Typesetting For Everyone

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Abstract

Continuing advancements in microelectronics are providing low cost, high speed processing capabilities to an increasingly larger segment of the population. Parallel developments in the areas of charge coupled device digitizers for input, and various non-impact printing technologies for output, are forming the basis for complete publishing capabilities that are available to everyone, from corporate executives to housewives.

Non-impact printers are presently available which provide 300 dot per inch resolution, multiple font selection, and 8 pages per minute output for under $3000. Prices for such capabilities will drop to $1000 by 1987. Improvements in quality and speed are primarily limited by memory costs, speed, and the capabilities of raster image processors.

In the Fortune 1000 environment there are ever increasing areas within such companies that are involved in various forms of publishing and, until a power center is identified, it will be difficult to determine how and when this market will mature.

Important to all market segments utilizing this new technology is the understanding of capabilities, limitations, and future developments. Operating with a knowledge of these factors will enable the successful application of products across broad markets and functions from prepress departments to the home computer.

Typesetters and imagesetters based on non-impact imaging devices are steadily decreasing in price while improving in resolution and functionality. Similar progress in the areas of digitizers and bit-map terminals are enabling the configuration of low cost publishing systems and the application of such devices in traditional as well as evolving markets.

Transition

One of the areas making non-impact printers useful for typesetting applications is the transition to low cost digital typography (Figure 1).

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Transition to Low Cost
Digital Typography

- Low resolution and limitations of the output device
- Necessitates more attention to editing for specific output devices
- Limits the available fonts
- Drives the creation of new designs

Figure 1: Transition to Low Cost Digital Typography

As type has been developed for such devices, designers and users of type have faced the problems posed by the limited resolution of current, commercially available products. Resolution limitations and differences in imaged dot characteristics (shape, size, substrate penetration, edge acuity, etc.) necessitate more attention to editing of type. This in turn initially limited the availability of quality typography, particularly at resolutions below 500 lines per inch.

As type suppliers began to understand the characteristics of various non-impact imaging technologies the quality of available typography improved due to special bit map editing of the characters and new type designs which were developed specifically for use on such devices.

Interesting to note is that two non-impact printers, imaging with the same resolution, spot size, energy profile, image transfer mechanisms, etc., but with different fusing characteristics can produce entirely different printed dots, and therefore two different esthetic looks of the characters.

Further, character spacing (including kerning and hyphenation and justification accommodations) at these low resolutions also requires very careful consideration. Often times the spacing used at typesetting resolutions (600 lines per inch and above) is not easily devisable into the typical 300 lines per inch increments (going to 480 lines per inch) in use today. Further, some machines do not allow the imaging of one resolution element, thus the addressability may be 300 lines per inch, but the resolution may effectively be less.

Type Licensing

The availability of type is also dependent on the structure of licensing agreements by the various type vendors and the decision on what strategy to use in marketing type.

This is sometimes referred to as "The Name Game". Here the issue is whether the user of type will opt for traditional typeface names and designs, or if other typeface names are suitable (which are not recognized by the industry, but have designs highly similar to the traditional faces).

Although not an issue in the United States at this time, the legalities of copying a typeface design and simply giving it a new name are beginning to be addressed in Europe where actual character designs and artwork may receive some copyright protection. In the United States only typeface names are protected.

These issues (for Europe) can become increasing more complex when a judgement must be made as to how much alteration of an original typeface design is required before it is no longer considered the same design and can thus be used without copyright infringement. Procedures for this judgement are evolving through a World Intellectual Property Organization convention being developed in Europe.

Due to the complex issues involved in digital typography, manufacturers and suppliers of non-impact printing equipment which require typeface libraries are tending to turn to specialized vendors to solve their type requirements.

More Type

Aside from the traditional reasons of increased readability and more efficient utilization of space, vendors are also driven by competive pressures into expanding type availability. For these reasons, and the very moderate increment in purchase price, we can expect to see continued improvements in quality and diversification of type offerings.

It is not unrealistic to expect the "Type of the Month Club" in the near future where the amount of type procured is only limited by the memory space provided for storage of this type. Look to the day when typeface names will be advertised on television.

Generally speaking, the acquisition of type from third parties can involve several potential expenses for the acquirer of the type: (1) Initial cost for digital data, (2) costs to have digital data edited for the specific imaging device, and (3) ongoing royalty payments for each transfer of the typeface to an end user.

Digital Type Storage Formats

There are three general methods currently in use for the storage of digital type: stroke, outline or vector, and bit map (Dunn, 1983).

Stroke notation (Figure 2) has dominantly been used for storage of type on cathode ray tube (CRT) based imaging systems. The overlap of strokes is typically 50 percent due to the gausian energy profile of the writing spot. Stroking data is not generally compatible with raster imaging and offers no advantages (over outline) and therefore is generally not used in the newer technologies.

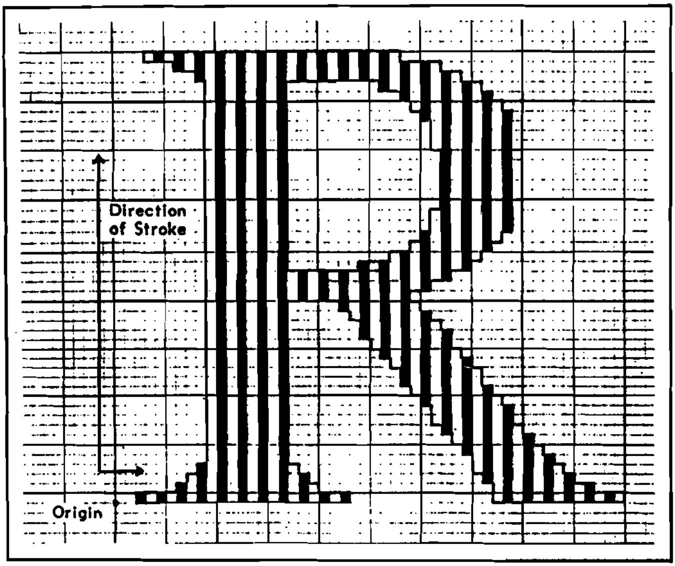


Figure 2: Stroke Notation

Vector or outline formats (Figure 3) for type are finding increased usage for applications requiring high flexibility. The vector format necessitates specialized hardware to decode it and generate the bit maps ultimately required. It is also difficult to edit and can compromise character legibility when used for a wide range of point sizes on low resolution output devices.

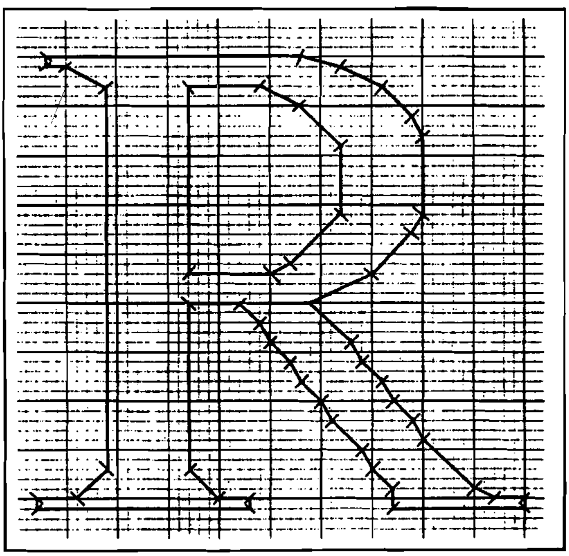


Figure 3: Outline Format

On the other hand, vector format requires less storage space than bit map or stroke formats and allows scaling, rotation, and obliquing from a single (or multiple) master.

There are many companies working on the optimization of outline type for a variety of applications. Special algorithms addressing the peculiarities of various output technologies (particularly in the low resolution category), multiple masters for specific point size ranges, and high vector encoding frequency are all being investigated as ways to reduce deviation between printed character shape and the original character design.

Bit map storage of type (Figure 4) offers the highest correlation between original characters and output characters. Editing of bit map type is relatively simple although labor intensive. Fonts can be individually optimized at each point size for the output device characteristics. Typically bit map type is stored in some form of run length code, which is decoded in the Raster Image Processor (RIP).

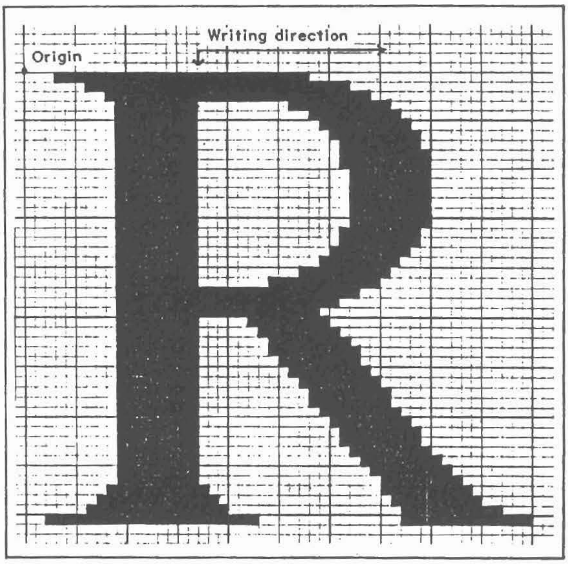


Figure 4: Bit Map Format

A disadvantage of bit map typography is its high data storage requirements. A bit map of each character at each size, weight, rotation, and oblique angle must be stored to maintain optimum quality, especially at low resolutions. Even at high resolutions, bit map data is difficult to manipulate (size, rotate, etc.) and maintain quality. The necessity of hand editing for the above variables and the output device characteristics also involves considerable skill and labor.

The use of bit map type in a printer is less complicated and faster than other type formats, as stored characters are more easily read out of memory without any pre or post processing (except to decode the run length code).

Raster Image Processors

One key technology making the use of non-impact printers possible is the Raster Image Processor. This device transforms data from a coded format into a bit map form compatible with the sequential imaging of raster scan lines down (or across) a page (Dunn, 1985). The coded graphic elements which must be transformed may include one or more of the following:

Page Description - This describes what types of elements are on a page and where these are located. Depending upon where the digital type data is stored and how it is utilized, this may include the X-Y coordinates for each character position, as well as the coordinates for images.

Type - Previously discussed were type storage formats and how type would be used in these formats.

Vectors - Information in vector form includes some line drawings and information passed from vector based systems. Outline type is also generally in vector form.

Graphic Primatives - These are elements such as circles, squares, polygons, and graphics which can be represented by combinations of these elements. Typically these are stored as mathmatical instructions.

Patterns - These are highly structured images used repetitively, such as tints, borders and lines.

Logos - Corporate or product identification symbols may be stored in bit map or vector format. In either case, the method of acquisition and editing must be addressed.

Pictures - Continuous tone pictures are generally captured using some type of input scanner. It is more efficient to manipulate and store these pictures in continuous tone form, translating them to halftone bit maps upon output to the imaging device.

Low Cost Input Devices

The past year has shown substantial improvments in the price/performance ratio of charge coupled device based monotone digitizers for continuous tone pictures and line art. Prices range from $300 to well over $5000, and functions such as data compression, optical character recognition, and cropping, sizing, and threshold control at input are available. At the low end, resolutions are in the 200-300 line per inch range (over an 8.5 inch page width). More sophisticated units are capable of over 900 lpi for an 8.4 inch scanning width using optically abutted charge coupled devices and interpolation techniques. Further, the size of individual arrays (number of elements) continues to increase.

While the resolving power and processing capabilities of low cost models are probably currently not suited to commercial printing production environments, they may be viable solutions to the lower quality monotone applications.

Displays

Bit map displays are becoming the dominant display technology, principally due to their What You See Is What You Get (WYSIWYG) capabilities. In reality, due to the limited resolving power of current display tubes, the screen provides a WYSIMOLWYG (What You See Is More Or Less What You Get) display where operators can get a good idea of the content and placement of elements on the page.

WYSIWYG or WYSIMOLWYG displays are necessary for the efficient usage of non-impact printers with word processing front-ends, as operators are unable to make accurate pages without visual feedback on element placement from the screen. As such, a current trend is for traditional word processing terminals to:

(1) Feed bit map composing terminals and eventually

(2) be replaced by bit map terminals.

WYSIMOLWYG is primarily used to display representative fonts in place of the actual fonts to be used at output. The intention of this font representation is to provide feedback to the operator on page balance, line endings and page endings.

Here again the display resolution limits character spacing decisions on the display (typically 75-100 dots per inch).

For representative fonts, it is desireable (whether on a display or a proof printer for later typesetting) that the font width tables of the output device (as well as kerning, etc. if in use) be used to get line endings, etc. from the display.

Typically eight typefaces are used for WYSIMOLWYG.

Serif Medium, Bold
Serif Italic Medium, Bold
San Serif Medium, Bold
San Serif Italic Medium, Bold

Personal Computers and Publishing

The availability of low cost standardized microcomputers with bit map displays and price erosion of non-impact printers has lead to the development of software programs which, when combined with the appropriate hardware, offer low-end publishing capabilities. Also significant here is the development of interfaces which allow files generated with PC based software to be output on higher resolution phototypesetters to photofilm or paper, using the typeface libraries of the output devices.

Figure 5 shows two of the major personal computer hardware manufacturers, a small sampling of the many software companies who have page composition programs for these personal computers, and how the components might be configured.

PC's & Publishing

Apple –

Macintosh

Adobe

- **Aldus**
- **Boston Software**
- **Others**

Canon

Linotype

IBM–

IBM PC

Page Planner

- **Bestinfo**
- **Concept (QMS)**
- **Studio Software**

Linotype

Figure 5: Personal Computers and Publishing

Figure 6 lists some of the attributes of the Apple Macintosh. Such products are significant due to their low cost, ease of use, software availability, and hardware support. They are also exemplary of the continued improvement in the price/performance of computer hardware and output devices.

The Significance of the Macintosh

- First bit-mapped system under $3000
- Simple user interface
- M68000 based
- Ability to handle various point sizes and styles plus graphics
- 'High resolution' display
- Full function RIP with Canon CX
- Micro-based publishing system
- Variety of page make-up software

BUT -

-Very slow

-Interfaces just arriving

Apple talk ($50 a connection)

Figure 6: Significance of the Macintosh

Some observers have commented that the 8 pages per minute output speed of the Canon LBP-CX (and products based on this output engine) is too slow. This is a moot point as this engine is not intended for volume output applications; mean time between failures is estimated to be 50,000 prints, and the 8 page per minute speed is a requirement of the electrophotographic process (Dunn, 1985). At the rated 8 page per minute speed the Canon product could produce over 3000 pages per shift and could exceed the mean time between failure in less than one shift month. It is also doubtful that an inexpensive microcomputer could keep generating new pages at a rate sufficient to feed the Canon, nor is it recommended that the CX be used at these daily rates.

The point is, it is not important for the raster image processor to keep up with the output speed capabilities of the Canon (or similar) product as it is intended for low volume applications such as master making, proofing, and single copy documents.

Printers, Technologies, and Resolution

The design of a non-impact printer is dependent upon its intended application. The advantage of non-impact printers is the flexibility with which products can be designed. Among the printer design issues are: multiple input trays, 2000 sheet input trays, simplex versus duplex (double sided), duty cycle required, and on-line bindery capability.

Primary output technologies being used in non-impact printers are: electrophotography, ink jet, magnetography, ion deposition, and those employing special substrates such as electrostatic, electroerosion, thermal transfer, etc.

With electrophotography there are a number of methods being used to image the photoconductor. Laser, light emitting diodes, liquid crystal shutters, and light shutter arrays using conventional light sources are among the techniques.

Those methods which employ arrays, whether used with electrophotography or not, should be approached with caution. The probability of an element failing in either the manufacturing process or while in actual use dramatically increases with arrays, and also depends on the size of the array. Particularly with low resolution printers, the failure of a single element within the array is easily detected with the naked eye.

Ink jet appears to be one of the primary contenders in the area of color and numerous manufacturers are pursuing the limits of the process in this area. It is also generally a quiet process, relative to other methods of imaging, but it does require specialized substrates to achieve optimum results (particularly with color), and the inks are water soluable which could require an overcoat for protection.

Magnetography has excellent possibilities for both high resolution and high rates of reproducing multiple copies from a single image writing. Here the advantage of the chromium dioxide imaging material is its ability to hold a latent image from which multiple cycles of toning and imaging can take place without rewriting the image.

The disadvantage of the process is the low sensitivity of the recording medium to light which necessitates a medium power YAG or Argon laser for image recording using the Curie point principle. If conventional magnetic recording heads such as those used for magnetic memory recording are employed, the resolution is limited by their packing density. Several manufacturers are developing recording heads capable of higher packing densities (in the 300 lines per inch and up range).

The resolution of non-impact printers has steadily increased since their introduction, as shown in Figure 7. It should be noted that the majority of these devicee have been based on laser electrophotography.

RESOLUTION PROGRESSES

company	resolution (lpi)	applications
		Dot Matrix
HP (early)	180	
IBM,Fujitsu, Ferix,Minolta, Delphax,Bull	240	
		Proofs
Canon,Xerox,Ricoh	300	Typesetting
Hitachi, Canon, Agfa	400-480	Line Art Halftones
IBM	600	
Tegra	506x1012	
		Film Imaging
Data Recording Systems	800(optional 1000)	
	1800	Color Scanners

Figure 7: Resolution Progresses

Applications for non-impact printers are determined by, among other factors, the resolution. It is clear that 300 lines per inch is sufficient for proofs of type in many applications and 600 lines per inch is practical for original type, line art, and halftones in certain markets. At resolutions above this we begin recording at, or close to, the resolutions used in phototypesetters and other more or less conventional graphic arts output recorders (except color scanners) used with photopaper or film.

Even at resolutions below those of conventional processes, non-impact printers can be competitive with the quality achievable at the low end of offset lithography, due to the fewer number of image transfers between the original and final image (See Figure 8).

THE RESOLUTION ISSUE

	Transfers
●Typesetting: 700+ lpi	
-Photopaper	1
Paste-up	
Line shot	2
Contact to plate	3
Ink to plate	4
Plate to blanket	5
Blanket to paper	6
●Non-Impact Printing: 180+ lpi	
Direct NIP (special materials)	1
Indirect NIP	
Expose drum	1
Tone drum	2
Transfer toner to paper	3
Fuse	4
plus process variables	

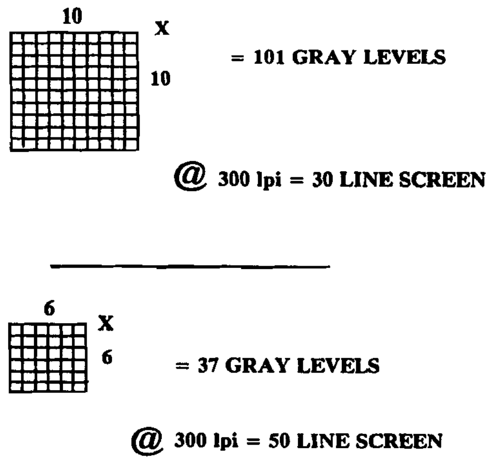
Each image is an original and, with appropriate toners, 300 lpi approaches the low end of offset quality

Figure 8: The Resolution Issue

End users find a particularly bewildering situation when evaluating manufacturers' claims of resolution. The resulting image resolution is quite often lower than the imaging system as transfer mechanisms degrade the original imaged quality. Other factors related to the original imaging method such as line scan overlap, spot size, and energy profile all affect the final results. Further, toner particle size, fusing, paper finish and many other parameters effect the final results.

Halftones output on non-impact printers currently involve a compromise between line screen ruling and number of gray levels when operating at a fixed output resolution. Figure 9 depicts two different combinations of screen ruling and gray levels when imaging with a conventional halftone cell structure at 300 lines per inch. Note this assumes the output device is capable of resolving a single pixel on the final output image.

HALFTONING



WHICH IS BETTER? –

50 LINE SCREEN WITH 36 GRAY LEVEL

OR

30 LINE SCREEN WITH 100 LINE GRAY LEVEL

Figure 9: Halftoning on Low Resolution Output Devices

Although this is certainly not the only method for constructing halftone dots, and a wide variety of techniques including error diffusion, dispersion, and random pattern algorithms are being investigated, there currently remains the basic compromise between line screen density and gray level values when working at fixed resolutions.

Markets and Applications

For non-impact based typesetters, or as outlined in this paper - imagesetters, the markets and applications are determined by four primary factors:

- Resolution required
- Volume and types of graphics used
- Run length
- Cost (for hardware, software, and consumables)

In the low end/high speed sector of this market we have seen non-impact printers steadily decline in cost to their present level of about $3000 (300 lines per inch, 8 pages per minute). For 1986 we project this will decline to $2000 and prices of $1000 and under are anticipated in the 1987/1988 time frame.

Further, the applications into specialized markets have been greatly extended by developments in the area of computer-to-plate. Figure 10 shows the on-going technologies here. Silver based plates sensitive to the wavelengths of the helium-neon laser can be used in commercial raster-based typesetters (imagesetters) employing this light source.

NOW PRINTING PLATES
(computer-to-plate)

- Ag Based
  - -3M: onyx
  - -Mitsubishi: DigiPlate
- Electrostatic
  - -Gestetner in Agfa P-400
- Erosion
  - -Aluminum/Plastic: IBM

Runlength: 2000 to 10,000+

Plate image quality: 65 - 130 line screen

Figure 10: Computer-to-Plate

Electrostatic paper plates are in use with standard electrophotographic printers using toner image transfer.

The electro-erosion process imaging aluminum-coated plastic plates provides the required oliophylic/hydrophylic properties of an offset printing plate.

Run lengths for these methods of direct-to-plate imaging range from 2000 to well over 10,000 impressions and screen rulings of 130 have been achieved (on the basic material with conventional contact imaging).

Opportunities

Dunn Technology projected over three years ago that development in the area of low cost non-impact printers/typesetters/imagesetters would lead to the franchising of the technology in a manner similar to quick print shops. This in fact has occurred (Figure 11) and is in practice.

FRANCHISING is HERE

- A la quick print shops-

  -Use their equipment and do it yourself

  or

  -Pay for the service

- Area/Market evaluation and assistance
- Technical Assistance to set-up shop and learn the technologies
- Hot - line for quick answers

Figure 11: Franchising is Here

Other opportunities include applications in specialized, niche markets where current resolution limitations and the cost trade off between consumables and prepress labor are favorable. These markets include:

- Checks - complete with booklet bindery
- Forms and financial printing
- Real estate and other specialized directories, catalogs, and listings
- Music stores
- Pictures on credit cards

Also key to these applications are the print-on-demand capabilities of non-impact imagesetters. Cost justification can often be done on the savings in eliminating obsolete stock and storage space alone.

Conclusion

Quality (i.e., resolution) will continue to improve at all speeds and price ranges. The limiting factors on the adoption of the technologies are:

- Memory speed and cost
- Service capability
- Software to utilize
- Market education

With current OEM prices for 1 megabyte of random access memory in the $100 range and steadily declining, along with access speed increasing, the limitations of memory speed and cost are becoming less important.

Service availability and capabilities will become a real bottleneck for users and it is likely the market will react too slowly, too late. The principle difficulty here is the multidiscipline training requirements. Laser printer service encompasses electrophotography, thermodynamics, lasers, optics, microelectronics and mechanical engineering among other disciplines.

Advanced features are developing at a rate at which it is difficult to keep abreast. Host and word processing software to practically utilize these features lags behind such developments and will continue to do so until some stabilization of the market/technologies occurs. (We do not foresee this in the near future.)

Perhaps the most underdeveloped area is that of market education. The path of information transfer between the laboratory and the consumer is long and fraught with many diversions and alterations. As the consumer becomes educated it would also appear to place demands for more honest representation of products, a much needed improvement.

Market awareness will also raise the quality expectations of the users being serviced by such technology and their demands on turn around times will increase.

The range of markets and applications will continue to expand and as resolution and functionality improves we must seriously consider the impact on traditional methods and tools employed in the graphic arts.

Literature Cited

Dunn Technology, Inc.
1983. "Low Cost Non-Impact Printers" (Dunn Technology, Inc.)

Dunn, S. Thomas
1985. "Definition of a RIP", The Dunn Report (CA),
Vol. III, No. 3, pp. 1-4-