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Printwheel Typescript Variations Caused by the Manufacturing Process

REFERENCE: Behrendt, J. E. and Muehlberger, R. J., **"Printwheel Typescript Variations Caused by the Manufacturing Process,"** *Journal of Forensic Sciences,* JFSCA, Vol. 32, No. 3, May 1987, pp. 629-639.

ABSTRACT: Typescript specimens from several printwheels of different manufacture were examined to ascertain how the manufacturing process may influence type design. Among the parameters considered were the composition, molding process, sequence, and physical design of the printwheel. It was found that each parameter may affect modifications in a typefont. These variances in type design may cause difficulties in the classification of printwheel type styles.

KEYWORDS: questioned documents, typewriters, printing equipment, printers, printwheels, type style classification

The rapid growth in the use of the printwheel printer, beginning with the introduction of Diablo Systems, Inc., HyType in 1972, has given birth to new typewheel manufacturers and the retooling of many long-standing type producers. Once dominated by printwheels compatible with either a Qume or Diablo printer, the world market now offers a variety of printwheel printers, and consequently, there has been a dramatic proliferation of different printwheel designs. The resultant variations in typescripts of the same typestyle can be related to the manufacturing process. With an understanding of the process used in the production of the printwheel, the examiner of questioned documents will be better equipped to resolve the problems imposed by the printwheel prepared document.

Printwheel Manufacture

To evaluate the significance of variations in printwheel typescripts, it is necessary to understand the manufacturing process. The printwheel, one part of the electronic printing system, is designed to meet the requirements of the printer. The size of the printwheel and the hub attachment assembly are physical features which must complement the mechanical components of the printer. The composition of the printwheel is dependent upon the electronic energy levels controlling the hammer strike.

Types of Printwheels

The types of printwheels presently on the market can be categorized as monoplastic, dual plastic, and metal. Monoplastic printwheels are completely plastic and are molded in a sin-

Received for publication 23 May 1986; accepted for publication 16 June 1986.

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gle operation using a thermoinjection process. These printwheels are the least expensive and the most popular on the market. The monoplastic printwheel also has the shortest average life of the three types.

Dual plastic printwheels are designed for greater durability than monoplastic but at a lower cost than metal printwheels. Two types of dual plastic printwheels are available, the most common of which comprises a glass fiber reinforced polyammide center and spoke assembly. The character sort, which is the particular collection of characters on a specific printwheel, is molded onto the spokes using a glass fiberfilled thermoset plastic. The second type of dual plastic printwheel has a plastic hub and spoke assembly with a metal plated character sort.

The metal printwheel is made of precut metal spokes with a molded thermal plastic character sort bonded to the tips. The characters are generally metal plated after molding. A damper ring, which is a circular strip of rubberized material, is placed on the spokes to prevent rebounding of the characters as a result of excessive vibration. Metal printwheels are designed to be the most durable, yielding consistent high-quality print, but are necessarily the most expensive.

One typescript variation which is a function of the manufacturing process is stroke width. Stroke width—the thickness of the lines comprising the character—can vary according to the composition of the printwheel. Monoplastic printwheels on average were observed to produce characters with the thinnest stroke width. Metal printwheels tended to produce the widest strokes. However, stroke width may also be affected by the engraving of the manufacturer or by the type of paper and ribbon used in the printer.

Type Design

The font design on a printwheel is necessarily influenced by the physical dimensions of the printwheel itself. The diameter of the wheel, the number of spokes, the length and width of the backpads (the wider area found at the outer edge of a spoke which provides support for the character), and the order of characters, or character sequences, are all parameters that will affect modifications in a font from one printwheel design to another. Differences in the physical dimensions of a printwheel are depicted in the photograph of the Diablo 620 and 630 printwheels (Fig. 1). The broader spokes, larger diameter, and wider backpads of the 620 printwheel are less constraining to the type designer than the smaller, narrower configu-

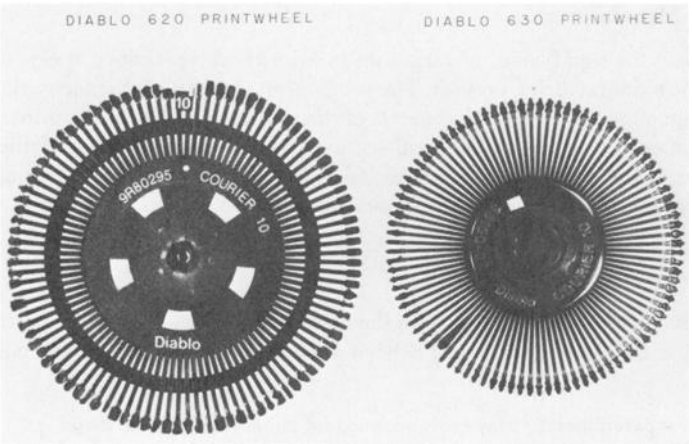

FIG. 1—*Design differences between printwheels for two noncompatible printers.*

ration of the 630 printwheel. The effect of these physical parameters on the typestyle is illustrated in the comparison chart showing some of the characters from Courier 10, Diablo 620, and Diablo 630 printwheels (Fig. 2). The differences in character size and width are especially apparent in the serif lengths and extensions of such letters as a lower case "r."

Font design and modification are normally performed with computer graphics in the computer assisted design (CAD) section of a printwheel manufacturer. The CAD section is given the printwheel specifications which include the number of spokes, width of the spokes, sequence of the wheel, type of wheel, and font desired. All CAD design work is accomplished on an instrument that displays a computerized representation of the backpad and character for each font. The CAD section, working from a set of standard font designs, attempts to place each character in its corresponding position on the printwheel. Problems arise when a sequence dictates a certain order of characters occurs that do not fit the specified spatial limitations. In this situation, the type designer will modify the characters to accommodate design parameters (Fig. 3). Once the characters have been placed, further modifications in design may be made to allow for optical alignment and artistic reasons. A modified character may seem out of place to the type designer, who may then make subtle changes to other characters to give a more satisfactory appearance to the typestyle. When the type designer is satisfied with the font design, the next step is to program the engraving instructions. The final product is stored on a computer tape used for the engraving of the mold.

Before the relatively recent development of CAD technology, hand drawings were used to design printwheel type styles. If sequence problems necessitated a design change in one character, it was not unusual for only that character to be modified.[2] CAD allows greater latitude in design decisions as modifications can be made quickly and easily without having to redo all of the graphic work. The net result is that changes in type style may have occurred between pre-CAD and post-CAD designs. Unfortunately, the manufacturer seldom documents these changes and considers both to be identical type styles.[2]

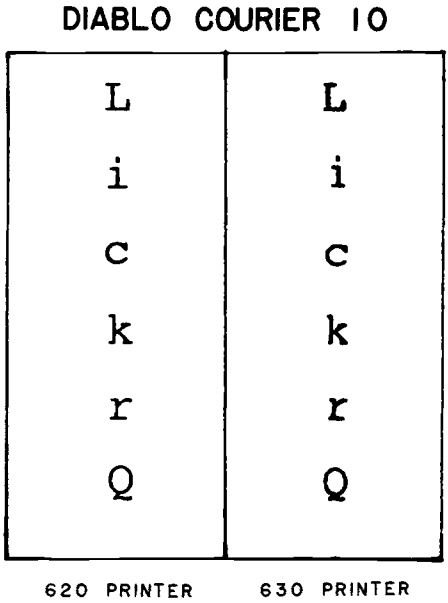

FIG. 2—*Design differences in type script of two Diablo Courier 10 printwheels.*

[2]C. Slutz, personal communication, type designer, Qume Corporation, San Jose, CA, 1985.

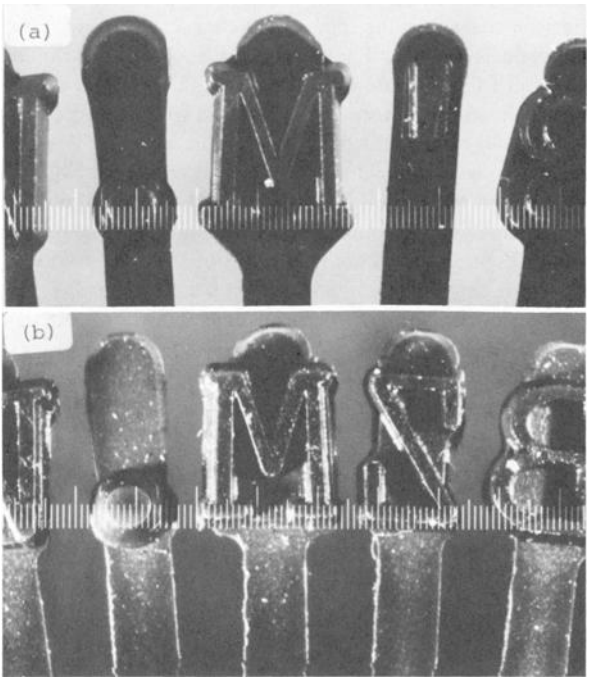

FIG. 3—*Modification of a character to conform to spatial limitations imposed by printwheel sequence. Note shortening of base of the* "M" *on the printwheel in* (b), *which was necessitated by its proximity to the* "Z."

As mentioned previously, the shape and width of the backpad is one parameter that may have an influence on the font design. A type designer must consider how each character will be supported on the spoke to prevent breakage upon impact. There are several different means of providing the required character support, and in some instances, the design of the backpad may be indicative of the manufacturer. Some manufacturers contour the backpad to the shape of each character. One company, such as GP Technologies (GPT), uses a standard rectangular shaped backpad for all characters. A third method uses a uniform shape modified to provide support to extending character serifs. This type of design is exemplified by printwheels manufactured by TPI Services SA and Shand Printing Devices LTD (Fig. 4).

In addition to the backpad, other types of support may be used for the typeface. A printwheel must be thin enough to be flexible, yet strong enough to absorb the impact energy. These conflicting requirements are reconciled by making the backpad thicker than the spoke to which it is attached. The additional thickness may be added to the rear or front of the backpad or by raising the area immediately beneath the character. The type of support base is determined to a large extent by the engraving of the character mold. Companies that use a shallow engraving make the backpad area much thicker to provide the requisite strength. The alternative, exemplified by GPT, uses a deeply engraved character mold, thus obviating the need to thicken the backpad.

It is not uncommon to find ejector pin markings on the rear of a printwheel (Fig. 5). The ejector pin markings may be located on either the backpad or spoke. As the name implies, ejector pins are used to remove the printwheels from the mold. During the removal process, misregistration of the ejector pins may cause the spoke to break. To solve this problem, some manufacturers mold a separate ring around the circumference of the printwheel. The ring is

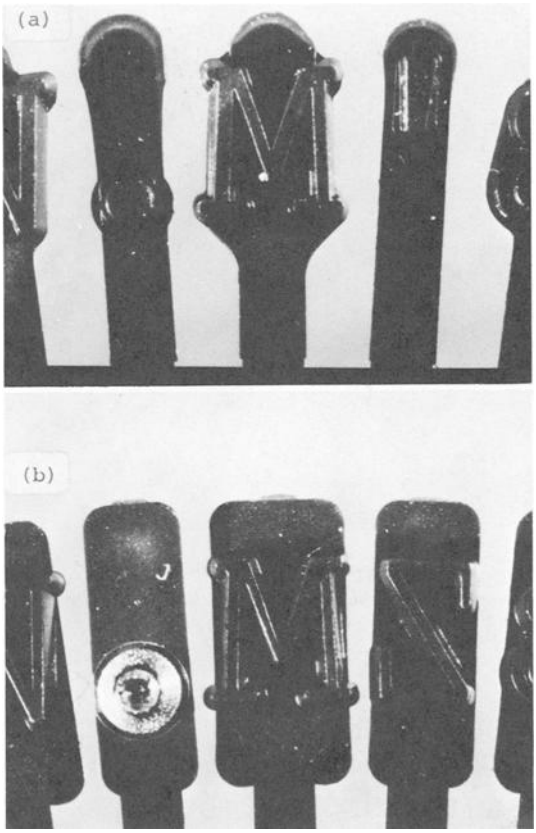

FIG. 4—*Custom contoured backpads exemplified by Diablo Systems, Inc.* (a) *versus uniformly shaped backpads of GP Technologies* (b).

used to lift the printwheel from the mold without risk of breakage and is removed from the printwheel after the molding process.

Taken together, the presence or absence, size, shape, and location of ejector pin markings; the design of the backpad and character support; and the depth of engraving of the type characters may aid the document examiner in determining the manufacturer of a printwheel.

Custom designing a font for a printwheel is extremely expensive. A more economical method of font design is simply to copy a competitor's typestyle by photographing the printwheel, enlarging the characters to approximately ×50, reproducing the design of the characters, and reducing the specifications back to original size.[3] Differences may still occur as a result of engraving techniques, but will be much more subtle and may not be readily apparent from the printed document. The net effect is two manufacturers producing almost indistinguishable type styles. For example, Fig. 6 is an illustration of specimens from two printwheels for a Diablo 630 printer. One was manufactured by GPT and the other by Caracteres SA (CSA). Diablo uses both sources and informs us that one copied the other.[3]

[3]D. Bogert, personal communication, technical specialist, Diablo Systems, Inc., Freemont, CA, 1985.

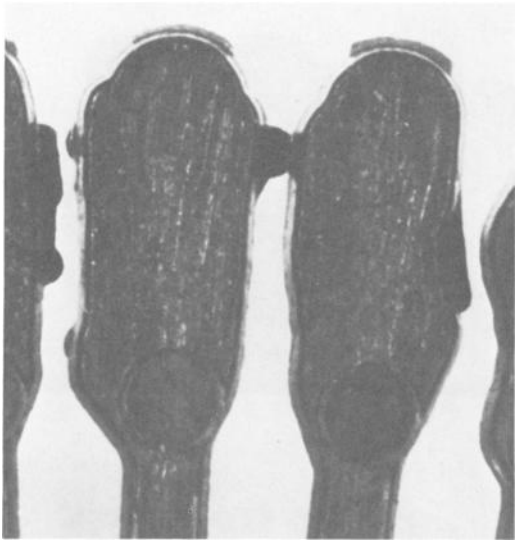

FIG. 5—*Circular ejector pin markings visible on rear of backpads. Ejector pins push upward on printwheel to remove it from mold. Note also plastic bridge between the two spokes, caused by warpage of the soft mold under the pressure of the thermoinjection molding process.*

CSA ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz

GPT ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz

FIG. 6—*Similarity in type design of two different manufacturers. Both companies act as subcontractors to Diablo Systems, Inc. for the production of printwheels for Diablo Model 630 printer.*

Printwheel Molds

Most of the better printwheel manufacturers use a hardened steel mold. The mold comprises several pieces. The base of the mold usually contains the cavities for the hub assembly, spokes, and backpad shapes. In the case of the metal wheels, the hub assembly is not part of the mold. The top half of the mold normally contains the character shapes and may consist of several sections. Typically, the upper- and lower-case letters, numerals, and punctuation marks are contained in one segment. Other segments contain the various special characters that can be interchanged to form the different sorts available in a particular font. In high-volume type styles, however, a single master ring containing the entire sort may be used to avoid registration problems.[2]

A printwheel manufacturer typically produces from only one mold for each printwheel font, although the manufacturer may make several molds. A hardened steel mold is expensive, but can produce over one million printwheels. If demand dictates, however, several molds may be used to satisfy production requirements.[2,3]

A less expensive mold using a brass alloy is known as a soft mold. While much cheaper to make, a soft mold is less durable than the hardened steel mold. Soft molds also may cause production problems. Under the intense pressures of the thermoinjection process, a soft

mold may warp slightly. This allows excess plastic to escape between the spoke cavities and may result in the joining of two spokes[3] (Fig. 5).

Printwheel molds were traditionally hand engraved. Computer assisted manufacturing (CAM) now allows this process to be done mechanically using the digitized computer tapes made in the CAD section. Differences do occur between hand engraved and CAM produced molds, but are seldom discernible on a printed document.[2]

Printwheel Production

The production practices of printwheel manufacturers are varied. Some manufacturers only produce printwheels; others also manufacture printers. Each group can be further subdivided according to their marketing activities. Some printwheel manufacturers market solely on an original equipment manufacturer (OEM) basis, while other companies operate in both the OEM and compatible printwheel markets.

The printer/printwheel manufacturers normally fall within one of three subcategories. Most will manufacture a portion of the printwheels bearing their name and will subcontract for the remainder. Other companies will produce all of their printwheels, or at least claim to. A third category would include companies such as Olivetti, which manufactures printwheels for internal use and for sale to other printer manufacturers through its subsidiary, Eleprint.[4]

Subcontracting

Subcontracting between printwheel manufacturers is a common practice in the industry. There are several reasons why a manufacturer would subcontract a portion of its production. Some companies do not wish to invest in the equipment and technology needed to produce a high-quality printwheel. Some may manufacture a limited number of high-demand type styles and subcontract for other type styles as a means of offering a greater choice to their customers. Other companies subcontract for overseas distribution.

A major reason for subcontracting is to compete in the compatibility market. Many companies will market printwheels to fit a competitors' product. Usually what they are selling, however, is a printwheel bearing their name but produced by another company. This is done to help control tooling and equipment costs.

Special or proprietary type styles is another cause for subcontracting. Although copying type styles is not infrequent in the printwheel industry, there are certain type styles which are unique to a manufacturer. For various reasons, these type styles are vigorously defended by the proprietor against competitors who would attempt to market the same or similar type styles. A prime example is the Madeline type style made by CSA.

When a printwheel manufacturer subcontracts for a specified type style, for example, Courier 10, the specifications supplied are usually limited to the physical parameters of the printwheel such as hub design, number of spokes, sequence of the wheel, and so forth. Actual font design is left to the discretion of the subcontractor. For example, Diablo Systems, Inc., subcontracts to CSA for a portion of its 630 printwheels. CSA is asked to produce a certain number of printwheels bearing a Courier 10 type style, so CSA will design a Courier 10 to fit the parameters of the printwheel. Diablo also manufactures Courier 10 630 printwheels internally. Although there are subtle differences between the 2 fonts, both are distributed as Diablo printwheels. However, Diablo also subcontracts with GPT. Thus the net results are three Diablo 630 printwheels of different manufacture on the market, all being distributed as Diablo products.[3]

Subcontracting is not a phenomenon confined to printwheel manufacturers. Several

[4]E. Capone, personal communication, product manager, Docutel Olivetti Corporation, Tarrytown, NY, 1985.

sources may actually supply a printer manufacturer simultaneously. For example, Burroughs contracts with ABL for its printwheels. ABL is a conglomerate comprising TPI Industries and Shand Printing Devices.[5] Consequently, Burroughs printwheels can come from two separate manufacturers and thus exhibit differences in the type styles. Other companies, such as Olympia, will manufacture internally and simultaneously use several outside sources.[6] Some typewriter manufacturers will subcontract with another typewriter manufacturer for their printwheels. Juki purchases printwheels for their typewriters from Triumph/Adler [*1*]. Triumph/Adler, though, subcontracts itself for some of their printwheels.[7] Figure 7 is a comparison illustrating some of the design differences between two printwheels being marketed as Triumph/Adler Courier 10 printwheels for the same model typewriter.

Private Label Printwheels

Some large manufacturers and distributors of word processing equipment will contract with a printwheel manufacturer to have printwheels produced bearing their name or logo. As mentioned, Burroughs is one example, Wang Industries another. Private labels are also distributed by some large office supply companies, such as Federal Marketing, Inc. Classification of these type styles would indicate the manufacturer and not the actual distributor. In fact, the same manufacturer may supply two different sources. Therefore, the same printwheel can be marketed under different names with no indication on the printwheel itself of the actual manufacturer. A case in point, ABL supplies both Burroughs and Federal Marketing with their Wang-compatible printwheels.

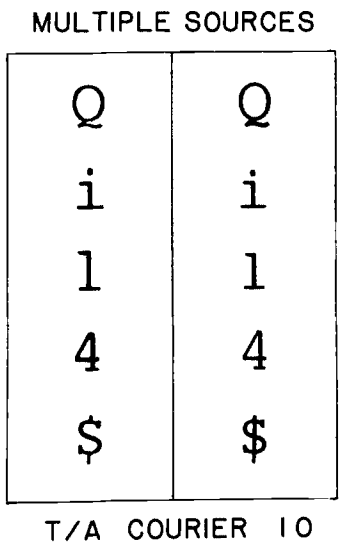

FIG. 7—*Design differences in typescript of two Triumph/Adler Courier 10 printwheels for the same typewriter.*

[5]R. A. Hardcastle, personal communication, senior scientific officer, Forensic Science Laboratory, Birmingham, U.K., Aug. 1985.

[6]W. A. Lubrano, personal communication, vice president of marketing, Olympia USA, Inc., Somerville, NJ, Nov. 1985.

[7]F. J. Delfino, personal communication, vice president, Government Accounts, Triumph/Adler, Union, NJ, 1985.

Compatibility of Printwheels

To comprehend the concept of compatibility or interchangeability of printwheels, it is necessary to realize that the printwheel is part of an electronic system for printing. This system consists of the printwheel, the printer, and the electronic components.

Several physical restraints will limit the compatibility of printwheels. The size of the printwheel and design of the hub assembly may restrict the use of certain printwheels on a particular type of printer. An excellent example is the Model 620 Printer made by Diablo Systems, Inc. This printer will accept only the patent protected plastic printwheel manufactured solely by Diablo. Some printer models have restrictions in the electronic energy levels needed for striking the impact hammer and will accept only plastic or only metal printwheels. Other models have no restrictions and will accept both metal and plastic printwheels.

The printers of many major printer manufacturers can have full physical compatibility with different printwheels but be subject to software or programming restrictions. Therefore, a printwheel bearing a particular sequence can be effectively operated only by a printer programmed to support that sequence. Using a printwheel on a printer which is programmed for a different sequence may produce an illegible output. The Wang System is one which will support only printwheels bearing the Wang sequence of characters. Some sequences, such as WPS (proportional spacing), may require additional programming support for operation.

There are a number of printwheel sequences that are partially compatible; that is, the alpha/numeric characters are the same, but some of the special symbol characters will differ. Because of the few differences in characters and character position found between the word processing (WP) and American Standard Code for Information Interchange 96 (ASCII 96) sequences, physically compatible printwheels of these two sequences can be effectively interchanged on the same printer without any additional software support. Virtually all Qume printers, for example, will accept both WP and ASCII 96 printwheels [2]. With some printers, however, it may be necessary for an operator to become familiar with the different characters and their corresponding locations on the keyboard to use effectively partially compatible printwheel sequences (Fig. 8).

Classification of Printwheel Type Styles

The classification of printwheel type styles is complex, for several reasons. Variations are affected in a type style by the physical parameters of the printwheel, sequence, and production practices in the industry. It is the latter factor that complicates a determination of source for a printwheel produced document. Unlike the circumstances that existed for conventional and single-element ball typewriters, there is no longer a clear division between printwheel manufacturers and printer manufacturers. As set forth in the section on subcon-

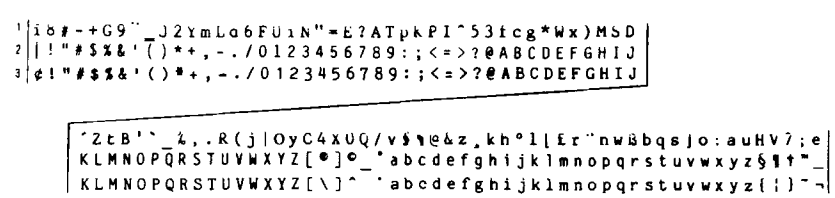

FIG. 8—*Comparison of three different printwheel sequences. Note total noncompatibility of the Wang sequence* (line 1) *versus the almost total compatibility of the WP sequence* (line 2) *and the ASCII 96 sequence* (line 3).

tracting, a firm may be a printwheel manufacturer, printer manufacturer, a combination of both, or merely a distributor of printer, printwheel, or combination thereof.

There are several possibilities, therefore, whereby agreement can exist in type styles between printwheel produced documents. It may be that the manufacturer indicated by the type style classification is the source of the questioned printwheel. If so, the manufacturer may distribute the same printwheel for different companies as illustrated in the previous example of the Burroughs and Federal Marketing Wang compatible printwheels. Another possibility is that the same type style is produced by two different manufacturers.

There are several reasons for the apparent differences between type styles. The discrepancies may represent a change in the manufacturing process, such as a pre-CAD and post-CAD engraving, a variation caused by sequence or other physical considerations, a reflection of the same printwheel manufacturer using multiple sources, or an actual difference in manufacturers. The first three factors may be differences in the font of a single manufacturer. Ascertaining the source of the discrepancies may not be possible from an examination of the type style alone.

Other more subtle design characteristics indicative of a manufacturer, such as stroke width, shading, and serif length, may be used to differentiate typescripts. Although these characteristics are clearly the result of manufacturers' differences when typed specimens of known origin are compared, when the examiner is confronted with a document of unknown origin, any of these more subtle differences could be attributable to the effect of the hammer intensity, paper, or ribbon. Therefore, differentiation should be predicated on differences in character shape.

Special Symbols

Special symbols should be accorded greater significance when classifying a printwheel produced document. These symbols, which are characters other than the alphanumeric characters of a printwheel sort, can vary by manufacturer, sequence, or type style. Oftentimes, special symbols are the only basis for differentiation between character sorts. Unfortunately, these symbols are not always contained within the text of a questioned document.

In some instances, a special symbol may be constructed from multiple characters, such as the "¢" symbol for the Wang sequence which is composed of the "c" and the "/" symbols. This constructed character is a function of the programming for that sequence. Therefore, any Wang-compatible printwheel is designed accordingly. Constructed symbols can be direct indicators of source, regardless of the manufacturer of the printwheel.

The presence or absence of special symbols in a typed strikeup may also be ascribed to the system keyboard. Not all keyboards are equipped to reproduce the entire character sort. Unless all the characters within a sort are known, care should be taken in the classification of printwheel typescripts.

Summary

The recent development of the printwheel as a preferred printing device for electronic printers has introduced several problematical variables which must be considered in the examination of printwheel typescript. Differences do exist in printwheel typescripts between manufacturers; however, differences also may occur among typescripts of the same manufacturer as a function of the manufacturing process. Manufacturing induced variations can range from obvious changes in letter design to subtle variances in stroke width and serif length. These typescript variations may severely complicate the classification of printwheel typescripts. Ironically, determining the source of a printwheel produced document may not require typestyle classification, but only the mere recognition of a distinctive character sort for a specific sequence.

References

[1] Rile, H., American Society of Questioned Document Examiners Typewriter Survey, Lake Tahoe, NV, 1983.
[2] *Supply catalogue,* Qume Corporation, San Jose, CA, Sept. 1984.

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