 claimed "its standard of purity must be even a fraction higher than the Treasury's 99.9 per cent, for only silver that is at least 99.97 per cent pure is processed into the silver nitrate that goes into film emulsion." See "The Story of Silver," Folder 6, Box 73, KHC. Also in 1945, Kodak placed an ad across many national magazines about silver, centered on a photograph of employees in pristine white lab coats stacking bar after bar of shining silver, protected from the workers' hands by their thick white rubber gloves. "As for purity," the ad copy reads, "the Treasury standard, high as it is, is exceeded—every ounce of silver is a 'special melt' refined to a purity higher than for any other use." Advertisement, *Life* (January 15, 1945), 45.

constant temperature and humidity."[115] But why go to all this trouble for film? As the article made clear, cinema by then depended upon total replicability, the promise "that a camera man can get the same kind of good results at one time with one piece of film that he can with another piece from different stock at another time."[116] By the time of this article's publication, the film industry took for granted that making motion pictures required perfect consistency in image-making apparatus, a consistency which Kodak's rigid standards of purity could provide.

Conclusion

Long thought of in the public imagination as a consumer photography company, Kodak has for the last 125 years also been a large industrial chemical firm, with chemical engineers and chemists in managerial roles. Still, Kodak did not begin as a chemical company. The story of how Kodak became an industrial chemical firm in the first place starts with emulsion failures, but was propelled by the exigencies of safely and consistently manufacturing a new material, celluloid. Making this new material, about which the firm at first conducted little fundamental research, involved careful processes, standardized training, and above all else a goal of purity. This dedication to purity encompassed not only chemical inputs, but also the cleanliness of the plant and its equipment and the visual perfection of finished products. All of this meant that in the limited cases where Kodak drew attention to its own motion picture film products—by the 1910s the company's largest output[117]—they did so in order not to focus on the material itself but on one quality of it: its purity. Most of the time, however, the end result of Kodak's intense efforts within its plant was to produce a transparent photosensitive plastic that would efface itself in front of film audiences. Filmgoers would not need to reflect on how the flickering images on the screen in front of them were being brought to their eyes.

By 1970, Kodak itself, touting its environmental initiatives, claimed that from "early in Kodak's history" the firm was committed to "asserting control over purity" and keeping away "impurities" from its film and the raw materials that made it.[118] This "almost obsessive preoccupation," as Kodak's same publicity termed it, arose in tandem with the rise of

---

[115] "Sidelights on Manufacture of Motion Picture Film," 272.

[116] Ibid., 270.

[117] George Eastman wrote to the Federal Trade Commission in 1916, "…in our own case we make what one might term an inordinate profit on motion picture films, which are by far our largest item of output." Eastman to Edward W. Hurley, March 29, 1916, GELC.

[118] *Kodakery* 28, no. 13 (April 2, 1970). One copy in Folder 22, Box 44, KHC.

the chemical engineer within Kodak's workforce and management.[119] But we cannot take for granted Kodak's own story of their exceptionalism, which hinges on the great sensitivity of their products to the environment. Many other industrial chemical products, not least explosives and their constituents, were themselves unstable and at threat of contamination. Kodak's story prompts us to ask, where else did the chemist's mandate of purity diffuse into other chemical firms? How else did purity, as industrial and technical idea, come to be reflected in product marketing and come to interpellate itself with concurrent cultural anxieties around purity? The role of purification within chemicals manufacturing should not be taken for granted—it deserves further critical investigation. The layers of substance that make finished film embodied persistence of artisanal knowledge within the otherwise chemical engineering-centered Kodak, with emulsion remaining the province of traditional and longstanding practices of knowledge-keeping and hand-making, while the celluloid base was developed by and under the control of technically-trained chemical specialists using rational practices. We should likewise be careful about assuming that this co-existence is unique to Kodak.

Chemists could create consistency through the same rational processes and often in the same setting, the laboratory, that also developed and researched "new" materials. To be sure, Kodak was not resting on its laurels during this period, a time which saw the company attempt to make longer lasting film, a non-flammable film, and faster emulsion. But these notable endeavors were secondary to the simple achievement of a standardized film that produced a predictable image: the basis of the mass production of movies that was to come. Replicability and durability of film were the twin consequences of Kodak's transformation into a chemical company that most powerfully transformed the world outside Kodak's walls. These features were the material basis of motion pictures' rise to become the dominant visual medium of the first half of the 20th century. Through the controls and obsessions of chemical science, cinematic images could multiply without changing: a new mass medium could be born.

Acknowledgments
Research for this article was supported by funding from the History Department of Rutgers University–New Brunswick and the Center for Cultural Analysis (CCA) at Rutgers. Thank you to Lee Grieveson, Jamie Pietruska, and Jackson Lears for comments on drafts of this article. Parts of this paper were first shared with the research seminar "What is Photography?" held at the CCA, as well as the Society for the History of Technology an-

[119] Ibid.

nual meeting in 2021. I also thank two anonymous reviewers for their highly valued suggestions and comments, and I especially wish to thank journal editor Andrew Popp for guidance and support throughout the process.

Bibliography of Works Cited

Books

Ackerman, Carl W. *George Eastman*. New York: Houghton Mifflin, 1930.

Bennett, Jane. *Vibrant Matter: A Political Ecology of Things.* Durham: Duke University Press, 2010.

Blum, Deborah. *The Poison Squad: One Chemist's Single-Minded Crusade for Food Safety at the Turn of the Twentieth Century*. New York: Penguin, 2018.

Braverman, Harry. *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century*. New York: Monthly Review Press, 1974.

Brayer, Elizabeth. *George Eastman: A Biography*. Baltimore: Johns Hopkins University Press, 1996.

Burstein, Daniel Eli. *Next to Godliness: Confronting Dirt and Despair in Progressive Era New York City*. Urbana: University of Illinois Press, 2006.

Chandler, Jr., Alfred D. *The Visible Hand: The Managerial Revolution in American Business.* Cambridge, MA: Belknap Press of Harvard University Press, 1977.

Cohen, William A., ed. *Filth: Dirt, Digust, and Modern Life*. Minneapolis: University of Minnesota Press, 2005.

Collins, Douglas. *The Story of Kodak*. New York: H.N. Abrams, 1990.

Coppin, Clayton A. and Jack High. *The Politics of Purity: Harvey Washington Wiley and the Origins of Federal Food Policy*. Ann Arbor: University of Michigan Press, 1999.

Cronon, William. *Nature's Metropolis: Chicago and the Great West*. New York: W. W. Norton, 1991.

Daston, Lorraine, and Peter Galison. *Objectivity*. New York: Zone Books, 2007.

Douglas, Mary. *Purity and Danger: An Analysis of Concepts of Pollution and Taboo.* New York: Routledge, 1966, 2002.

Eastman Kodak Company v. Jacob Kleinhans, John B. Stobhaeus, Henry A. Weidig and Hugo L. Kleinhans. (*EKC v. Kleinhans et. al.*) NY Supreme Court. Appellate Division. 4th Department. Monroe County. August 19, 1903. Appeal Book on Appeal from Judgment. Rochester: E. E. Andrews Printing, 1904.

Eissler, Manuel. *A Handbook on Modern Explosives: Being a Practical Treatise on the Manufacture and Application of Dynamite, Gun-cotton, Nitro-glycerine, and Other Explosive Compounds, Including the Manufacture of Collodion-cotton.* London: Crosby Lockwood and Son, 1890.

Fulton, Levi S. And George W. Eastman, *A Practical System of Book-keeping by Single and Double Entry*. New York: A.S. Barnes & Co., 1851.

Friedel, Robert D. *Pioneer Plastic: The Making and Selling of Celluloid*. Madison: University of Wisconsin Press, 1983.

Gilman, Arthur. *The Cambridge of Eighteen Hundred and Ninety-six: A Picture of the City and Its Industries Fifty Years After Its Incorporation.* Cambridge, MA: Riverside Press, 1896.

Grieveson, Lee. *Cinema and the Wealth of Nations: Media, Capital, and the Liberal World System.* Oakland: University of California Press, 2018.

Hounshell, David A., and John Kenly Smith, Jr. *Science and Corporate Strategy: Du Pont R&D, 1902–1980*. Cambridge: Cambridge University Press, 1988.

Jenkins, Reese. *Images and Enterprise: Technology and the American Photographic Industry, 1839 to 1925*. Baltimore: Johns Hopkins University Press, 1975.

Levy, Jonathan. *Freaks of Fortune: The Emerging World of Capitalism and Risk in America*. Cambridge, MA: Harvard University Press, 2012.

Löhnert, Peter, and Heinz Mustroph. *Die Entwicklung der Produktion Photographischer Materialien: Der Aufbau und die Ersten Jahre der Filmfabrik Wolfen von der Gründung 1909 bis 1918.* Wolfen, Germany: VEB Filmfabrik Wolfen, 1989.

Maxwell, Richard and Toby Miller. *Greening the Media.* New York: Oxford University Press, 2012.

Melosi, Martin V. *The Sanitary City: Urban Infrastructure in America from the Colonial Times to the Present*. Baltimore: Johns Hopkins University Press, 2000.

Mintz, Sidney W. *Sweetness and Power: The Place of Sugar in Modern History*. New York: Viking, 1985.

Ndiaye, Pap. *Nylon and Bombs: Dupont and the March of Modern America*. Baltimore: Johns Hopkins University Press, 2007.

Parikka, Jussi. *A Geology of Media*. Minneapolis: University of Minnesota Press, 2015.

Sandage, Scott A. *Born Losers: A History of Failure in America*. Cambridge, MA: Harvard University Press, 2005.

Smith, Carl. *City Water, City Life: Water and the Infrastructure of Ideas in Urbanizing Philadelphia, Boston, and Chicago*. Chicago: University of Chicago Press, 2013.

Smither, Roger B. N., and Catherine A. Surowiec. *This Film is Dangerous: A Celebration of Nitrate Film*. Brussels: FIAF, 2002.

Taft, Robert. *Photography and the American Scene: A Social History, 1839–1889*. New York: Macmillan, 1942.

Thomas, Courtney I.P. *In Food We Trust: The Politics of Purity in American Food Regulation*. Lincoln: University of Nebraska Press, 2014.

Thompson, Kristin. *Exporting Entertainment: America in the World Film Market, 1907–34*. London: BFI Publishing, 1985.

United States v. Eastman Kodak Company. (*US v. EKC*). US Circuit Court, Western District of New York, August 24, 1915, no. A–51. Appeal to US Supreme Court. Petition: March 8, 1916; withdrawn: February 1921. Abridged Transcript of Record.

White, Richard. *Railroaded: The Transcontinentals and the Making of Modern America*. New York: W.W. Norton, 2011.

Young, James Harvey. *Pure Food: Securing the Federal Food and Drugs Act of 1906*. Princeton, NJ: Princeton University Press, 1989.

Articles, Chapters in Books, and Dissertations

Bakker, Gerben. "How Motion Pictures Industrialized Entertainment." *The Journal of Economic History* 72, no. 4 (2012): 1036–63.

Bustamante, Carlos. "Agfa, Kullmann, Singer & Co. And Early Cine-Film Stock." *Film History: An International Journal* 20, no. 1 (2008): 59–76.

Calomaris, Charles W. and Larry Schweikart. "The Panic of 1857: Origins, Transmission, and Containment." *Journal of Economic History* 51, no. 4 (1991): 807–34.

Duncan, Pansy. "Celluloid™: Cecil M. Hepworth, Trick Film, and the Material Prehistory of the Plastic Image." *Film History* 31, no. 4 (2019): 92–112.

Hounshell, David A. “The Evolution of Industrial Research in the United States,” in *Engines of Innovation: U.S. Industrial Research At the End of an Era*, edited by Richard S. Rosenbloom, 13–85. Boston: Harvard Business School Press, 1996.

Immerwahr, Daniel. “All That Is Solid Bursts into Flame: Capitalism and Fire in the Nineteenth-Century United States.” *Past & Present*. Published ahead of print, March 9, 2024, https://doi.org/10.1093/pastj/gtad019.

Latour, Bruno. “Why Has Critique Run Out of Steam? From Matters of Fact to Matters of Concern.” *Critical Inquiry* 30, no. 2 (2004): 225–48.

Le Guern, Nicholas. “Contribution of the European Kodak Research Laboratories to Innovation Strategy at Eastman Kodak.” PhD diss., Photographic History Research Centre, De Montfort University, 2017.

Link, Stefan, and Noam Maggor. “The United States as a Developing Nation: Revisiting the Peculiarities of American History.” *Past & Present* 246, no. 1 (2020): 269–306.

Lovejoy, Alice. “Celluloid Geopolitics: Film Stock and the War Economy, 1939–47.” *Screen* 60, no. 2 (2019): 224–41.

Mercelis, Joris. “‘Men Don’t Like to Work Under a Woman’: Female Chemists in the Photographic Manufacturing Industry, ca. 1918–1950.” *Ambix* 69, no. 3 (2022): 291–319.

Pritchard, Michael. “The Development and Growth of British Photographic Manufacturing and Retailing 1839–1914.” PhD diss., Imaging and Communication Design, De Montfort University, 2010.

Reynolds, Terry S. “Defining Professional Boundaries: Chemical Engineering in the Early 20th Century,” *Technology and Culture* 27, no. 4 (1986): 694–716.

Roberts, Lissa. "The Death of the Sensuous Chemist: The 'New' Chemistry and the Transformation of Sensuous Technology." *Studies in History and Philosophy of Science* 26, no. 4 (1995): 503–29.

Roth, Lorna. "Looking At Shirley, the Ultimate Norm: Colour Balance, Image Technologies, and Cognitive Equity." *Canadian Journal of Communication* 34, no. 1 (2009): 111–36.

Singerman, David Roth. "The Limits of Chemical Control in the Caribbean Sugar Factory." *Radical History Review* 2017, no. 127 (2017): 39–61.

———. "Inventing Purity in the Atlantic Sugar World, 1860–1930." *Enterprise & Society* 16, no. 4 (2015): 780–91.

Slaton, Amy E. "Introduction," in *New Materials: Towards a History of Consistency*, edited by Amy E. Slaton, 1–36. Ann Arbor: University of Michigan Press, 2020.

Smiley, Michelle. "'An American Sun Shines Brighter': Art, Science, and the American Reinvention of Photography." PhD diss., History of Art, Bryn Mawr College, 2020.

Solares, Israel G., and Edward Beatty. "Engineers & Corporate Management, ca 1870–1930: The Invisible Hand Redux." *Enterprise & Society* 25, no. 2 (2024): 486–511.

Spehr, Paul C. "Unaltered to Date: Developing 35mm Film," in *Moving Images: From Edison to the Webcam*, edited by John Fullerton and Astrid Söderbergh Widding, 3–27. Bloomington: Indiana University Press, 2016.

Sturchio, Jeffrey. "*Festschrift*: Experimenting with Research: Kenneth Mees, Eastman Kodak and the Challenges of Diversification." *Science Museum Group Journal* no. 13 (2020): http://dx.doi.org/10.15180/201311.

The Home of Kodak. Rochester, NY: Eastman Kodak Company, 1929.

The Home of The Kodak. Rochester, NY: Eastman Kodak Company, 1893?

Yue, Genevieve. “The China Girl on the Margins of Film.” *October* no. 153 (2015): 96–116.

Newspapers and Magazines

American Soap Journal & Manufacturing Chemist

The Cambridge Tribune

Life

Motion Picture News

Archives

Bundesarchiv, Lichterfelde, Berlin, Germany.

George Eastman Museum, Rochester, New York.

Rare Books, Special Collections, and Preservation, River Campus Libraries, University of Rochester, Rochester, New York.