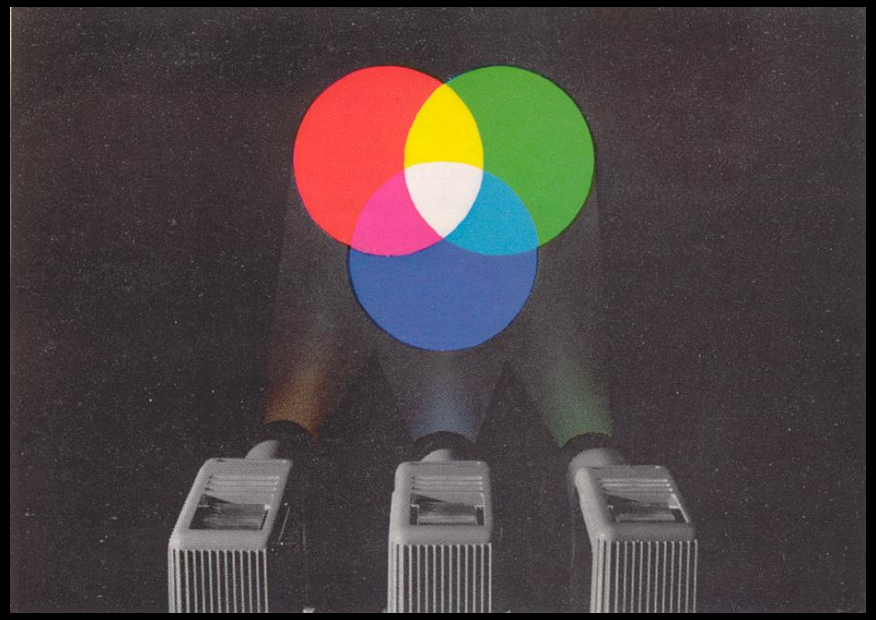
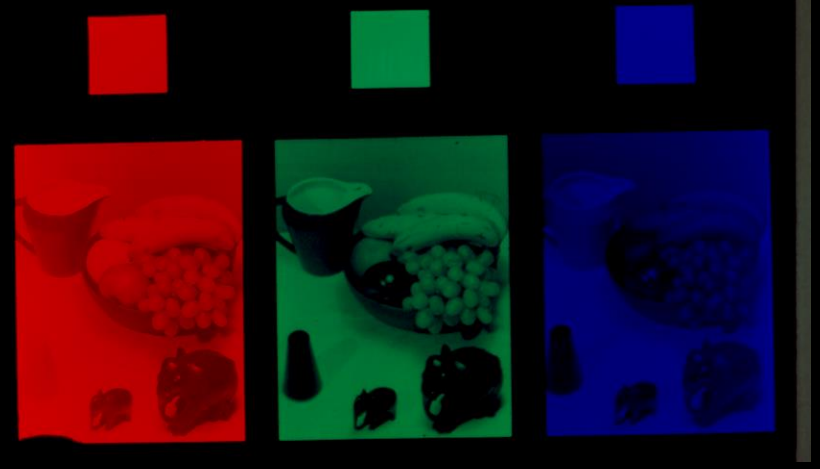
Early Colour Systems

BRIAN PRITCHARD

All the early colour systems were based on the separation system where the scene is split into two or three images recorded on black and white film

To get a full range of colours three separations are needed but as we will see later just two separations were used in most of the early systems





Two Colour Picture

Three Colour Picture

Charles Maxwell

- In 1855 he was the first person to conceive how the three-colour principle could be applied to photography.

The early pioneers had several problems that had to be overcome so that colour moving images could be shown

1. Making the films sensitive to red, green and blue - making them panchromatic.

The first films were only sensitive to BLUE light

Orthochromatic films were then introduced and were sensitive to BLUE and GREEN light

In 1919 Kodak Panchromatic films were introduced that were sensitive to BLUE, GREEN and RED

The early pioneers had to colour sensitise their own films, this meant dyeing the emulsion before exposure.

The film is bathed in a solution of the dye in the dark The film is dried and is then ready for exposure.

H W Vogel discovered in 1873 that the colour sensitivity of silver halides could be extended by the use of *naphthalene red*, *magenta*, *methyl violet* and *cyanine*.

These dyes had been replaced by other dyes; *Erythrosine* was used generally for green, yellow and some orange sensitivity.
In 1903 König discovered the sensitising properties of the *isocyanine* dyes
These are *Pinachrome, Pinavirdol, Orthochrome T*

In 1905 the *carbocyanines* were discovered by König; these are more powerful red sensitizers than the *isocyanines*. The best known is *Pinacyanol*

The most important facts about sensitising dyes are:

1. The dye must stain the silver halide
2. They must stain without a mordant
3. A dye sensitises for the rays absorbed by the dyed silver halide
4. The maximum sensitiveness agrees with the maximum absorption of the dyed silver halide

There are two methods of sensitising:

1. Bathing the coated film in a solution of the dye
2. Incorporating the dye with the emulsion before coating

The amount of dye is very small – the usual concentration
Varies from 1 part in 1000 to 1 part in 75,000

As an example these are the recommendations for sensitising blue sensitive plates.
The stock solution is a 1:1000 solution of the dye in methyl alcohol

	Water	Stock Dye Solution	Time of bathing 3-4 minutes. Rise well in methyl alcohol after sensitising and dry as quickly as possible
Pinachrome (Sensitol Green) Orthochrome Pinaverdol Pinacyanol Pinachrome Violet (Sensitol Violet)	100	10	

George Albert Smith, who we shall meet later, advised the Kinemacolor Company of America in 1912 when they were having trouble with sensitising.

He suggested that sufficient dye should be made up to sensitise 6 x 200 ft films. ‘Weigh out 0.39 gramme Pinachrome and dissolve it in absolute alcohol 14 ounces. When thoroughly dissolved add to the mixture 14 ounces of distilled water.’

1 oz (ounce) is approximately 30ml so 14 ozs is 420ml

‘Have a bath of 44 pints of filtered water (distilled for preference) and add to the above 28 oz of dye solution to it, stirring carefully to ensure even mixing. This bath must not be colder than 64° and not warmer than 70°.
Having the film wound on a frame in the dark, or in a very safe red light, immerse it in the solution for 11 minutes taking the usual precautions to ensure the absence of air bells.’

A pint is approximately 600 ml so 44 pints is about 26 litres

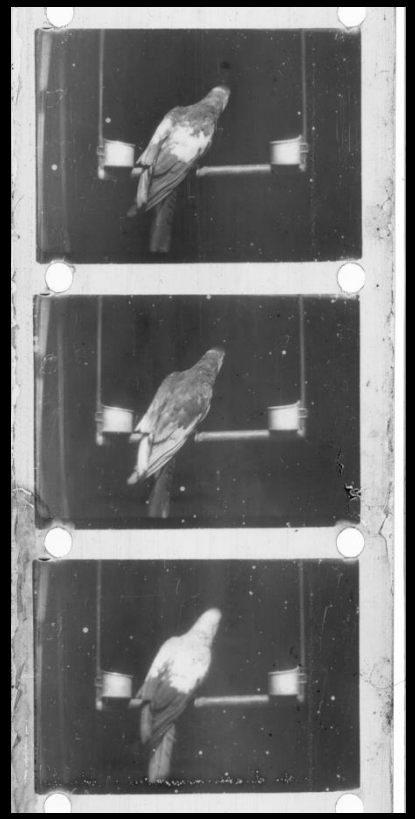
Keep the film gently moving under the surface of the bath.
The bathing must be done in absolute darkness, and the film must not be exposed to red light henceforth until used in the camera.
After bathing as described for 11 minutes, the film must be washed for 10 minutes In gently-changing water,

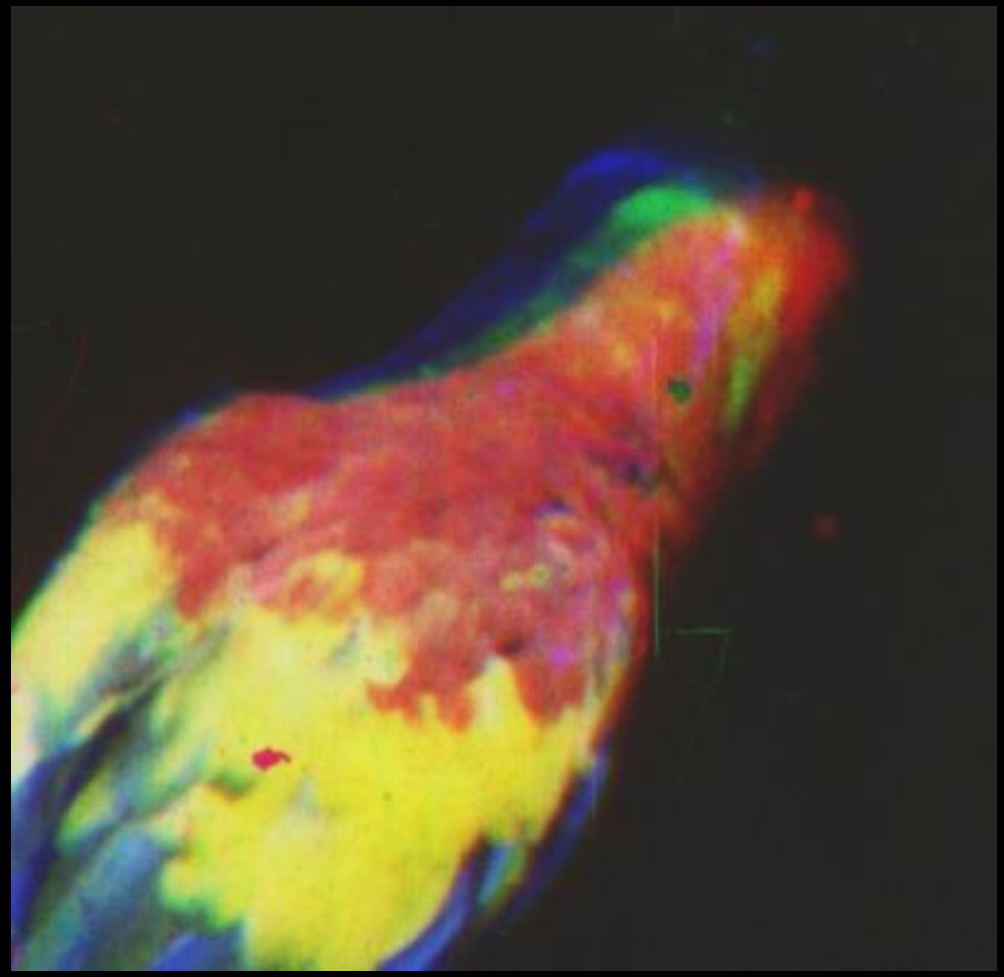
or passed by stages for 10 minutes through a series of 5 washing baths filled with distilled water. It is then placed on a drum to dry in a very safe green light, which light is immediately turned off while the drying proceeds.

The temperature of the drying-room should not be above 75° or the emulsion may melt and run. A changing supply of clean, dry, warm air, should be arranged for in the drying room.'

He goes on to say the second film is bathed for 11½ minutes
the third 12 minutes, then 12 ½, 13 and 14 minutes for the sixth film

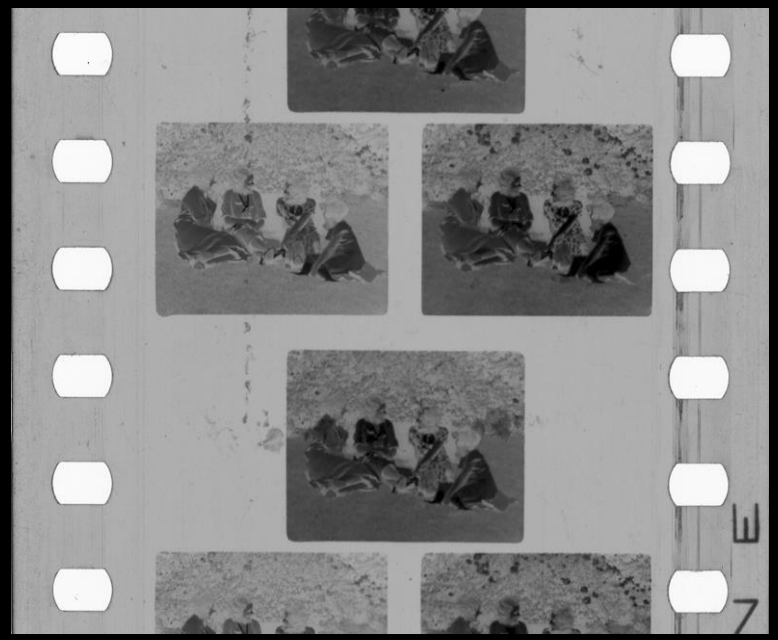
2. Solving the time/parallax errors that occur when you are shooting consecutive frames through red, green and blue filters.





Various pioneers tried to solve this problem by shooting the three images on a single frame

The systems were always complicated and introduced other problems such as parallax problems from having three lenses set on different axis as well as loss of sharpness and increased grain because of the smaller frame sizes



Francita color

Raycolor

Ulysees 3 colour

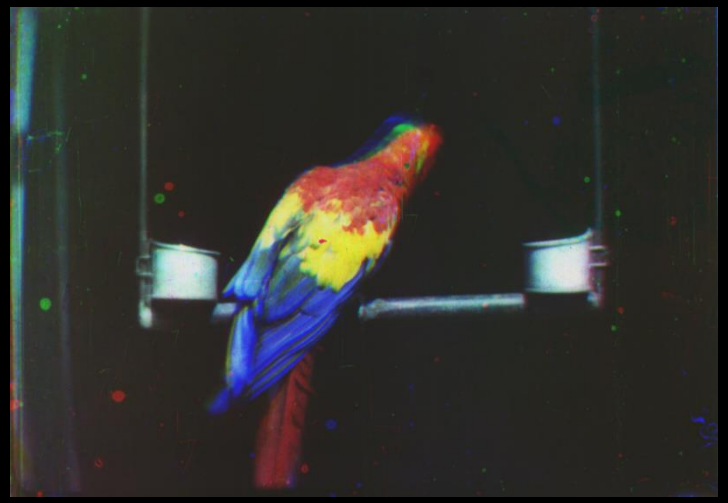
3. Combining the three frames back through the three colour filters

The difficulties here are:
a) Flicker - the images need to be projected fast enough.

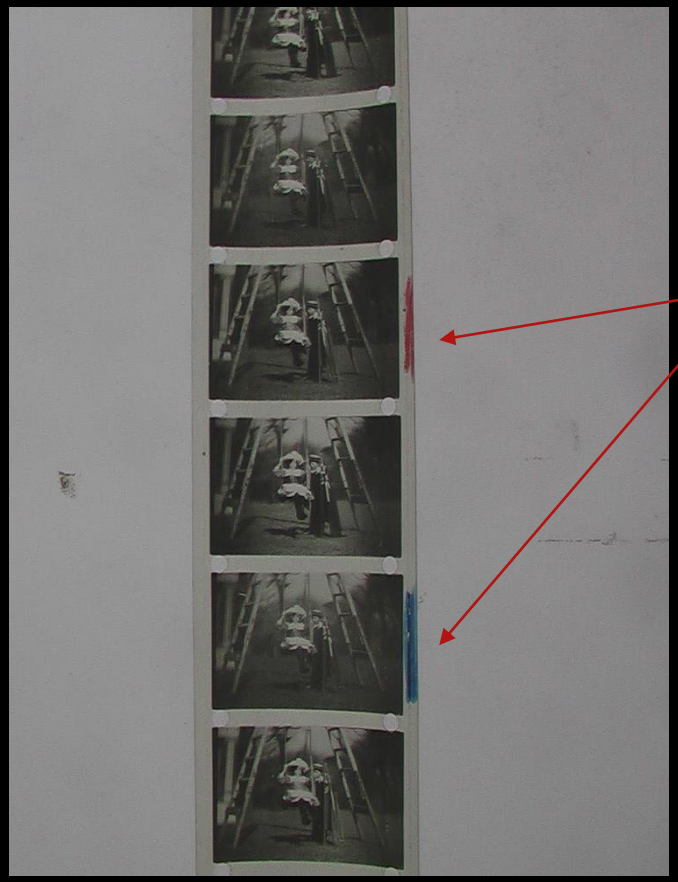
Obviously the camera needs to have shot the film at a high enough speed so that the projection can be at a high speed

b) The correct frames need to be projected through the correct filters – blue frame through the blue filter and so on.

Correct



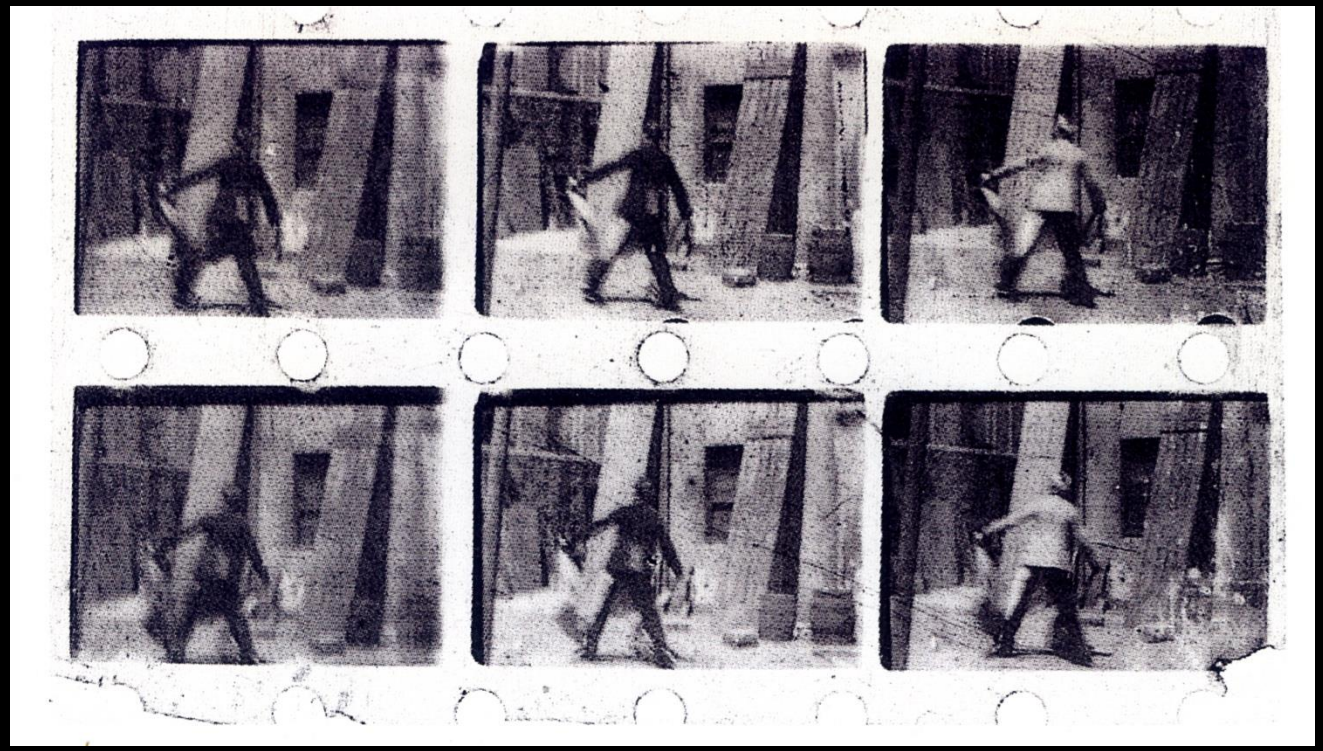
Incorrect



Here Turner has identified the red and blue frames so the projector could be laced up correctly

Many of the early three colour systems were only taken as far as basic tests.
In 1898 Lascelles-Davidson who was associated with Friese-Green patented a camera with three lenses and rotating colour filters.

In 1903 Lascelles-Davidson along with Jumeaux patented a three colour projection apparatus.



The first system that came close to a working method was the Lee-Turner system. Invented by Raymond Turner and financed by Marshall Lee, they did produce a series of test films in 1901

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49 BRECKNOCK ROAD,
CAMDEN ROAD, N.

London, 19th April 1890

Mr Edward Turner has been with us for nearly a year during which time he has given us every satisfaction as assistant in Studio, printing & general work. We have always found him attentive to his work & most anxious to improve himself & at the same time shall be pleased to have reference made to us at any time

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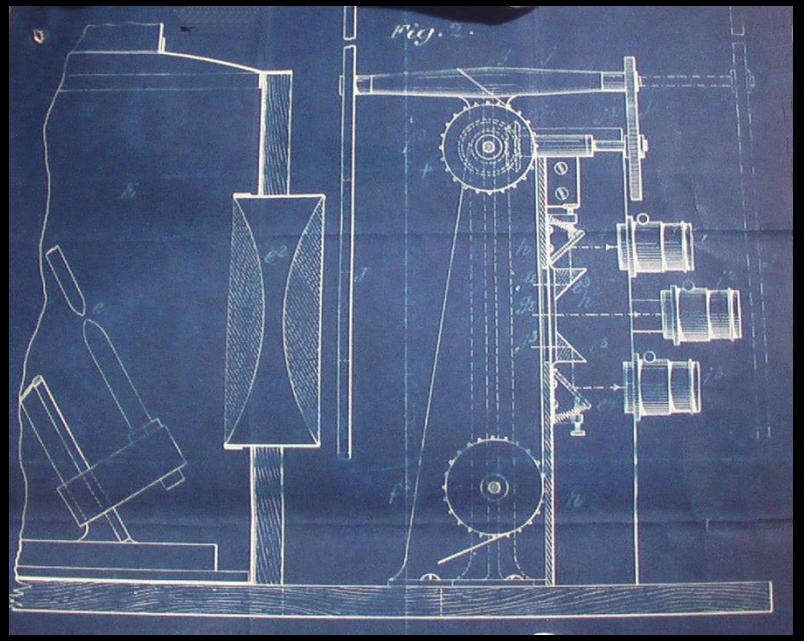
URB 6/5

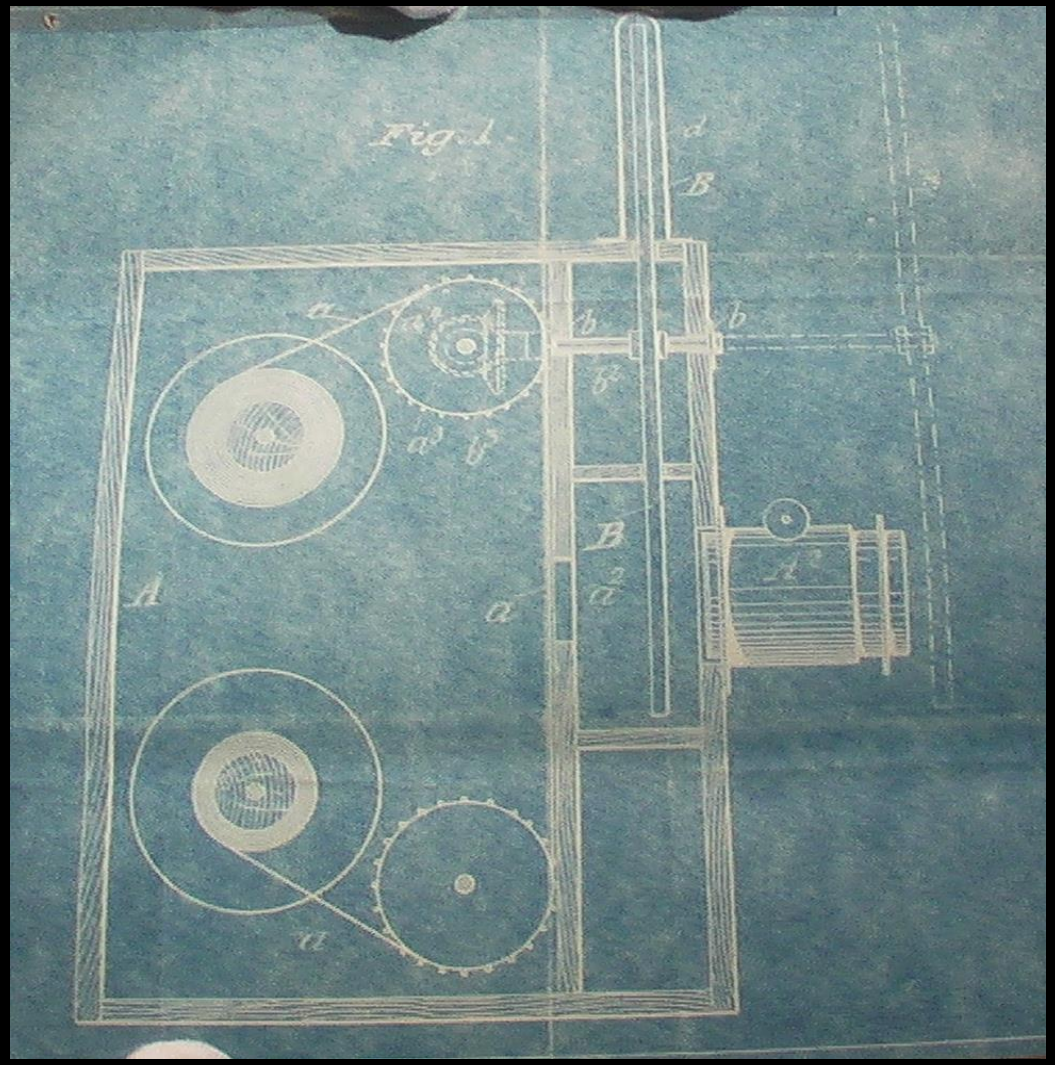
SIX PENCE

An Agreement

made the first day of June one thousand nine hundred and one Between Frederick Marshall Lee of Wincanton in the County of Somerset Esquire and Edward Raymond Turner of 8 Queen's Road Hounslow in the County of Middlesex Esquire (who together with their executors administrators and assigns are where the context so requires or admits hereinafter referred to as the Grantors) of the one part and Charles Urban of 5 Warwick Court Holborn in the County of Middlesex Esquire of the other part Whereas the Grantors are the Inventors and owners of a process and machines for the taking and reproduction of animated photographs in colour which property is hereinafter referred to as the said process and they have agreed with the said Charles Urban to permit him and his permitted assigns to experiment with the said process with a view to improving and perfecting it upon the terms hereinafter mentioned

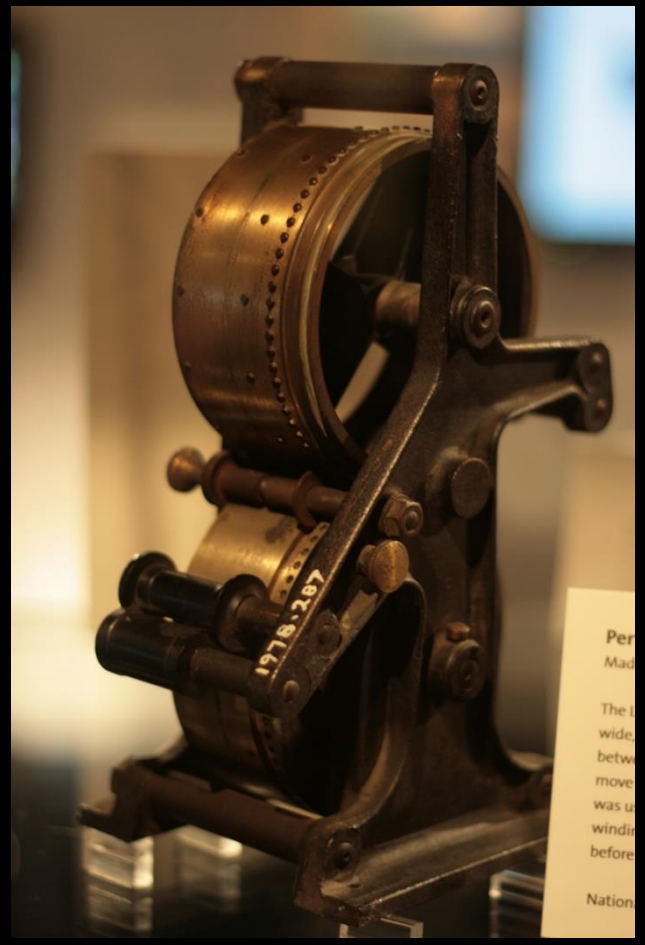
Now it is hereby agreed and declared by and between the parties hereto as follows:

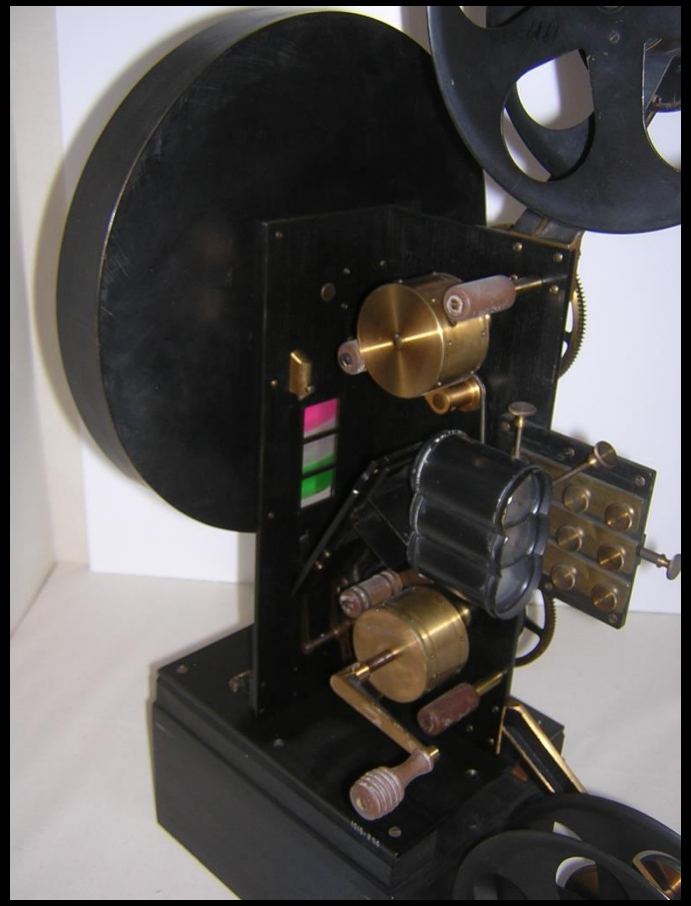




Blueprints for Turner's Projector and camera

Turner had a perforator, a camera and a projector made by Alfred Darling and used 1½" wide film. He had worked in the stills photographic trade and had learnt about colour sensitising.



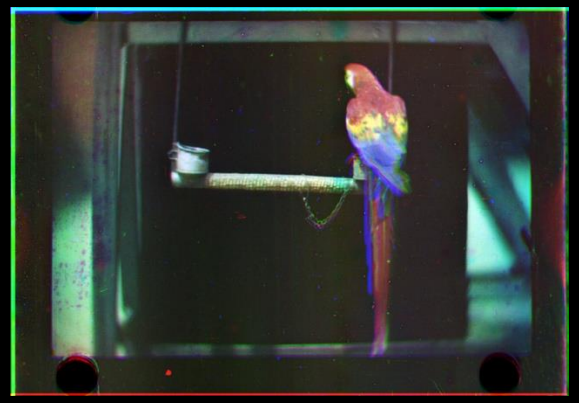


Mr Ives said in the SMPE Journal in 1926:

Lee and Turner were employed in my workshop in London and who with my consent patented a scheme which I had disclosed to them but which I told them was of more theoretical than practical at that time. I considered it a great joke when their patent rights were sold for real money; but as I predicted, the method was not practically satisfactory

Turner made a number of test films –



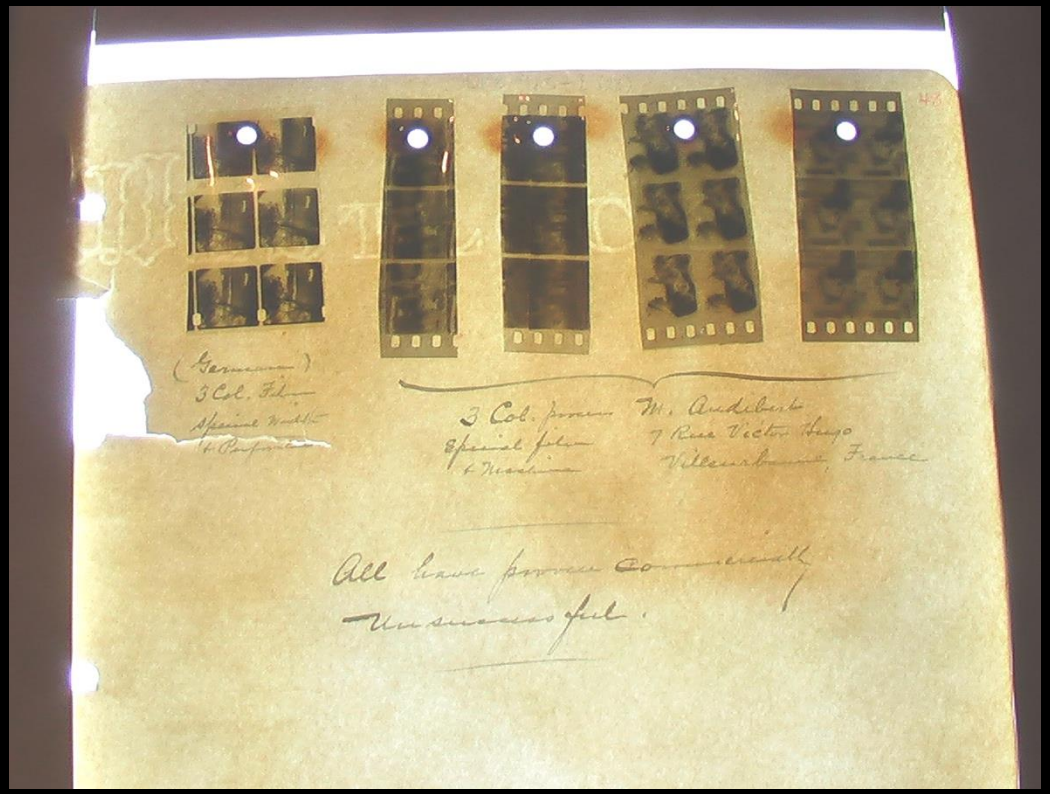


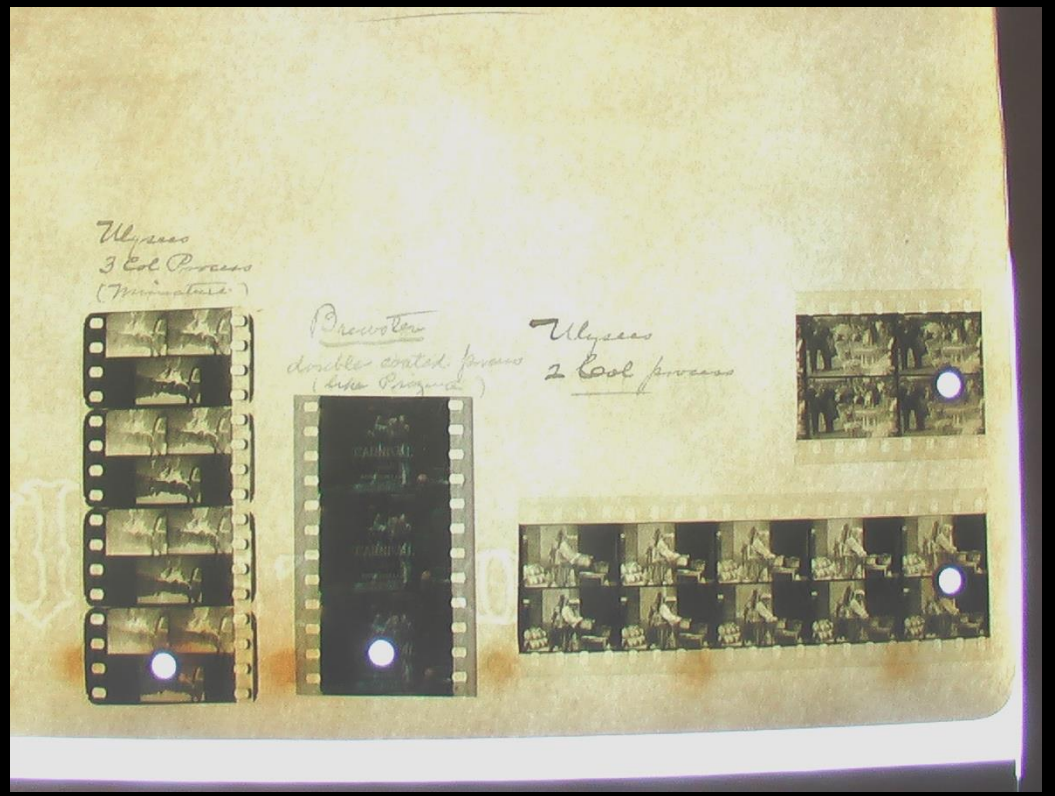



Digital reconstructions from the three separations

Marshall stopped financing the project and Turner managed to secure the backing of Charles Urban.

Urban was doing much research into colour systems and collected samples which are now kept at the National Media Museum in Bradford, UK



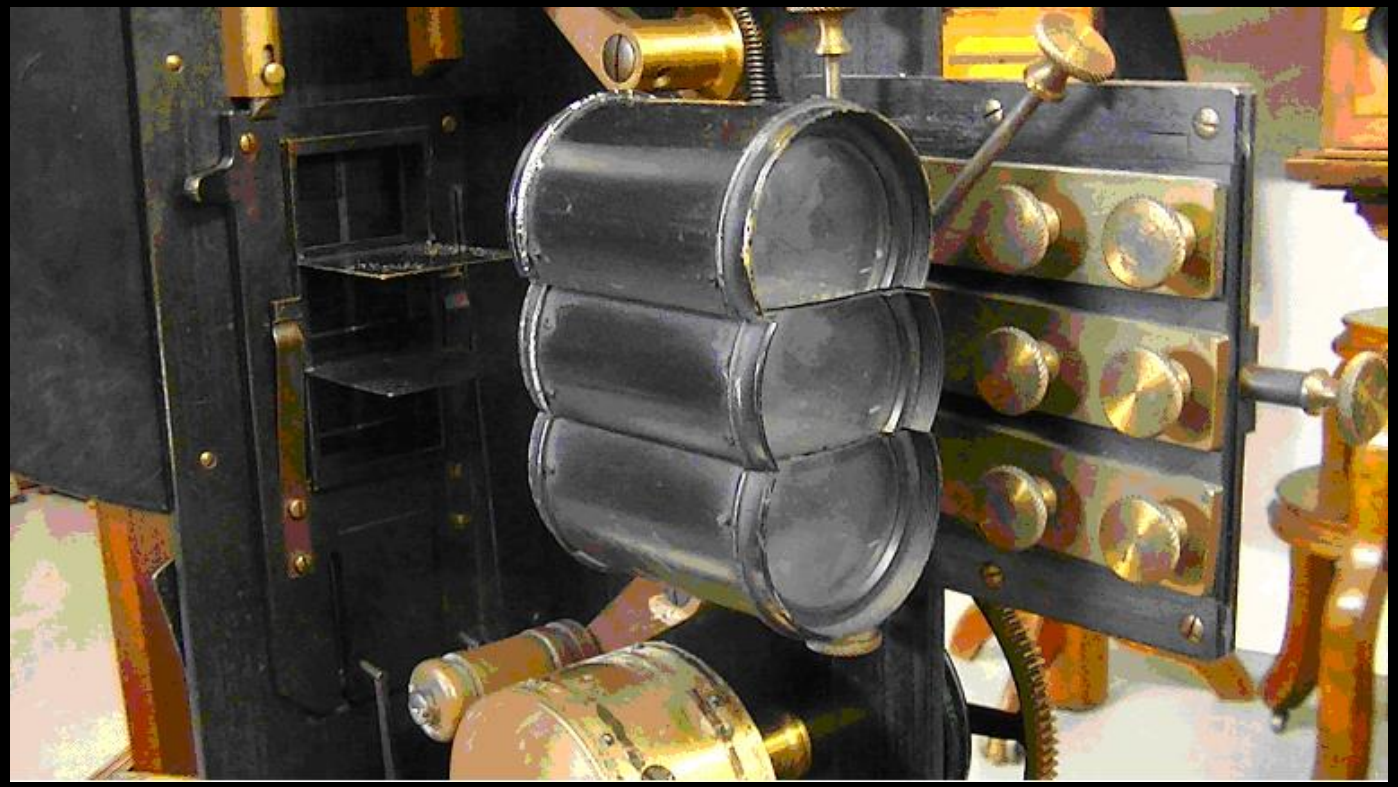


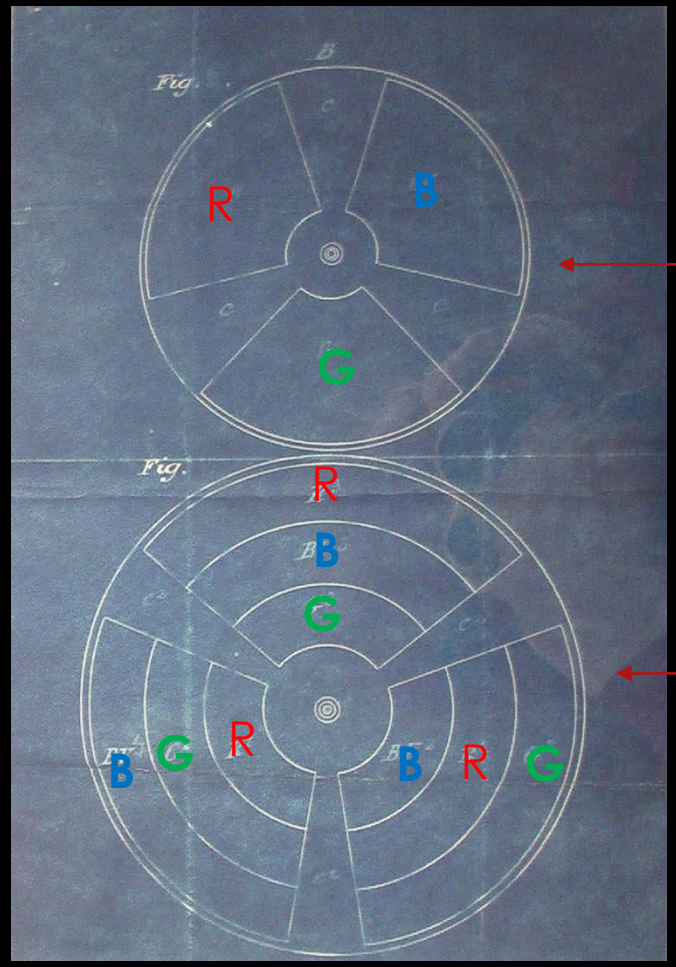
Samples of 4 colour
Prizma-color: Red, Green
Blue and yellow

Turner was having great problems obtaining a steady picture on the screen.

His projector had three lenses and he was projecting three frames at a time through red, green and blue filters. The projector pulled down one frame and the filter wheel rotated so that the frames were projected through the correct filter.

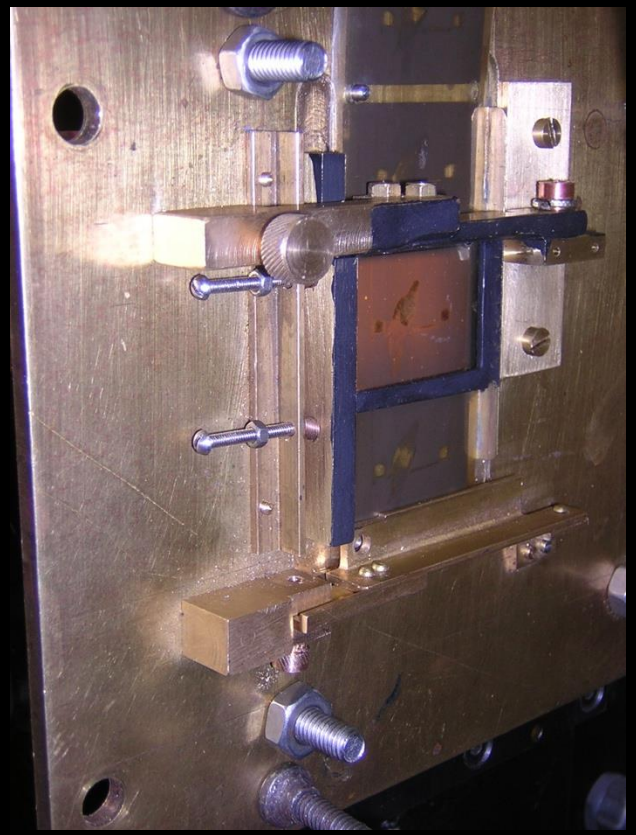
Frame 1 was projected through, for example, the red filter, frame 2 through the green filter, frame 3 through the blue filter. The projector pulled down one frame, the filter rotated so then Frame 2 was through the green filter, frame 3 through the blue filter and frame 4 through the red filter.





Camera

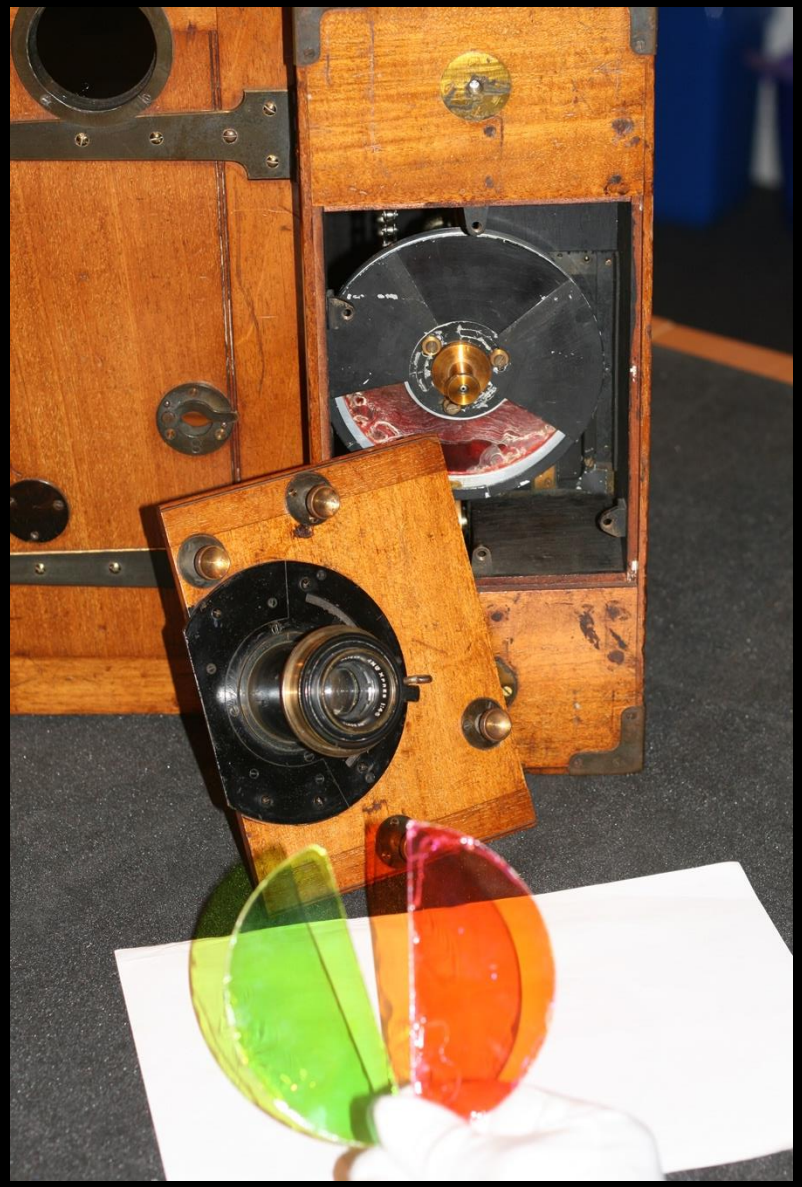
Projector



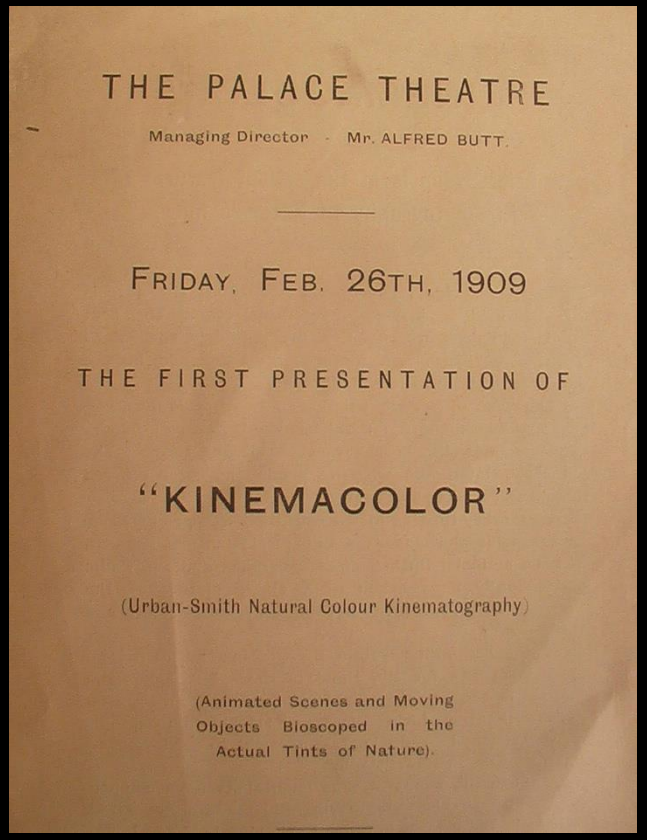
Turner had problems with his sensitisation

Unfortunately, Turner had a heart attack in his workshop and died in 1903.
Urban employed George Albert Smith to complete the project but he was unable to do so saying the system would not work and went on to modify the system calling it ‘Kinemacolor’

Kinemacolor used two colours, red and green and ran the camera and projector at 32 frames a sec - Turner used 16 frames per sec relying on his 3 frame system to avoid flicker



This is a Kinemacolor camera showing a spare set of filters



THE PALACE THEATRE

Managing Director - Mr. ALFRED BUTT.

FRIDAY, FEB. 26TH, 1909

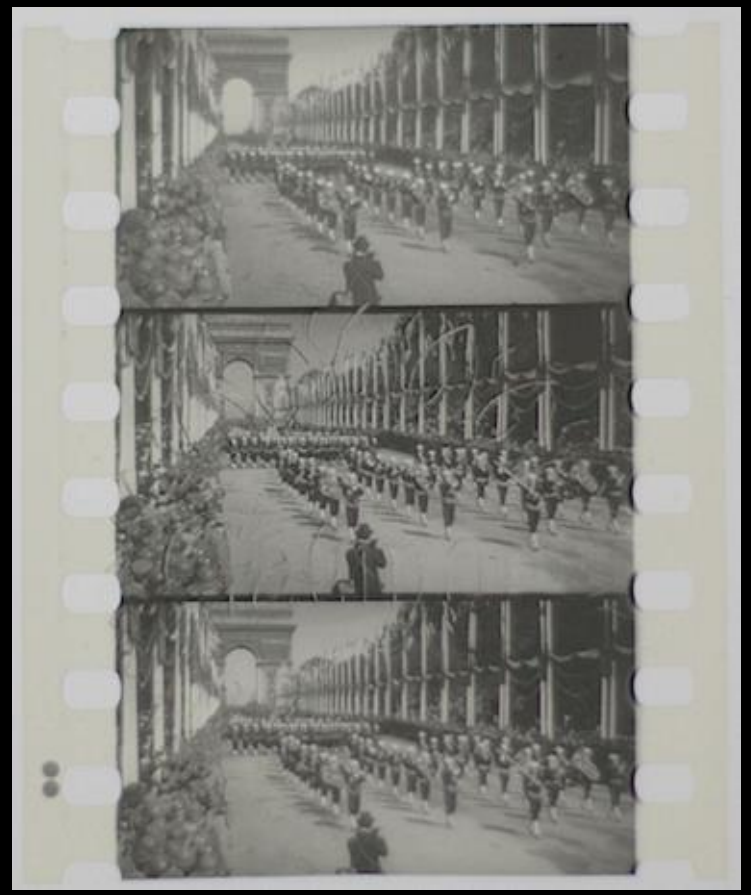
THE FIRST PRESENTATION OF

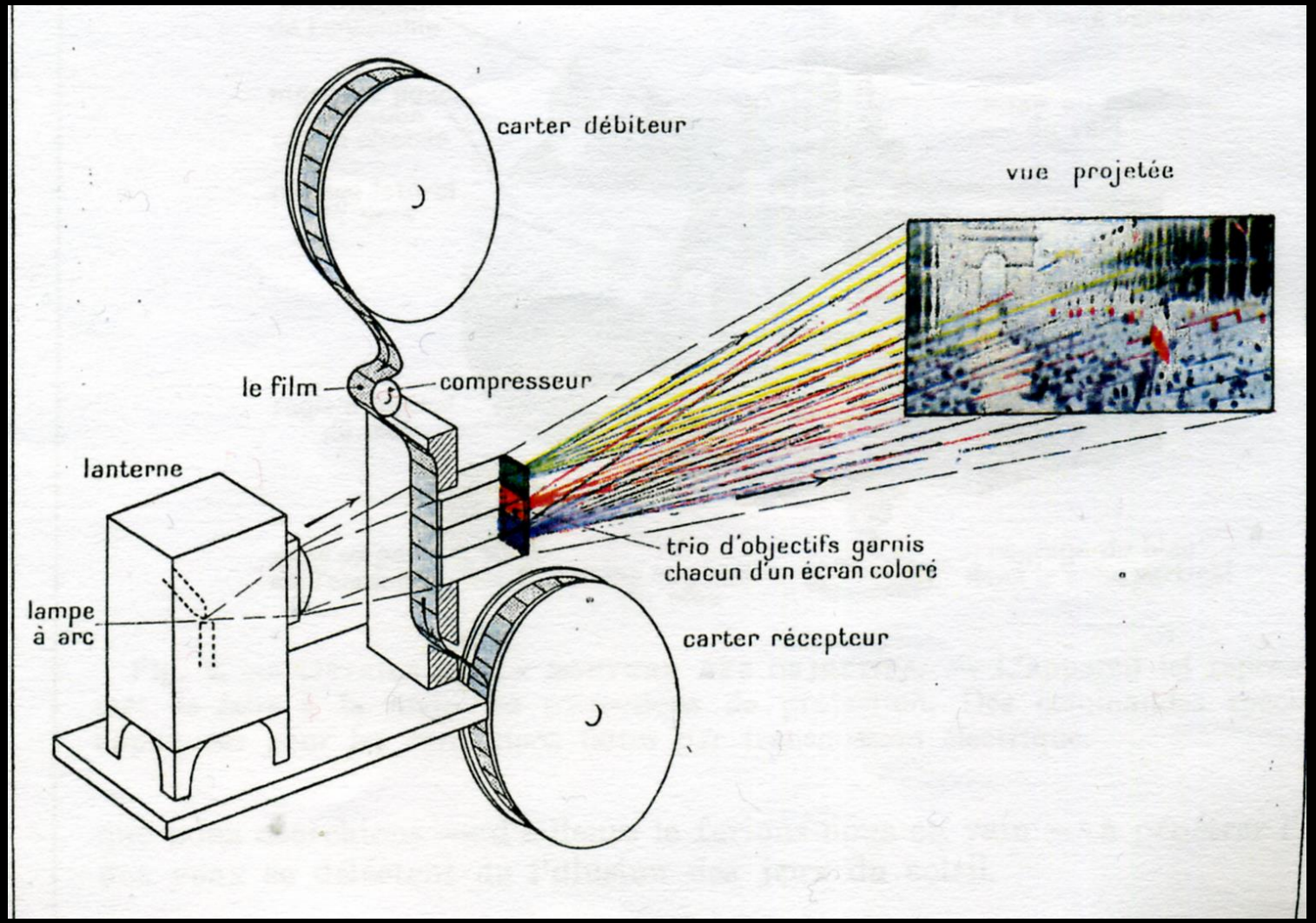
"KINEMACOLOR"

(Urban-Smith Natural Colour Kinematography)

(Animated Scenes and Moving Objects Bioscoped in the Actual Tints of Nature).

In 1913 Gaumont patented a triple lens system but it had serious problems with parallax. The system was not shown until 1920, because of the First World War.

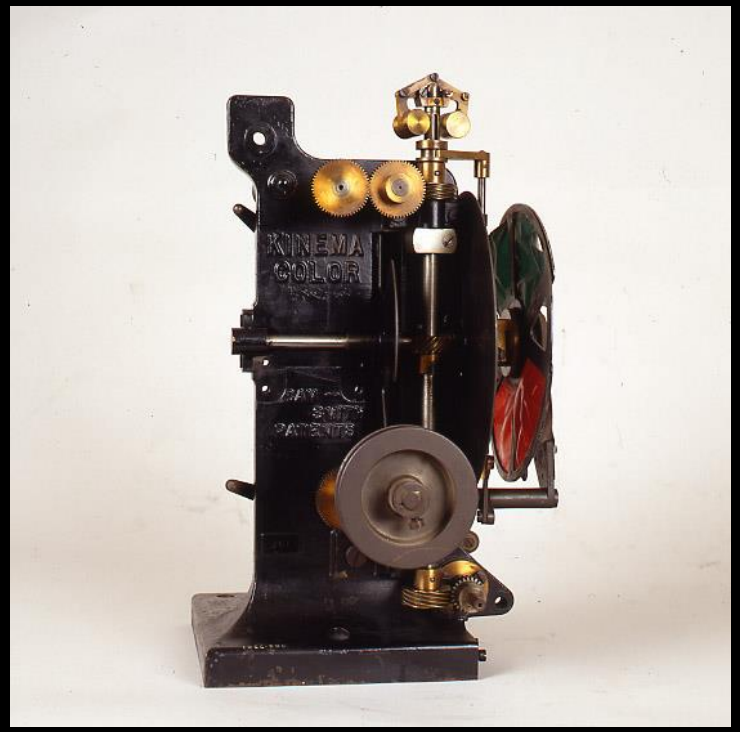




The picture was only three perfs high; the projector showed three frames at once and then pulled down 9 perforations and showed the next three frames.
It required constant attention to keep the frames in register and required a special projector. A few demonstration films were shown before the process disappeared.

Around the same time William Friese-Green was using a similar process to Smith,
He used a red filter and a green filter on the camera and then painted alternate frames red and green.

Kinemacolor was very successful with cinemas all over the country showing Charles Urbans's films. They used projectors supplied by Urban. They were heavyweight machines as the films had to run at 32 FPS



A film of Friese-Greene's was being exhibited at a theatre in Brighton, and a Mr Lyons, who held certain Kinemacolor rights in Brighton, persuaded Kinemacolor to bring an action against the Friese-Greene Theatre to prevent showing of the picture.

F.S. Edge, a well known racing car expert, financed the Friese-Greene defence. Kinemacolor lost the action and appealed, winning their appeal. The case went to the House of Lords, and the judgement was reversed in favour of Friese-Greene. Smith's patent was revoked.

N° 26,671 A.D. 1906

Date of Application, 24th Nov., 1906
Complete Specification Left, 12th Apr., 1907—Accepted, 25th July, 1907

PROVISIONAL SPECIFICATION.

Improvements in & relating to Kinematograph Apparatus for the Production of Coloured Pictures.

I GEORGE ALBERT SMITH, F.R.A.S., Laboratory Lodge, Roman Crescent, Southwick, Brighton Animated Picture Maker do hereby declare the nature of this invention to be as follows:—

A practical method by which the well-known animated photographs or bioscope moving pictures may be projected in the colours of nature approximately instead of in black & white as usual. The method is based upon the well-known principles of 3-colour photography, but use is made of the principle of persistence of vision to effect the necessary superimposition of coloured images. In all previous attempts to apply the principles of 3-colour photography to animated pictures the difficulty of accurate superimposition has proved fatal to success. By my method 2 colours only are recorded, red & green, & these two records are exhibited in such rapid alternation that persistence of vision causes the colours to blend into one view, which appears in approximately correct colours. The steps of the process are as follows:—

1. An animated picture of a coloured scene is taken with a bioscope camera in the usual way, except that a revolving shutter is used fitted with properly adjusted red & green colour screens. A negative is thus obtained in which the reds & yellows are recorded in one picture, & the greens & yellows (with some blue) in the second, & so on alternately throughout the length of the bioscope film.

2. A positive picture is made from the above negative & projected by the ordinary bioscope projecting machine which, however, is fitted with a revolving shutter furnished with somewhat similar coloured glasses to the above, & so contrived that the red & green pictures are projected alternately through their appropriate coloured glasses.

3. If the speed of projection is approximately 30 pictures per second, the two colour records blend & present to the eye a satisfactory rendering of the subject in colours which appear to be natural.

The novelty of my method lies in the use of 2 colours only, red & green, combined with the principle of persistence of vision.

Dated this 22nd day of November, 1906.

G. ALBERT SMITH.

COMPLETE SPECIFICATION.

"Improvements in, and relating to, Kinematograph Apparatus for the Production of Coloured Pictures".

I, GEORGE ALBERT SMITH, of Laboratory Lodge, Roman Crescent, Southwick, Brighton, in the County of Sussex, Animated Picture Maker, do hereby declare the nature of this invention and in what manner the same is to be performed,

[*Price 8d.*]

REVOKED PATENT.

Patent No. 26,671, of A.D. 1906, has been revoked by Order of the High Court.

THE PATENT OFFICE,
26th April, 1915.

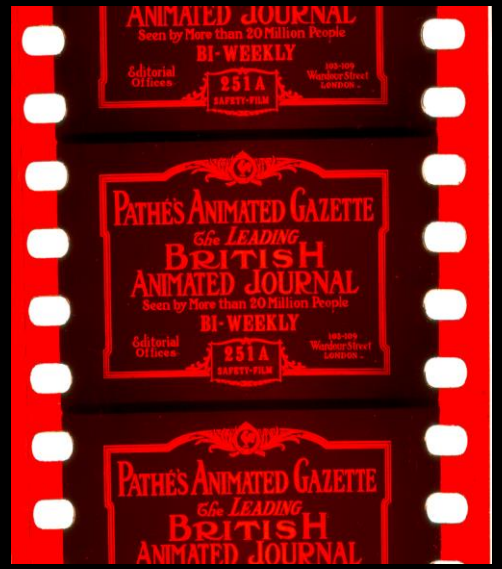
(4942r—7.) Wt. —G. 1617. 125. 5/15. D & S. G. 2.

Urban had to stop showing his films and proceeded to destroy them and returned to the US.

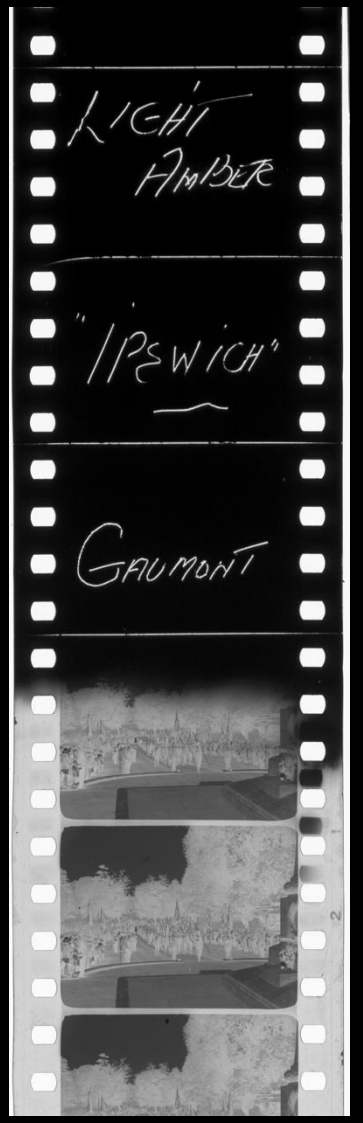
However Friese-Greene's system did not have any commercial success.

The problems that caused the pioneers difficulty in projecting films in ‘colour’ had led to the introduction of ‘coloured’ films. Films that were tinted or toned or both.

A tinted black and white film has a colour range from the tint colour to black.



Tinting was carried out by dyeing the emulsion, quite a time-consuming process as each separate colour had to be applied separately and the scenes joined together. Eventually stock manufacturers made pre-tinted stock.



Toning produces the ‘opposite’ of tinting, the colour range is from white to the tone colour applied. Rather than the film emulsion being dyed, the silver image is changed from black to a colour.

Owing to the limited number of colored metallic compounds available for toning purposes it is possible to obtain only a limited range of tones by the above methods. Certain inorganic compounds, however, have the peculiar property that when immersed. in a solution of a basic dye the dye comes out of the solution and attaches itself to the compound. The dye is then said to be mordanted and the inorganic compound is called the mordant. Silver ferrocyanide is a typical mordant. If therefore, a silver image is converted more or less to a silver ferrocyanide image and then immersed in a solution of a basic dye, a mordanted, dye image is produced.

Extracts from 'Tinting and Toning Eastman Positive Films' Eastman Kodak Co 1927 4th Edition

As a result of a series of experiments in our Research Laboratory it has been found that the most satisfactory method of mordanting a motion picture black and white image is to immerse the film in a special uranium toning bath until the black silver image just commences to turn brown. At this stage sufficient silver ferrocyanide has been formed to mordant basic dyes strongly and if the time of immersion is prolonged so that the image is appreciably colored it will not mordant as well.

Probably something you should not try at home!
Uranium is radioactive!

Immersion of the film in an acid solution of potassium ferricyanide will produce a satisfactory mordant image, but if the film is left for too long a period in the acid ferricyanide bath the mordanting action of the silver ferrocyanide image is destroyed. The uranyl ferrocyanide which is deposited along with the silver ferrocyanide in the uranium toning bath serves as a signal which indicates the point at which the film must be removed from the mordanting bath. .

7Green Tinted Nitrate Base Page 7

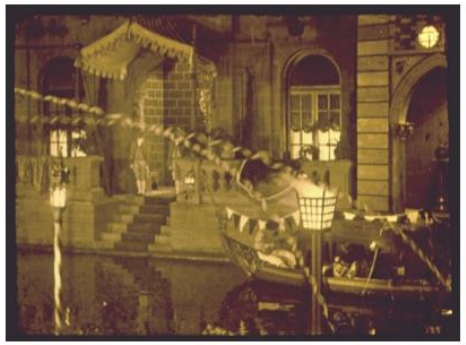
8. Blue Tinted Nitrate Base Page 7

EASTMAN TINTED SAFETY BASE FILM

9. Lavender Tinted Nitrate Base Page 7

10. Red Tinted Safety Base Page 7

11. Pink Tinted Safety Base Page 7



12. Orange Tinted Safety Base Page 7

31. Uranium Tone-Green Base Thin Positive Pages 29 and 36

32. Uranium Tone-Pink Base Thin Positive Pages 31 and 36

33. Uranium Tone- Light Amber Base Thin Positive Pages 31 and 36

34. Iron Tone-Yellow Base Thin Positive Pages 31 and 36

35. Iron Tone-Green Base Thin Positive Pages 31 and 36

36. iron Tone-Blue Base Thin Positive Pages 31 and 36

Meanwhile work was proceeding in the US and Europe to try to perfect a commercial colour system. Most inventers had given up trying to use three colour systems and had settled on two colour.

One of the most important factors they had to consider was that most cinema owners did not want systems that required special projectors; they wanted to switch from colour to black and white easily and obviously did not want to buy more projectors.

The next important invention was duplex film stock – that is stock with emulsion on both sides.
This enabled one side to be dyed one colour and the other side another colour thus producing film that did not need filters to produce colour and could be projected on black and white projectors.

There were numerous systems that used this technique. The colour that each emulsion was dyed or sometimes toned varied as well as the method of obtaining the two colour separations.

Brewster Color c1912-1935 Two and three-colour (American)
Busch colour 1926 Two-colour (Germany)
Chemicolor 1936 Two-colour (British)
Chimicolor 1931 Three-colour (France)
Cinechrome 1921-1929 Two-colour (British)
Cinecolor 1932-1954 Two-colour (American)
Cinecolor 1930-1936 Two-colour (British)
Colcin Colour 1913 Two-colour (British)
Colorcraft 1929 Two-colour (American)
Cosmocolor 1935 Two-colour (American)
Dascolor 1935 Two-colour (Belgium)
Fox Nature Color 1929-1930 (American)
Franchita 1931-1937 Three-colour (France)
Harmonicolor 1936 Two-colour (France)
Harriscolor 1928 Two colour (American)
Herault Trichrome 1926 Three-colour (France)
Hillman Colour 1930-1935 Two-colour (British)
Horst 1926-1930 Three-colour (Germany)
Kelleycolor 1924 Two-colour (American)
Kodachrome 1915 Two-colour (American) (A different system to the later Kodachrome)
Magnacolor 1931-1946 Two-colour (American)
Multicolor 1928-1932 Two-colour (American)
Photocolor 1930 Two-colour (American)
Polychromide 1918-1937 Two colour (British)
Raycol Colour 1929-1933 Two-colour (British)
Sennett Color 1930 Two-colour (American)
Splendidcolor 1929 Three-colour (France)
Talkicolor 1929-1933 Two-colour (British)
Vitacolor 1930 Two-colour (American)
Zoechrome 1929-1932 Three-colour (British)

Some two colour systems

Dascolor

Cinecolor

Polychromide

Kodachrome

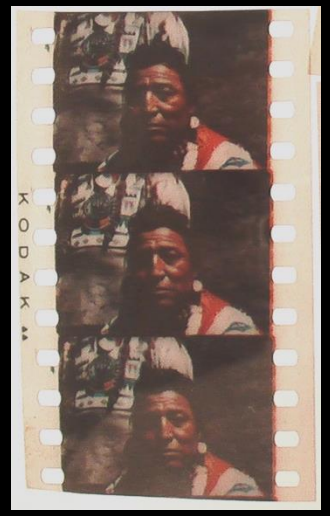
Multicolor

Brewstercolor

Technicolor

Prizmacolor

Trucolor



Zoechrome

British Chemicolor

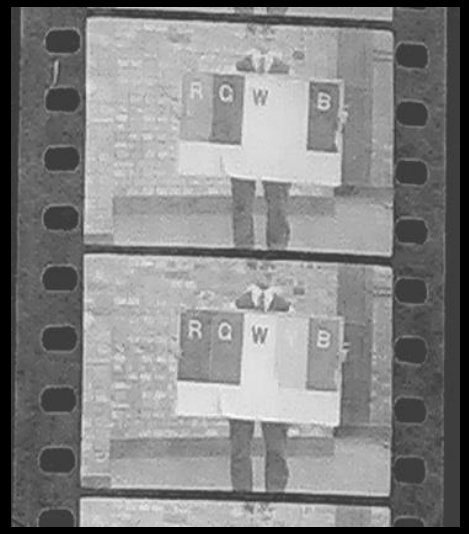
The original negative could be shot

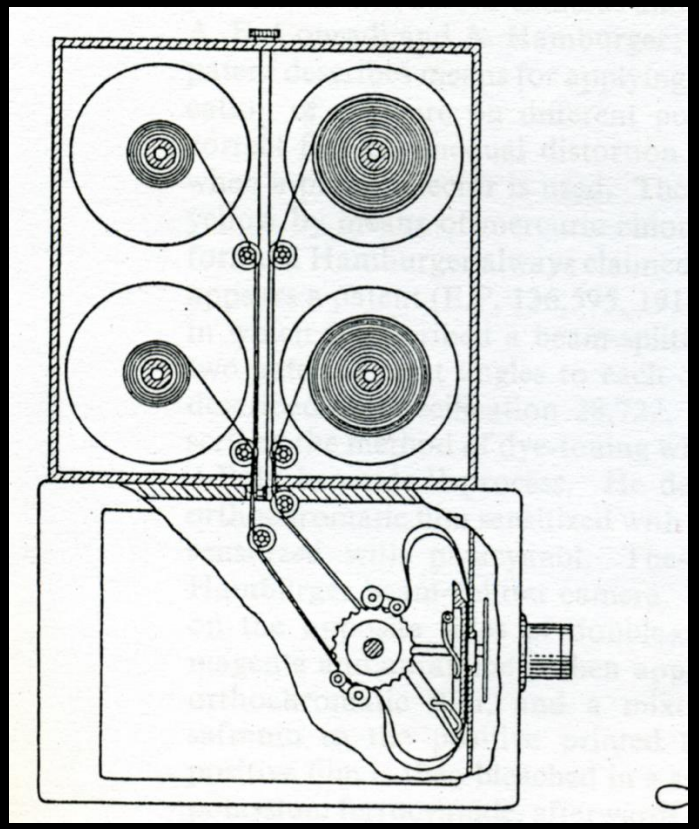
a) Sequentially, that might cause time-parallax errors

b) Using multiple frames shot simultaneously onto a single frame causing loss of quality and increased grain

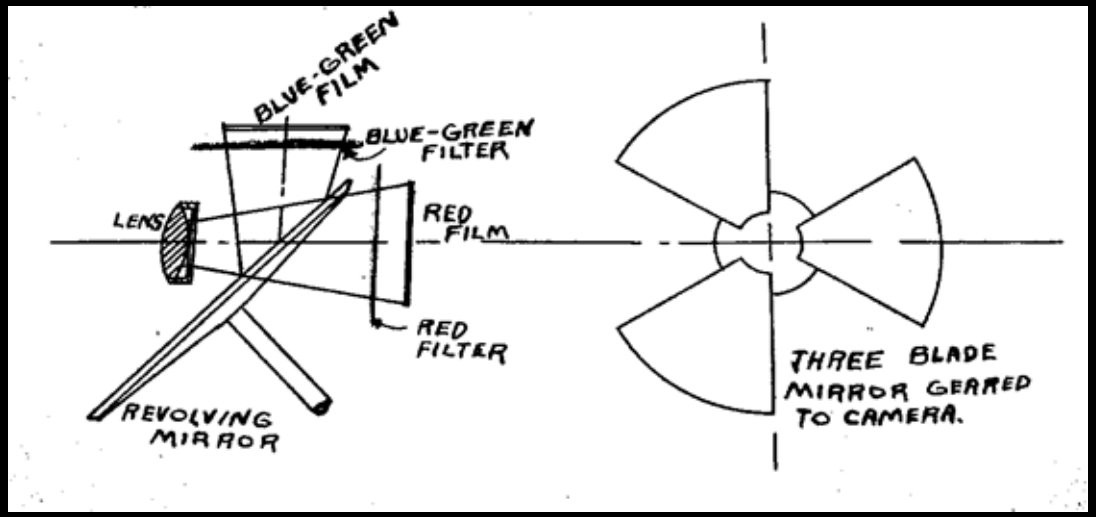
c) Using a bi-pack camera where two rolls of film were exposed together in the camera

d) Using a camera with a beam splitter photographing onto two rolls of film





Multicolor camera



Brewster colour camera

Raycolor

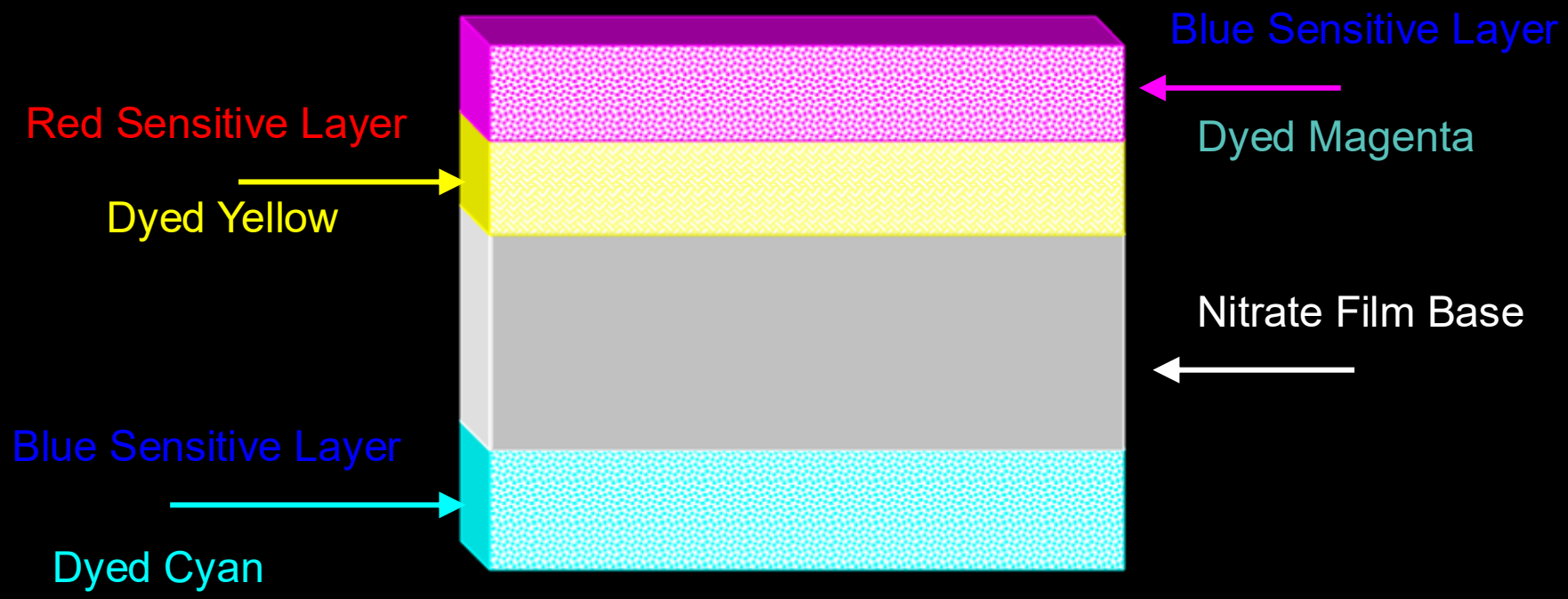
Eventually some three colour systems came along to challenge the two colour systems.

In 1934 Dr Bela Gaspar invented Gasparcolor.

- It is a three colour subtractive reversal print stock
- It uses the dye bleach, also called dye destruction, process.
- It has to be exposed using separation positives, this means that live action will suffer from time-parallax errors unless precautions were taken so it was mainly used for animation subjects

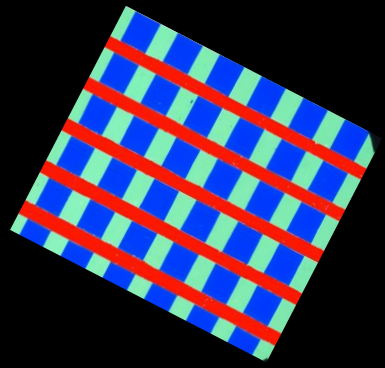
For live action either three separations from a beam splitting camera were necessary, or a Vinten camera running at 72 frames-per-second with rotating three-colour disc. Separations were made and the speed came down to 24fps when combining the three frames.

Gasparcolor

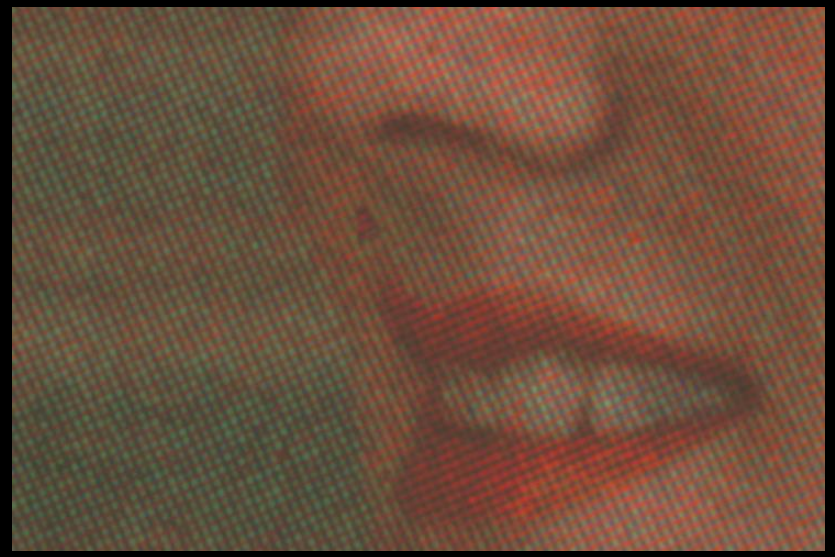


Around the same time came Dufaycolor

Dufaycolor used black and white film that was coated onto a safety film base that had red, green and blue ink lines printed on it.



Reseau

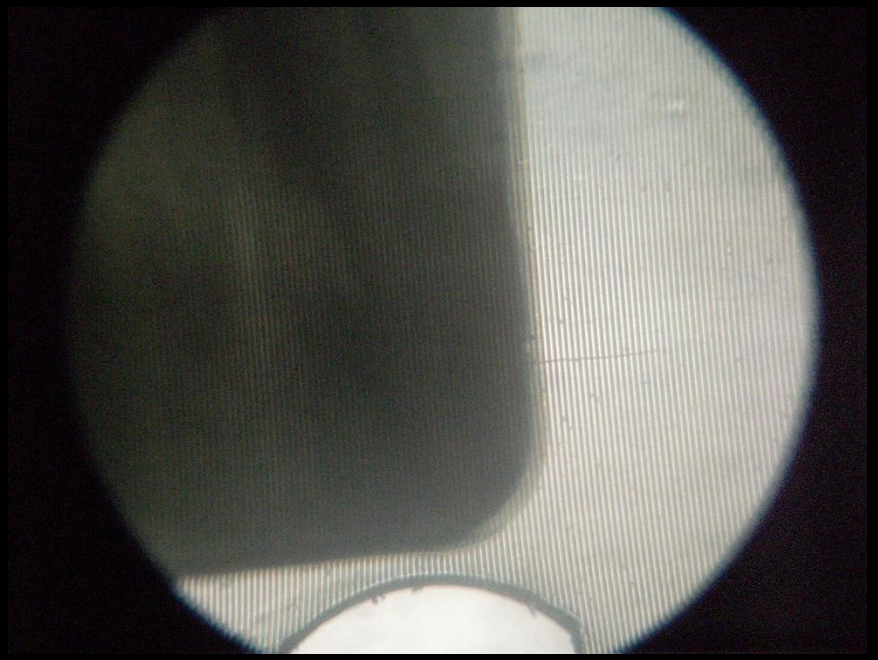


The main problem with Dufaycolor was a lack of brightness caused by having to project through the reseau which absorbed two thirds of the light. The only major feature made with Dufaycolor was ‘Radio Parade’ made in 1934 although quite a number of shorts were made.

Kodacolor 1928

Keller Dorian1923

Eastman 5306 1951



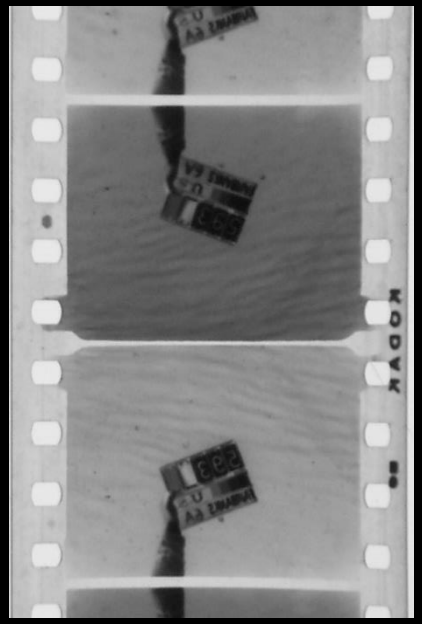
Lenticular Film: Invented by Berthon in 1909

Technicolor had started in 1917 with a two colour system, it was not a success.
A prism behind the lens split the scene into two images recording one through a red filter and one through a green filter onto adjacent frames.

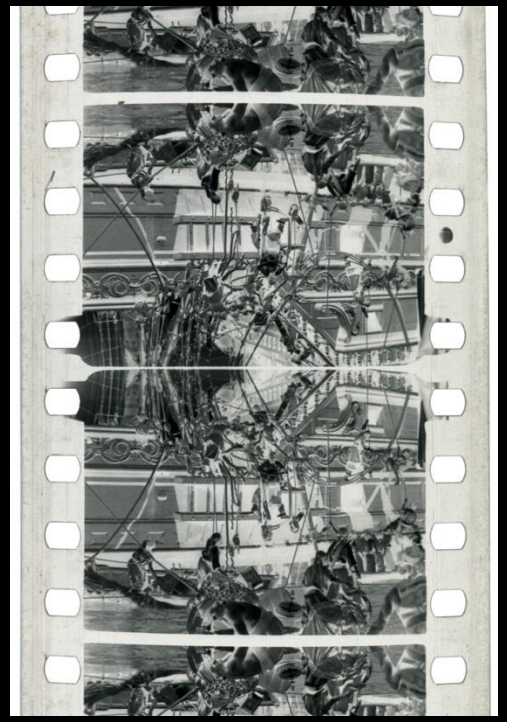
The print was projected through a special projector that showed two frames at once through appropriate filters.

The system had all the usual problems, registration and a special projector needed and also the rolls of film lasted half the time.

Their second system 1922-27 also had problems. A two colour system, it used a prism to split the scene into two frames, one of which was recorded upside-down



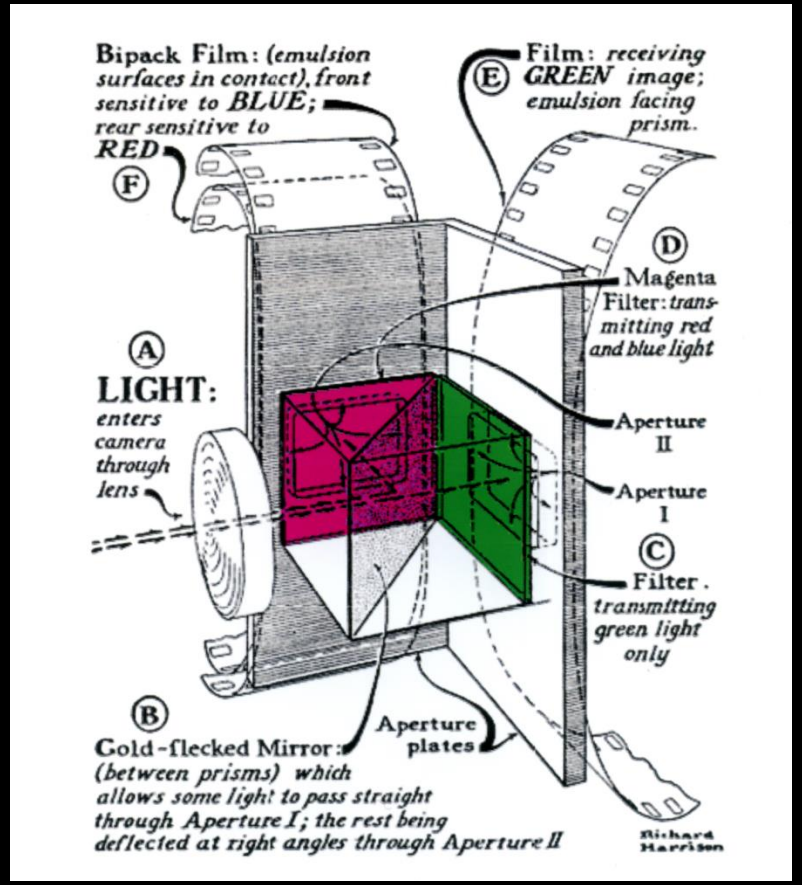
A special printer printed the negative into two separate prints on thin print stock which were then developed in a tanning developer to make relief images that could be dyed red and green. The two prints were then cemented together. Perhaps the most famous film using this process was 'The Black Pirate' starring Douglas Fairbanks.



In 1928 came process number 3. The same camera was used but from the negative two matrices were made. These were positive prints with a relief image that could be soaked in dye and then physically printed onto a film stock that had a thick clear emulsion – known as imbibition printing.

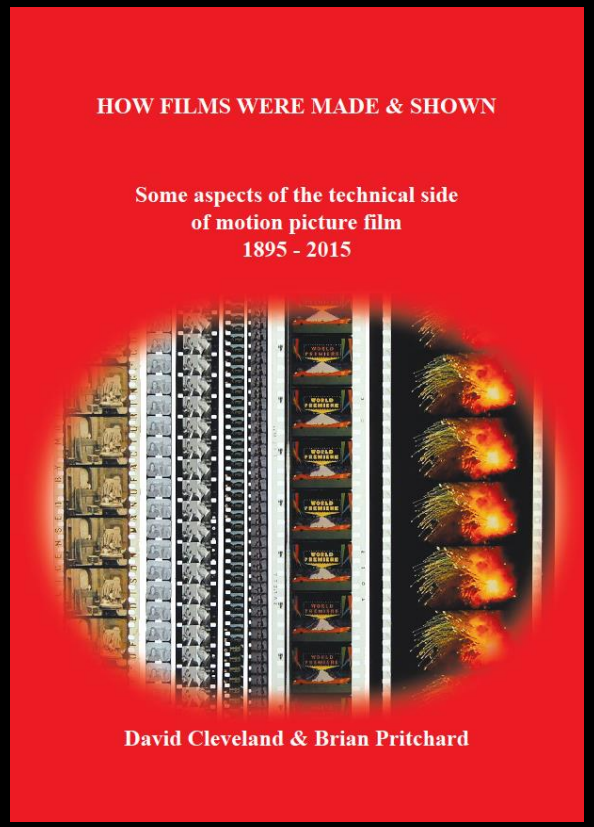
The Gold Diggers of Broadway (1929)
Sound was on Vitaphone disc

In 1932 Technicolor added a third colour, the process lasting another 20 years.
A special camera was used that filmed onto three rolls of film through a prism



2 Colour Technicolor

3 Colour Technicolor



Many of the pictures in this presentation are taken from ‘How Films Were Made and Shown’, a book by David Cleveland and myself.