twenty

towards a more accurate preservation of color

heritage, research and the film restoration laboratory

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In his film *Dreams* (USA/Japan, 1990) director Akira Kurosawa cast fellow filmmaker Martin Scorsese as Vincent van Gogh. This ingenious choice was generally understood as a tribute to the latter's efforts to promote and advance the preservation of color films, an issue that had in particular come to the fore with the fast fading of color film stocks dating from the 1970s onwards (Stern 1995: 155). Using the master painter to evoke the film artist and his conscious color choices, Kurosawa and Scorsese created an image that, perhaps unintentionally, offers a metaphor that extends well beyond the color film art and technology of the past century's later decades.

Van Gogh was a master of color in the nineteenth century, during which new pigments and dyes were invented that came to characterize that century's changes in color technologies and aesthetics. The characteristic sunflower yellow, that of toxic chrome yellow pigments, however, has now darkened to a mere shadow of its original color, as recently confirmed with original van Gogh paint samples (Monico et al. 2011). The problem of

"authentic" color is far from unique to modern color film: the earliest colors of cinema, the so-called "unnatural" applied colors, are much more akin to painting or lithography in their aesthetics and application than the later "natural" color film stocks.[1]

Far from being an easily defined or measurable characteristic of a painting, a film or any other object, color can be a very elusive quality to translate from one medium to another. Not only is it impossible to faithfully capture the hue and saturation of many natural and artificial dyes and pigments of, for instance, Van Gogh's paintings on conventional color photographic materials (such as, ironically, the Eastmancolor used for *Dreams*); the same problem of reproduction also extends to preservation of early applied color on modern film stock. In order to take the quest for faithful color restoration initiated by Scorsese back to motion picture's varicolored infancy, this essay is particularly concerned with the preservation of the dazzling variety of colors in early cinema (see Cherchi Usai 2000; Read 2009).

The methods of "applied color" comprise tinting (the immersion of the film in a dye bath, coloring the entire emulsion), toning (the transformation of the neutral silver image into one consisting of colored metal salts), combinations of tinting and toning, as well as the techniques of hand- or stencil coloring.[2] Preservation of these early colors has come a long way. The approach to consider applied colors mere "bells and whistles" has given way to methods of honoring and trying to approximate the original colors (Hertogs and De Klerk 1996: 18).

The "Desmet-method," originally developed by and named after Noël Desmet of the Cinémathèque Royale in Brussels, Belgium, was designed to recreate the dramatic effects of tinting and/or toning in particular and has been widely employed in Europe since the 1990s (Desmet and Read 1998: 147).[3] In this method, special printing values and procedures are applied in printing a black-and-white negative onto color positive stock to obtain a visual appearance similar in color to a tinted and/or toned reference print. The contribution of Desmet's technique to the restoration and study of early color cannot be overstated: replication of a film's original tinting and toning scheme – where available – is now commonly considered good archival procedure as part of the original film's appearance.[4] Hand- and stencil-colored films, where different colors were selectively applied to specific image areas, cannot be recreated with Desmet's method, and are now commonly preserved on color intermediate or negative material, using photochemical or sometimes digital intermediate routes. For tinted, toned, hand- or stencil-colored films, "color restorations" have thus become commonly accepted, even expected.

But might something still be missing? Much as previous generations of archivists chose to ignore the applied colors entirely – just preserving a film's "content" as black-and-white images – is there a danger of ignoring

some visual characteristics of early color out of ignorance, negligence or necessity? By reviewing the progress in the restoration of early color, focusing on the work of Haghefilm Conservation B.V. with the Nederlands Filmmuseum, now EYE Film Institute Netherlands, and George Eastman House (GEH), this essay tries to map out historic, current and future techniques in order to start answering these questions. First, a case study of a tinted and toned sequence from a famous example of the EYE collections will be discussed. The colors of this two-color combination can be captured photographically all at once, or alternatively, one at a time, and recreated by different photographic and chemical preservation routes. Then, photographic and chemical investigations will be discussed, which confirm and help to understand the remaining visual differences to the original Desmet method. Subsequently, the approach of the principles of archeometry to film preservation will be considered, as recently demonstrated for metal tones at George Eastman House. In conclusion, the future opportunities for color film preservation will be mapped, which emerge and offer the possibility to elevate the technical approaches to the scientific sophistication of those in archeology and fine arts.

tinting: the return of (an) applied color, a short history and current shortcomings

The situation in the Netherlands provides an instructive case study. The EYE Film Institute Netherlands has been a key player in both color film preservation and its academic discussion and theorization, organizing for example the seminal 1995 workshop "Disorderly Order – Colours in Silent Film."[5] For their preservation efforts, the institution has been working closely with Haghefilm Conservation B.V. for more than twenty years, and this shared history and the evolving approaches to preservation reflect general trends.

In its early years as a preservation laboratory in the 1980s, Haghefilm focused on preservation of black-and-white and "special" film formats (such as 22 mm and 28 mm), before venturing into color and ultimately, from the early 1990s onwards, by trial and error, adapted the Desmet approach.[6] In the late 1980s, applied color was usually preserved on internegative material, a color stock specifically made for creating color negatives from positive prints. What seemed a faithful approach to capture a film element's original colors, however, actually introduced its own problems, even in a case as straightforward as a monochrome colored tint. As Giovanna Fossati observed, a "reproduction of a tinted nitrate has the same 'white' whites as a toned nitrate, giving a substantial difference in appearance" (1996: 14). Ironically, with Desmet's approach, in which a black-and-white negative is used and photographic means are applied to re-generate the coloring effects on color print stock, rather than chemically treating a

black-and-white positive, a more faithful representation of the original is yielded than with the color internegative route.

In the Desmet method, starting from a tinted and/or toned nitrate print, a black-and-white preservation negative is created, which is then used to print a new projection copy on modern color positive stock. When printing the color positive, two passes in the printer are normally required if the images to reproduce are tinted (or tinted and toned), one if the images are toned only. In one pass, the images carried by the negative can be printed with white light, in order to simulate the silver images of the tinted original on the positive, or with colored light, in order to obtain an image in which the dark parts are colored in a selected hue, similar to a chemically created tone. In another printer pass, necessary in order to simulate the effect of a tint, the positive stock is evenly exposed, without any negative, to colored light (a procedure known as flashing), resulting in a complementary effect that colors predominantly the highlights, which produces a visual impression not unlike chemical tinting. Using reference samples with different settings of printing and flashing values can help in better approximating the original. The printing values can then be refined after one or more so-called "correction prints." The nitrate original and the modern color positive are inspected side-by-side on an inspection bench until a close match is achieved.

Due to the lower price of black-and-white stock, Desmet's method utilizing a black-and-white preservation negative was developed as an economically advantageous route over the color internegative one. More importantly, concern over the archival stability of color materials makes the use of black-and-white masters archivally preferable.[7]

Other differences remain, however. Tests, in which black-and-white sensitometric control wedges (strips with different known exposure that allow technicians to measure the photographic behavior of film stocks and printing and developing methods) were tinted and compared to wedges printed on pre-flashed material (like in the Desmet method) to match the tint's hue, confirmed and quantified the main difference rooted in the nature of flashing. Basically, as the image's overall density increases, the color shifts (eventually reaching neutrality in the maximum density the film material allows) in the Desmet method, whereas it remains evenly strong in the chemical tint. Flashing mostly affects highlights; while in a chemically tinted film the amount of dye attached to the gelatin is unrelated to the image density. This does not matter much for the shadow areas, since they appear black to the eye in either method, but, compared to a chemical tint, a Desmet-print can visibly show a certain "muddiness" and a change or lack of color in the grays.

It is sometimes noted that an overall loss in contrast accompanies the Desmet method; indeed, flashing originated as a means for contrast control. However, it should be noted that chemical tinting also decreases a

film image's contrast and was sometimes deliberately employed towards this end, as discussed by Anke Wilkening (2009: 98) for the tinting of *Die Nibelungen* (Fritz Lang, 1924). Also, the structural difference between black-and-white and color film stock itself may account for visual differences. Black-and-white film contains silver grains (randomly arranged, invisibly small curled up filaments, or threads, of silver). Color film on the other hand contains layers of yellow, cyan and magenta dyes in a less defined random arrangement of more diffuse, so-called dye clouds. These three dye layers may allow for matching the color of a particular, different dye, but often fall short of matching its saturation. In addition, since the black-and-white image component in a Desmet print is also comprised of dye clouds rather than silver particles, it may appear less crisp and less neutral than the image of black-and-white material made up of silver grains. It is these phenomena that account for the visual shortcomings of the Desmet method – minor to some, substantial to others, even to the point that some viewers voice a preference for black-and-white *tout court* over Desmet prints. A last point, affecting the original experience of applied colors and the projection of modern prints, is unrelated to film materials and dye chemistries, but should not go unmentioned in this discourse. Light sources for motion picture projection have changed, and consequently the same chemical tint will look somewhat different projected on carbon arc versus modern xenon light, and to make matters worse, this change might be slightly different for the chemical tint and for its Desmet match. Like the shortcomings of the Desmet process, this aspect raises the inevitable ethical restoration question: how closely approximated is close enough?

two colors: tint and tone, by means of discrete restoration routes including vintage chemical recipes

One of the gems of the EYE Film Institute Netherlands collections showcased in the 1995 Disorderly Order workshop was the 1912 Pathé film *De molens die juichen en weenen*, original title *L'âme des moulins*, directed by Alfred Machin.[8] Featuring stencil colors in different sequences as well as tints and tones, the film can serve as a showcase of the whole gamut of Pathé's applied colors in the pre-WWI era. **Plate 31** shows a reproduction of a frame from an especially beautiful scene, a *chiaroscuro* night shot of a man walking towards a mill from *De molens die juichen en weenen*.[9] The shot is toned blue and tinted pink. Even in the printed reproduction, the color is recognizable as a blue typically resulting from an Iron Blue tone.[10] The pink is similar to the color obtained with eosin or amaranth, dyes historically commonly used for tinting (Read 2009: 34; Read and Meyer 2000: plate 8.2). EYE Film Institute Netherlands kindly made the nitrate available to the authors for a restoration comparison of selected scenes on different stocks and through different routes.

In addition to these discrete restoration routes, a black-and-white print of a selected scene was chosen to tint and tone "by hand," using chemical recipes.

One might think that carefully inspecting the original and recognizing the chemistry of a tint or tone might give a definite answer regarding the make-up of the colors, but this is not straightforward or practically possible. Eosin, for instance, was historically used for pink tinting (Löbel 1912: 281). Chemically speaking, however, it is a slightly unusual dye. Commonly, tinting dyes are acidic, and oftentimes an addition of citric or acetic acid is recommended in historic recipes to aid the tinting process. However, in this case the acid dye eosin actually changes color to orange, different from the pink tint obtained when just dissolving the salt of the dye without added acid in water. Interestingly, a similar color is observed at the edge of the frame in an irregular shape, suggesting decomposition and/or fading. Has acid released from nitrate decomposition locally affected a color change from pink to orange? To make matters more complex, a similar orange is observed in the area of the image where the evening sun is seen – potentially suggesting a deliberate stencil color effect, which can only clearly be observed when projecting preservation copies on the screen, rather than the ravages of time and acid.

Lastly, while the color of Iron Blue is fairly easy to identify for the trained eye when inspecting the original film material, it is far from unambiguously defined. Paul Read has reported on the amazing color of Iron Blue but also on its fading by projection and ageing (Read and Meyer 2000: 272). Indeed, the vibrant color of "new" Iron Blue, made by following the Eastman recipe, is never seen in vintage originals, presumably due to ageing (Eastman Kodak 1922). A preliminary experiment following a recipe from Pathé's 1926 manual *Le Film vierge Pathé: Manuel de dévéloppement et de triage* (Didiée 1926: 129) resulted in a somewhat duller blue upon testing with modern stock. Such variations are not necessarily a surprise to those familiar with the traditional pigment chemistry of Iron Blue compounds that predate moving images. As with the variety of traditional pigments (Prussian Blue, Turnbull's Blue, Berlin Blue, Antwerp Blue, etc.) known for what is essentially the same chemical component, the exact color of the Iron Blue tone might well depend on the exact way of its preparation, the size of its particles, and thus perhaps even on the microstructure of the silver it is derived from.

towards an archeometry and chemistry of motion picture color

Film preservation is a relatively young discipline. Efforts to set up ethical and methodical guidelines have been informed by the first decades of film restoration, and have often been pursued independently by archives or even individuals seeking parallels between film restoration and the ethical principles set up in the classical disciplines of restoring art, archeological finds and other artifacts (Edmondson 2004). While some principles have indeed been generally accepted for film preservation – such as the reversibility of any action taken – others are harder to transfer, based on the fact that film restoration is restoration by duplication – creating a new object of what is often (perhaps uncritically) seen as an inherently reproductive art. Yet this "restored" object is not only different from its original by virtue of being a copy, but also by practical and technical limitations. Today it is impossible to create, for example, a Technicolor dye transfer print, or a black-and-white print on nitrate base. And, for tinted and toned originals, only very few laboratories routinely or even commercially engage in chemical tinting and toning of modern restoration copies.

Perhaps the latter limitation makes it even more important to follow the lead of classical restoration disciplines. In the scientific arena, the restoration of art and archeological artifacts is supported by various branches of conservation science and of archeometry, i.e., the use of scientific means to study archeological artifacts (Wagner 2007). Similar studies have been, arguably for the first time, conducted on motion picture film samples in 2008/2010 at George Eastman House's Kay R. Whitmore Conservation Center, using the technique of so-called X-Ray Fluorescence (Ruedel and Podsiki 2013 [forthcoming]).

Chemical approaches, however, should not be limited to the scientific study of the historic material itself. Indeed, the issues discussed above regarding tinting, including eosin and its comparison to the nitrate original with its decomposition patterns, can be regarded as a form of experimental archeology, as pioneered by Paul Read (1998). Such experiments can encourage a closer look into the analog and digital methods of simulating tints on modern film stock, and thus further the understanding of both materials. They have also proven very valuable in teaching and outreach, as in experimental archeology. Even if they fail to encourage a more widespread revival of the craft (for a variety of reasons, including practical and budget-related ones), they are worthwhile in their own right for the study of color history and technology.

There is, however, one other discipline of science that is even more rarely considered for application in film preservation than conservation chemistry and archeometry: Imaging Science (Saxby 2002). A comparatively young formal interdisciplinary field, it explores the physical, chemical, optical, but also the neurological and psychological factors concerning the perception of what we call color. Thus, it is the only field that scientifically considers the entire process relevant for film preservation, from understanding a historic color technology, to matching it as closely as possible using modern techniques, and, finally, the viewing of the result by a modern audience. In current practice, Imaging Science is often concerned

with the proper reproduction of an original's colors (often of historic and art objects) and includes study of the color and chemistry of different colored materials, as for instance, in the "art-si" project at the University of Rochester which has explored spectral imaging for more faithful capturing of the colors of painting (RIT 2005). Given that film restoration employs reproduction of colors, often using chemistries different from the original, this is clearly another discipline that has much to offer the field of film preservation, perhaps presenting possibilities to devise specific capturing and reproduction routes for more faithful rendition of particular historic color systems.

future opportunities

With a new generation of film preservationists entering into the field and specializing in various aspects of the discipline, future enriching and transdisciplinary opportunities arise, in which new experiments and approaches will be inspired by fields as diverse as art conservation, archeometry and imaging science. Those film preservationists open to – or, even better, trained in – relevant technologies and fields may find (especially under the threat of the "death" of analog, carrier based photographic film) an opportunity to further preservation technologies and routes, while engaging in a constant dialogue with archives, academics from both the arts and the sciences, and the restoration laboratories.

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notes

1. Eastmancolor (established in the United States) and Agfacolor (Europe) are examples of *chromogenic* film, which is characterized by the use of dye couplers in layered photographic emulsions. Unlike "unnatural" color systems, these systems aim at photographically capturing a scene's original colors and reproducing them in the photographic film by means of dyes generated during development. The chromogenic systems were preceded by the famous Technicolor system, which shares characteristics of both systems: original colors are captured (albeit on three separate black-and-white film strips), but the positive prints are produced in a process that is essentially lithographic rather than photographic. Generally speaking, these colors are more stable than those of chromogenic film, and can share the saturation and vibrancy otherwise unique to the earlier applied colors.
2. As the color is not noticeable in the darkest areas of the images, tinted films display a tonality ranging from black to the chosen tinting color; in other words, highlights (including the areas between the perforations) look colored while the underlying image appears neutral. The coloring agent is usually an acid dye. Examples include the textile dye Orange G and the food dye tartrazine. As the colored component is formed from the image's silver, toned films rather display a tonality ranging from the deep color of the tone to white; in other words, highlights (including the areas between the perforations) ideally appear neutral, while the image itself is colored. The colored component can be an inorganic, colored metal compound (metal toning), or a more or less colorless metal salt (e.g., silver iodide) subsequently dyed with a basic dye (mordant or dye tone). Examples for metal toning include Prussian Blue (Iron Blue) and silver sulphide (sepia).
3. Similar methods were concurrently developed elsewhere; see for example Case (1987).
4. In an ideal scenario, a tinted and toned copy from the film's original country and time of release would be available. Foreign prints need to be treated with caution as "texts" as their tinting might well be different from the original release. Tinting instructions can be found in "cutting continuities" (basically, protocols of the final edited version of a film) or in "slugs" (short pieces of leader which might contain hand-written instructions) in the original negatives, although in that case the exact hue of a certain color might still be somewhat ambiguous. Often, original negatives might also be arranged by tints, rather than in their narrative chronology, which can help in establishing their original colors. Interesting exceptions are tinted titles in otherwise black-and-white films. In some cases, these are considered of too little relevance to compromise the quality of the photographic images by printing on color stock, or to justify the extra effort of positive splicing in preservation prints.
5. A transcript of the workshop is printed in Hertogs and De Klerk (1996).
6. After having been bought by contemporary film laboratory Cineco in 1995, the synergy of the two companies led to a newly found creative experimentation: Johan Prijs (one of the Haghefilm founders) started experimenting with original camera negative Fuji 64D as a preservation internegative. Originally a highly unusual duplicate material, currently, films with stenciled colors are photographically reproduced almost exclusively with the help of this stock, due to its generally better reproduction of the hues and saturation of the original.
7. This advantage is considered so substantial that, for instance, in the recent digital restoration of the originally tinted and toned Abel Gance 1919 masterpiece *J'Accuse!* (EYE Film Institute and Lobster Film in collaboration with Haghefilm Conservation B.V.), the digital files were written out to black-and-white duplicate negative for subsequent Desmet color grading, rather than applying the colors digitally and recording to color intermediate. Employing a black-and-white negative has the further advantage of largely

eliminating discolorations that are considered to be age and decomposition related, and thus not part of the original. The Desmet printing route on color stock then allows the re-application, photographically rather than chemically, of the colors in a way that somewhat resembles the original tints and tones. Indeed, while the saturations of particular color dyes cannot be achieved on modern film stocks, careful timing allows quite close matching of the original hues.

8. The film is also known under the English title *Windmills that Cheer and Weep.*
9. Reproduced courtesy of the EYE Film Institute Netherlands.
10. Blue dye tones are well documented. See for instance Read (2009).

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