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## The Classification of Office Copy Machines from Physical Characteristics

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**ABSTRACT:** The identification of office copier machines has been simplified by the computerization of their class characteristics. The class characteristics examined are paper type, type of toner, reduction/enlargement capabilities, paper supply, presence of identifying marks, fusion method, and color capabilities. These known class characteristics are then compared against the established data base to limit the search to the possible manufacturers.

**KEYWORDS:** questioned documents, photocopiers, classifications, fusion method, photocopy

The identification and classification of photocopies presents special problems to the document examiner [1, 2]. The following discussion will deal with the identification of office copy machines by utilizing their class characteristics through the use of a computer. If the machine cannot be identified by its class characteristics, there is little the document examiner can do to aid the investigator in locating suspect machines. Once the suspect machine has been located, a comparison can then be made between the questioned and known specimens using any unique markings which may appear on the evidence.

Photocopy machines do have class characteristics and these class characteristics can act as a method of searching a file for the machines which most closely resemble the one used to produce the evidence. The vehicles for this search are DB MASTER, a data base management package, and an Apple II computer.

### Method

There are eleven class characteristics which the FBI Laboratory uses to classify photocopies. The majority of these characteristics are searched by a yes or no response. This approach was chosen because of the quickness of the response time.

### *Paper Type*

Paper type is the first class characteristic to be considered. The two types of paper considered are plain or coated. Plain paper is standard bond of a minimum weight specified by the photocopier manufacturer. Coated paper is treated with a metal oxide, typically zinc oxide,

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to create a charge-sensitive surface. A metal object such as a coin will leave a dark mark when rubbed against coated paper.

#### *Toner Type*

Type of toner is divided into two categories: liquid and dry toner. This determination can be made by observing the photocopy under slight magnification (approximately  $\times 30$ ). If discrete particles of toner can be seen, it is dry toner. Dry toner has a raised, glossy appearance on the paper and can be scraped off the page with a scalpel. Liquid toner in contrast appears to have dyed the individual paper fibers. The Landa Process, developed by Benny Landa for Savin, can be distinguished from other liquid toners by appearance at magnification of  $\times 100$ . The color of the toner is much darker and has the appearance of printer's ink. The older Savin machines have been retrofitted to accept this new technology. Canon and Savin are the most common plain paper, liquid toner machines in the domestic market. Figure 1 is an example of Savin's Landa Process at  $\times 100$  magnification.

#### *Toner Application*

The toner applications of concern here are either the magnetic brush or cascading development procedure. This class characteristic pertains only to dry toner photocopy machines. This choice is subtle and may not be apparent in simple text reproduction. Cascade toner development is indicated if the photocopy has a large black area reproduced (larger than

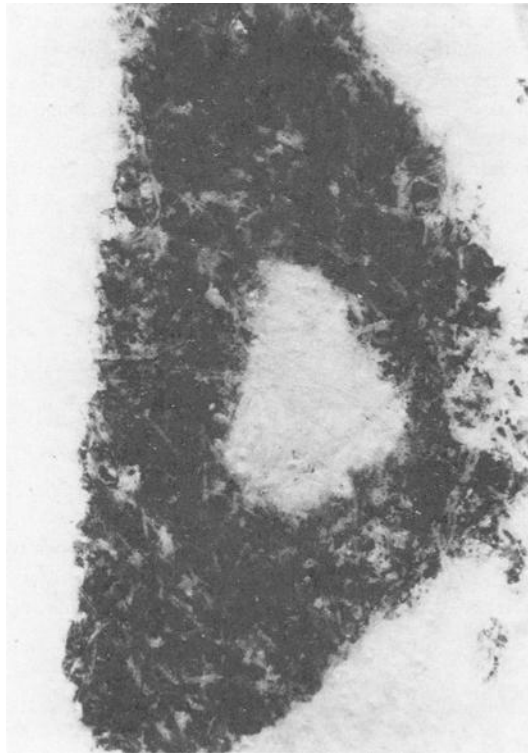


FIG. 1—Landa process (liquid toner) at  $\times 100$  magnification.

1/2 by 1/2 in. [1.3 by 1.3 cm]) and this area is significantly lighter in the center than it is on the edges. This is so because of the point charge effect in electrostatics. To be its most stable, an electrostatic charge will migrate to edges and points where its charge density will be greatest. This occurs instantaneously after the electrostatic charge is placed on the drum and the copy focused onto it. When toner is cascaded onto the drum it causes mechanical abrasion in the already charge weakened areas, and the toner adheres poorly to this area. If the toner is more gently applied by a magnetic brush, this effect is minimized.

### *Reduction*

Another feature of the classification process is reduction. This is a simple choice between reduction or no reduction. Most photocopy machines, because they use an optical system, reduce or enlarge the copy somewhat. The reduction addressed in this characteristic is the obvious attempt by the manufacturer to reduce copy size significantly.

### *Enlargement*

This class characteristic is divided into a choice of enlargement or no enlargement. The enlargement addressed is the obvious attempt by the manufacturer to enlarge the copy size significantly.

The data base also contains the actual reduction and enlargement ratios that are available for these photocopy machines. Care must be exercised because a document may be reduced or enlarged numerous times.

### *Magnetic*

Photocopy machines which use dry toner use either a monocomponent or dual component toner. These plain paper, dry toner machines produce copies which may or may not be magnetic. Monocomponent developers incorporate the properties of toner and developer in a single particle. These toner particles are composed of magnetic pigment and eliminate the necessity for a separate carrier. The toner composition of this monocomponent development system results in the image registering a high degree of magnetism. Dual component developers consist of toner and a separate carrier. The toner is nonmagnetic and adheres to the magnetic carrier beads which provide the charge and transportation to the paper [3]. Monocomponent toner particles are larger than dual component toners, since they must also act as a carrier. As a result, dual component machines which deposit a much smaller toner particle produce a higher contrast image than monocomponent machines [4].

To determine the degree of magnetism of a toner, the Magnetic Ink Detector is used. Figure 2 is a schematic of this device. A simpler but much less sensitive method is to rub a magnet across the photocopy and place a magnetic viewer in contact with it. If the magnetic viewer visualizes the image, the toner is magnetic. Before the development of the Magnetic Ink Detector, only monocomponent toners could be reliably detected due to their strongly magnetic character. It has now been observed that some dual component machines exhibit a low level of magnetism. This is probably due to the slight retention of developer particles. Using this class characteristic as a criteria in the classification of a piece of evidence greatly reduces the number of possible manufacturers.

### *Paper Supply*

The paper supply category is divided into a choice of sheet fed or roll fed. If the photocopy is a size other than standard sheet sizes or has unique cut marks, this is an indication that the photocopy may have been made on a machine with a roll fed paper supply. Obviously, a

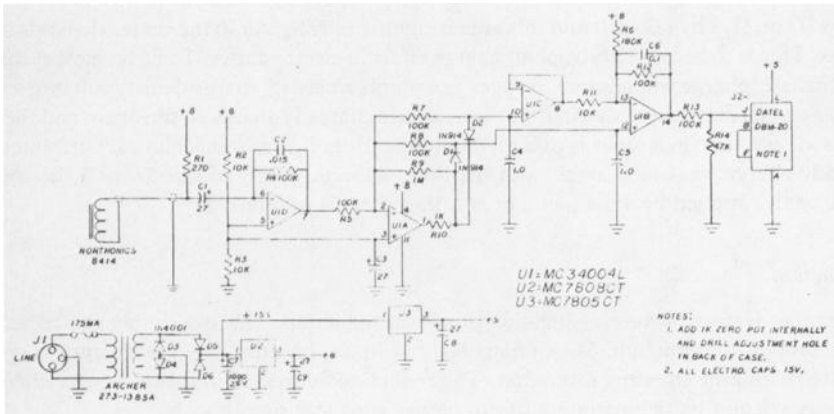


FIG. 2.—Schematic of the Magnetic Ink Detector.

photocopy from a sheet fed photocopy machine which has been cut down from its original size may exhibit these same characteristics. Because of this, paper supply should be used cautiously as a class characteristic.

### Marks

Since we are attempting to identify a machine manufacturer, the marks are not the unique "trash marks" by which an identification is made, but instead belt, roller, and picker bar marks which are placed on the photocopy during its transit through the mechanical portion of the machine. Examples of these types of marks are shown in Figs. 3 and 4. Figure 3 shows marks produced by a Savin 880 machine. Savin liquid toner machines typically have a vertical line of any length running down the reverse side. This mark is typical of only Savin liquid machines. Figure 4 shows marks produced by a Canon NP-80. Canon liquid toner machines have a horizontal line of any length running across the bottom of the reverse side. This mark is typical of Canon liquid toner machines, but the Savin models 7040 and 7050 liquid toner photocopy machines also have this same horizontal mark. The Savin photocopy machines can be distinguished by the presence of the Landa Process. Both of these marks are caused by mechanics internal to the machine and are unique to these manufacturers.

### Fusion Method

The fusion method is the most important class characteristic. It is also the most difficult to determine, thus extreme discretion should be used in its classification. This category in conjunction with the other characteristics will limit the possible manufacturers and models to a workable number. Care must be exercised when classifying both the samples for the known standard file and also the questioned document. The differences between the following fusion methods are subtle. Through experimentation the optimum magnification was determined to be  $\times 100$ . Much greater magnification centers on too small an area and does not allow the viewer to clearly see the edges, paper fibers, and marks left by the various rollers or belts on the toner. A lower magnification level centering on a larger area is suitable for determining the type of toner (dry or liquid) but not the particular method of fusion for that toner. The most important consideration related to this characteristic is to be cautious. The more known samples viewed, the greater the document examiner's expertise will become. Do not

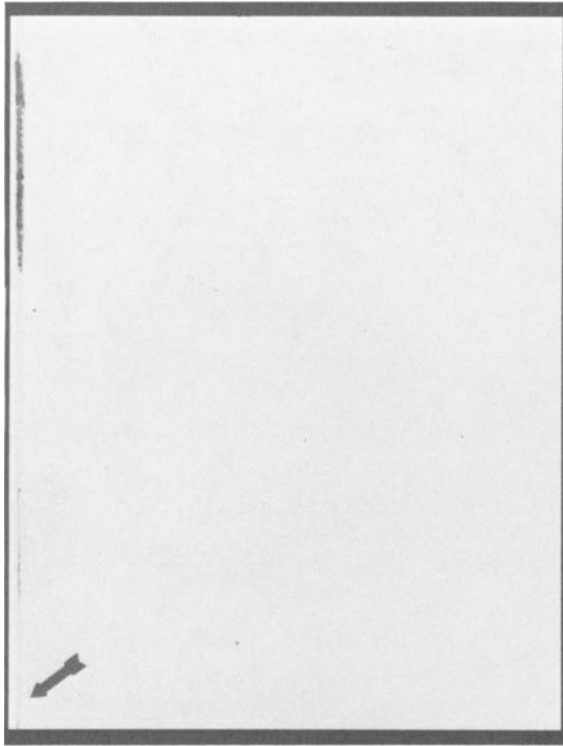


FIG. 3—Savin 880 liquid toner photocopy machine.

assume that the document was produced on one photocopy machine: the letterhead and body of text may have been prepared on more than one machine.

The following is a description of these fusion methods.

**Radiant Heat**—Radiant heat is intense heat applied to the toner during the fusing process. The dry toner appears like heated tar on the street and has a glossy, bubbly appearance. Liquid toner is also classified in this category because heat is involved in the fixing process. The determination of the correct type of toner will eliminate any erroneous results. Liquid toner will have a flat appearance and the paper fibers will appear to be dyed. Examples of radiant heat machines are the Xerox 3109 and IBM Copier II machines. Figure 5 is an example of dry toner fused by radiant heat.

**Heat and Pressure**—Heat and pressure is exactly what its name conveys: the dry toner is melted and then flattened by pressure. The pressure is produced by a belt or roller (where the tension on the hard roller is slight). Laser printers have been added to this category because they exhibit similar characteristics. Examples of machines using this process are Eastman Kodak 100, 150, and Oce 1725.

**Cold Pressure**—Cold pressure is a unique fusion process found on both coated and plain paper machines. The toner is dry and has not been melted by heat. The pressure is produced by a roller, and under magnification the toner appears as though it could be scraped off the paper with a scalpel. The identifying factor is the absence of heat. A few examples of cold pressure machines are the 3M 839, A. B. Dick 695, and Canon 120.

**Hot Soft Roller**—The hot soft roller fusion method uses a combination of heat and a soft roller. The soft roller gives the dry toner a texturized appearance which is similar to the first application of paint on a wall. This category is not large, but care must be exhibited during

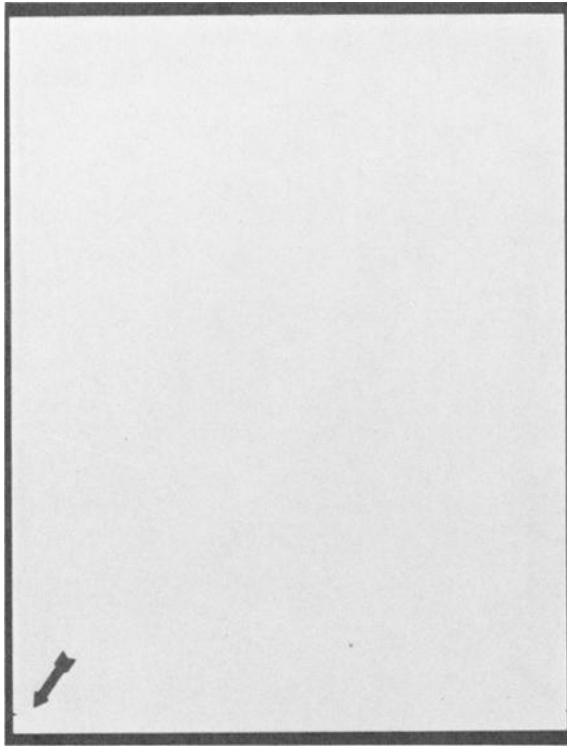


FIG. 4—*Canon NP-80 liquid toner photocopy machine.*

classification so that the presence of a hard roller is not overlooked. Examples of this fusion method are Xerox 8200, Minolta EP-530R, and Saxon SX30. Figure 6 represents this fusion method.

*Hot Hard Roller*—This fusion process melts the dry toner, and the hard roller presses the toner into the paper so that the paper fibers are evident. Examples of machines using this method are the A. B. Dick 7100, Olivetti Copia 1710, Royal 122, and Royal 115. Figure 7 is an example of this fusion method.

*Blotter*—The blotter fusion method applies to liquid toner machines.

*Air Dry*—The air dry fusion method applies to liquid toner machines.

*Hard/Soft Roller*—The fusion method classified as hard/soft roller is a combination of a hard and soft roller. This category has been combined because of the difficulty in determining which roller was positioned on the bottom during the fusing process. The toner is fused on the copy paper as it passes between these rollers before exit from the photocopy machine. If the hard roller is on the top, there will be tracks apparent on the surface of the toner. The paper fibers will also be evident. If the soft roller is on the top, the toner will have a texturized appearance. The edge of the toner also acts as an aid in determining the order of the rollers. The toner will be slightly flattened if the soft roller is on the bottom. On the other hand, if the hard roller is on the bottom, the pressure will flatten the toner into the paper fibers. The specks of toner near the edge and on the surface of the document also contribute to the evaluation. The entire document should be examined because the identifying characteristics are not always apparent in every portion of the document. This and the fact that

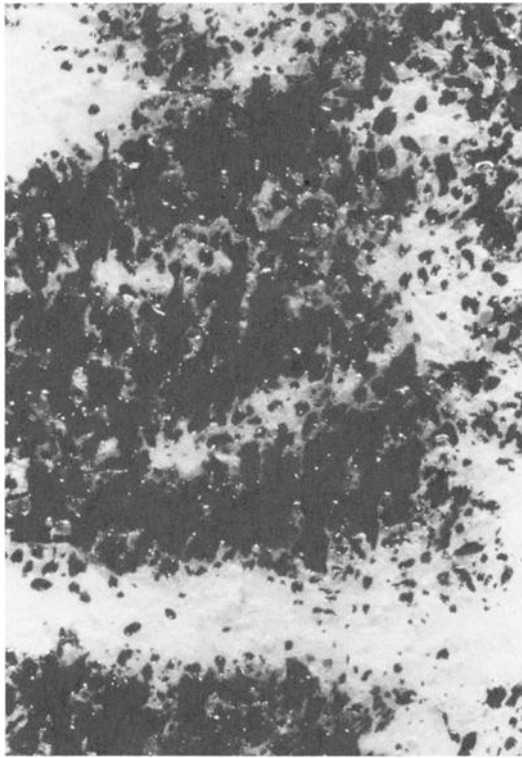


FIG. 5—*Radiant heat fusion method (dry toner).*

more than one machine may have been used to prepare the document emphasizes the importance of viewing the entire document. Examples of models using this fusion method are the Canon NP-250, Minolta EP-350Z, Mita DC-213RE, and Panasonic FP-1520. Figure 8 is an example of the hard/soft roller fusion method. Figures 5 through 8 are dry toner at  $\times 100$  magnification.

### *Color*

The tenth class characteristic is the ability of the photocopier machine to produce color. Until a few years ago this was not considered a significant category. The introduction of the color development cartridge by Canon and the advent of the personal photocopier (PC) machines have made this a significant category.

There are two types of color photocopier machines, the full-color and single-color machines. The full-color dry toner machines are the Xerox 6500, Canon Color T, Canon NP Color, and 3M 137. In the last year there has been an influx of several new processes associated with full-color photocopier machines. One new process is thermal transfer. Examples of models using this process are the Sharp Electronics Corporation's CX-5000, Ricoh Corporation's color copier, and the Toshiba America Inc.'s FC-50S. The Sharp CX-5000 is being promoted as a coin operated model which will provide greater access to color for the general public. The Ricoh color copier is not being marketed as yet in the United States. The Toshiba FC-50S and Sharp CX-5000 are not only a thermal transfer process using an inked ribbon



FIG. 6—*Hot soft roller fusion method (dry toner).*

but also are digital photocopy machines. Canon this year introduced a prototype color laser copier at the National Office Machine Dealers Show. All of these copiers produce color copies using plain or heat sensitive paper of bond weight.

The last color process, as would be expected, is photographic. The Kis Color One is a true cibachrome process using a wet bath. The copies or, actually, photographs are excellent and emerge in a glossy or matte finish on photographic paper. The Kis Color One cannot be distinguished from a regular photograph unless a screen print original is copied. In this case, a dot pattern will be present similar to that found on full-color photocopy machines using dry toner. The Ilford, Inc. models also use the cibachrome process. The Konica Business Machines' Color 7, also using a photographic process, produces excellent copies. This machine uses a photosensitive paper the same weight as plain paper.

Canon pursued the development of color photocopiers and became the first manufacturer with an extensive line of single-color machines. It first entered the market with its PC line featuring interchangeable color cartridges. These models have cartridges which contain the toner and developer in one unit and which slip in and out of the photocopy machines easily. The color cartridges are available for the Canon PC's in black, red, green, brown, light blue, and dark blue (the Canon dark blue looks almost black). The next move for Canon was to adapt its mid-volume machines for color. These larger machines must use a color developer unit which houses the color toner. Each different color toner has its own color developer unit. The paste-up originals and copy must be inserted for each desired color on a single sheet. Under  $\times 100$  magnification, the large single-color photocopy machines sampled exhibit a



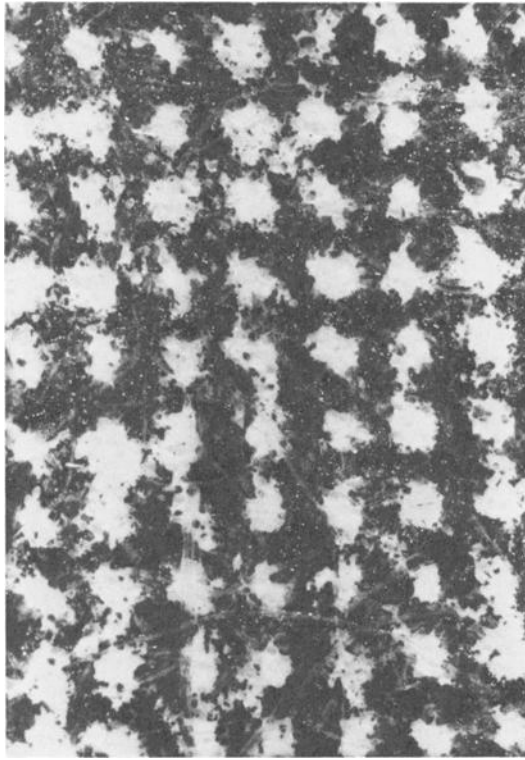


FIG. 7—*Hot hard roller fusion method (dry toner).*

small presence of the previous color used. The small personal machines tend to leave a heavier residue of the previous color. These small photocopier machines do not have a cleaning brush or blade to wipe off the excess toner. The presence of previous colors may be detected by a thorough examination of the whole document. These traces can then be used to help eliminate various manufacturers and models. The different toner colors are red, green, dark blue, brown, light blue, and white (introduced by Mita Corporation America in July 1986). The difference between the dark blue and light blue toner is easily distinguishable. The dark blue contains a great deal of black toner, and light blue is a royal or sky blue. Mita's white toner has a washed out light-brown appearance on white paper, but produces a nice contrast on colored paper. Toshiba introduced the first push-button color photocopier in 1985. Since then, most of the manufacturers have introduced at least one push-button model or one model with interchangeable color cartridges. Black is the standard toner with a choice of red, green, blue, or brown as a second color depending upon the manufacturer. Savin Corporation has developed a liquid toner photocopier machine which houses all four colors (black, red, green, and blue) simultaneously. The V-35 and V-45 models are push-button machines utilizing and Landa Process technology.

Another area of importance is whether or not the dry color toner is magnetic. Even though the photocopier machine may use monocomponent black toner, which is magnetic, the different color toners may not be magnetic. The various toner colors appearing on a particular model of machine may be a mixture of magnetic and nonmagnetic toners. This characteristic coupled with the variety of colors present on the document will reduce the number of

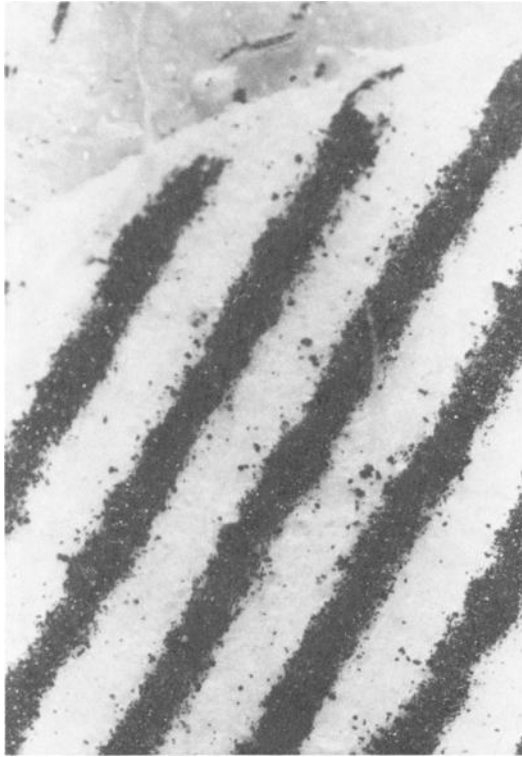


FIG. 8—*Hard/soft roller fusion method (dry toner).*

potential possibilities drastically. Fortunately for the document examiner, the various manufacturers use a variety of combinations of color choices, and the composition of toners is different between manufacturers. Examples of a few single-color machines are the Canon PC's, Canon NP-250, Canon NP-270, Gestetner 2112RE, Mita DC-142RE, Sharp Z-60, Sharp SF-8200, Xerox 1035, Savin 7010, Toshiba BD-4121, and 3M 537.

### *Laser*

This class characteristic has been added since laser printers use the xerographic process, the same process employed by office copy machines. At present there are only a handful of manufacturers of desktop laser printers. Canon manufactures the print engine used in a variety of models, the most noteworthy being the Hewlett-Packard laser jet series introduced in May 1984. The laser jet (a personal computer laser printer) has received wide acceptance and led to a few more manufacturers entering the market. The Canon desktop laser printers and their clones use disposable toner-drum cartridges similar to the ones in their PC line [5]. Xerox Corporation moved a step forward when it introduced the 4045 copier/printer in April 1985. This machine has a sheet bypass for individual photocopying. The versatility of this feature for desktop laser printers may lead to a new industry standard. This minor modification allows a laser printer to perform two functions—printer and photocopier.

### Editor

The last category is the ability of the photocopy machine to edit a document. The editor or mask and trim function can be either an internal component of the machine or an external attachment. The mask and trim feature in combination with enlargement or reduction can greatly alter the appearance of a document. A logo or body of text can be easily shifted from one position on a page to another without leaving any telltale lines. The logo or text is first stored in memory and then placed at the new specified *x* and *y* coordinates.

### Conclusion

An integral part of the Office Copy Standards File is the collection of known standards. These standards include information on foreign as well as domestic photocopy machines. Since a great majority of the office copy machines are not manufactured in the United States, foreign models refers to those machines not marketed in the United States. These known samples provide the source for the data base, which spans the period of 1950 through 1986. At present, the data base contains information on approximately 1700 models. Where samples are available, microscopic slides have been prepared for comparison with questioned documents. Literature as well as samples is maintained on the manufacturers and individual models. The Office Copy Standards File is updated by attendance at trade shows and subscriptions to *Datapro*, *Dataquest*, *Buyers Laboratories Inc.*, *Info-Market*, and *Office Equipment and Products (OEP)*.

In addition to the above the described data base, a Similar Models file is maintained which is a cross-reference of similar photocopy machines. There are approximately 650 known models that are sold under numerous names manufactured by a few companies. The data stored is manufacturer's name, model, and similar machines.

The identification of photocopy machines is becoming as difficult as typewriter identification. Unlike typewriter manufacturers, the photocopy manufacturers are not copying each other's machines; the large manufacturers are selling them to smaller companies to distribute under their own label. Thus one photocopy model may have several clones.

In summation, the computerization of the physical characteristics of office copy machines does drastically narrow the field of possible manufacturers of the questioned document. There are a few cases where the specific model or a manufacturer can be determined, and the determining factor in these instances is usually the unique marks produced by a specific machine or manufacturer.

The paper type, type of toner, fusion method, and color of the toner are the most valuable class characteristics for limiting the possible manufacturers. The fusion method is the most difficult to classify of these physical characteristics. Date of introduction, manufacturer, model, and discontinued date of manufacture are four other categories that have not been mentioned as a searching tool. Each of these groups may be searched separately. The date of introduction and the discontinued date are the most significant of these four categories since they can be used to assist in dating a document.

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