

On the Agfacolor Process

Class: Moving Image and Sound Training

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“The desire for motion pictures in color has been a persistent and an earnest one.”

J.L. Forrest and F.M. Wing, ‘The New Agfacolor Process’¹

In the history of motion picture colour photography, several key processes act as milestones along the path of its development. Some, such as tinting and stenciling, were essential points to pass as the search continued for panchromatic film stock techniques. Others, such as Dufaycolor and Thomson Color, proved to be brief diversions that ended in developmental dead-ends. The Technicolor process, perhaps the most famous of all colour film processes, was not quite a dead-end, but was so expensive a process that the high tolls of this particular path made it unviable for most. Thus one of the most important turns on the road to universally available colour filmmaking was the development in Germany of the AgfacolorNeu negative-positive process in 1939; Helmut Gernsheim argues that with the exception of polaroid, “all modern colour films... are more or less based on the Agfacolor patent”.²

The reasons the Agfacolor negative-positive process is so fundamentally important to the development of colour film technology is how little additional technology was required to operate it. While the chemistry and make-up of the film stock are quite complex, and will be discussed in some detail below, Agfacolor stock required the development or purchase of very little new

¹ Forrest, J.L. and Wing, F.M., ‘The New Agfacolor Process’, in *The Journal of the Society of Motion Picture Engineers*, Vol. 29, No. 3, Easton, 1937, p. 250

²Gernsheim, Helmut, *A Concise History of Photography*, New York, 1986, p. 28

equipment to shoot, develop or project. In its 35mm format, Agfacolor has a 4-perf negative pulldown, meaning at the time of its release it could be used in any standard 35mm camera available. Similarly, once processed, the Agfacolor print could be shown on a regular 35mm projector – allowing perhaps for one small modification, to be addressed later. It is the processing of Agfacolor where some complications arise, but allowing for minor modification of the development apparatus and including additional chemicals and more time for the process to be completed, Agfacolor was not considerably more complex to develop than regular monochromatic film. The relative simplicity of the Agfacolor process made it a defining step in the development of film colour, and its successors were able to follow its example by improving upon its methods while keeping costs down by adhering to its integral tripackstructure.

“Monopack (tripack) was revolutionary because it recorded three emulsions sensitive to the primary colours on a single base. This was much cheaper than three-strip Technicolor since it did not require a special camera. Agfacolor... demonstrated great progress [by depending] on integral tripacks or monopacks which automatically separated the colours of an image when exposed in an ordinary camera.”³

Agfa (Aktien-Gesellschaft für Anilin-Fabrikation⁴) was founded in Berlin in the 1860s, as a manufacturer of dyestuffs, and did not enter the field of photography until 1898, producing its first motion picture film stock in 1903. As such, the use of colour was integral to Agfa long before the development of Agfacolor.

³ Street, Sarah, *Colour Films in Britain: The Negotiation of Innovation 1900-55*, London, 2012, p. 108

⁴Enticknap, Leo, *Moving Image Technology: From Zoetrope to Digital*, London, 2005, p. 18

The silver halide emulsions used in film are sensitive only to blue light in the spectrum⁵, but as far back as 1873, the German chemist Hermann Wilhelm Vogel had deduced that adding forms of synthetic organic dyestuffs to the silver halide emulsion extended its sensitivity to other colours.⁶ It was the Dane, J. H. Christensen, who developed an emulsion of collodion bromide and amyl-acetate that would allow film to be immersed in dyestuffs, creating coloured gelatin images.⁷ His patents were acquired by Agfa in 1912 and became the basis for the first 'Agfa Colour' system, which was released to the German market in 1916.⁸ The Agfa Colour screen plate, released the same year as Technicolor's two-colour Process 1 (Technicolor and Agfacolor similarly share their names with their trial-run incarnations), was an additive three-colour photographic system that after a series of developmental stages resulted in a full-colour image, which due to the irregular sizes of the dye deposits suffered some "clumping" of colour particles.⁹ This clumping made Agfa Colour unsuitable for motion picture filmmaking, as the "restless swarming of the particles obscures observation".¹⁰

In 1930 the company succeeded in producing a two-colour subtractive process, which they licensed to Ufa (Universum Film AG), then Germany's leading film company, as Ufacolor. The first Ufacolor film, *Bunte Tierwelt* (*The Colorful Animal Kingdom*), a short set in a Hamburg zoo, was released in 1931.

⁵ Berger, Heinz, *Agfacolor*, Wuppertal, 1950, p. 14

⁶ *Ibid.*, p. 3

⁷ *The Photographic Journal of America*, Vol. 52, Issue 3, New York, 1915, p. 164

⁸ Coe, Brian, *Colour Photography: The first hundred years 1840-1940*, London, 1978, p. 64

⁹ *Ibid.*, p. 68

¹⁰ Schneider, Wilhelm, 'The Agfacolor Process', Fiat Final Report 976, Office of Military Government for Germany (US), 1947, p. 5

“All the while, however, there was a recognition that only a three-stage process could achieve true color reproduction.”¹¹

In 1932, as the iconic three-strip Technicolor Process 4 first began to light up movie theatres, Agfa was only releasing the second film format under its Agfacolor brand. The 1932 Agfacolor ‘lenticulated’ film was an additive three-colourrollfilm system for still photography that achieved its colour through tiny lenses on the film support and a striped colour filter placed over the camera lens.¹² The system reproduced a decent colour image, but the amount of light absorbed by the filter made it utterly unsuitable for moving pictures. A subtractive process was clearly the only way forward.

AgfacolorNeuverfahren debuted on October 17, 1936. This subtractive three-layer three-colour 16mm reversal film stock was released for still photography and amateur cinematography, and had been developed by Agfa technicians Wilhelm Schneider and Gustav Wilmanns at the company’s factory in Wolfen, a “commercial realisation of [Dr. Rudolf] Fischer’s integral tripack principle”¹³, patented in 1911. Dirk Alt suggests that “Agfa had assigned priority to the development of the reversal process to pre-empt the launch of Kodak’s subtractive color film stock Kodachrome in Germany,”¹⁴ Kodachrome having been released in the USA the previous year. The difference between AgfacolorNeu (henceforth Agfacolor) and Kodachrome is what defines the

¹¹Kapczynski, Jennifer M., ‘Imitation of Life: The Aesthetics of Agfacolor in Recent Historical Cinema’, in *The collapse of the conventional: German film and its politics at the turn of the twenty-first century*, eds. Jaimey Fisher and Brad Prager, Detroit, 2010, p. 46

¹² Ibid., p. 72

¹³ Coe, *Colour Photography*, p. 129

¹⁴ Alt, Dirk, “‘Front in Farbe’: Color Cinematography for the Nazi Newsreel, 1941-1945’ in *Historical Journal of Film, Radio and Television*, Vol. 31, Issue 1, London, 2011, p. 45

success of Agfacolor. Kodachrome captured the image's colour record on three separate layers, similar to Technicolor except on a single strip of film. But with Kodachrome, "the coupler elements (i.e. the chemicals which converted the exposed film into three visible dyes) themselves were not present in the emulsion as exposed, but introduced during processing. This made both the chemistry of the film emulsion (five layers, each one to three microns thick) and processing of it enormously complex".¹⁵ The secret to Agfacolor's success was that it contained these coupler elements within the film emulsion during the manufacturing process – the addition of certain chemicals during the developing process triggered these couplers, producing colour. After negative development, a "single colour development produced the three colour images simultaneously in all three layers".¹⁶ Because of this, whereas Kodachrome required 28 separate steps to process, Agfacolor could be processed in as few as four.¹⁷ The new process was awarded a grand prize at the Paris World Exposition in 1937.¹⁸

Reversal film stock that was easily developed was a major step for Agfa, but reversal film remains unsuitable for mass distribution owing to the absence of an original negative. But the integral tripack system of Agfacolor meant it could be adapted without enormous complication to a negative-positive process, and as Grant Lobban states, "Like traditional black and white filming, a negative-positive system is preferred when a large number of prints are required."¹⁹ Development of such a process would take another few years

¹⁵Enticknap, op. cit., p. 91

¹⁶ Coe, Brian, *The History of Movie Photography*, Westfield, 1981, p. 137

¹⁷Enticknap, op. cit., p. 92

¹⁸Kapczynski, op. cit., p. 46

¹⁹Lobban, Grant, 'The Restoration Business: Preserving the Cinema's Colourful History', in *Image Technology*, Vol. 87, Issue 6, London, 2005, p. 30

however. Nazi propaganda minister Josef Goebbels, a devout cinephile, closely followed the development of Agfacolor²⁰, and encouraged its development even throughout the years of World War II²¹, determined to harness colour cinema as a method of communicating political and social messages to the people as well as rivalling America's Technicolor system.²² As such no expense was spared in creating a negative-positive 35mm form of Agfacolor. By 1939, the first short film produced in the Agfacolor negative-positive process was ready, the musical *Ein Lied Verklingt* (*A Song Fades Away*), premiering in April, "almost exactly 100 years from the birth of photography".²³ It was enough to convince Ufa of the system's "aesthetic viability"²⁴, and they immediately ordered production of the first Agfacolor feature film.

Ufa's musical comedy *Frauen sind doch bessere Diplomaten* (*Women Are Better Diplomats*), directed by Georg Jacoby, began shooting in July 1939, but did not receive its premiere until late October 1941, owing partially to technical difficulties in adjusting to the Agfacolor process, and also to the large number of reshoots required after one of the film's stars, Karel Štěpánek, fled to Britain in 1940.²⁵ However, the film was well received as a landmark in German engineering and entertainment – Jennifer Kapczynski quotes one contemporary headline as proclaiming: "The New German Color Film. The American Monopoly is Broken."²⁶ Germany would produce nine Agfacolor features²⁷ before the Third

²⁰ Ibid., p. 47

²¹ Gluck, Bruno, 'The Manufacture of Agfacolor Material', Fiat Final Report 943, Office of Military Government for Germany (US), 1947, p. 1

²² Enticknap, op. cit., p. 91

²³ Berger, op. cit., p. 30

²⁴ Alt, op. cit., p. 45

²⁵ Ibid., p. 45

²⁶ Kapczynski, op. cit., p. 47

Reich fell in 1945, including *The Golden City* (dir: Veit Harlan, 1942), *Münchhausen* (dir: Josef von Báky, 1943) and *Kolberg* (dir: Harlan, 1945). The German Government also shot considerable amounts of footage for the military on Agfacolor 16mm reversal film, although much of this has since been lost.

So how does Agfacolor work? In their article for *The Journal of the Society of Motion Picture Engineers* in 1937, Forrest and Wing wrote: "The new Agfacolor film comprises a single unitary film structure consisting of a support or base upon which is coated in thin superimposed layers three light-sensitive silver halide emulsions, each made particularly sensitive to one of the primary colors."²⁸ Thus Agfacolor is a subtractive film process, taking in light, with each layer removing the colour to which it is sensitised. Of these three layers the upper layer (outermost from the celluloid base) is "color-blind (blue-sensitive only) and containing a color coupler capable of forming a yellow image simultaneously with the developed silver image. The middle one is green sensitive and contains a magenta image-forming color coupler, and the lower one is red sensitive and contains a blue-green (cyan) image-forming color coupler."²⁹ In his book *Agfacolor*, Dr. Heinz Berger, an Agfa technician who worked at the Wolfen factory and later, after the war, at the Agfa Photo works in Leverkusen, West Germany, adds that there is an important fourth layer in Agfacolor stock, a yellow filter.

"In order to counteract the blue-sensitivity in the latter two cases, it is only necessary to coat these two onto the celluloid base underneath the blue-sensitive layer, and to place a yellow filter layer under the latter. This filter layer absorbs all the blue light reaching it, so that

²⁷ Alt, op. cit., p. 45

²⁸ Forrest and Wing, op. cit., p. 254

²⁹ Gluck, op. cit., p. 3

the two emulsions below it are effectively capable of recording green and red light only.”³⁰

This tripack system (also, confusingly, referred to as a ‘monopack’), therefore allows an even distribution of the three colours that make up white light, with the yellow filter layer preventing the image from being oversaturated by the blue of the spectrum. The structure of Agfacolor film is best demonstrated in the image below.

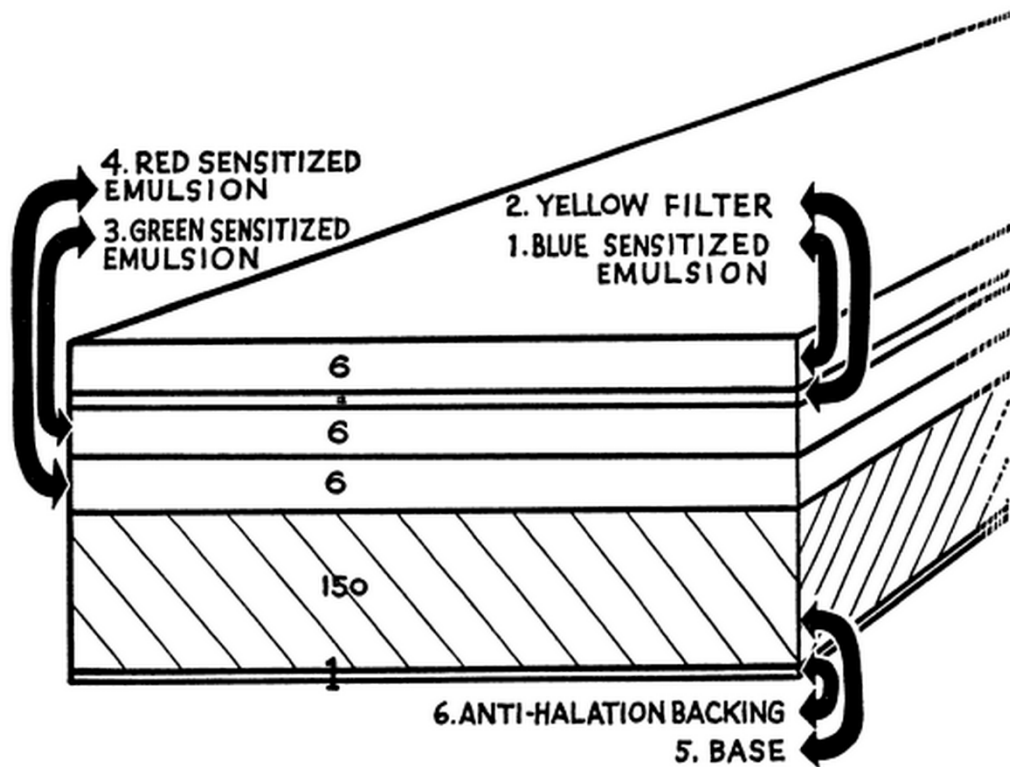


Figure 1: Cross-section of the Agfacolor tripack³¹

The precise thickness of the layers of Agfacolor is as follows:

- Blue layer – 6 microns
- Yellow filter – 2 microns
- Green layer – 6 microns
- Red layer – 6 microns
- Film base – 150 microns
- Anti-halation base – 1 micron
- Total – 171 microns³²

³⁰ Berger, op. cit., p. 14

³¹Spottiswoode, Raymond, *Film and its Techniques*, Berkeley, 1951, p. 212

³²Harcourt, William M., ‘Agfa Colour’, London, 1946, p. 4

This means that Agfacolor film is less than 0.2mm thick, and hardly noticeably thicker than regular black and white film. Early Agfacolor used cellulose nitrate as its base³³ (this was phased out and replaced with cellulose acetate in the years following the war – more on preservation of Agfacolor will follow below), the same as was used for black and white cinematography. The anti-halation backing, which prevents any light passing through the emulsion from being reflected back through it by the base, was initially made of a brown-black colloidal silver for the reversal film, but proved unsuitable for the negative film because it let too little light through and blocked the image in the camera's viewfinder.³⁴ The negative film therefore has a coloured anti-halation backing, which since it only needs to absorb light that would be reflected back into the third red-sensitised layer, is dyed green – a colouring that is “destroyed by the developer”³⁵ and thus has no effect on the final colour image.

This brings us to the development process. As has been discussed, Agfacolor's defining characteristic was that it was the first full-colour negative-positive process, meaning multiple copies of the film could be made from a colour negative produced during development. That development was a relatively straightforward process that could use much of the same equipment used in developing monochrome film. Schneider, who composed an extensive report on Agfacolor for the US Military's FIAT (Field Intelligence Agency, Technical) division, wrote: “In principle, the Agfacolor material is treated in the conventional manner, the developing and the fixing baths being supplemented

³³ Fischer, Maurice, 'Early Agfa Colour Materials', http://www.photomemorabilia.co.uk/Colour_Darkroom/Early_Agfa.html

³⁴ Schneider, op. cit., p. 46-47

³⁵ Ibid., p. 47

only by a bleaching bath to remove the silver formed in the film.”³⁶ Harcourt adds: “Almost any existing developing machine (with a few alterations) can be used; indeed the developing machines in Germany which were used for this process were all of the normal type and none had been specially built for the process.”³⁷

It is worth noting that “there is little enough to distinguish an undeveloped Agfacolor negative film from any ordinary roll-film: the normal celluloid film base has the common dyed gelatin anti-halation layer on the back, and what appears to be the usual sensitive gelatin emulsion on the front”.³⁸ Thus the Agfacolor film that comes out of the camera, while containing within its dye couplers a record of the colours of the image, remains a black and white image, similar to the reversal stock, but in processing forming a colour negative.³⁹ Coe writes: “After the three-layer film had been exposed, it was developed first in a black and white negative developer, and then in a colour-forming developer which reacted with the couplers in each layers to form, simultaneously, cyan, magenta and yellow.”⁴⁰ Baths had to be worked at low temperatures, not exceeding 65°F (18°C), so as to keep the film from frilling.⁴¹ The chemicals used to activate the dye couplers include p-phenylenediamine, p-aminophenol, alkali, sulfite and potassium bromide, introduced in development in an aqueous

³⁶ Ibid., p. 54

³⁷ Harcourt, op. cit., p. 6

³⁸ Berger, op. cit., p. 1 – He continues: “*To the naked eye, then, there is nothing to indicate the wealth of accumulated knowledge, research and technology that has been put into the Agfacolor process, or to suggest the wealth of color which appears in the developed images.*”

³⁹ Lobban, op. cit., p. 30

⁴⁰ Coe, *Colour Photography*, p. 129

⁴¹ Coote, Jack H., ‘Current Processes of Colour Kinematography’, in *British Kinematography*, Vol. 11, Issue 3, London, 1947, p. 87

solution.⁴²Now that both a black and white and a colour negative image remains in the film, the silver halides are bleached out of the film using Farmer's reducer, leaving only the colour negative behind.

"Agfacolor-Negative images have complementary colors! This means: red lips are reproduced as green, blue sky as yellow to orange, etc."⁴³

From this colour negative with its reversed tone and colour values, multilayer positive film could easily be printed for wide release. The printing could be done with any standard film printer – with the Germans in the 1940s favouring a Debie.⁴⁴However, while no additional apparatus was required, it is true to say that printing tripack films was not cheap. Since the printing stock must similarly contain the three layers and separations of the shooting stock, Agfacolor printing stock cost around the same amount as the shooting stock. To draw a comparison, at the same time monochrome release print stock cost less than a third of what negative stock cost.⁴⁵

It was important that the dyes used in producing the image would not be water-soluble, otherwise they would be washed out of the image during the processing.⁴⁶Once the silver has been removed, the images created by the Agfacolor process are highly transparent and "exceptionally well suited for projection. Because of the absence of silver grains, even larger-sized images may be projected than is customary with black-and-white film."⁴⁷ As discussed above, Agfacolor prints could be projected through any regular 35mm projector,

⁴² Schneider, op. cit., p. 26-27

⁴³*Agfacolor f: A Guide or Processing of Agfacolor Negative-Positive Materials*, Agfa, New York, 1961, p. 8

⁴⁴ Harcourt, op. cit., p. 5

⁴⁵Spottiswoode, op. cit., p. 218

⁴⁶ Schneider, op. cit., p. 10

⁴⁷ Forrest and Wing, op. cit., p. 256

provided, however, that certain measures were taken to properly record and playback the soundtrack.

In his report on Agfacolor to the British Intelligence Intelligence Objectives Sub-Committee in 1946, William Harcourt noted the sound issues that Agfacolor produced. This was because the bleaching process removed all the silver from the film print, including the black from the soundtrack, leaving only a blue soundtrack. This was too faint for normal photocells to read, causing sound complications, most notably at the premiere of *Women Are Better Diplomats*.⁴⁸ By the end of the war, however, “all the theatres in Germany were equipped with special blue-sensitive photo cells which had been developed by Zeiss Icon in Dresden, and by A.E.G. in Berlin.”⁴⁹ While replacing photocells in projectors throughout Germany had been possible, selling Agfacolor abroad without forcing cinemas to upgrade or alter their equipment would require a different solution to the Agfacolor sound issue. The only way the black soundtrack could be maintained in the developed film would be for it to not be exposed to the silver-reducing bleach. The technique elected, described by Harcourt as “a great nuisance”⁵⁰, is to omit the bleaching bath and replace it with a high-viscosity solution of bleaching agent applied to the picture via a nozzle.⁵¹ To prevent it attacking the soundtrack, the nozzle’s opening is set only wide enough to coat the picture. “By this layout an accurate separation between the picture and the sound tracks is obtained.”⁵² The diagrams below help to explain this process.

⁴⁸Kapczynski, op. cit., p. 47

⁴⁹ Harcourt, op. cit., p. 13

⁵⁰ Ibid., p. 13

⁵¹ Schneider, op. cit., p. 58

⁵² Ibid., p. 58

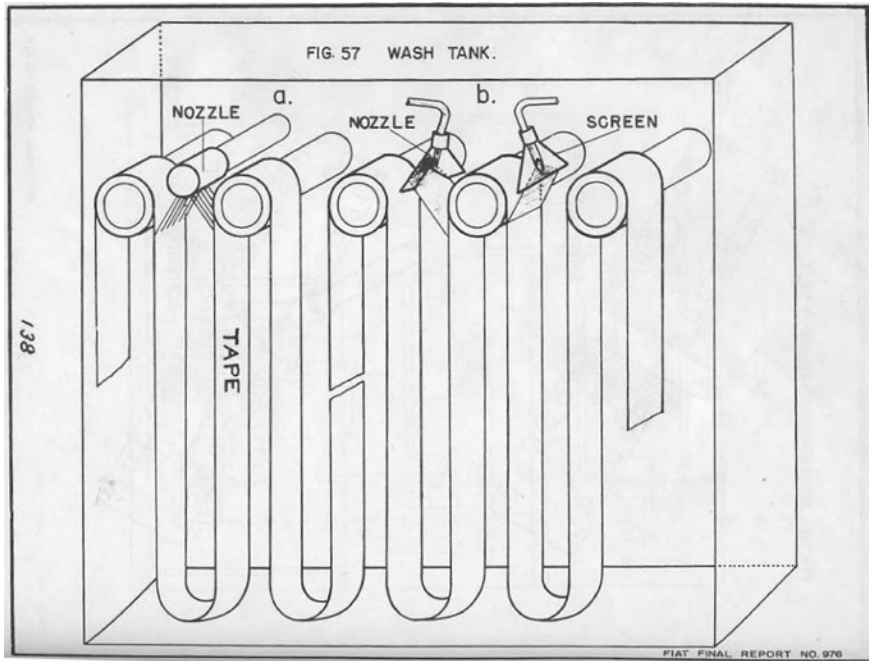


Figure 2: The nozzle applies the bleaching agent⁵³

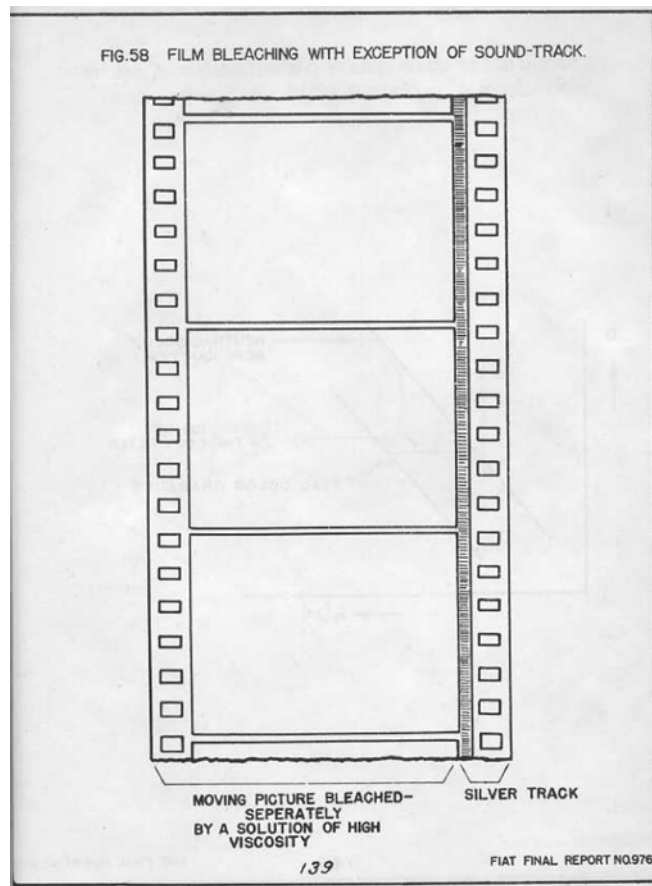


Figure 3: The silver soundtrack has not been bleached⁵⁴

⁵³Ibid., p. 138

⁵⁴ Ibid., p. 139

“After the defeat of Germany, Agfa’s patents became a spoil of war.”⁵⁵

Now that we have seen how the Agfacolor process came about and functioned, we can look at the effect it had on filmmaking internationally. While Agfa endured in both East and West Germany (in the former as ‘Orwocolor’⁵⁶), offshoots of it spread throughout the globe. The Soviets “liberated” the factory at Wolfen, seizing batches of Agfacolor stock that went as far as Prague and Moscow – by 1946 Sergei Eisenstein was filming colour scenes for *Ivan the Terrible, Part II* (1958, release delayed) on Agfacolor taken from Wolfen. Under names such as Sovcolor and Magicolor⁵⁷, the Russians released their own full-colour films, amongst them Sergei Bondarchuk’s colossal *War & Peace* (1966/67). Andrew Dudley writes: “Early in its history [Agfacolor] was typed as a ‘socialist’ method since the Soviets and Czechs seemed to be the most likely exploiters of Agfa.”⁵⁸

But adaptations of the Agfacolor process sprung up across the world. In Belgium Gevacolor emerged, and was used in France, India, and even Australia, where it was used to film *Jedda* (Charles Chauvel, 1955) – Agfa and Gevacolor would later merge in 1964 to form Agfa-Gaevert. In Italy an Agfa derivative, Ferraniacolor, appeared in 1952, and was used to shoot *Aida* (ClementeFracassi, 1953), one of Sophia Loren’s first starring roles. In Japan,

⁵⁵Misek, Richard, *Chromatic Cinema: A History of Screen Color*, Malden, 2010, p. 52

⁵⁶Batistová, Anna, ‘Glorious Agfacolor, Breathtaking Totalvision and Monophonic Sound’ in *Color and the Moving Image: History, Theory, Aesthetics, Archive*, eds. Simon Brown, Sarah Street, and Liz Watkins, New York 2013, p. 49

⁵⁷Limbacher, James L., *Four Aspects of the Film*, New York, 1968, p. 63-64

⁵⁸ Andrew, Dudley, ‘The Post-War Struggle for Colour’, in *Color: The Film Reader*, eds. Angela DalleVacche and Brian Price, New York, 2006, p. 44

the Fujicolor process was highly influenced by the Agfacolor patents.⁵⁹ Despite this, the great Japanese director Yasujiro Ozu shot his colour films (*Equinox Flower* (1958), *An Autumn Afternoon* (1962)) on Agfacolor stock, preferring its more sober tones.

The Americans benefitted perhaps the most from Agfacolor, even if they rarely used it under that name. Agfa's US brand, Ansco, was taken over by the US Government in 1941 due to its ties to Nazi Germany, making Ansco a separate company once more (Agfa had merged with it in 1928). Two Ansco scientists accompanied a Federal commission to Germany in 1945 where Agfa chemists were interrogated about the manufacture of their product (these interviews led to the production of a series of FIAT reports, including those quoted in this research paper).⁶⁰ However, Ansco Color was not seen until 1947, in the Academy Award-winning two-reel short documentary *Climbing the Matterhorn* (Irving Allen).⁶¹ Stanley Donen would later shoot his colourful musical *Seven Brides for Seven Brothers* (1954) on Ansco Color.

While these film stocks were all variations on Agfacolor, one of the system's most important legacies was to spur Kodak on to create Eastman Color, which it released in 1950. Eastman Color was a multi-layer coupler-incorporated negative-positive process that produced a "colour negative to match the quality of 3-strip photography".⁶² Two key advancements in Eastman Color set it apart from Agfacolor and its derivatives, making Eastman Color the defining colour system of the latter half of the Twentieth Century. Firstly, it used smaller resin in

⁵⁹Misek, op. cit., p. 52

⁶⁰ Andrew, op. cit., p. 46

⁶¹Ryan, Roderick T., *A History of Motion Picture Color Technology*, Bath, 1977, p. 122

⁶²Lobban, op. cit., p. 30-31

its dye couplers, forming a “finer grain looking image than the larger long-chain molecules in the layers of its Agfacolor-type competitors”.⁶³ Secondly, the couplers are coloured in two layers of the tripack, providing masking and thus a greater definition between the colours, improving the negative stock.⁶⁴

Like the more famous Eastman Color, Agfacolor prints have been known to suffer colour-fading. Even from the outset it was known that the emulsion layers and yellow filter did not stop unwanted portions of colour from reaching the green and red-sensitised layers. Because of this colours sometimes degraded, and Agfacolor was particularly prone to this in reprinting. “At the beginning, to keep the build up of errors in the colour reproduction to a minimum, all the prints had to be first-generation copies made from the original negative, despite the risk of damage.”⁶⁵ As such, original prints of Agfacolor films often suffer bad colour-fading. Many were produced with a nitrate filmbase, meaning that their storage and preservation are of the utmost importance. However, just as Agfacolor film can run in regular 35mm or 16mm cameras, so too can established archiving practices be applied to it. Storing Agfacolor film in cool, dry conditions with low relative humidity is, as always, the surest way to address its survival.

“Aside from its leading position in colour since the twenties, Technicolor had behind it the enormous prestige of the USA. Agfacolor, on the other hand, was a process without even a viable industrial, let alone national, support.”⁶⁶

⁶³ Ibid., p. 31

⁶⁴Enticknap, op. cit., p. 92

⁶⁵Lobban, op. cit., p. 30

⁶⁶ Andrew, op. cit., p. 41

Perhaps it was its links to Nazi Germany, or the arguable inferiority of its colour, but Agfacolor could never in its lifetime compete with Technicolor. Technicolor's strong, vibrant colours drowned out Agfacolor's pastel-like colours and faded edges⁶⁷. "The look of Agfacolor is quite unmistakable: it comprises a palette of graying greens, darkly saturated reds, and wan blues that contrasts sharply with the bright tones of American Technicolor."⁶⁸ Because of these strong colours, its blacks never look jet black, while its lighter shades look muted and pale.⁶⁹ A recent watching of *Münchhausen* revealed this; its glowing reds and vivacious purples contrast strongly with weak pastel pinks and greying, lifeless beiges. While not as strong as Technicolor's colours, Agfacolor's look is less artificial, if perhaps less mesmerising. The reduced costs compared to Technicolor made it an essential development that has, through many interpolations, altered the way colour films have looked for the last 75 years.

⁶⁷Introduction by Friedemann Beyer, head of the F.W. Murnau Foundation', USA, 2004, Kino International Corp., on the DVD of *Münchhausen* (1943)

⁶⁸Kapczynski, op. cit., p. 41

⁶⁹ Andrew, op. cit., p. 44

Bibliography

Agfacolor Manual: A Guide for Processing of Agfacolor Negative-Positive Materials, Agfa, New York, 1961

This manual, produced by Agfa, has a promising title for a research paper of this variety, but turned out to be simply a DIY guide for amateur photographers using Agfa filmrolls. Mostly chemistry terms relating solely to darkroom developments, and of practically no use to this paper.

Alt, Dirk, "Front in Farbe": Color Cinematography for the Nazi Newsreel, 1941-1945' in *Historical Journal of Film, Radio and Television*, Vol. 31, Issue 1, London, 2011

A fascinating article about the use of 16mm Agfacolor reversal film by the German Army during the war, it was sadly impossible to quote it at length without veering off topic. It's most notable revelation was how most the Agfacolor materials the army shot during the war was printed in monochrome, because it was to be screened in newsreels alongside black and white film and the "Nazi aesthetic" did not permit intercutting between film formats. Full of useful information about the major screenings of Agfacolor films in Germany during the war years.

Andrew, Dudley, 'The Post-War Struggle for Colour', in *Color: The Film Reader*, eds. Angela DalleVacche and Brian Price, New York, 2006

This discussion of how Technicolor and Agfacolor and its derivatives fought for supremacy in France and, ultimately, both lost, is too brisk an overview to be of much use, but contains some useful information about the postwar history of Agfacolor and its relationship to Gevacolor and Ferraniacolor.

Batistová, Anna, 'Glorious Agfacolor, Breathtaking Totalvision and Monophonic Sound' in *Color and the Moving Image: History, Theory, Aesthetics, Archive*, eds. Simon Brown, Sarah Street, and Liz Watkins, New York 2013

A discussion of Agfacolor's role in Czech cinema after the war. Far more discursive of the politics of Czechoslovakia behind the Iron Curtain than about film, it had several interesting points to make about the Czech film industry that, sadly, in a paper of this relatively narrow breadth, could not be included. In a major thesis project on Agfacolor, it would be essential study.

Berger, Heinz, *Agfacolor*, Wuppertal, 1950

Written by an actual Agfacolor technician, this guide to Agfacolor was written in German by subsequently translated into English after Agfa still photography products began to make inroads into Britain and America. While much of the book is taken up with developing paper prints, Berger opens with a lengthy discussion of the Agfa company and the evolution of the Agfacolor process that proved extraordinarily useful in clarifying information for this paper.

Coe, Brian, *Colour Photography: The first hundred years 1840-1940*, London, 1977
A beautifully illustrated book, Coe's writing here is far more concerned with still photography than cinematography. There was some good information about the development of the Agfacolor process, but not much that could not be found elsewhere. His clear writing style however made him far more quotable than other sources writing the same points.

Coe, Brian, *The History of Movie Photography*, Westfield, 1981
A superb overview of the history of motion picture photography, Coe's book, like many of its time, seems to gloss over Agfacolor, and as such was of surprisingly little use to this research paper.

Coote, Jack H., 'Current Processes of Colour Kinematography', in *British Kinematography*, Vol. 11, Issue 3, London, 1947
An extremely brief article on colour filmmaking for the 1940s. It provided no information not expressed in far greater detail elsewhere.

Enticknap, Leo, *Moving Image Technology: From Zoetrope to Digital*, London, 2005
One of the definitive sources on filmmaking technology, Enticknap's book is a superb overview, but he is never one to dwell on one topic, and Agfacolor is no exception to that rule. His writings were particularly useful in drawing comparison to Technicolor and Eastman Color, but otherwise his discussion of Agfacolor was limited to facts with few figures.

Fischer, Maurice, 'Early Agfa Colour Materials',
http://www.photomemorabilia.co.uk/Colour_Darkroom/Early_Agfa.html
An amateur photographer's extraordinarily well-researched web page had considerable detail about Agfacolor and its development. He quoted limited sources, so I was loathe to return to his webpage for several references. It is, however, regularly updated, and has had adjustments made even this month, suggesting that care is being taken to keep it up to date and properly informed.

Forrest, J.L. and Wing, F.M., 'The New Agfacolor Process', in *The Journal of the Society of Motion Picture Engineers*, Vol. 29, No. 3, Easton, 1937
This early article on the still emerging Agfacolor process from an early incarnation of the SMPTE journal was loaded with information, but I could not help but feel untrusting of it. How the writers could be so certain about the production of a material at that stage largely limited to Nazi Germany cause me to raise an eyebrow more than once. Regardless, it is still an essential source as the first major American writing on the Agfacolor process.

Gernsheim, Helmut, *A Concise History of Photography*, New York, 1986
Another book about photography that kept cinematography at the peripheral. It was unable to consider Agfacolor 35mm photo film without referring to its motion picture equivalent. Another excellent book on photography that was sadly of limited use to this paper.

Gluck, Bruno, 'The Manufacture of Agfacolor Material', Fiat Final Report 943, Office of Military Government for Germany (US), 1947

One of two FIAF reports quoted in this paper, this one was produced first and is considerably less detailed. Almost everything it had worth saying would be repeated in Final Report 976.

Harcourt, William M., 'Agfa Colour', London, 1946

This typo-riddled report for the British Intelligence Objectives Sub-Committee (even its title is misspelled) is of particular use for clarifying and simplifying issues discussed in other papers, as it is not written in technical language and seems designed to inform those unfamiliar with film production what this newly liberated Agfacolor product is. Because of its simplistic phrasing, I did not quote it much, but used it as a guide to help me understand certain issues raised in other papers. In that sense it was an essential source for this paper.

'Introduction by Friedemann Beyer, head of the F.W. Murnau Foundation', USA, 2004, Kino International Corp., on the DVD of *Münchhausen* (1943)

This discussion of the film *Münchhausen* attached as an extra on the 2004 DVD release of the restored film by Kino International was an interesting discussion of the history of the film that proved largely irrelevant to this paper. In terms of a history of how the film was made and how it was subsequently restored, it is an excellent resource.

Kapczynski, Jennifer M., 'Imitation of Life: The Aesthetics of Agfacolor in Recent Historical Cinema', in *The collapse of the conventional: German film and its politics at the turn of the twenty-first century*, eds. Jaimey Fisher and Brad Prager, Detroit, 2010

An excellent paper discussing the continued influence of Agfacolor on the aesthetic of German cinema from 1945 to the present, much of its information was unfortunately outside the scope of this discussion. It did provide some useful information about the history and look of Agfacolor that I was unable to find elsewhere. Another good resource that would be essential for an expanded thesis on this subject.

Limbacher, James L., *Four Aspects of the Film*, New York, 1968

This book was disappointingly light on information about the Agfacolor process, and I only came to use it for basic information and film titles.

Lobban, Grant, 'The Restoration Business: Preserving the Cinema's Colourful History', in *Image Technology*, Vol. 87, Issue 6, London, 2005

Lobban's article, which I came across late in my research, proved pivotal in explaining elements of the makeup of Agfacolor and its relationship to Eastman Color. Brief, but thorough.

Misek, Richard, *Chromatic Cinema: A History of Screen Color*, Malden, 2010

Another book that showed great promise but, with regards to Agfacolor, was of very little use to my research.

Ryan, Roderick T., *A History of Motion Picture Color Technology*, Bath, 1977
What should have been a goldmine of information proved frustratingly empty - this is another book produced during the Cold War that suspiciously glosses over the role of Agfacolor in film history. It has pages of information on the technical specs of both Ansco Color and Gevacolor; had it provided the same detail on Agfacolor it would have been invaluable, as such I couldn't trust its information on the other brands would translate to Agfacolor, and thus could not use much of it.

Schneider, Wilhelm, 'The Agfacolor Process', Fiat Final Report 976, Office of Military Government for Germany (US), 1947
The most invaluable source in the writing of this paper, Schneider, another Agfa chemist, wrote this extensive chemistry- and manufacture-centric report for FIAT. It is in-depth, well-written and well-illustrated, if perhaps a little complex for the non-scientist reader. An essential history of the Agfacolor process and its methods at the end of World War II.

Spottiswoode, Raymond, *Film and its Techniques*, Berkeley, 1951
Yet another book that is a thorough overview of film, but does not go into much useful detail. Its discussion of the tripack system is brief and covered in better detail elsewhere, but as a text it remains a useful broad discussion.

Street, Sarah, *Colour Films in Britain: The Negotiation of Innovation 1900-55*, London, 2012
Agfacolor and its subsidiaries sadly never took hold in Britain until Eastman Color arrived there in the mid-1950s, so this article was low on information. Essential reading for a paper on Technicolor, however.

The Photographic Journal of America, Vol. 52, Issue 3, New York, 1915
A brief piece of information in this journal helped clarify some early patent information. I did not investigate in any depth beyond that.