EP-odds and ends

Notes on Apple 4 Fonts

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1. The idea

The standard bitmap fonts on the Apple Macintosh series of computers have become so much a part of the System interface that it is hard to conceive of a Macintosh without them. Following the adoption of TrueType technology for Macintosh System 7 the idea was put forward of developing TrueType outline versions of the four fonts involved: ChicagoTM, GenevaTM, New YorkTM, and Monaco^{TM1}. This "Apple 4 Fonts project" was taken on by Bigelow & Holmes in 1988. The notes which follow have not been worked up into any kind of formal paper but we thought that readers of *EP-odd* might be interested in knowing of the alternatives that were considered and how we eventually tackled the project. These notes were originally circulated as electronic mail, a medium in which informality and grandiloquence frequently co-occur. The original style has been preserved as an example of contemporary Silicon Valley 'font-speak'.

Given that the Macintosh System 7 would have built-in TrueType outline font technology, the standard Macintosh screen bitmap fonts would become obsolescent. Apple was faced with several alternatives:

(a) Keep the Apple fonts in bitmap format for display on screens only, but substitute different, outline fonts for printing. (This would have been like the solution for the original LaserWriters, which for New York substituted Times[®] Roman glyphs coerced to New York metrics; for Geneva, Helvetica[®] glyphs coerced to Geneva metrics; and for Monaco, Courier glyphs coerced to Monaco metrics. There was no substitute for Chicago.)

This would have been a retrograde choice. It would have had the advantage of being relatively easy, but the disadvantage of shackling System 7 to an outmoded technology. The screen bitmap fonts could not have been scaled, rotated, or transformed with the same quality and facility as outline fonts. This would have made it difficult to use the system with other resolution displays, with gray-scale, and so on.

(b) Abandon the original Apple fonts for both screen and printer, in favor of outline fonts from outside vendors. This would have been a draconian solution that would have eliminated the problem of updating the Mac fonts, but would have had the

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disadvantages of changing the distinctive look of the Mac interface, of creating a gap between Mac systems, and of making Apple dependent on outside font vendors for its core system fonts.

(c) Develop outline versions of the principal Macintosh bitmap fonts. This was technically and artistically the most difficult alternative and would involve the most development work. But the difficulties also made this the most interesting path, and gave Apple the greatest flexibility, freedom and strategic independence for any future system strategy. In addition, should the need arise, the basic four Apple fonts could someday be expanded into complete families, including roman, italic, bold italic, and so on.

Traditional font developers and vendors license their fonts with various restrictions. For example, fonts might need to be encrypted to discourage piracy of designs and digital data; users might be prohibited from modifying designs or from adding and replacing characters, or from encapsulating fonts with documents, exchanging fonts on networks, and so on.

From the font developers' perspective, such restrictions are often reasonable, because US copyright law does not protect typeface designs, and provides only minimal protection to typeface digital data and programs. Because the creation and development of new fonts is a costly undertaking, like software development, font developers want to maintain some control over the commercial fate of their fonts. Nevertheless, from the users' perspective, fonts are more useful when users can freely modify the forms, add or replace characters, develop special versions for special purposes, exchange them over networks, and so on. Moreover, strategically, Apple could maintain the most options for its System software by using Apple-owned fonts that are not subject to restrictions from outside vendors. By developing a set of TrueType fonts based on existing Macintosh fonts, Apple could provide fonts for Macintosh users that would be free of most of the common proprietary restrictions. The Apple fonts would be "open fonts", so to speak. Furthermore, by providing fonts whose outlines and hints were clear, Apple could help users better understand the workings of the TrueType outlines and hints, since the fonts would serve as examples.

2. The design methods

Typeface design, like graphic design, is an applied art. A successful type design is a solution to a problem, which may involve aesthetics, technology, legibility, semiology, and pragmatics. The problems and methods involved in designing the Apple Fonts included:

(a) Converting bitmap fonts to outline fonts

The design process would be *bottom-up*—starting from bitmaps and going to outlines, rather than *top-down*—starting from master outlines and rasterizing to bitmaps. Various techniques for converting bitmaps into contours defined by mathematical curves have already been developed and applied to fonts. (The interested reader is referred to References [1] and [2].) In general, all of these techniques work best with high resolutions. Ideally, for software conversion of bitmap to outline without human intervention, the

resolution of the input bitmap should be twice the resolution of the em square (body size) of the output outline font. For a TrueType resolution of 2048 units per em, the bitmap font should be 4096 pixels per em. In practice, with considerable human designer intervention, bitmap fonts with resolutions as low as 100 pixels per em can be converted to outlines, though the quality is not as high as for fonts that are developed with more accurate methods.

Unfortunately, the standard Apple font bitmaps ranged from 12 pixels to 28 pixels per em—far too low for automatic conversions from bitmaps to quadratic curves. This meant that the outlines for the Apple Fonts had to be developed from scratch, not from conversions of bitmaps.

(b) Design and digitization tools

B&H chose to use a combination of traditional letter drawing techniques, tablet-based digitization hardware and software, design processing software, and interactive font design tools. For all four Apple Fonts, Ikarus font software from URW was used on two different platforms — VAX minicomputer and Macintosh IIx. We experimented with several different font design tools for the Macintosh, but Ikarus offered several advantages. It could be used on two different platforms, which increased the range of its functions. The VAX-based system provided several batch-oriented processes for digitizing from drawn artwork, preparing, cleaning, and adjusting the font outline data. The Macintosh-based IkarusM system provided good interactivity for direct design at the computer, and facilities for converting from Ikarus to TrueType outlines. Also, we were familiar with Ikarus, having used it extensively for several years to develop our Lucida[®] family of fonts, so development was more efficient with familiar tools.

In many cases, the designs were first developed with traditional tools — pencil and paper. When a pencil sketch was ready, it was redrawn precisely on dimensionally stable Mylar drafting film. This production drawing was then digitized using an Aristo tablet and Ikarus software on a VAX. After further processing, proofing, critiquing, editing, correcting, etc. on the VAX, the font files were transferred to a Macintosh IIx, where further testing and editing was done using IkarusM. At a later stage, we installed a tablet on the Macintosh so that designs could be digitally input at either platform.

The Ikarus software allowed B&H to digitize and process the letter designs at a very high resolution — 15 000 units per em. This very high accuracy, almost eight times the target TrueType em square of 2048 units, helped us to produce clean and regular data. We wanted a high degree of accuracy because "clean" outline data facilitates the hinting of fonts. Our outline fonts in the Ikarus IK format were converted to unhinted TrueType outlines using a special beta-test version of IkarusM which outputs TrueType. We tested a couple of different Ikarus-to-TrueType curve-conversion algorithms developed by URW, before choosing one that gave the kind of curve point-distribution we wanted. (URW has since released a commercial version of IkarusM which produces TrueType output.) Additional adjustments of the TrueType font data structure, its tables, headers, etc. were made using "Ingredients" software from Projective Solutions.

Unhinted TrueType outlines were further tested at Apple, at screen, printer, and typesetter resolutions. Adjustments to the designs were achieved in a variety of ways, depending on the nature of the changes. Fundamental changes to letter designs were made in Ikarus format on the Macintosh and the fonts reconverted to TrueType. Many

other changes were made by editing TrueType outlines directly, with Apple's RoyalT font editor. In the final stages of the font development, Apple's internal designers contributed many fine-tunings to the designs using various Apple tools. Apple also implemented all the hints on the fonts.

(c) Metrics

To make sure that the outline fonts could adequately replace the bitmap fonts, it was important to preserve the main metrics (such as body size, cap-height, x-height, advance widths, etc.) of the bitmap fonts in the outline fonts. This was a difficult problem because the bitmap fonts were not linearly scaled. The original bitmap fonts had been developed by interactive hand-editing at each screen size, and the designer(s) had adjusted the metrics of each size according to how the font looked on the screen. This meant that the proportional widths of letters changed from bitmap size to size. Some letters become proportionally wider, some narrower. These changes had not, however, been done according to a single ratio. Therefore, it was impossible to make a single outline font that would agree in metrics with the bitmap fonts, because the bitmap fonts did not agree among themselves.

To find the best compromise for each letter width, we calculated its arithmetic mean, median, and mode from the bitmap metrics. We started each letter design at the mean width, and tested it with other letters. If the resulting visual effect showed that some adjustment was necessary to achieve a good rhythm in text, the width metric might be adjusted toward the median or the mode. In some cases, it was necessary to adjust the width toward an extreme (outlying) width value.

In adjusting the visual look of letterforms in coordination with their width values, we found it helpful to consider the weighting of the letters according to their character frequencies, i.e. which letters are most frequent, which infrequent, and so on. For example, since 'e' is the most frequent letter in English, representing more than 12% of English text, any change in its width value will have a strong effect on the overall width of an average text. A change in 'z', on the other hand, will have a minimal effect. The letter frequencies are different for capitals and lower-case, so that also had to be taken into account. The resultant width values are hence derived from a series of compromises and adjustments between visual, metrical, and orthographical–linguistic pressures on the designs.

(d) Family coordination

The Apple bitmap system fonts are used together, but they share few design characteristics. They are more like a loose confederation than a tightly knit family. In this way, their relationship is like that of Times, Helvetica, and Courier — different and unrelated designs caught up in a single net, more by historical accident than by design. When B&H began to develop the set of four Apple fonts, one major question was how much to coordinate their design features. We had learned from experience to ask this question early in the design process. Before starting the Apple Fonts project, we had spent several years developing the Lucida family of types, which is a coordinated set of seriffed, sansserif, fixed-pitch, and other styles, intended for digital displays on screens, medium resolution printing, and high-resolution typesetting. Lucida has been used on a wide variety of systems and publications and so we believed that our experience in developing that "super-family" could be helpful to the Apple Font development.

The heart of type design, even for computer systems, lies in visual perception, not in logic or mathematics. Designers are seldom able to compute the features of a design from first principles. Instead, type design is an experimental art, trial and error being its basic method. We sketched out some ideas of how the Apple Fonts could be tightly coupled into a super-family, but ultimately rejected the idea because it would necessitate a homogenization of the designs, and hence a loss of their distinctive differences.

However, the bitmap sizes were similar enough in some ways to permit a lower-level coordination — that of "alignments". To allow users to mix New York, Geneva, and Monaco without being surprised by unpredictable differences in apparent size, we coordinated the heights of capitals and lower-cases, as well as basic stem weights. The basic design features are distinctive for each font, but the letters sit on the same baseline and have the same heights and depths. We felt that this provided a useful degree of rationality, without diminishing individuality.

Chicago, which is not only different from the Macintosh fonts, but divergent from most text fonts, was not drawn into the coordinated group. Because Chicago is such a distinctive element in the Macintosh interface, we decided to make the outline font conform as closely as possible to the bitmaps.

The decisions that shaped the individual designs are further discussed in Section 3 below.

(e) Hinting

TrueType fonts are *hinted*. That is, they include programs as well as outline data. The programs are principally used to adjust the outlines to the digital rasters of displays and printers, so as to ensure high-quality, legible output throughout the range of resolutions. The hinting of the Apple fonts was done by others, but throughout the design process, we were aware of, and designed for, the eventual hinting of the fonts. The repetitive elements, such as serifs or stem terminals, were carefully designed and organized into classes. Stem weights were carefully coordinated. Alignments of rounds and straights were carefully adjusted throughout the fonts. In general, the cleaner and more regular the outline data, the easier it is to apply hints to the fonts. However, this does not mean that fonts should be entirely homogenized, because subtle differences in form are often important to the overall look of a typeface. So, there is also a good deal of variation in certain features of the fonts, but a carefully planned variation. Weed for clean, regular outline data and good visual rhythm, but also wanted to produce lively designs with a pleasing degree of variation.

3. The Apple font designs - historical styles and semiological forms

The Macintosh screen bitmap fonts are so low in resolution that they offer no way to determine the fine features of an outline font, which may be 100 or 200 times finer in resolution. Therefore, we had to use various detective methods to determine which historical or stylistic antecedents, if any, the designs should adhere to.

1. New York. The bitmaps show that New York is a seriffed font. Certain features also suggest that it is a vaguely "Old-style" face, in the Anglo-American typographic parlance

(also called "Garalde" or "Antiqua" in European terminologies). The Old-style faces began with the types of Aldus Manutius in 1495 and lasted through the work of William Caslon, who died in 1766. The style encompasses the designs of Garamond, Granjon, Van Dijk, Kis, and other type designers who worked in the 16th, 17th, and early 18th centuries. Old-style types retain some affinity with the writing of Renaissance humanists and scribes, whose writing styles were the models for many early printing types. Times Roman, though a 20th century design and much altered by various hands for various reasons, is distantly derived from Old-style models.

Despite the loose affinities between New York and Old-style faces, we thought it best to avoid imitating Times Roman or Garamond (which appears today in many versions, some more and many less faithful to the work of Claude Garamond). For one thing, the proportions and width metrics of New York are very dissimilar to those of Garamond and Times. In bitmap form, New York has a very large x-height and short ascenders, descenders, and capitals. This is a consequence of designing fonts directly for the screen, where the designer is tempted to increase the x-height in order to gain as many pixels as possible to define the lower-case forms, which account for the majority of text. Ascenders, descenders, and capitals become abbreviated as a result. Partly as a consequence of the extra-large x-height, the widths of New York characters are wider than those of Garamond, Times, and most other Old-style faces. Since typefaces work best when they have their own visual integrity, an attempt to make a Garamond or Times with New York metrics would inevitably lead to unhappy distortions. A second important point was that imitations of Times and Garamond would be unnecessary. Those popular designs would certainly become available in TrueType format sooner or later, and users who wanted particular designs would be better off to obtain the real things, not imitations. This left us free to develop New York as a coherent design that could take its own form, within the constraints of the existing New York metrics.

The result is a typeface that shows many typical Old-style features: a medium stem weight (1/6 of the x-height) and medium density or "colour" in text; wedge-shaped serifs on the x-line and on ascenders; strongly bracketed base-line serifs; moderate contrast between thick and thin elements, such as between stems and hairlines; generous widths to most lower-case characters. After some experimentation, we decided on an early Renaissance feeling, more like the types used by the Venetian publisher Aldus than like those cut by Garamond a half-century later. This tendency can be seen in the terminals of lower-case letters like 'a', 'c', 'f', 'r', and 'y' which have a sharp, angled cut-off, more like the pen-written humanist minuscule that was the model for Renaissance roman types, than the blob-like rounded terminals found on those letters in later Renaissance designs like Garamond.

Our studio has always specialized in difficult design projects, and this was no exception. It was a fun challenge to develop forms with clear affinities to scribal handwriting within the very strict confines of a set of bitmaps developed on a computer screen in the 1980s.

The New York capitals were based on Renaissance interpretations of classical Roman inscriptions (though somewhat narrowed in order to fit the New York bitmap metrics). Early in her lettering career, Kris Holmes studied the tradition of brush-writing roman capitals with Robert Palladino, a former monastic scribe who had been a student of Fr Edward Catich, the expert on the classical capitals of the Trajan inscription. Later Kris also studied briefly with Catich himself. Kris's feeling for the swing and flow of the

classical capitals is evident in the cohesiveness and confidence of New York caps, even though these are far from tracings of traditional inscriptions or type designs.

Despite these historical tendencies, New York is not a resuscitation of a traditional typeface. Unlike Renaissance types, New York has a very large x-height, as previously mentioned, and the internal elliptical counters of the letters 'o' and 'O' are upright, making the letters bilaterally symmetrical. In Renaissance faces, the internal counters of round letters are always tilted, reflecting the typical ductus of pen-written letters. The Apple character set is much larger than that found in historical Renaissance faces, so it was necessary to design new characters to meet the needs of modern typography within the *canon*, so to speak, of the New York Renaissance style.

Given its name, we wanted the New York type to exhibit some of the sophistication, the confidence, the style and braggadocio of the Big Apple itself — the big-time, glittery, urban excitement of Broadway, Fifth Avenue, and the hot spots of the metropolis. One feature that gives New York a forceful effect is its very large x-height. Set in text, Apple New York seems at least one or two point sizes larger than the same size of Garamond or Times. At small screen sizes, there is not much significant difference between the original bitmap New York and the new TrueType New York, but as the point size increases, or when the font is printed on a laser printer, all the subtle and refined modulations of TrueType New York become evident — the crisp, sharp detailing of serifs and terminals, the emphatic bracketing or flaring of stems into serifs in capitals and lower-case, the lively springing of the arches from thin hairlines to thick stems in 'n', 'm', 'h', and related letters.

New York, in comparison to some familiar Old-style faces, is a stronger, more emphatic face than Garamond, broader and more generous in scope than Times, and produces larger screen bitmaps than either. New York is also more calligraphic in feeling than either Garamond or Times, though not so calligraphic as Palatino. The New York caps have a classical look, though being somewhat narrow in proportion, do not take up as much horizontal space as some other classical capitals. TrueType New York is a good face to choose when a Renaissance look is desired, but when low- or medium-resolution technology or other circumstances make a large x-height, strong design preferable to more delicate traditional Old-style faces. New York is also useful when one simply wants a change from the ubiquitous Times Roman or the various Garamonds.

2. Geneva. Geneva is a sans-serif type. Unlike New York, for example, it lacks the short thin strokes at the terminals of its main strokes. As font aficionados know, there are many styles of sans-serif. The well-known Helvetica sans-serif is a style known as "Grotesque" (this is not a pejorative term, but the traditional typographic name for a semi-constructive style of typeface design developed in the 19th century). Helvetica was derived from a late 19th century German sans-serif called Akzidenz Grotesk. Indeed, Helvetica, developed in the mid-1950s, was first named Haas Neue Grotesk, but as with movie stars, its name was later changed for marketing reasons. The style and name of Akzidenz Grotesk was in turn derived from an earlier English typeface, Grotesque, produced by the Thorowgood foundry in 1832.

It was clear from the original Apple bitmaps that Geneva was more or less "Grotesque" in style, but was not an obvious imitation of any existing design. As with New York, we decided that it would be better to develop an entirely new design, within the metrical restrictions of Geneva and within the design style of Grotesque, than to try to

imitate any existing sans-serif. The reasons were similar to those cited for the New York design. An adaptation of an existing design to Geneva metrics would inevitably cause unpleasant distortions, and, in any case, users would sooner or later be able to get familiar Grotesque faces such as Helvetica and Univers in TrueType format.

In designing Geneva, we followed many of the Grotesque stylistic features — slightly narrowed character widths, a visually near-monoline appearance (though a moment's study will reveal that actually the line thickness varies considerably, for example at the join of the arch of the 'n' to the straight stem), smoothly modulated arches in the 'h', 'n', 'm', etc., slightly hyper-elliptical rounds, as in 'o' and 'g', a somewhat geometric feeling to the capitals, and, of course, a large x-height.

However, Geneva has some features not found in well known grotesques such as Helvetica and Univers. In particular, the semi-enclosed counters of letters like 'a', 'c', 'e', and 's' are more open; the terminals do not enclose the internal spaces as much as in other Grotesques. Even though the terminals end with a horizontal cut-off, there is more breathing room for the internal white space. This keeps the counters open and the terminals from visually joining at small sizes, which allows for better differentiation of the letterforms. Also for better differentiation, the small white triangles that define the joins of letters like 'n' and 'p' are cut deeper than normal. That small, bright white nick in the outline helps define the individual characters. Better differentiation and individuation makes for better legibility, because readers can tell different characters apart more easily. The Geneva capitals, while following the main Grotesque style, have slightly more classical forms, and are designed to work well together. Hence, a line of Geneva capitals makes an interesting but readable pattern, and because of the slightly narrowed widths, is somewhat economical in space.

The result is a sans-serif that can be successfully used for various kinds of text as well as for headlines and display. In addition to its use on the screen, Geneva can be used for printing when a new sans-serif look, different from common Helvetica, is desired.

3. Monaco. TrueType Monaco is Kris Holmes's salute to Macintosh programmers, electronic mail users, and others who are often faced with fixed-pitch text. At the beginning of the Apple Fonts development, Kris made a persuasive argument that TrueType Monaco should be made into as lively and legible and fun a font as possible, while remaining fixed-pitch (monospaced). She believed that users of fixed-pitch fonts on the Macintosh should not have to put up with stiff, rectilinear designs left over from primitive dot-matrix terminals and line printer fonts, nor with traditional typewriter fonts, which, despite their many good qualities, were never designed for low resolution digital imaging. Instead, she thought it would be possible to start over entirely, re-think the look of the standard fixed-pitch fonts for the Macintosh environment, and create a design that would be more exciting to use and more legible.

The original Monaco bitmaps came in only two sizes, 9 and 12 point (12 and 15 pixels per body, respectively), which limited their flexibility and usefulness on the screen, since scaling of bitmaps to other sizes inevitably produced inferior quality. The bitmap Monaco designs have the squared-off look common to fonts on earlier generations of terminals and printers. This is not entirely unreasonable, since it could be argued that retrograde functions like terminal emulation should have a retro look. Kris, however, felt that more life could be given to the monospaced style.

In designing Monaco, we were able to draw upon the experience and knowledge gained from designing two other original families of fixed-pitch faces for bitmap screens and laser printers: Lucida Sans Typewriter and Lucida Typewriter. Lucida Sans Typewriter in particular has enjoyed a great deal of popularity, appearing on a wide variety of workstations, graphics terminals, terminal emulators, and line printer emulators. We had also done experimental versions of fixed-pitch fonts for AT&T Bell Laboratories and other research institutions. The Lucida Typewriter and Sans Typewriter families were necessarily closely allied in form and feeling to the other members of the Lucida family. Monaco presented an opportunity to create a new monospaced typeface that could have a uniquely individual style.

Because Monaco would be used for programming, it was crucial to achieve adequate differentiation of letter forms. In particular, programmers often complain when the designs of the letters 'O' (capital O) and '0' (zero) are similar, and when capital 'I', lower-case 'I', and figure '1' are similar. The bitmap Monaco fonts were not satisfactory in this regard. The problem is further complicated in orthographies that use the 'Ø' (capital O-slash). Therefore, TrueType Monaco has a careful differentiation of these forms. The zero has a diagonal slash through the centre, which effectively differentiates it from the capital 'O' in a manner common in older terminals, but the zero slash does not protrude from the body of the letter, which distinguishes zero from O-slash. Capital 'I' has four horizontal serifs, whereas lower-case 'I' has only two serifs, asymmetrically arranged, one at top left and one at lower right. The figure '1' has two horizontal baseline serifs, but only one flag-shaped diagonal serif at top left, differentiating it from both 'I' (upper-case I) and 'I' (lower-case I).

TrueType Monaco also has an improved differentiation of curved, rounded, and straight letters. At low bitmap resolutions, amateur designers are sometimes tempted to make all the letters "squarish" — straightening up the sides of 'o', 'v', 'A', and so on. But when all the letters are basically rectangular, they cannot be differentiated, with consequent loss of legibility. In TrueType Monaco, curves remain curved, diagonals diagonal, and so on. The face is hardly traditional, but it has much of the legibility of traditional designs.

Monaco achieves its liveliness in various ways. The lower-case 'a' of bitmap Monaco is a "single-storey" 'a', unlike that of Geneva, for example, which is a "two-storey" 'a'. This feature is usually found in *cursive* rather than upright lettering, and is a distinctive and rather charming feature of bitmap Monaco. Therefore, it was retained in TrueType Monaco, and propagated to related letters, including 'b', 'd', 'g', 'p', 'q'. This cursive feature makes Monaco very distantly related to the formal calligraphic handwriting of the 16th century, the so-called *chancery cursive*, which was written by Queen Elizabeth I, among others. (Modern versions of the traditional chancery cursive included ITC Zapf Chancery designed by Hermann Zapf, or Lucida Calligraphy by B&H.) The asymmetrical treatment of the serifs of TrueType Monaco 'I' and 'i' is another cursive feature. So are the joins of the arched letters like 'n', where the arch springs from a relatively low point on the stem, giving an active feeling to the letters. Hence, despite its predominantly sans-serif and technical bias, Monaco has many elements derived from cursive handwriting. These give the face a lively but readable pattern in text.

4. Chic If Monaco is the TrueType Mac font least faithful to its bitmap predecessors, Chicago is the most faithful. Macintosh Chicago is a distinctive design. There are few faces quite like it in traditional typography, even among so-called "display" faces, used for headlines and titling. Because Chicago is deeply integrated into the Macintosh System, used in menus, titles, etc., it is a fundamental part of the look of the Macintosh. To change the design would be to change the look of the Mac user-interface, and neither Apple nor B&H wanted to do that. Therefore, we designed TrueType Chicago to produce bitmaps that would be nearly bit-for-bit identical to the standard bitmap Chicago at 12 point on the screen.

In analysing Chicago, we noted that it was a highly "constructive" face. That is, nearly all the letters were constructed out of a small number of simpler design elements — stems, corners, etc. The idea to construct fonts geometrically is hardly new. It was especially popular in the Renaissance, as seen in various works, such as those by Felice Feliciano or Albrecht Dürer. It occurred to us that it would be possible to preserve the distinctive look of Chicago by following its underlying theme and constructing it out of a small set of geometric elements, in a modern version of the Renaissance constructed alphabets. Of course, the Renaissance geometers and lettering artists never dreamed of anything like Chicago.

The bitmap Chicago contains no curves, only staircases, but at a normal reading distance from the screen, 12–24 inches, the jagged corners seem smoothed out and possibly curved, while the main stems and main parts of curves remain straight — vertical or horizontal. When printed out on a laser printer with the text-smoothing option 'on', bitmap Chicago is rendered with pseudo-circles at its outer corners, rather than diagonal staircases. With these aspects in mind, we developed a plan to use straight lines and arcs of circles to construct the whole font. By using semi-circles for the internal arches and counters, and quarter-circles for the outer corners, we were able to impart a Romanesque feeling to the design. It was built from thick columns and roman arches, directly on the Macintosh, using IkarusM.

We did add some features that are not seen at 12 point, but which improve legibility at larger sizes and higher resolution. Among such features is a sliver cut into the join of the arch to the main stem of letters such as 'n', 'm', 'h', etc. This small, simple feature helps differentiate the top of 'n' from the top of 'o', for example, which is especially important when both letters have straight vertical sides. The lower-case 'a' often has a troublesome join of the upper arm with the lower bowl. While this was left at 12 point, to maintain bit-for-bit fidelity, we modified it slightly for larger sizes.

Despite these few modifications, we did not attempt to bring Chicago into line with the traditional aesthetic criteria of font design, but instead attempted to faithfully translate most of Chicago's features, even the more quirky ones, into outline format.

We also added a large number of extra characters to Chicago. Not only did we fill out the standard Macintosh character set (in which bitmap Chicago was deficient), but we also added several glyphs for control characters that can be accessed by the system and applications.

Chicago imparts a "fun" quality to the look of the Mac, and designing the TrueType Chicago was also great fun. The basic design was to be preserved, and the main design problem was how to construct it simply, elegantly, and logically.

4. Conclusion

We hope that the above summary gives some idea of the technical and artistic planning and development that B&H put into the Apple Fonts. What it leaves out is the important work that Apple's own typographic staff put into the font planning and production of the fonts. The Apple font team of programmers and designers made many contributions to the project, including the important task of hinting the fonts.

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