

An introduction to typographic fonts and digital font resources

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Type has evolved from blocks of wood or metal bearing the raised character shape to the many and varied digitized representations of the character that are available through computer system technology. Typography is the art or technique of composing printed material from type. The evolution of digital type into the computers of today has opened the door of typography to people who have had little or no previous knowledge of the subject. It has also introduced a higher level of complexity to document composition and presentation service software than was previously required. Discussed in this paper are the art of composing printed material, the selection of an appropriate type design for a given application, the information required to create and manage a digital font resource, and the computer system's use of digital font resources to produce typographic-quality documents. These matters are examined in a way that introduces the reader to typographic fonts, the additional complexities involved, and the need for consistency in the definition and application of digital font resources.

The evolution of digital type

Type is an entity that defines the shape of a graphics character; it has evolved from small blocks of wood or metal bearing the raised shape of the character to the many and varied digitized representations of character shapes available in computer system technology. The shape or image of a digitized graphics character, as it appears on a presentation medium, is composed of approximately 60 to 1200 dots per linear inch. The presented character image may be produced by wire matrix printers, laser printers, all-points-addressable (APA) displays, or any other digitally based output devices. The character-shape information, as it appears within a computer system, may be quite different from the dots as they are

arrayed on output. The data representation of the character shapes may be defined using either a bit-map or raster image, but they may also be represented as graphics drawing orders or as mathematical expressions. The style variations available in digitized type are limited only by the density of the dots and the type designer's creativity. Figure 1 shows the typographic letter h in simulated magnification, produced by an array of dots.

Collections of type sharing a common technology for presenting the character image are often gathered together into a *font*. A font is a set of type having a characteristic design of how the characters should appear to the reader. Example type families are Helvetica™ and Monotype Bodoni™, example typefaces are roman, italic, and bold, and example type sizes 12-point and 10-point. These concepts will be discussed in more detail later in this paper.

Historically, a font has been a collection of lead slugs containing the raised images of the characters. A *typesetter* or *compositor*, as the person who sets the type is called, is responsible for selecting and arranging the various pieces of type according to the document style required and the typesetter's personal

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knowledge of the rules of typography. *Typography* is the art or technique of composing printed material from movable type. The typesetter is, to a great extent, an artist who composes the document.

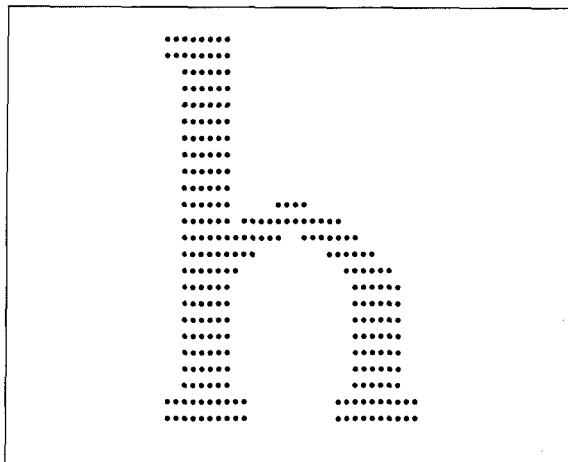
With the advent of low-cost mechanical and electro-mechanical typewriters, the specialized world of producing printed documents was opened up to nonspecialists, but with a general loss of appearance. The typesetter had the ability to select from a wide variety of type styles and sizes to compose a document that was attractive and easy to read. The width of each individual character used by the typesetter had been designed to create an even texture or color when the characters were positioned together on a line. One of the primary attributes of the fonts available to the typesetter is letter spacing, or the space between letters. Well-chosen letter spacing, including *Kerning* (i.e., extensions as in the italic *f* and *j*), and *ligatures*, or ties such as *fi*, is the first building block of superior typographic communication.

With typewriters, the number of type styles and sizes was greatly reduced (usually to one per typewriter) and the ability to use proportionally spaced characters was essentially eliminated. Some typewriters, however, do make use of incremental character widths to give the appearance of proportional spacing. These are known as proportional-spaced machines, or PSMs.¹

Today, the use of computers, APA displays, laser printers, and digital fonts has opened the door to full-function typography for all to use. However, most users have little of the background art and technology of typographic composition in which the typesetter has been trained. Digitized fonts, with their potential for varied styles, sizes, and character widths, greatly increase the complexity of document-composition and presentation-service software. The resulting diversity of techniques and products being developed to address this new technology has created many different ways of doing the same thing, but without guidance as to typographic logic and taste.

¹ Most typewriters use monospaced or uniform-character-increment fonts. Because each typewritten character has the same width space, the lowercase *i* and the period occupy as much space as the uppercase *M*. Such a font works well with single-pitch typewriter escapements. Typographic fonts differ from typewriter fonts in that each character has spacing established by its shape and proportion—the lowercase *i* has a narrow width; the uppercase *M* has a wide width. Typographic fonts are generally considered more legible than monospaced fonts and produce more readable text.

Figure 1 Representation of a graphics character



In this paper, we attempt to pass on some of the typesetter's wisdom in composing documents by extrapolating the use of typographic fonts to the computer-system processes required to support typographic document composition. We present the rudimentary information required to produce a digital font resource for typographic applications.

Typographic fonts

Typographic fonts can go beyond basic neatness and legibility to give the advantage of heightening the impact and impression of your information. The availability of a wide variety of digital font styles and sizes gives individual users options that until now were available only through commercial typesetters. Calling on this capability, a person in business, for example, can maximize the potential of print communication.

In delivering a printed message, typographic fonts offer the following four important advantages.

Documents composed with typographic fonts can attain visible distinction and clarity. Typeset copy, like any attractive object, invites one to look at it and encourages the eye to keep moving through the text. Appropriate use of typographic fonts also generates appeal through the use of typefaces with a style and personality that match the message. An individual user can express and intensify just about any sentiment with type.

The message is more legible and readable. *Legibility* is the quality of type and its spacing and composition that affects how rapidly, easily, and accurately one character can be distinguished from another. The greater the speed, ease, and accuracy of perception, the more legible the type. *Readability* goes a step beyond perception or recognition, and bears on the act of reading itself; it takes into consideration how comfortably printed matter can be read over a sustained period. Legibility and readability are ob-

Readers can take in a more complex message at a faster rate when a document has been prepared using good typographic principles.

viously important. With typographic fonts, one can use any of a great variety of faces and styles for each distinct editorial element of a message—headings, text, captions, footnotes, passages to be stressed, anything written that plays a role in getting the writer's thoughts across to the reader.

The reader's comprehension improves because, as is well known, the more clearly a writer expresses a message, the more firmly this message is instilled in the reader's mind. A thought that has been securely retained can be more readily recalled. Readers can take in a more complex message at a faster rate when a document has been prepared using good typographic principles.

The printing cost is reduced because, within a comparable range of letter sizes, typeset copy uses significantly less space than the same text prepared with fixed or uniform-character-increment typewriter fonts. Studies have indicated compactions of 20–76 percent, with an average of 46 percent. Compaction can lead to important savings when a document is to be reproduced in large quantities and widely distributed.

There are literally thousands of font styles and sizes from which to choose. The availability of such a range of choices offers a great opportunity to create a precise effect, but it also makes selection of the right font or combination of fonts more difficult.

Font selection

The selection of the right font and the layout of the copy depend upon the objective of the publication. For graphics applications (e.g., charts, posters, signs, advertising) the choices are virtually unlimited, because thoughts are conveyed through novelty and imagination. For document applications (e.g., books, magazine articles, reports, newspapers), however, the choice is much more limited. Formatting also limits the choices, because formatting is used to provide guideposts from which the reader comes to expect certain classes of information. For example, the document designer decides on the number of levels of headings for a given document and chooses a different font for each heading. The reader comes to recognize the subordination of thought via these fonts. For document applications, font selection and page layout determine a reader's ease of comprehension and the length of time one can read a given text without fatigue. The character design and page layout information presented here apply primarily to document composition applications.

In appearance, a typographic font is characterized by a variety of attributes, including the following: family (design name assigned by the font designer), weight, posture, proportion, and size. The design of a particular family is further characterized by serif, sans-serif, x-height, and stress, plus many other attributes defined by various individuals or groups within the type industry. Characterizing the appearance of a font is much like trying to characterize the appearance of a painting or other work of art, but it is necessary when one is attempting to define fonts for use in computer applications.

A *type family* includes all variations of weight, posture, proportion, and size for a specific design name. A *typeface* is a specific weight, posture, and proportion of all sizes within a family.

Type family selection. The selection of a type family depends on the availability of that family on a given computer system. There are countless type families available in the world, ranging in style from simple stick characters to those that are highly ornate. These type families are often classified into categories, but

no universal classification scheme has been agreed upon.² Many of the type designs have names protected by trademarks and are licensed by the owner. It is not practical to acquire the rights to every type family, but, because of similarity in type designs among fonts of a given classification, it is often more practical to acquire rights to a few fonts from each class.

Substitution of one typographic font for another becomes an interesting problem if the owners of each node within a computer network acquire different type families for their system. A person wishing to interchange documents over a network for review or approval normally wants the document to appear the same (at least have the same line and page endings) to all who receive it. Because of the proportional spacing of most typographic fonts, it becomes very difficult to find two fonts with identical spacing. Thus, whether an unformatted document or a formatted document is interchanged, the selection or substitution of a different font from that specified in the document may very well result in significant differences of appearance in the printed page.

Typeface selection. The choice of typeface within a type family depends on the availability of the particular design variation. Typefaces are generally identified among nine variations of weight, two or three variations of posture, and nine variations of proportion. Most computer systems do not support every variation.

The *weight* of a typeface is the relative darkness or lightness in appearance of the characters. It is nor-

² Type and computer industry representatives have recognized the need for consistency in this area of type classification, along with the need for consistency in font-character content and font-resource format. Through the dedicated effort of Edwin Smura (Xerox Corporation), a work item has been established by the ISO (International Organization for Standardization) for the development of an *Information Processing: Font and Character Information Interchange* standard. With the participation of industry representatives throughout the world, this proposed standard has progressed to the stage of a Draft International Standard (DIS), which puts it into final review prior to approval as an International Standard (IS).

Participants in this standardization activity have also recognized the continuing need for publicly sharing in the interchange of font-related information, and have taken action to form the Association for Font Information Interchange (AFII). AFII is a nonprofit professional society open to any individual or organization having an interest in the areas of font design, development, and application. Information about AFII can be obtained by writing to Alan Griffiee at IBM Boulder, 51E/025-1, P.O. Box 1900, Boulder, Colorado 80301.

Figure 2 Examples of two weights of the same typeface and size



mally measured on a scale of 1 to 9, corresponding to ultra-light, extra-light, light, demi-light, medium, demi-bold, bold, extra-bold, and ultra-bold (though the names may vary among font suppliers). Two weights of a font are shown in Figure 2.

The *posture* of a typeface is the slant or angle at which the characters appear to lean. There are normally only two postures defined: upright (roman) or inclined (italic). Sometimes a backslant posture is also used, as is the case with many APL characters. Posture is not a rotation of the characters, nor is it a shear or stress applied to the characters. Posture is a design variation. As illustrated in Figure 3, the shape of an italic character is modified to give it a more pleasing appearance than would be obtained simply by applying a simple slant to the characters, as though by pushing.

The *proportion* or *proportionate width* of a typeface is the relative relationship of character height and width. As with weight, proportion is normally measured on a scale of 1 to 9, corresponding to ultra-condensed, extra-condensed, condensed, semi-condensed, normal, semi-expanded, expanded, extra-expanded, and ultra-expanded (though again the names may vary among font suppliers). Two proportions of characters of a font may appear as shown

Figure 3 Comparison of roman and italic type



Figure 4 Comparison of two proportions of characters of the same font



in Figure 4. In selecting the category to use, the designer considers which form is more familiar to the readers.

Font size selection. The size (height) of a typographic font is normally measured in points. Seventy-two

points equals approximately one inch, with the precise value being slightly different in the United States and in Europe. Type height includes some white space above and below the printed character to provide for adequate minimal spacing between the lines of type.

Document text is most readable when set within a range from 9 to 12 point. To accommodate special circumstances, however, one may sometimes want to consider using a smaller or larger type size. For example, footnotes, indexes, or captions could be set smaller (6–8 point) because they are subordinate to the main text; titles and headings may be larger (14–72 point), because of their importance as signposts. Figure 5 is an example showing a single font (Sonoran Serif, available on the IBM 3800 series Advanced Function Print Systems) in various sizes from 6 to 16 points.

The document designer must also consider where the document will be read and the characteristics of the people reading it. A document to be read by the elderly or by small children, for example, or at a great distance, under weak light, or while moving, should clearly be set in a larger-size type.

Document composition with typographic fonts

The layout of the characters of a typographic font on a page is characterized by the attributes of case, line width, leading, justification, and emphasis. Each of these attributes influences the readability of the text being composed. It is not necessary to become a typographic specialist, but it is important that the person creating a document and the software designer of document-formatting programs understand how persons read, and that they become familiar with the practical rules of typographic page layout.

One aspect of reading is illustrated in Figure 6; the point here is that we read word shapes, rather than the words themselves or their constituent letters. We also look at a number of shapes at one time and move our eyes in jumps called *saccadic jumps*. Figure 7 illustrates the part of the word that contributes most to the shape of the word. Which form of the word is easier to read? Not only do we read by recognizing shapes, but we also receive most of our visual cues from the tops of those shapes.

Consider which of the words in Figure 8 is the more readable; there is debate over this point. The original research indicated that the serif type families were

more readable because the serifs along the tops of the characters keep the eyes moving more smoothly and provide more cues. Later research indicates that the more readable families are those first encountered by the reader in learning to read. There is a familiar basis for the common use of the serif; it was first employed by Roman stonecutters in lettering public buildings and monuments. Serifs were cut into the stone first to act as stops to prevent the bodies of the letters from overrunning the line. Type that imitates the Roman style of lettering generally retains the serifs and thus the familiarity.

Case. Capital letters (uppercase) can be used in several ways. The text of this paper so far has used capitals conventionally—to open sentences and begin proper names. Thus, the text has been set in uppercase and lowercase. These terms are derived from the days of individual metal type slugs, when capital letters were stored in a case above those containing the small, or lowercase, letters. When text is set in both uppercase and lowercase, the eye receives the visual cues inherent in the familiar shapes of the words.

Figure 5 Examples of various point sizes of a single font

6 Point Bembo
8 Point Bembo
10 Point Bembo
12 Point Bembo
14 Point Bembo
16 Point Bembo
18 Point Bembo
20 Point Bembo
24 Point Bembo
30 Point Bembo

THIS PARAGRAPH IS TYPESET ENTIRELY IN UPPERCASE. THE PHYSICAL FACT IS THAT WORDS TYPESET IN ALL UPPERCASE LET-

Figure 6 Illustration of the relationship between word shape and readability

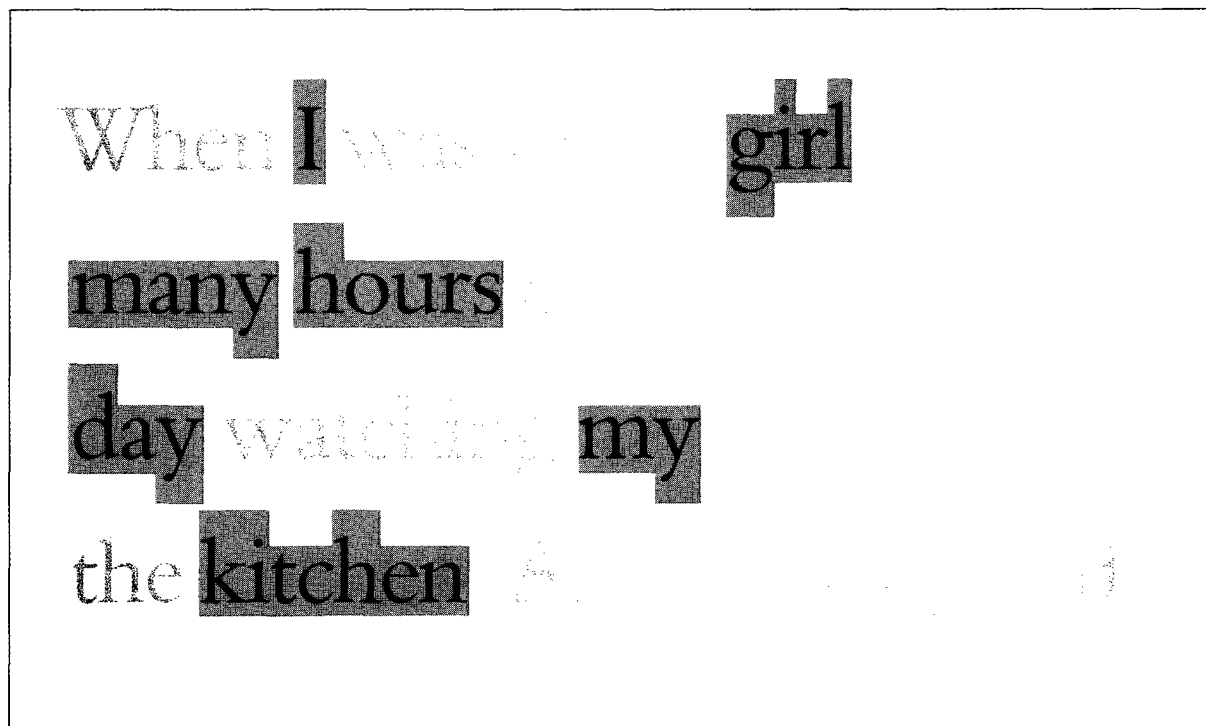


Figure 7 Comparison of the contributions of the upper and lower portions of a word shape to readability

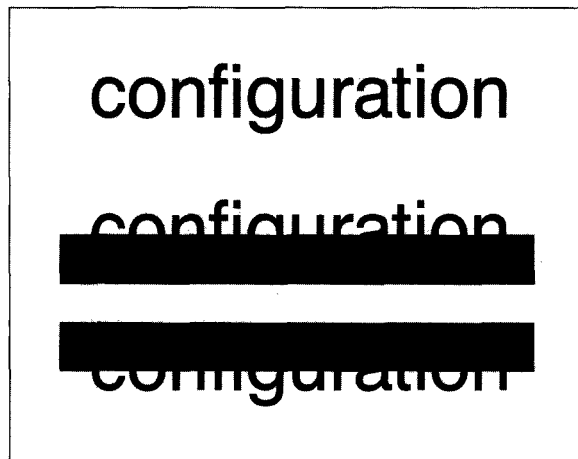


Figure 8 Effect of serif on readability



TERS OCCUPY UP TO 30 PERCENT MORE SPACE THAN THEY WOULD IF TYPESET IN UPPERCASE AND LOWERCASE LETTERS. THIS IS THE ADDITIONAL COST OF USING CAPITALS FOR EMPHASIS. THERE ARE OTHER, MORE EFFECTIVE TYPOGRAPHICAL MEANS FOR STRESSING A WORD, SENTENCE, OR PASSAGE. MOREOVER, TYPE SET ALL UPPERCASE IS MUCH LESS READABLE.

Line width. A basic factor governing readability is the length of the line the eye must follow before returning to the next line. Type sizes between 9 and 12 points are most readable when set to a line width of 18 to 24 picas, where a pica is approximately one-sixth inch.

The most readable line contains between seven and ten words. Long, eye-tiring lines can be eliminated by setting text type in several columns on the page, each within readable limits. The correct line length makes the saccadic jumps easier.

Leading. The space between lines of type affects readability. The technical word for adjusting the inter-line space is *leading* (rhymes with heading). This term goes back to the days when lead-alloy type was used, and typesetters placed slender pieces of lead between lines to add space. Assuming an effective line length, the most important consideration in determining the appropriate space between lines of type is to keep the reader from *doubling*, that is, to avoid the eye's tendency to read the same line twice. Typographic fonts are normally designed with a nominal amount of leading built into the character height; the overall height of a type slug is known as the body size.

Justified or unjustified text. Text that is set *unjustified* has lines of type that are flush or aligned on the left and uneven or unaligned on the right. This is known in the trade as *flush left* and *ragged right*. Another option is to set type flush left and right. The technical term for this is *justified*. Copy set unjustified can have several advantages. Unjustified text has even word spacing; that is, no space has been added between words to align the text. Unjustified text avoids the irregular spacing between words that can produce *rivers* of white running down a page where the gaps connect. Irregular spacing, inherent in justified text, decreases reading speed and can cause doubling back. Editors are well aware of those possibilities and take steps to avoid them.

Ragged right and justified text have their uses; here the abstract is set ragged right, and the body of the text is justified. Square blocks of type on the page have an orderly, controlled appearance. A key factor is the width of the line. Short, justified lines generally result in excessive white space between words, whereas longer lines result in tighter word spacing. The requirements of the job are the best guide in deciding whether to justify. For purposes of illustration, many of the type specifications mentioned in

this paper are listed in Figure 9 as they apply to the *IBM Systems Journal*. This type has also been generated digitally.

Emphasis. At certain places in the text, the writer and editor may want to emphasize a particular word, phrase, or editorial element. Typographic fonts offer many ways to do this, with varying degrees of force. Some of the preferred methods to achieve emphasis are the following:

- Change from one type family to another.
- Alter the type size.
- Use a bolder or lighter typeface in the same type family.
- Add space around a significant section of text.
- Indent a section of text or move it into the left or right margin.
- Use rules (borders) to highlight and distinguish sections of type.
- Replace roman with italics for a word, a phrase, or a paragraph.
- Begin a paragraph with a larger or bolder initial capital letter.
- Use characters such as bullets, arrows, daggers, or other geometric shapes.

Application of digital typographic fonts

The advantages of properly selecting and using typographic fonts for clear communication and emphasis of ideas cannot be overemphasized. It is one thing, however, to know about the possibilities, and yet another to implement them. In the case of traditional typographic fonts, the typesetter made most of the font-selection and document-composition decisions. When digital typographic fonts are used, the computer system becomes involved in making those decisions. The application of digital fonts has an impact on and involves interdependencies among most aspects of text processing. For further illustration, type specifications for the *IBM Systems Journal* are set forth in a formal document.

Computer-activated printing began with a limited number of uniform-character-increment fonts available to a computer system. The dependencies were often minimal and often transparent to the end user. Today, however, with a large number of proportionally spaced typographic fonts being available to a system (and not always the same set of fonts on each system in a network), the dependencies become critical items of design consideration.

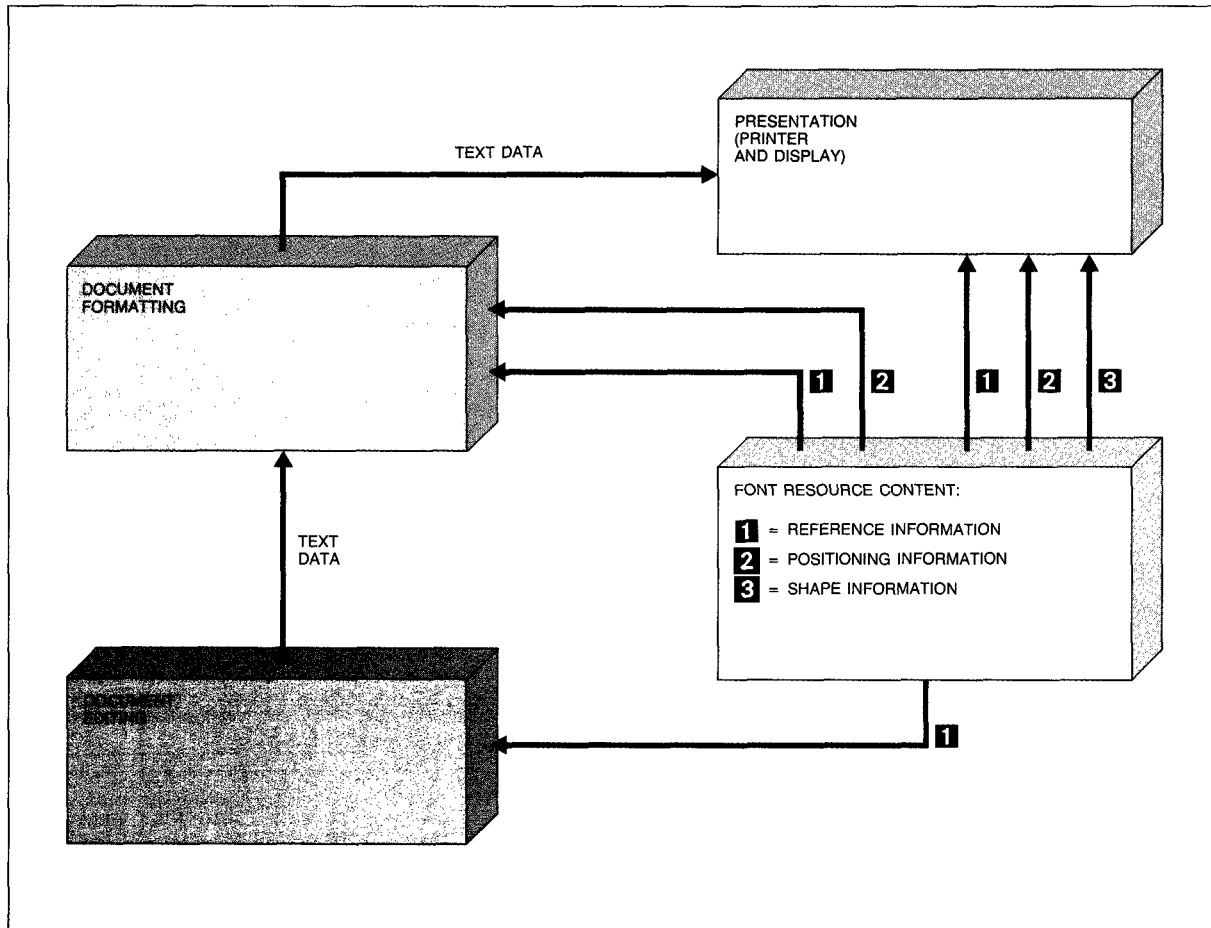
Figure 9 Partial listing of type specifications for the *IBM Systems Journal* for comparison

ABSTRACT:	9 POINT HELVETICA MEDIUM ITALIC 18 PICAS MAXIMUM WIDTH FLUSH LEFT, RAGGED RIGHT
ARTICLE TITLES:	24 POINT HELVETICA BOLD CONDENSED 18 PICAS MAXIMUM WIDTH FLUSH LEFT, RAGGED RIGHT
AUTHORS' NAMES:	10 POINT HELVETICA REGULAR 18 PICAS MAXIMUM WIDTH FLUSH LEFT, LINE FOR LINE AS SHOWN
TEXT:	10 POINT TIMES ROMAN 18 PICAS COLUMN WIDTH, JUSTIFIED 1 LINESPACE BETWEEN PARAGRAPHS
INITIALS:	FIRST LETTER OF EACH ARTICLE: 30 POINT TIMES ROMAN BOLD FOOT OF INITIAL ALIGNS WITH TEXT OF SECOND TEXT LINE
MAIN HEADINGS:	10 POINT HELVETICA MEDIUM 18 PICAS MAXIMUM WIDTH FLUSH LEFT, BREAK FOR SENSE
BOLDFACE HEADINGS, IN-LINE:	10 POINT TIMES ROMAN BOLD
ITALIC HEADINGS, IN-LINE:	10 POINT TIMES ITALIC
CITED REFERENCES:	8 POINT TIMES ROMAN, WITH ITALIC AND BOLDFACE AS SHOWN, 17 PICA TEXT WIDTH. REFERENCE NUMBERS HANG IN MARGIN. 18 PICAS TOTAL COLUMN WIDTH, JUSTIFIED
INSETS (BLURBS):	14 POINT HELVETICA BOLD CONDENSED 14 PICAS MAXIMUM WIDTH CENTERED ON COLUMN WIDTH RULES TOP AND BOTTOM PER STYLE TO 18 PICA COLUMN WIDTH

We now discuss document- or text-processing tasks that relate directly to fonts. A document may contain only text, or it may be a composite containing text, graphics, and images. This paper discusses primarily text documents, or the processing of text around graphics or image objects. Figure 10 provides a general model of the text-processing use of fonts.

A text-processing system is the collection of hardware devices, software, and firmware programs required to generate, modify, display, and/or print text. Those components may be contained in a simple independent system, or they may be included within a more complex document-processing system and/or communication network. Text processing may be the primary function of the component (e.g., a text-editing program) or it may be an auxiliary function of the component (e.g., part of a graphics editor, device service program, or resource management program).

Figure 10 Application environment involving fonts



A text-processing system may be as simple as an electronic typewriter with cartridge fonts. At the other end of the spectrum, a text-processing system may consist of host computers that are parts of a distributed network of computer systems, a series of host-dependent workstations with access to host text-processing programs, and a network of attached intelligent workstations with a variety of text-processing applications, together with a variety of printers.

The following are examples of text-processing systems and components, demonstrating the diversity of the environment that must be addressed:

- Personal computer with a character display and a dot matrix printer
- Office workstation with a WYSIWYG (What You See Is What You Get) editor/display and an APA laser printer
- Graphics workstation with a high-resolution color display and software applications for rotating and scaling text to annotate figures
- Publishing workstation with preview devices (displays and printers that allow the user to preview at a lower quality, but faster speed, the appearance of the final output) and software applications for page layout and composition
- Workstation in a network with distributed storage and distributed print systems
- Font library management program for application program access to any required font attribute
- Device service program with the ability to transform character-shape information into different device-specific formats

- Displays and printers with different resolutions and device-specific formats for their character-shape information

A text-processing system basically performs the three tasks of editing, formatting, and presentation. Each of these three tasks has dependencies on the others and on different parts of the font resource information.

Document editing. The editing task basically permits a user to create or modify a data file (either temporary or permanent) containing text in a syntax that is consistent with an architected document content format. Depending on the type of editor, the additional text-processing tasks of formatting and presentation may also be provided via a WYSIWYG editor. However, the editing task involves the generation or modification of the text information only. The editing task is the primary means by which users identify the fonts they want to use for presenting the document.

Document formatting. Document formatting is the task of determining where information will appear on a presentation surface and the creation of a data file (temporary or permanent) that contains the document data along with formatting controls. The presentation surface may be a video display, a sheet of paper, or some other output medium. The formatting process uses information from a variety of sources (e.g., user, system defaults, document defaults, and fonts) and produces an output data file that may be specific to the requirements of a particular device or generalized for presentation by any of several devices.

Document presentation. Document presentation is the task of transforming the information contained in the formatted data file to a visible form on a physical presentation surface. This task involves the use of a hardware device and software for device service or control. The task of document presentation may be as simple as taking bit-map image data and generating the corresponding image on the presentation surface, or it may involve translating an encoded data file, merging referenced information, and transforming the image information from a parametric form to a form required by the device. In either case, the character-shape information contained in the font must be obtained, possibly transformed, and properly positioned for presentation.

The above tasks are not necessarily performed on a single or integrated system. A workstation used for

editing may be remote or detached from the system where formatting occurs. A document for distribution and remote presentation may be formatted by the sender, who may not know what devices or resources are available for presentation. Many different document-content architectures, document-interchange data streams, and device data streams may be involved, but all require the means of referencing fonts, positioning the characters of a font, and presenting the character shapes on the presentation surface.

Font referencing. Font referencing is the process of identifying or describing the desired font. Referencing is required by the editing, formatting, and presentation tasks because a user must specify the desired fonts in the document for the formatting process to acquire character-positioning information, and because the presentation process must acquire character-positioning and shape information. Referencing may involve specific identification of a font resource, or it may involve describing the font by listing the attributes that are important to the user.

Font referencing includes character association, which is the process of associating graphics characters used in text data with the appropriate characters of a font. Characters used in text data may be specified as members of encoded graphics character sets, as entity references in document markup, or by other document-encoding techniques. The process of character association requires knowledge of the document-encoding techniques, the font-character identification technique, and a method of mapping the characters specified within a document to font-character identifiers.

The identification of fonts within a document is the most critical dependency, because every document created contains its own copy of the information in a format that is fixed at the time of creation. Such documents may be interchanged among systems, or they may be stored in a library for recall several years later. If the method of identifying fonts is different among systems or if it changes over time, the process of identifying the correct fonts becomes more difficult, requiring reference tables and mappings.

Character positioning. Character positioning is the process of determining where a given character is to appear on the presentation surface. This function is initially performed by the document-formatting task, but is often at least partially repeated by the document-presentation task. Thus there is an interdepen-

dency between these two tasks—positioning and presentation—to position characters in the same manner. Character positioning includes determination of page and line breaks and the flow of text around graphics or image objects that also appear in the document. The document-formatting process

Character positioning is the second most important font dependency, because each document that is created must be formatted and presented to be of any use.

makes use of font information along with user, system, and document-content information. Thus fonts provide only a portion of the information required for character positioning.

A character may have an absolute or relative position with respect to a previous character. That is, the formatting process may specify where each individual character is to be positioned, or it may specify where the first of a string of characters is to be positioned, leaving it to the presentation process to position successive characters in the string. In either case, the process must know each character's escape-ment values, its other dimensions, and perhaps additional attributes specifying the coordinate system, reference point, rotation, kerning, ligatures, etc.

Character positioning is the second most important font dependency, because each document that is created must be formatted and presented to be of any use. Information is created to be shared. In some cases, the content is paramount, and the format of the information is not a consideration as long as the person reading it can comprehend what is being said. In other cases, the person creating the information may want to preview on a display or local draft printer what is going to be produced for final publication. Alternatively, the person creating the information may want to distribute a soft copy of a document so that several persons may comment on

the content. In the latter case, the document must be formatted in the same manner, or at least close enough for a line-by-line comparison of what is to be produced.

Character-shape presentation. Character-shape presentation is the process of forming the character image on the presentation surface. This process is performed by a display or printer hardware device, supported by software and/or hardware processes, that translates the character-image information from its font-resource format to that required by the presentation device. Font resources may support a variety of shape-definition techniques, some public and some private. Many font designs are privately encoded, and the key to translation of the character-shape information is available only through license agreements. Other font designs are in the public domain, and anyone may have access to the character-shape information.

Consistency of character-shape information, that is, having a common shape-representation technique, is the least critical of the font dependencies. The presentation of individual character images may be done differently on every device that produces them. This may be done as long as the character images are positioned where they are supposed to be—as defined by the formatting task—and the images appear reasonably close to the shapes defined by the font designer. A 60-dot-per-inch, \$200 printer should not be expected to produce images of the same quality as a 600-dot-per-inch, \$20 000 printer. It does not make a significant difference whether a 240-dot-per-inch printer uses a laser technique to present an image of the same quality as a 240-dot-per-inch resistive-ribbon printer.

Format of digital font resources

A *font resource* has traditionally been considered to be a collection of characters of a specific typeface and size. This was a useful concept when one could hold a tray of lead type having a specific typeface and size or could define a bit-map digital font having a specific typeface and size. That definition, however, loses some of its meaning when applied to scalable outline techniques for representing character images. A *digital font resource* may be more correctly defined as a specific collection of graphics characters, with associated descriptive, character-positioning, and character-shape information required by a computer system to represent a specific type family and one or more typefaces and type sizes.

To assist the computer system in its task of document composition, a digital font resource must be created that contains not only the information defining the graphics-character images but also the associated identifying and positioning information required for font selection and character placement. That information must then be made available to each of the text-processing tasks, regardless of where they may reside in a distributed network.

Storage and access of font information must consider two factors of critical importance—ownership of the data (not all font information may be generally shared or distributed without appropriate permission), and the interdependencies of the data (descriptive and positioning information must be commonly available both to the devices that present the document and to the applications that generate or format the document).

When a font is generated, all required information may be contained in a single font file, but that may not be the format that is most useful within a text-processing system. Processing system or application variations may require a font to be divided into subsets and/or reformatted. Each processing-system component or application process may require different subsets of the font information. The following are examples of the purposes for which font information may be stored for use:

- Network distributed library, with database program access and communication of the information over the network
- Host system library, with shared data access or resource management program interface to any attached device or workstation application
- Workstation-resident library or collection of files, with shared access available to the applications running in that or another workstation through user action
- Font data compiled or linked into a particular text-processing application, with access available only to the modules within that application
- Data resident within and available only to a specific presentation device, which data may have been made available to the device by down-line loading or by exchangeable read-only storage

Various storage and access techniques require appropriate subsets of the font information and a flexible font format that permits identification of individual attributes. Most processes require descriptive information and many require character-positioning in-

formation, whereas only presentation devices may require character-shape information.

Within a computer system, there are dependencies between the document-formatting and document-presentation programs on common or duplicate sets of character-positioning information. Among computer systems, there are dependencies on a common method of identifying or referencing the font resources. There are also dependencies on a common method of selecting alternate font resources if the desired one is not available. It is extremely important for the consistent formatting and presentation of documents that the font information used by these programs and systems be consistent.

Concluding remarks

It has been the objective of this paper to introduce the concepts and advantages of using typographic fonts. At the same time, we have indicated some of the potential pitfalls. We have shown the need for consistent solutions to the many and varied ways of implementing digital typographic fonts on computer systems. The type industry is rapidly changing, and many of the document-composition facilities that were previously available only through the acquisition of expensive equipment are now becoming available to the general public through low-cost hardware and software implementations.

Persons who use typographic fonts and those who develop the hardware and software implementations must recognize both the potentials and the pitfalls involved. It is now very easy to clutter a document and make it gaudy and difficult to read through inappropriate font use. It is now all too easy to make font-resource implementation mistakes by thinking a typographic font is a simple extension of a typewriter font or a display-symbol set. Through the discussion of typographic fonts, their potentials, and their dependencies, we hope that the user will welcome the opportunity to employ them in home and office communications.

IBM is participating in the definition of an international font standard for the attributes that describe a font resource. At the same time, we must retain the flexibility to permit the use of new technologies for designing and presenting character images.

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