A SHORT HISTORY OF SLIDES (TRANSPARENCIES)

Tony Wright

1st August 2014

AUTOCHROME 1903

- Additive colour "mosaic screen plate" process.
- Glass plate coated on one side with a random mosaic of microscopic grains of potato starch dyed red, green, and blue which act as colour filters.
- Lampblack fills the spaces between grains, and a black-and-white panchromatic silver halide emulsion is coated on top of the filter layer.
- Loaded into the camera with the bare glass side facing the lens, so that the light passed through the mosaic filter layer before reaching the emulsion.
- The plate was reversal-processed into a **positive transparency**.

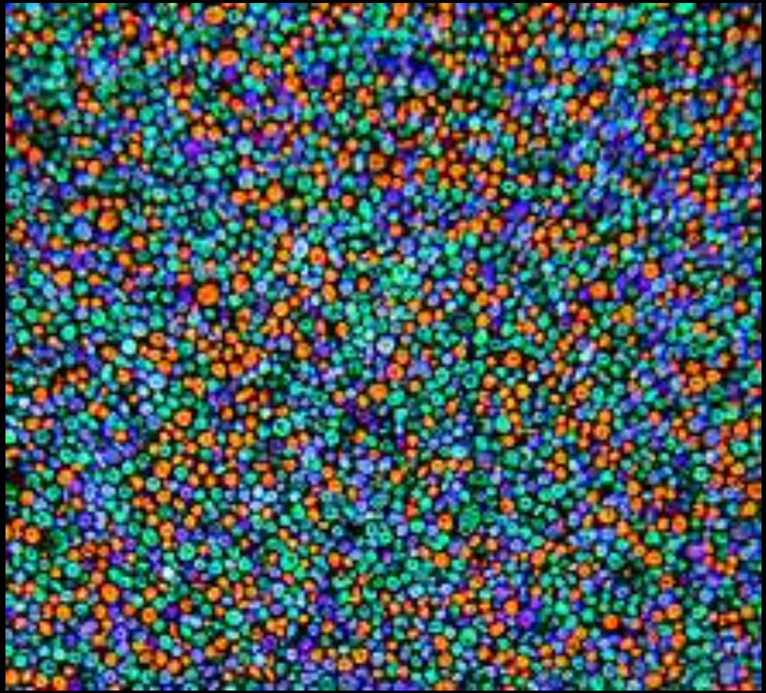
AUTOCHROME

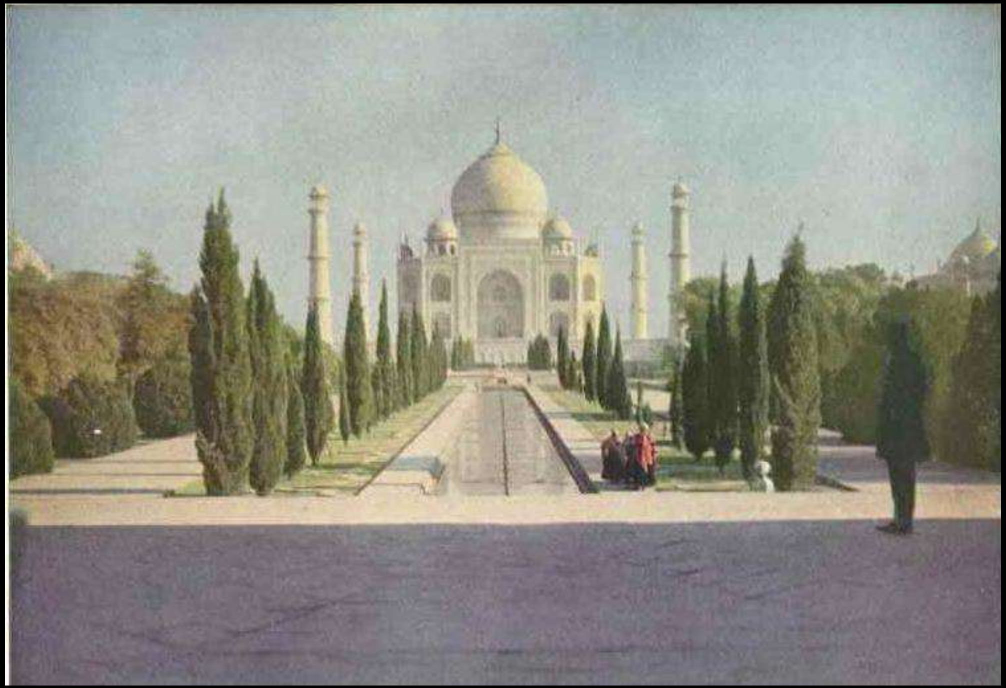
- The plate was first developed into a negative image but not "fixed"
- The silver forming the negative image was chemically removed
- Then the remaining silver halide was exposed to light and developed, producing a positive image
- The luminance filter (silver halide layer) and the mosaic chrominance filter (the coloured potato starch grain layer) remained precisely aligned and were distributed together, so that light was filtered in situ

AUTOCHROME

- Each starch grain remained in alignment with the corresponding microscopic area of silver halide emulsion coated over it
- When the finished image was viewed by transmitted light, each bit of the silver image acted as a micro-filter, allowing more or less light to pass through the corresponding coloured starch grain, recreating the original proportions of the three colours
- At normal viewing distances, the light coming through the individual grains blended together in the eye, reconstructing the color of the light photographed through the filter grains

AUTOCHROME





KODACHROME 1935

- **Kodachrome** was a non-substantive, colour reversal film
- Used for both cinematography and still photography. Because of its complex processing requirements, the film was sold process-paid
- For many years it was used for professional colour photography, especially for images intended for publication in print media
- Because of the uptake of alternative photographic materials, its complex processing requirements, and the widespread transition to digital photography, Kodachrome lost its market share
- Manufacturing was discontinued in 2009 and its processing ended in December 2010

KODACHROME

- Kodachrome films are non-substantive, they did not incorporate dye couplers into the emulsion layers
- The dye couplers were added during processing
- Emulsion layers are thinner and less light is scattered upon exposure, meaning that the film could record an image with more sharpness than substantive films
- Transparencies made with non-substantive films have an easily-visible relief image on the emulsion side of the film
- Kodachrome films have a dynamic range of around 12 stops

KODACHROME STABILITY

- Kodachrome's long-term stability under suitable conditions is superior to other types of colour film. This is because developed Kodachrome does not retain unused colour couplers.
- It has been calculated that the yellow dye, the least stable, would suffer a 20% loss of dye in 185 years.
- Kodachrome's color stability under bright light, for example during projection, is inferior to substantive slide films. Kodachrome's fade time under projection is about one hour, compared to Fujichrome's two and a half hours
- Images on Kodachrome slides over fifty years old retain accurate color and density
- It has been calculated that the yellow dye, the least stable, would suffer a 20% loss of dye in 185 years.

KODACHROME SENSITIVITY

K-14 process		
Kodachrome 25 film	35 mm, daylight	1974–2001
	Movie film, 16 mm, daylight	1974–2002
	Movie film, 8 mm, daylight	1974–1992
	Professional film, 35 mm, daylight	1983–1999
Kodachrome 40 film	35 mm, Type A	1978–1997
	Movie film, 16 mm, Type A	1974–2006
	Movie film, S-8, Type A	1974–2005
	Sound Movie film, S-8, Type A	1974–1998
	Movie film, 8 mm, Type A	1974–1992
Kodachrome 64	35 mm, daylight	1974–2009
	126 format, daylight	1974–1993
	110 format, daylight	1974–1987
	Professional film, 35 mm, daylight	1983–2009
	Professional film, daylight, 120 format	1986–1996
Kodachrome 200	Professional film, 35 mm, daylight	1986–2004
	35 mm, daylight	1988–2007
Cine-Chrome 40A	Double Regular 8 mm, tungsten	2003–2006

An alkaline bath softens the cellulose acetate phthalate binder. A spray wash and buffer removes the rem-jet antihalation backing.

First Developer

All exposed silver halide crystals are developed to metallic silver via a PQ developer. The yellow filter layer becomes opaque because it has a combination of Lippmann emulsion (very tiny grains) and Carey Lea silver (metallic silver particles that are small enough that they are yellow rather than gray.)

Wash

Red light re-exposure through the base

This makes the remaining undeveloped silver halide in the cyan layers developable.

Cyan developer

The solution contains a color developer and a cyan coupler. These are colorless in solution. After the color developer delops the silver, the oxidized developer reacts with the cyan coupler to form cyan dye. The dye is much less soluble than either the developer or the coupler so it stays in the red layer of the film.

Wash

Blue light re-exposure from the top

This makes the remaining undeveloped grains in the blue sensitive layer (the yellow layer) developable. The now opaque yellow filter layers prevents the blue light from exposing the magenta layer (the green sensitive layer, which is also sensitive to blue light). It is important to avoid stray printing light exposing the film base of film.

Yellow developer

Analogous to the cyan developer.

Wash

Magenta developer

This contains a chemical fogging agent that makes all of the remaining undeveloped silver developable. If everything has worked correctly, nearly all of this silver is in the magenta layers. The developer and magenta coupler work just like the cyan and yellow developers to produce magenta dye that is insoluble and stays in the film.

Wash

Conditioner

Prepares the metallic silver for the bleach step.

Bleach

(Iron EDTA) Oxidises the metallic silver to silver halide. The bleach must be aerated. The former ferricyanide bleach did not require aeration and did not require a conditioner.

Fix

Converts the silver halide to soluble compounds which are then dissolved and washed from the film

Wash

Washes the fixer out of the film.

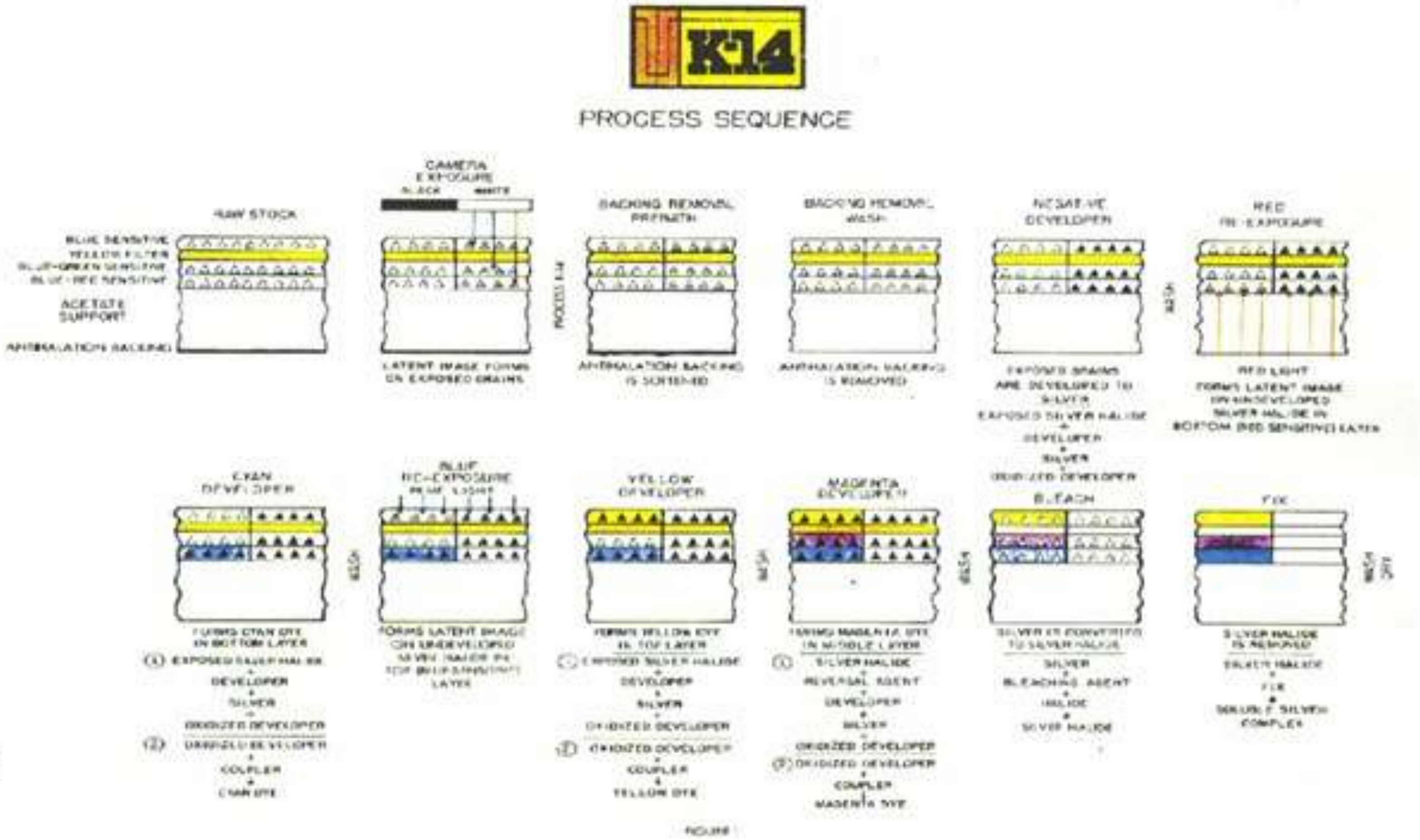
Rinse

Contains a wetting agent to reduce water spots.

Dry

The result is three different color records each with the appropriate dye, just like other color films. The original Kodachrome process in 1935 used dye bleaches and was a far more complex process. Although the formulae have changed over the years, the basic process steps have followed a similar pattern since the introduction of "selective re-exposure" Kodachrome in 1938.

Kodachrome Process



KODACHROME


Kodachrome
64
Kodak
36 EXP. FILM

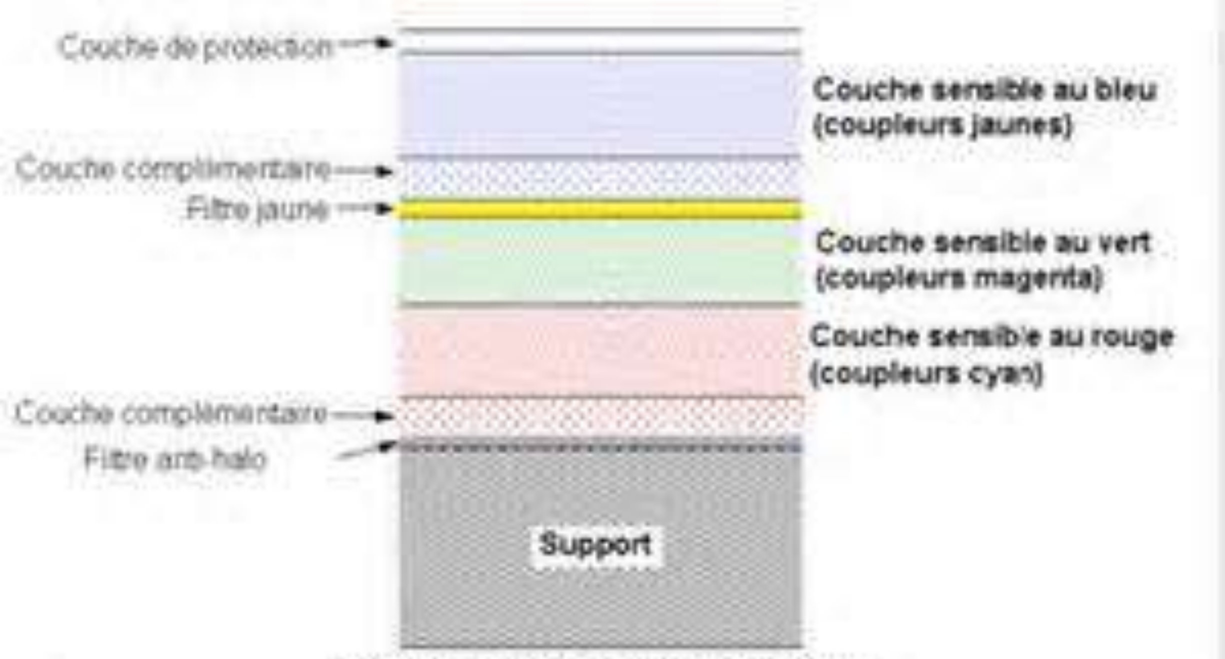

KODACHROME TRANSPARENCY
PROCESSED BY Kodak


NATIONAL GEOGRAPHIC

EKTACHROME 1940

- **Ektachrome** , a substantive coulour reversal film, used it extensively for colour photographs where Kodachrome was too slow
- Ektachrome, initially developed in the early 1940s, allowed professionals and amateurs alike to process their own films
- Ektachrome was a product that small professional labs could afford equipment to develop
- Modern Ektachrome films were developed using the E-6 process
- High film speeds were available and the processing could be “puhed” to increase these to 1600ASA
- By late 2013, all Ektachrome products were discontinued.

EKTACHROME



Film diapositive couleurs type Velvia

- The steps for developing color transparency films using process E6 are:
- First developer bath: 6:00 @ 100.0 °F. This uses a potassium hydroquinone monosulfate - phenidone black & white film developer, with the preferred form of phenidone being 4-hydroxymethyl-4-methyl-1-phenyl-3-pyrazolidinone (13047-13-7). The first developer forms a negative silver image in each layer of the film. The first developer is time and temperature sensitive because it controls contrast.[2]
- First wash: Water stop bath, 2:00 @ 100.0 °F. This step once used an acetic acid stop bath, but was replaced with a water-only bath for process economy, with concomitant slight reduction of first developer strength.[2]
- Reversal bath: 2:00 @ 96-103 °F. This bath prepares the film for the color developer step. A chemical reversal agent is absorbed into the emulsion, which is instantly effective. The reversal step can also be carried out using 800 footcandle-seconds (8.6 klx·s) of light - this variation is used by process engineers to troubleshoot reversal bath chemistry problems such as contamination and issues of low tank turnover as process volumes decline.[2]
- Color developer bath: 6:00 @ 96-103 °F. This step is carried out to completion. The developer contains CD-3 developing agent, and acts upon the chemically exposed silver halide that was not developed in the first developer to form a positive silver image. The metallic negative silver image formed in the first developer has no part in the reaction of this step. As the color development progresses, a metallic positive silver image is formed and the color developing agent is oxidized. Oxidized color developer molecules react with the color couplers and color dyes are formed in each of the three layers of the film.[2] Each layer of the film contains different color couplers, which react with the same oxidized developer molecules but form different color dyes. Variation in color developer pH causes color shifts on the green-magenta axis with Kodak E100G & E100GX and Fujichrome films and on the yellow-blue axis with older Ektachrome films.[3]
- Pre-bleach bath: 2:00 @ 90-103 °F. This bath was previously called "conditioner", but was renamed pre-bleach in the mid-1990s to reflect the removal of formaldehyde from the process used in the final rinse. In this solution, formaldehyde acts as a dye preservative and EDTA is used to "kick off" the bleach. The pre-bleach bath relies on carry-over of the color developer to function properly, therefore there is no wash step between the color developer and pre-bleach baths.[2]
- Bleach bath: 6:00 @ 92-103 °F. This is a process-to-completion step, and relies on carry-over of pre-bleach to initiate the bleach. The bleach converts metallic silver into silver bromide, which is converted to soluble silver compounds by the fixer. During bleaching, iron (III) EDTA is converted to iron (II) EDTA (Fe^{3+} EDTA + Ag + $Br^{-} \rightarrow Fe^{2+}$ EDTA + AgBr) before fixing. Kodak also has a process variant which uses a higher concentration of bleach and a 4:00 bath time; but with process volumes declining, this variant has become uneconomical.[2]
- Wash step (optional): Rinses off the bleach and extends the life of the fixer bath. This wash step is recommended for rotary tube, sink line and other low volume processing.[2]
- Fixer bath: 4:00 @ 92-103 °F. This is a process-to-completion step.[2]
- Second fixer stage (optional): Using fresh fixer. The archival properties of film and paper are greatly improved using a second fixing stage in a reverse cascade.[4] Many C-41RA (rapid access) minilab processors also use 2 stage reverse cascade fixing for faster throughput.
- Final wash: 4:00 @ 92-103 °F.[2]
- Final rinse: 1:00 @ 80-103 °F. Up until the mid-1990s, the final rinse was called a stabilizer bath, since it contained formaldehyde. Currently, the final rinse uses a surfactant, and miconazole, an anti-fungal agent.[2]
- Drying: Drying in a dust-free environment.[2]

SLIDE MOUNTING