Chapter 5 A very brief history of colour photography

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Abstract

In 1816 Joseph Nicephore Niepce had yet to invented photography, although he had already shared with his brother Claude his concern to "find a way to fix colours" (Niepce, 1973). Other curious and practitioners of the new technique shared the same feeling, and their endeavours led to a first accessible solution: hand-applied colour. From the dawn of photography come splendid examples of skillfully painted daguerreotypes and the wonderful albumen prints of the Beato brothers painted by Japanese artists in Yokohama studio in 1860.

The search for a photochemical process capable of fixing light, shadows and colours at the same time has engaged scholars and scientists in a continuous chase of techniques. Similar to other human events, such a race would see losers and winners. From Levi Hill's first "false" discovery to John Joly's intuition, upon which the digital photography is still based today. From Thomas Sutton's photography, which put into practice physicist J. C. Maxwell's theories, to the first digital camera by Steven Sasson and Kodak. We should not forget the marvellous photographs taken by Sergei Mikhailovich Prokudin-Gorskii, the first to bring colour photography out of laboratories and studios into the real world.

Colour photography as an expressive medium developed along with the evolution of the photochemical process. Before becoming a consolidated reality it had to wait for the stability of the results achieved by the Lumiere brothers' Autochrome films. Most important photographers in the history of photography have challenged themselves with colour photography, thus showing its expressive potential. However, colour photography has never freed itself from the halo effect of a means intended for commercial or vernacular purposes. Only when William Eggleston opened the first exhibition of colour photographs at the MoMA in New York in 1976, a real change of pace and consideration took place.

Keywords:

Colour photography, photography, history.

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1. Introduction

We are all used to colour photographs to the point that we take them for granted. Family photographs, travel photographs and photographs of our memories are in colour, maybe a little faded and timeworn, but they are in colour. When we take a photograph using our smartphone, the photograph is in colour.

In the world of photography, colours might be considered natural because of the very fact that photography exists. However, it has not always been so. Photography originated in black and white, almost despite general expectations and only after many mistakes, some early enthusiasm and much study did it turn into colours.

The history of photography is a dense mesh of paths and stories that are difficult to separate from one another. It is impossible to talk about cameras without talking about the evolution of the chemical-physical - and now also electronic - aspects of its processes. It is also impossible to talk about the personalities who have studied its history without mentioning genres and artistic movements.

Here we will try to pay particular attention to the aspect of colour in photography, exploring how it was considered a fundamental requirement from the very beginning and therefore a much sought after element. We will outline how it became an integral part of each photographer's expressive language, to all intents and purposes. The names and events covered in this paper are by no means exhaustive as the history of photography is made of many more fascinating stories and equally mesmerising characters that, for the sake of space, we are not able to include here.

2. At the beginnings

2.1 The Camera Obscura

On a bright sunny day, a ray of light finds a small hole in the curtain closing a door, creeps in and is projected onto the opposite wall, bringing with it the image of the outside world.

The step from the moment of awe to the study and repetition of the physical phenomenon was a "short" one: in his 'Problems' (in ancient greek: Προβλήματα, Problémata) Aristotle had been one of the first to study it (Ferrini, 2002), but it was the Arab scientist Alhazen Ibn Al-Haitham (Basra, c. 965 – Cairo, c. 1039), just before the end of the first millennium, to dive into the study of light reflection and give a name to the 'box' that allowed this phenomenon: the *camera obscura,* the darkroom.

In the 16th century, the Italians Gerolamo Càrdano (Pavia, 24 September

1501 – Rome, 21 September 1576) and Daniele Matteo Alvise Barbaro (Venice, 8 February 1514 – Venice, 13 April 1570), in close succession, improved the optical performance of the *camera obscura,* first by adding a biconvex lens to the pinhole and then a diaphragm with a diameter smaller than the one of the lens.
Thanks to the German Jesuit Athanasius Kircher (Geisa, 2 May 1602 – Rome, 28 November 1680), in 1646, the *camera obscura* transitioned from being a simple entertainment spectacle to a real tool in the hands of illustrators and painters. A drawing darkroom was built in Amsterdam in which the artist and his assistants could comfortably work inside to produce engravings or paintings.
Among the many users of the *camera obscura* worth mentioning here is Giovanni Antonio Canale (Venice, 18 October 1697 – Venice, 19 April 1768), commonly known as Canaletto. The 18th-century Venetian Vedutista, renowned for the incredible precision of his perspectives and geometries, used a portable *camera obscura* now housed in the Museo Correr in Venice (Canaletto's Camera obscura - Google Arts & Culture, 2021). The contemporary use of the *camera obscura* by Cuban-American photographer Abelardo Morell (Havana, 17 September 1948) (Abelardo Morell, 2021) in his projects 'Camera Obscura' and 'Tent-Camera', is also of great artistic interest.

2.2 The Magic Lantern

The origin of the Magic Lantern is still confused, but it is commonly accepted that its discoverer was by the same German Jesuit mentioned above, Athanasius Kircher: in 1646, Kircher published 'Ars Magna Lucis et Umbrae' (Kircher, 1671) in which he included the use of a convex lens to enhance the projection of images with the aid of candles or sunlight.
The Magic Lantern is technically the reverse of the *camera obscura*: a light source enclosed inside a box emits a light that, passing through a hole and through a drawn glass, projects what is drawn on the glass onto a surface outside the box.
All the magic is in the decorated and coloured glass that is projected from a miniature onto an external surface. The bigger the distance, the larger the projected image.
"The most colourful images appear on your white wall!" wrote Goethe (Frankfurt, 28 August 1749 – Weimar, 22 March 1832), "[And even if they were only faint ghosts], they still delight us when we admire them with the naivety of children, thrilling to the marvellous apparitions" (Goethe, 1774). The enthusiasm could only be boosted further with the discovery that a quick

transition from one glass to another could give the impression of movement. Adding to that, the superimposition of two or more glasses could make the projected scene look even more complex. The apex of fervour was reached when a simple mechanism could make superimposition and movement coexist.
With the Magic Lantern we find ourselves in a field closer to cinema than to photography (although the magic lantern principle will return powerfully in the slide projector). To some extent, we could say that the public 'knew' that colour images 'existed', they saw them and therefore somehow it was deemed possible to obtain them, although they were still the outcome of a 'manual' procedure.
Meanwhile, the c*amera obscura* was becoming an increasingly common technological aid for creating images, engravings or paintings. However, it was still an evanescent image, which would disappear as soon as the light that projected it vanished. Further studies and experiments were needed, especially with those materials and chemical compounds that blackened under the action of the air or, preferably, of the light.

3. The birth of photography

On 22 June 1802, the Journal of the Royal Institution of Great Britain published a contribution by Thomas Wedgwood (Etruria, 14 May 1771 – 10 July 1805) and Humphrey Davy (Penzance, 17 December 1778 – Geneva, 29 May 1829), the former the heir to a dynasty of potters and the latter one of the most influential chemists of the time. The title of the article was "An account of a method of copying paintings upon glass and of making profiles by the agency of light upon nitrate of silver." In fact, the publication gave way to the invention of photography. It combined, for the first time in a resourced way, the scientific knowledge of optics and chemistry available at that time.
Wedgwood and Davy successfully created 'outlines' (or 'silhouettes') but could not prevent these images from fading when viewed in a light brighter than candlelight.
Nevertheless, the groundwork had now been laid, and it was up to Niepce (Chalon-sur-Saône, 7 March 1765 – Saint-Loup-de-Varennes, 5 July 1833), William Henry Fox Talbot (Melbury, 11 February 1800 – Lacock, 17 September 1877) and Louis-Jacques-Mandé Daguerre (Cormeilles-en-Parisis, 18 November 1787 – Bry-sur-Marne, 10 July 1851) to complete the journey of discovery. This culminated on 7 January 1839 when Daguerre presented a process that would later take his name at the Academy of Sciences in Paris. As it happens, despite the strive for conquering colour -an endeavour

that Niepce had already shared with his brother in 1816- photography was first born in black and white.
The newly discovered photograph was greeted with great surprise: at last, a face or a landscape could be recorded in great detail and with great ease. However, a great disappointment immediately followed the surprise: the colours were missing!

3.1 Hand-applied colour

The first clients of such a newly discovered photograph and their photographers immediately advanced the request for colour photography. In a short while, they found the easiest way to solve the problem: applying colour manually.
"When the photographer has succeeded in obtaining a good likeness, it passes into the artist's hands, who, with skill and colour, give to it a life-like and natural appearance" (Rintoul, 1851).
To be precise, the colouring procedure is not as simple because of the characteristics of the daguerreotype, which consists of silver or silver-plated copper plate, polished to a mirror finish, which is then exposed to iodine vapour. The surface of the daguerreotype is extremely delicate and the colouring process was not accessible to everyone. In 1842, London-based daguerreotypist Richard Beard (Plymouth, 22 December 1801 – Hampstead, 7 June 1885) filed a series of patents illustrating several methods for colouring, the simplest of which involved "stippling dry colours onto different parts of the picture and then settling the colours by breathing on them2 (Coote, 1993).
While in Europe, the hand-application of colour on photographs was almost a necessary expedient to satisfy the expectations of customers and practitioners, in Japan, this technique became very popular and gained fame as a refined and respected art form from 1860 onwards. Much of the credit for this success can be attributed to Felice Beato (Venice, 1832 – Florence, 29 January 1909), who certainly had the foresight to entrust the colouring of his albumen prints, obtained from wet collodion glass plates, to Japanese water-colourists. The beauty of the result of this collaboration can be admired in the prints and albums that Felice Beato sold at his studio in Yokohama (Views of Japan, Getty Museum, 2021).
However, there was still a problem. No matter how good the artist was at colouring the photograph, the selection of colours was still arbitrary. The colours selected could be different from those of the recorded scene. Photography was increasingly required to be able to faithfully record the colours as well as the lighting of the scene. Hand-colouring of photographs

remained widespread until the middle of the 20th century, especially in portrait and wedding photography (see, for instance, the Polish *monidło*). However, its use eventually declined, a process that was accompanied by the equally rapid advent of the colour film.

4. The colour revolution

At the time of the birth of photography, the nature of colour had been known for around 200 years: Isaac Newton (Woolsthorpe-by-Colsterworth, 25 December 1642 – Kensington, 20 March 1726) used a prism in 1666 to divide a beam of light into the seven colours of the spectrum. Moreover, Magic Lantern shows were quite common among people. However, more knowledge was needed.

The breakthrough came in 1861 when Scottish physicist James Clerck Maxwell (Edinburgh, 13 June 1831 – Cambridge, 5 November 1879) presented a brilliant demonstration of his three-colour additive method at the Royal Institution in London (Evans, 1961). The presentation combined physics and physiology. To best explain the experiment, Maxwell asked photographer Thomas Sutton (Kensington, London, 1819 – Kensington, London , 19 March 1875), who would also be the inventor of the Single-Lens Reflex Camera, to expose a ribbon of tartan on three wet collodion glass plates, each exposed through a coloured filter: red, green and blue.

Then the three sheets of glass were projected on a wall, one on top of the other in register, each filtered through the original coloured glass. To everyone's amazement, the colours of the tartan ribbon were displayed on the wall. However, above all, the world's first colour photograph was brought to view.

While Europe was racing to find a process capable of fixing colours, the United States of America proved to be fertile ground for two events that, above all, by crossing their paths, would mark the evolution of photography. In 1885, while searching for a strong, transparent material to use in his lectures, the Reverend Hannibal Goodwin (Ulysses, 21 April 1822 – Ulysses, 31 December 1900) came across celluloid. After months of experiments, he mixed nitrocellulose with nitrobenzol and diluted it with alcohol and water. The mixture was then spread on a glass plate, and once the volatile components had evaporated, celluloid remained, as transparent as glass and as flexible as paper.

That was a blessing in disguise for photographers, who finally had a flexible material that could be coated with a photosensitive emulsion.

Goodwin decided to apply for a patent on 2 May 1887 for "a photographic pellicle and process of producing the same [...] especially in connection with

roller cameras", but did not obtain it until 13 September 1898 after several corrections and numerous legal actions (Moran, 2021).
A few kilometers away from Goodwin, another inventor, George Eastman (Waterville, 12 July 1854 – Rochester, 14 March 1932), had already started to produce and market cameras. In 1889, he replaced the roll of photosensitive paper with a roll of film he had invented with a process very similar to the one of Reverend Goodwin.
George Eastman and his new company, Kodak, applied for a patent on 9 April 1889 and received it on 10 December 1889, just 11 months later.
While there seem to be all the ingredients for a spy novel, the apparent unequal treatment had been caused by the Reverend Goodwin's consistent inaccuracies in his replies to the multiple requests for clarification sent by the patent office. Clearly, the Kodak's patent application drafted by the chemist Reichenbach must have been much more precise.
Goodwin nevertheless took legal action against Kodak in order to have his patent recognized as preceding George Eastman's film. In the meantime, the ANSCO company which had acquired the Goodwin Film and Camera Co. of New Jersey, succeeded in winning the case against Kodak in 1914 and was paid $5 million (New York Times, 1914), about $130 million today.

4.1 Synthesis and Interference of Colour

The first steps into direct colour in photography bring us to meet four characters of different fortunes.
The first one is the American Reverend Levi Hill (26 February 1816 − 9 February 1865), who announced as early as 1850 that he had discovered a process for fixing colours based on the daguerreotype. When, after much reluctance, the process called Hillotype was disclosed to the public, it proved so complex that it was deemed almost fraudulent, and Hill was accused of painting his daguerreotypes. In 2007, after six months of research, the curators at the Smithsonian's National Museum of American History confirmed both the process and the fraud: Hill had succeeded in fixing some of the colours, but external pressures led him to add the missing ones by hand. "Hill was indeed a genius, but he was a flawed genius" (The J. Paul Getty Trust, 2007). At the age of 48 in 1865, he died by the continuous inhalation of chemicals vapours he had used in his experiments.
The second character, Gabriel Lippmann (Bouneweg, 16 August 1845 – SS France, Atlantic Ocean, 13 July 1921), professor of physics at the Sorbonne in Paris, announced in 1891 to the Academy of Sciences that he had discovered a direct method for obtaining and maintaining colours in photographs. The procedure consisted of recording the interference of the

electromagnetic waves of direct light with its reflection. That was an original method, different from all others in that it used the fundamental components of light itself and did not require inks and pigments. To achieve this, Lippmann used a panchromatic plate behind which was placed a mercury mirror. The incident light waves interfering with their reflections create a kind of texture within the thickness of the emulsion (where each colour corresponds to a specific spatial value), achieving a correct separation of colours. As a result, when the plate is viewed in white light, it will show a correct colour reproduction of the photographed scene (Lippmann, 1891). It was an exact, but also very complex procedure, which prevented it from becoming a popular commercial product. Nevertheless, thanks to this research result, Lippmann won the Nobel Prize in 1908.

Luis Ducos du Hauron (Langon, 8 December 1837 – Agen, 31 August 1920), a multi-faceted scientist with a background as an amateur painter, is our third protagonist. Du Hauron was well aware that mixing red, green and blue in different proportions could result in infinite shades of colour. He decided to investigate the matter as a physicist and came up with a procedure that seemed to give good results, which he presented to the French Society of Photography in 1868. He was not aware that on the same day, just before him, another inventor, Charles Cros (Fabrezan, 1 October 1842 – Paris, 9 August 1888), was at the French Society of Photography to describe exactly the same process. The two became friends and began a maintained collaboration until Cros decided to move onto something else. The procedure devised by Ducos du Hauron involved taking three negatives filtered with green, orange and violet, respectively. These would then be printed on dichromated gelatine film coloured with pigments complementary to the shot's filters (red, blue and yellow). They would finally be superimposed in register until a colour image was obtained (Langlois, 2017) (Ducos du Hauron, 1897).

Our fourth character is the Soviet Sergei Mikhailovich Prokudin-Gorskii (Murom, 30 August 1863 – Paris, 27 September 1944) who used his experience as a chemist to extensively experiment with colour separation. To minimise the time between exposures, he first used and then perfected a camera with an oblong, sliding back designed by his friend and mentor Adolf Miethe (Potsdam, 25 April 1862 – Berlin, 5 May 1927), an important German chemist who was also involved in research into colours in photography. Prokudin-Gorskii had, above all, the merit of taking colour photography out of the laboratories and studios: he decided to travel and explore the vast territories of Russia to record the splendour of the pre-revolutionary Russian Empire. For the purpose, the Tsar Nicholas II gave him a pass and presented him with a darkroom carriage where he could work during long journeys

(Prokudin-Gorskii, 2012). The wondering took Prokudin-Gorskii to Paris, where he opened a photographic studio, still in operation today, and died in 1944. Sergei Mikhailovich Prokudin-Gorskii's great work is preserved in the Library of Congress of the United States of America (Prokudin-Gorskii, 2021).

5. Additive colour synthesis

5.1 The Krōmskōp

"The Krōmskōp is an optical instrument which accomplishes for light and colour what the Phonograph accomplishes for sound and the Kinetoscope for motion" (Ivers, 1898).

Thus begins the preface to the volume that Frederic Eugene Ivers (Litchfield, 17 February 1856 – Philadelphia, May 27, 1937) dedicated to the Krōmskōp, a device he had invented that allowed the vision of negatives created by applying the theory of colour separation demonstrated a few years earlier by J. C. Maxwell.

The transparent positives, also known as kromograms, were made according to the dictates of colour separation and were then placed on Ivers' device and displayed through special red, green and blue filters. The correct orientation of a mirror provided the necessary backlighting to appreciate the chromatic precision achieved fully.

With the viewer, Ivers also developed and marketed equipment that could create kromograms, but the future was just around the corner. After a few years, the initial enthusiasm for the incredible beauty of the colours that could be achieved left behind the complexity of the process to pave the way to the simplicity of the newcomer: the Autochrome process.

5.2 The Joly's Process

Colour photography was, in fact, a reality. It required complex processes, extreme precision and bulky cameras. The three-shot process for colour separation was an insurmountable obstacle for many, not only from a financial perspective.

At Trinity College, Dublin, in 1895, John Joly (1 November 1857 – 8 December 1933) took a considerable and consistent step forward in the evolution of colour photography technology: the theoretical foundation still rested on Maxwell's colour separation, but he managed to relieve it of the complexity of three consecutive shots. The brilliant intuition was to compress and miniaturize the three coloured filters on a single glass plate. Very thin coloured lines (aniline dyes mixed with rubber) were drawn and juxtaposed

to the photographic plate. Once the negative, which was in black and white, had been developed, it was superimposed on the coloured screen used for filming (or a similar one), and the colours could be seen through the transparency (Hirsch, 2004).
For the production of glass plates with coloured lines, Joly designed a machine capable of drawing very thin (<0.1mm) juxtaposed and non-overlapping lines.
Joly's additive process was the first to be introduced on the market and remained available for a few years; however, the poor colour fidelity due to the partial colour sensitivity of the emulsions of the time limited its success and diffusion (Coe, Brian, 1978).

5.3 The Autochrome

The Auguste (Besançon, 19 October 1862 – Lyon, 10 April 1954) and Louis (Besançon, 5 October 1864 – Bandol, 6 June 1948) Lumière brothers had been working on colour photography since the last decade of the 19th century. They had published their first article on the subject in 1895, almost at the same time they made their most famous discovery: the Cinematograph.
In 1903 they applied for a patent for their process, the Autochrome, and a year later, they finally made a presentation at the French Academy of Sciences.
Compared to Joly's work, the Lumière brothers realised that combining photographic emulsion and coloured filters into a single body was possible. In so doing, they further simplified the process and materials needed to take photographs, which was designed to be viewed "by hand" or by using a "diascope" (Diascope - RIHS Graphics Collection Survey Project, 2021) or magic lanterns.
The production of Autochrome plates was complex but fascinating. The key ingredient that managed to revolutionise the world of photography after 100 years of applied chemistry was potato starch. Using a very fine sieve, the Lumières selected grains with a diameter of 10-15 microns that were then coloured red, green and blue-violet. They then spread them on a glass plate, the empty spaces filled by sprinkling charcoal powder. The plate was then pressed to thin the grains and improve the passage of light, and finally varnished to protect the starch from moisture. Finally, the photographic emulsion was applied. It is estimated that more than 600,000 grains of starch fit into one square centimeter.
The Autochrome commercial success was immediate, and Alfred Stieglitz (Hoboken, 1 January 1864 – Manhattan, New York, 13 July 1946) was an enthusiastic ambassador for it: "Colour photography is an accomplished fact!

The seemingly everlasting question of whether colour would ever be within the reach of the photographers has been definitely answered. […] The possibilities of the process seem to be limitless […] In short, soon the world will be made with colour, and Lumière will be responsible […]" (Stieglitz, 1907).
Autochrome production continued until 1932, at a rate of around 6,000 units per day when the advent of new technology sparked a new revolution.

6. The subtractive synthesis of colour

Luis Ducos du Hauron can also be considered the forerunner of the subtractive theory of colours. As early as 1860 he proposed using the same filters used in additive synthesis to make three positives dyed with the respective complementary colours: cyan, magenta, and yellow (which subtract - hence the name - the corresponding primary colour). By superimposing these colours, it is possible to reproduce all the other colours (Ducos du Hauron, 1860).
If the additive method requires a large amount of light to display the colour white, the subtractive method needs a simple sheet of paper or very clear glass.
The need to obtain three different exposures was the driving force behind creativity. Many solutions were found, from the simplest one, such as sliding back with three positions with different filtering, to the most complex ones such as single-shot cameras that, thanks to complex games of prisms and mirrors, were able to record three exposures at the same time.

6.1 The rise of Tripack

Frederic Ivers, the inventor of the Krōmskōp, made the first attempt to combine the three plates used in colour separation into a single element. Ivers' "Hiblock" system, presented in 1916, was a sandwich in which a green-sensitive film was inserted between two sheets of glass that reacted to blue and red. After exposure, the sheets were developed separately.
In 1928, Colorsnap made its first appearance in England, promising natural colours with any camera, affordable costs and effortless reproduction of any size. The promises were soon broken to their disappointment, forcing the company to hand-colour the black-and-white prints they could make from the first tripack element. In less than a year, the company was forced to close.
The congenital problem of the tripack, which had not been adequately investigated, lay in the behaviour of the light as it passed through the numerous layers of transparent material. The continuous deviations of the

light rays blur the images of the second and third layers, making a 'geometric' correspondence between the layers and any magnification impossible.
The only possible solution was to apply the three emulsions rather than physically separate them. They adhere to each other directly on the support, be it glass or plastic film.
Rudolph Fischer (Berlin, 1881 - Berlin, 1957) patented the using of what would later be called colour couplers in 1912 and 1914 and coined the term chromogenic (Hirsch, 2004). Fischer suggested that these colour couplers necessary for the creation of cyan, magenta and yellow should be embedded in specific layers of tripack so that the coloured images would be obtained after development. Unfortunately, during the development, the colour couplers mixed in the emulsion and compromised the result. However, Fischer's insight paved the way for the commercial success of tripack.

6.2 The Kodachrome

"[…]Kodachrome
They give us those nice bright colors
They give us the greens of summers
Makes you think all the world's
a sunny day
I got a Nikon camera
I love to take a photograph
So mama don't take my Kodachrome away […]" (Simon, 1973)

The Kodak Kodachrome was the first tripack to achieve real technical and commercial success. It was the undisputed queen of colour photography from 1935 to 2009, marking the imagination of entire generations of photographers. It even earned a song by Paul Simon, which is a perfect fit given that two professional musicians, Leopold Mannes (New York, 26 December 1899 – Tisbury, 11 August 1964) and Leopold Godowsky Jr. (Chicago, 27 May 1900 – New York, 18 February 1983), worked on its invention. Their good initial work impressed Kodak's director of research laboratories Kenneth Mees (Wellingborough, 26 May 1882 – Honolulu, 15 August 1960), so much that he decided to support their research, which eventually resulted into the definitive Kodachrome.
Like Fischer, Mannes and Godowsky struggled with colour couplers leaking into the emulsion during development. However, they managed to circumvent the problem: Kodachrome was a colour positive (or so-called 'slide') film produced by a subtractive colour photography process, in which colour pigments were added during the complex stages of developing, dyeing

and bleaching. That was a very complicated 28-station process that forced Kodak to centralize the development of Kodachrome in its Rochester, NY facilities.

6.3 The Agfacolor-Neu

In 1936, Agfa also announced its own tripack: the Agfacolor-Neu, which started from and improved on Rudolph Fischer's insights into colour couplers. Agfa's laboratories figured out how to embed the colour couplers in the individual layers of the emulsion. This made its development process less complex than that of Kodachrome, so that individual photographers could even carry it out in their private darkrooms.
One hundred years had passed since the official birth of photography. With the commercialization of Kodachrome and Agfacolor-Neu, colour photography was finally a concrete reality available to all.

6.4 Colour Photography inspire new languages

The name Kodachrome is also inextricably linked to some great photographers who were the first to explore colour in photography as a new language or, trivially, as a new opportunity to record reality.
The American photographer Eliot Porter (Winnetka, 6 December 1901 – Santa Fe, 2 November 1990) devoted almost his entire career from 1935 to shooting birdlife and landscapes, recording the wonderful colours of nature; in 1941, he won a Guggenheim Fellowship to devote himself entirely to birdlife. Inspired by Ansel Adams (San Francisco, 20 February 1902 – Monterey, 22 April 1984), who called him "the master of the colour of nature" (Porter, 1979), and by the writer Henry David Thoreau (Concord, 12 July 1817 – Concord, 6 May 1862), Porter is considered one of the noble fathers of nature photography.
In the years immediately following World War II, colour photography on film reached a point of no return: emulsions were sufficiently stable and accurate in colour reproduction, films were available for a wide variety of cameras, and a network of developing labs began to thicken. While this progress supported the image professionals, it also helped to create a new category: the occasional photographer who recorded the family parties and holidays.
In 1953, LIFE magazine published a 24-page full-colour report on New York for the first time. In a world of photojournalism, where black and white photography ruled, also for technical reasons, a breakthrough had been made. The author of the report was a young Austrian photographer, Ernst Haas (Vienna, 2 March 1921 – New York, September 12, 1986). Already a member of the exclusive Magnum Agency, as soon as he arrived in the United States,

he began experimenting with the Kodachrome colour, arousing considerable criticism within the agency itself. At the time, colour was reserved for commercial and advertising photography and was not considered to have any journalistic or artistic value.
It was only in 1976 that colour photography became an established means: John Szarkowski (Ashland, 18 December 1925 – Pittsfield, 7 July 2007), the curator of photography at the Museum of Modern Art in New York, decided that William Eggleston's (Memphis, 27 July 1939) colour photography deserved a solo exhibition. It was a rupturing event that gave rise to numerous criticisms and deep rifts in the world of photography and art.
However, by then, the road was marked, and colour photography could shed its vernacular mantle and move towards new horizons: Luigi Ghirri (Scandiano, 5 January 1943 – Roncocenesi, 14 February 1992), Franco Fontana (Modena, 9 December 1933), Stephen Shore (New York, October 8, 1947), Candida Höfer (Eberswalde, 4 February 1944) are just a few of those great photographers who have used colour as an extraordinary tool of artistic expression.

7. Polaroid's instant colour

The story goes that the spark of creativity was ignited by his daughter Jennifer. After posing for a photograph, she insisted with her father that she wanted to see it immediately, which was impossible in 1943. Edwin H. Land (Bridgeport, 7 May 1909 – Cambridge, Massachusetts, 1 March 1991), a physicist of prolific intelligence, worked secretly for three years on how to please his daughter. In 1947 he succeeded in making the first public demonstration of his instant-development film. After pressing the shutter release button, the camera mechanism ejects the film by passing it through two rollers. This compression breaks the containers hidden in the white frame characteristic of the Polaroid. After about 60 seconds, depending on the ambient temperature, the negative could be peeled off so that the image could be appreciated firmly imprinted on the positive.
In 1963 Land released the colour version of his film, the Polacolor, and in 1972 he debuted a new 'integrated' film design, which no longer needed to be 'torn'.
The Polaroid system was a commercial success, loved by amateurs and artists, who often made it their primary tool.
Land died in 1991, ten years before his Polaroid Corporation was declared bankrupt.
Edwin H. Land also had the intuition to invite some of the great photographers of the time to collaborate with Polaroid: free material in

exchange for feedback and a few works as gifts. The specificity of Polaroid fascinated some of them who made it their tool, if not their icon. David Hockney (Bradford, 9 July 1937) started with his collages in the early 1980s when he realised "he had never seen a similar result with photography" (The David Hockney Foundation: 1982, 2021).
It is almost hard to imagine Andy Warhol (Pittsburgh, 6 August 1928 – New York, 22 February 1987) without a Polaroid camera in his hand, as his personal image is so closely linked to the camera that accompanied him for almost twenty years without interruption.

7.1 Demosaicing and Digital Photography

In order to complete the history of colour photography, we cannot fail to mention the birth and definitive advent of digital photography.
Digital photography was born in Kodak's laboratories in 1975 thanks to Steven Sasson's (New York July 4, 1950) work, who was asked by his director what could be done with the new CCD sensors. Sasson then built a camera that could record a 100x100pixel (equivalent to a resolution of 0.01Megapixel) black and white image on a cassette, which needed a television set and 23 seconds to display it. The technology and the idea were right, but the courage was probably lacking, and Kodak decided not to fund the project further, believing that "no one would want to look at their pictures on a screen" (Kodak, 2021). A year later, Steve Jobs (San Francisco, 24 February 1955 – Palo Alto, 5 October 2011) would present the first Apple computer.
A milestone in digital colour photography was the invention and patent filing by Bryce E. Bayer (Portland, 15 August 1929 – Bath, Maine, 13 November 2012) of Kodak of the eponymous filter which simulates the physiological characteristics of human vision, and allows digital sensors to create colour images through demosaicing algorithms (Kodak, 1976). The demosaicing algorithm is a digital process able to build a digital image from the incomplete sampling of colours due to the Bayer filter, it is also known as colour reconstruction or CFA interpolation. Demosaicing is a fundamental part of image elaboration necessary to render these images in a viewable format.
In 1981, the Sony Mavica FD5 was the first digital camera available on the mass market, using a floppy disc to store images of size 570x490 pixels. Sasson created the first digital SLR camera in 1989, but again Kodak's commercial department decided to hold off on the idea: they thought it was more convenient to profit from patent sales than to invest in and ride what was now clear to be the future.
In 1990 thanks to Thomas (Ann Arbor, 14 April 1960) and John (Ann Arbor,

6 October 1962) Knoll the first version of Photoshop were released. Photoshop is a raster graphics editor that is so closely linked to digital photography that it has become a standard.
In 2004 Kodak, and then in 2006 Canon and Nikon announced they no longer produced film camera.
Now, digital has brought colour photography into every pocket through smartphones. Unlike at the beginning of this story, black and white photography has become an option as if, ideally, to complete the circle.

8. Conflict of interest declaration

The authors declare no conflict of interest.

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10. Short biography of the author

Giovanni Vanoglio is a professional photographer, active in social, music and theatre photography. After graduating in Urban Planning at IUAV from the University of Venice, he has been collaborating with companies and national magazines. He specialises in contemporary landscape, a field of photography he has been developing in ongoing personal projects.

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