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Two-Color Kodachrome

Umberto Eco may have said it best,in his 1985 article, "How Culture Conditions the Colours We See": "Colour is not an easy matter" (157). While Eco's pithy observationwas a means of launching into a linguistic, or, in his words, "general semiotic"analysis of color, his remarksseem tailor-made for investigationsinto the rapidly changing nature of color technologies and aesthetics in silent cinema. Historians and preservationists face a number of pitfalls in approachingcolor systemsfromthe silent era; dangers include the damaged quality of the archive, the ethical and practical dilemmas of preservation, color's inherent instability, and the hazards oflinear or progressive historicism. Paolo Cherchi Usai describes one of the overarching difficulties in*Silent Cinema: An Introduction* (2000): "Much as we may know that a certain colour once existed in a silent film, we must also acknowledge that it is now virtually impossible to experience its actual rendering onscreen. As time goes by, the entity slowly mutates into an imaginary object, a creation of the mind" (40). This complements the provocative, "polemical question" asked by Kim Tomadjoglu in her introduction to a2009 double issue of *Film History* devoted to color in silent cinema: "Can one definitively discuss the use of color as a stylistic or narrative device by viewing contemporary restorations of early unique silent films?" (4). Tomadjoglu and Usai recognize that our search for definitive answers or utopian recreations will remain virtuallyimpossible; but

rather than consider their viewsdefeatist, we arebetter served to understandit as a call-to-arms, or a challenge to contemporary scholars, one encouraging us to continue carefully carving out new realms in the largely forgotten, resplendent world of silent cinema. As Usai aptly concludes, "From a cultural standpoint, colour film preservation (as much as film preservation itself) is a necessary, interesting mistake" (40). Despite the inherent difficulties of suchan endeavor, this research effort—an exploration of the Eastman Kodak Company's experimental Two-Color Kodachrome process—will commit itself to this process, makinga necessary, interesting mistake, rewinding the cinema century with the hope of discovering diverse and divergent possibilities previously unimagined.

Color has become hot topic in contemporary cinema studies (some might sayred-hot). Within this surge ofhistorical interest in early color, we can discern two curious trends: (1) "In general, the European community of preservationists and academics is significantly ahead of their North American counterparts;" and (2) "Most of these histories have taken the form of articles or essays rather than books…as if bringing together multiple voices were the only way to address color's visual diversity" (Tomadjoglu 4; Misek 1). While it is beyond the scope of this essay to begin speculating about the underlying causes of these trends, bothforce us to acknowledge that when investigating early color, onlyinternational, interdisciplinary approaches will suffice. There is still much that is mysterious and unknown about the phenomenon of color, as Wendy Everett notes in *Questions of Colour in Cinema* (2007):

> "It would seem that one of the main reasons why colour continues to fascinate on so many levels is the gap between its perception as a simple physical property and the extreme complexity of its nature and identity. Far from being a straightforward property of the objects around us, colour is, in reality, both a physical characteristic of light and pigment and a psychological and physical sensation, both an objective and subjective phenomenon" (10).

In "Color and Cinema: Problems in the Writing of History" (1979), Edward Branigan reminds us that there are "different *ways of seeing* the history of color," that our choices as historians are never neutral, our ways of seeing the world in some sense "determine *what we see*" (16, his emphasis). While Branigan repeatedly claims the goal of his projectis simply to review different historical approaches (broken down into the categories of adventure history, technical history, industrial history, and ideological history), he remains partial to an ideological Marxist critique, frequently invoking Jean Louis Commoli's "Technique et ideologie" (1971-72) to support his assertion that technologicallyrefined 'natural' photographic color processes cannot be separated from the "social and economic matri[ces] in which they find their function" (28). Branigan argues that color enhances the "camera's claim to scientific accuracy," and in this way contributes to the camera's use as a tool that "hold[s] the members of a society in a certain set of relationships or bond" (25). In *Chromatic Cinema: A History of Screen Color* (2010), Richard Misek also tracks patterns ofhistorical inquiry, organizing historical accounts of cinematic color into the following categories: "technological histories, aesthetic histories, didactic histories that privilege the role of ideology, period-specific histories, country-specific histories, process-specific histories, and histories that variously explore the technological, aesthetic, economic, and ideological factors in combination" (1). By

focusing onTwo Color Kodachrome, an obscure and largely forgotten color film process,we can discovera way to counter conventional narratives of film history, which often followlinear, progressive paths to the present.While this research effort willlargely focus on the technical specificationsof the Two-Color Kodachrome process,and on the unsung efforts of a remarkable Kodak research scientist, it will not ignore the understanding thatall historical efforts, all attempts to recover or unearth buried or obscured pasts, ultimately reveal themselves less as commentary on the historical past and more as commentary on the historical present.

The Two-Color Kodachrome subtractive color process was invented by John George Capstaff in 1914 for the Eastman Kodak Company of Rochester, New York. Born in Gateshead-on-Tyne, England on February 24, 1879, Capstaff was recruited by C.E. Kenneth Mees, director of the Kodak Research Laboratories, in 1913 to run the Photography Division of the KRL. Prior to joining Kodak, Capstaff, a tireless inventor, had already begun experimenting with still color photography, filing a British patent for a precursor to the Two-Color Kodachrome process in early 1910 (*Journey: 75 Years of Kodak Research*, 1989). As Jane Baum McCarthy describes in "The Two Color Kodachrome Collection at the George Eastman House" (1987), "Capstaff first observed the effect of tanning bleach one day in 1910 when he used an old negative to make a darkroom safelight he needed in the course of his work. After bleaching, washing, and dyeing the plate, he was surprised to find that it showed a dye image" (1).

StillTwo-Color Photograph experiments by John Capstaff: (left) Still Life, ca. 1914, IMP/GEH 78:385.45; (right) Mrs. Capstaff, ca. 1914 IMP/GEH 78:385:8. Photo Credit-Image: Volume 30, No. 1

Arriving in Rochester in 1913, Capstaff was promptly directed to apply his photographic prowess to the production of a "superior color process" (*Journey* 29). Capstaff's work at Kodak can be seen as a direct response to orders coming straight from George Eastman himself. An excerpt from a 1911 Eastman speech demonstratesthe provocative challenge Eastman set for his inventors:

> "Photographs in color have been the dream of inventors for many years…the making of pictures in color…has been a purely manufacturing one, and apparently a very simple one, namely: the application of three transparent colors in minutely divided particles upon a glass or other transparent support. What seemed at first to be a very easy problem, however, has proved for 40 years to be unsolvable" (Cited in *Journey* 29).

In this way, early Kodak experimental color processes were part of a tradition committed to producing 'realistic' color through indexical photographic means, a pursuit, in the words of Andre Bazin, of "the reconstruction of a perfect illusion of the outside world in sound, color, and relief" (Cited in Gunning 4). In "Colorful Metaphors: The Attraction of Color in Early Silent Cinema" (2003), Tom Gunning proposes that thisquest for 'realistic' or 'natural' color—exemplified by pioneering cinematographicprocesses such as Kodak's Two-Color Kodachrome, Gaumont's Chronochrome, Prizmacolor, early Technicolor, and Smith and Urban's

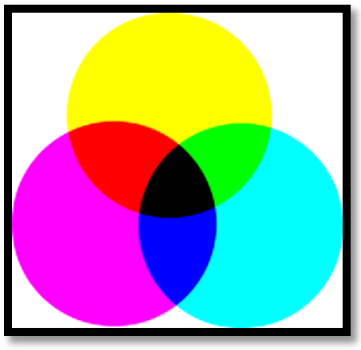
Kinemacolor—was just one approach to color in the silent era. Gunning describes a popular alternative early twentieth century cinematic color traditiondevoted toachieving "purely sensual," or "fantasy effects," through the practices of tinting, toning, hand painting, and stencil coloring. Gunning ties both of these cinematic color trajectories to a wider "surge" of color into "all areas of daily life," a process he tracesto the 1860s and describes as "one of the key perceptual transformations of modernity" (5). But this 'invasion' of color in the modern erawas not without its detractors; as Tomadjoglu notes, "Color was thought to be dangerous because it represented the emerging mass culture: a 'chromocivilization,' in which color was not only a 'power in itself,' but one which opposed the traditional values of the monochromatic black-and-white world" (4). Despite some of theseclass-based cultural debates regarding color, for many color pioneers, the economics were simply indisputable—there was money to be made by bringingeithersensuousor natural color to the cinema.

In *Moving Image Technology: From Zoetrope to Digital* (2005),Leo Enticknap describesGunning's dueling traditions as "photographic color" and "artificial color" (75). Whereas artificial color processes "introduce colored dye to the film independently of the recorded monochrome image," photographic processes "attempt to record a greater range of the visible color spectrum…at the point of photography, and then to reproduce that recording accurately in projection" (75). The field of early color was remarkably diverse, with artificial color techniques battling with additive *and* subtractive photographic color systems for widespread dominance and acceptance. In this way, Capstaff was just one of many "obscure

pioneers with fertile imaginations," and the period in which Two-Color Kodachrome emerged is perhaps best seen asan opportunistic land-grab scenario, marked by "aggressive competition (mostly among the United States, United Kingdom, and France) between processes which each in turn emerged, enjoyed an ephemeral public life, and then sank into oblivion" (Usai 33; 37). In *The Way of All Flesh Tones: A History of Motion Picture Processes, 1895-1929* (1983), Robert Nowotny captures this California Gold Rush ethos: "Fortunes were gambled, and often lost, as early experimenters produced a wide variety of color systems…each of [which] contributed to the advancement of the motion picture, culminating in the successful development of and eventual acceptance of the now-famous three-strip method developed by Technicolor" (4).While Nowotny's formulationissomewhat simplified and overly determined, he does turn our attention to alternate possibilities, reminding us that this was a fascinating, multifarious period of film history. While in retrospectTwo-Color Kodachrome may be considereda failure, a process too complicated and expensive toever viably contend for market dominance, it remains significant, for it "represents the initial experiment by the large Eastman Kodak Company in the field of color cinematography…in that respect, Capstaff's Kodachrome serves as the foundation of more successful things to come" (152).

The Two-Color Kodachrome process was perhapseven more ephemeral than its direct competitors, largely existing in therealm of scientific experimentation and testing. As a system based on the principle of subtractive color synthesis, Two-Color Kodachrome wasa practical improvement on systems based on additive color synthesis, which often required convoluted projection arrangements. Unlike

additive systems, which would superimpose three black-and-white images of the same object exposed through three primary color filters (blue, red, and green), projecting the three resulting images through filters of the same three colors, in systems based on subtractive synthesis, a single beam of white light is projected through two or three images made in the subtractive primary colors of yellow, magenta, and cyan (in the case of Two-Color Kodachrome, light is projected through red and green overlaps). Each colored image absorbs just one section of the entire color spectrum, and the resulting image displayed onscreen would be the result of the 'subtraction' of certain colors from the entire spectrum of light (Usai 33-34). Because of this, color films made through subtractive processes could be projected without requiring elaborate changes to the equipment used toproject black-and-white films, a potential boon for the creators of a widely accepted subtractive synthesis process.



Subtractive synthesis. Usai: "in the resulting color film, the colours that appear on the screen are those which have been filtered—that is, subtracted—from the entire spectrum of white light. A complete picture obtained through this process is a combination of partial images in yellow, magenta, and cyan" (34). The color accuracy of Two-Color Kodachrome was inherently limited by its use of only red and greencolor records.

In *A History of Motion Picture Color Technology* (1977), Roderick Ryan explains that while subtractive processes eliminated some of the problems associated with films

based on additive synthesis—the use of the wrong film/filter combinations; lack of synchronization of the color records; lack of superimposition of color records—the color in a subtractive synthesis, "for *good or bad*, became a part of the print before it left the laboratory" (65, my emphasis). In 1915, Capstaff began to adapt the subtractive principles he discovered working in the field of still photography to color cinematography. The Two-Color Kodachrome processfirst required the construction of a camera with two lenses, one placed directly above the other. Film was advanced through the camera two frames at a time, with the simultaneous exposure of one frame through a red filter and one through a green filter. Caroline Yeager and James Layton offer a succinct description of the complexTwo-Color Kodachrome printing process:

> "Shot with a dual-lens camera, the process recorded filtered images on black-and-white negative stock, then made black-and-white separation positives. The final prints were actually produced by bleaching and tanning a double-coated duplicate negative (made from the positive separations), then dyeing the emulsion green/blue on one side and red on the other" (Yeager and Layton)

While Two-Color Kodachrome achieved impressive results, often described as a "rather ethereal palette of hues," capable of producingwarm flesh tones, the process itself was expensive, time-intensive, and suffered from its own optical problems and lens restrictions (Yeager and Layton). Martin Hart of the American Widescreen Museum notesthe two most glaring problemsof the Kodachrome process: 1) "Color accuracy, like any two-color system, was compromised; and 2)"The image being printed on both film surfaces made it more subject to scratching of the emulsion. Since scratches and other damage would be unique to only one of the colors, the

results were perhaps more disturbing than a scratch through all emulsion layers on a single side of film" (Hart).

Left: black-and-white negatives carrying different color records; Middle: the processed film after color treatment; Right: the composite image. Photo Credit: The American WideScreen Museum and Film Technology Center.

The bleaching, tanning, and dyeing process of the duplicated negative is the key to the Two-Color Kodachrome Process. An excerpt from "The Invention and Development of Photography," from the June 5, 1915 issue of *Scientific American*, explains how this innovation functioned:

> "direct transformation of a negative in black silver into a positive in which the silver of the negative was represented by clear gelatine…the transformation being correct throughout, so that all the gradation of the original negative was reproduced in the resulting positive…When…put into the specially prepared dye bath, the dye goes into the gelatine most easily where the silver was absent in the negative; that is, where there was least light in the original photograph or in the part represented by deep shadows; while in the part corresponding to the high-lights, where there was much silver in the negative, the dye penetrates more slowly, so that as the dye slowly enters the film, the original negative is transformed into a positive produced in colored dye…The process is thus seen to be simplicity itself" (Cited in Nowotny, 147).

'Simplicity itself' may be a bit of an overstatement. Glenn E. Matthews, in a Society of Motion Picture Engineers article "A Motion Picture Made in 1916 by a Two-Color Subtractive Process" (1930), offers an alternative explanation of theduplicated negative bleaching, tanning, and dyeing process, one that elucidates the description provided in the *Scientific American* article. He describes:

> "The working principle underlying the two-color process known as *Kodachrome* is the use of tanning bleach for treatment of the duplicate negative, which removes the negative image and differentially tans the area where the image existed. When the film is treated subsequently with dyes capable of dyeing soft gelatin, a positive dye image is produced" (624).

The double-coated negative was bleached in a solution composed of equal parts:

Solution A:

- Potassium ferricyanide 37.5 grams
- Potassium bromide 56.25 grams
- Potassium dichromate 37.5 grams
- Acetic acid 10.0 ml
- Water to 1.0 liter

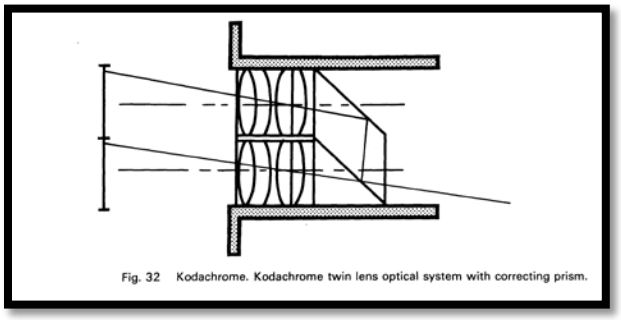
Solution B:

- Potassium alum 5% solution (Ryan 70)

After bleaching, the film was "fixed in an acid, alum-free hypo solution and washed for twenty minutes. Following this, the film [was] immersed in a 5% ammonia solution for three minutes, then return[ed] to the ammonia solution for an additional five minutes" (Ryan 71). After drying, the film was passed twice through a dye applicator machine, which appliedcolorsreferred to

as‘Kodachrome Red’ and ‘Kodachrome Green’ to opposite sides of the film (Ryan 71).

Two-Color Kodachrome’s dual-lens camera and complex printing process resulted in a variety of optical errors and lens restrictions. The simultaneous exposure of two frames through two lenses resulted in parallax (“The apparent displacement of an object as seen from two points”), a problem exacerbated when the object being photographed was closer to the camera (Ryan 230; 67). To counteract parallax problems, a beam-splitter with a correcting prism was constructed; however, the beam-splitter led to magnification problems. As Ryan explains, “the optical path from the object to the lens which receives the light reflected by the prism is greater than the path from the object to the lens which receives the light transmitted by the prism” (Ryan 68).



The beam-splitter introduced to alleviate parallax problems caused by Two-Color Kodachrome’s dual-lens camera. Photo Credit: Roderick Ryan, A History of Motion Picture Color Technology (1977).

The two-frame exposure also introduced lens restrictions: “the maximum diameter for any circular lens used in the process was the height of a single frame. Thus a two inch lens was limited to a speed of f/2.8 and a three inch

lens to a speed of f/3.7" (Ryan 68). The "limited light gathering" capacity of these lenses, in conjunction with absorption from the colored filters *and* the beam-splitter made lighting these films extremely difficult (Nowotny 149). Some of the parallax and magnification problems could be rectified during the printing process, but as Nowotny notes, "the background, however, would remain out of register. This problem was particularly pronounced if the background contained distinct horizontal lines" (151). In addition, lighting difficulties led to severe differences in contrast, which were "often impossible to correct" (151).

The complicatednature of the Two-Color Kodachrome process may explainboth why the process never became commercially viable and also why there are so few extant films available for research purposes. The first fiction film made using the Two-Color Kodachrome process was *Concerning One Thousand Dollars* (1916), an experimental short that also served as an advertisementfor a Kodak still camera. Filmed on the rooftop of the Kodak Research Laboratory and in Mr. Eastman's garden, *Concerning One Thousand Dollars* was preserved as part of the National Film Preservation Foundation's *Treasures from American Film Archives* series (Matthews 625). The second installment in this series, *More Treasure from the American Film Archives 1894-1931* (2004), also includes*The Flute of Krishna* (1926), a fascinating Two-Color Kodachrome collaborative effort between modern dancer and choreographer Martha Graham and filmmaker Rouben Mamoulian (who, in 1935,would direct *Becky Sharp*, the first feature length film to use the three-

strip Technicolor process). In 2009, the L. Jeffrey Selznick School of Film Preservation at the George Eastman House, with support from the Haghefilm Foundation (Amsterdam), preserveda six-minute short titled *Kodachrome Two-Color Test Shots No. III* (1922). The short, whichcombines footage of actresses Hope Hampton, Mae Murray, and Mary Eaton with footage of a Los Angeles neighborhood shot by Capstaff himself, was shown throughout the country in a series of privately held screenings (Yeager and Layton).In 1929, the Fox Film Corporation, seeing the potential of the Two-Color Kodachrome process, built laboratories in New York and California with the intention of producing Kodachrome films under the banner Fox Nature Color. This was a serious commitment to the fledgling system, and, as Yeager and Layton explain, "In 1930, anticipating the use of Two-Color Kodachrome on a large scale, Fox ordered twenty-one 35mm cameras and ten 70mm Grandeur cameras from W.P. Stein & Co. of Rochester, New York…None of the cameras Fox purchased were ever used as intended, but some of the 35mm cameras were repurposed for VistaVision" (Yeager and Layton).

The arrival of sound-on-film technologiesin the late 1920s temporarily hindered the development of colorfilm processes. Two-Color Kodachromewas further derailed by the introduction of an improved two-color Technicolor process in 1928, and, finally, by the introduction of a three-color Technicolor process in 1932. It seems as if during this periodKodak was pursuing too many avenues of research, or, perhaps, pursuing the wrong avenues, investing time and money that could have been spentimproving

Two-Color Kodachrome instead in the development ofill-fated products such as Sonochrome (1929), a pre-tinted film stock designed not to interfere with the printing of optical soundtracks on film. While Technicolor was a much smaller company than Kodak, it invested heavily in research and development, and, as Gorham Kindem notes, "Eastman Kodak never undertook financial risks proportionately equal to Technicolor's in its quest to secure a virtual monopoly over film color through patent protection of its major inventions" (Cited in Neale 20). Ultimately, Kodak failed to capitalize on the innovations of Capstaff's Two-Color Kodachrome process; in later years, the company would reuse the name *Kodachrome* for a 16mmfilm introduced in 1935, and for 35mm and 8mm home movie formats introduced in 1936 (Yeager and Layton). But despite the lost opportunity of Two-Color Kodachrome, as Yeager and Layton point out, "Kodak still helped to carry the day in the color sweepstakes for feature films through its close partnership with Herbert T. Kalmus [one of the founders of Technicolor]. Kodak created the negative, intermediate, and positive film stocks for what would become the predominant color system to rule the industry from 1928 to 1974: the Technicolor dye transfer process" (Yeager and Layton).

Two-Color Kodachrome, like many early color processes, presents unique challenges to preservationists and historians. Whether restoring early color films through photochemical or digital means, there are practical and ethical dilemmas that must be addressed. But the questions raised by color preservation are not simply historical; as Tomadjoglu explains, "We cannot afford to ignore how colour

has been reproduced in the laboratory over the past thirty years, nor how we will confront the problems of colour reproduction, and to what degree economic, commercial, and industrial factors may drive our decisions in the future" (4). While the rising digital tide has exacerbatedconcerns both past and present, as Ulrich Ruedel notes, the "digital revolution" may also offer preservationists an "unprecedented opportunity to more closely recreate the colours of various heritage processes and their distinct 'look'" (47). Preservation is always a form of approximation, and, as noted by Usai, contemporary renderings of historical colors are creations of the mind, imaginary objects that never stop mutating and transforming. In the case of Two-Color Kodachrome, modern film stocks, obsolescent machines and technologies, damaged archives, and the unknown nature of Kodachrome red and green dyes have lead to an even greater degree of creativity in the preservation process. It is critical that as we move forward, we continue to interrogate our own motivations and desires as historians and preservationists, moving past questions such as, "How did these obscure technologies develop and function?" and "How best can we restore or re-create these films using current technologies?,"and instead begin to askourselves, "Why do we care so much about forgotten, obsolescent technologies?," and "What relations with the figures and films of the past are we hoping to cultivate?"Ultimately, as Dipesh Chakrabarty reminds us, human beings from all historical periods and geographic regions are, "always in some sense our contemporaries, and the writing of history must implicitly assume a plurality of times existing together, a disjuncture of the present with itself" (Chakrabarty 2000: 109).

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http://www.cinetecadelfriuli.org/gcm/ed_precedenti/screenings_recorden.php?ID=6401

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