

Classification of Ink Jet Printers and Inks

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This study evaluates and compares ink samples from current and discontinued ink jet printer models in an effort to classify and date the formulations of ink. The physical and chemical properties of black ink samples printed with 18 types of cartridges (used in 32 different printer models) and unprocessed samples from eight black ink cartridges were analyzed. This research found that: (1) processed and raw inks from the same model cartridges produced varying spectral results and consistent chemical results, (2) many of the inks could be differentiated and classified and (3) the limited sampling of inks available for dating could be correlated to an introduction or revision date.

Introduction

Color printers are rapidly moving onto center stage in the world of computers. Thanks to ink jet printers becoming increasingly affordable and delivering better results, ink jet technology is much more prevalent today than when it was first introduced in 1969 by A.B. Dick (Kelly, 1993). More specifically, two of every three computer printers sold in 1995 were ink jet machines and sales are expected to continue to rise in 1997 (Consumer Reports Buyer's Guide, 1997). To remain competitive in this growing market, manufacturers of ink jet printers continually introduce more sophisticated models.

Ink jet printers are obviously used in many legitimate applications, however they also provide a useful tool in criminal operations. Evidence pertaining to this type of activity includes counterfeit traveler's cheques, business checks and other negotiable documents, threatening or harassing letters, and transposed signatures from legitimate documents. The document examiner is likely to encounter evidence generated with ink jet technology now more than ever and he or she should be equipped with the tools to accurately evaluate this technology. This investigative information may be beneficial in sourcing or eventually dating a document based on the class characteristics of the ink used in the printers. To provide information on a printed document in question, a scientific approach to differentiating the inks used in the ever-changing models of ink jet printers is necessary.

Previous studies have identified physical properties that differentiate printer technologies, such as

a laser printed document from an ink jet printed document (FBI Fundamentals of Questioned Documents Course, 1988 and FBI Examination of Typewriters Seminar, 1989). Research conducted by Lewis and Kondrat (1996) evaluated the characteristics of ink jet printed documents using samples available during 1996. This study took that comparison a step further by evaluating ink jet ink samples from current and discontinued printer models in an effort to classify and date the formulations of ink.

Methods and Materials

In order to become more familiar with ink jet technology, the ink jet process was reviewed and historical printer and ink jet ink cartridge information was collected. Then, physical and chemical properties of black ink samples from thermal ink jet printers, along with unprocessed ink samples, were compared to determine:

1. If ink samples produce different results before and after exposure to high temperatures during the printing process (in the event a situation arose where printed samples could not be obtained for comparison).
2. If a dichotomous key for the classification of thermal ink jet print cartridges could be developed to reduce the range of possible sources used to generate a printed document.
3. The feasibility of dating ink jet inks based on the introduction date or revision date of ink formulations.

This study focused on computer printers utilizing the drop on demand thermal process. Other types of machines use the thermal ink jet technology, such as multifunctional office machines, but they were not covered

in this project. The scope of this study was limited to black ink samples from original manufacturers. Samples were obtained from 18 types of ink cartridges used in 32 different printer models, along with unprocessed ink samples from eight black ink cartridges.

Ink jet printing process overview

Ink jet machines print by firing ink from tiny nozzles into a moving printhead (Consumer Reports Buyer's Guide, 1997). One of two technologies is then used to direct the ink droplet: continuous and drop on demand. Continuous ink jet machines electrostatically deflect the ink droplets through a single nozzle printhead to the desired surface (Drago, 1996). Drop on demand printers deposit ink as needed. Drop on demand technology is further subdivided into a piezoelectric process and a thermal process. The piezoelectric process utilizes a pressure pulse to force ink out of a chamber and onto the paper. This is commonly seen in solid ink jet printers. Solid ink jet technology relies on a solid block of ink or "crayon" that is melted in a slot and dropped onto the paper where it re-solidifies immediately (Color Printer and Color Copier Guide, 1996 and Drago, 1996). A more recent variation of applying solid ink is to spray the wax on a drum and roll the paper against the drum (Drago, 1996). To date, Tektronics is the sole marketer of solid ink jet printers (Color Printer and Color Copier Guide, 1996).

In contrast to the piezoelectric process, thermal ink jet technology works through a heat vaporization process. Ink is provided in cartridges that install in the printhead carriage. Ink from the cartridge fills an orifice, or nozzle, where electrical pulses heat the ink to a vaporization temperature, which causes liquid bubbles to expand (Figure 1). A firing chamber forces the ink bubbles out of the chamber on to a substrate, which transfers the ink to the paper. As the bubble collapses a void results, and ink refills in the void (Drago, 1996). After numerous print

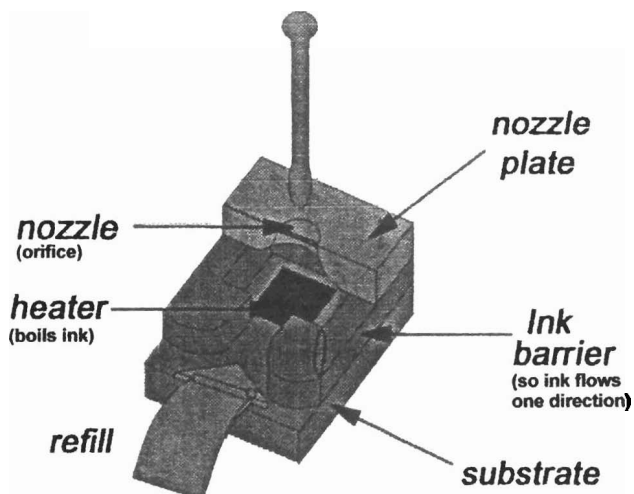


Figure 1. Thermal ink jet print element.

jobs, the ink cartridge supply is depleted and the cartridge must either be replaced or refilled.

Background information on printers

Most ink jet printers introduced during the 1990's utilize the drop on demand thermal process. Appendix A charts information on the majority of ink jet printers introduced during this period. The printers are listed alphabetically by printer manufacturer and subsectioned by model. The chart includes data regarding: the types of ink cartridges the printers accept, print technology, cartridge slots, printer introduction dates, ink introduction dates, discontinuation dates of printer models, ink manufacturer's location, printer manufacturer's location, and comments (The Laser, LED, and Ink Jet Printer Guide, 1993; Consumer Reports Buyer's Guide, 1997; Color Printer and Color Copier Guide, 1996; and Printer Guide: Page and Ink Jet Models, 1994, 1995, 1996).

The types of ink cartridges are classified as color or black. If "yes" appears in the column for both "Color Cartridge" and "Black Cartridge", then the printer uses a four color process of cyan, magenta, yellow, and black. If "no" appears in the Color Cartridge column, then the printer uses black only. If "optional" appears in the Color column, then the printer uses *either* a true black or a three-color process of cyan, magenta, and yellow. Finally, if "no" appears in the Black Cartridge column, then the printer uses a three color process only and no true black ink. This information is useful in microscopically differentiating between two types of printers. For example, the Canon BJC-70 uses a four color process, the Canon BJC-240 uses *either* true black or a three color cartridge, the Hewlett Packard ThinkJet uses black only and the Hewlett Packard DesignJet 750c uses a three color process only (Printer Guide: Page and Ink Jet Models, 1994, 1995, 1996).

The "Print Technology" column identifies the process as drop on demand (dod) or continuous (cont). The "# of Cartridge Slots" column identifies how many ink jet cartridges can be installed in the printer at the same time. A printer using a four-color process must have at least two slots, one for a three-color ink cartridge and one for a black cartridge. For example, the Hewlett Packard DeskJet 682C has two cartridge slots. On the other hand, a printer with one slot may use only a three-color ink cartridge, only a black ink cartridge, or must interchange between the two types. For example, the Hewlett Packard 400 has one slot and uses black ink only, the Hewlett Packard DesignJet 755cm uses a three color ink cartridge only, and the Hewlett Packard Deskjet 600C accepts *either* a three color cartridge or a black cartridge.

The column entitled "Introduction Date: Printer" lists the date a printer model was first made available in the United States by a manufacturer. For example, the Apple Color Printer was introduced in January 1993 (Printer Guide: Page and Ink Jet Models, 1994, 1995, 1996). The "Date Discontinued" column indicates if a printer model is no longer sold. If the actual year of discontinuation was available, then it is recorded. Otherwise a

number one or two is noted: Number one indicates that a model was discontinued before Spring 1996 and number two means that the printer was taken off the market prior to December 1996 (Consumer Reports Buyer's Guide, 1997 and Printer Guide: Page and Ink Jet Models, 1994, 1995, 1996).

Finally, the "Comment" column provides miscellaneous information ranging from detailed manufacturer data to comparable model numbers to future dates of obsolescence. For example, the Brother HJ-100I is manufactured by Canon, the Canon BJC-4000 and the Canon BJC-4100 are the same printer, and the ink jet cartridges for the Hewlett Packard PaintJet series of printers will no longer be manufactured after 1999 (Canon Online, 1997 and Hewlett Packard Online, 1997).

Every effort was made to ensure that this list is comprehensive, but it is by no means a complete list of information for every ink jet printer marketed. The voids will be updated as information is located on these printers and will be presented in future publications.

Background information on ink jet cartridges

Ink is consumed during in the printing process, so the ink cartridge must be refilled or entirely replaced. Cartridges may be refilled using ink kits sold by numerous aftermarket supply companies, such as Nu-Jet, Jetfill, Nu-Kote, Pelikan, and Reink. While approximately 30 companies label ink and cartridges, only two companies actually manufacture the ink used in these kits: Pelikan/Nu-Kote (who recently merged) and Reink (Lewis, 1996 and Nukote Online, 1997). These companies also sell the pre-filled cartridges, as do the printer manufacturers.

Ink cartridges are designed to be compatible with a select group of printers. Appendix B cross references ink cartridges with their respective printers. This guide includes ink cartridges marketed by the printer manufacturers. Secondary ink marketers are not covered at this time. The ink cartridges are listed alphabetically by manufacturer and subsectioned by cartridge number. The corresponding printer models are listed in the next column. An X in the "Color Cartridge" or "Black Cartridge" column designates if that cartridge number is for color ink, black ink, or both. If a different number is assigned for the color and black ink cartridges, then the number is listed in the appropriate column (Nukote Online, 1997).

The "OEM" column identifies whether the company or another vendor manufactures the ink. For example, Apple re-labels ink made by Canon, yet Canon manufactures their own. The "Introduction Date: Ink" column lists the date the ink formulation used in that particular printer was first introduced by a manufacturer. If an ink formulation was revised, then the next column, Ink Revision Date, lists this information. For example, the ink used in the Canon BJC-210 was first introduced in August 1992 and was later revised in July 1996 (Canon Material Safety Data Sheets [MSDS], 1997).

The "Comment" column provides other related information about the ink jet cartridges. For example, the

Hewlett Packard Deskjet 1600C uses separate cartridges for cyan, magenta, and yellow.

As with the printer information, every effort was made to ensure that this list is comprehensive, but it is by no means a complete list of information for every ink cartridge marketed. This research is ongoing and the voids will be updated as information is located on these cartridges, along with those offered by secondary marketers, and will be presented in future publications.

This project centered on evaluating black ink samples from original manufacturers. Samples were obtained from 18 types of ink cartridges used in 32 different printer models, along with unprocessed ink samples from eight black ink cartridges. There are two exceptions: The Pelikan/Nu-Kote BC-01/BC-02 is a raw sample of an aftermarket ink and three printer samples are from a three color process with no true black: Canon BJC-240, DECWriter 520I and Hewlett Packard Deskjet 320. The raw ink was sampled directly from the ink cartridge onto filter paper.

This study followed a procedure already well established for examining writing inks (Brunelle, 1984). The ink jet inks were examined microscopically, using infrared lighting techniques, and chemically. Instrumental analysis using Fourier Transform Infrared Reflectance (FTIR) or gas chromatography (GC) was not performed at this time, but may be done at a later date.

The microscopic exams of the printed samples were conducted using a Wild M3Z stereomicroscope, in conjunction with a Techni-Quip fiber optic light source. The Foster and Freeman VSC-1 was utilized for examinations with infrared reflectance and infrared luminescence lighting conditions. (Note: The barrier filters used to detect infrared luminescence blocked wavelengths above 625nm.)

The chemical tests consisted of waterfastness, solubility, and thin layer chromatography (TLC). Waterfastness was tested by applying drops of tap water directly to the printed document and wiping the water off with a Kimwipe to determine if the ink would bleed. For solubility and TLC, ink samples were removed from each printed document. The ink sample size equaled the size of one 10-point lower case typed letter. The solubility of each sample was then evaluated using ethanol, methanol, methanol/H₂O, and pyridine. The most effective solvent overall was a 1:1 solution of methanol and water; therefore this was used to extract the ink for TLC. Most of the samples were extracted from the paper within 15 minutes, however one of the Hewlett Packard samples took 24 hours to extract. The solubility should be checked at regular intervals to determine if the sample has extracted. The samples in this study were evaluated at 5 minutes, 15 minutes, 30 minutes, and 24 hours. TLC was used to evaluate the separation of ink components, particularly dyes and other organic components.

The TLC plates were spotted 20 mm from the bottom and 10 mm apart with the extracted ink samples, paper standards, and solvent standards. The plates were desiccated in an oven for 10 minutes at 150°F before spotting and aired dried thoroughly after spotting. Next, the

plates were placed in an equilibrated developing chamber containing the solvent system comprised of 105 ml Ethyl Acetate, 52 ml Ethanol, and 45 ml Distilled Water. Each plate was developed for 12 minutes. In order to achieve the best separation, two types of TLC plates were used for each sample. The plates used in this study were Whatman precoated silica gel PE SIL G polyester back plates (20 × 20 cm) and Whatman precoated silica gel 60A glass plates (20 × 20 cm). Each developed plate was examined visually under natural, long and short-wave ultraviolet, and infrared lighting conditions. Any bands observed under these conditions were marked in pencil and the retention factors (R_f) were calculated. In thin layer chromatography, the retention factor is the ratio of the distance the solute, such as the dyes, travels to the distance the solvent front (solvent system) moves (Bauer, 1978). Lastly, the plates were either photographed or scanned into the computer to preserve the results.

Results and Discussion

The physical and chemical properties of the ink from printed documents and unprocessed ink samples from black ink cartridges were compared to determine: (1) if ink samples produce different results before and after exposure to high temperatures during the printing process, (2) if the thermal ink jet print cartridges could be classified, and (3) if ink jet inks could be dated based on their introduction or revision date of ink formulations. Appendix C summarizes the results of infrared luminescence (IRL); infrared reflectance (IRR); waterfastness; solubility in methanol/H₂O, ethanol, pyridine, and methanol; and thin layer chromatography. It should be noted that an X in the "Ink" column designates a raw ink sample and an X in the "Copy" column represents a printed specimen.

Comparison of raw ink and printed samples

The raw ink samples produced interesting results. Six of the raw ink samples had corresponding printed samples: The Canon #BC-02, Epson #S020093, HP #51629A, HP #51626A, HP 92261A and Lexmark #1361400. No printed samples were collected with the Pelikan BC-01/02 or Canon BC-01. Under infrared luminescence and reflectance, the raw ink and printed sample results varied. Only the Hewlett Packard cartridge #51629A and the Lexmark #1361400 reacted the same as their printed counterparts. The remaining raw ink samples produced results differing from the printed samples. For example, the HP #51626A raw ink began luminescing at 695 nanometers (nm), but the printed sample for the same cartridge did not begin luminescing until 735nm.

These differences in the physical properties may be due to a change in ink chemistry that occurs during the thermal printing process. The ink jet ink chemistry is comprised of colorants (dyes or pigments) and vehicle components used as print quality enhancers, dry time control agents, humectants, surfactants, and preservatives (Drago, 1996). Basically, these components affect how the ink interacts with the paper. Exposure to high temperatures may alter one or more of these vehicle components causing the raw inks to luminesce (lum), reflect, or transmit under IRL and IRR at different wavelengths of light than the printed samples (Brunelle, 1984).

The chemical test results of the raw inks and their printed counterparts were more consistent. These tests evaluated the colorants used in the inks. All of the sets produced the similar results, except the Epson #S020093. Considering that the Epson raw ink sample was collected in July 1997 and the printed sample was obtained prior to 1994, the observed differences are probably due to revision of the ink formulation in 1994 (appendix B) and are not an effect of the printing process. The remaining sets included contemporaneous raw ink and printed samples. The TLC results shown in Figure 2 exemplify the similarities. The Canon #BC-02 raw ink (TLC sample #2) and the Canon #BC-02 from a BJI200ex printer (TLC sample #1) exhibited the same banding and R_f values. No additional banding was observed under alternate lighting conditions, which suggests that the results correspond to the separation of the colorants. The consistency of these findings confirms that no change occurred in the colorants during the thermal printing process. Interestingly, the Pelikan BC-01/02 raw ink (TLC sample #3), which is a replacement cartridge for the Canon BC-01 or the Canon BC-02, exhibited banding and R_f values different from the Canon BC-02 raw ink (TLC sample #2).

Classification of printed ink samples

Many of the printed ink samples could be differentiated by their physical and chemical attributes for classification purposes. Appendix C summarizes these results. When viewed under IRL and IRR, the reactions of printed samples prepared with the same ink cartridge varied. One set included samples from the Canon #BJI-201 which is used in the BJC-600e, BJC-610, and BJC-620 printers. These samples exhibited weak luminescence at different wavelengths under IRL, but reacted consistently under IRR. This phenomenon may be explained by the diversity of paper sources printed samples were

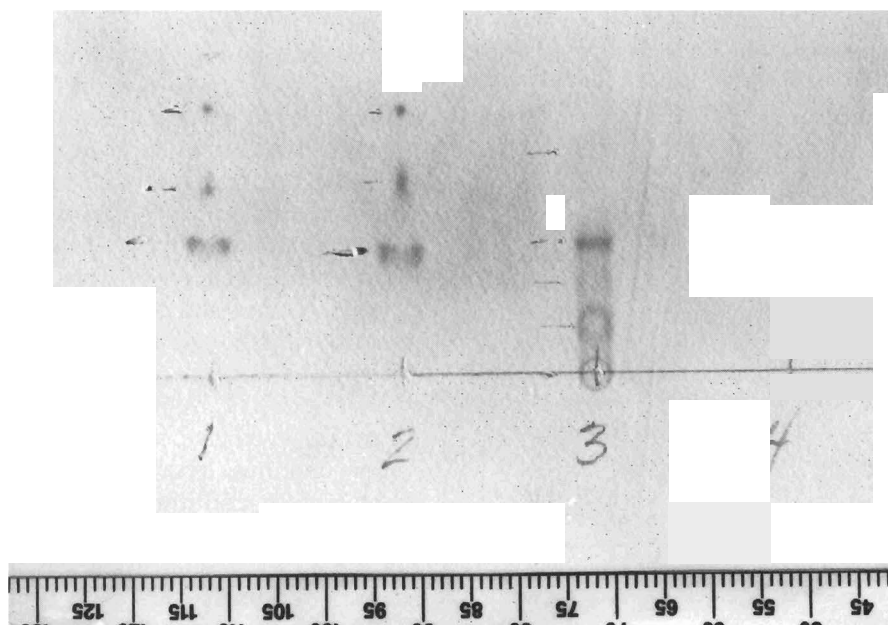


Figure 2. TLC results for printed Canon BC-02 ink from a BJ200ex (#1), raw Canon BC-02 ink (#2), raw Pelikan BC01/02 ink (#3), and paper standard (#4).

collected on. The ink chemistry is geared towards ink and paper interaction, therefore the paper source may cause these deviations in results. In fact, this occurrence is further demonstrated in samples from the HP Paintjet printer (which uses the HP ink cartridge #51606A) collected on bond paper and ink jet paper. Figures 3 through 6 compare the results. This ink on bond paper absorbed under IRL at 695nm. In contrast, the same ink on coated ink jet paper exhibited luminescence at this

wavelength (Figure 3). At 735 nm, the coated ink jet paper sample continued to luminesce while the bond paper sample only exhibited weak luminescence (Figure 4). Both samples absorbed under IRR at 665nm (Figure 5). Lastly, under IRR at 735nm, the bond paper sample continues to absorb, but the coated ink jet paper sample began to transmit (Figure 6). These results demonstrate that the interaction between the ink and the paper surface may impact the results of physical examinations. Cau-

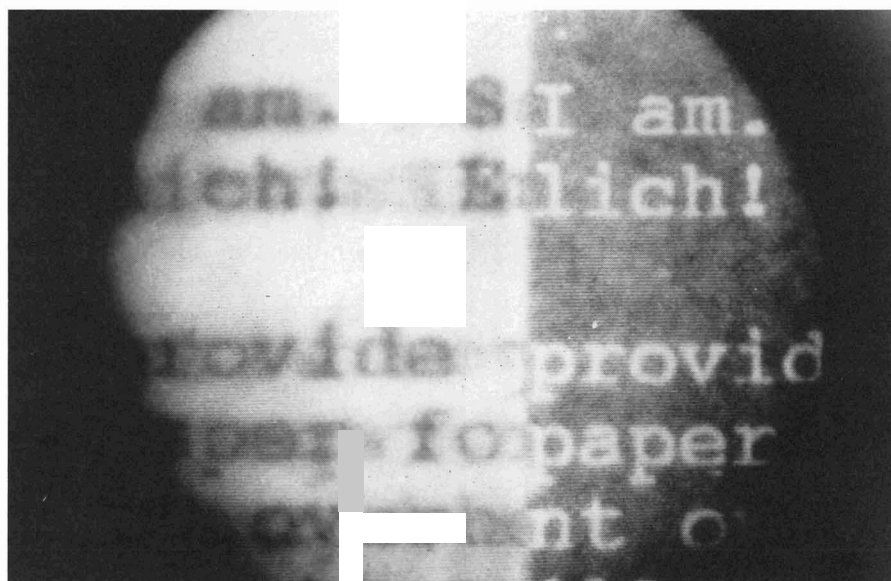


Figure 3. IRL results exhibited at 695nm for the Hewlett Packard Paintjet with bond and ink jet paper. The bond paper is shown on the left and the ink jet paper on the right.

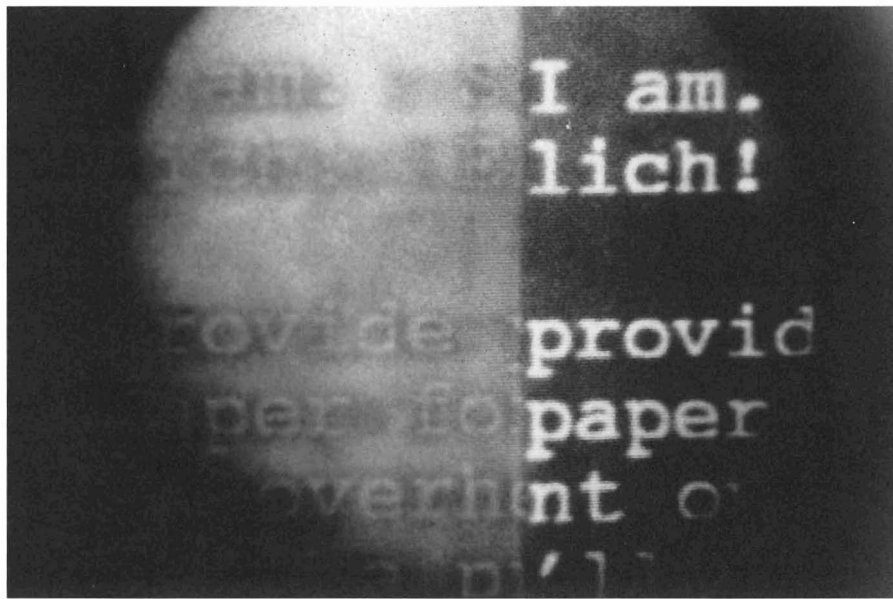


Figure 4. IRL results exhibited at 735nm for the Hewlett Packard Paintjet with bond and ink jet paper. The bond paper is shown on the left and the ink jet paper on the right.

tion should be used in relying on the ink jet ink characteristics obtained solely from physical examinations.

Chemical tests on the printed samples produced more consistent results. Samples prepared with printers using the same ink cartridge number reacted uniformly, except for the samples collected before and after revisions of the ink formulations. These will be discussed in the next section. As

with the other findings, these results are summarized in Appendix C. Figure 7 exemplifies the TLC results of the Epson #S020093 used in the Stylus 400 (TLC sample #9) and Stylus 600 (TLC sample #10) and the Epson #S020108 used in the Stylus 800 (TLC sample #11). The samples from these three printer models exhibited the same banding and R_f values because the same ink formulation is used in these cartridges. In contrast, the banding

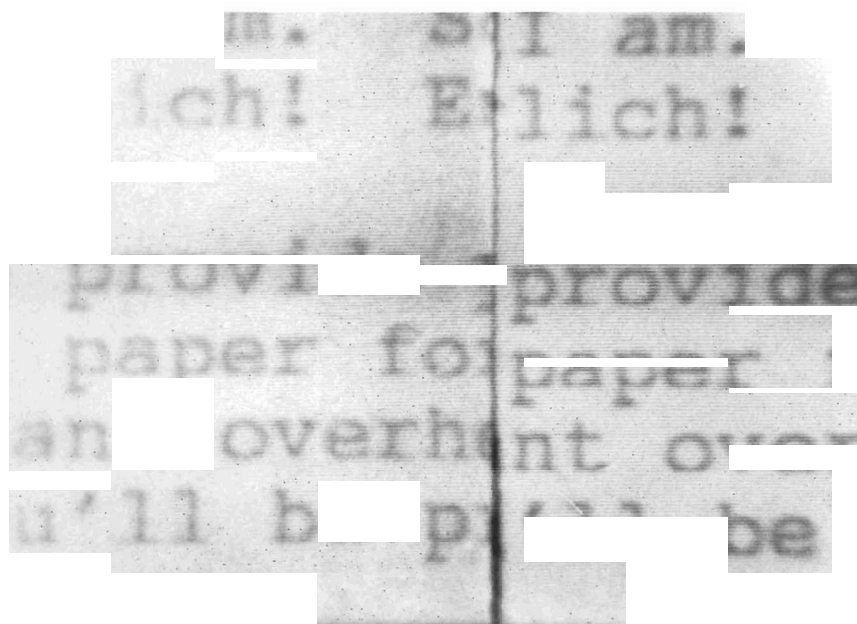


Figure 5. IRR results exhibited at 665nm for the Hewlett Packard Paintjet with bond and ink jet paper. The bond paper is shown on the left and the ink jet paper on the right.

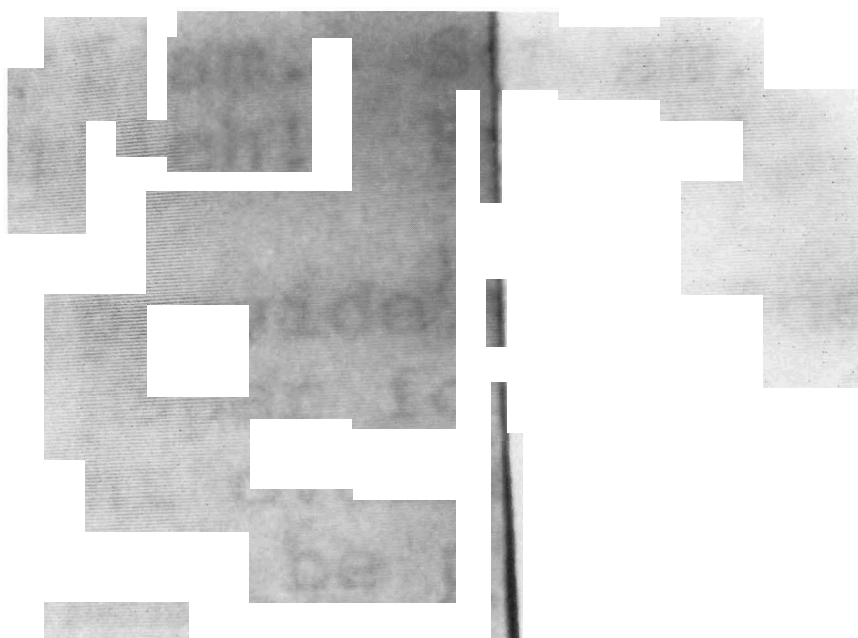


Figure 6. IRR results exhibited at 735nm for the Hewlett Packard Paintjet with bond and ink jet paper. The bond paper is shown on the left and the ink jet paper on the right.

and R_f values of the Epson samples differed from other ink samples, such as the Canon BC-02 used in the BJC-200ex (TLC sample #1) shown in Figure 2.

It should be also be noted that some of the samples were insoluble: for example, the Hewlett Packard (HP) Ink Cartridge #51629A used by the HP DeskJet 660C, 670C, and 680C. These samples

were waterfast and were not extractable with any of the solvents used during this study. This may be due to some ink jet ink manufacturers using pigments instead of dyes in newer formulations of their inks (Drago, 1996).

Dating of ink formulations

The final evaluation consisted of examining ink

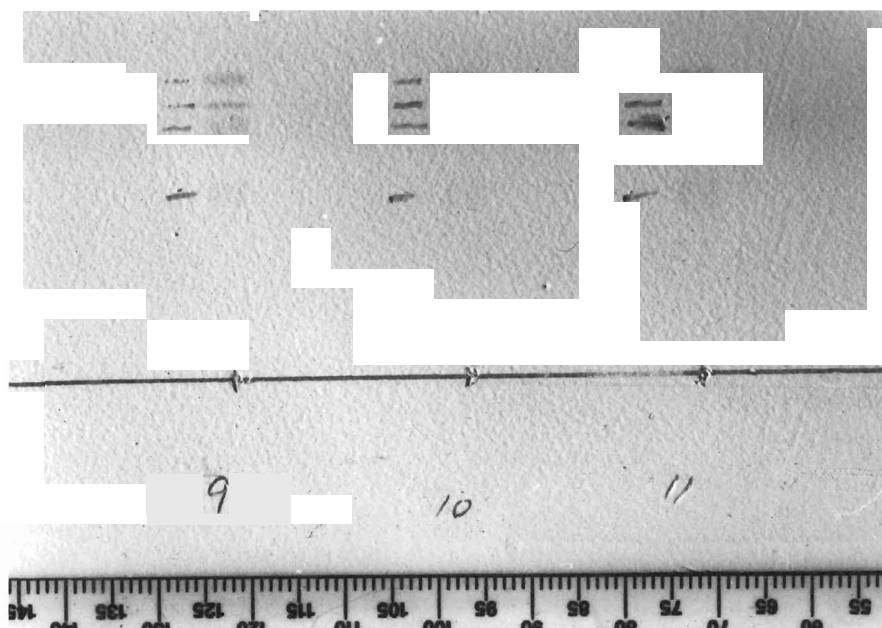


Figure 7. TLC results for Epson #SO20093 ink used in the Stylus 400 (#9) and Stylus 600 (#10) printers and Epson #SO20108 ink used in the Stylus 800 (#11).

Table 1.

Sample no.	Cartridge no.	Printer	Sample date	Introduction date of ink	Revision date of ink
6	Canon BJI-201	BJC-600e	1994	April 1993	Nov. 1995
7	Canon BJI-201	BJC-610	1994	April 1993	Nov. 1995
8	Canon BJI-201	BJC-620	1997	April 1993	Nov. 1995
12	Epson #S020034	Stylus Color	1993	Not Avail.	Feb. 1994
16	Epson #S020034	Ink Sample	1997	Not Avail.	Feb. 1994
35	HP #51626A	DeskJet PLUS	1989	Not Avail.	Aug. 1993
20	HP #51626A	DeskJet 400	1997	Not Avail.	Aug. 1993
21	HP #51626A	DeskJet 540	1997	Not Avail.	Aug. 1993
22	HP #51626A	DeskJet 560	1997	Not Avail.	Aug. 1993

samples collected before and after revisions in the ink formations. This comparison disclosed interesting results. Sets of ink samples from the Canon BJI-201, Epson #S020034, and HP #51626A were collected before and after published revision dates of the formulations (Table 1).

Other introduction and revision dates of inks are listed in appendix B and the results for these samples are detailed in Appendix C (Epson MSDS, 1997; Hewlett Packard MSDS, 1997; Canon MSDS, 1997; Brother MSDS, 1997; Lexmark MSDS, 1997; Okidata MSDS, 1997; and Xerox MSDS, 1997). When the physical characteristics were observed under IRR and IRL, the results were inconsistent. However, as described previously, a unique ink/paper interaction may render these exams ineffective for differentiation. The chemical results proved otherwise. The TLC results were uniform for samples of the same ink obtained at the same time; the results differed between samples of inks obtained before and after revision dates. These results suggest that ink jet inks can be dated based on their introduction or revision dates, however the samples available for this study were limited. Therefore, a broader sampling of inks should be evaluated to further validate these findings.

Conclusion

Ink jet technology is evolving rapidly. This presents both difficulties and opportunities for the document examiner. On the one hand, examiners need to keep up with the changes; but on the other hand, it offers the opportunity to source or date a document. In any event, the document examiner needs to consider how these changes impact the characteristics of ink jet printers and their inks.

This study demonstrated the feasibility of differentiating and dating raw ink and processed samples. In particular, many of the inks used in drop on demand thermal ink jet printers can be differentiated and dated by their physical and

chemical properties. Because the results of an unknown are only as good as the references to which it is compared, a comprehensive database should be available. This research developed a starting framework for such a collection of inks, ink cartridges, and printers. The database created during this research is being expanded in order to keep pace with new products and technological developments.

This study investigated the class characteristics of original equipment manufacturers (OEM) ink jet inks and printers, but the potential does not end there. One area that should be scrutinized is the properties of the ink used in after market refill cartridges. Another is how useful defects in the paper registration, speed of the drum, and drum cleanup may be in sourcing a document (Drago, 1996).

Ink jet technology already impacts forensic document evidence as we see it today. Continued research can provide information to classify, and perhaps eventually to source, a document in question.

Acknowledgments

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Appendix A. Ink jet printer information

Copy	Manufacturer	Model	Color cartridge	Black cartridge	Print technology	# Cartridge slots	Introduction date	Discontinued	Country of manufacture	Comments
	Apple	Color Printer	YES		N/A		Jan-93	1	Japan	Manufacturer: Canon
	Apple	Color Stylewriter Pro	YES	YES	dod		Feb-94	1	Japan	
	Apple	Portable Stylewriter	NO	YES	dod	1	Jul-93	1	Japan	Manufacturer: Canon
	Apple	Stylewriter II	NO	YES	dod	1	Jan-93	1	Japan	
	Apple	Stylewriter 1200	NO		cont.	1	Apr-95		Japan	
	Apple	Color Stylewriter 2200	YES		dod		Jun-95		Japan	
X	Apple	Color Stylewriter 2500	YES	YES	dod				Japan	Manufacturer: Canon
	Brother	HJ-1001	NO		dod	1	Sep-91	1	Japan	Manufacturer: Canon
	Brother	HJ-400	NO	YES	dod	1	Jun-93	1	n/a	Utilizes Canon Bubblejet technology
	C-Tech	Speedjet CJ-300	NO	YES	dod	1	Nov-93		Japan	
	Calcomp	Techjet Personal Inkjet	NO	YES	dod	1	Nov-93	1	Japan	
	Calcomp	Techjet Color GT/PS	YES		cont		Nov-95		Japan	
	Calcomp	Techjet 175I	YES		dod		Nov-95		Japan	
	Canon	BJ-5						1		
	Canon	BJ-10e						1		
	Canon	BJ-10ex	NO		dod	1	Aug-91	1	Japan	
	Canon	BJ-10sx	NO		dod	1	Dec-93	1	n/a	
	Canon	BJ-20						1		
	Canon	BJ-100	NO		dod	1	Jun-94	1	n/a	
	Canon	BJ-200	NO		dod	1	Oct-92	1	Japan	
	Canon	BJ-200e						1		
X	Canon	BJ-200ex	None Listed	YES			Jan-95	1	None Listed	
	Canon	BJC-210	YES	YES	dod		Aug-95		Japan	One cartridge for Cyan, Magenta, & Yellow
X	Canon	BJC-240	Optional	YES		1				
	Canon	BJC-Photo	Optional	YES					Japan	
	Canon	BJ-30	N/A	YES	cont.		Mar-95		Japan	Also avail. in a monochrome version
	Canon	BJC-70	YES	YES	dod		Mar-95		Japan	
	Canon	BJ-300	NO		dod	1	Nov-90	1	Japan	
	Canon	BJ-330	NO		dod	1	Nov-90	1	Japan	BJC-4100
X	Canon	BJC-4000	YES	YES			Aug-94	1	Japan	
	Canon	BJC-600	YES	YES			Nov-94	1	Japan	
X	Canon	BJC-600e						1	Japan	
X	Canon	BJC-610	YES	YES	dod		Aug-95	2	Japan	
X	Canon	BJC-620							Japan	
	Canon	BJC-800	YES		dod		Oct-91	1	Japan	
	Canon	BJC-820	YES		dod		Oct-91	1	Japan	
	Canon	BJC-880								BJC-4000
	Canon	BJ-230	NO	YES	dod	1	Jun-93		Japan	
	Canon	BJC-4100	YES	YES	dod		Aug-95	2	Japan	
X	Canon	BJC-4200								
X	Canon	BJC-4550								Manufacturer: Olivetti
	Citizen America	Projet II	Optional	YES	dod		Nov-93	1	n/a	
	Digital	DECColor Writer	y		dod		May-94		Italy	Manufacturer: Olivetti
X	Digital	DECWriter 65								
	Digital	DECWriter 100i								
	Digital	DECWriter 110i	Optional	YES			Oct-94	1	n/a	

Appendix A. Continued

Copy	Manufacturer	Model	Color cartridge	Black cartridge	Print technology	# Cartridge slots	Introduction date	Discontinued	Country of manufacture	Comments
	Digital	DECWriter 120i	YES	YES			Oct-94	1	n/a	
	Digital	DECWriter 500i	Optional	YES	dod		May-94	1	n/a	Manufacturer: Olivetti
X	Digital	DECWriter 520ic						1		
	Digital	DECWriter 550ic						1		
	Digital	DECWriter 90ip	None Listed	YES			Nov-94	1	None Listed	
	Eastman Kodak	Diconix 180SI	NO	YES	dod		Sep-91	1	Japan	Equipped w/NiCad batteries
	Epson	Stylus 300					Jun-95	1		
X	Epson	Stylus 400	#S020089	YES			Aug-94	1	Japan/USA	
X	Epson	Stylus 600	#S020089	YES						
	Epson	Stylus Photo	#S020110	YES						
X	Epson	Stylus 800	#S020089	YES			Oct-94		Japan/USA	
	Epson	Stylus 3000	Yes-3 cart	YES						
	Epson	Stylus 1000	NO	YES	dod		May-94		Japan/USA	
	Epson	Stylus 1500	YES	YES	cont.		Feb-96			
X	Epson	Stylus Color	YES		dod		Jun-94		Japan	Available for MAC also
X	Epson	Stylus Color 200								
	Epson	Stylus Color 500								
	Epson	Stylus Color II	YES	YES	cont.		Aug-95	2		
	Epson	Stylus Color IIS	YES	YES	cont.		Aug-95	2		
	Epson	Stylus Pro	YES	YES	cont.		Aug-95			
	Epson	Stylus Pro XL	YES		cont.		Aug-95		Japan	
	Gestetner	C6770	YES		dod		1994		n/a	
	Gestetner	C970	YES		dod		Mar-95		Japan	Manufacturer: Canon
	Hewlett Packard	DesignJet 750c	Yes-3 color cart.	NO			Sep-95			
	Hewlett Packard	DesignJet 755cm	Yes-3 cart	NO			Sep-95			
X	Hewlett Packard	Deskjet 320								
	Hewlett Packard	Deskjet 340	Optional	YES	cont.	1	Sep-95		USA	
X	Hewlett Packard	Deskjet 400	Optional	YES	dod	1				
X	Hewlett Packard	Deskjet 540	YES	YES				1		
X	Hewlett Packard	Deskjet 560C	YES	YES	dod		Mar-94	1	USA	
	Hewlett Packard	Deskjet 855 Cxi	YES	YES	dod		May-96			
	Hewlett Packard	Deskjet 855 C	YES	YES	dod		Jul-95			
	Hewlett Packard	Deskjet 855 Cse	YES	YES	dod		May-96			
	Hewlett Packard	Deskwriter 660C	YES	YES	n/a		May-95		n/a	
	Hewlett Packard	Deskwriter 600	Optional	YES	dod		Jul-95		USA	
	Hewlett Packard	Deskjet 820Cxi	YES	YES	dod		Apr-96			
X	Hewlett Packard	Deskjet 820Cse	YES	YES	dod		Apr-96			Windows only
X	Hewlett Packard	Deskjet 670C	YES	YES	dod					
	Hewlett Packard	Deskjet 682C	YES	YES	dod	2	May-96		n/a	DOS/Windows

Appendix A. Continued

Copy	Manufacturer	Model	Color cartridge	Black cartridge	Print technology	# Cartridge slots	Introduction date	Discontinued	Country of manufacture	Comments
	Hewlett Packard	Deskjet 680C	YES	YES	dod	2	May-96			
X	Hewlett Packard	Deskjet 660C	YES	YES	dod		May-95		n/a	
	Hewlett Packard	Deskjet 660	Optional	YES	dod		Jul-95			
	Hewlett Packard	Deskjet 660CSE	YES	YES	dod		Oct-95			
	Hewlett Packard	Deskjet 600C	Optional	YES	dod	1	Jul-95			
X	Hewlett Packard	Deskjet 694C	YES	YES	dod					
X	Hewlett Packard	Deskjet 870Cxi	YES	YES	dod					
	Hewlett Packard	Deskjet 340	Optional	YES			Sep-95			
X	Hewlett Packard	Deskjet 1000Cse	YES	YES						
X	Hewlett Packard	Deskjet 1200C	YES	YES			May-93	1	USA	Cyan, magenta, yellow cartridges sold separately
X	Hewlett Packard	Deskjet 1600C	YES	YES			Jul-95			Cyan, magenta, yellow cartridges sold separately
	Hewlett Packard	Deskjet 1600CM	YES	YES			Jul-95			
X	Hewlett Packard	Deskjet Plus	NO	YES		1		1		
X	Hewlett Packard	Deskjet 500	NO	YES	dod	1	Aug-90	1	USA	
	Hewlett Packard	Deskjet 500C	YES		dod		Oct-91	1	USA	
	Hewlett Packard	Deskjet 550C	YES		dod		Oct-92	1	USA	
	Hewlett Packard	DeskJet 850c	YES	YES			Jul-95			
	Hewlett Packard	DeskJet 855cm	YES	YES						
	Hewlett Packard	DeskWriter	NO	YES	dod	1	Jul-89	1	USA	
	Hewlett Packard	DeskWriter C	YES		dod		Aug-91	1	USA	
	Hewlett Packard	DeskWriter 550C	YES		dod		Oct-92	1	USA	
	Hewlett Packard	DeskWriter 560C	YES		dod		Mar-94	1	USA	
	Hewlett Packard	DeskWriter 680C	YES		dod		May-96		USA	
	Hewlett Packard	DeskWriter 850c								
	Hewlett Packard	DeskWriter 855cm	YES	YES						
	Hewlett Packard	DeskJet Portable		YES						
	Hewlett Packard	DeskWriter Portable		YES			1990?			
	Hewlett Packard	PaintJet XL300	Yes-3 cart		dod		May-92	1993-94	n/a	Will discontinue cartridge manufacture in 1999
X	Hewlett Packard	PaintJet	YES	YES	dod		Aug-87	1993-94	USA	Will discontinue cartridge manufacture in 1999
	Hewlett Packard	PaintWriter	YES	YES				1		

Appendix A. *Continued*

Copy	Manufacturer	Model	Color cartridge	Black cartridge	Print technology	# Cartridge slots	Introduction date	Discontinued	Country of manufacture	Comments
X	Hewlett Packard	ThinkJet	N/A	YES	dod	1		1		
	Hewlett Packard	QuietJet	N/A	YES				1		
	IBM	4070IJ	NO	YES	dod	1	Jul-92	1	n/a	Sold printer business to Lexmark in March 1991
	IBM	4072 ExecJet	NO	YES	dod	1	Oct-90		Japan	Sold printer business to Lexmark in March 1991
	IBM	PS 4079	YES		dod		Oct-92		n/a	
	JRL systems	JR670-1	NO	YES	dod	1	Mar-92	1	USA	Manufacturer: Canon
	JRL Systems	JR670-2	NO	YES	dod	1	Mar-92	1	USA	Manufacturer: Canon
	JRL Systems	JR670-3	NO	YES	dod	1	Mar-92	1	USA	Manufacturer: Canon
	Lasermaster Corp	Winprinter 360XLS	NO	YES	dod	1	Nov-92	1	Japan	Utilizes bubble jet technology
	Lexmark	1020	1380619	1361400	cont.		Oct-95	2	USA	
X	Lexmark	2030	1380619	1361400						
X	Lexmark	2050	1380619	1361400						
	Lexmark	WinWriter 150c	1380619	1361400	dod		May-95		USA	
	Lexmark	ExecJet IIc	1380619	1361400	cont.		Aug-94		USA	Bought IBM printer business in March 1991
	Lexmark	4072 ExecJet	NO		dod		Oct-90		Japan	Bought IBM printer business in March 1991
	Lexmark	4076	1380619	1361400			Oct-93		USA	
	Lexmark	Medley	1380619	1361400	dod		Apr-95		USA	Medley 4c
	Lexmark	Medley 4C	YES		dod		Apr-95		USA	
	Lexmark	IBM ExecJet II 4076	NO	YES	dod		Oct-93		USA	
	Lexmark	Color Jetprinter 4079 plus	YES		cont.		May-95		Japan	
	Lexmark	Color Jetprinter PS 4079	YES		dod		Oct-92		n/a	
	Lexmark	2070	1382060	YES	dod		Oct-95	2	USA	
	NEC	JetMate	NO	YES	dod		Jun-93	1	n/a	
	Okidata	Okijet 2010	YES		dod		May-95		USA	
	Olivetti	JP 360	YES		dod		n/a		n/a	
	Olivetti	JP 450	YES		dod		n/a		n/a	
	Olivetti	JP 50	NO	YES	dod	1	n/a		n/a	
	Royal Consumer	CJP 450	NO	YES	dod	1	Jan-92		Italy	Also sold as Olivetti JP-150; Royal is division of Olivetti
	Tandy/Radio Shack	JP 250	NO	YES	dod	1	Aug-92	1	n/a	Utilizes bubble jet technology
	TEC America Electronics	IJ-6301A	NO	YES	dod	1	Apr-93	1	Japan	
	Tektronics	Colorquick	YES		dod		Jan-89	1	Japan/USA	Manufacturer: Sharp
	Tektronics	Phaser 140	YES		dod		Oct-94		n/a	
	Texas Instruments	Micromarc	NO	YES	dod	1	May-93	1	Japan	Manufacturer: TEC
	Texas Instruments	Micromarc Color	YES		dod		May-94	1	Italy	Manufacturer: Olivetti
	Xerox	Personal Printer 4004	NO	YES	dod	1	Oct-93		n/a	

Appendix B. Ink Cartridge Cross Reference

Ink	Ink cartridge manufacturer	Ink cartridge #	copy	Printer model	Color cartridge	Black cartridge	OEM	Date introduced	Date revised	Comments
	Apple	M3330G/A	X	Color Stylewriter 2500		X	Canon	n/a	n/a	
	Apple	M3329G/A		Color Stylewriter 2500	X		Canon	n/a	n/a	
	Canon	BC-01		BJ-5	X	X	OEM	Nov-90	Jul-96	Pelikan brand for BC-01, BC-02, & BX-2
				BJ-10e	X	X	OEM	Nov-90	Jul-96	
				BJ-10ex	X	X	OEM	Nov-90	Jul-96	
				BJ-10sx	X	X	OEM	Nov-90	Jul-96	
				BJ-20	X	X	OEM	Nov-90	Jul-96	
	Canon	BC-02		BJ-100	X	X	OEM	Aug-92	Jul-96	Pelikan brand for BC-01, BC-02, & BX-2
				BJ-200	X	X	OEM	Aug-92	Jul-96	
				BJ-200e	X	X	OEM	Aug-92	Jul-96	
			X	BJ-200ex	X	X	OEM	Aug-92	Jul-96	
				BJC-210	X	X	OEM	Aug-92	Jul-96	
				BJC-240	X	X	OEM	Aug-92	Jul-96	Also Photo & Neon Cartridges
	Canon	BC-05	X	BJC-240	X	X	OEM	Jan-96	n/a	
	Canon	BC-06		BJC-Photo	X	X	OEM			
	Canon	BC-10		BJ-30	N/A	X	OEM	Jul-94	Jul-96	Also BCI-10
				BJC-70	X	X	OEM	Jul-94	Jul-96	
		BC-11		BJC-70	X	X	OEM			
	Canon	BHI-642		BJ-300	X	X	OEM	Dec-90	Jul-96	
				BJ-330	X	X	OEM	Dec-90	Jul-96	
	Canon	BC-20	X	BJC-4000	X	X	OEM	Jul-94	Jul-96	
				BJC-4100			OEM	Jul-94	Jul-96	
	Canon	BC-21		BJC-4000	X	X	OEM	Jul-94	Jul-96	Also sold as #BCI-21; four separate cartridges
				BJC-4100			OEM	Jul-94	Jul-96	
			X	BJC-4200			OEM	Jul-94	Jul-96	
	Canon	BC-22	X	BJC-4000	X	X	OEM			Black ink only printers
	Canon	BJI-101		Notejet		X	OEM	Nov-92	May-95	
	Canon	BJI-201		BJC-600		X	OEM	Apr-93	Nov-95	
			X	BJC-600e		X	OEM	Apr-93	Nov-95	
			X	BJC-610		X	OEM	Apr-93	Nov-95	
			X	BJC-620		X	OEM	Apr-93	Nov-95	C, Y, M sold separately
	Canon	BJC-643		BJC-800		X	OEM	Nov-91	Jul-96	
	Digital	LJ50X		DECWriter 100i		X				
				DECWriter 110i		X				
				DECWriter 120i		X				
				DECWriter 500i		X				
			X	DECWriter 520ic		X				
				DECWriter 550ic		X				
	Digital	LJ90X		DECWriter 90ip		X				
		# not available	X	DECWriter 65						
	Epson	S020093	X	Stylus 400	#S020089	X	OEM		Jun-96	Shelf life expires two years after production
				Stylus 600	#S020089	YES	OEM		Jun-96	
				Stylus Photo	#S020110	YES	OEM		Jun-96	

Appendix B. *Continued*

Ink	Ink cartridge manufacturer	Ink cartridge #	copy	Printer model	Color cartridge	Black cartridge	OEM	Date introduced	Date revised	Comments
	Epson	S020108	X	Stylus 800	#S020089	X	OEM		Jun-96	Shelf life expires two years after production
	Epson	S020118		Stylus 3000	Yes-3 cart	X	OEM		Jun-96	
	Epson	S020034	X	Stylus Color	X	S020036	OEM		Feb-94	Shelf life expires two years after production
	Epson	S020036	X	Stylus Color	S020034	X	OEM		Feb-94	
	HP	51644A		DesignJet 750c	Yes-3 cart	No-3 cart col	OEM			
				DesignJet 755cm	Yes-3 cart	No-3 cart col	OEM			
	HP	51645A		DeskJet 850c	51641A	X	OEM		Nov-95	
				DeskJet 855cm	51641A	X	OEM		Nov-95	
				DeskWriter 850c	51641A	X	OEM		Nov-95	
				DeskWriter 855cm	51641A	X	OEM		Nov-95	
				DesignJet 750c		X	OEM		Nov-95	
			X	Deskjet 820Cse	51641A	X	OEM		Nov-95	
			X	Deskjet 870Cxi	51641A	X	OEM		Nov-95	
			X	Deskjet 1000Cse	51641A	X	OEM		Nov-95	
			X	Deskjet 1200C/PS	51640C/M/Y	X	OEM		Nov-95	
			X	Deskjet 1600C	51640C/M/Y	X	OEM		Nov-95	C, M, & Y sold separately
				DesignJet 755cm		X	OEM		Nov-95	
	HP	51641A		DeskJet 850c	X	51645A	OEM		Nov-95	
				DeskJet 855cm	X	51645A	OEM		Nov-95	
				DeskWriter 850c	X	51645A	OEM		Nov-95	
			X	Deskjet 820Cse	X	51645A	OEM		Nov-95	
			X	Deskjet 1000Cse	X	51645A	OEM		Nov-95	
				DeskWriter 855cm	X	51645A	OEM		Nov-95	
	HP	51633A		DeskJet Portable		X	OEM		Aug-94	
				DeskWriter Portable		X	OEM		Aug-94	
	HP	51639A		PaintJet XL300	Yes-3 cart	X	OEM			Cartridges to be discontinued in 1999
	HP	51606A	X	PaintJet	51606C	X	OEM			
				PaintWriter		X	OEM			Cartridges to be discontinued in 1999
	HP	51604A	X	ThinkJet	N/A	X	OEM		Nov-95	
				QuietJet	N/A	X	OEM		Nov-95	
	HP	92261A		ThinkJet	N/A	X	OEM		Nov-95	Used with thermal paper and tractor feed
				QuietJet	N/A	X	OEM		Nov-95	
	HP	51629A	X	Deskjet 400	C4533 (KIT)	X			Nov-95	Also photo print cartridge #C1816A
				Deskjet 600	N/A	X			Feb-97	
			X	Deskjet 660C	51649A	X			Feb-97	
			X	Deskjet 670C	51649A	X			Feb-97	

Appendix B. Continued

Ink	Ink cartridge manufacturer	Ink cartridge #	copy	Printer model	Color cartridge	Black cartridge	OEM	Date introduced	Date revised	Comments
X	HP	51649A	X	Deskjet 680C	51649A	X			Feb-97	
				Deskjet 682C	51649A	X			Feb-97	
				Deskjet 693C	51649A	X			Feb-97	
			X	Deskjet 694C	51649A	X			Feb-97	
			X	Deskjet 660C	X	51629A			Feb-97	
			X	Deskjet 670C	X	51629A			Feb-97	
			X	Deskjet 680C	X	51629A			Feb-97	
				Deskjet 682C	X	51629A			Feb-97	
				Deskjet 693C	X	51629A			Feb-97	
			X	Deskjet 694C	X	51629A			Feb-97	
	HP	51626A	X	Deskjet PLUS	N/A	X			Aug-93	
			X	Deskjet 540	51625A	X			Aug-93	
			X	Deskjet 560C	51625A	X			Aug-93	
			X	Deskjet 540	X	51626A			Aug-93	
			X	Deskjet 560C	X	51626A			Aug-93	
				Deskjet 320	51625A	X			Aug-93	
			X	Deskjet 320	X	51633A			Aug-93	
	Lexmark	1361400	X	2050	X	X			Aug-96	
			X	2030	X	X			Aug-96	
				1020	X	X			Aug-96	
				4072 Execjet	X	X			Jan-96	Also sold as # 1382050
	Okidata Pelikan	52109301 BC-01/02		4076	X	X			Jan-96	Also sold as # 1382050
				Okijet 2010	X	X		May-95	n/a	
				Secondary marketer		X	NuKote			For Canon printers using cartridges #BC 01 and BC-02
				Z659X		X	NuKote			For Digital DECwriter 110i, DECcolorwriter 120i, 520ic; Fujitsu Breeze 100 Plus; Mannesmann Tally T7018, T7040; NEC Jetmate 400, 800; Olivetti JP150, 250, 350; Seikosha Speedjet 360C, 460C; TI microMarc; Triumph Adler JPR 7845, 7860
	Xerox	8R7638		Docuprint XJ4C				Dec-96	Jan-97	

Appendix C. Exam Results for All Exams—Destructive and Nondestructive
The American Society of Questioned Document Examiners, Inc.

	Ink	Manufacturer	Ink Cartridge #	Clr	Blk	Copy	Printer Model	Black or Color	IRL	IRR	Waterfast	MEOH/H2O	ETOH	Pyridine	Meth.	Examples of TLC R _f
		Apple	M3330G/A		X	X	Color Stylewriter 2500	Black	Absorbs to 780 Slt. Lum @ 780	Absorb @ 610nm Reflects 695–780 Transmits @ 830	No	Yes; purple	No	No	Slight	.52: dk. purple
2	X	Canon	BC-01				Ink Sample	Black	Reflects @ 610nm Lum @ 630nm	Absorb to 735nm Reflects @ 780 Transmits @ 830	No	Yes; dark purple	Slight after 15 min	No	Yes	.23, .25, .52
3	X	Canon	BC-02				Ink Sample	Black	Reflects @ 610nm Lum @ 630nm	Absorb to 735nm Reflects @ 780 Transmits @ 830	No	Yes; dark purple	No	Slight	Slight @ 24 hrs.	.23, .25, .52
4	X	Pelikan	for Canon BC-01 & -02				Ink Sample	Black	Lum @ 610nm	Absorb to 735nm Reflects @ 780	No	Yes; purple	No	No	Slight	0, .08, .17, .27
5		Canon	BC-02		X	X	BJ-200ex	Black	Lum @ 735nm	Absorb to 735nm Transmits @ 780	No	Yes; black	No	No	Slight	.23, .25, .52
6		Canon	BC-05	X		X	BJC-240	3-Color	Absorbs	Absorb to 830nm Transmits @ 1000	No	Yes; light blue	No	No	No	0
7		Canon	BJI-201		X	X	BJC-600e	Black	Slt Lum @ 735nm	Absorb to 735nm Transmits @ 780	No	Yes; black	No	No	No	.15, .19, .46
8			BJI-201		X	X	BJC-610	Black	Slt Lum @ 830nm	Absorb to 735nm Transmits @ 830	No	Yes; black	No	No	No	.15, .19, .46
9			BJI-201		X	X	BJC-620	Black	Slt Lum @ 780nm	Absorb to 735nm Transmits @ 780	No	Yes; black	No	No	No	.29, .32, .60
10		Canon	BC-20		X	X	BJC-4000	Black	Absorbs to 780 Slt. Lum @ 780	Absorb to 735nm Reflects @ 780 Transmits @ 830	No	Yes; dark purple	No	No	No	0.6
			BC-21		X	X	BJC-4200	Black	Absorbs to 780 Slt. Lum @ 780	Absorb to 735nm Reflects @ 780 Transmits @ 830	No	Yes; purple	No	No	No	0.6
		Digital	LJ50X	X		X	DECWriter 520ic	3-Color	Absorbs	Absorb to 715nm Reflects @ 735 Transmits @ 1000	No	Yes; light purple	No	No	No	.49: Pink
13			Not available		X	X	DECWriter 65	Black	Absorbs	Absorbs to 1000nm	Yes	No	No	No	No	n/a
14		Epson	S020034		X	X	Stylus Color	S020036	Lum @ 630nm	Absorbs to 735nm Transmits @ 830	No	Yes; pale black	No	No	No	0.12

Appendix C. Continued

The American Society of Questioned Document Examiners, Inc.

Ink	Manufacturer	Ink Cartridge #	Clr	Blk	Copy	Printer Model	Black or Color	IRL	IRR	Waterfast	MEOH/H2O	ETOH	Pyridine	Meth.	Examples of TLC Rf
15	Epson	S020093		X	X	Stylus 400	Black	Lum @ 780nm	Absorb to 850 Slightly Reflects @ 1000nm	No	Yes; dark purple	No	No	Slight	.55, .6, .64, .79
16	Epson	S020093		X	X	Stylus 600	Black	Slt Lum @ 780nm	Absorbs to 850 Transmits @ 1000	No	Yes; dark purple	No	No	Slight	.55, .6, .64, .79
17	Epson	S020108		X	X	Stylus 800	Black	Lum @ 695nm	Absorbs to 850 Transmits @ 1000	No	Yes; purple	No	No	Slight	.55, .6, .64, .79
18	X	Epson				Ink Sample	Black	Reflects @ 610nm Lum @ 630nm	Absorbs to 735 Reflects @ 780 Transmits @ 1000	No	Yes; dark purple	Bright Yellow	Pale Yellow	Black	.12, .21, .24, .29, .4, .57 (yellow)
19	X	HP				Ink Sample	Black	Absorbs	Absorbs	No	No	No	No	No	0
20	X	HP				Ink Sample	Black	Absorbs @ 610 Slt. Lum @ 695	Absorbs to 780 Reflects @ 830	No	Yes; purple	No	No	Slight (Purple)	.40, .60, .65
21	X	HP				Ink Sample	Black	Absorbs @ 610 Reflects @ 630	Absorbs to 735 Reflects @ 780 Transmits @ 1000	No	Yes; dark blue	No	No	Slight (Purple)	.38, .43
22		HP		X	X	Deskjet 660C	Black	Absorbs	Absorb to 1000nm	Slight bleeding	No	No	No	No	n/a
23				X	X	Deskjet 670C	Black	Absorbs	Absorb to 1000nm	Slight bleeding	No	No	No	No	n/a
24				X	X	Deskjet 680C	Black	Absorbs	Absorb to 1000nm	No	No	No	No	No	n/a
25				X	X	Deskjet 694C	Black	Absorbs	Absorb to 1000nm	Slight bleeding	No	No	No	No	n/a
26		HP		X	X	Deskjet 400	Black	Slt Lum @ 780nm	Absorbs to 780 Transmits @ 830	No	Yes; light purple	No	No	Slight (Purple)	.43, .63, .68
27				X	X	Deskjet 540	Black	Slt Lum @ 780nm	Absorbs to 735nm Sltly Reflects @ 780 Transmits @ 830	No	Yes; light purple	No	No	No	.43, .63, .68
28				X	X	Deskjet 560C	Black	Lum @ 695nm	Absorbs to 735nm Sltly Reflects @ 780 Transmits @ 830	No	Yes; light purple	No	No	No	.43, .63, .68

Appendix C. Continued

The American Society of Questioned Document Examiners, Inc.

	Ink	Manufacturer	Ink Cartridge #	Clr	Blk	Copy	Printer Model	Black or Color	IRL	IRR	Waterfast	MEOH/H2O	ETOH	Pyridine	Meth.	Examples of TLC Rf
29					X	X	Deskjet PLUS	Black with inkjet paper	Absorbs @ 610 Slt. Lum @ 735	Absorbs to 735nm Sltly Reflects @ 780 Transmits @ 830	No	Yes; blue	No	No	No	0.36
30					X	X	Deskjet PLUS	Black with bond paper	Absorbs to 715 Reflects @ 735 Lum @ 780	Absorbs to 735nm Sltly Reflects @ 780 Transmits @ 830	No	Yes; blue	No	No	No	0.36
31		HP	51625A	X		X	Deskjet 320	3-Color	C-Lum to 1000nm M-Lum to 1000nm Y-Reflects to 830nm	All Reflect @ 610nm Transmit @695	No	Yes; light purple	Slight	Slight	Slight (Lt. Purple)	.58 (blue), .6 (Magenta)
32		HP	51645A		X	X	Deskjet 820Cse	Black	Absorbs	Absorb to 1000nm	Slight bleeding	No	No	No	No	n/a
33					X	X	Deskjet 870Cxi	Black	Absorbs	Absorb to 1000nm	Slight bleeding	No	No	No	No	n/a
34					X	X	Deskjet 1000Cse	Black	Absorbs	Absorb to 1000nm	Yes	No	No	No	No	n/a
35					X	X	Deskjet 1200C/PS	Black	Absorbs	Absorb to 1000nm	Yes	No	No	No	No	n/a
36					X	X	Deskjet 1600C	Black	Absorbs	Absorb to 1000nm	Slight bleeding	No	No	No	No	n/a
37		HP	51606A		X	X	PaintJet	Black on inkjet paper	Absorbs to 665 Lum @ 695	Absorb to 735nm Transmits @ 780	Slight	Yes, but no color chg	No	No	No	0.49
					X	X	PaintJet	Black on bond paper	Absorbs to 610 Transmits @ 715 Lum @ 735	Absorb to 665 Wk. Absorb @ 695 Transmits @ 735	Yes	No	No	No	No	n/a
39		Hp	92261A		X	X	ThinkJet	Black	Absorb to 665 Lum @ 695	Absorb to 780 Transmits @ 780	Yes	No	No	No	Slight	n/a
40		Lexmark	1361400		X	X	2050	Black	Absorbs	Absorb to 1000nm	Yes	No	No	No	No	n/a
41		Lexmark			X	X	2030	Black	Absorbs	Absorb to 1000nm	Yes	No	No	No	No	n/a
42	X	Lexmark	1361400				Ink Sample	Black	Absorbs	Absorb to 1000nm	Yes	No	No	No	No	n/a