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Bridging Science, Art, and Industry

History of Color in Cinema

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Movies in Color

Almost as old as movies themselves

- Kinetiscope projector invented by Edison with Wm. Dickson 1891
- 1890 first motor driven camera had been invented (same team)
- Early films used tinting, toning and hand-coloring

- 1st color film (Dickson & Edison)
  - 1895, *Anabelle's Dance*, captures Anabelle Moore dancing
  - Embodies the Art Nouveau spirit of movement and color
  - Hints at the mystical connection that cinema would develop with viewers *(The World Viewed, Cavell)*

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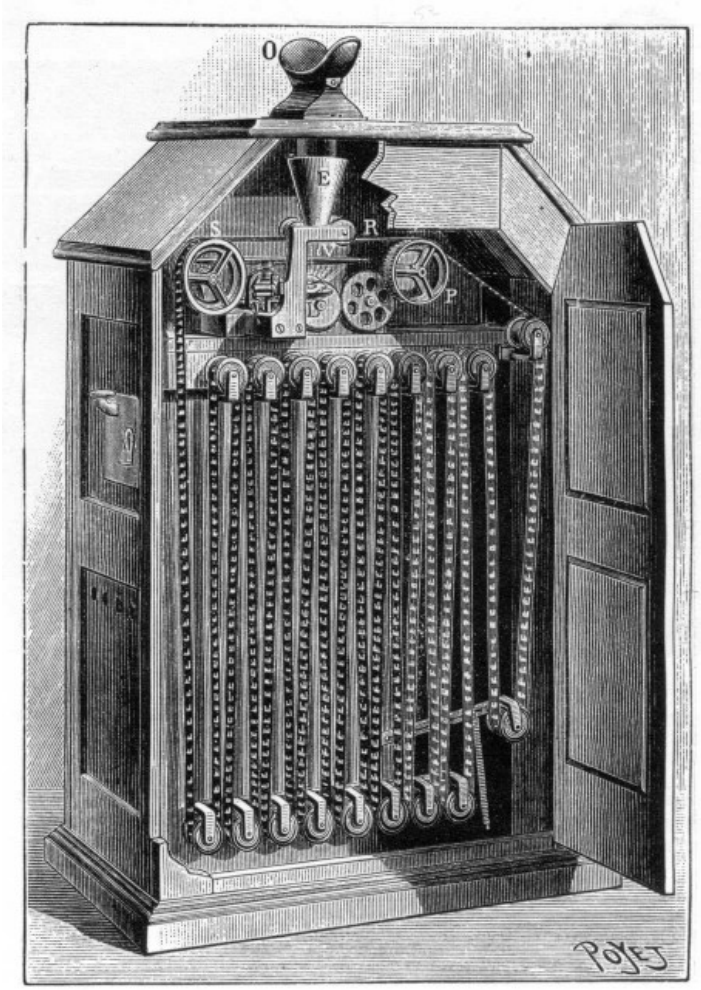

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Auguste and Louis Lumière

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- Patented cinematograph which allowed simultaneous viewing
- Patented film perforations to guide film through camera/projector
- Focused attention on color photography —patented autochrome

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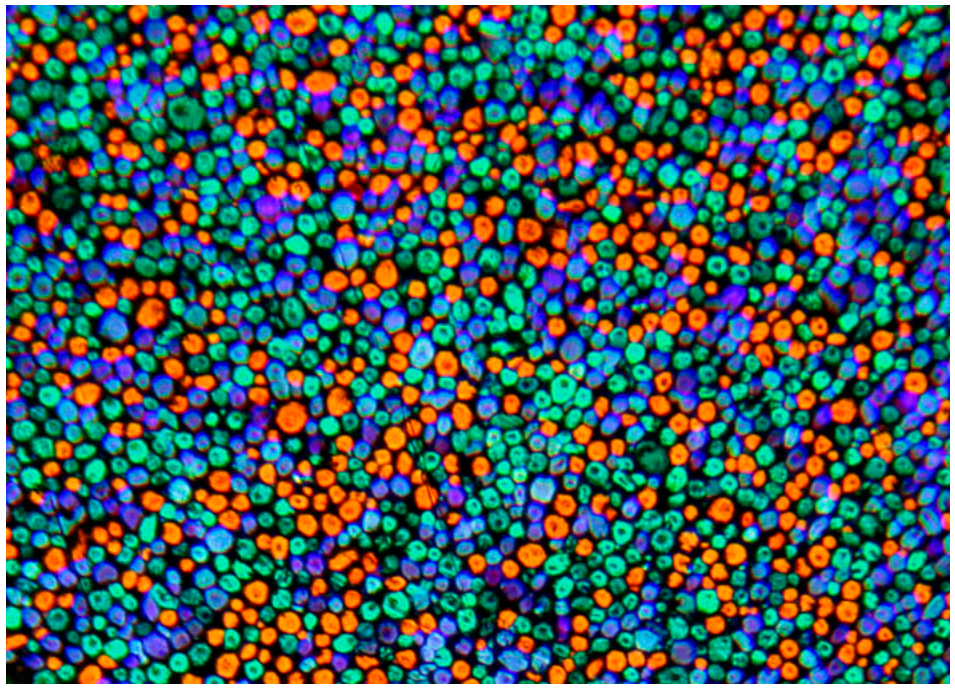

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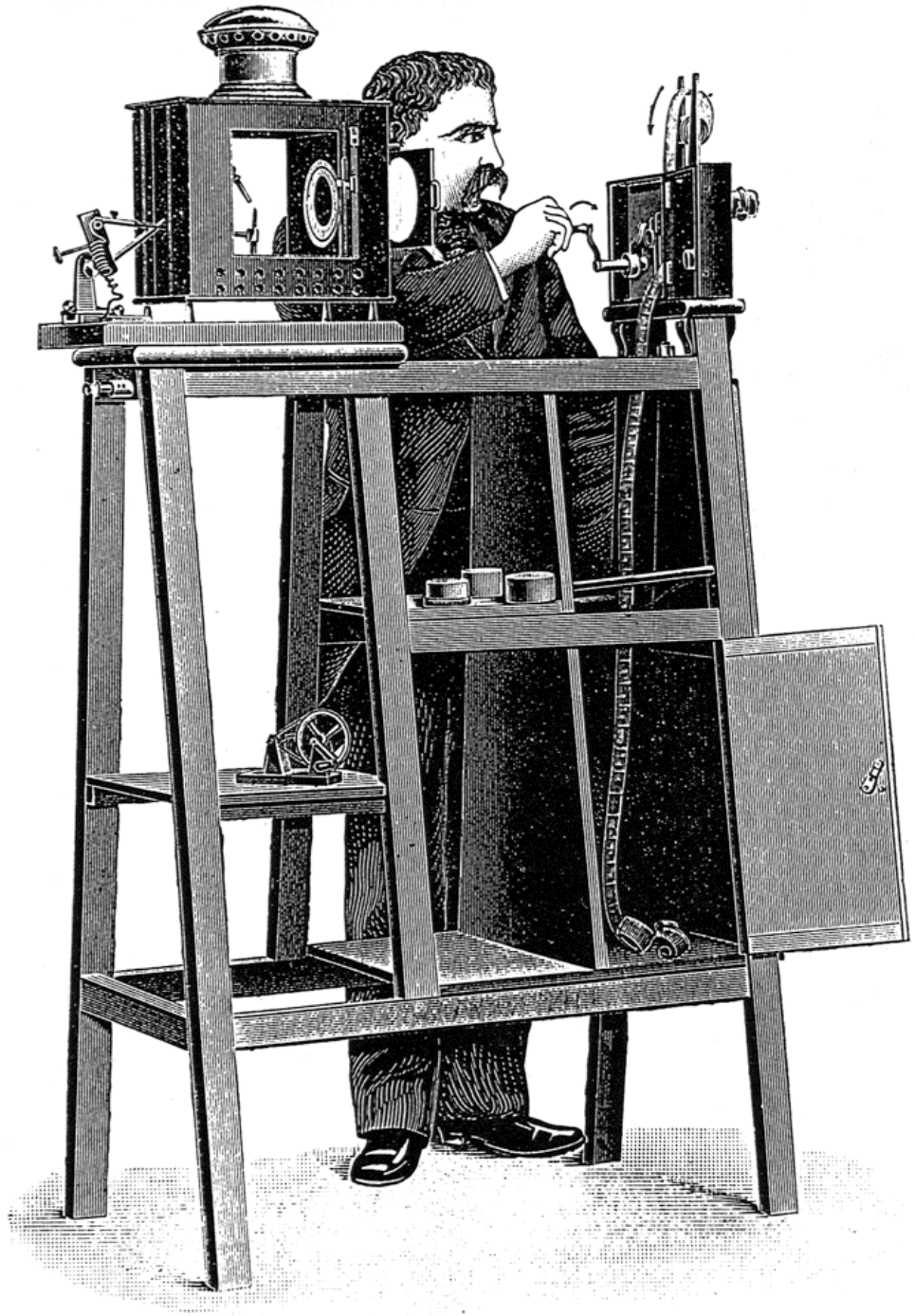

Le cinématographe Lumière: projection.

Marie-Georges-Jean Méliès

- French illusionist & filmmaker
  - Directed 531 films (1896–1913)
  - Théâtre Robert-Houdin in Paris
  - Special effects, multiple exposures, time-lapse photography, dissolves
  - B&W mostly – some color
  - Many films strange and surreal – began science fiction and horror films
  - 1902 – *A Trip to the Moon* – frame by frame painting – 21 painters

2011 – Martin Scorsese's ***Hugo***

- starts as an adventure film and ends as a historical drama

Women Dominated the Industry

Workforce for hand-coloring was almost entirely women

- They were thought to be more dexterous, more sensitive to color, and they could be paid less
- Prior to the invention of cinema, women dominated the hand-coloring market for lantern slides


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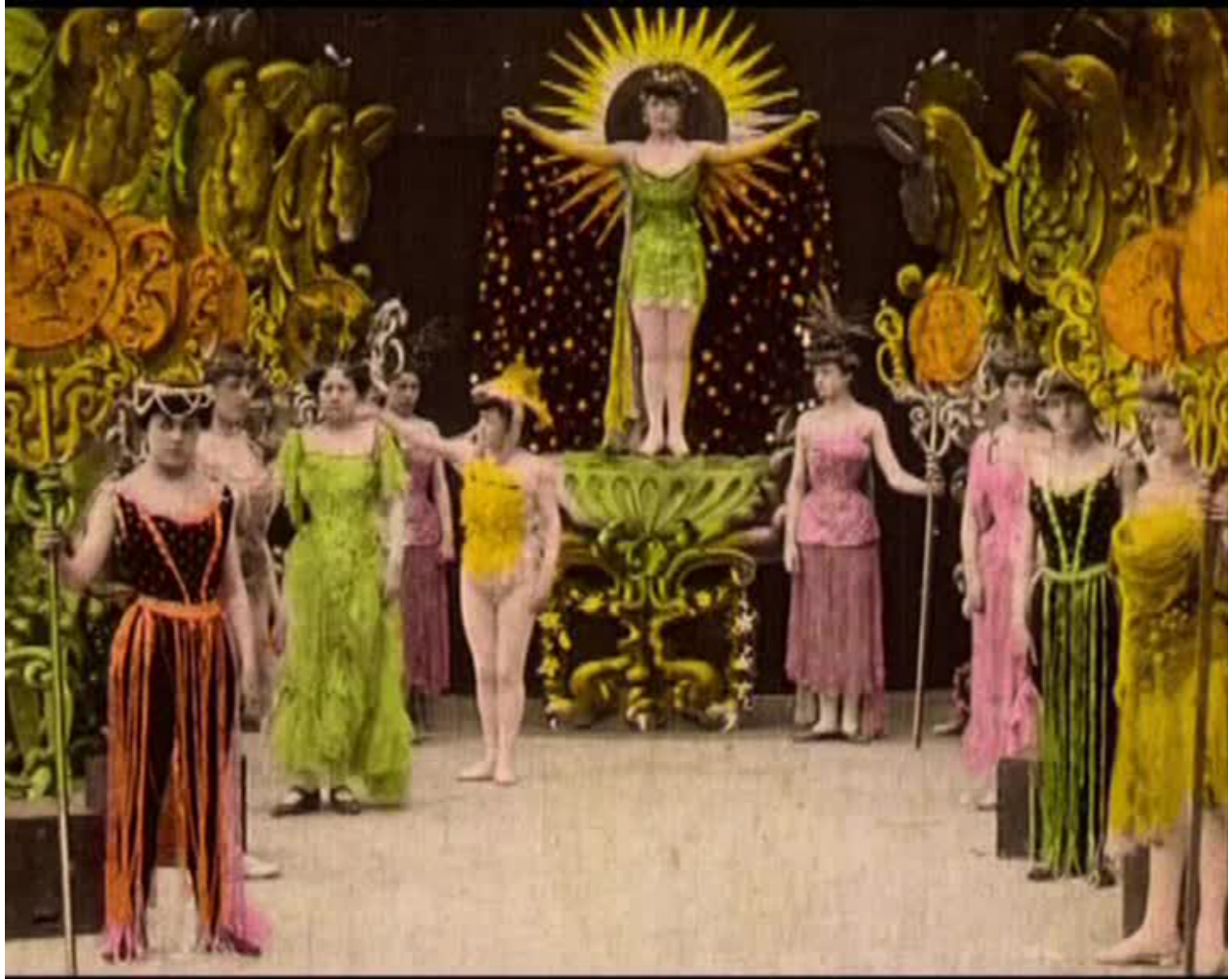
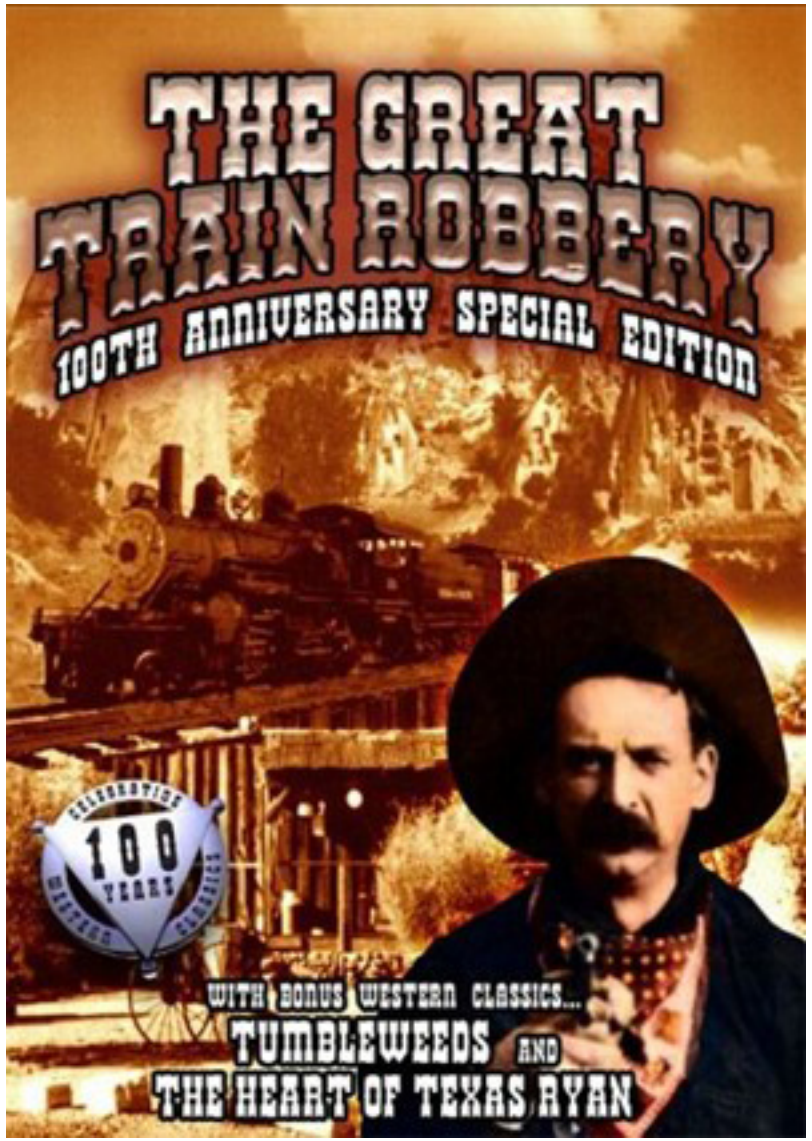


Film Tinting in Cinema

- Used for movies as well as still photography
- With tinting , the stock or emulsion is given overall tint – red for firelight or blue for nighttime
- Sonachrome (1929) Kodak pretinted film stocks
  - 17 colors:
    Peachblow, Inferno, Candle, etc.

Film Toning in Cinema

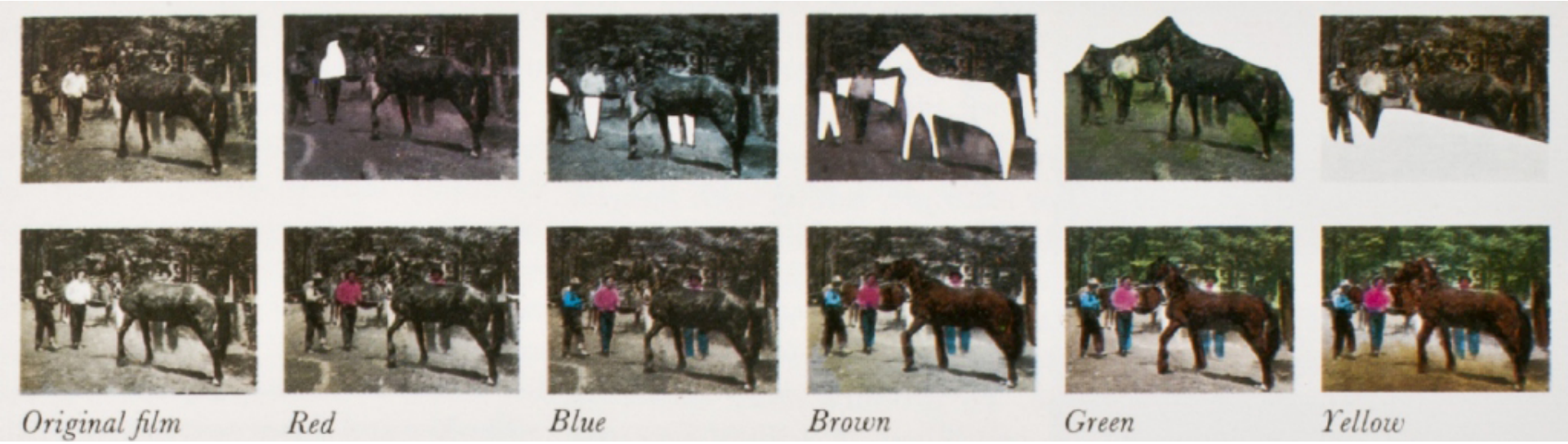
- Toning replace silver image with mordant dyes giving a hue to the shadows
- Tinting, toning, hand painting sometimes applied together *The Great Train Robbery (1903)*
- Sometimes considered the 1st silent movie – 12 minutes
  - Produced by Thomas Edison
  - Filmed by Edwin Porter



Stencil-Colored Movies

- Stencil coloring displace hand coloring in early 20th century
- Used etched glass plates to apply dyes to portions of the scene
  - *Pathé Color* – Pathe Freres – 1905 was the first commercial stencil process
  - Pantograph cut areas to make dye masters – high speed dyeing machine – could work on enlarged image (reduced back to film size)
  - Still a frame-by-frame process but the stencils could be reused on subsequent prints
  - No longer used after 1930

Stencil Process



- Usually 3 to 6 color used for a given frame
- Acid dye transferred onto a black and white image
- Colors were usually pastels

Last Days of Pompeii – 1926

Original release prints of the film were entirely colorized by the Pathechrome stencil color process.

Handschiegl Color Process

- 1916 – three-color lithographic stenciling process
- Engraver Max Handschiegl and cinematographer Alvin Wyckoff
- Used for Joan the Woman Cecil DeMillle (1917)
- Was a foundation for the dye-imbibition process used in Technicolor 3

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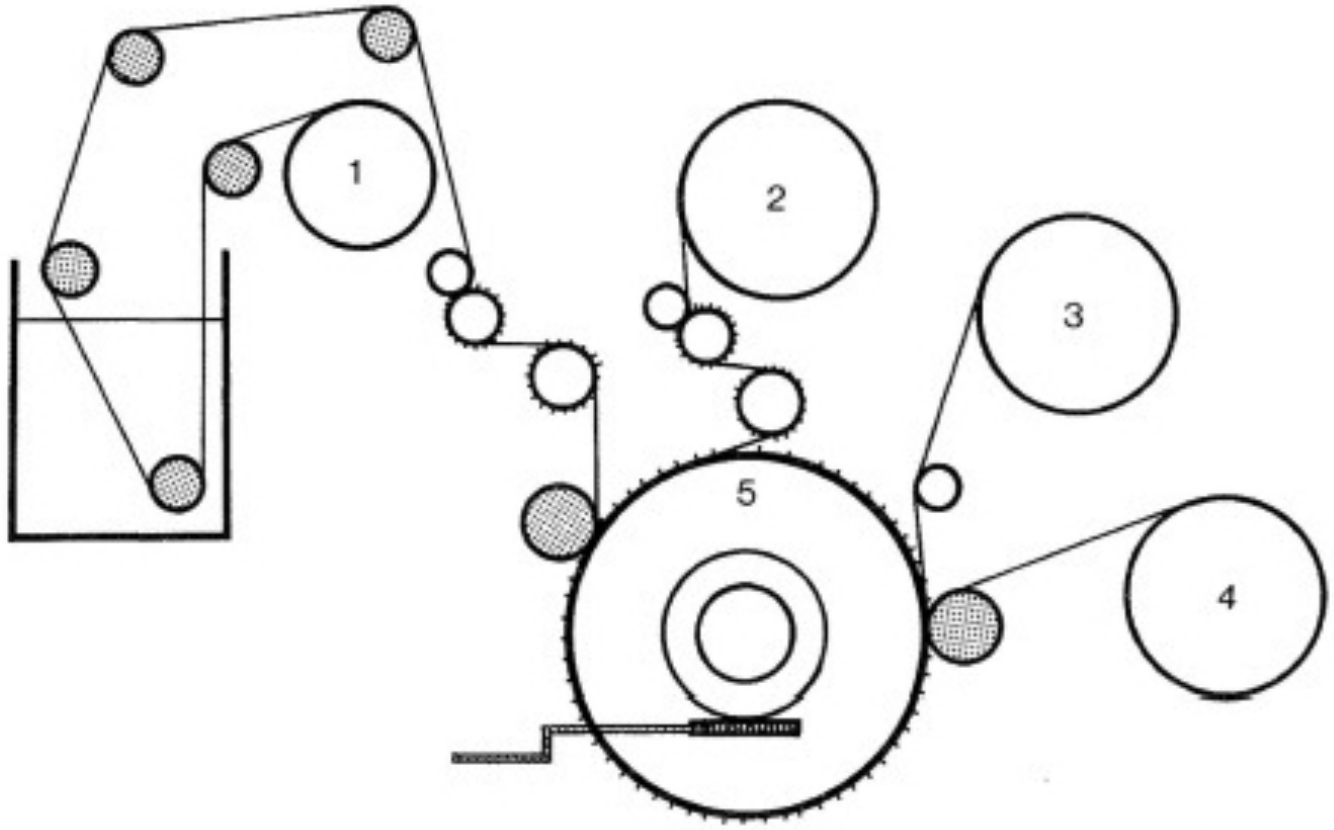
Handschiegel Dye Transfer Machine



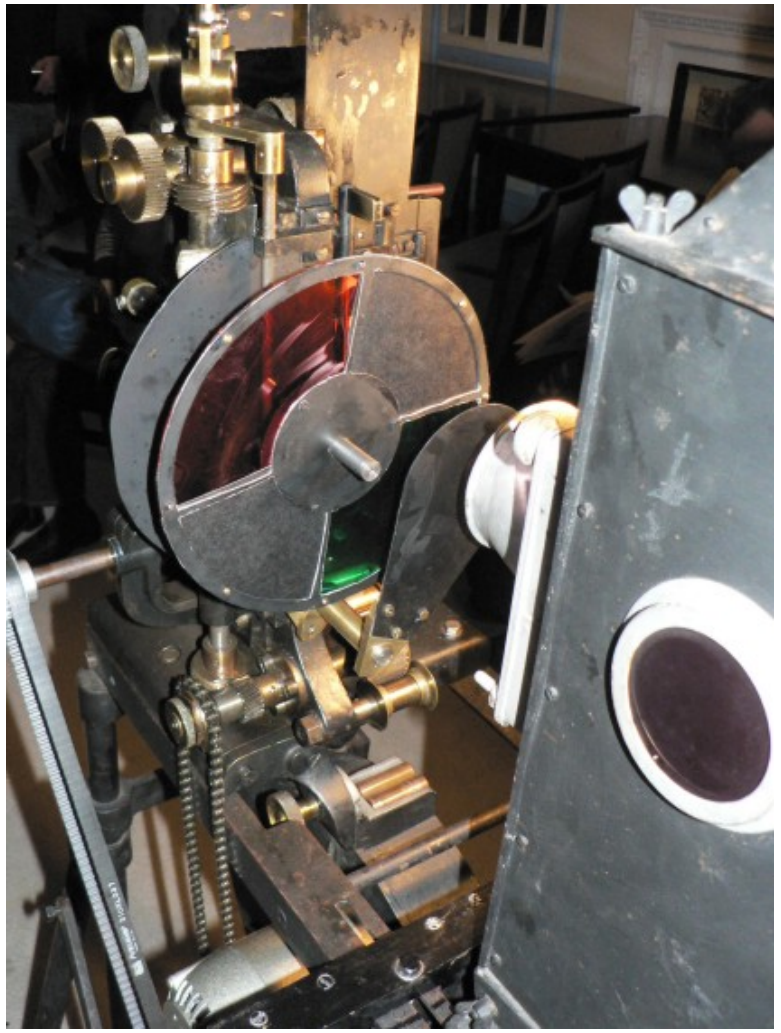
The bleached and dyed negative is brought into contact with the positive on a large sprocket drum for transfer of dye

1. Positive film in
2. Negative film in
3. Negative take-up
4. Positive take-up

LIGHTS OF OLD BROADWAY (1925, Monta Bell)

Kinemacolor

- George Smith, Brighten Eng.
- 1st films captured in color
  - 1906 – additive color system
  - Commercially used 1908—1914
  - Two color process, 32 fps
- B&W panchromatic film
  - photographed through alternating red & green filters
  - Positive films made from negs. projected through same filters
- 300 theaters, 54 films
  - Were copycat processes but plagued with color fringing



Images never good enough and projector installations too expensive

Kinemacolor

32 frames per second of each color

Kinemacolor

32 frames per second of each color

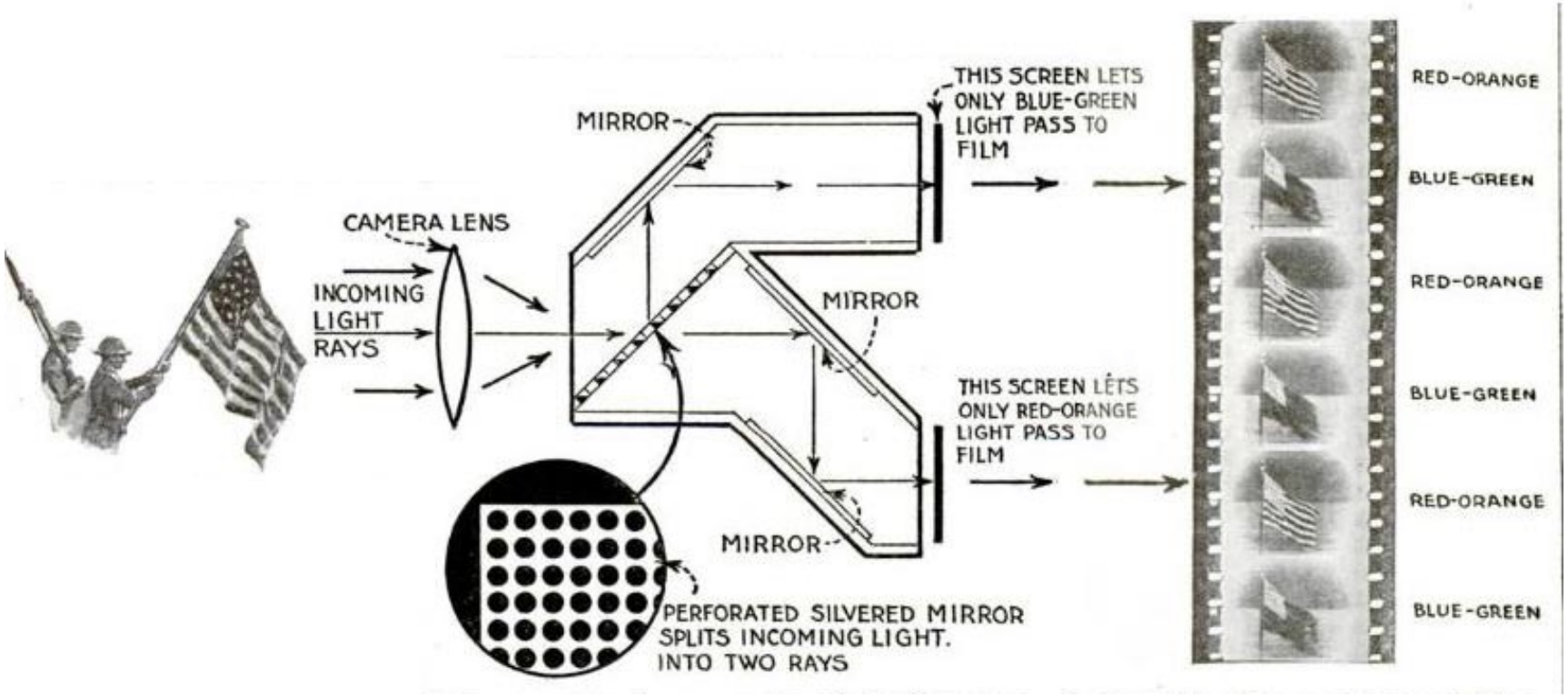
Kinemacolor

32 frames per second of each color

Prizma I Color

William Kelley and Charles Raleigh – 1913

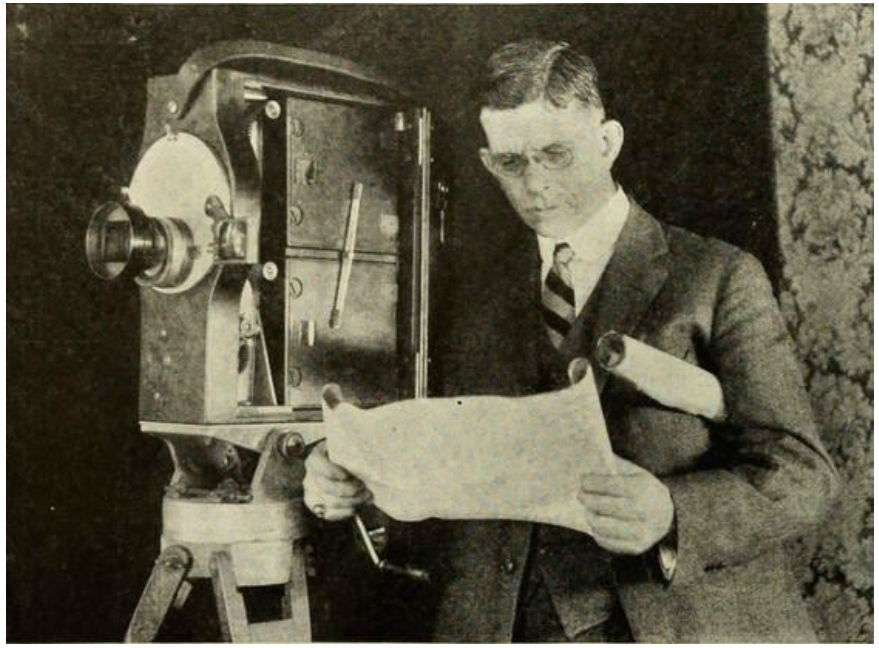
- Started as two-color additive system (like Kinemacolor)
- 1917 – demonstrated a four color process
  - Red, green, yellow, blue



Single Film Projection

William Kelley converted Prizma to subtractive system

- Projecting a bi-pack film sandwich
- 1917 – two films simultaneously exposed in special camera
  - One sensitive to orange-red
  - Other to blue green
  - Each toned with its complementary color
  - Projected with ordinary projector
- Made a stereoscopic version of the camera

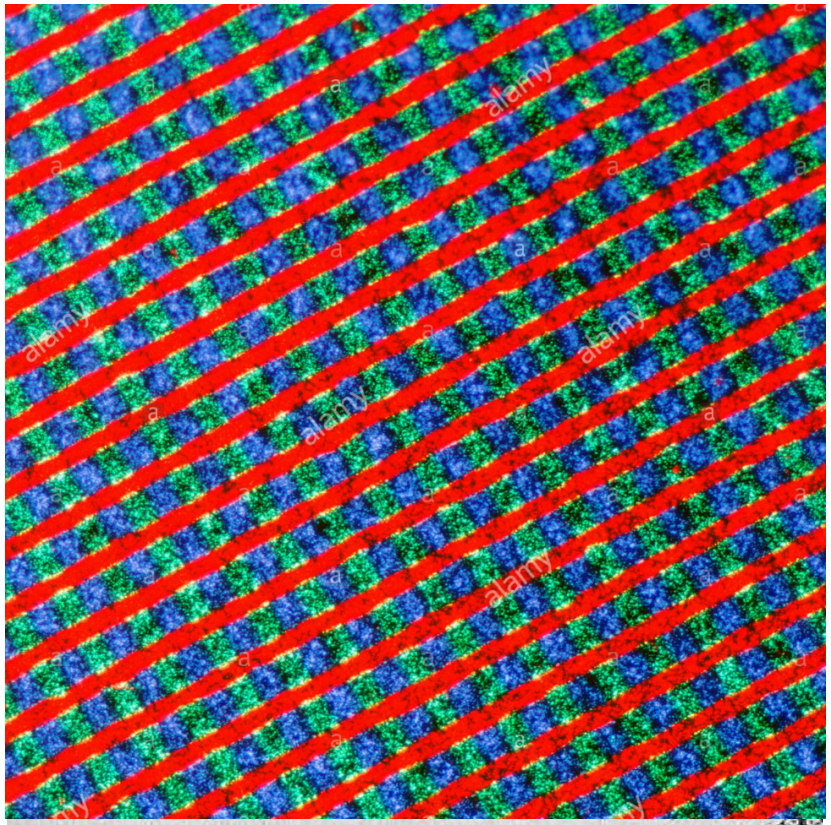


Prisma is Sold

- 1922 considered the apex of Prisma color
- Lost suite of Technicolor for patent infringement
- Prizma camera used for 3D film *Power of Love*
- 1923 Samuel Goldwyn produced *Vanity Fair*
- 1928 bought by Consolidated Film Ind.
- Sold patents: Cinecolor

Dufaycolor

- 1908 by Louis Dufay
  - Based on Lumière Autochrome
  - Additive single film process
- 1926 purchased by Spicers
  - Converted to movie film (1931)
  - Fine mosaic RGB laminated to B&W film base
  - Only used for two pictures and several shorts
  - Overtaken by Kodak and Agfa
- Switched to still photography film
  - Lingered until 1956

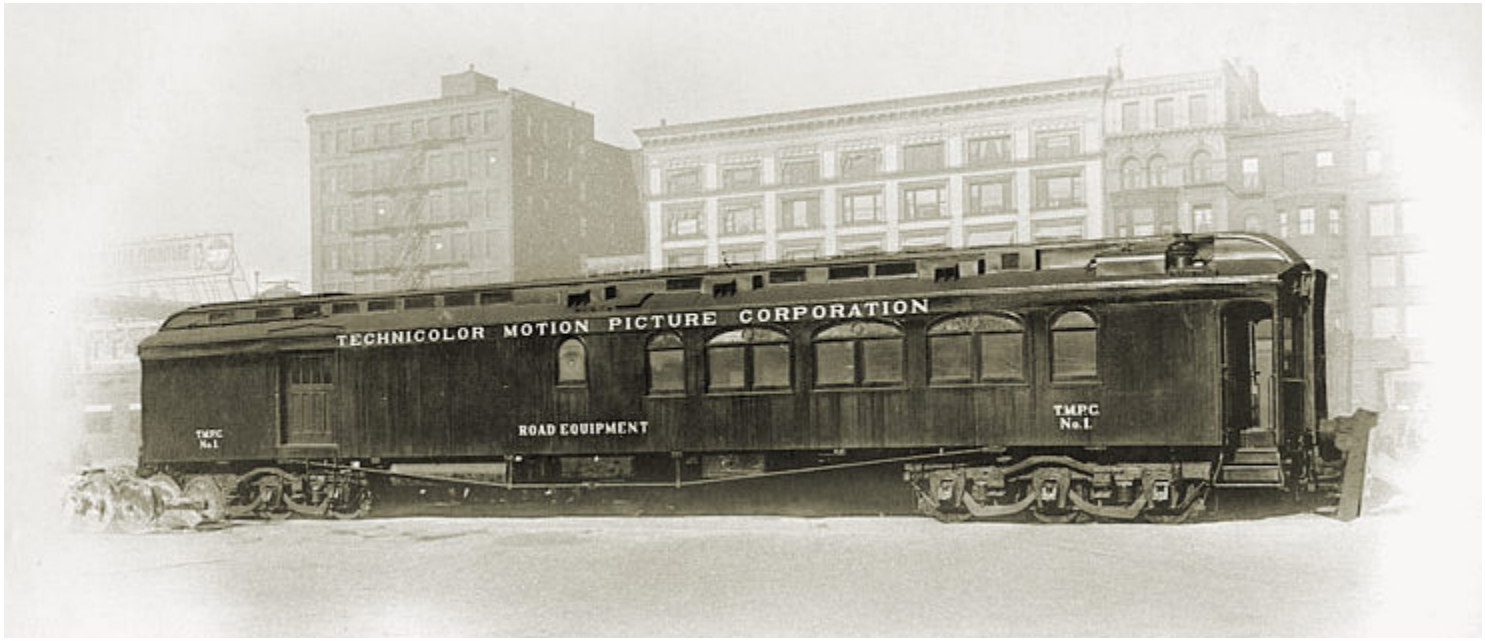


Dufay film frame showing laminated color mosaic layer
Discolored with time

Dufay film frame restored to original color appearance

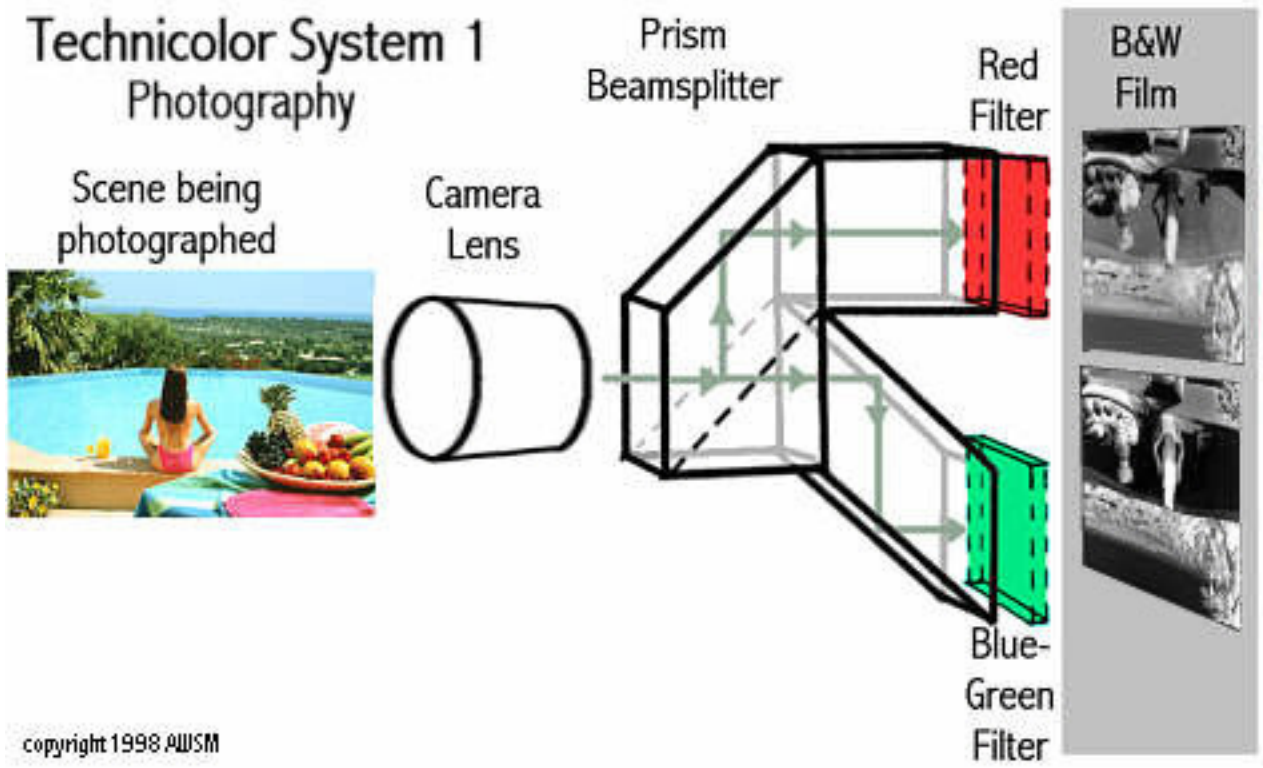
Technicolor I

- Technicolor Corp. “tech” from MIT was founded in 1914 by Kalmus, Comstock, & Wescott
- Most widely used color process from 1922 to 1952
- Initially 2-color process -- Goal was “flicker free”
- Suffered from alignment and additive color problems



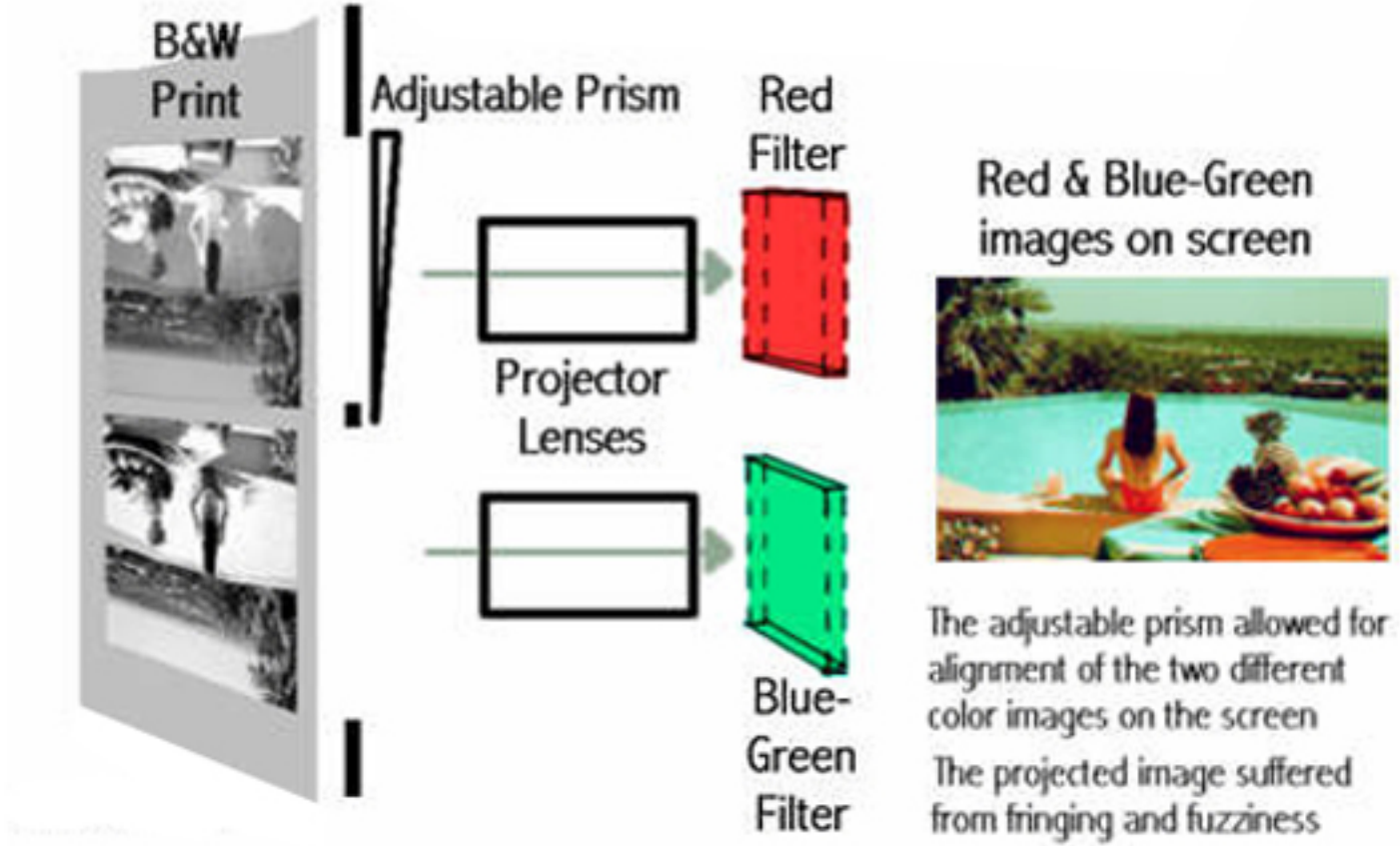
Technicolor I Capture

- Prism behind single lens splits light through red and green filters onto two frames of filmstrip



Technicolor I Projection

- Projector had two apertures with appropriate filters
- The B&W positive film was projected through filters to reconstruct the original image



Technicolor II

- 1922 Technicolor II , a subtractive process, launched
- Camera was the same
  - Green and red filter frames were printed on separate films.
  - Green filter positive frames were toned orange/red.
  - Red filter positive frames were toned cyan/green
  - Two prints cemented back-to-back to form a projection print
  - Special projector & screen register unnecessary
  - Images were brighter

1922 The Toll of the Sea
1st Technicolor II release

Technicolor II

- Used in:
  - Ten Commandments (1923)
  - Phantom of the Opera (1925)
  - Ben Hur (1925)
  - The Black Pirate (1926)
- Technical problems:
  - Cemented film strips – emulsions not on the same plane
  - Soft focus and cupping from film uneven thickness of film
  - Emulsion on both side doubled the scratching
  - Splicing was difficult leading to film breaks

Technicolor III

- Released in 2028, referred to as Technicolor Process 3
- Based on 1916 dye transfer patent (Max Handschiegl)
- Still two-color
- Dye-imbibition – hardened gelatin submerged in dye bath
- Transferred to blank film stock with gelatin layer coated with mordant
- *Song of the Flame* 1st 65mm Vitascope widescreen

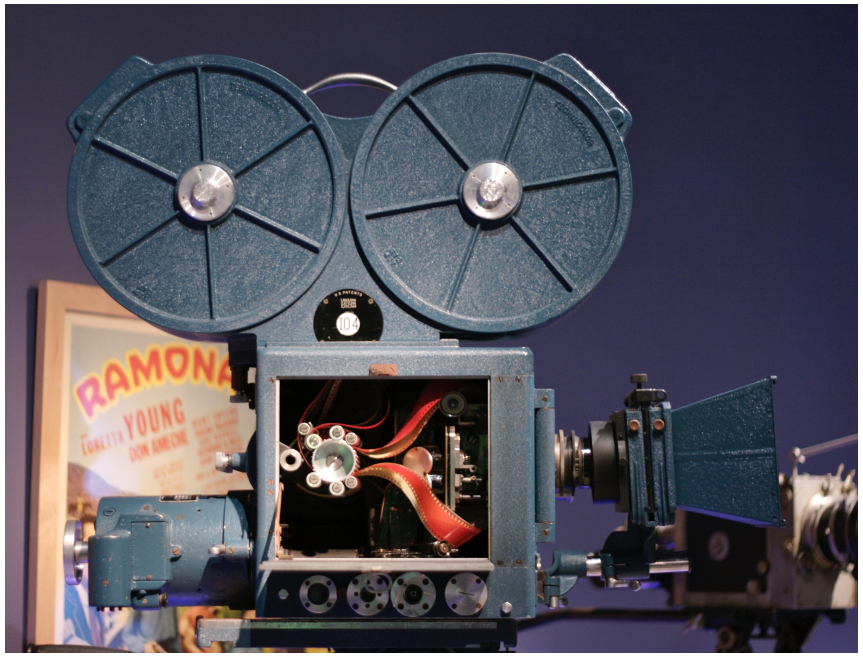
On With the Show

1929 – first all-color

All talking movie

Technicolor 4

- 1932 unveiled 3-color process —full spectrum (CMY based)
- Beam splitter divided image into three components
- 1/3 through green filter to panchromatic film
- 2/3 through magenta filter to remove green—then onto pair of films spooled together



- One orthochromatic (not red sensitve) to capture blue then to a panchromatic film to capture remaining red image

Printing Technicolor 4

Becky Sharp 1935
Gone With The Wind
Signin' In The Rain
Adventures Of Robin Hood
Joan Of Arc
Snow White

Printing Technicolor 4

- To make a print – each film was copied onto a light-sensitive gelatin film strip
- Soaked in a dye bath of the complementary color
- Images transferred to B&W film with sound track prerecorded soaked in mordant solution
- Color was rich and natural
- Required very bright light – ASA 5

Becky Sharp 1935
Gone With The Wind
Signin' In The Rain
Adventures Of Robin Hood
Joan Of Arc
Snow White

1942 Casablanca

Serious films were shot in Black and White through the 1940s

1950's Kodak and Technicolor

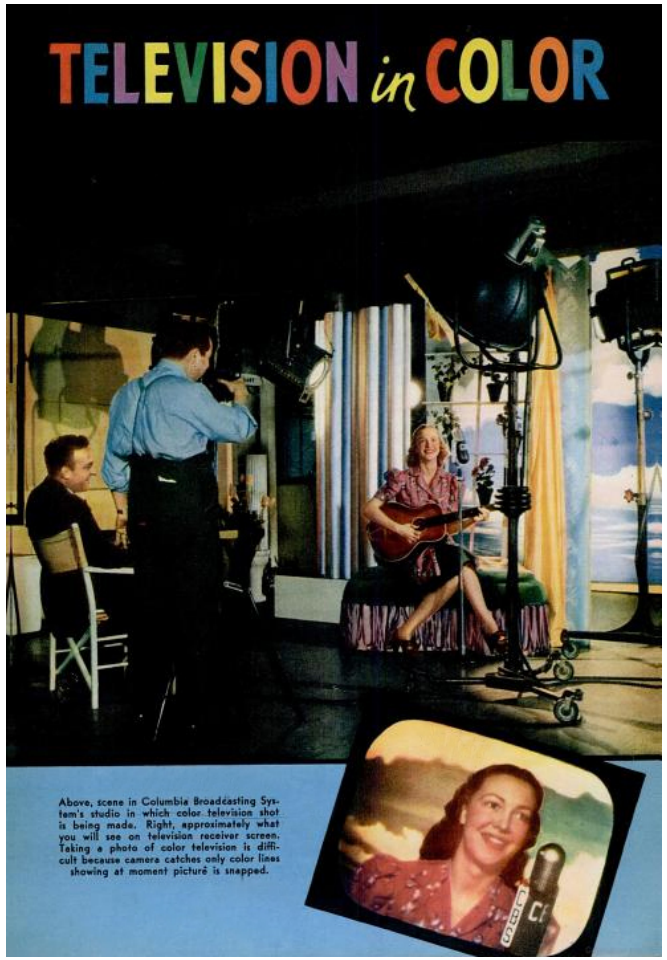
- Kodak and Agfa had introduced films in 1930's that recorded all three colors on a single strip
- Both were reversal films available for 8 and 16mm markets
- 1950 first Kodak negative film
- 1952 Kodak print film
- Used for making Technicolor prints
- Saved camera rental, greater versatility
- Technicolor does not fade – film fades quickly

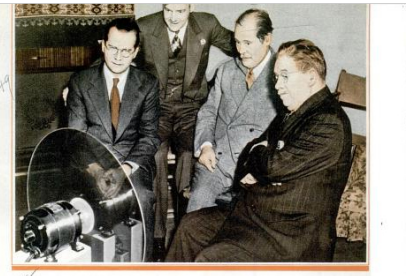
Cinema Responds to Television

- In the 1950s color became a common medium accessed in peoples homes
- Cinema had a new competitor searched for ways distinguish
- Color television came into common use during the 1950s after 20 plus years

1941 Popular Mechanics

- Describes color television as the next big thing





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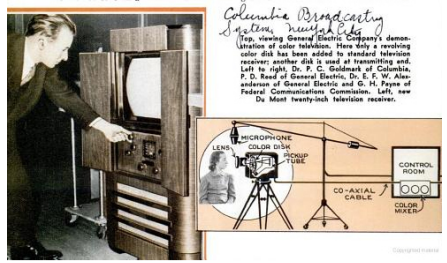
By JULIAN LEGGETT

AFTER five years in its "swaddling clothes" of black and white, television is on the verge of changing to fancy dress. Within a short time, experts tell us, pictures in all the colors of the rainbow will be flashing through the air to the receiver screens of a favored few Americans living near transmitting stations.

Television in color has come with a rush, having been developed and demonstrated successfully in the laboratory while most of the nation still awaited the arrival of black-and-white television. Its secret is a couple of disks containing red, green and blue filters. One disk rotates



Columbia Broadcasting System, Inc.

Top, viewing General Electric Company's demonstration of color television. Here only a revolving color disk has been added to standard television receiver; another disk is used at transmitting end. Left to right, Dr. F. C. Goldmark of Columbia, P. D. Reed of General Electric, Dr. E. F. W. Alexanderson of General Electric and G. H. Payne of Federal Communications Commission. Left, new Du Mont twenty-inch television receiver.

K1349

in front of a pickup tube at the transmitting end. Synchronized with it is the second disk which rotates in front of the receiver tube in the individual set. When the red filter is in front of the pickup tube, only those parts of the scene or picture being televised which contain red register in the pickup tube. At the same instant the red filter in front of the receiver tube in the individual set permits only red portions of the picture to reach the viewing screen. The same holds for the green and the blue filters, with each operation performed at lightning speed.

Comparatively few people understand how television works, even the black-and-white variety. If you place a strong magnifying glass over a photograph reproduction in a daily newspaper, you see that the original photograph, when it was made into an engraving, was broken up into a field of black dots varying in diameter and hence, to the eye, in density. To get a television image, the original subject in effect is broken into a number of electrical impulses which do approximately the same things when they arrive on the television viewing screen—they

Above, Rockwell Kent, looking in mirror, sees how he appears to television audience. Mirror is shown above lens of television camera in General Electric's studio at Schenectady, N.Y.

Above, Dr. Goldmark, CBS engineer, at still projector of color television equipment which he developed. Left, sketch of how color television works. The setup is identical with black-and-white television, save that color disks are used at transmitting and receiving ends and that controls include color mixer.

Above, at the controls in General Electric's television studio. This is a natural-color photo, as is the one below which shows a tester applying voltage to television receiving tube. The mask is protection against tube explosion.

appear in lines which create a picture. This picture is composed of 441 tiny lines—a standard in the industry.

Special equipment scans, or goes over the entire scene or picture being televised, picking up light waves which in turn are converted into the electrical impulses that are transmitted, then changed back into light waves at the receiving end, thus forming the picture. Dr. Peter C. Goldmark, chief engineer of Columbia Broadcasting System's television department, who developed the tri-color television system demonstrated recently, employs a scanning method different from that used in most black-and-white systems. The picture is completely scanned every sixtieth of a second, instead of every thirtieth of a second. However, at the end of the first sixtieth of a second, only two colors have been used. The third color requires an additional 1/120 of a second, bringing the total to one-fortieth of a second for a single picture in

full color. The Goldmark system works like this:

Odd-number lines are scanned in red in 1/120 of a second and the even-numbered lines are scanned in green in 1/120 of a second. At this point the whole picture has been scanned, but there is no blue. Time thus far: one-sixtieth of a second.

Now the red on the odd-number lines has faded and these same lines are scanned in blue in 1/120 of a second. Now the whole picture has been scanned one and one-half times, but in full color only once. Time: one-fortieth of a second.

The green on the even-number lines has now faded, so these same lines are scanned in red in 1/120 of a second. At this point the picture has been scanned twice, but in full color only one and one-third times. Elapsed time: one-thirtieth of a second.

Now the blue on the odd-num-

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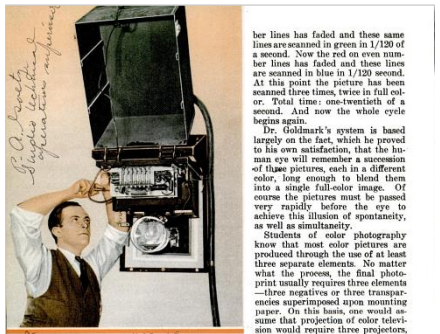
Above, typical scene in studio, with dancer and others performing for General Electric's television camera. This is a natural-color photo. Below, Dr. Alexanderson holding color disk of the type used in color television work. This also is a color photo.



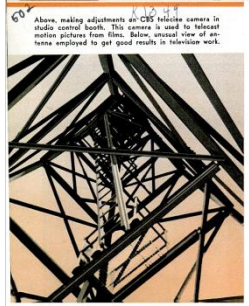
ber lines has faded and these same lines are scanned in green in 1/120 of a second. Now the red on even number lines has faded and these lines are scanned in blue in 1/120 second. At this point the picture has been scanned three times, twice in full color. Total time: one-twentieth of a second. And now the whole cycle begins again.

Dr. Goldmark's system is based largely on the fact, which he proved to his own satisfaction, that the human eye will remember a succession of three pictures, each in a different color, long enough to blend them into a single full-color image. Of course the pictures must be passed very rapidly before the eye to achieve this illusion of spontaneity, as well as simultaneity.

Students of color photography know that most color pictures are produced through the use of at least three separate elements. No matter what the process, the final photoprint usually requires three elements —three negatives or three transparencies superimposed upon mounting paper. On this basis, one would assume that projection of color television would require three projectors, all focused on the same scene and the resulting light mixed. This might be fairly simple if it weren't for the fact that each color beam needs the same transmitting area. In other words, a picture in three colors would require approximately three times as much space in the comparatively narrow transmitting band of ether assigned by the Federal Communications Commission.

The Goldmark system, by which only a single color is transmitted at one time but so rapidly that the human eye blends the colors to form the full-color image, solves this problem.

Originally the Columbia system employed motion-picture film, with the scene being first photographed on the film and then televised. Now Dr. Goldmark has found that direct pickup, televising the scene without using the film, is possible. In the direct pickup method achieved experimentally in the Columbia laboratories, no more intense light level is required than has been needed for



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Above, making adjustments on CBS telecine camera in studio control booth. This camera is used to telecast motion pictures from films. Below, unusual view of antenna employed to get good results in television work.

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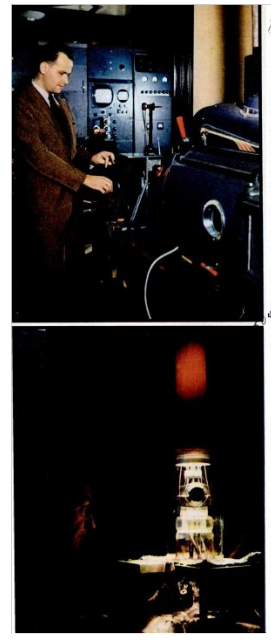
Du Mont television equipment—camera, controls, synchronizing signal generator, power supply and other units—all capable of being packed into auto (above) and (right) a flying anola used to televise receiving tube at General Electric.

black-and-white television. In actual practice, however, color pickup probably will be improved by employing additional light, but the amount of light needed does not appear to present a problem, Dr. Goldmark points out.

An additional feature of the Columbia color television is color control, which will be used to justify the color values of scenes televised out of doors with those taken indoors. Sunlight has a different color from artificial light and refracts in different shades. With color, during a dramatic scene on the screen a room will suddenly, in effect, leap into flame at the turn of a dial. The same room, with another turn of the dial, will be made to shift from afternoon sunset to moonlight to morning glow. To establish a musical theme, an actual aura of "blue" can be cast on the image of a dance orchestra and character hints, emotional phases or "cooler" settings will be at the transmitting engineer's finger tips.

Color television, as demonstrated by Columbia, gives lifelike realism, seeming to add a third dimension. An idea of



what it is like may be gained from this:

Two receivers stand side by side, one showing black-and-white pictures, the other color pictures. On the first screen a girl appears strolling through a garden. The picture is just what you would expect to see in a vacation snapshot. On the other screen, the girl is discovered wearing a gay yellow hat, a bright blue dress and colored ribbons, the garden lawn has come to life in a gay green, and flowers in pink, blue, red and orange literally have leaped into being. The contrast is startling. In another scene the blue of the water stands out in sharp contrast to the blue of the sky as a trim yacht sends by—evidence of the effect of color control.

Dr. E. F. W. Alexanderson of General Electric also is working on television in color. In a recent demonstration, no additional equipment other than a revolving disk was employed to convert black-and-white pictures to color.

A two-color twenty-four inch revolving disk was installed about twelve inches in front of the picture end of the cathode-ray tube in a standard receiver. As the disk whirled at 1,800 revolutions per minute, its transparent field of orange-red and greenish-blue reproduced a program coming from a distant studio in realistic colors. At the studio a similar disk was whirling in front of the iconoscope pickup tube of the transmitter. In early experiments, General Electric engineers tried both two and three-color disks. With two colors and a speed of 1,800 revolutions per minute, the same colors succeeded each other thirty times per second. With three colors they (Continued on page 128A)

Top, Dr. Goldmark threads colored movie film into machine which projects it for telecast in full color. Bottom, examining fifty-kilowatt broadcasting tube which undergoes tests similar to those employed for television transmitting tubes at General Electric. Both these photos are taken from natural-color film.

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Television in Color

(Continued from Column 3)

succeeded each other twenty times per second, producing a color flicker. Therefore, the two-color disk, which gives good results without flicker, is being used experimentally for the present, the engineers feeling that this type is most practical for standard commercial receivers.

Allan B. Du Mont, television manufacturer, revealed recently that his engineers are developing a purely electronic means of producing television in color. This method is intended to eliminate the use of filters at the pickup, and color wheels at the receiver, substituting a special screen for automatically selecting and rendering the elementary colored images in proper sequence, without color wheels or other moving parts. For the present, Du Mont believes the industry should concentrate on commercializing good black-and-white television, since he views the problems as being rather in the direction of evolving satisfactory flexible standards which would allow either transmission of black-and-white or colored pictures agreeable to the majority of television interests. Thus, he reasons, might be laid a firm foundation for some day will be wheeled into the drawing-room or living room like a tea table, connected to an existing television receiver and scenes projected on it "comparable in a small way to anything one now sees in the average movie."

K1350

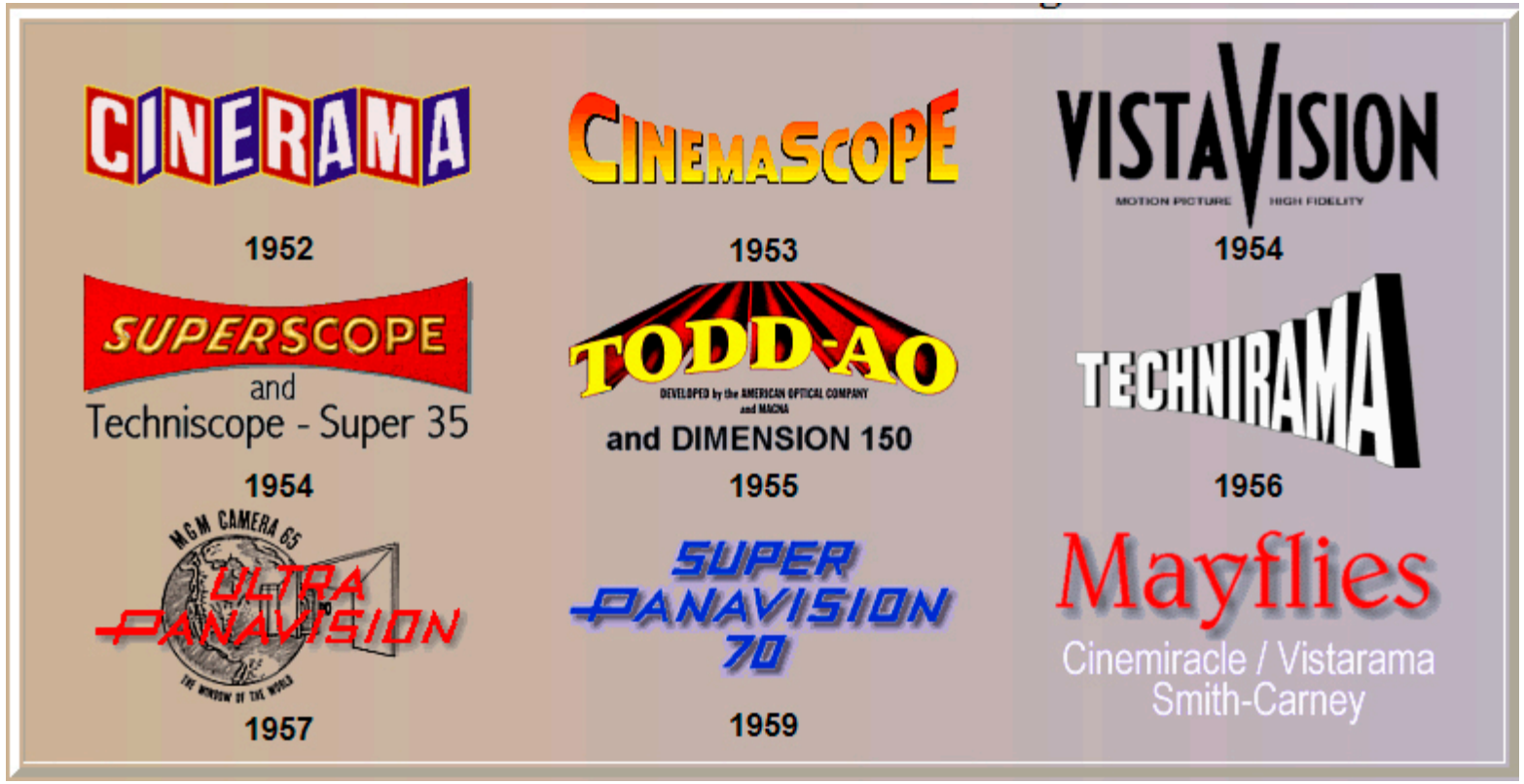
Floodlights on Swinging Bracket "Panoram" with the Camera

So that floodlights can follow the action in making indoor movies, there is a bracket that mounts on a panoramic head to swing freely with the camera. The bracket fits all types of reflectors and its arms can be set at any angle.

How Is It Different Than Film?

- Broadcast medium–Does not record an image
  - Recording was afterthought (video tape – 1951)
- More a performance less an art
  - This has changed over the years
- 1946 RCA got into camera development
  - 1953 model at right
  - Based on video pick-up tube

Widescreen Formats



- In response to television in the home
  - More color; wider screens; stereo sound; 3D films

Cinerama

- Invented by Fred Waller
  - Had roots in the 1920s (*Napoleon* 1927), 1939 World's Fair (*Vitarama*)
- Widescreen process that works by simultaneously projecting images from 3 synchronized 35mm projectors on deeply curved screen – 146 degree arc
  - Shoot with 3 camera sharing a common shutter
  - Required special theatres (tents)
  - Later replaced with a single camera and 70mm film

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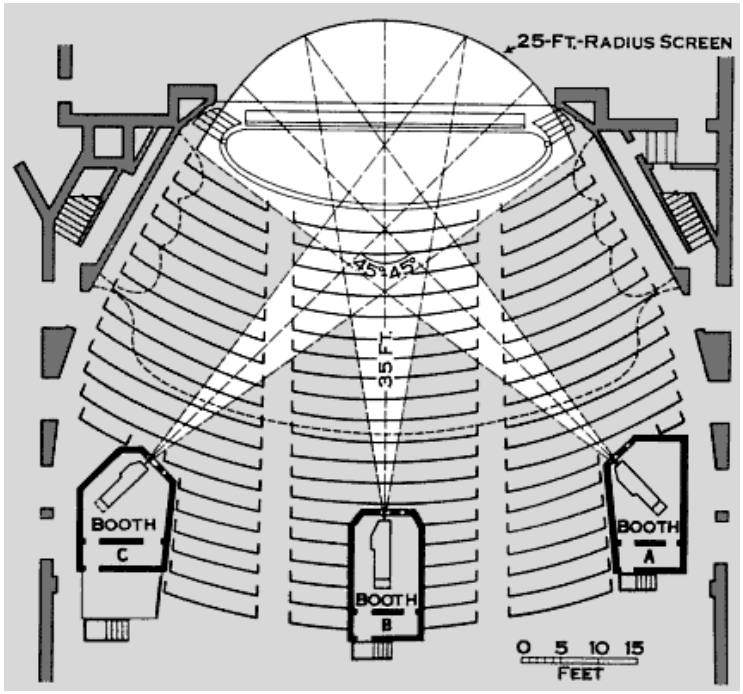

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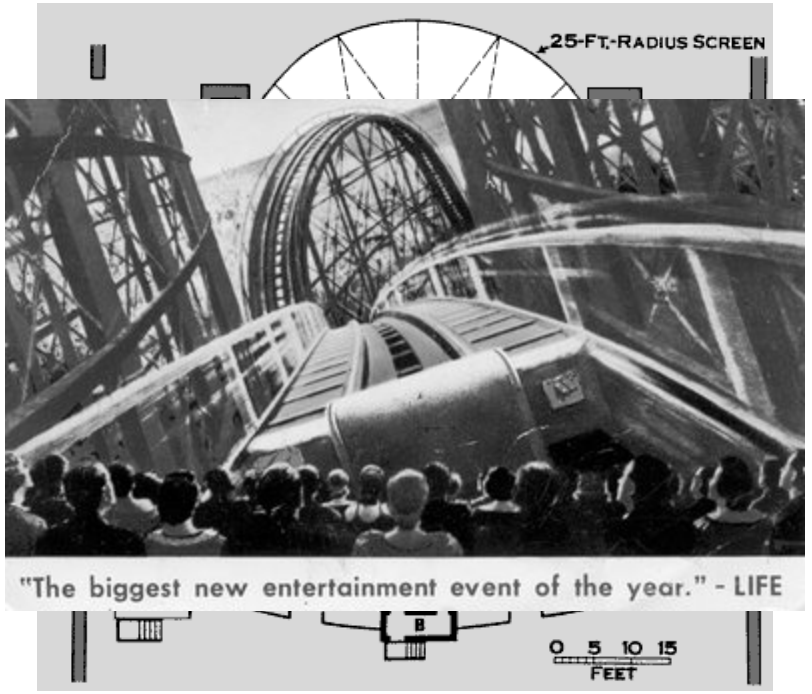

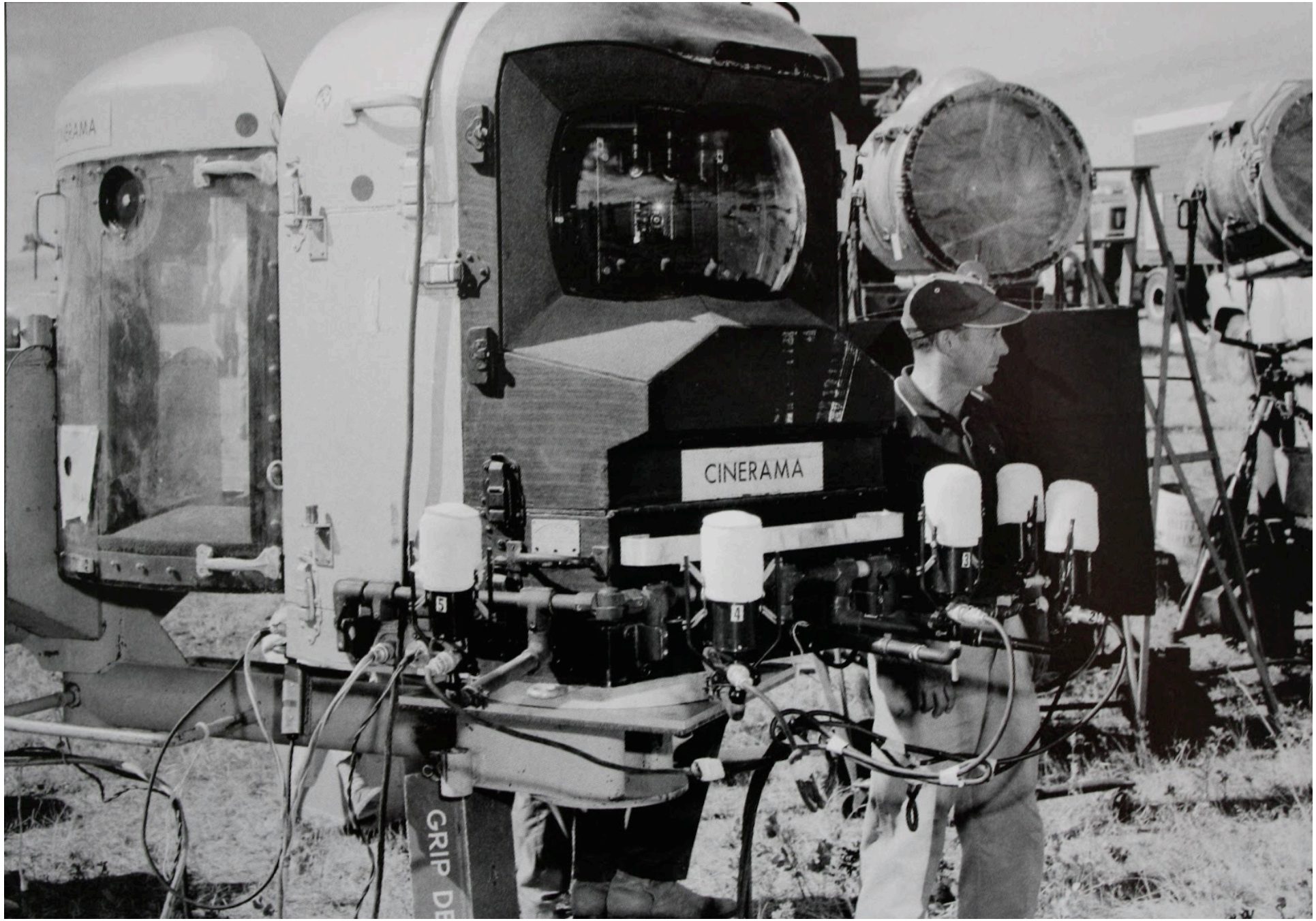
CINERAMA


Sunset Bl
6300 W
CINERAMA
ONE WAY
For Lease
Early Bird
Parking
$3.00

Panavision

- 1953: Robert Gottschalk and Richard Moore
  - Made anamorphic projection lens for wide screens
    - Technology from WWI for tank periscopes
  - Lenses adopted for cameras

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CinemaScope

- Shot and projected with anamorphic lenses
  - Created image with aspect ratio 2X that on the film itself
  - First film *The Robe* (1953) Richard Burton, Jean Simmons

Superpanavision (70mm film)

- Ben Hur 1959—large commercial success
- 1962 *Mutiny on the Bounty* way over budget
  - MGM liquidated their assets to cover costs
  - Panavision acquired MGM's camera equipment division

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Technicolor Demise

- Strategic error in moving to 3D camera
  - 6 film strips simultaneously – heavy and unwieldy
  - Only 2 films made
- Business error – not licensing technology
  - Prints had to be made in their labs
  - Slow to turn them out
  - Cameras were rented
  - Panoramic formats
- 1974 – last US movie
  The Godfather Part II
  - 1975 US plant closed
  - European plants closed
  - 1990 China plant closed

Life After Death

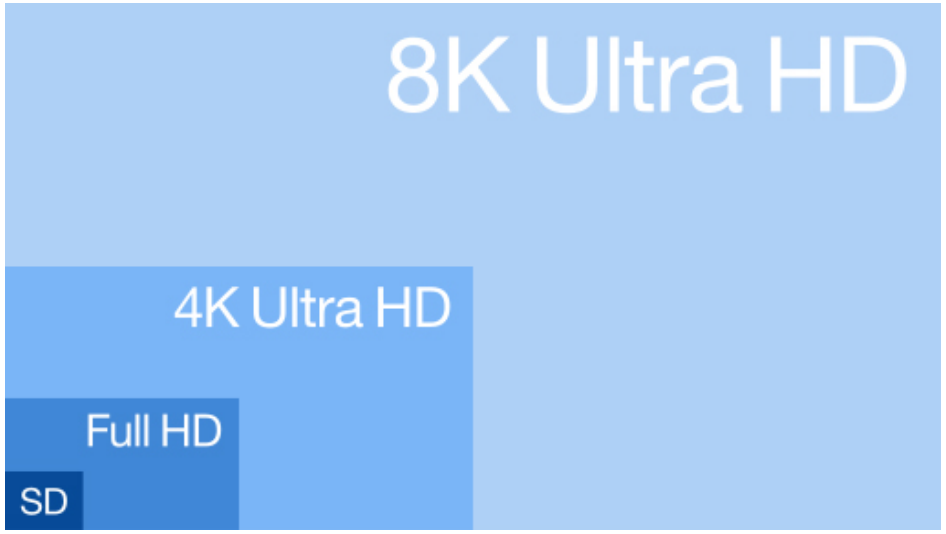
- Technicolor company outlived the process
  - Video and audio duplication
  - Sold several times
  - Process revived for archival value
- 1997 – reintroduced for cinema
  - People value the look, rich colors, and fade resistance
  - Now part of French group Thomson
  - Discontinued dye transfer in 2002
- Now film makers digitally imitate the look

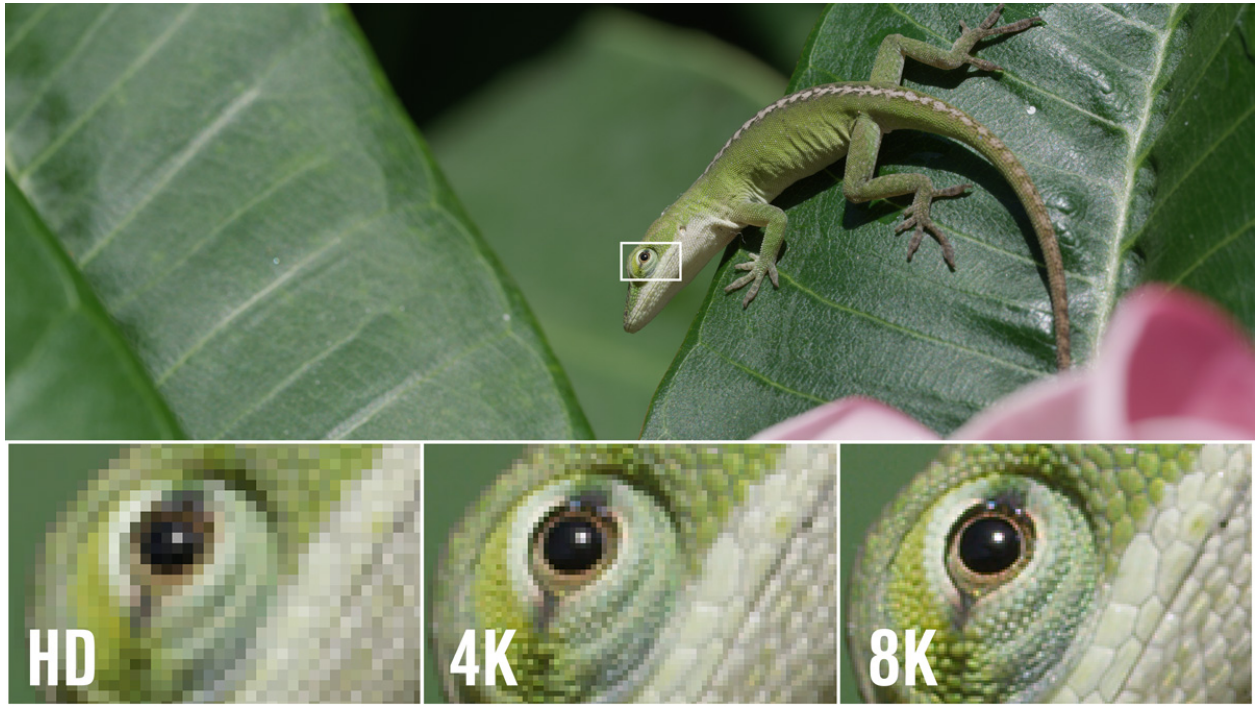
Cinema of the new millennium


Canon
7x 19.7
8K
Canon
8K
EOS C

Cinema Resolutions

- 1997 4K Dalsa sensor
- 4096 (4046) x 2048 (8.2M) fills a 35-mm frame
- Allows use of existing lenses
- Sensitivity of about ASA 400

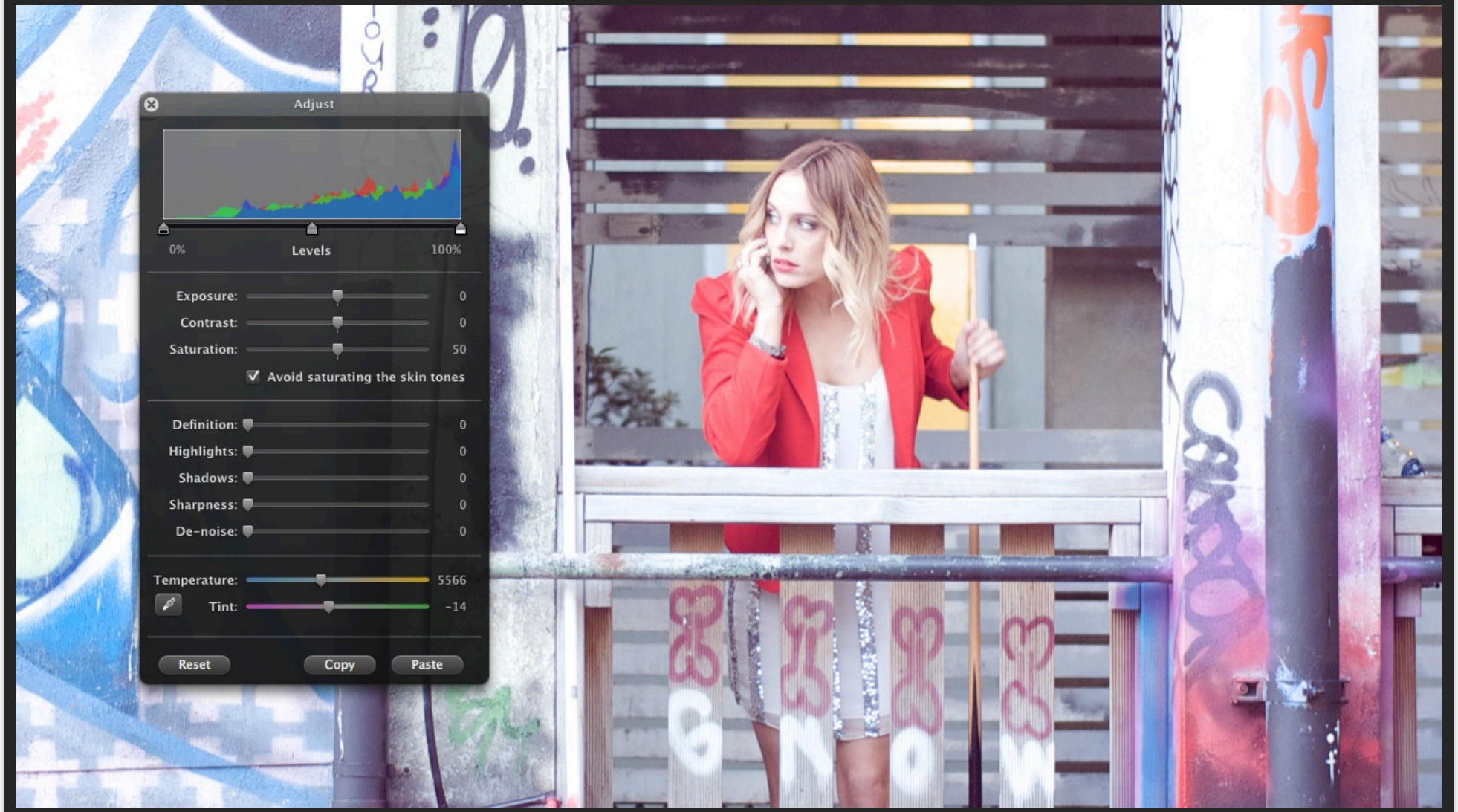




4K CMOS sensor

Digital Cinema Camera

- Full frame 4, 6, 8K CCD/CMOS
  - Red camera link
- Adjustments for
  - Gain, Knee, Slope
- 16 stops of exposure latitude
- 0-36 selectable frame rate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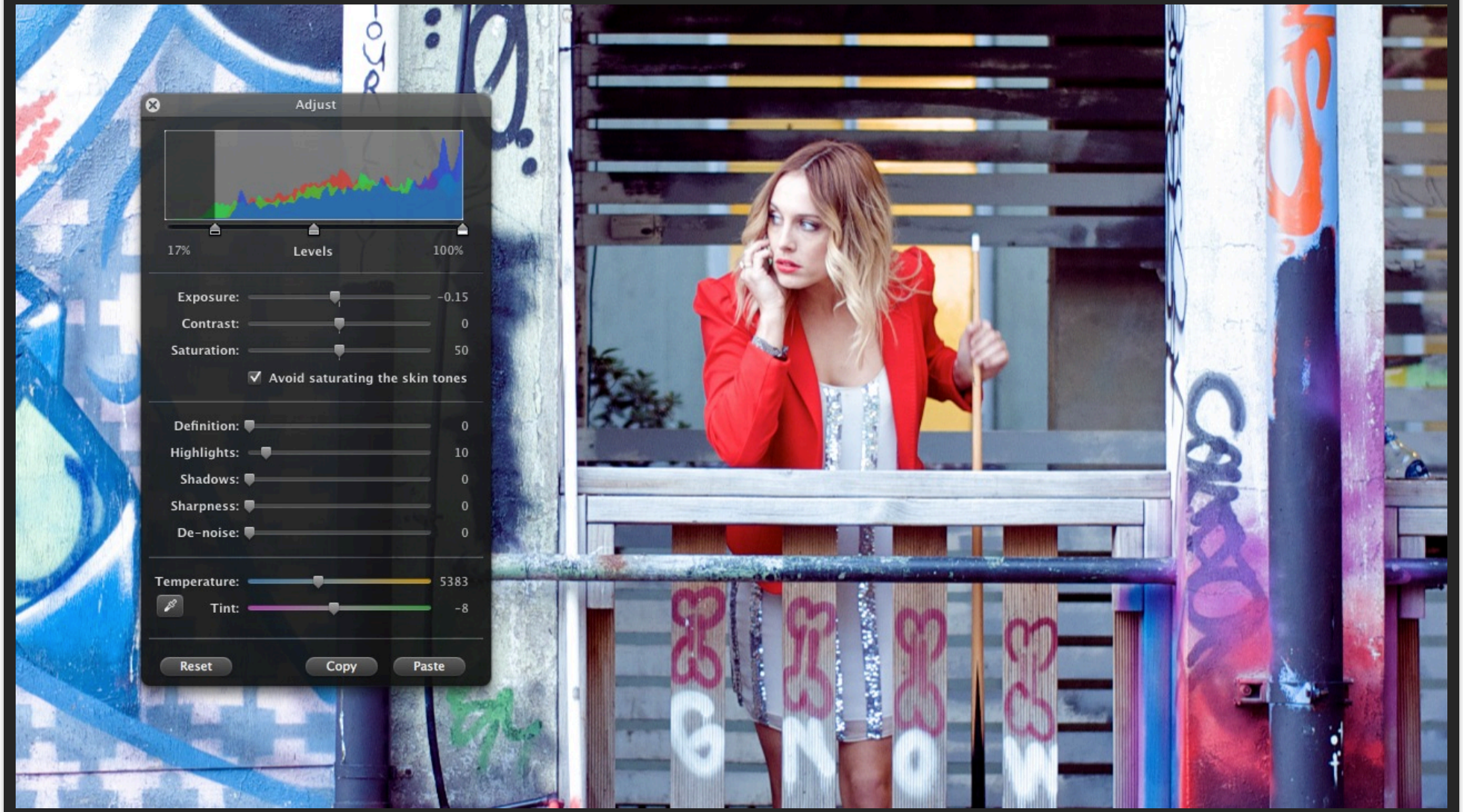
0%
Levels
100%
Exposure: 0
Contrast: 0
Saturation: 50
Avoid saturating the skin tones
Definition: 0
Highlights: 0
Shadows: 0
Sharpness: 0
De-noise: 0
Temperature: 5566
Tint: -14
Reset
Copy
Paste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17%
Levels
100%
Exposure: -0.15
Contrast: 0
Saturation: 50
Avoid saturating the skin tones
Definition: 0
Highlights: 10
Shadows: 0
Sharpness: 0
De-noise: 0
Temperature: 5383
Tint: -8
Reset
Copy
Paste

Could not have been made on film?

Current Projector Approaches

- **3/6 laser cinema projectors** – *state of the art*
  - Sony, Cristie, Barco
  - Optically addressed LCDs
  - Digital light processing
- 60,000 Lumens – 105 foot wide screen – adjustable brightness
- Can use non-reflective screens – no hot spots
- ~ $165K

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Cinema Olympia Paris