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Moving Images and Sound: Basic Training

11/19/14

Stumped with Kodacolor[1]

Introduction

Everything about the Kodacolor film format was ambitious. Eastman Kodak licensed a complicated additive color process that required microscopic lenticules, took a "systems approach"[2] to creating color images from black and white film stock; and promised all of this to amateur filmmakers in an easy-to-use package epitomized by their slogan "you push the button, we do the rest."[3]

Eastman Kodak released Kodacolor in 1928 and production likely stopped in 1935. For a brief period Kodak had achieved a unique distinction, it gave amateur filmmakers access to something that professionals did not have: the ability to shoot films in natural color. First conceived as a format for amateur filmmaking, Kodacolor was never realized as a professional motion picture stock despite Kodak's best efforts those of other lenticular entrepreneurs to do so. Kodak made two final attempts to market lenticular film to the motion picture and television industries in the 1950s, but had little success. Neverless, during its brief run, Kodacolor maintained a following in the amateur filmmaking community until it was superseded by

[1] This title comes from the text of an article called "Little Missy Blue Dress" in the March 1933 issue of *Personal Movies* quoted in Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 55.
[2] Ryan, *A History of Motion Picture Color Technology*, 55.
[3] "Eastman Kodak Company Presents Kodacolor," 522–523.

Kodachrome. Kodacolor was one of the last additive color processes before additive color was all but abandoned for motion picture film.

The Kodacolor Party

George Eastman introduced Kodacolor film stock in grand style on July 30, 1928. Among those invited to the "Kodacolor party" were Thomas Edison, Hiram Percy Maxim (founder and then-president of the Amateur Cinema League), and General John Pershing, and General James G. Harbord. Harbord "noted Kodacolor's potential application for the military,"[4] which never materialized. The group of invited guests, which also included Television pioneer E.F.W. Alexanderson and US Commissioner of Education John Tigert, suggested that George Eastman had high hopes for "the widespread applications and impact of Kodacolor."[5] Eastman invited his guests to shoot footage in Kodacolor, which was then developed and screened later in the evening.[6] But the story of Kodacolor technology started much earlier.

The World Before Kodacolor

Kinemacolor and Chronochrome were two major color processes which had a small footing in theatrically released motion pictures prior to the release of Kodacolor.[7] Kinemacolor was a two-color system "based on successive frame exposure through mechanically operated filters."[8] Because it captured color information in successive frames, shooting fast-moving

[4] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 37.
[5] Ibid.
[6] *Kodacolor Party HD*.
[7] Leo Enticknap writes that "By the end of the 1910s they [Kinemacolor and Chronochrome along with other early color processes] probably accounted for 2–3 per cent of the total film footage shown in the world's cinemas at most." *Moving Image Technology*, 82.
[8] Enticknap, *Moving Image Technology*, 81.

subjects would lead to "fringing" also known as "visible flicker and color smearing"[9] (see image 1).

In the Chronochrome system, a camera with three lenses captured three additive color records simultaneously. A triple-lens projector with filters played them back. These early additive technologies remained extremely marginal because they "required a specially designed camera and projector which could only be used in conjunction with the colour system for which they were marketed."[10]

Lenticular screen technologies like Kodacolor were "attempts to record and reproduce all three primary color records from a single frame of film" without specialized cameras, "thus eliminating the 'mechanical complication' which ultimately killed off Kinemacolor and Chronochrome."[11] Color information recorded simultaneously on the same frame meant that during projection, objects in motion would not exhibit color fringing.

Not only were these earlier color processes like Kinemacolor and Chronochrome too complicated for mass theatrical distribution, they were also impossible to market to consumers. On the other hand, a lenticular process could be modified to suit the average home moviemaker, and without he or she having to invest in much additional equipment.

"Eastman Scientists Find the Way"[12]

The release of Kodacolor had little to do with scientific discoveries coming out of Eastman Kodak's labs. In 1908 Gabriel Lippmann, a Franco-Luxembourgish physicist, first

[9] Ibid.
[10] Enticknap, *Moving Image Technology*, 82.
[11] Ibid., 83.
[12] Most section headings in quotation marks are taken from "Eastman Kodak Company Presents Kodacolor," 522–523. The exceptions are "This is the Magic of Kodachrome..." which is taken from a 1954 Kodachrome photography ad.

theorized a lenticular film system,[13] suggesting that each section of a honeycomb structure on a film base would act like a tiny lens and "each of these lenses would image only that portion of the light which was directly in front of it."[14] The tiny lenses focusing the light rays would create a series of individual dots on the film and "if the dots were beyond the resolving power of the eye they would not be seen as individuals but as a single blended picture."[15]

In 1908 Rodolphe Berthon patented a process combining Lippmann's theories with recent developments in screen film for still photography. Berthon utilized embossed film stock and filters placed on the lens of a camera, essentially the basis for Kodacolor. Berthon went into business with Anthon Keller-Dorian and the two men formed the Société Keller-Dorian-Berthon to ready the process for large-scale commercialization,[16] but the relationship between Berthon and Keller-Dorian did not remain amicable.[17]

Eastman Kodak licensed the process from Keller-Dorian and set out to adapt it to the consumer market. With the process already developed, Kodak had to "standardize the methods for making the lenses" and develop "a suitable emulsion strongly sensitive to green and red light and yet with sufficiently fine grain for the minute structure of the separate color elements to be resolved."[18] In addition Kodak had to work out procedures for its own labs to process exposed Kodacolor film on a mass scale. The process had to be refined to a point where consumers could

[13] A basis for Lipmann and later Berthon's ideas was published in 1895 by F.W. Lancaster and idea of using a banded filter in 1896 by R.E. Leisegang, although the filter Leisegang proposed wouldn't have worked. See Ryan, *A History of Motion Picture Color Technology*, 50.
[14] Ryan, *A History of Motion Picture Color Technology*, 50.
[15] Ibid.
[16] Mees, "Amateur Cinematography and the Kodacolor Process," 11.
[17] See my section on "Competing Formats" below.
[18] Ibid., 12.

use it without the need to purchase much new equipment (in particular Kodak sought compatibility with the Ciné-Kodak camera that it had been selling since 1923).[19]

"As Simple as Simplicity Itself"

The Kodacolor stock itself shared the dimensions of standard black and white 16mm film stock, including the same pitch and acetate film base, so Kodacolor could be used with existing cameras. However, the base side of Kodacolor stock was embossed with hundreds of tiny lenticules (microscopic cylindrical lenses) running in vertical columns along the entire length of the film. During production, steel rollers pressed out the lenticules on the base side of the raw stock in twenty-two lenses per millimeter.[20] The other side of the film contained a standard black and white panchromatic emulsion. The user loaded the camera with the emulsion facing away from the lens—the opposite of conventional film stock.

Two varieties of Kodacolor emulsion existed and both were reversal stock, requiring a two-stage development process. The reversal process develops the very same piece of exposed film into a positive image that can then be projected—there is no need to make a separate print. Kodak released the original version of Kodacolor emulsion in 1928 and in 1932 Kodak introduced the more sensitive second generation stock.[21] The film was available to consumers in fifty foot and one hundred foot spools.[22]

The theory behind the Kodacolor format is actually quite complicated. Kodacolor depends on the properties of additive color mixing to represent the spectrum of visible colors on

[19] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 39.
[20] Ryan, *A History of Motion Picture Color Technology*, 52.
[21] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 49.
[22] Eastman Kodak Company, "Taking Kodacolor Pictures," 7.

a projection screen. Additive color "is color created by mixing light of two or more different colors"[23] and the additive primaries are red, green, and blue light. Combining all three additive primaries produces white light. But essentially any color can be produced by combining different proportions of the additive primaries. For example, combining red and green makes yellow, combining green and blue yields cyan, and combining blue and red yields magenta, but the possibilities for combination are infinite.

Kodacolor required a filter with red, green, and blue bands (see image 2). The user oriented the filter so the stripes of color were vertical. "Exposures are made through the color filters, so the image is cut up into a lot of little sections...each section being taken through one of the filters."[24] Behind each lenticule "there would be formed on the emulsion a group of three dots—one dot corresponding to the red filter; one, to green; and the third, to the blue filter"[25] (see image 3). The density of the silver bromide crystals on the emulsion were in direct proportion to how much of each particular color struck that area. After exposure, the emulsion contained a patchwork quilt of color information in a series of dots that, when developed to a positive, was too small for the human eye to detect. For example, if someone shot a pure red object, after development to a positive the red areas will be transparent and the blue and green areas opaque. For composite colors (made up of different amounts of red, green, and blue light) the three areas on the emulsion will vary in density depending on the amounts of red, green, and blue light necessary to produce that color.[26]

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[23] "Additive Color." Wikipedia.
[24] Mees, "Amateur Cinematography and the Kodacolor Process," 8. Mees notes that this principle was put into practice through the Lumiere Autochrome still photography plate in 1907.
[25] Ibid., 11.
[26] Phillips, "The Kodacolor Process." 241.

After the film was developed the areas corresponding to each color record would be transparent (allowing light to project that color record through) and the darker areas opaque (allowing less light). Keep in mind that after development Kodacolor looked exactly like a strip of black and white film, but because of the three-color filter it had color information encoded across the entire length of the emulsion, to later be decoded by the projector's lens and filters (see image 4).

Projecting Kodacolor reverses the process that took place in camera and a three-color filter (exactly the same as the one on the camera) is needed to produce a color projection. If the filter is not installed Kodacolor will be projected as a black and white image. The light rays from the projector pass through the transparent parts of the film strip and are blocked by the opaque areas of the film. The rays then pass through the filter on the projector lens "with each ray contributing its speck of light to the color or blend of colors at one point"[27] If the colored dots on the projection screen are tiny enough, "they overlap and blend on the eye's retina" and we perceive them as if they are superimposed.[28] For example, if a tiny dot of red light is right next to a tiny dot of green light on a screen, the viewer will perceive the image as yellow. The same principle is used for flat screen televisions and computer monitors where red, green, and blue subpixels light up at different rates depending on what color is being displayed.[29]

In order for this optical system to work the projector must be an exact inversion of the camera; the relative apertures and focal lengths must be exactly the same. Thus, in some cases, projectionists would need to fit a compensator onto the lens of the projector.[30]

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[27] Mees, "Amateur Cinematography and the Kodacolor Process," 16.
[28] "Additive Color." Wikipedia.
[29] "Pixel." Wikipedia.
[30] Mees, "Amateur Cinematography and the Kodacolor Process," 16–17

"A Privilege Only Ciné-Kodak Owners May Enjoy"

The Kodacolor format could not overcome the requirement for proprietary equipment, although it used less complicated equipment than previous color formats. One could say that with Kodacolor more of the technology was now found in the film strip to allow wide compatibility with existing equipment. The trend toward embedding technology in a widely compatible strip of film was especially important to the film industry and to movie theaters, and culminated in the development of tripack color film stocks.[31]

According to Dino Everett, "Kodacolor was possibly the slowest film stock ever produced," probably rating less than 1 on the ISO scale. As the camera needed to be loaded with the photosensitive emulsion away from the lens this reduced the amount of light hitting the emulsion. The necessary color filter installed on the camera also absorbed some light.[32] Due to this enormous light requirement, Kodacolor filmmakers—for the most part—were forced to shoot outdoors in bright sunlight.

When shooting Kodacolor the camera aperture could not be adjusted and had to remain open at f/1.9 (creating a shallow depth of field). In fact, with the Kodacolor filter snapped into place the user could no longer manually change the aperture.[33] While Kodak offered Kodacolor as a "privilege"[34] to users of Ciné-Kodak cameras (specifically Ciné-Kodak Models A, B, BB, K, [35] and later the Special[36]), it did license the Kodacolor system to other manufacturers. This

[31] I am borrowing in the general sense from Leo Enticknap's thesis throughout his book *Moving Image Technology*.
[32] Everett, Phone Interview.
[33] Phillips, "The Kodacolor Process," 240.
[34] "Eastman Kodak Company Presents Kodacolor," 522–523.
[35] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 43
[36] Tuttle and Schwartz, "The New Ciné-Kodak Special in Medicine," 5.

included Bell and Howell, which had a Kodacolor lens for its Filmo cameras and projectors,[37] and Ampro Corporation, which produced Kodacolor filters.[38]

At first, the use of neutral density filters provided the only way to control exposure and these were included with Kodacolor filter kits (see image 5). Kodak later manufactured an adjustable Kodacolor filter that did not require the use of neutral density filters.

Each roll of Kodacolor required a special diaphragm cap because color sensitivities of the film could not be reproduced precisely in every batch (see image 2). The emulsion was tested, a particular cap chosen, and then attached to the roll of raw film stock. The cap was meant to be discarded after the roll was finished and replaced with a new cap.[39] Forgetting to replace caps when changing rolls, could result in poor color reproduction. While it did not require neutral density filters, the Kodacolor adjustable filter had many complicated instructions and warnings about which diaphram caps to use and which not to use.[40]

According to a manual, Kodak also offered a specific Photoflood Ratio diaphragm cap. This cap was used instead of the normal diaphragm cap when shooting Kodacolor indoors with Kodak's Photoflood Lamps.[41] However, I not aware of indoor Kodacolor footage produced by home moviemakers—the only indoor footage I found was Kodak's test footage[42] and footage taken by medical professionals (see below).

"Rather than promoting it as the new standard, Kodak's ads for Kodacolor presented it as a new effect with an air of exclusivity."[43] The Ciné-Kodak camera, Kodascope projectors, and

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[37] Bell & Howell Company, "Create New Wonderlands Movie Makers," 722–723.
[38] Nemeth, "The Kodacolor Resource Page."
[39] Mees, "Amateur Cinematography and the Kodacolor Process," 15
[40] Eastman Kodak Company, "Taking Kodacolor Pictures," 3
[41] Ibid., 14–17.
[42] *Kodacolor Party HD*.
[43] Askari, "Early 16mm Colour by a Career Amateur," 158.

Kodacolor film represented the top tier of Kodak's consumer products at the time.[44] "Kodacolor film cost twice as much as its black-and-white counterpart," but the cost of developing at an Eastman processing station was included and Kodak would optionally add titles and color background.[45]

Eastman Kodak never envisioned Kodacolor would remain an exclusively amateur format. It had larger plans for the product "In December 1930, the Keller-Dorian Company entered into an agreement with Eastman Kodak Company and Paramount Pictures, Inc., and a research program was begun in an effort to utilize the lenticular process for 35mm entertainment motion pictures."[46] The companies involved hoped to create a workable system for motion picture release prints. Unfortunately "despite intensive research by Eastman Kodak in the early 1930s, lenticular color could not be made to work in a negative-positive process, only reversal. This prevented its use within the professional film industry, for which large numbers of release prints were needed."[47] Paramount withdrew from the project in 1936 and Kodak decided to focus on the development of Kodachrome.[48] In addition, members of the Society of Motion Picture Engineers demonstrated that an optical soundtrack on lenticular film was impractical. The rows of lenticules would break up a variable area soundtrack into serrated steps instead of the necessary smooth curve.[49]

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[44] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 44. A full Kodacolor kit in 1928 (with camera, filters, projector, and screen) was advertised at $508 dollars. Based on the CPI inflation calculator (http://www.bls.gov/data/inflation_calculator.htm) the equivalent cost of this kit in 2014 is $7,071.33. See "Eastman Kodak Company Presents Kodacolor," 522–523.
[45] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 44.
[46] Ryan, *A History of Motion Picture Color Technology*, 51.
[47] Enticknap, *Moving Image Technology*, 83
[48] Ryan, *A History of Motion Picture Color Technology*, 51.
[49] Batsel and Sachtleben, "Sixteen-Millimeter Sound Pictures in Color," 82–84.

Again, in 1951 with a demonstration of 35mm Eastman Embossed Print Film, Eastman Kodak planned to introduce lenticular film to the American film industry. And although "Twentieth Century Fox decided in 1953 to use it as a release printing format, they quickly abandoned the idea because by this stage tripack stocks…[which did not require special filters like lenticular stock] were rapidly being adopted industry-wide."[50]

Yet again, in 1956, Eastman Kodak introduced 35mm Eastman Embossed Color Kinescope Recording Film for the purpose of recording color television programs. The film had some success when the National Broadcasting Company used it to record several shows, but was shortly abandoned.[51] Ultimately Kodacolor would remain an amateur format, and lenticular film stock would be consigned to the margins of the motion picture and television industry.

Kodacolor was primarily employed by amateur cinematographers (and primarily wealthy amateurs at that), but one article mentions its use in producing full-color films of medical operations such as a cataract extraction using special indoor spotlights.[52] Jack E. Haynes, an official photographer of Yellowstone Park for the National Park Service, may have also shot Kodacolor footage of the park.[53]

Other "Equipment Necessary"

Marsha Gordon notes that "slip-on projection filters converted preexisting projectors to exhibit Kodacolor...later projector lenses had the filters built in."[54] In a catalog description Kodak advertises a filter and compensator as a set for the Kodascope Model B. The compensator

[50] Ryan, *A History of Motion Picture Color Technology*, 84.
[51] Ibid., 51.
[52] Tuttle and Schwartz, "The New Ciné-Kodak Special in Medicine," 5–7.
[53] Amidon, "The Unwritten Record: Kodacolor Decoded."
[54] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 58

screws into the barrel of the projector and the filter fits over the existing projector lens. Kodak offers the Kodacolor assembly for Kodascope Model A as a single unit which replaces the standard lens (see image 5).

The other limitation was the size of the projection: "the maximum picture size recommended by Kodak was 16½ by 22 inches."[55] Kodak sold a special aluminum-sprayed silver screen exactly this size.[56] The aluminum spray brightened an already fairly dim image by reflecting more light. The color filter on the projector, which absorbed a lot of light, combined with the relatively low power of projector bulbs at the time severely limited the size of the projection.[57]

Competing Formats

Berthon and Keller-Dorian eventually went their separate ways. The Kislyn Corporation (founded in 1930) worked for the "promotion of Berthon's process in the United States,"[58] in direct competition with Keller-Dorian/Kodak. Kislyn became embroiled in lawsuits over patents held by Keller-Dorian's company and Berthon. Kislyn also struggled to sell its product in the midst of the Great Depression. The Kislyn Color process was never used commercially in the US. However, Siemens and Halske manufactured a German version of Kislyn Color called Opticolor.[59]

In the 1920s many other companies hoped to capitalize on a lenticular color process for filmmaking as it seemed like a promising technology for delivering color films to theaters. The

[55] Askari, "Early 16mm Colour by a Career Amateur,"158
[56] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 41.
[57] Everett, Phone Interview.
[58] Ryan, *A History of Motion Picture Color Technology*, 51.
[59] Ibid., 51.

development of lenticular motion picture film became "a worldwide obsession."[60] Even Technicolor explored using a lenticular process, and in 1929 considered a "possible combination of Kodacolor and 3-color I.B. [imbibition],"[61] Some formats that relied on lenticular or screen processes released around the same time as Kodacolor include Lenticular Agfacolor, Autochrome motion picture film, and Dufaycolor[62]—although no evidence exists of these processes making major commercial inroads in the US, especially with amateur filmmakers.

Subtractive color processes were developing in tandem to additive processes; in fact "the chemistry enabling subtraction to take place on a single negative was understood in the same year Berthon began developing lenticular stock."[63]

Lenticular color became a "stop-gap" process for color cinematography as Technicolor was still experimenting, and tripack color film was still years away. Two-color Technicolor had a limited release for shorts and a few features during the 1920s.[64] But this subtractive process still had a number of technical problems related to the fact that it used two thin pieces of film stock cemented together. Technicolor process 3 and process 4 (three-strip) came shortly after.[65] While Technicolor marketed color technology to the professional film industry, Kodacolor had its committed group of amateurs. But in the realm of color technology for the film industry, Technicolor had beaten Kodak to the punch—making color release prints for the major studios using a subtractive process where additive color processes would never would be practical. The development of subtractive tripack film stocks (Kodachrome in 1935, Agfacolor Neu in 1936,

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[60] Lange, *Discovering Cinema: Movies Dream in Color*.
[61] Ruedel, "The Technicolor Notebooks at the George Eastman House," 50, 54.
[62] Flueckiger, "Screen Processes."
[63] Winston, "A Whole Technology of Dyeing: A Note on Ideology and the Apparatus of the Chromatic Moving Image," 115.
[64] Enticknap, *Moving Image Technology*, 86.
[65] Lange, *Discovering Cinema: Movies Dream in Color*; "Technicolor." Wikipedia.

and Eastman Color in 1950) essentially foreclosed on lenticular color as a viable process for both the film industry and for amateurs.[66]

"Stumped with Kodacolor"

Amateurs compared notes on Kodacolor in publications such as *Movie Makers* and *Personal Movies*. Based on research of these and other publications, Marsha Gordon writes that there was a "degree of lingering end-user bewilderment"[67] by home moviemakers over how to use Kodacolor in their cinematography. Magazine articles such as "King Kodacolor" were needed to soothe "any potential anxieties" by suggesting natural subjects and outdoor scenes "begging to be shot in color."[68] Even so, "Kodacolor remained more difficult for amateurs to integrate with other colour processes and monochrome stock"[69] An article in *Personal Movies* summarizes the predicament of amateur filmmakers: "Do you experience difficulty in finding suitable material for Kodacolor pictures? Most amateur movie photographers do. Those who have found it rather easy to arrange and film short stories and playlets in black and white become 'stumped' with Kodacolor."[70]

Kodacolor's need for bright light and its difficult focusing (due to a shallow depth of field created by the lens remaining at f/1.9), resulted in a high bar to entry. A British Ciné-Kodak manual suggests running the camera at half-speed to compensate for the film's low sensitivity to light. However, running the camera more slowly creates other problems such as jerkiness when

[66] Enticknap, *Moving Image Technology*, 90–93.
[67] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 49.
[68] Ibid., 49–50.
[69] Askari, "Early 16mm Colour by a Career Amateur," 158.
[70] Valentine, Ruth "Little Missy Blue Dress," *Personal Movies*, March 1933, quoted in Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 55.

filming motion.[71] The high light requirement prevented amateurs from recording movies inside the home: "no Christmas mornings by the fire, no baby frolicking in the bathtub, and no late-night cocktail parties."[72]

Gordon points out that "Kodacolor was not a perfect travel companion." The fragility of the Kodacolor filter was one concern, and a manual suggests bringing two filters on long trips.[73] In addition, once loaded, a filmmaker had to commit to an entire roll of Kodacolor—with its onerous requirement of bright sunlight and its burden of a shallow depth of field.

Perhaps to cope with this problem, in 1931, an inventor named Emil M. Mueller patented a unique reel holder which allowed an operator to shoot a partial reel and then change to another reel with minimal exposure of the film to light.[74] For similar reasons, the Simplex Corporation may have also manufactured a 16mm camera with a removable magazine designed to shoot Kodacolor.[75] This way a filmmaker could switch back and forth between Kodacolor and a more flexible standard black and white stock.

Even with all of its technical limitations, shooting films in natural color opened up all kinds of new possibilities for amateur filmmakers. "Articles on Kodacolor advocated the counterintuitive practice of shooting more expensive stock in a seemingly monochromatic winter landscape" to observe the surprises that color can capture.[76] Filmmakers were encouraged to reexamine shooting natural settings with new eyes. Technicolor supervisor Natalie Kalmus recognized that the advent of color cinematography meant more than just dim color images on

[71] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 43
[72] Ibid.
[73] Ibid.
[74] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 55.
[75] Ibid., 60, n. 55.
[76] Askari, "Early 16mm Colour by a Career Amateur," 157.

chalkboard-sized projection screens, calling the new experimentation in camerawork "color consciousness"—a new way of seeing the world.[77]

"This is the Magic of Kodachrome": The End of Kodacolor

In 1935 Kodak released Kodachrome 16mm film stock, which used a two-color subtractive process. Kodachrome was a color reversal stock that used color dye couplers in successive layers. When developed "a chemical reaction converts each layer of photosensitive emulsion into a visible dye of the corresponding color"[78]—during projection, the color came from the film itself, not the addition of filters. Kodachrome could produce images in natural color, but did not have the inherent disadvantages of Kodacolor—it could be used without special filters and diaphragm caps, and users could control exposure more precisely. Kodachrome required less light than Kodacolor, allowing shooting in a variety of lighting conditions. In addition, with Kodachrome, "natural color sequences could be spliced next to monochrome sequences with fewer technical limitations."[79]

Opinions differ as to when the Kodacolor party ended for good. Leo Enticknap writes that Eastman Kodak withdrew Kodacolor from the market in 1938,[80] Both Wikipedia and Marsha Gordon say 1935.[81] The year 1935 coincides with the introduction of 16mm Kodachrome,[82] so circa 1935 sounds more likely. Kodachrome was introduced at the same price

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[77] Kalmus "Color Fundamentals," quoted in Askari, "Early 16mm Colour by a Career Amateur," 157.
[78] Enticknap, *Moving Image Technology*, 90.
[79] Ibid., 158.
[80] Enticknap, *Moving Image Technology*, 83.
[81] "Kodacolor (filmmaking)," Wikipedia; Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 36.
[82] "KODAK: Chronology of Motion Picture Films - 1889 to 1939"; "Home Color Movies May Be Made without Camera Filters" p. 246

point as Kodacolor so there was virtually no reason for consumers to hesitate.[83] Amateurs flocked to Kodachrome and Kodacolor faded into oblivion.

"Making the Picture": Preservation and Presentation of Kodacolor

Kodacolor was notoriously difficult to copy, as discussed previously, thus photochemical printing as preservation would likely be the most complicated and expensive option. Because Kodacolor is a black and white stock copying onto a color stock could not be accomplished by contact printing. Nor would it be feasible to copy from Kodacolor to Kodacolor would be overly complex for several reasons. Kodacolor was only available between 1928 and 1935 so finding undeveloped stock would be rare indeed. Furthermore, because precision equipment embossed the microscopic lenticules on the film base, new Kodacolor film stock cannot be "home-brewed." One would likely need to attach filters to both the "projector" and "camera" sections of an optical printer which would probably result in severe degradation of the image. Luckily color fading is never an issue with Kodacolor because it is a black and white stock.

Printing Kodacolor to color negative film is a much better option. Film Technology Company in Los Angeles produced both a digital scan and a polyester color negative of an original Kodacolor film for the City of Vancouver Archives.[84] They transferred the Kodacolor to color film stock using an optical printer. By attaching a Kodacolor filter to the "projector" end of the printer, they could print the original Kodacolor film to a color internegative. Unfortunately

[83] "Home Color Movies May Be Made without Camera Filters" p. 246
[84] Cumming, "Exploring Lenticular Kodacolor."

Film Technology no longer offers this service.[85] I could not find another vendor that offers optical printing for Kodacolor.

Kodacolor film stock presents a number of unique preservation issues. First, there is the fact that it may be hard to actually identify, especially by someone untrained in film formats. Kodacolor was typically shot by amateurs and there is a high probability that many historical societies and similar collections that do not specialize in moving images may have rolls of it and not understand the differences between Kodacolor and other 16mm stocks. To the naked eye, Kodacolor looks no different from standard black and white 16mm stock, and it feels the same in one's hands as well. Sections of Kodacolor could be spliced in between sections of regular 16mm stock, although both Gordon and Askari report that the collections they examined have all Kodacolor stock spliced together on a separate reel.[86]

Identification of Kodacolor by edge code is possible as the stock can read "Kodacolor,"[87] although I am unsure of whether all versions of the stock used this edgecode. The striations are only barely visible at 10x magnification—they would be hard to see with a standard loupe.[88] The lenticules are clearly visible at 200x magnification (see image 6).

Secondly, there are presentation issues. As discussed earlier, Kodacolor used proprietary equipment. Presenting Kodacolor in its original form requires a special filter be attached to the lens of a projector. One of the intended projectors, Kodascope Model B, has a reputation for being hard on film—Dino Everett called it a "destructive projector."[89] Projectors from this period

[85] Film Technology Inc., Phone Interview.

[86] See Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal." and Askari, "Early 16mm Colour by a Career Amateur."
[87] Amidon, "The Unwritten Record: Kodacolor Decoded."
[88] Cumming, "Exploring Lenticular Kodacolor."
[89] Everett, Phone Interview.

also had a much dimmer bulb and inferior optics to more modern 16mm projectors. The purpose-built Kodacolor screen can brighten the image, but is not required. In order to present Kodacolor to audiences now, Dino retrofits more modern projectors with Kodacolor lenses using electrical tape.[90]

Kodacolor filters have a reputation for being fragile, and "prone to the adhesive drying out (over these past 85 years) causing some separation of the colors from the backing glass. When this happens there will be a noticeable reduction in the color of the filter affected (ie: if blue filter separating, less blue on screen)."[91] However, tinkerers can create their own Kodacolor filters and instructions to do so exist online.[92] Original lenses and filters are also often available on eBay.

In general, all preservation procedures for diacetate film stock apply to Kodacolor. No one I spoke with could identify any preservation concerns specific to Kodacolor stock not concurrent with standard 16mm diacetate stock. All diacetate stock is susceptible to vinegar syndrome. Since Kodacolor film was *A* wind, there may be more chance of emulsion damage due to poor handling.[93] The *A* wind can also make splicing more difficult.[94]

Fortunately, vendors can provide digital scanning and color restoration of Kodacolor film as software has recently become available. One of these vendors is Video & Film Solutions[95] which advertises, "Because of the age of the remaining Kodacolor films, non linear shrinkage and other decomposition effects have changed what was a constant in the color method. A

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[90] Everett, Phone Interview.
[91] Everett, "Kodacolor."
[92] See Nemeth, "The Kodacolor Resource Page."
[93] Everett, Phone Interview.
[94] Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 47
[95] In her article, Marsha Gordon also mentions that Skip Elsheimer at A/V Geeks transferred a Kodacolor film to DVD. Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 57.

software package to do digital color decoding of B&W scans of Kodacolor was developed at Video & Film Solutions. This enables high resolution scanning of Kodacolor on any scanner and decoding the color from those B&W scans. It can correct not only for age related problems, but also problems inherent in the format."[96] In some digitizations of Kodacolor online, I have seen vertical lines running up and down the image. Video & Film Solutions claims their software can digitally interpolate the vertical line area to reduce the appearance of lines.[97] They premiered their software at The Reel Thing Symposium in 2013.[98] Another vendor that does scanning and color interpolation is Colorlab in Maryland. They are able to output the digital file to film at the client's request.[99]

Because it was such a rare format, few vendors work on the reformatting of Kodacolor and some of them even confuse Kodacolor with other early color film stocks like Kodachrome. [100] Many archives have collections of Kodacolor films including Northeast Historic Film, the George Eastman House, The National Parks Service of the US, the archive of the City of Vancouver, and the National Archives of the US among others.

Conclusion

Kodacolor was a transitional format in the history of color cinematography. While Kodak's ambitions were always to eventually adapt the technology to the professional filmmaking world, home moviemakers ended up—almost accidentally—with a way to shoot films in natural color decades before color became the standard for feature films. As software has

[96] "Kodacolor Decoding."
[97] "Kodacolor Decoding."
[98] Amidon, "The Unwritten Record: Kodacolor Decoded."
[99] Plionis, Phone Interview with Colorlab.
[100] "16mm Film."

become more widely available for the proper digitization of Kodacolor film, museums, archives, and historical societies ought to reexamine their collections with an eye toward identifying Kodacolor films so that others can learn more about the history of the format and the people who used it.[101]

Acknowledgements

I would like to thank Ralph Sargent (who sent me a sample of Kodacolor film), Dino Everett, and Marsha Gordon for their assistance in my research. Thanks also to Katie Sanderson at the Metropolitan Museum of Art for photographing my sample of Kodacolor stock under a microscope.

[101] For example, despite the fact that Kodak had laboratories around the world that could process the film I have yet to see Kodacolor footage that was not shot by a North American.

Image 1: An example of color fringing in Kinemacolor. **Source:** Timeline of Historical Film Colors website (http://zauberklang.ch/filmcolors/cat/rotary-filters/)

Figure 23 – Kodacolor.
a Kodacolor banded filter, Blue, Red and Green.
b Ratio diaphragm cap for camera lens.

Image 2: An illustration of the Kodacolor filter (above) and diaphragm cap (below). **Source:** Timeline of Historical Film Colors website (http://zauberklang.ch/filmcolors/timeline-entry/1240/)

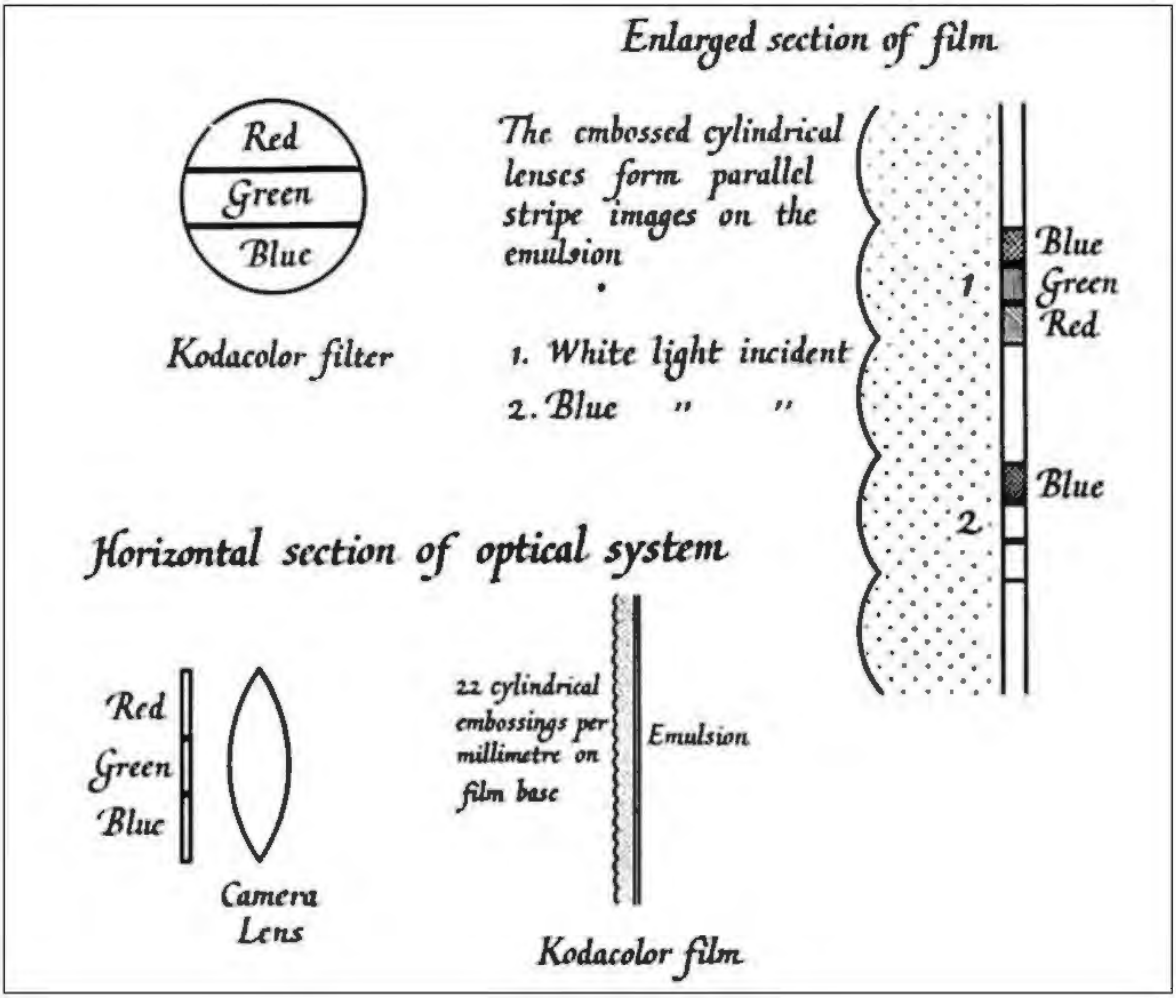


Image 3: A diagram of the Kodacolor process. Note the three color areas on the emulsion behind each lenticule. **Source:** Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 42.

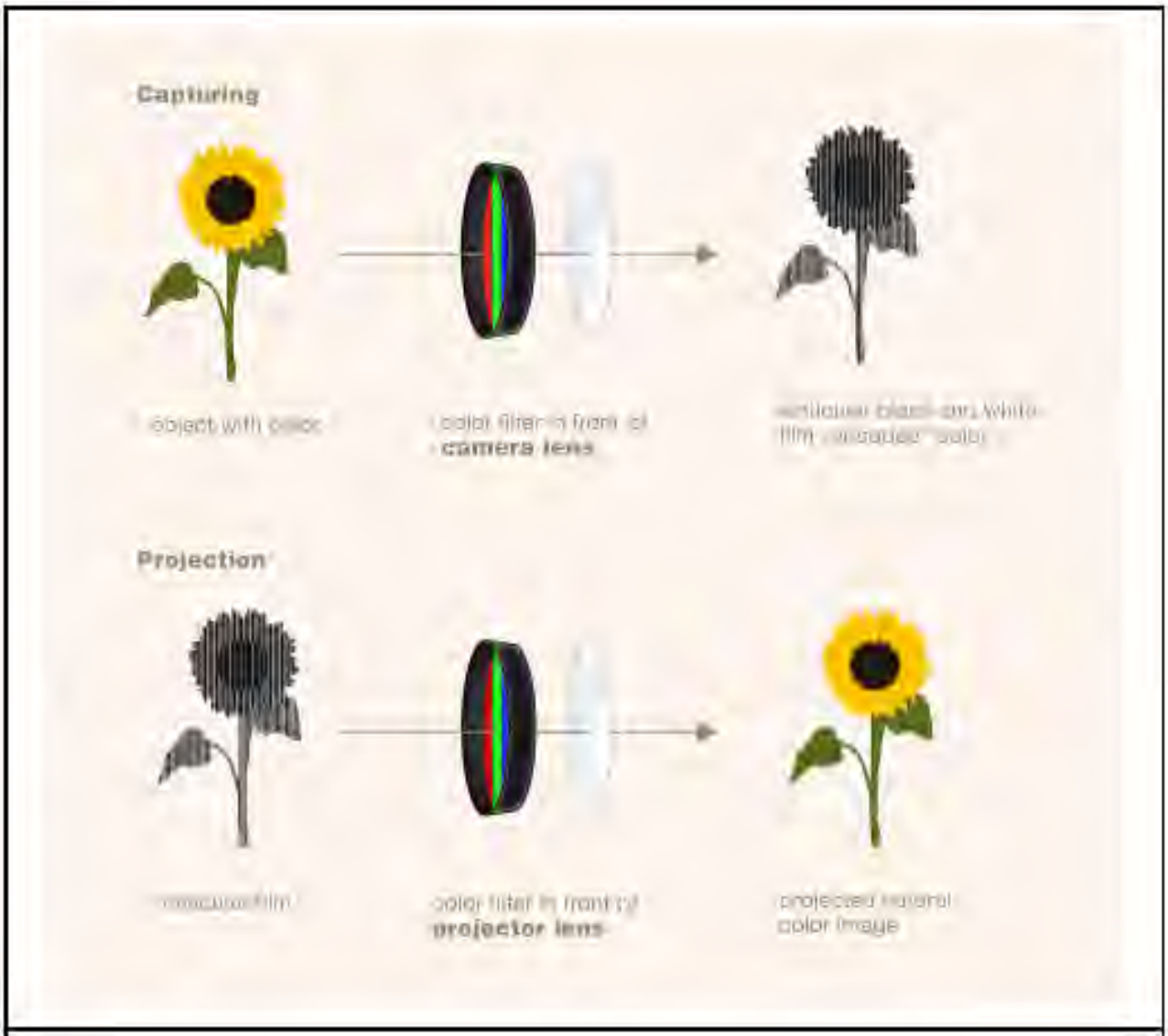


Image 4: A diagram which illustrates how the filters work in both image capture and projection. **Source:** Timeline of Historical Film Colors website (http://zauberklang.ch/filmcolors/timeline-entry/1240/)

KODACOLOR FILTER EQUIPMENT

KODACOLOR ASSEMBLY

for

Ciné-Kodak, Model B, f.1.9 or Ciné-Kodak, Model BB, f.1.9

THE Kodacolor Assembly for Ciné-Kodak, Model B, *f*.1.9, consists of the Kodacolor Filter, the .3 neutral density filter, a 50-foot aluminum reel and a cup receptacle which is screwed inside the camera to hold the filters when not in use. The Model BB Kodacolor Assembly includes only the filters.

For Kodacolor, merely slip the Kodacolor Filter into the Ciné-Kodak, and load with Kodacolor Film.

The price of the Kodacolor Assembly for either the Ciné-Kodak, Model B, *f*.1.9, or BB, *f*.1.9, is $15.

KODACOLOR ASSEMBLY

for Kodascope, Model B

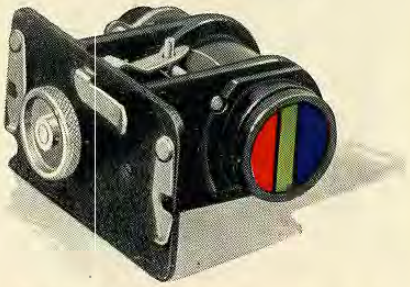
THE Kodacolor Assembly for Kodascope, Model B, consists of a Kodacolor Filter, a compensating lens and a cup receptacle for holding the filter.

To adapt Kodascope, Model B, for Kodacolor, merely screw the compensating lens into the barrel and slip the Kodacolor Filter over the lens.

Price of Kodacolor Assembly for Kodascope, Model B, complete is $18.

KODACOLOR LENS UNIT

for Kodascope, Model A



THE Kodacolor Lens Unit for Kodascope, Model A, replaces the standard lenses on that projector, and instantly adapts it for Kodacolor projection. The standard unit is lifted from its place and the Kodacolor Lens Unit substituted. Two catches secure it, and the projector is ready for Kodacolor.

The Kodacolor Lens Unit for Kodascope, Model A, is priced at $20 complete.

Note: Some older models of Kodascope, Model A or B, require a change in the illumination system for Kodacolor projection. If you possess such a model, and wish to adapt it for Kodacolor, consult your dealer.

Image 5: An image from a Kodak catalog that illustrates the available filters for cameras and projectors. **Source:** Gordon, "Lenticular Spectacles: Kodacolor's Fit in the Amateur Arsenal," 40.

Image 6: Kodacolor's lenticules are visible at 200x magnification. **Source:** Cumming, Jesse. "Exploring Lenticular Kodacolor" (http://www.vancouverarchives.ca/2012/12/06/exploring-lenticular-kodacolor/)

Annotated Bibliography

"16mm Film." *Network Sound and Video*. Accessed November 9, 2014. http://www.networksoundandvideo.com/16mm-film.html

The website of vendor Network Sound and Video. On the website they confuse Kodacolor with Kodachrome, which clued me into the fact that not all vendors are familiar with Kodacolor.

16MM HOME MOVIES - 1934 Newly Discovered Kodacolor , Chicago World's Fair , Lake Tahoe 3323, 2012. http://www.youtube.com/watch?v=Rj1LyNfUWig&feature=youtube_gdata_player

Home movies of a beach and Lake Tahoe. Claims to be Kodacolor. Not sure of the provenance, but it is available from Periscope archive, a for-profit operation.

"1930 Ad Eastman Cine Kodak with Kodacolor Movie Maker Original Advertising WW3 | eBay." Accessed September 21, 2014. http://www.ebay.com/itm/311095261400?_trksid=p2060778.m1438.l2649&ssPageName=STRK%3AMEBIDX%3AIT

Original color print ad for Kodacolor. Talks about the ease of use and how equipment that that consumer already owns can be used to shoot color movies. Also calls Kodacolor "the greatest single triumph in the history of photography."

"1954 Kodachrome Photography Ad." *Etsy*. Accessed November 3, 2014. https://www.etsy.com/listing/175829740/1954-kodachrome-photography-ad?utm_source=OpenGraph&utm_medium=PageTools&utm_campaign=Share

This ad for Kodachrome inspired the title of one of my section headings.

"Additive Color." *Wikipedia, the Free Encyclopedia*, October 25, 2014. https://en.wikipedia.org/w/index.php?title=Additive_color&oldid=621731330

This page helped me understand additive color better. It talks about how the human retina blends additive primaries together, which proved valuable in explaining Kodacolor.

Amidon, Audrey. "The Unwritten Record: Kodacolor Decoded: Early Color Footage of Yellowstone National Park." Accessed November 16, 2014. http://blogs.archives.gov/unwritten-record/2014/07/24/kodacolor-decoded-early-color-footage-of-yellowstone-national-park/

A blog post by the National Archives that describes their discovery of Kodacolor footage from Yellowstone Park. They believe the footage was taken by one of the park's official photographers. The article mentions that the Kodacolor film was digitized and the color information decoded by Video & Film Solutions.

Askari, Kaveh. “Early 16mm Colour by a Career Amateur.” *Film History* 21, no. 2 (January 1, 2009): 150–P6. doi:10.2307/40406020

A biography and analysis of Alexander Black, a influential pioneer in amateur filmmaking, called a “career amateur.” Askari discusses the effects of newly introduced color processes on the amateur world, arguing that they were developing a new “color consciousness.”

Batsel, C.N., and L.T. Sachtleben. “Sixteen-Millimeter Sound Pictures in Color.” *Journal of the Society of Motion Picture Engineers* 23, no. 1 (July 1934). http://www.archive.org/details/journalofsociety23socirich

This article proved that an optical variable area soundtrack would be impractical on lenticular film.

Bell & Howell Company. “Create New Wonderlands Movie Makers.” *Movie Makers: Magazine of the Amateur Cinema League*, November 1928

A magazine ad by Bell and Howell that advertises Kodacolor filters for the Filmo camera and projector.

Bigelow, Sue. “Lenticular Kodacolor,” November 13, 2014

Sue Bigelow is the Digital Conservator at at the City of Vancouver Archives. She gave me some of the details on Film Technology’s transfer of the Kodacolor films held in their collection.

Cumming, Jesse. “Exploring Lenticular Kodacolor | AuthentiCity.” Accessed November 9, 2014. http://www.vancouverarchives.ca/2012/12/06/exploring-lenticular-kodacolor/

A blog post about some Kodacolor film that was found in the archives of the City of Vancouver. The article discusses the preservation of the film by Film Technology Inc—this vendor produced a digital file and a color negative for the archive. The post also included some excellent images of Kodacolor film under a microscope, one of which I used in the paper.

Eastman Kodak Company. “Instructions for Shipping Eastman Kodacolor Film.” Eastman Kodak Company, n.d. Hugh M. Hefner Moving Image Archive, University of Southern California

This manual indicated that Kodak had laboratories around the world which could process Kodacolor film stock.

———. “Taking Kodacolor Pictures,” n.d. Hugh M. Hefner Moving Image Archive, University of Southern California

A Kodacolor users manual produced by Eastman Kodak. This provided images and a lot of insight into the complications for filmmakers using the stock. It also revealed that Kodak had special lights for filmmakers who wanted to shoot indoors.

“Eastman Kodak Company Presents Kodacolor.” *Movie Makers: Magazine of the Amateur Cinema League*, August 1928. The Library of Congress

An early advertisement for Kodacolor that included information about all the equipment required and the cost of the equipment.

Enticknap, Leo Douglas Graham. *Moving Image Technology: From Zoetrope to Digital*. London: Wallflower, 2005

This work introduced me to Kodacolor, put the format in historical context with other competing color formats and explained why it was superseded in both the professional and amateur marketplace, arguing that the fact that is was a reversal stock and had too much proprietary equipment to ever become a part of the professional motion picture industry. It also gave a basic overview of how Kodacolor worked. It provided a basic timeline for the beginning and end of Kodacolor. The book also gave me information about subtractive color processes that came after Kodacolor.

Everett, Dino. "Kodacolor," October 31, 2014

Dino is a moving image archivist at the University of Southern California. He sent me a number images related to Kodacolor, including catalog advertising and an instruction manual. He gave me a lot of information about the preservation and presentation of Kodacolor. He mentioned that the lens filter used for projection is prone to drying out.

———. Phone Interview. Telephone, October 31, 2014

Dino answered a number of my questions related to how Kodacolor worked. He also described how he has retrofitted more modern projectors to show films shot in Kodacolor. He said that Kodacolor is "quite possibly the slowest film stock ever produced."

Film Technology Inc. Phone Interview, November 18, 2014

I spoke with an employee at Film Technology Inc about Kodacolor. He told me that they used to handle it using an optical printer, but are no longer working on film processing as of October.

Flueckiger, Barbara. "Keller-Dorian." *Timeline of Historical Film Colors*. Accessed October 19, 2014. http://zauberklang.ch/filmcolors/timeline-entry/1362/

Provides historical and technical information about the Keller-Dorian process, including patent applications, diagrams, and photos of equipment.

———. "Kodacolor / Keller-Dorian Color." *Timeline of Historical Film Colors*. Accessed September 21, 2014. http://zauberklang.ch/filmcolors/timeline-entry/1240/

The site includes images, diagrams, patent applications and an extensive bibliography of primary and secondary sources related specifically to Kodacolor. This site helped me find additional sources to consult.

———. “Lenticular Screen Processes.” *Timeline of Historical Film Colors*. Accessed September 24, 2014. http://zauberklang.ch/filmcolors/cat/lenticular-screen/

Comprehensive list of all lenticular screen processes. Each process has an entire page devoted to it which includes links to primary and secondary sources related to the process. This gave me historical context and information about competing processes.

———. “Screen Processes.” *Timeline of Historical Film Colors*. Accessed October 19, 2014. http://zauberklang.ch/filmcolors/cat/screen-processes/

A comprehensive list of all color technology that used screen processes of one kind of another. This gave me historical context and information about competing processes.

“Gabriel Lippmann.” *Wikipedia, the Free Encyclopedia*, November 6, 2014. https://en.wikipedia.org/w/index.php?title=Gabriel_Lippmann&oldid=628838862

Contained basic information about the life and work of the physicist Gabriel Lippmann.

Gordon, Marsha. “Lenticular Spectacles: Kodacolor’s Fit in the Amateur Arsenal.” *Film History* 25, no. 4 (October 1, 2013): 36–61. doi:10.2979/filmhistory.25.4.36

This article provides a thorough look at the history of the Kodacolor format, it’s associated capture and playback devices, how it worked, its use by amateur filmmakers, and its technical problems. It also included diagrams and advertisements which I found useful. The article argues that while Kodacolor offered something spectacular (natural color) for amateur cinematographers that the professional motion picture world wasn’t using, it proved finicky and overly complicated to use, especially in a travel environment. This article contains relevant information for nearly every section of my paper.

“Home Color Movies May Be Made without Camera Filters.” *The Science News-Letter* 27, no. 732 (April 20, 1935): 246. doi:10.2307/3911172

A journal article about the introduction of Kodachrome. It helped me pinpoint the year of introduction as well as the fact that, when introduced, Kodachrome had the same price point as Kodacolor.

“Keller-Dorian Cinematography.” *Wikipedia, the Free Encyclopedia*, August 2, 2014. http://en.wikipedia.org/w/index.php?title=Keller-Dorian_cinematography&oldid=593284784

Basic information about the Keller-Dorian color process.

Kenneth Mees, C.E. “Amateur Cinematography and the Kodacolor Process.” *Journal of the Franklin Institute* 207, no. 1 (January 1929): 1–17. doi:10.1016/S0016-0032(29)91269-2

An article written by director of the research laboratories at Eastman Kodak. It discusses the development of reversal film for amateurs and the development of color processes including

Autochrome and Keller-Dorian. Mees describes the Kodacolor process at great length and refers to the three spots of color as being too small for the viewer to see, much like a pixel.

"Kodacolor Decoding." Video & Film Solutions. Accessed October 19, 2014. http://www.videofilmsolutions.com/Kodacolor

Advertises a software package developed by Film & Video Solutions for decoding the color information on Kodacolor, even if the film has shrunken or decomposed. Also handles color decoding of film original shot on Kodacolor, but later duplicated with contact printing.

"Kodacolor (filmmaking)." *Wikipedia, the Free Encyclopedia*, August 21, 2014. http://en.wikipedia.org/w/index.php?title=Kodacolor_(filmmaking)&oldid=622235904

A broad overview of the history of Kodacolor.

Kodacolor Party HD, 2010. http://www.youtube.com/watch?v=4T8tXM5ZA48&feature=youtube_gdata_player

Edited footage of George Eastman's Kodacolor release party in 1928. Guests included Thomas Edison, General John Pershing, Hiram Percy Maxim. The footage reveals how the digitization of Kodacolor can produce vertical lines across the image. The video was edited for the George Eastman House. The video had visible vertical lines in the Kodacolor footage.

"KODAK: Chronology of Motion Picture Films - 1889 to 1939." *Kodak Official Website*. Accessed September 21, 2014. http://motion.kodak.com/motion/About/Chronology_Of_Film/index.htm

Basic timeline of introduction and discontinuation of Kodak motion picture films. The website shows that Kodacolor was introduced in 1928 and Kodachrome was introduced in 1935.

Lange, Eric. *Discovering Cinema: Movies Dream in Color*. DVD. Lobster Films, 2004

Film discusses the processes leading up to lenticular color and the large investment in this color process during the 1920s. It also discusses the history of Technicolor. It was another source that helped me put Kodacolor in historical context.

"Media Transfer." Accessed November 9, 2014. http://www.advancedmediallc.com/media-services/media-transfer-preservation-satisfaction-guaranteed

The website of a vendor that offers film transfers for Kodacolor.

Nemeth, Darren. "The Kodacolor Resource Page," 2010. http://www.giantsquidaudiolab.com/kodacolor_page/kodacolor.html

Includes photos of Kodacolor equipment and stock, including an Ampro filter, as well as film stills. There is information about creating your own Kodacolor filters.

Phillips, F. B. “The Kodacolor Process.” *The Geographical Journal* 80, no. 3 (September 1, 1932): 240–42. doi:10.2307/1783581

Provided details about the Cine-Kodak camera, how the filter attached, and how it blocked the ability to change the aperture. It also mentioned that the process was becoming better known to travelers.

“Pixel.” *Wikipedia, the Free Encyclopedia*, November 14, 2014. https://en.wikipedia.org/w/index.php?title=Pixel&oldid=630193759

This article discussed subpixels and how they are used in televisions and computer monitors. It allowed me to make the connection to Kodacolor.

Plionis, Dean. Phone Interview with Colorlab, November 18, 2014

Dean told me that Color Lab handles Kodacolor preservation digitally: they scan the film and then interpolate the color with software. They can then output that digital file to film if the client wants. He said they have done projects like this in the past.

Ruedel, Ulrich. “The Technicolor Notebooks at the George Eastman House.” *Film History* 21, no. 1 (January 1, 2009): 7–60. doi:10.2307/27670756

An examination of the archival documents related to the Technicolor Corporation held by the George Eastman House. The article mentioned that Technicolor considered a lenticular process and wanted to combine Kodacolor and a three-color process.

Ryan, Roderick T. *A History of Motion Picture Color Technology*. London ; New York: Focal Press, 1977

Provides an overview of the theories and early experiments in lenticular color. Explains the process in more technical detail than other sources with different diagrams. It contained an important diagram of a diaphragm cap included with rolls of Kodacolor. This book first gave me the notion of Kodacolor as “pre-pixel” format. It also described the Eastman Embossed Print Film and Eastman Kinescope Film processes in great detail.

Sargent, Ralph. “Kodacolor,” October 27, 2014

Ralph Sargent works at Film Technology Inc. in Hollywood. Marsha Gordon recommended I speak with him as she had consulted him for her article “Lenticular Spectacles.” Ralph answered some questions I had related to the preservation of Kodacolor and he sent me a sample of undeveloped Kodacolor stock to examine.

“Technicolor.” *Wikipedia, the Free Encyclopedia*, October 27, 2014. http://en.wikipedia.org/w/index.php?title=Technicolor&oldid=630881654

Gives a basic overview of the history of Technicolor.

Tuttle, H.B., and R. Plato Schwartz. “The New Ciné-Kodak Special in Medicine.” *Journal of the Society of Motion Picture Engineers* 21, no. 1 (July 1933). http://www.archive.org/details/journalofsociety21socirich

Article that talked about the use of Kodacolor, the Ciné-Kodak Special camera, and special lighting equipment in filming various medical procedures.

Winston, Brian. “A Whole Technology of Dyeing: A Note on Ideology and the Apparatus of the Chromatic Moving Image.” *Daedalus* 114, no. 4 (October 1, 1985): 105–23. doi:10.2307/20025012

This journal article informed me about how additive and subtractive color processes were being developed simultaneously.