

Class Characteristics of Counterfeit Protection System Codes of Color Laser Copiers

Janis S. Tweedy

Total Security Concepts, Inc., 750 South Plaza Drive, Suite 210, Mendota Heights, MN 55120

As the quality of the color laser copiers increased at the end of the 1980s, it became apparent that they could be used to produce credible copies of important documents. In an effort to stop their use as a counterfeiting tool, changes were made to the machines to prevent the copying of important documents as well as to identify the color laser copier used to make the copy through the inclusion of a code on each color laser copy. Submitting the copies to the U.S. Secret Service Laboratory can allow for decoding to identify the make, model, and serial number of the copier used. However, by studying the code present on a color laser copy, a forensic document examiner may determine the possible manufacturer of the color laser copier used to produce the copy which may be useful as investigative information. Also, the forensic document examiner can identify a color laser copier as the one used to produce questioned copies if the questioned copies display the same code as produced by the known color laser copier.

Introduction

The color copier has been around since 3M debuted their Color-in-Color copier in 1969 (Shiver and Nelson, 1991). The technology was constantly improving and when Canon introduced their Color Laser Copier in 1987 (Wooten, 1993) with its high-quality color reproduction capacity, there was much concern that the color laser copiers would be used to counterfeit documents and currency. In 1990, the Japan Business Machine Makers Association (JBMA) adopted a Counterfeit Protection System that included two procedures in an effort to decrease the counterfeiting and positively identify color laser copiers that were being illegally used (MAFS Workshop, 2000).

The first procedure involved the installation of a chip which was programmed to recognize designated portions of currency and other valuable documents. If someone tried to copy currency or the designated documents, the copier would spoil the image and make it useless to the counterfeiter.

The second procedure caused each color laser copier to add a code to all color laser copies which

could identify which color laser copier was used to produce them. The code contains the make, model, and serial number of the color laser copier used. A search of the literature revealed few articles which described the identification of color laser copiers through the use of this code (Shell, 1995; Li and Leung, 1998).

Methods and Materials

The counterfeit protection system code is comprised of a pattern of yellow dots which are produced with yellow toner and are nearly invisible to the naked eye. This pattern covers the entire surface of the document but is more easily seen in areas of the document where there is no other printing.

In order to study the code pattern, it needs to be visualized. There are at least three methods that can be used to visualize the code patterns:

- 1) Microscope Method: Using good illumination and a microscope having a magnification range up to approximately 30X, the yellow dots can be seen. In order to protect the document, a transparent sheet can be placed over the color

laser copy and a marker can be used to record the position of the dots. This can be a laborious method as it may take quite a number of dots to see the repeated patterns for some copiers.

2) VSC Method: Using the Video Spectral Comparator or similar instrument, the toner dot pattern can be visualized by using the UV light and LP1 filter. Figure 1 shows an image from a VSC-4 using the UV light setting and LP1 filter. The zoom is at its closest/greatest magnification setting. This image shows an area approximately ½ inch in width. It is from a Canon CLC 2400.

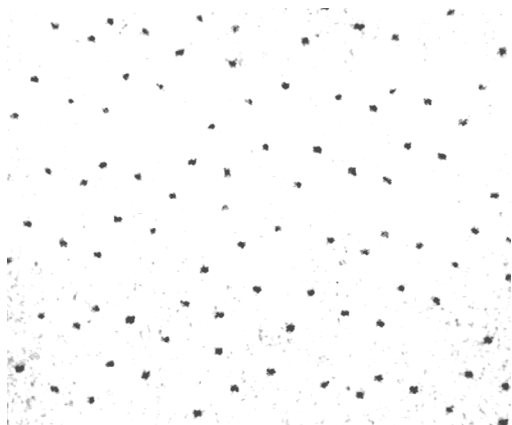


Figure 1

3) Scanner Method: Scan in a color image of the document and select an area that contains little printing. This selected area is then transferred to Adobe Photoshop (or similar program) and the commands Image/Adjust/Contrast-Brightness are selected. The Contrast is increased to 100%. Enlarge the image until pixels of color are easy to select and then use the commands Image/Adjust/Replace Color and select a color (not yellow). Adjust the lightness so the color is no longer visible. This is repeated until only the yellow pixels remain. Change the image to a grayscale image and again use Image/Adjust/Contrast-Brightness to bring the contrast to 100%. It is then possible to print out the pattern of dots in black and white and evaluate it. Figure 2 shows a printout of a visualized pattern. It is approximately 1:1 and is from a Minolta CF 910.

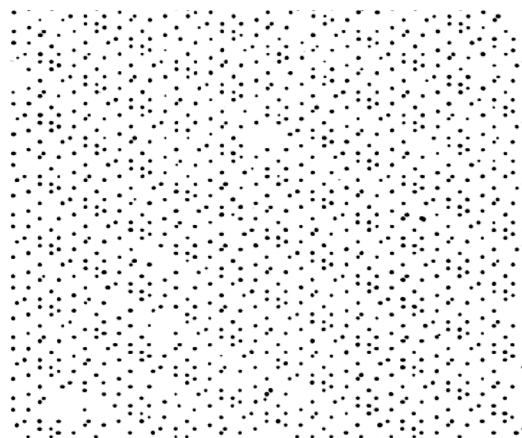


Figure 2

Anyone who is going to be examining color laser copies for the presence of the yellow dot pattern should try the different methods above on known samples prior to working on questioned copies. Due to their dense patterns and large dots, patterns from Canon laser copiers may be the best to practice on.

All of the examinations and interpretations of the counterfeit protection system code patterns have been done for the purposes of this paper with the color laser copy in a portrait orientation.

When it has been determined that there is a code pattern present which can be visualized and it is desired to have the code pattern decoded to identify the make, model, and serial number of the color laser copier used, the U.S. Secret Service must be contacted. They are acting as agents for the various color laser copier manufacturers and have the software necessary to do the decoding. They have advised that their local agents be contacted regarding criminal cases and the request be made through them.

Sending the material to the U.S. Secret Service Laboratory will have some turnaround time involved and it may be helpful to have some information immediately available as to a possible make of copier to assist in any ongoing investigation. The class characteristics (pattern type and vertical pattern separation distance) of the visualized code pattern can be evaluated by the forensic document examiner. Comparisons can be made to known code patterns to identify the manufacturers who have similar class characteristics. Using a source such as Appendix H, a list of possible makes and models of color laser copiers can be assembled.

If, during an investigation, known samples from a suspect color laser copier are obtained and a comparison shows that the pattern from the questioned copies is identical to that from the color laser copier, then the color laser copier can be identified as the source of the questioned documents.

It is also possible to group copies to show that they came from a common source by showing that the code patterns present on each are the same. A color laser copier can be used to produce many different types of documents.

There is one exception to the above procedure that must be considered when dealing with the identification of Xerox color laser copiers. The Xerox code pattern is made up of rectangular patterns that consist of 8 rows and 15 columns of dots (Appendix B). On examples obtained from several Xerox 5750 color laser copiers at different times, the code pattern remained unchanged on some while the other copiers displayed code patterns that were partly different. On the copiers with the partially-changing code patterns, the code pattern on 8 of the columns remained the same, regardless of when the samples were taken, while the remaining 7 columns varied. It is assumed that the unchanging portion reflects the make, model, and serial number of the color laser copier while the changing portion must reflect the time and/or date or other information. Therefore, it is possible for a Xerox copier to be identified as the source of a questioned color laser copy even though all columns of the code pattern do not match. It may also be possible to identify the time and/or date that the copy was made.

Results

There are many color laser copiers on the market today but there are only 7 original equipment manufacturers (OEMs) that produce them, i.e., one company can make copiers and the copiers can be sold under several different company labels. This can be seen in Appendix H.

Information was collected from manufacturers, local dealers, and published sources (Buyers Laboratory Inc., 1999 and 2000). Samples of color laser copies from over 65 different copiers that included 33 different models were obtained in the field and from sales offices. Study of this information and analysis of the code patterns of the samples showed that the patterns were consistent with and identifiable to seven

different OEMs. While patterns from several OEMs are relatively easy to identify, others are more difficult. In addition to the general shape and spacing of the patterns, on more diffuse patterns it is important to determine the vertical distance between similar pattern features to help identify the different OEMs.

To determine this vertical distance, look at the pattern, often along a vertical direction, to see the presence of repeating features or patterns. Measure the distance between the repeating features to the nearest 1/100th of an inch (plus or minus .01 inch). The approximate vertical distances in inches found by the author to be characteristic of the code patterns from the different OEMs follows:

Canon	.18"
Hewlett-Packard	.32"
Minolta	.32" and .48" (2001 introduced models)
Sharp	.50" (for the AR-C150 only, not earlier models made by Ricoh)
Toshiba	.55" (for the FC 15 or FC 22, not the earlier models made by Minolta)
Ricoh	.64"
Xerox	.66"

In Figure 3, this distance is shown by vertical lines for a Canon CLC 1000. Figure 4 shows this distance for a Xerox 5750.

Appendices A through G show examples of the code patterns from the different OEMs as well as examples of showing how to determine the distance between repetitions of the pattern. Together these two class characteristics can be used to identify the OEMs.

Appendix H shows a list of the OEMs and the makes and models of color laser copiers that can be associated with them. In parentheses are the Domestic Introduction Date, whether the copier has been discontinued (D) and whether a sample from that type of color laser copier (*) was collected.

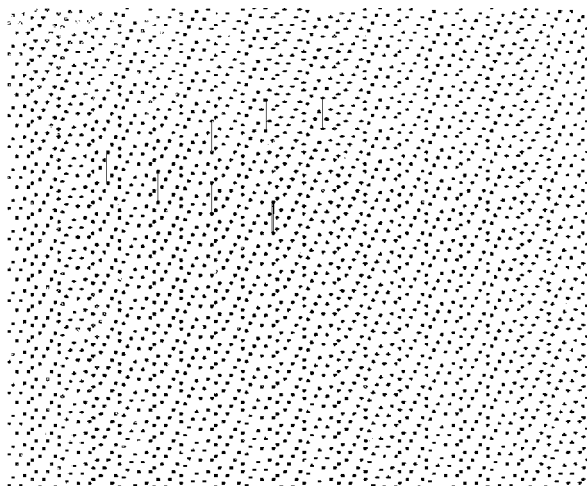


Figure 3

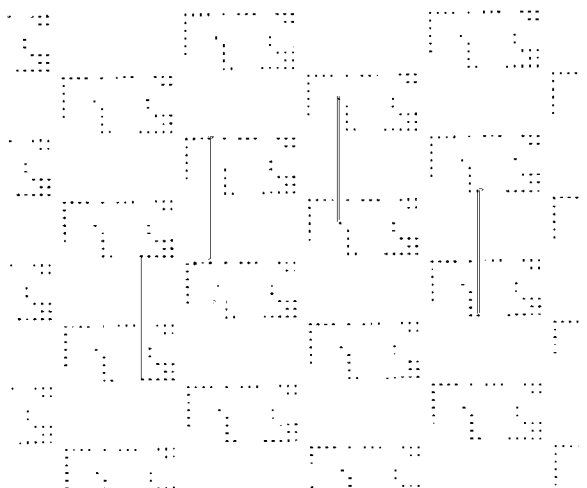


Figure 4

Discussion

The information presented in this study focuses primarily on color laser copiers which were introduced from approximately 1995 to the first half of 2001.

Originally, the color laser copiers were stand-alone units. However, now all of the color laser copiers studied for this paper are units that can

also function as a network printer. This means the system could be used like a stand-alone photocopier to make a color laser photocopy or be connected to a computer to print color laser documents from it.

In all cases but one, counterfeit protection system code patterns were found on both the color photocopies and color computer-printed documents. As the one exception, it was noted that photocopies produced by the Hewlett-Packard Color Laser Jet 8550 MFP did display the counterfeit protection system code patterns, however, documents produced as the output of the computer did not display the pattern. As only one sample has been collected from this unit (which the author was not present to see), further samples need to be collected to determine whether this is representative of that machine.

Information has been received that color laser printers (that do not have a photocopying capability) may be exhibiting the counterfeit protection system code patterns. A limited number of samples and information (Li, Chan, and Cheng, 2001) have been collected from color laser printers. A list of color laser printers that do produce a counterfeit protection system pattern code follows (this is not meant to be a comprehensive list):

Canon:	C2100 CLP, CLBP 360 PS and CLBP 400
Epson:	Acu Laser C8500 and C2000 (the C8500 displays a code similar to Xerox)
Ricoh:	AP 305 and AP 505 (the AP 204 does not); see paragraph below
Savin:	SLP 517c (the SLP 416c does not); see paragraph below

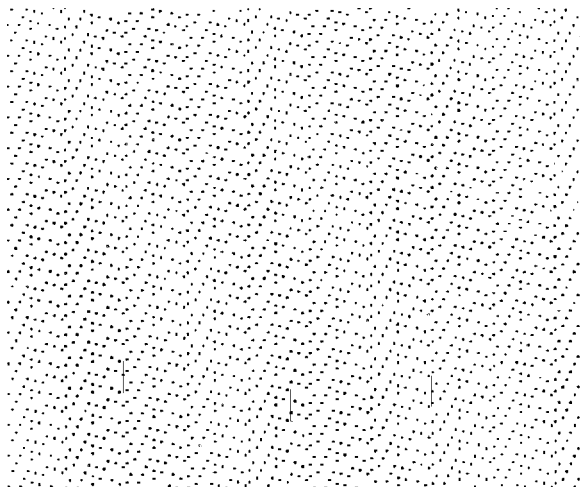
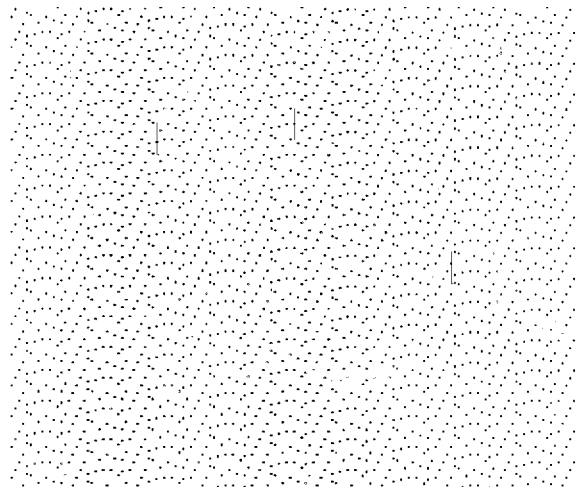
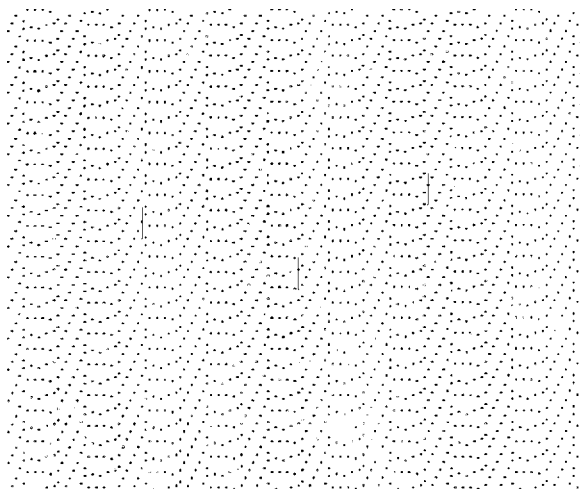
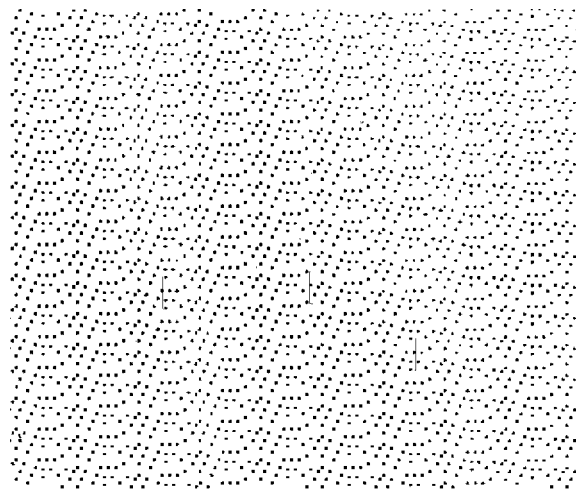
Samples collected from the Ricoh AP 305 and AP 505 and a Savin SLP517c printer displayed a code consistent with laser copiers manufactured by Ricoh. However, while the pattern type and spacing were consistent with a Ricoh machine, the pattern consisted of only 2 dots. See Figure 5. The author wonders whether this abbreviated pattern serves only to identify the manufacturer and not to individualize the printer.

References

- Buyers Laboratory Inc. (1999 and 2000). *Copier Specification Guide*.
- Li, C.K., Leung, S.C. (1998). The Identification of Colour Photocopiers: A Case Study, *Journal of the American Society of Questioned Document Examiners*, Vol. 1, No.1, pp. 8-11.
- Li, C.K., Chan, Wai-Chung, Cheng, Yau-Sang (2001). The Differentiation of Colour Laser Printers. Presented at the American Society of Questioned Document Examiners annual meeting, Des Moines, Iowa.
- MAFS Workshop (2000). Minneapolis, MN.
- Shell, Errol (1995). Forensic Evidence Relative to Canon Full-Colour Photocopiers, *RCMP GAZETTE*, Vol. 57, No. 3, pp. 22-24.
- Shiver, F.C., Nelson, L.K.(1991). Nondestructive Differentiation of Full-Color Photocopies, *Journal of Forensic Sciences*, Vol. 36, No. 1, pp. 145-152.
- Wooton, Elaine X. (1993). Updated Results: Using the Canon Color Copier to Facilitate Forensic Document Examinations. Presented at the American Society of Questioned Document Examiners annual meeting, Ottawa, Canada, 2000.

Figure 5

In conclusion, the presence of counterfeit protection system code patterns on color laser copies can be of assistance to the forensic document examiner because it can allow the individual copier to be identified as the maker of the color laser copy in question and/or allow the examiner to link questioned documents (they may consist of copies of different types of documents) to a common source. Investigative information can also be provided to investigators on possible copiers if it is needed immediately.

Appendix A**Canon OEM Codes****Figure A1. Canon 1000****Figure A2. Canon 1120****Figure A3. Océ 110****Figure A4. Océ 115**

The Canon OEM code pattern is very dense with much pattern repetition. The code patterns appear to form narrow vertical columns. The vertical pattern separation distance is approxi-

mately 0.18 inches. The vertical lines show how the vertical pattern separation distance can be determined.

Appendix B

Xerox OEM Codes

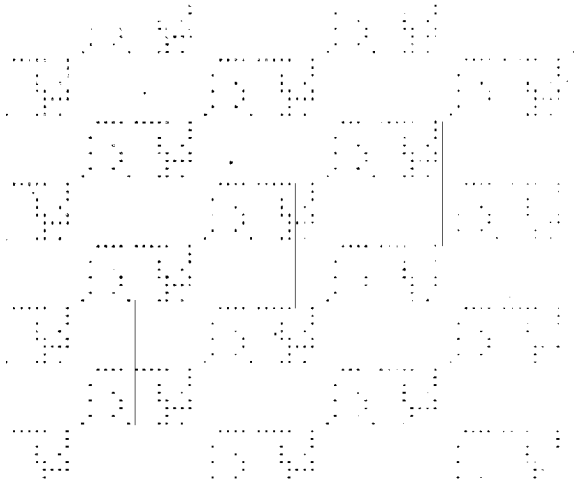


Figure B1. Xerox DocuColor 12

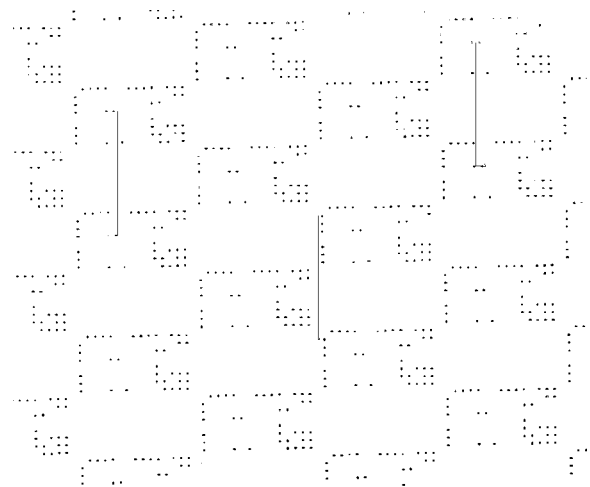


Figure B2. Xerox 5750 (Collected 3/00)

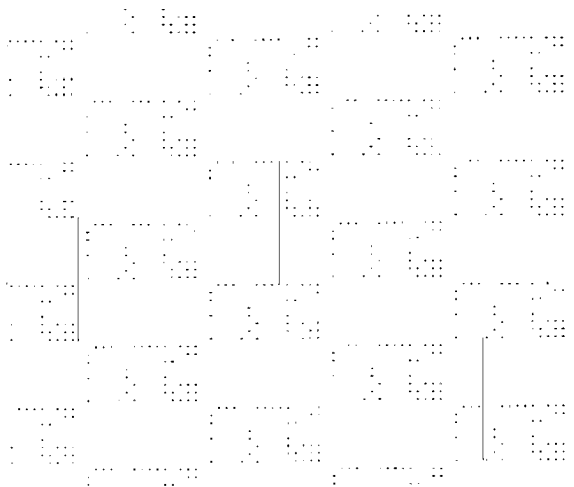


Figure B3. Xerox 5750 (Collected 5/00)

The Xerox counterfeit protection system code pattern is probably the easiest to recognize of all the patterns. It consists of an 8 x 15 grid of dots.

The vertical pattern separation distance is approximately 0.66 inches. The vertical lines show how this distance can be determined.

There appears to be an option on some copiers that allows the time and date that the copy is produced to also be displayed in the code. For example, the middle and bottom codes were produced on the same Xerox 5750 copier. However, the samples were collected at different times. By studying the patterns, it is evident that the code is similar on the 8 columns on the right side of the pattern (to reflect the make, model, and serial number) but there is a difference on the remaining 7 columns (presumably to reflect a date and/or time or other information).

Other samples were collected from different Xerox 5750s which did not show the difference. Therefore, it must be kept in mind when working with Xerox code patterns that part of the code pattern in the "blocks" may be similar between copies from the same copier and part of the code pattern may not be the same, even though they are from the same copier.

Appendix C

Ricoh OEM Codes

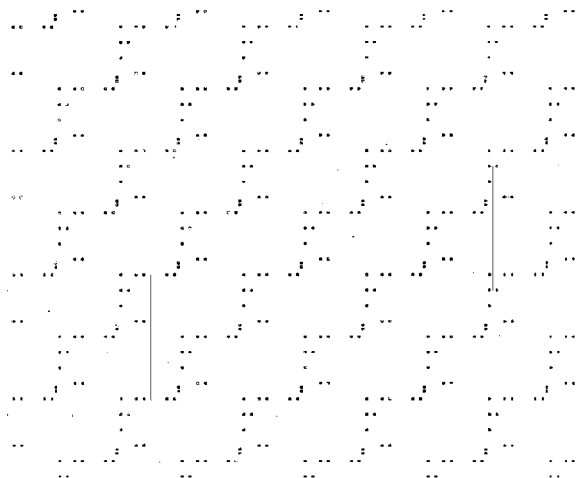


Figure C1. Ricoh Aficio Color 4106

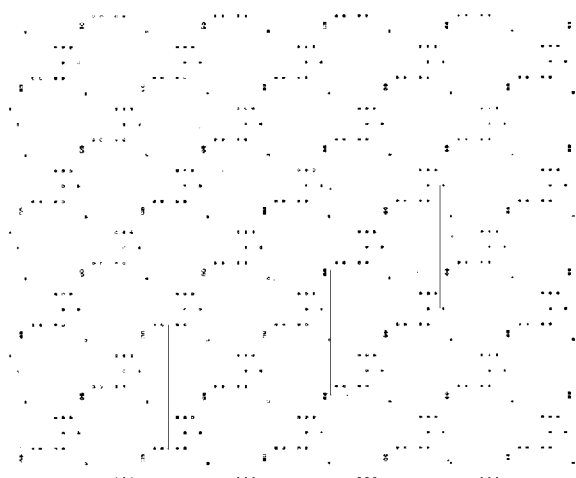


Figure C2. Gestetner 2703

Figure C3. Lanier 5606 DC

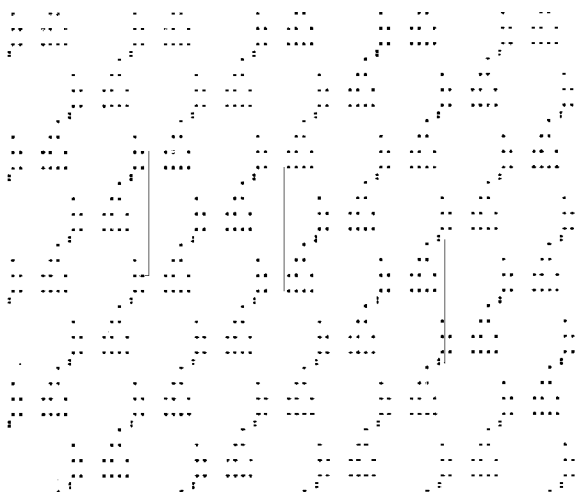
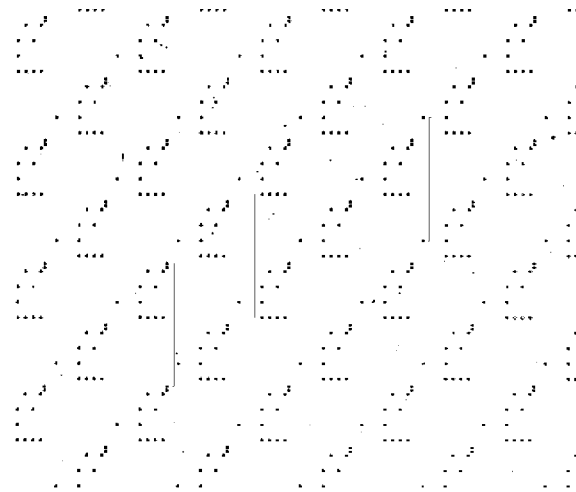


Figure C4. Savin SDC 410



The Ricoh OEM code patterns look like complete pattern blocks in an arrangement that moves from the lower left to the upper right. These patterns are pretty distinctive and easily

recognizable.

The vertical pattern separation distance is approximately 0.64 inches. The vertical lines in the patterns show how this can be measured.

Appendix D

Minolta OEM Codes

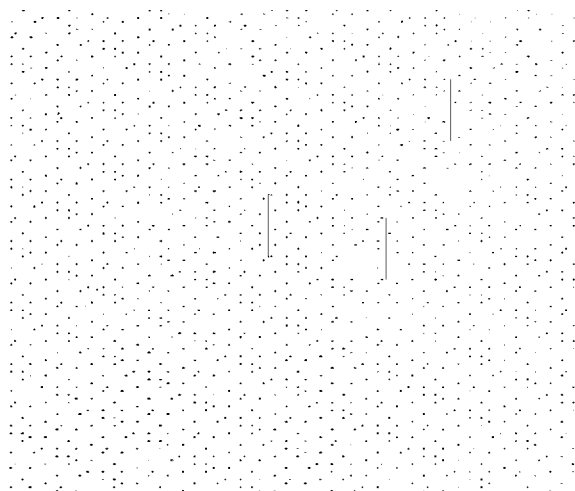


Figure D1. Minolta CF 910

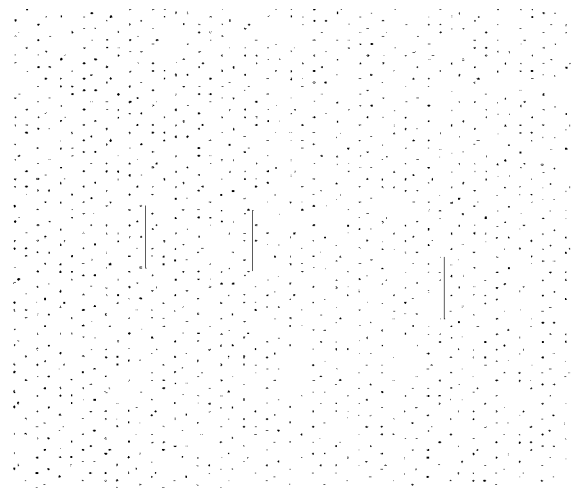


Figure D2. Konica 7823

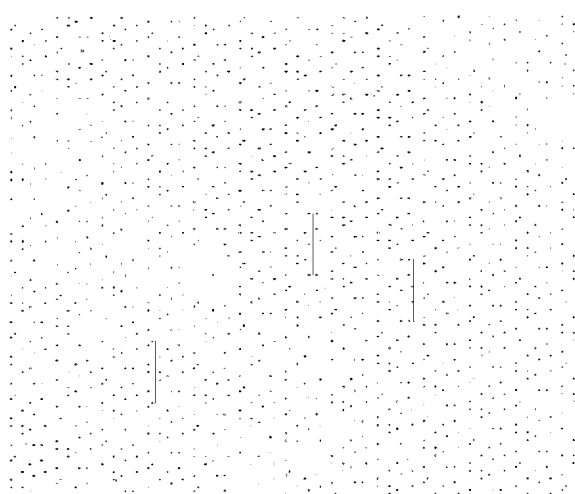


Figure D3. Kyocera Mita Ci7600

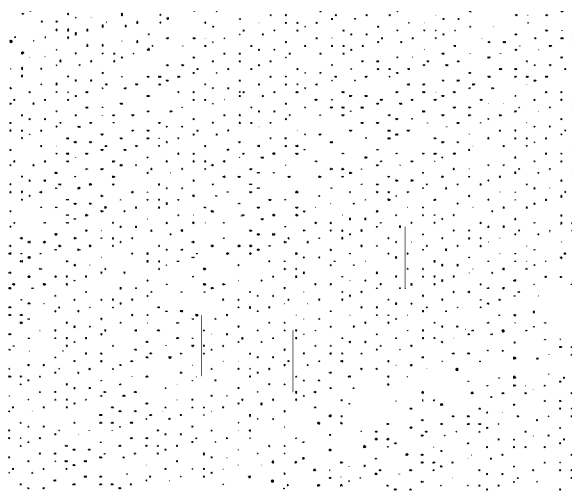


Figure D4. Pitney Bowes CD 6100

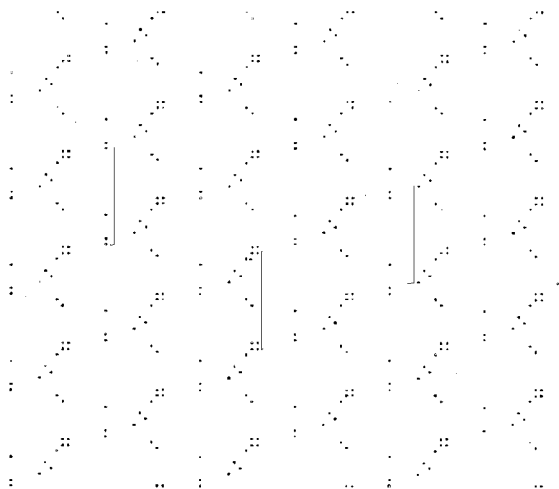
The Minolta OEM codes are very diffuse and sometimes difficult to work with. Voids which appear in the patterns above are probably the result of very light toner dots that were not recorded when the document was scanned.

Minolta now displays two vertical pattern separation distances, 0.32 inches and 0.48 inches,

but the pattern arrangements are similar. The larger spacing was noted on machines introduced in 2001. The vertical lines in the patterns show how this can be measured. The Hewlett-Packard Color Laser Jet 8550 MFP also has approximately the same spacing, however, its pattern appears to be more regular (Appendix G).

Appendix E

Sharp OEM Codes



Sharp has recently started to manufacture their own color laser copiers. The Sharp AR-C150 was the first machine on the market made by Sharp. Earlier Sharp models (such as the AR-C861 or AR-C862) were made by Ricoh.

This code pattern appears to have a column of dots that alternates with another column with dots.

The vertical pattern separation distance is approximately .50 inches. There are three vertical lines added to the pattern to show how this distance can be measured.

Figure E. Sharp AR-C150

Appendix F

Toshiba OEM Codes

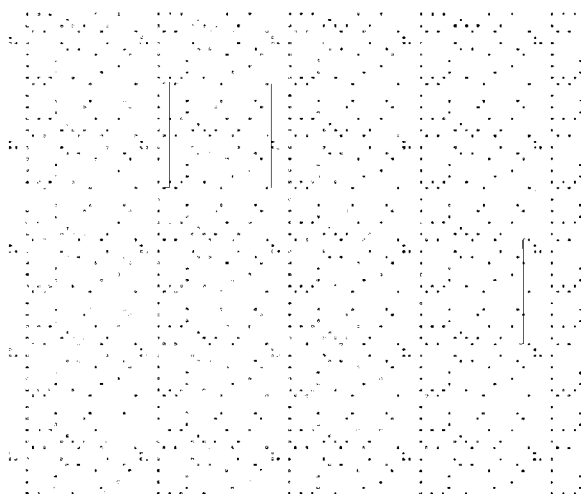


Figure F1. Toshiba FC 15

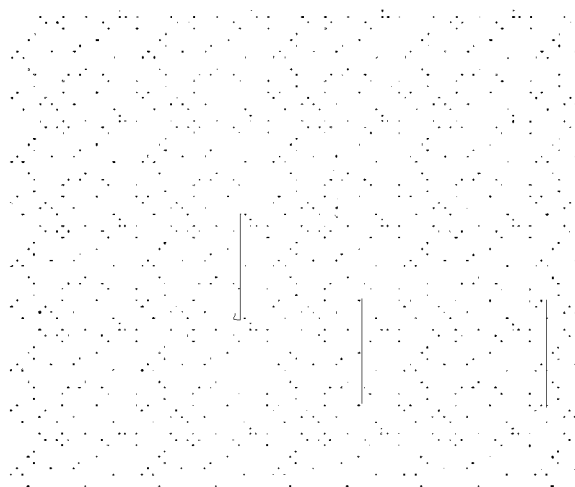


Figure F2. Toshiba FC 22

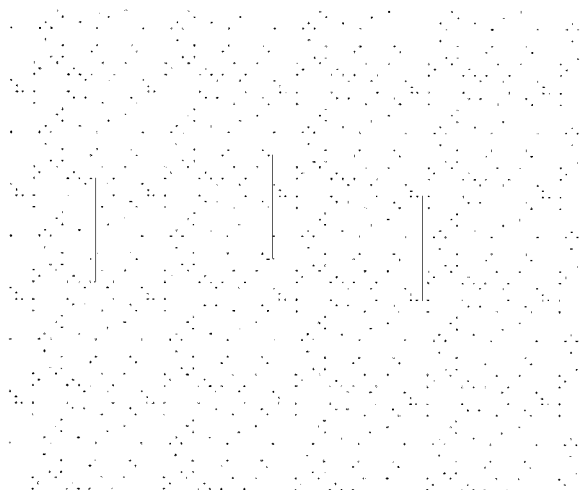


Figure F3. Lanier 5722

Toshiba has recently started to manufacture their own color laser copiers. A previous model (the FC 70) was made by Minolta.

The Toshiba code pattern is a diffuse pattern which is sometimes difficult to examine. The dots are small. However, the pattern appears to be running in vertical columns.

The vertical pattern separation distance is approximately 0.55 inches. There are three added lines in the patterns to show how this distance can be measured.

Appendix G

Hewlett-Packard OEM Codes

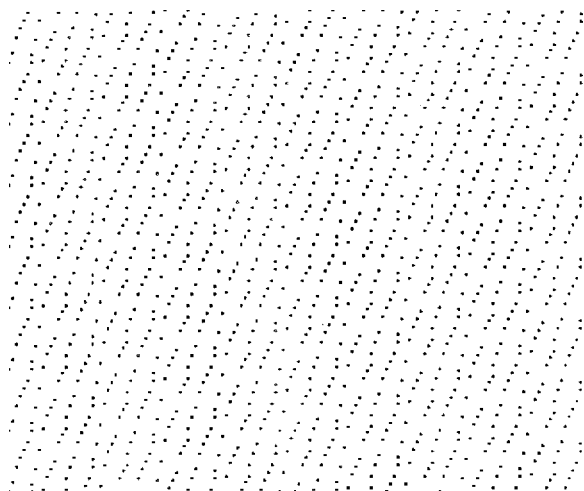


Figure G1.
Hewlett-Packard Color Laser Jet 8550 MFP

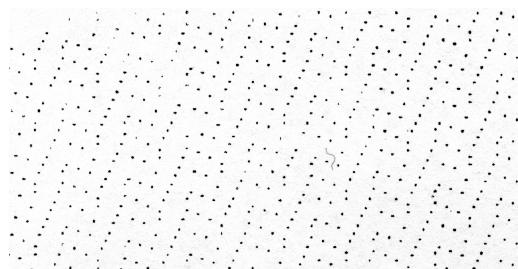


Figure G2. Canon C2100

The vertical pattern separation distance is approximately .32". The vertical lines show how this can be measured. This distance is similar to that found on a Minolta OEM machine. However, the horizontal pattern separation distance of these Hewlett-Packard OEM machines is smaller than that of the Minolta (1.6" versus 1.9" approximately). This distance can be determined by measuring the distance between similar points in the pattern which occur on a horizontal line.

The pattern of the Hewlett-Packard OEM machines appears more regular than that of the Minolta. The pattern appears to move up and to the right.

This is listed as a Hewlett-Packard OEM, however, the engine of the copier is made by Canon.

Of interest, a color laser printer made by Canon, the C2100, produces a pattern similar to the Hewlett-Packard (Figure G2).

Appendix H

OEM Manufacturers and Their Products

(From approximately 1995 to early 2001)

Canon OEM

Canon CLC 320 (5/96, D)
 Canon CLC 350/550 (3/93, D, *)
 Canon CLC 700L/700S (1/97, D, *)
 Canon CLC 800S (1/97, D)
 Canon CLC 900/950 (3/98, D, *)
 Also sold as: Danka C1600/1650 (7/98, D)
 Oce CS 90/95 (4/99, D)
 Canon CLC 1000 (2/97, *)
 Also sold as: Danka C2000 (7/98, D)
 Oce CS 200 (4/99)
 Canon CLC 1120/1150 (5/99, *)
 Also sold as: Oce CS 110/115 (1/00, *)
 Canon CLC 2400 (9/98, *)
 Also sold as: Oce CS 150 (10/99, *)
 Canon CLC 5000 (2/01, *)
 Canon also made copiers for Kodak

Minolta OEM

0.32 inch pattern separation:

Minolta CF 900 (4/96, D)
 Also sold as: Kyocera Mita Point Source
 Ci7500 (9/96, D)
 Pitney Bowes CD 6000 (10/96)
 Toshiba FC 70 (2/97)
 A.B. Dick under Minolta's label
 Minolta CF 910 (1/99, *)
 Also sold as: Konica 7823 (3/99, *)
 Kyocera Mita Point Source
 Ci7600 (5/99, *)
 Pitney Bowes CD 6100 (4/99, *)

0.48 inch pattern separation:

Minolta 2001 (2/01, *)
 Also sold as: Konica 7920 (4/01)
 Kyocera Mita C 1530 (1/01, *)

Ricoh OEM

Ricoh Aficio Color 2003 (11/96, D)
 Also sold as: Gestetner 2703 (1/98, D, *)
 Lanier 5603 DC/5603 DC-E
 (4/97, D)
 Savin SDC 103 (11/96, D)
 Selectec PA 2003 (7/98)
 Ricoh Aficio Color 2103/2203 (1/97, D)
 Also sold as: Gestetner 2703D/2703DE
 (1/98, D)
 Lanier 5603 DC-AD/5606 DC-E
 (4/97, D)
 Savin SDC 103A/103E
 (1/97, D, *)
 Ricoh Aficio Color 3006 (3/99)
 Also sold as: Gestetner CS 206 (3/99)
 Lanier 5706 (5/99, *)
 Savin SDC 306 (3/99, *)

Ricoh Aficio Color 4006 (4/00)
 Also sold as: Gestetner CD 206 D (4/00)
 Savin SDC 306D (4/00)

Ricoh Aficio Color 4106 (6/99, *)
 Also sold as: Gestetner CS 206 DE (6/99)
 Lanier 5806 E (7/99)
 Savin SDC 306E (6/99, *)

Ricoh Aficio Color 4506 (approx. 8/00, *)
 Also sold as: Gestetner CS231 (1/01)
 Lanier 5631 (4/01)
 Savin SDC 326A (1/01)

Appendix H (continued)

OEM Manufacturers and Their Products

(From approximately 1995 to early 2001)

Ricoh OEM (continued)

Ricoh Aficio Color 5106 (NA, D, *)
 Also sold as: Gestetner 2606 (1/98, D)
 Lanier 5606 DC (2/97, D, *)
 Savin SDC 206 (9/96, D)

Sharp AR-C861 (4/97) (later Sharp models are made by Sharp)

Ricoh Aficio Color 5206 (9/96, D)
 Also sold as: Gestetner 2606 E (1/98, D)
 Lanier 5606 DC-E (2/97, D)
 Savin SDC 206E (9/96, D, *)
 Sharp AR-C862 (4/97)
 (later Sharp models are made by Sharp)

Ricoh Aficio Color 6010/6110 (7/99, *)
 Also sold as: Gestetner CS 210/210 E (7/99)
 Lanier 5710/5710 E (8/99)
 Savin SDC 410/410E (7/99, *)

Ricoh Aficio Color 6513 (4/01, *)
 Also sold as: Gestetner CS 213 D (4/01)
 Savin SCD 413 (4/01)

Xerox OEM

Xerox DocuColor 4 CP (10/99, D)

Xerox DocuColor 12 (8/99, *)

Xerox DocuColor 30 CP (3/99)

Xerox DocuColor 30 Pro (3/99)

Xerox DocuColor 40 CP (9/98)

Xerox DocuColor 40 Pro (4/96)

Xerox DocuColor 5750 (4/97, D, *)

Xerox DocuColor 5799 (10/97, D)

Xerox DocuColor Office 6 (4/98, D)

Xerox Document Centre Color Series 50 (9/99)

Sharp OEM

Sharp AR-C150 (9/99, *)

Earlier Sharp models were made by Ricoh.

Toshiba OEM

Toshiba FC 15 (8/00, *)

Toshiba FC 22 (1/00, *)
 Also sold as: Lanier 5722 (4/00, *)

Earlier Toshiba models (FC 70) were made by Minolta.