

- What is a digital print
- How to identify digital prints
- Deterioration
- Preservation

The Digital Print: New Approaches for Conservation



What is a digital print?

There is currently no common definition for the term digital print.

Digital printing technologies are developing very fast and digital print processes are increasing in number and complexity.

Today they can be applied to a variety of different supporting materials, from small objects to very wide surfaces.

Therefore, it is important to set limits to the use of this term «digital print» for our purpose of conservation.





"Digital Print Fashion", an exhibition at Phoenix Art Museum.





An installation view of Barbara Kruger's "Forever." Photo Credit: Timo Ohler



What is a digital print?

Definition by the Image Permanence Institute

[...] «the term digital print will refer to that class of prints created using the most common modern, non-impact printing technologies: inkjet, dye sublimation, and electrophotographic. Pictorial images generated with silver-halide, light-sensitive papers using laser or LED exposure from digital files will also be included. The printed material can include pictorial images, text, line art/graphics or any combination of the three. Printing substrates will be limited to paper (uncoated and coated) or polyethylene laminated papers (also referred to as resin-coated or RC papers).»



Digital Print Format

Books – volumes for a wide public, theses, artists books and personal photobooks

Periodicals – magazines, newsletters, journals, etc.

Documents – documents (laser or inkjet printers), photocopies (electrophotography)

Photographs – from family snapshots to fine art, printed by both traditional and digital output

Graphic objects – from advertising to fine art, created using the same printers, inks, and papers as digitally printed photographs

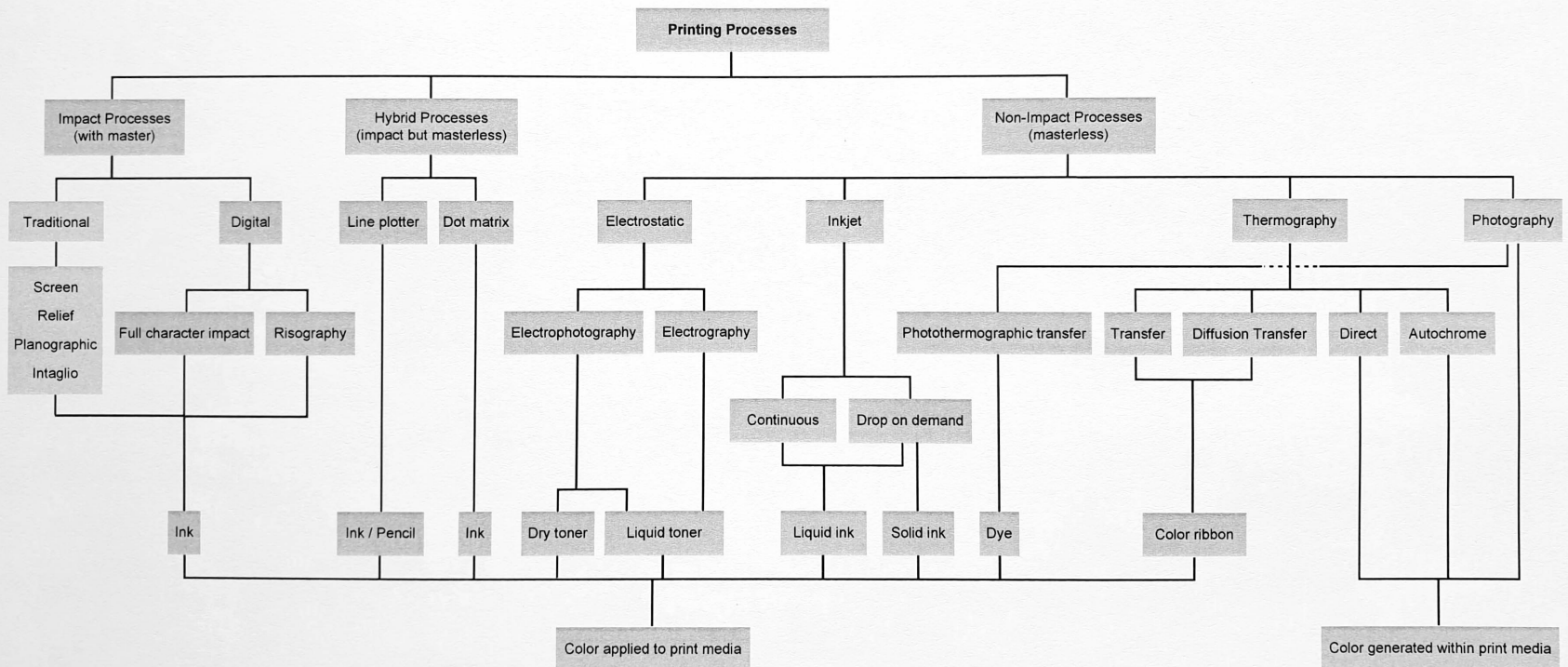
Computer Art – other forms of art, output onto paper using digital print systems

Ephemera – such as identification cards, event tickets, receipts, flyers, postcards, etc. printed using inkjet, electrophotography, and dye sublimation



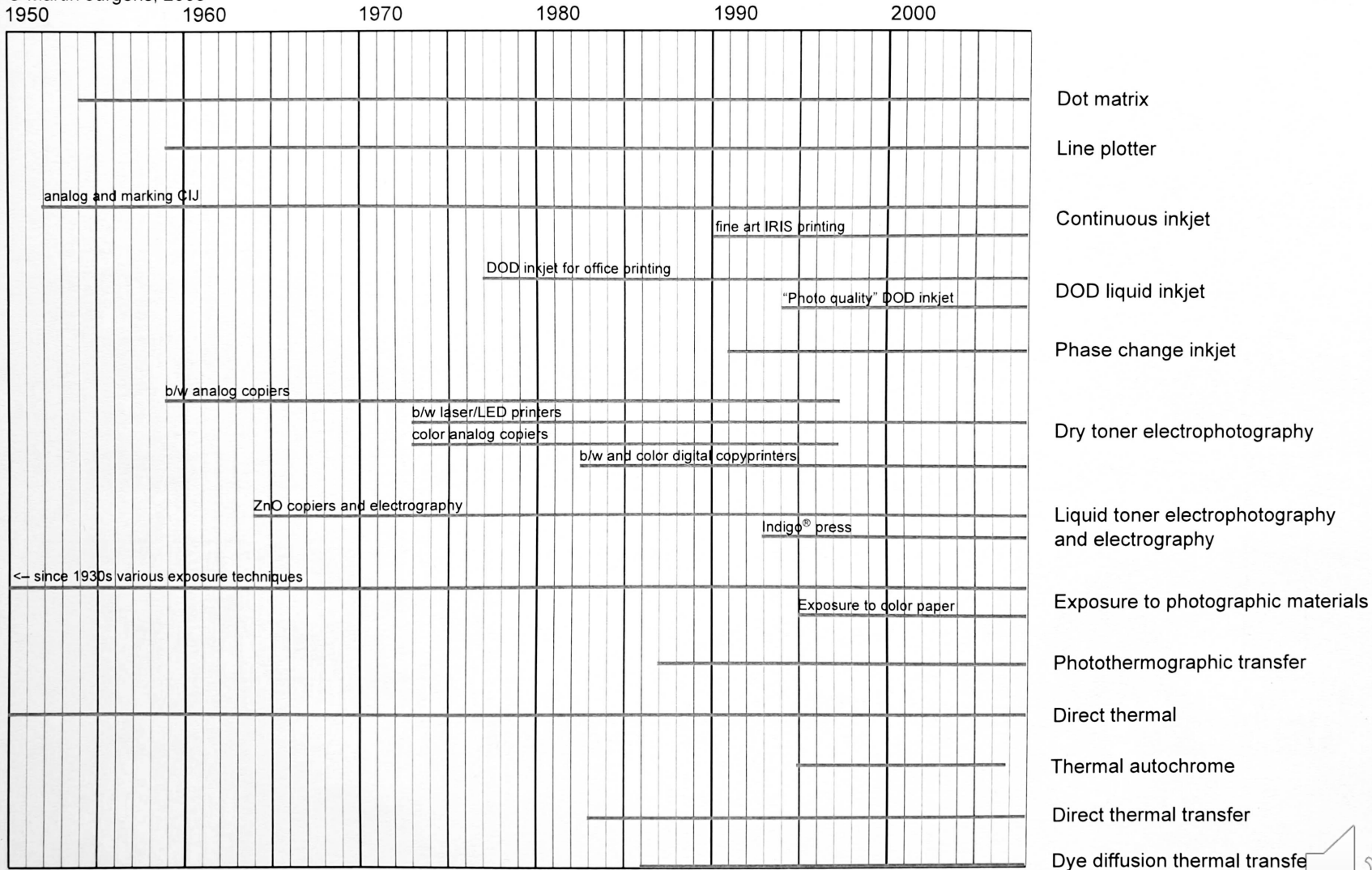
Process chart of the major digital printing technologies.

© Martin Jürgens, 2008



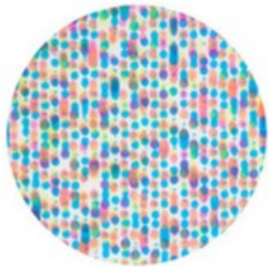
Timeline of the major digital print processes

© Martin Jürgens, 2008



- Dot matrix
- Line plotter
- Continuous inkjet
- DOD liquid inkjet
- Phase change inkjet
- Dry toner electrophotography
- Liquid toner electrophotography and electrography
- Exposure to photographic materials
- Photothermographic transfer
- Direct thermal
- Thermal autochrome
- Direct thermal transfer
- Dye diffusion thermal transfer





50x Magnification

Inkjet



100x Magnification

Electrophotography



100x Magnification

Dye Transfer

Digital Printing Technologies

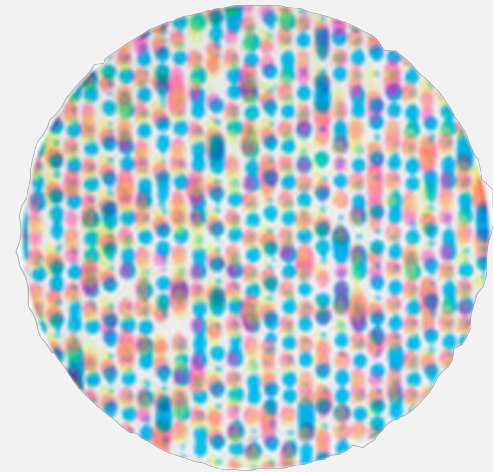
Image Credit: IPI's DP3 Project



Technology

- 1867: first printing device that used drops of ink emitted from a nozzle developed by Lord Kelvin to record telegraph transmissions
- 1970's: several devices not commercially successful
- 1984: Hewlett Packard first desktop inkjet printing device for computer hardcopy
- Later on: improvements in print quality, inclusion of colour, and printing of photographic images

Inkjet



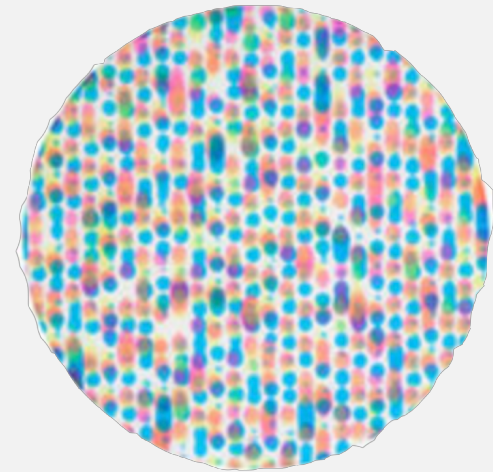
Technology

All inkjet printers use
drops of ink emitted from a nozzle
to create coloured dot patterns on paper (or
other printing substrates).

Two main types of printers:

- continuous inkjet
- drop-on-demand inkjet

Inkjet



Continuous Inkjet

Continuous inkjet printers emit a constant stream of charged ink drops.

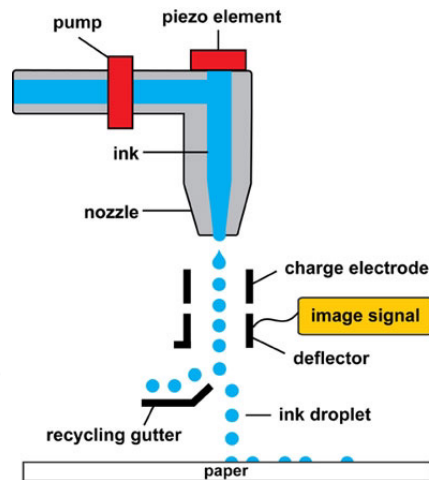
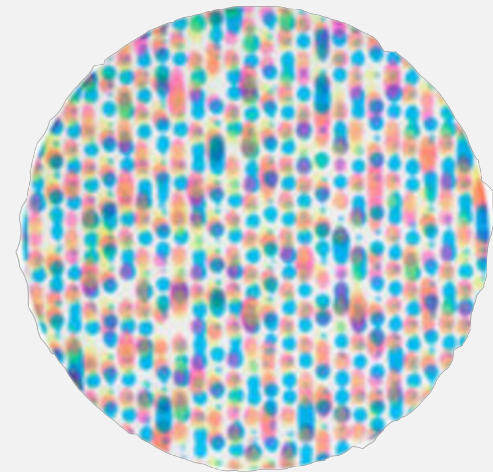


Image Credit: IPI's DP3 Project

- deflection and recycling system
- printing paper attached to a large cylinder that rotates under the print head

Large printers are only used in commercial printing environments and not frequently for printing individual images. They may compete with offset lithography.

Inkjet



Drop-on-Demand Inkjet

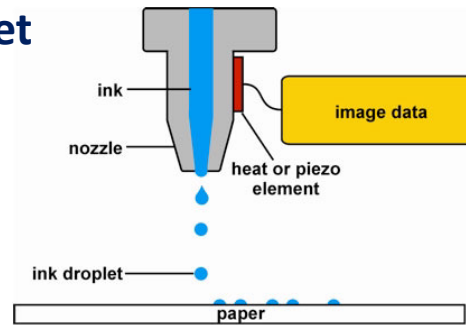


Image Credit: IPI's DP3 Project

DOD printers only eject drops of ink as required.

- No deflection or recycling system.

Two different technologies:

- thermal inkjet printing, also known as bubble jet printing (heating element inside the print head)
- piezo printing (ceramic piezo electric tile)

In both systems ink is only forced out of the nozzle when the digital signal asks for it.

All desktop inkjet printers, and most wide format printers use drop-on-demand technology.

Inkjet

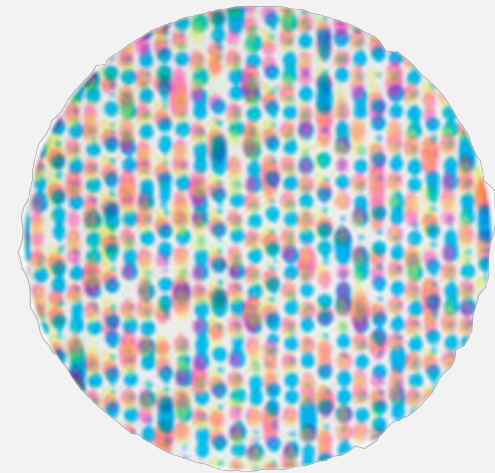


Image Structure

Half tone

- dark colours dots of ink close together
- light colours dots further apart
- shades of colour white of paper

Image quality

- distance of dots (farer dots, lower quality)
- lighter coloured inks (*light cyan* and *light magenta*)
- various levels of grey (b/w images)

circular with smooth edges



paper with a special coating

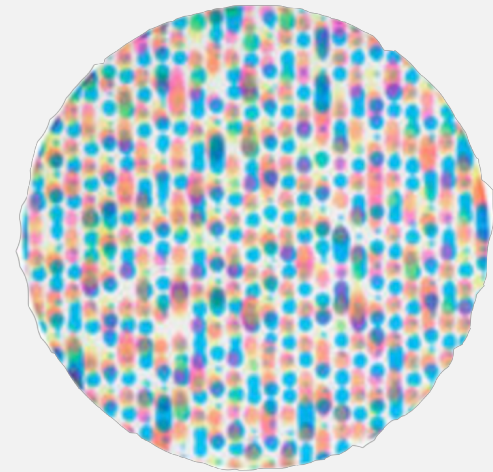
ragged with feather edges



plain office paper

Image Credit: IPI's DP3 Project

Inkjet



Colorants

- aqueous → document and photograph printing
- solvent → industrial and commercial applications
- UV-curable → applications

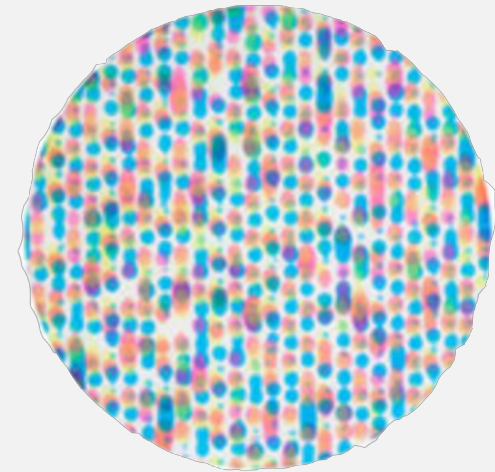
Aqueous inkjet inks

- dye → organic
- pigment → inorganic or organic or mixed

Inkjet colour sets

- 4 colours 
- 6 colours 

Inkjet



Papers

- Plain papers
- Inkjet-sized paper
- Photo-coated paper
- Polymer inkjet Photo-Coated paper
- Porous inkjet Photo-Coated paper
- Fine art inkjet paper

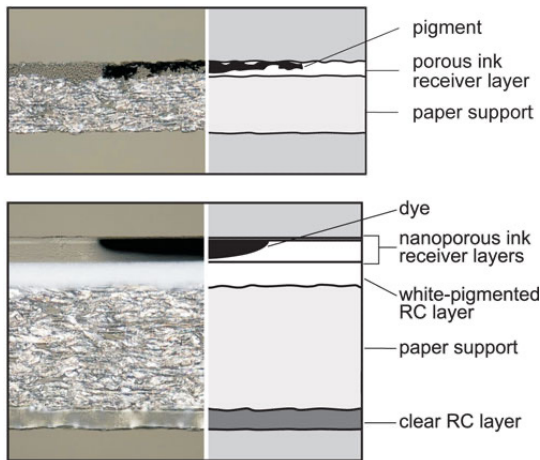
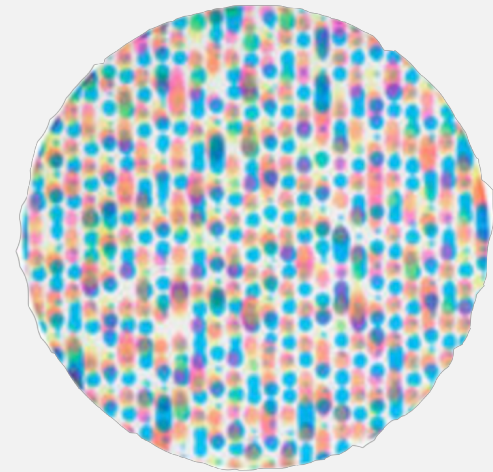
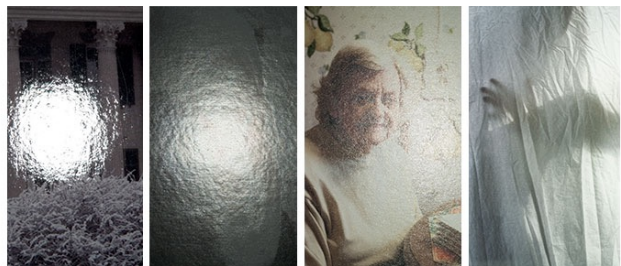


Image Credit: IPI's DP3 Project

Inkjet





Inkjet

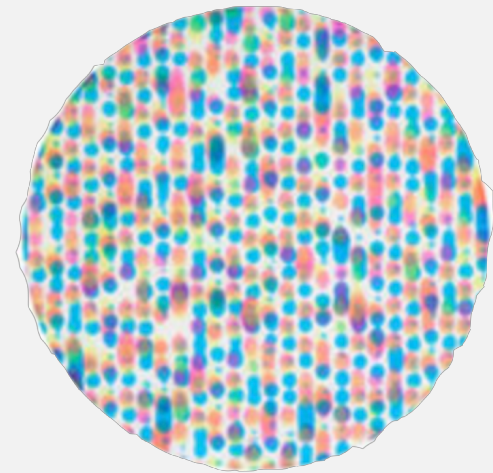


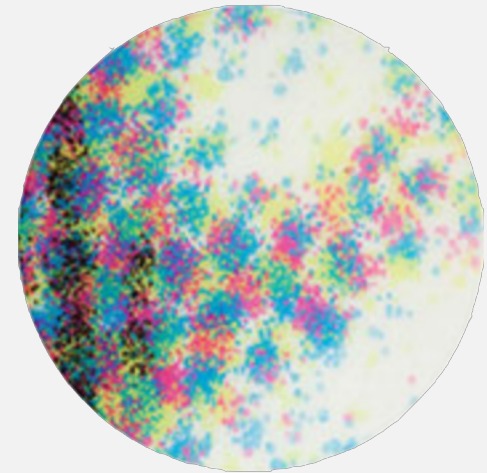
Image Credit: IPI's Graphic Atlas



Technology

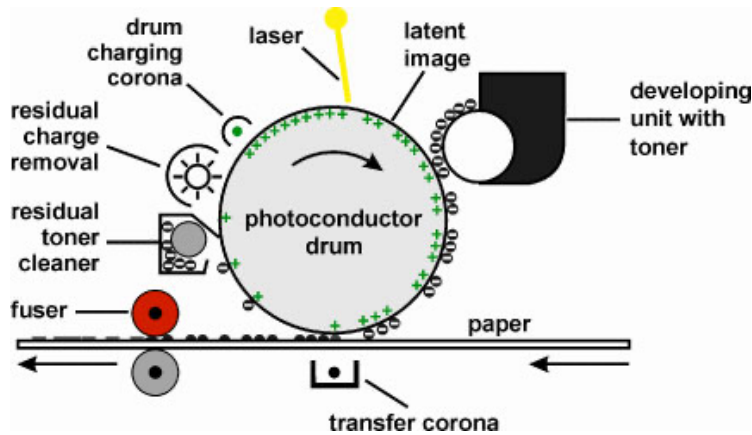
- 1930's: invented by Chester Carlson
- late 1950's: the most popular form of office copying
- mid 1970's: adapted for use as a hardcopy output method for computers
- 1980's: laser printing downscaled enough to be manufactured within a desktop-sized printer

Electrophotography



Technology

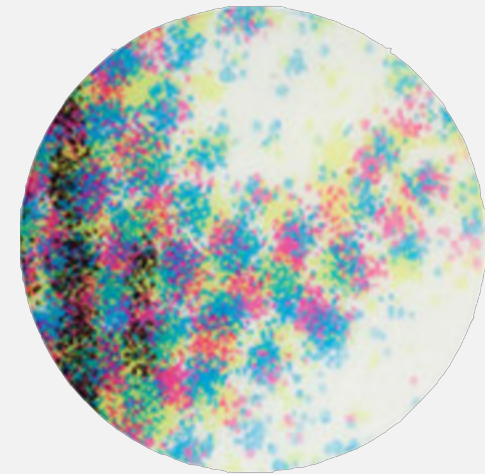
- Charging of the Photo-Conductor
- Exposure
- Development
- Transfer
- Fusing
- Cleaning



Colour images → four separate “impressions”
(cyan, magenta, yellow, black)

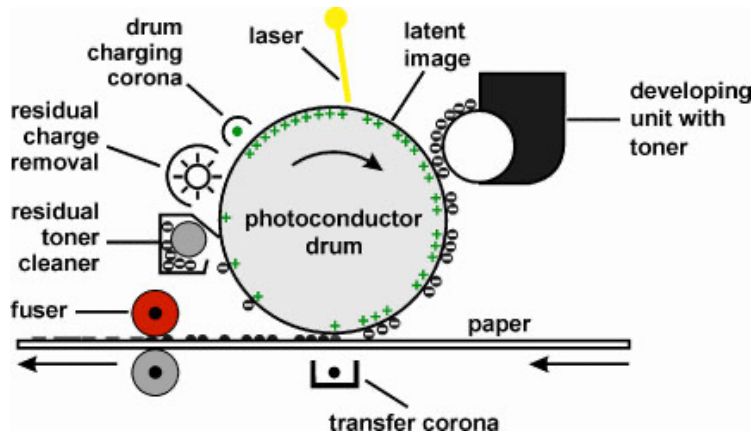
Image Credit: IPI's DP3 Project

Electrophotography



Technology

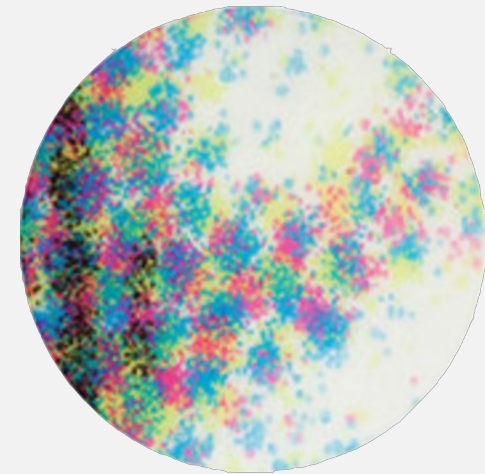
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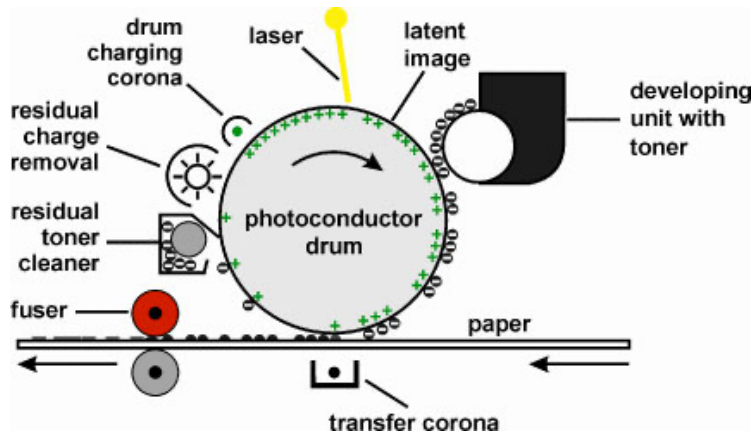
Image Credit: IPI's DP3 Project

Electrophotography



Technology

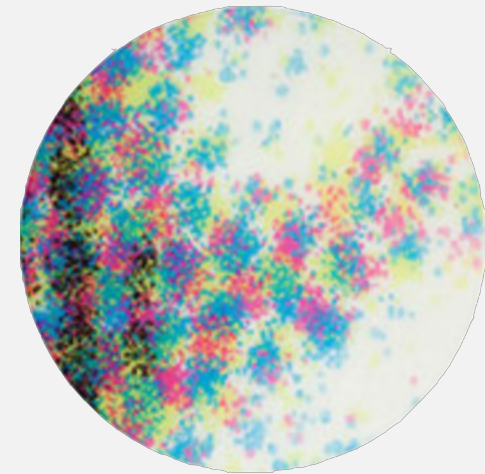
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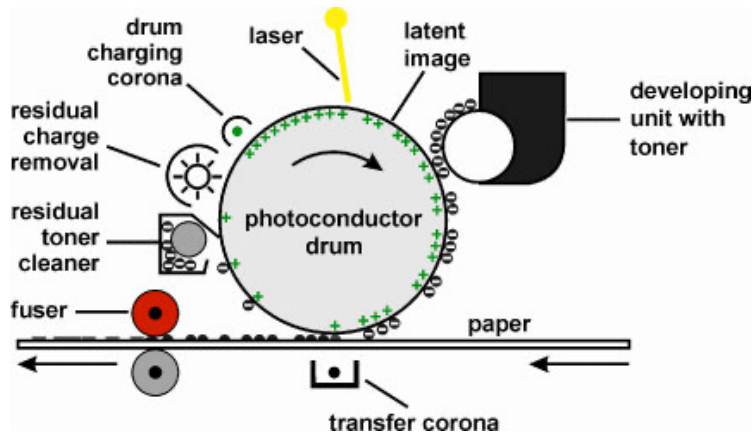
Image Credit: IPI's DP3 Project

Electrophotography



Technology

- Charging of the Photo-Conductor
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Colour images → four separate “impressions”
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Image Credit: IPI's DP3 Project

Electrophotography

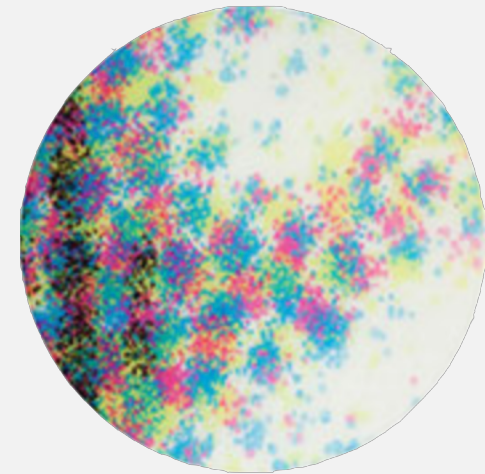


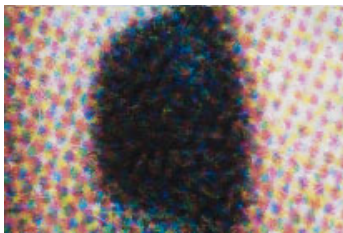
Image Structure

Half tone

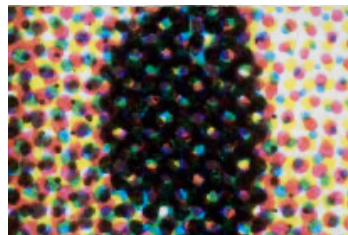
- dark colours dots of ink close together
- light colours dots further apart
- shades of colour white of paper

Image quality

- dusty appearance (dry toner)
- fine particles within the dot area (liquid toner)



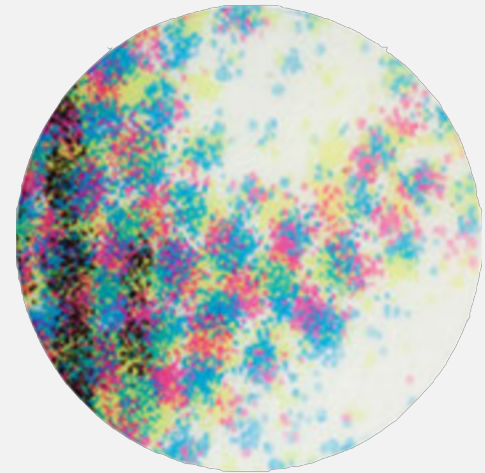
Dry toner image pattern



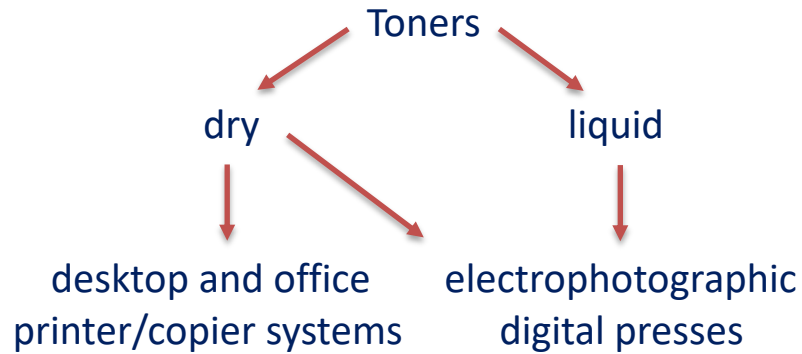
Liquid toner image pattern

Image Credit: IPI's DP3 Project

Electrophotography



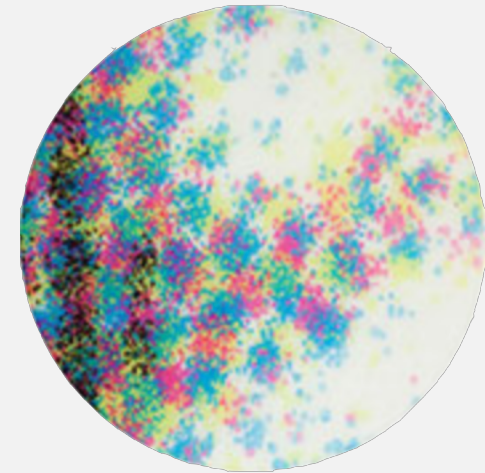
Colorants



Dry toners

- pigments or dyes embedded inside polymer beads
- “charge agents”
- “lubricating” particles
- fusing process melts the polymer beads to the surface of the paper

Electrophotography



Papers

Uncoated

- office paper or copier paper
- thin and easily bent or torn while handling

Coated

- heavy mineral coating
- dense, matt and smooth

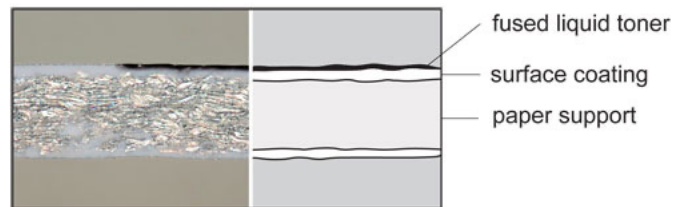
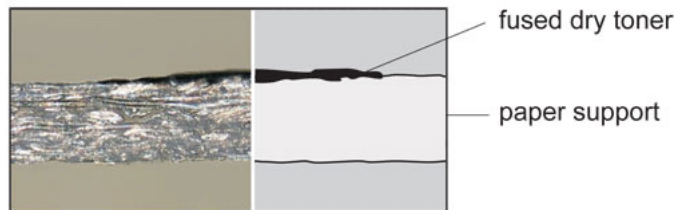
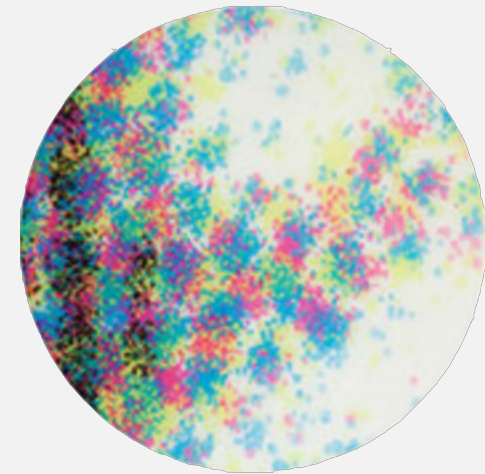
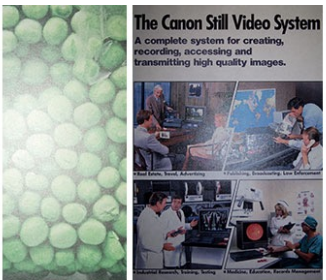
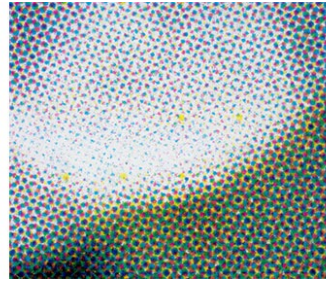
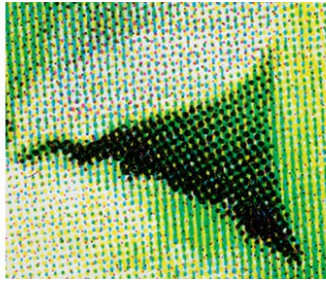


Image Credit: IPI's DP3 Project

Electrophotography





The Canon Still Video System
A complete system for creating, recording, accessing and transmitting high quality images.



Electrophotography

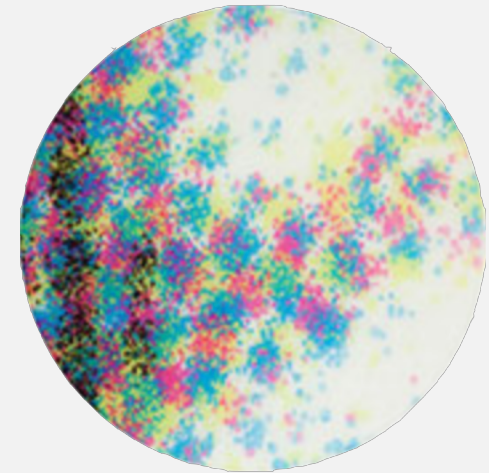


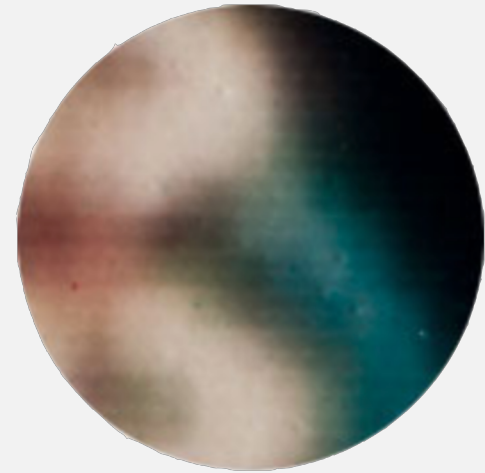
Image Credit: IPI's Graphic Atlas



Technology

- 1980's: dye sublimation ("dye sub") printers first became commercially available
- 1990's: reduced enough in size

Dye Transfer

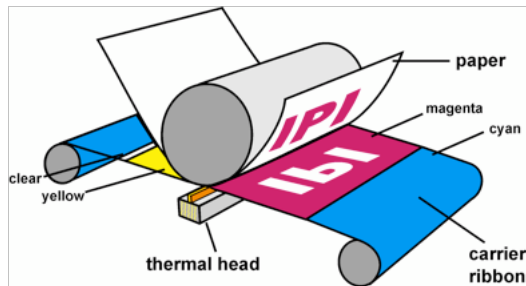


Technology

Dye sublimation printers

(**dye diffusion thermal transfer printing – d2t2**)

use heat to transfer cyan, magenta, and yellow dyes from a plastic donor ribbon to the paper via a thermal printing head.



A clear plastic sheet is applied over the dyes to protect them from moisture and airborne pollutants.

Image Credit: IPI's DP3 Project

Dye Transfer

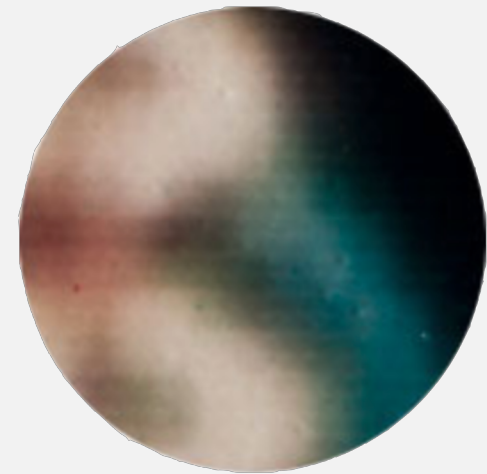


Image Structure

Continuous tone

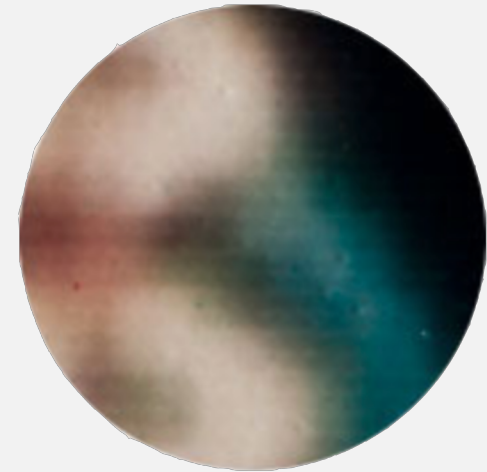
- millions of tiny squares
- different tone ranging from white all the way to black
- different densities (no need of white spaces between the squares)
- no white spaces between the image elements
- soft lines across the image surface (heater array)



Close up of a dye sublimation print

Image Credit: IPI's DP3 Project

Dye Transfer



Colorants

- cyan dye
- magenta dye
- yellow dyes dye

Paper

- RC papers (resin-coated) with a thin layer of polyethylene on each side
- plastic feel
- glossy

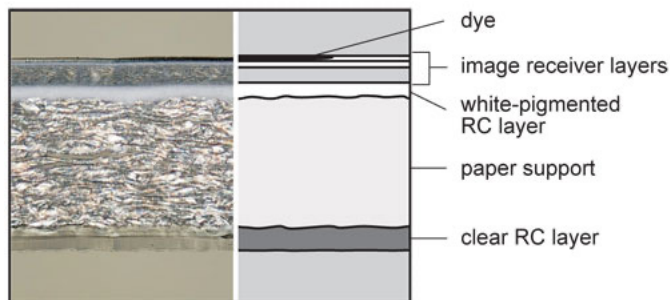


Image Credit: IPI's DP3 Project

Dye Transfer

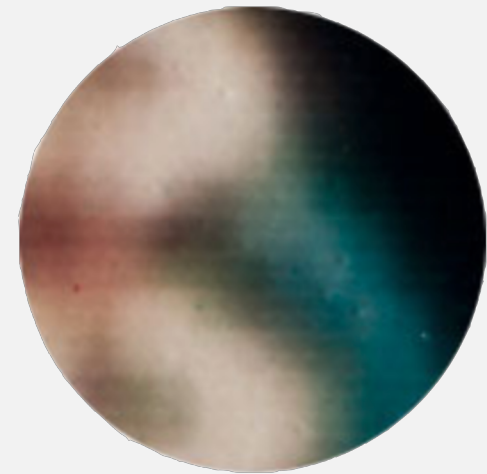
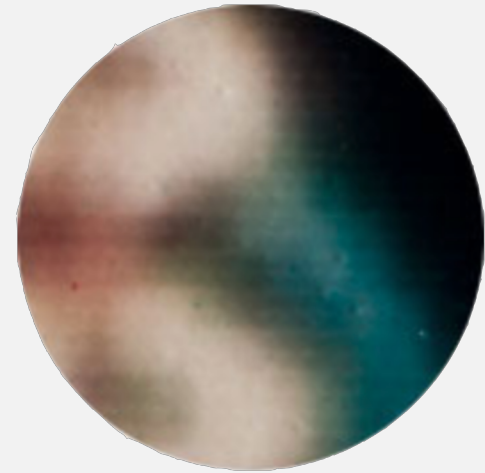




Image Credit: IPI's Graphic Atlas

Dye Transfer



How to identify digital prints

Tools

- magnifiers
- loupe
- stereoscopic microscope
- light

10x – 40x – 100x – 200x



How to identify digital prints

Print Identification Checklist

Clues to identifying a digital print; information recorded if known or if observed

Print name/number: _____

Artist's, printmaker's, or manufacturer's information: _____

Date of print: _____

Format: _____

Application and condition: _____

Polychrome or Monochrome

Media (Examined with naked eye and/or under magnification)

<input type="checkbox"/> Cockling	<input type="checkbox"/> Show-through	<input type="checkbox"/> Paper fibers visible	<input type="checkbox"/> Paper fibers invisible
<input type="checkbox"/> Paper	<input type="checkbox"/> RC paper	<input type="checkbox"/> Plastic	<input type="checkbox"/> Other: _____
<input type="checkbox"/> Uncoated	<input type="checkbox"/> Inkjet-sized	<input type="checkbox"/> Coated	

Surface (Examined with naked eye and/or under magnification)

<input type="checkbox"/> Matte	<input type="checkbox"/> Semimatte	<input type="checkbox"/> Semiglossy	<input type="checkbox"/> Glossy
<input type="checkbox"/> Uniform gloss	<input type="checkbox"/> Differential gloss	<input type="checkbox"/> Relief	<input type="checkbox"/> Colored bronzing
<input type="checkbox"/> Colorant in surface	<input type="checkbox"/> Colorant on surface	<input type="checkbox"/> Bronzing	<input type="checkbox"/> Other: _____
<input type="checkbox"/> Laminate	<input type="checkbox"/> Other surface finish: _____		

Quality of printing (Examined with naked eye and/or under magnification)

<input type="checkbox"/> Muted colors	<input type="checkbox"/> Brilliant colors	<input type="checkbox"/> Banding	<input type="checkbox"/> Color misregistration
<input type="checkbox"/> Low resolution	<input type="checkbox"/> High resolution	<input type="checkbox"/> Other: _____	

Image-forming pattern (Examined with naked eye and/or under magnification)

<input type="checkbox"/> Continuous tone	<input type="checkbox"/> Regular halftone	<input type="checkbox"/> AM (rosette) halftone	<input type="checkbox"/> FM halftone
<input type="checkbox"/> Diffuse grid or lines	<input type="checkbox"/> Irregular halftone	<input type="checkbox"/> Variable-size dots	<input type="checkbox"/> Other: _____
<input type="checkbox"/> Round dots	<input type="checkbox"/> Rectangular dots	<input type="checkbox"/> Lines	<input type="checkbox"/> Sharp dot borders <input type="checkbox"/> Diffuse dot borders
<input type="checkbox"/> Feathering	<input type="checkbox"/> Stray ("dusty") toner	<input type="checkbox"/> Photographic grain	<input type="checkbox"/> Other: _____

Colorants (Examined with naked eye and/or under magnification)

<input type="checkbox"/> Dyes	<input type="checkbox"/> Pigments	<input type="checkbox"/> Unknown	
<input type="checkbox"/> C (cyan)	<input type="checkbox"/> c (light cyan)	<input type="checkbox"/> M (magenta)	<input type="checkbox"/> m (light magenta)
<input type="checkbox"/> Y (yellow)	<input type="checkbox"/> K (black)	<input type="checkbox"/> k (gray)	<input type="checkbox"/> Other: _____

Other characteristics: _____

Assumed process: _____

This document completed by: _____ **Date:** _____

Source: Jürgens, Martin. [The Digital Print: Identification and Preservation](#). Los Angeles, Getty Conservation Institute, 2009



Digital Print Preservation Portal

DP3
digital print preservation portal

research
print
preservation

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INSTITUTE of Museum and Library SERVICES

IPI Websites

- Image Permanence Institute
- Graphics Atlas
- Dew Point Calculator
- eClimateNotebook
- Sustainable Preservation

Welcome

Welcome to the Digital Print Preservation Portal. The purpose of this website is to provide you with the information, skills, and tools you need to care for your digitally printed collection assets.

Virtually all forms of individual scholarly communication and artistic creation of images now depend on a few technologies for creating hard copy output. Inkjet, electrophotographic (laser), and dye sublimation materials account for the overwhelming majority of desktop documents and an increasing portion of short-run publications and monographs. The lines between imaging media and document media are disappearing, as documents are becoming a seamless blend of text and image. An enormous volume of digital output media is now entering institutional collections. Professionals need guidance even to determine what portion of the collections has been digitally printed.

This site is intended to be didactic and not just a reference, and so it is designed with a curriculum-like structure. Each of the following menu headings contains what can be considered a lesson that becomes a building block for the next.

- **Technologies** – descriptions of the major digital printing technologies
- **Identification** – learn methods to identify the various digital print types to ensure accurate care for each object type
- **Deterioration** – descriptions of the forces of deterioration and their manifestations in digital print collections

Abrasion-induced gloss change. The right side



Digital Print Preservation Portal

Digital Print Comparison Tool

Inkjet on Uncoated Fine Art Paper ▾



✓ Digitally-exposed Chromogenic

Dye Sublimation

Inkjet on Plain Paper

Inkjet on Uncoated Fine Art Paper

Inkjet on Porous-coated Fine Art Paper

Inkjet on Polymer-coated RC Paper

Inkjet on Porous-coated RC Paper

Inkjet on Porous-coated Baryta Paper

Inkjet on Porous-coated Canvas

Dry-toner Electrophotography on Plain Paper

Dry-toner Electrophotography on Glossy Paper

Liquid-toner Electrophotography on Glossy Paper

Offset Lithography on Glossy Paper

What To Notice

Image formed by dots

Dots in random or linear pattern

Feathered dot edges

Four or more ink colors

Orientation:



surface edge

Light Source:



0° 45° 90°

What To Notice

Image grain

Resin-coated support

Possible faint lines from printer

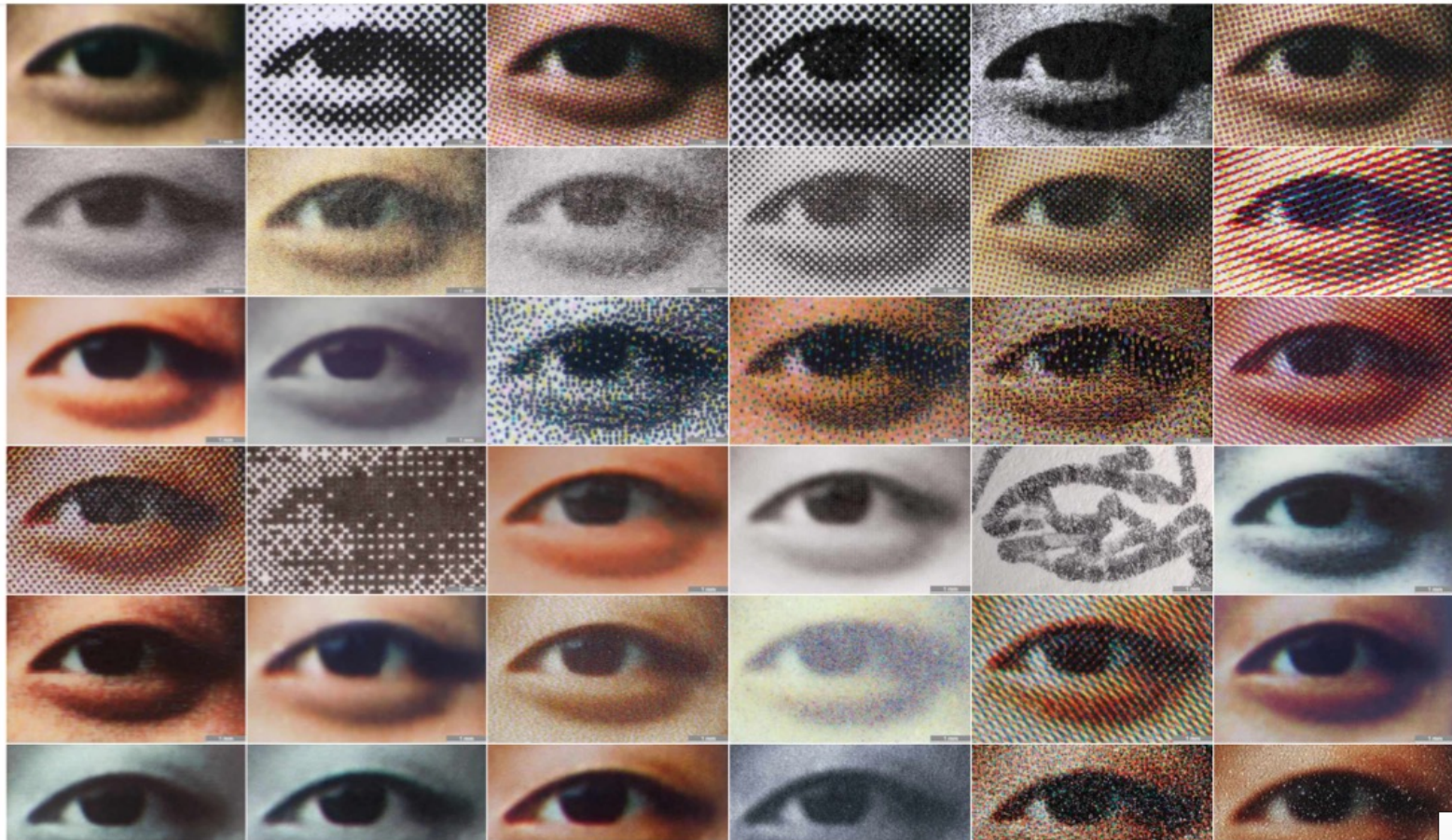
Matte to glossy surface



Martin C. Jurgens

the eye

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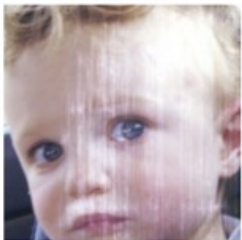
Fade



Yellowing



Gloss Change



Abrasion



Scratch



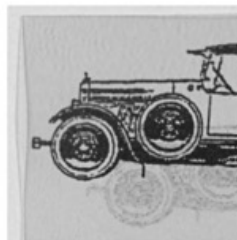
Cracking



Bleed



Delamination



Vinyl Offset

Deterioration

Image Credit: IPI's DP3 Project



Abrasion

Abrasion damage can appear in many forms:

- **colorant loss**
- **smear**
- **transfer**
- **polishing**
- **scuff**



Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



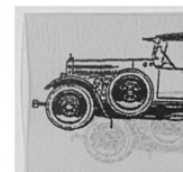
Cracking



Bleed



Delamination



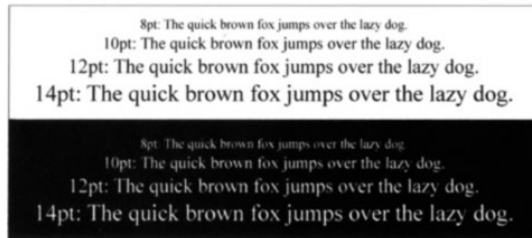
Vinyl Offset



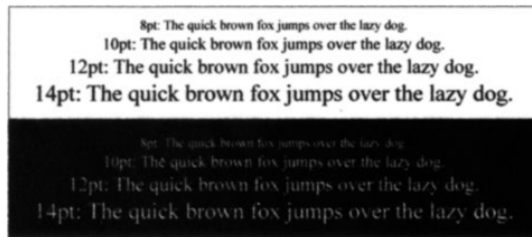
Bleed

Bleed is the undesired migration of colorants.

- | Effect | | Cause |
|---|----------|--------------------------------|
| • loss of sharpness and colour fringing | line and | • high humidity
• high heat |



Original Text



Text Exposed to High Humidity

Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



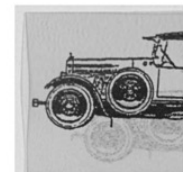
Cracking



Bleed



Delamination



Vinyl Offset



Cracking

Cracking is the result of surface layers of a print becoming brittle and is usually exacerbated with any physical flexing of the print.

Effect

- cracks to surface layers of the print

Cause

- excessively dry environment
- light
- pollutants



Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



Cracking



Bleed



Delamination



Vinyl Offset



Delamination

Delamination is the separation of layers within a print.

Effect

- lifting or separation of layers within a print

Cause

- light
- pollutants
- water exposure



Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



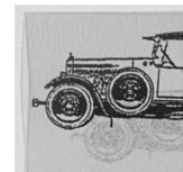
Cracking



Bleed



Delamination



Vinyl Offset



Fade

Fade is a well-known form of image decay occurring with both traditional and digital prints.

Effect

- lightening of print
- shift in colour

Cause

- heat
- light
- pollutants



Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



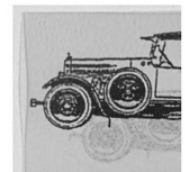
Cracking



Bleed



Delamination



Vinyl Offset



Colour Shift

If the print's individual colorants fade at unequal rates (for example the magenta dye fades faster than the cyan and yellow dyes), the image will shift in hue resulting in a specific colorcast.



Original Image



Color Shift in Image

Image Credit: IPI's DP3 Project

Deterioration



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Yellowing



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Abrasion



Scratch



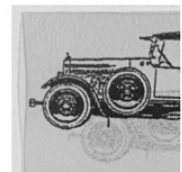
Cracking



Bleed



Delamination



Vinyl Offset



Gloss Change

Gloss change is caused by various harmful forces that result in a change to the reflectivity of the surface of the print.

Effect

- change in surface reflectivity

Cause

- moisture
- heat
- light
- pollution
- and/or abrasion



Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



Cracking



Bleed



Delamination



Vinyl Offset



Yellowing

Yellowing is the discoloration of a print's paper, making it appear more yellow and less bright, usually with an apparent loss of contrast.

Effect

- unprinted areas of the document or image turning yellow

Cause

- heat
- light
- pollutants
- poor quality storage and framing materials

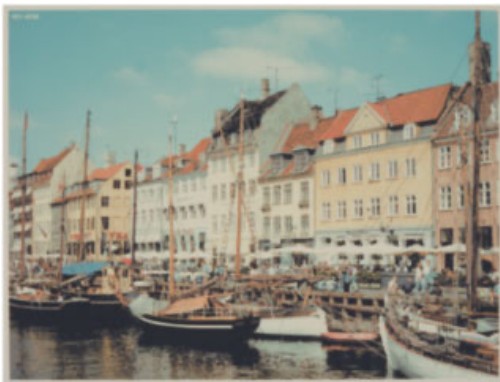


Image Credit: IPI's DP3 Project

Deterioration



Fade



Yellowing



Gloss Change



Abrasion



Scratch



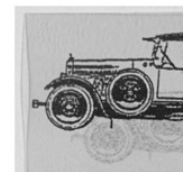
Cracking



Bleed



Delamination



Vinyl Offset



Preservation

- Storage management
- Mounting and housing
- Handling
- Display precaution
- Disaster preparedness, emergency response and recovery



Storage management

Risk Factor	Heat	Humidity	Air Pollution
Evidence of Decay	Bleed	Bleed	Bleed
	Cracking	Blocking	Cracking
	Delamination	Cracking Curl/cockling	Delamination
	Yellowing	Delamination Ferrotyping	Fade
		Mold	Yellowing

Print Type	Maximum Temperature	Relative Humidity Range
Dye Sublimation	20°C (68°F)	30-50% RH
Digital Electrophotography*	20°C (68°F)	30-50% RH
Inkjet (dye and pigment)	4°C (40°F)	30-50% RH

Image Credit: IPI's DP3 Project



Storage management

Category	Temp F	Temp C	Digitally Printed Documents and Books*		Digitally Printed Photographs		
			Inkjet	EP	Inkjet	Dye Sub	EP*
Room	68°F	20°C	Good	Good	No	Good	Good
Cool	54°F	12°C	Very Good	Very Good	Fair	Very Good	Very Good
Cold	40°F	4°C	Very Good	Very Good	Good	Very Good	Very Good
Frozen	< 32°F	< 0°C	Very Good	Very Good	Very Good	Very Good	Very Good

Image Credit: IPI's DP3 Project



Mounting and Housing

ISO standards

- 16245 *Information and documentation - Boxes, file covers and other enclosures, made from cellulosic materials, for storage of paper and parchment documents*
- 18902 *Imaging materials - Processed imaging materials - Albums, framing and storage materials*

Photographic activity test (PAT)



Istituto Centrale per il Catalogo e la Documentazione

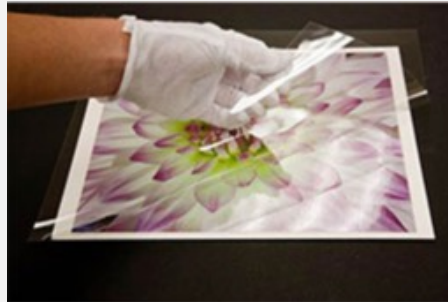
Image Credit: Federica Delia



Handling



Wear gloves



Protect from air



Avoid direct contact



Use secondary support



Avoid rolling

Image Credit: IPI's DP3 Project



Display precaution

- Environmental control (T and RH)
- Light exposure
- Pollution sensitivity
- Framing materials
- Mounting



Palazzo delle Esposizioni

Image Credit: Federica Delia



Bibliography

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Internet Sources

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