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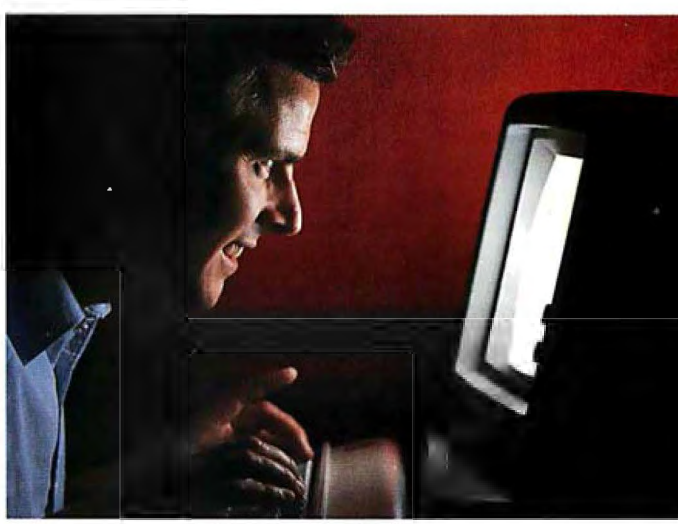
THEME

Printer Technologies

Ciarcia's ZyMOS AT-on-a-board

Turbo C, Turbo Basic, Turbo Pascal and Turbo Prolog: technical excellence



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EDITORIAL

Mere Conservatism—or Fear, Uncertainty, and Doubt?

During COMDEX last June in Atlanta, we conducted a Microcomputer Opinion Poll in the BYTE booth. We asked voters to tell us which machine they considered the best general-purpose microcomputer and which machine they thought would have the biggest market penetration. We asked voters to choose among the IBM PC AT, IBM PS/2 Model 50/60, the IBM PS/2 Model 80, the Compaq 386, the Macintosh II, or "other." (It has to be noted that Apple and many Apple developers pulled out of COMDEX some time ago and that interest in Apple products at COMDEX may be less than among the country's whole population of computer users and developers.) We also asked about preference for operating systems. A lively group of 9154 people came to our booth and voted in the poll. We asked them to identify themselves as end users, consultants, software developers, or hardware developers, and people identified themselves as follows:

end users	42 percent
consultants	37 percent
software developers	37 percent
hardware developers	17 percent

Clearly, many people belonged in more than one category.

Best General-Purpose Microcomputer

The results of the vote on best general-purpose microcomputer were surprising:

IBM PC AT	46 percent
Compaq 386	20 percent
IBM PS/2 Model 50/60	9 percent
Macintosh II	8 percent
IBM PS/2 Model 80	6 percent
All other machines	12 percent

Since our question asked nothing about the prices of machines, we expected most votes to be divided among the three most powerful machines: the Compaq 386, the IBM PS/2 Model 80, and the Apple Macintosh II. Nevertheless, almost half the voters went for the IBM PC AT. Among them, the three most powerful machines got 34 percent of the vote, with the bulk of that going to the Compaq 386—the 32-bit machine that is most familiar and has been on the market longest.

After seeing the AT's performance in this vote, we recognized that we should have included the Macintosh SE as well as the Macintosh II. If the AT got more support than the Compaq 386 or the PS/2 Model 80, it is quite possible that the Macintosh SE might have outpolled its more powerful sister machine.

Results were fairly even across the different types of voters, but the Compaq 386 got 25 percent of the vote among software developers. The IBM PC AT got a slightly higher vote among hardware developers than across the whole population.

Greatest Market Penetration

On the question concerning which machine will have the greatest market penetration, results were as follows:

IBM PC AT	43 percent
IBM PS/2 Model 50/60	22 percent
Compaq 386	14 percent
IBM PS/2 Model 80	7 percent
Macintosh II	6 percent
All other machines	7 percent

While only 9 percent thought the PS/2 Model 50/60 was the best general-purpose machine, 22 percent thought it would have the greatest market penetration. Among the 32-bit machines, the Compaq 386 again topped the PS/2 Model 80 and the Macintosh II.

Here, the PS/2 Model 50/60 got 25 percent of the vote among software developers as against 22 percent in the whole population. Hardware developers voted for the PS/2 Model 50/60 at a rate of 21 percent, lowest for any group.

Operating System Preferences

The main reason for asking this question, since operating systems often arrive with machines as standard equipment, was to see whether they were ready to embrace OS/2 and whether they expected Unix to gain supporters across different kinds of machines. Here are the results:

MS-DOS	52 percent
Unix	17 percent
OS/2 extended version	15 percent
OS/2 standard version	7 percent
Macintosh OS	5 percent
All other systems	4 percent

As expected, MS-DOS got the lion's share of the vote. It beat the combined vote for versions of OS/2 by 52 percent to 32 percent. Surprisingly, the extended version of OS/2—IBM's own version with mainframe-compatible database and communications facilities built in—topped the standard version of OS/2. Unix did well also, getting 17 percent of the vote, more than the extended version of OS/2 and more than twice as much as the standard version of OS/2. It looks as if some Macintosh II proponents are planning to use Unix.

MS-DOS had fewer supporters among software developers and consultants than across the whole population. Only 45 percent of the software developers and 48 percent of the consultants went for MS-DOS, but 54 percent of the end users voted for it.

Not surprisingly, Unix got 22 percent of the vote from software developers and only 14 percent from end users. The OS/2 standard version was equally popular among the different types of voters, while the OS/2 extended version did a little better among software developers and consultants.

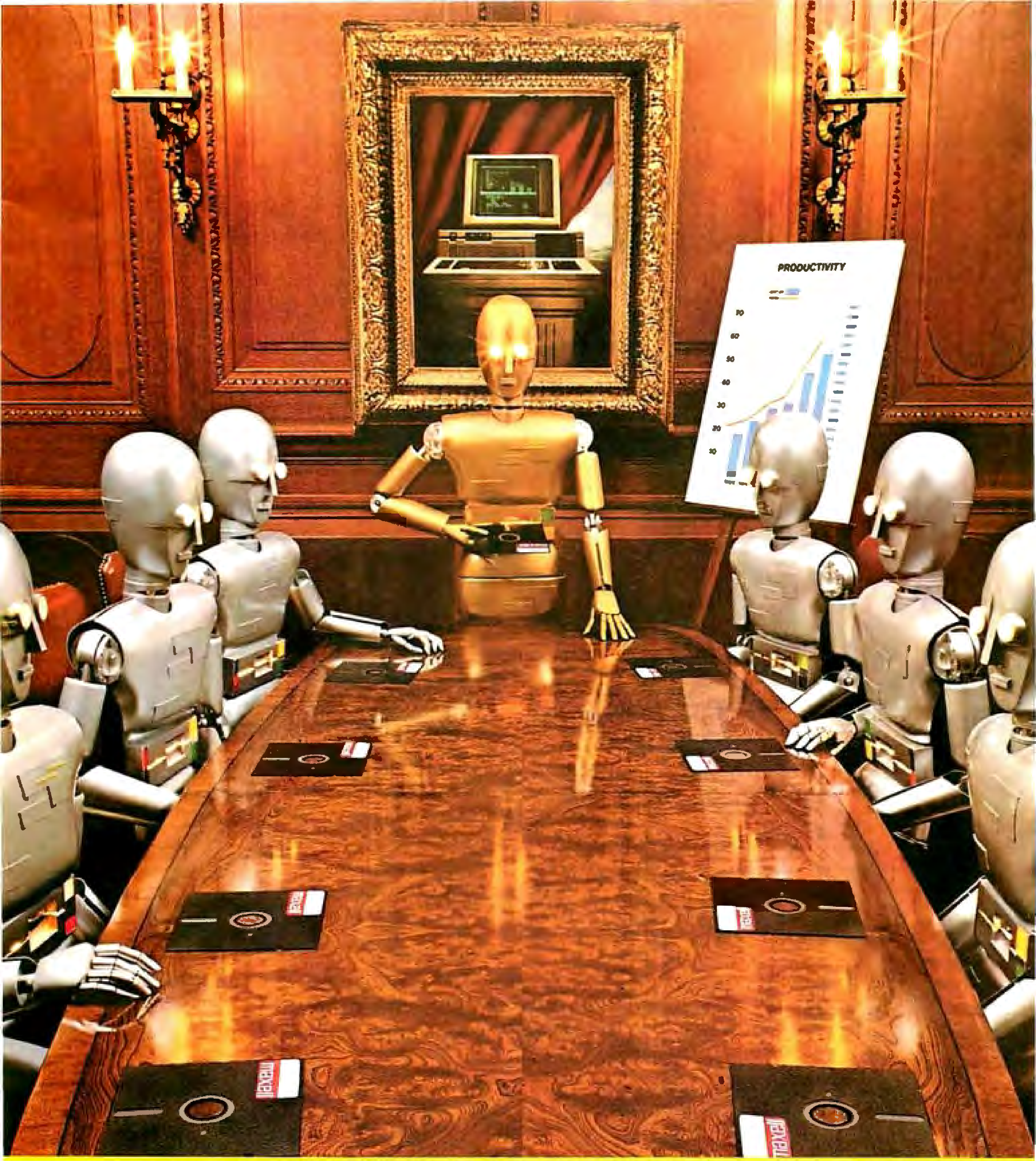
Conclusions, Anyone?

Although computer people often want the best and the latest and the most powerful, most people at COMDEX were reluctant to embrace the new generation of microcomputer hardware and software. True, neither the Macintosh II nor the PS/2 Model 80 was available when COMDEX took place, and that may account for their surprisingly weak showings.

But a larger factor is the unsettled character of the market as everyone waits to see whether IBM will permit PS/2 compatibles to be made under any conditions. There is a bit more receptiveness to OS/2 than to IBM's PS/2 machines: 32 percent of the voters were willing to go with OS/2, while only 15 percent thought a PS/2 machine is the best microcomputer. On the other hand, 29 percent thought the PS/2 machines would have the greatest market penetration.

We'll conduct this poll again in our booth this fall at the COMDEX in Las Vegas and let you know how preferences have changed.

—Phil Lemmons
Editor in Chief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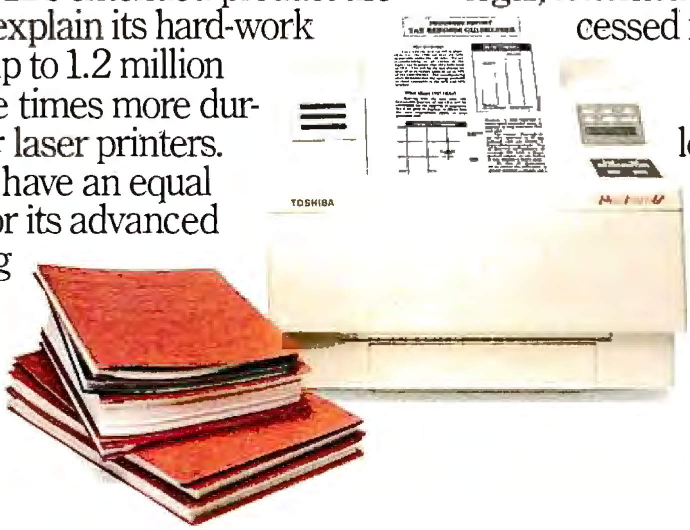

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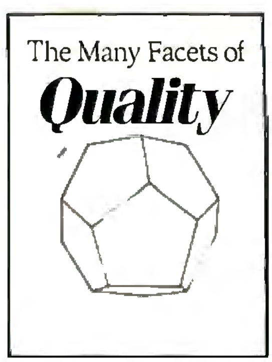

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LETTERS

and Review Feedback

Lyrix Flaws

It was with some concern that I read George R. Allen's review of the Lyrix word processor in the May BYTE. Why would anyone compare a word processor with a text editor? That's like saying that it's easier to use Lotus 1-2-3 than to program each application in BASIC. Lyrix calls itself a word processor, and it should have been compared with word processors.

I use Lyrix 4.0.5 under Xenix 03.01.01 on a Tandy 6000 HD system, so in the following comments I am guilty of comparing oranges with, say, tangerines. But with that admission, I'll proceed.

First, Mr. Allen claims that Lyrix "takes advantage of the file-security capabilities of the Unix environment." Lyrix does no more than acknowledge whether a file is writable or readable. Permission assignments must be made from Unix/Xenix, not from Lyrix.

Second, the spelling checker I have is painfully slow. It also fails to allow online additions to the dictionary and does not permit global passing of a correctly spelled nondictionary word. Furthermore, the hyphenation feature does no syllabification, and Lyrix removes any hyphens the writer puts in manually.

Other problems include an inability to send special characters to the printer in mid-line and the lack of an index, table of contents, and footnotes or endnotes.

One serious defect is that Lyrix takes over the function keys and the keypad when you enter the Edit mode. These function-key assignments are useful and contribute much to Lyrix's ease of use; however, when you leave Lyrix, you're left with the function keys unassigned.

Lyrix handles long documents well. Although page-oriented, it flows like a document-oriented word processor, and page breaks are indicated by a dashed line that also gives the page number.

But all in all, Lyrix is not comparable to any of the serious word-processing packages like Microsoft Word or WordPerfect. It doesn't even compare favorably with text editors originating in the TTY age.

David D. Farris
Huntsville, TX

When reviewing a product such as Lyrix, it is convenient to compare it to a heavily used product of a similar nature that operates in the same environment. In my full-time work, I use one of about eight mainframe Unix systems or one of several Xenix-based PC systems. All these systems use vi as a word processor, even though it is a text editor. At the time that I wrote the review (Fall 1986), none of my associates had any form of word- or text-processing systems other than vi running on their Xenix PCs. For these reasons, I chose to compare Lyrix to vi, if only to show that there is a better way.

I use version 5.0 of Lyrix, and I cannot duplicate your problems with the spelling checker. It is reasonably fast, and I can make on-line additions to the dictionary without any difficulties. I can also perform global passing of words without problems, using the ADD *command.*

I am not sure if you realize that you have an older version of Lyrix. Version 5.0 does have, for example, footnote and table-of-contents capability. I've experienced none of the problems that you have experienced, and I suggest that you contact SCO for assistance.

—George R. Allen

Lyrix Features

George R. Allen's review of Lyrix in the May BYTE failed to adequately address the program's primary strengths and weaknesses. Mr. Allen says that Lyrix has almost all the capabilities of vi. Since vi has regular expressions and Lyrix does not, Lyrix has almost none of the capabilities of vi. But since vi is a text editor and Lyrix is a word processor, that's as it should be.

However, Lyrix has some amazing features. The primary one is that Lyrix is almost totally customizable; you can add or delete menu options at your discretion. Best of all, the help screens are configurable. This, in addition to the customizable editing commands, means that you can configure Lyrix to look like any word processor you like, and the help screens can reflect the changes. I use Perfect Writer at home, so I configured the editing commands of my copy of Lyrix to reflect Perfect Writer commands.

With all these delights, the Lyrix designers made some strange decisions about the program's functions and capabilities. One of Lyrix's drawbacks is its slow editing speed. Mr. Allen touched on it a little, but he failed to give it the importance it deserved. For sheer editing speed, probably nothing could beat vi, and Lyrix doesn't even come close.

Other drawbacks have to do with Lyrix's use of rulers to control the various formatting decisions and its lack of defaults (that I could find) in text-spacing for a page. Also, you can use the Delete key for one line only; you must use the arrow keys to get back to the previous line. More disconcerting is Lyrix's tendency to insert new text in the middle of old text when wrapping a line in a paragraph. (These last two flaws are probably defects in my Lyrix terminal-configuration file and not a defect in Lyrix.)

Finally, Lyrix uses dot commands at the beginning of a line to specify options like line spacing. WordStar fans may like this, but it's annoying to the rest of us.

The only major bugs I found have to do with the way Lyrix reformats paragraphs. Lyrix assumes that anything with a period, colon, or semicolon is a sentence and puts two spaces after it. Also, when formatting paragraphs, Lyrix leaves the cursor at the bottom of the paragraph instead of leaving it where it started.

On balance, Lyrix does an adequate job as a word processor. It isn't as fancy as Microsoft Word, for instance, but its flexibility redeems it. Lyrix hasn't seriously challenged the "power" word processors, like WordPerfect 4.2, because its formatting isn't as powerful yet. But due to its modularity, I wouldn't take any bets on how long it will be before Lyrix gives the best DOS-based word processors a run for their money in printer control, if only because of its simplicity.

Darrel W. Riley
Seattle, WA

continued

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Inquiry 304

On the issue of whether Lyrix has most of the capabilities of vi, I think you and I differ on the semantics of the word capabilities. *Lyrix does have most of the capabilities of vi, even though vi is a text editor.*

Your comments on the customization features of Lyrix are correct. I have used the customization features to a much greater extent than I mentioned in the review. This feature is one of Lyrix's greatest selling points.

I did verify several of the problems that you pointed out, which I had not picked up in my usage. In regard to Lyrix's speed on my IBM PC, the occasional response problems also appear with vi on my PC, so I don't think that Lyrix itself has a significant speed problem. I may be a little biased, because the time-sharing systems that I use in my work are extremely slow due to the large number of users. Lyrix on my PC is faster than my systems at work by a large factor.

—George R. Allen

C, More

In the June C interpreter review, Mr. Unger didn't point out the most obvious advantage to using the C-terp interpreter. When you set up C-terp with your current compiler, C-terp offers exactly the same functions and features as the compiler. This means that you don't have to create two versions of a program, one for C-terp and one for the compiler.

By using C-terp, I can write a 10,000-line program using all the functions of the Microsoft compiler and still run it under the interpreter to find a bug or error. When you're dealing with large programs with long compile times, C-terp is a godsend. If I had to take my 10,000-line program (in 20 to 30 files) and, for example, change all occurrences of `get( )` to `getline( )`, I could never get a program developed.

C-terp is too expensive if you are only trying to learn C, but it is well worth the money for professional programmers. If you develop serious C programs, once you try C-terp you will never go back.

P. Lyle Mariam
St. Louis, MO

I pointed out in my review that if you have a copy of one of the five C compilers supported by C-terp, you can create a version of the interpreter that uses all the functions that are available with that compiler.

In fact, you can add other library functions to the interpreter using a simple but somewhat tedious procedure; I added the entire Essential Graphics graphics functions to a version of C-terp. It increases the size of the interpreter program and

continued

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Corporate Headquarters: 3243 Sunset Boulevard • West Columbia, South Carolina 29169 • 803/796-7800 • TWX 510-601-2645 *consequently decreases the size of the source code you can use.*

When used in this way, C-terp is a tremendous time saver for developing programs that you will later compile.

—John Unger

C Syntax Checker

I read John Unger's review of C interpreters (June) with great interest. C interpreters are created as program-development and debugging environments, not as compilers, and the error messages they generate are one of the most important issues to consider when selecting one. Mr. Unger deserves particular commendation for addressing this concern.

As a user of the Microsoft C compiler, I spent hours trying to locate mysterious errors before I realized that the most common mistakes are simple typos, which the compiler usually notices several lines past the place where they actually occur. Frustrated with missing braces and other details, I wrote a program (see listing 1) that performs a quick and rudimentary syntax check on my source code. The exit codes allow the use of this syntax checker in batch files, making the entire compilation even easier.

Jerzy Tomasik
Long Beach, CA

Listing 1: *Syntax checker for C source code.*

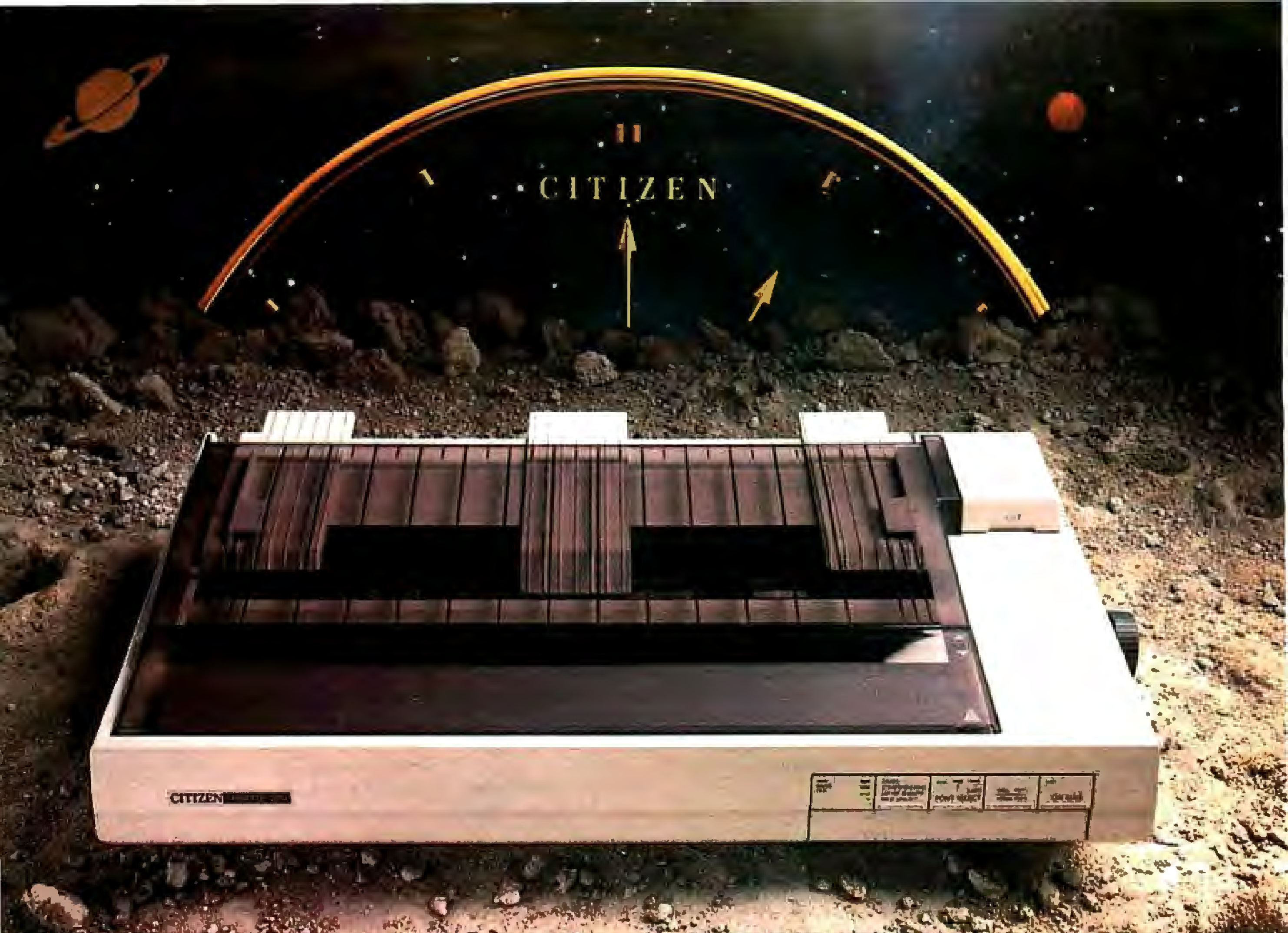
```
/* syntax.c Program running a quick
  syntax check on C source code
  Version 1.11
  J. Tomasik; created 05/23/87
*/
#include <stdio.h>

main( argc, argv )
int argc;
char *argv[];
{
  FILE *fopen(), *infile;
  char c;
  int lbrace = 0, rbrace = 0,
  squote = 0, dquote = 0, lpar = 0,
  rpar = 0; int rbrkt = 0, lbrkt = 0;
  int bytecount = 0, errorcount = 0;

  if( argc != 2 ) {
    printf( "SYNTAX checker for C
     source code, version 1.1 \n
     Copyright (C) J. Tomasik 1987,
     1988 \n \n" );
    printf( "Usage: syntax
     fname.ext \n" );
    exit(1);
}
infile = fopen( argv[1], "r" );
if( infile == NULL ) {
    printf( "Cannot open %s \n",
     argv[1] );
    exit(2);
}

while( (c=fgetc(infile)) != EOF ) {
    ++bytecount;
    if( c == '{' )
      ++lbrace;
    else if( c == '}' )
      ++rbrace;
    else if( c == '\'' )
      ++squote;
    else if( c == '\"' )
      ++dquote;
    else if( c == '(' )
      ++lpar;
    else if( c == ')' )
      ++rpar;
    else if( c == '[' )
      ++lbrkt;
    else if( c == ']' )
      ++rbrkt;
}
fclose( infile );
printf( "The file length is %d \n",
   bytecount );
if( lbrace != rbrace ) {
    printf( "There are %3d left and
     %3d right braces \n", lbrace,
     rbrace );
    ++errorcount;
}
if( lpar != rpar ) {
    printf( "There are %3d left and
     %3d right parentheses \n",
     lpar, rpar );
    ++errorcount;
}
if( lbrkt != rbrkt ) {
    printf( "There are %3d left and
     %3d right brackets \n",
     lbrkt, rbrkt );
    ++errorcount;
}
if( squote % 2 ) {
    printf( "The single quote marks
     are not paired \n" );
    ++errorcount;
}
if( dquote %2 ) {
    printf( "The double quote marks
     are not paired \n" );
    ++errorcount;
}
if( errorcount == 0 ) {
    printf( "No errors found, OK to
     compile \n" );
    exit(0);
}
else
    exit( errorcount );
}
```

continued



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Inquiry 47

Understanding C

In the review of C interpreters in the June BYTE ("Four C Language Interpreters" by John Unger), Mr. Unger lists a single "major shortcoming" of C-terp as "its lack of a built-in library." What is horrifying about this statement is that it shows a fundamental failure to understand the reason for the product's existence.

C-terp is for those who need to develop code for their compilers. It requires you to use the compiler's libraries, because it is trying to limit the degree to which the same source causes different results when run under the interpreter and when compiled by the compiler. In short, C-terp is designed to be a development environment. Indeed, you cannot order C-terp without specifying which compiler you will be using. To fail to understand that you must use your own compiler's library of routines with C-terp is to fail to understand the nature of the product. It's much like complaining that a calculator is a flawed product because it's too mathematical.

There also seems to be a notion that C interpreters are a great way to learn C. Certainly Gimpel Software is not perpetuating that misconception, but the idea exists nonetheless. BASIC is an ideal learner's interpreted language, because the significant unit in BASIC is the line. It is not idiotic to sit down at a computer keyboard and start writing BASIC to learn it. However, to produce code in a modular language you must understand the structure of the language, the scope of variables, and so on. In C, the words of the language are less important than the structure. Avoiding syntax errors is not the heart of learning C.

At the Eye Research Institute, we recently purchased a site license for C-terp because it is so useful. In particular, it has a good line editor, lets you run quick checks to make sure you didn't leave off a semicolon, and lets you quickly test what actually comes out of a function before developing too much code for easy debugging. Furthermore, C-terp is a dream for, say, graphics-routine development. With C-terp, you can interactively develop what you want to see. In such an application, it's a minor miracle to have your first compiled output the only compiled output.

Tom Clune
Boston, MA

First, let me add the next three words of the sentence that you quoted from my review. The entire phrase is, "its lack of a built-in library of mathematical functions." C-terp comes with a complete built-in library of extremely useful functions and is lacking only in this one specific area—support for math functions. Because both Run/C and Instant-C include mathematical functions in their built-in libraries, I thought it was fair to point out the omission of such functions in C-terp's.

C-terp is designed primarily for use in a development environment as a companion program to a specific C language compiler; this makes its own lack of math functions not as crucial. But C-terp can also be used alone, as a tool to learn C, to test concepts of the language, and to produce useful programs that can run within the confines of its interpreter environment. It is wrong to imply that C-terp must be used with a specific compiler. I agree, however, that any C language interpreter is most useful when it can work with source code that can be seamlessly ported between the interpreter and compiler environments.

I wholeheartedly support your opinion that trying to learn C using a mindset developed in BASIC is a serious mistake.

continued

 Inquiry 214

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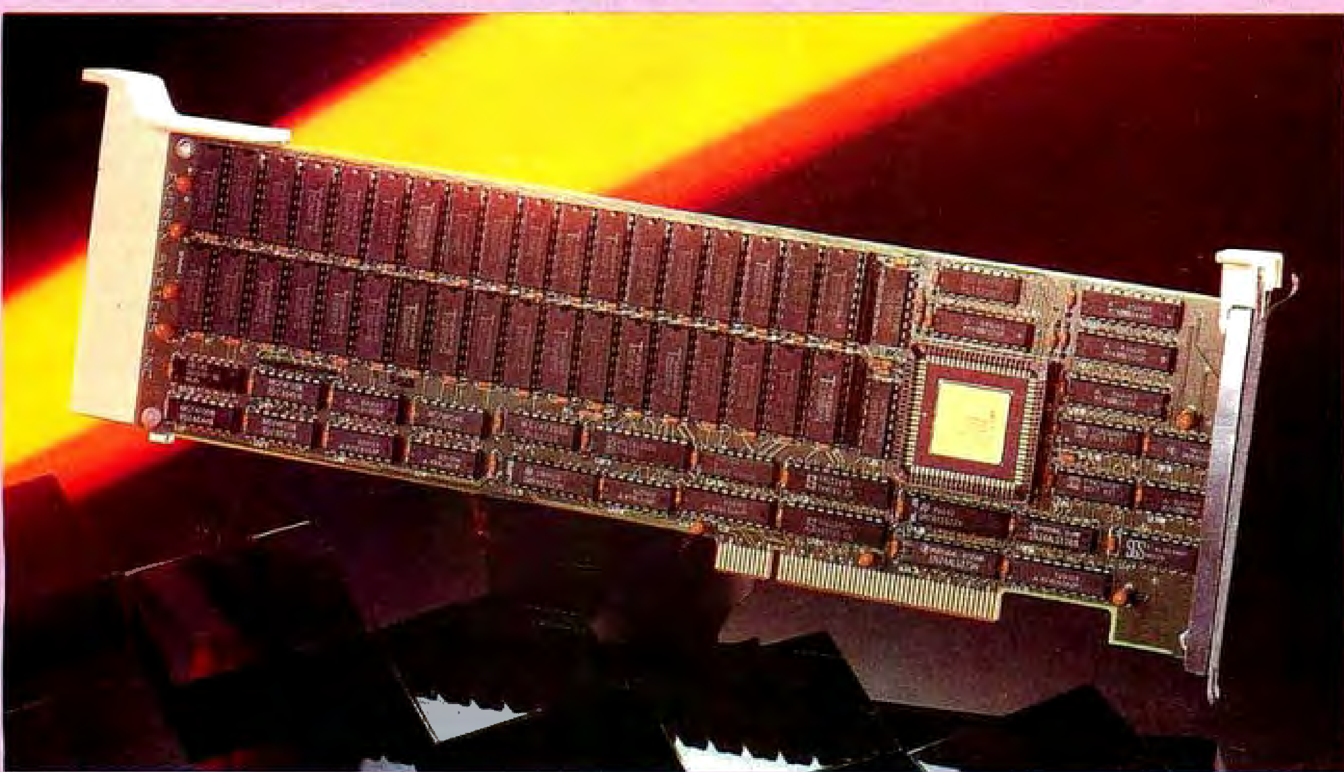

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Inquiry 167

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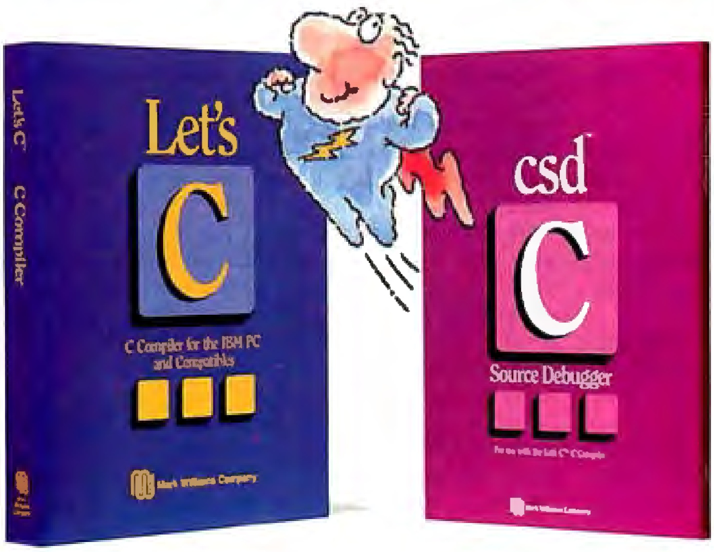

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However, an interpreter's ability to catch syntax errors quickly, which you yourself mention, does make it a useful learning tool for beginning C programmers.

—John Unger

Alternate Approach to DTP

The theme of the May issue of BYTE was desktop publishing; however, nowhere in the articles or charts was there any mention of the PowerText Formatter, an $89.95 desktop-publishing product announced and shown at PC-Expo in July 1986.

John W. Seybold's view of desktop publishing is but one approach; he dismisses all approaches other than WYSIWYG. But current Macintosh and IBM WYSIWYG software leaves a lot to be desired and suffers from some fundamental problems, and the alternatives may be more cost-effective, both in initial cost and in day-to-day operation in a production environment.

WYSIWYG is really only approximately what you get. The fonts differ from screen to page, and interletter and word spacing differ. What looks nice kerned on the screen can often end up as touching characters on the printout, and what seems to be centered on the screen may not be when it's printed.

Scaled fonts, such as those of PostScript, do not map onto dots very well. In addition, a good typographer will often change the shapes of letters in different sizes simply because they look better. Mathematics can't do this. As a result, scaled fonts are not as crisp and clear as fonts discretely designed for each point size.

WYSIWYG systems don't function very well in environments where several people supply the copy and where external artwork and halftones have to be factored in. And, at least on the IBM PC and the Macintosh, using WYSIWYG screens to lay out metro-size newspapers is somewhat like painting through a keyhole.

WYSIWYG requires a lot of hardware. In the PC arena, one really needs a PC AT–class machine, an EGA card, a hard disk drive, and a mouse, not to mention the laser printer. Can everyone who needs desktop publishing really afford all this hardware?

WYSIWYG is ideal for flyers and short newsletters. But is it really practical for books of 200 or more pages?

When you strip away the hype from desktop publishing, what you really find is a problem of economics. Typesetting costs a lot of money. That problem can be addressed by 300-dot-per-inch (dpi) laser printers, at least in typesetting textual material. Page-layout and composition programs have their place, but they are only a part of the typesetting and publishing problem. When the visual aspects of each individual page are as important as the textual aspects, then page-layout programs may be the ultimate solution. However, advertising material, flyers, and newsletters represent only a very small percentage of the printed material produced in this world. Are we to believe that the economic solution to the high cost of typesetting for each and every page printed is to sit in front of a screen with a mouse?

Your theme articles indicated that desktop-publishing hardware costs between $10,000 and $15,000, with software running between $200 and $800. But consider this: The street price of an HP LaserJet Series II printer is about $1700, a good set of times roman and helvetica fonts costs about $155, and the PowerText Formatter costs $89.95. Inset 2, a graphics-capturing and editing program from American Programmers Guild Ltd., costs $99, and a clone costs

continued

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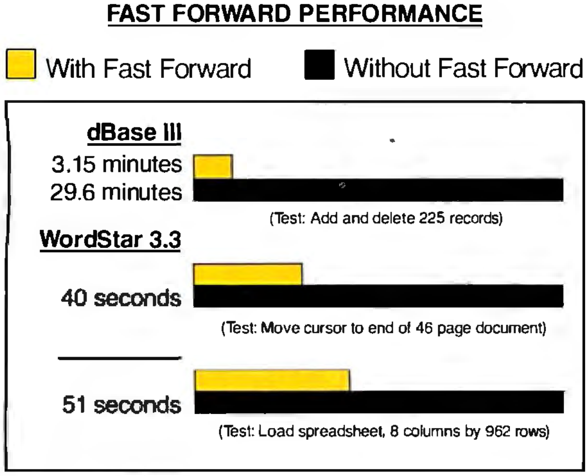

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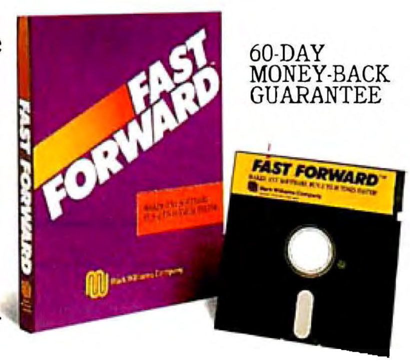

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David P. Guest
Beaman Porter Inc.
Harrison, NY

I stated in the first paragraph of my article that "desktop publishing is a slippery product without a clearcut definition." To explain how it emerged, I traced its history, uncovering the differences between desktop publishing and computer-aided typesetting. The latter is both narrower (in that it doesn't embrace publishing per se) and also much broader, in that it includes programs and systems that are, at least currently, much more sophisticated in terms of the inclusion of typographic niceties.

It should be clear that desktop publishing currently offers more limited (although very exciting) capabilities. I believe, however, that users at the desktop level will soon be able to command virtually all the resources of more traditional computer-aided composition capabilities. The much less intimidating interfaces of more traditional approaches are being profoundly modified. WYSIWYG is one such adaptation.

I was not involved with the preparation of Thom Holmes's article, which followed mine in the May BYTE. I did not select, include, or exclude any particular software packages listed there.

But I disagree with your assumption that PostScript, or any other page descriptor language, produces inferior type. The final product depends on the output device.

Nowadays, virtually all new output devices operate in a raster-imaging mode and therefore must deal with the laying down of pixels. It is the responsibility of such languages to output at a resolution within the capabilities of the selected imaging device. (At the desktop level, we are already moving from 300 dpi to much more, and, of course, those who can afford to are using recorders that write their output to photosensitive films or papers.) It is generally not the task of the publishing program to rasterize the output, unless a graphics editing or manipulation package is also included—and even in these cases, final output differs from what you see on the screen. It is true that scaled or even bit-mapped fonts on a video screen do not provide a meticulously faithful representation of final output. However, for review and formatting purposes, they are usually a lot more helpful than monospaced fonts.

The issue that you fail to address is how code-intensive a composition program is or must be. WYSIWYG, by providing a window that permits an interactive preview of the intended output, greatly simplifies the formatting process.

But I do agree that specific features of many WYSIWYG programs may be inadequate for the production of large, relatively standard documents. In such cases, WYSIWYG in and of itself will not provide the hoped-for benefits.

—John W. Seybold

Response to Bonus Issue

I am writing in response to your request for comments on your Summer Applications Software Today special edition. I enjoyed the edition very much.

I use my computers for both productivity and enjoyment. I own an 8-bit and a 16-bit MS-DOS machine, each with hard disk drives. I am more experienced in hardware, as I service computers on a full-time basis for one of the large small-computer retailers. In my spare time, I develop and sell personal robot hardware

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and software. In my full-time work, I handle a lot of software belonging to service customers, so I base my views on that as well as on the software I use for myself.

I was disappointed at your exclusion of FilePro 16 from your database software review. It is much easier to learn and use than the famous dBASE. One of my most important measures of a database program is how easy and inexpensive it is to convert data files from other software and operating systems to the one I use. Although all database software developers sell conversion programs, I don't like to pay for something I can do myself. I've found that I can write simple BASIC programs (about 10 lines long) to convert anything (including dBASE II and III, TRS-DOS, and Timex-Sinclair) for FilePro 16 use.

Next, a general comment on RAM-resident utilities. These utilities cause almost half of the customer software problems I encounter in my work with MS-DOS machines. The problem is a conflict between the utilities and the primary software. (I have all but stopped using the utilities myself.) The popular SideKick is a prime offender. The software developers always claim it is a hardware problem. In many cases, it may be a hardware *design* problem, but who cares—if it causes a problem, you can't use it.

In future issues, I would like to see coverage of CAD packages, including math and circuit packages, that most of us can afford (under $300). I would also like to see continued coverage of desktop publishing, and, again, I'd like it to include the inexpensive products. (I know you recently covered this area, but it's probably the hottest applications area today, and it's changing all the time.)

Just so you know my prejudices, the packages I use most often are WordPerfect, Crosstalk, FilePro 16, PrintMaster, and ClickArt, as well as graph packages and accounting packages. I have never found a need for spreadsheets.

Bruce C. Taylor
Tucson, AZ

OS-9 over Unix

What is the fuss over Apple supporting Unix on the Macintosh II? Both "The Apple Macintosh II," by Gregg Williams and Tom Thompson (April BYTE) and Bruce Webster's "Processor Wars" (According to Webster, June BYTE) mention the coming Unix.

I believe that OS-9/68000 would be a better choice. Also, OS-9/68000 is here today; not just promised like A/UX (or like OS-2 for the IBM PS/2 machines).

Perhaps one of your columnists should do a simple comparison of OS-9/68000 and A/UX.

Ramer W. Streed
Mankato, MN

CAD Appreciation

I enjoyed the article "IGES," by Ralph J. Mayer, in the June BYTE. It was well-written and gave more than just an overview of the intent of IGES and database-exchange problems.

Paul D. Watson
Plano, TX

FIXES

Soft PC

In the May What's New section, on page 44, we incorrectly stated the hardware requirements for Soft PC from Insignia Solutions. Soft PC is a simulated 8088 IBM PC XT and runs on Motorola-based hardware. It does not require a PC XT, nor does it require an Intel coprocessor. ■

CHAOS MANOR MAIL

Conducted by Jerry Pournelle

Mousing Around

Dear Jerry,

I am writing in response to your frequent comment that a mouse-oriented word processor seems ill-suited to its basic task. Having just finished writing two books using WordPerfect (now your word processor of choice, I read), I cannot imagine doing any serious *editing* without a mouse. To be sure, my hands do not seek the company of my keyboard's fuzzy little companion when I am entering large blocks of text, but for rewriting—a deletion here, a rearrangement there—nothing is more helpful than a mouse.

I use Logitech's mouse, finding it vastly superior to Microsoft's. I run MousePerfect as the mouse-interface program. MousePerfect is my own creation—not yet available for sale, although I hope to change that someday. It provides cursor movement, easy deletion, and menu-oriented commands, so you don't have to figure out whether to use the Control key or the Shift key with F6 to get text centered, for example. Of course, the keyboard remains fully available. I would be happy to send you a copy.

Howard E. Abrams
Atlanta, GA

I'd love to see a copy of MousePerfect.

I agree completely: For editing, a mouse is essential, and neither WordPerfect nor Q&A's writer (the other word processor I use a lot on big machines) supports mice. I can't use mice for writing, but it's good to be able to run the cursor around fast when you're trying to rewrite.

Logitech certainly makes the best mice for the money. I tend to use its Bus Mouse addressed to LPT2:, since I'm strapped for ports.—Jerry

Whither the Orb?

Dear Jerry,

In the April 1984 BYTE, you described with great enthusiasm the Omnisphere by Orb Inc. By the time I tried to order one, the company no longer had a telephone number. Edmund Scientific's catalog has a picture of something similar, but they don't have any in stock. Can you direct me to the manufacturer?

Michael Showe
Wayne, PA

The one in the catalog sure looks like the one I have. I have heard these globes are called Star Sculpture, and I will ask on BIX for sources; I bet that I find one.
—Jerry

[Editor's note: *According to Microbytes Daily (in the BIX news conference "microbytes"), two exhibitors at the recent CES show had low-cost versions of such "plasma spheres," globes that generate miniature lightning when you touch them. The two companies are: Rabbit Systems Inc., 100 Wilshire Blvd., Santa Monica, CA 90401, (213) 393-9830; and Imaginarium, 3530 North 16th St., Phoenix, AZ 85016, (602) 230-2880.*]

The Perfect Word Processor?

Dear Jerry,

I am surprised that you have not used WordStar 2000 Plus. The features that you seem to appreciate most, judging from your reviews of other word-processing software, are available in WordStar 2000 Plus. If you haven't reviewed it because you only review software sent to you by its manufacturer, then I think MicroPro is doing itself a great disservice by not having you try it.

I know several people who once were strong advocates of programs such as Perfect Writer, Microsoft Word, and WordPerfect, but switched after trying WordStar 2000 Plus for a few weeks. Incidentally, it doesn't use the same commands as WordStar; WordStar 2000 Plus uses commands that make more sense, and the screen is WYSIWYG.

One caution: It runs as slow as molasses, especially from floppies. An 80286-based machine is almost a necessity.

Ken Weybright
Cincinnati, OH

I think the problem was that I got WordStar 2000 Plus too early; it seemed interminably slow. I expect that on a Z-248 it would zoom along. Perhaps I should try it, although WordStar 4.0 seems good enough for most purposes and prints rings around most of its competition.

Thanks for the tip.—Jerry

Dear Jerry,

I am baffled by your love affair with WordPerfect. I'm well acquainted with

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the program—in fact, I teach how to use it at a local college—and it has always seemed to be slow and poorly designed (especially the technique for revealing codes in a split screen). I also find the system for selecting options from numbered menus tiresome and frustrating, and I'm surprised you don't feel this way, too. It wasn't so long ago that you wrote a column denouncing bulletin-board software that requires the user to pick an option from a numbered menu. In what way is WordPerfect any different?

I also teach Microsoft Word, and I find it considerably quicker than WordPerfect. I wonder, with your schedule, how much time you really have to try other word-processing programs in any depth. It takes several quiet hours of browsing through the manual to explore a program properly, and, from your column, it sounds as if several quiet hours are a rarity.

Although I teach WordPerfect and Microsoft Word, I don't use them myself. Personally, I feel that PC-Write is still the ideal word-processing program at any price. It certainly comes closest to your expressed ideal of simulating WRITE. (I've tried WRITE on Greg Benson's system, which I understand is identical to yours.)

PC-Write lets you customize your command codes; you can choose any key combination you like to control the functions of the program. It scrolls faster, it searches and replaces faster, and it's infinitely more versatile than the big programs. You mentioned it once in passing; have you ever had time to explore its potential? I think you'd like its design. But everyone has fierce brand loyalties in this business, and I don't suppose mine are any more logical than average.

Over the past few years, I have had the impression that your column focuses more and more on the time spent trying to make hardware items work with one another. I certainly find this myself. Each new purchase provides a whole new series of quirks and bugs to iron out. Things that should be simple often turn out to be ludicrously complicated.

For instance, I wanted to send text from the serial port of an IBM PC to the serial port of a Macintosh. I had the plugs, the cable, and the pinouts for both computers, but it still didn't work. Finally I spent $39 for a cable from a company that specializes in custom-made cables. It worked on the first try. I opened up the plugs and found the company had shorted pins 5 and 6 together at the IBM end. How did they know that would work? It's the sort of trick that you never find in a book, and seldom on a bulletin board; and it seems you can't deal with equipment without knowing these little fixes.

Even on the consumer level, systems still cause endless grief. I'm sure you receive plaintive calls for help, as I do, from users who get into trouble and lose a week's worth of text.

I love gadgets, computers especially, but sometimes I wonder if the slow growth in U.S. productivity over the past three or four years is partly due to business people getting diverted from their work and spending hours fiddling around with microcomputer systems, trying to get them to work properly.

I still use a word processor to write fiction, but I use a typewriter for correspondence. It's quicker.

Charles Platt
New York, NY

You're right: It's very hard to do a decent job of evaluating word processors. You have to get used to using them, and that takes some doing.

My problem with Microsoft Word is the lack of commands that do things I want

continued

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done fast. There's no "delete word" command, and it's pretty hard to devise a macro to do that. By contrast, WordPerfect has most of the commands I want, and since I run it in DESQview, it's easy to set up a bunch of DESQview macros.

PC-Write is indeed about the best thing PC and XT users can get, and the price is right. What it lacks is some of the built-in conveniences of WordPerfect. I agree, though, that I haven't said enough about PC-Write lately. Everyone ought to have a copy.

In the old days, we used to spend 25 percent above the cost of the computer and peripherals to hire someone for systems integration. It's a bit easier and considerably cheaper now than it was in the 1970s, but we agree that it's not easy enough.

As for correspondence, I find that WRITE on the CP/M Z-80 works quite well, but I'm probably going to change over to the Q&A editor. Running Q&A under DESQview on an 80386 gives some awesome power.—Jerry

Amiga Debate Continues

Dear Jerry,

In the March Chaos Manor Mail, you ended your reply to Warren Block's letter with, "It's still harder to port to Amiga than Atari."

That claim is not true when you are talking about programs written for high-level operating systems, such as Unix. Any program that runs under Unix can run on the Amiga with almost no changes. The operating system provides primitives that are similar to those found on Unix, and Intuition provides a user interface at least as powerful as the windowing facilities found on most Unix systems. As a result, languages on the Amiga can easily provide the same system constructs found on higher level machines, making it easy to port code from these machines to the Amiga.

If you're talking about porting programs written for machines like the Apple II or the Commodore 64, then yes, you are right. After all, the Atari ST is no different from these computers, except for the replacement of the 6502 with the 68000 and the 64K bytes of memory with a megabyte or more.

The ST hardware is truly wonderful—it's got a 68000 with who knows how many thousand transistors. Unfortunately, the ST is equipped with an operating system as primitive as the vacuum tube. The Atari ST is the only 68000 machine to limit the number of folders in the system to 40, and the only machine that will not warn the user when such a limit is exceeded.

Keeping all this in mind, it should be clear why it is easier to port programs from an 8-bit microcomputer to an Atari ST than to an Amiga. Take a program written for your favorite 8-bit microcomputer, apply some mechanical translation into 68000 code, and voilà—you have a program ready to run on the ST. The translation doesn't have to be super-efficient. After all, most programs written for the 8-bit microcomputers of the late 1970s and early 1980s are no longer than 64K bytes, and even if the translation expands it by 400 percent, it will still fit within 256K bytes.

What sets the Amiga apart from these 8-bit micros and the ST computers is the multitasking operating system that befits 16-bit 8-megabyte multiprocessor hardware. Why should multitasking make a difference in how easy it is to port to a machine? When you are programming for a multitasking environment, you have to be polite and follow a few rules. Instead of "busy-waiting" (i.e., running in a loop to see if a key is pressed), you

continued on page 314

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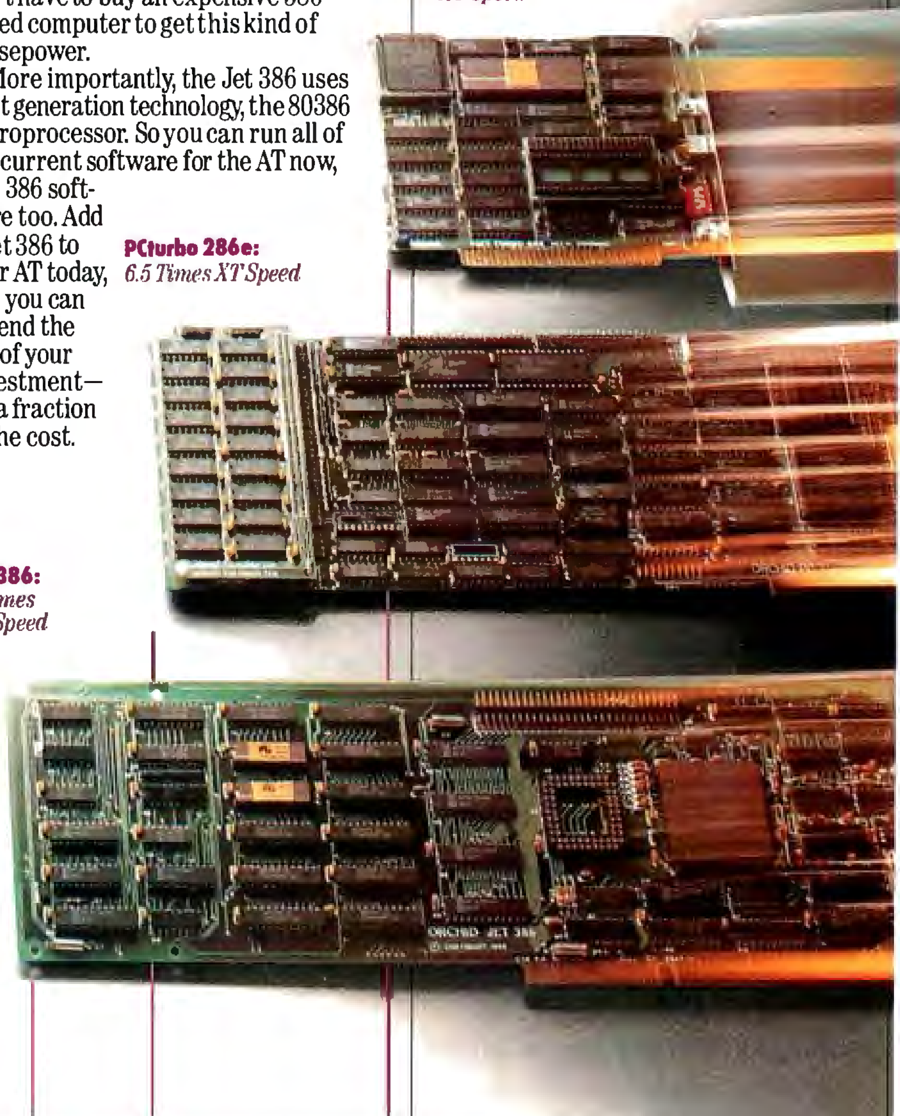

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MICROBYTES

Staff-written highlights of developments in technology and the microcomputer industry.

Chip Makers Criticized for Bad Attitude

The U.S. semiconductor industry has lots of problems, Intel Fellow Gene Meieran told attendees at a recent conference on electronic materials and processes. But those problems are less the result of lagging technology and more the fault of manufacturers' poor attitudes, primarily toward vendors, customers, and, to some degree, their own products. "Manufacturers are going to have to change," Meieran said, "but that change is not one of technology; it is a change of attitude."

"We are way ahead [of the Japanese] in technology," Meieran said, "but we go around shooting ourselves in the foot." He pointed to one example after another of how U.S. chip makers are self-destructive, paying particular attention to the traditional adversary relationship between manufacturers and vendors, as well as between manufacturers and customers. "Anybody who looks at the vendor or customer as an adversary will not make it," he said.

Meieran used as an example the different attitudes of U.S. and Japanese vendors that Intel encountered when looking for a specific semiconductor. "The U.S. vendor asked us what we wanted, why we wanted it, and tried to tell us we didn't know what we were doing," he said. "The Japanese vendors didn't say anything, but went back to their engineers and worked on them instead. Six months later we had sources from two Japanese companies."

As part of their attitude adjustment, U.S. manufacturers have to begin sharing information with suppliers and customers, Meieran said, even secret and proprietary information, no matter how painful it is. "However, sharing plans and information goes both ways," Meieran told Microbytes Daily. "If a customer wants more control, the customer must be willing to pass certain information back to the manufacturer."

An outgrowth of these attitudinal shifts will be greater partnerships between manufacturers and customers, partnerships like the agreements between Intel and IBM. "We [Intel] look at partnerships as being very important," he said. However, such partnerships will be made at a cost to manufacturers who supply second sources. "The really big change [in the semiconductor industry] will be in the reliance upon sole sources," he said. "Many companies are moving to single-source vendors, and many suppliers will disappear off the face of the earth."

A Look at Apple's Cray Simulation Engine

Apple Computer (Cupertino, CA) has been using its Cray XMP-48 supercomputer, part of a $20 million installation operated by its Advanced Technology group, primarily as a simulation engine for designing new visual interfaces. Microbytes Daily reporters Nick Baran and Jon Erickson recently got a tour of the facility and filed this report.

The Cray consists of four CPUs operating at 9.5 nanoseconds per cycle, 8 million 64-bit words of program memory, and 8 million words of I/O-buffer memory. The I/O system supports multiple 50-megabit-per-second channels (called Hyperchannels) and one high-speed channel operating at 850 megabits per second (called the HSX channel). For storage, the system includes eight 1.25-gigabyte drives, for a total of 10 gigabytes, and several tape-backup systems.

The HSX channel is connected directly to a high-performance frame-buffer system from a young company named Ultra Corp. (San Jose, CA). The Ultra frame buffer allows graphics images from the Cray to be displayed directly on a CRT. According to Sam Holland, manager of advanced technical projects, Apple is the first company that Cray has allowed to access the HSX channel directly. In fact, Apple is the only company to use the Cray in an actu-

continued

Nanobytes

One industry analyst, in an interview about Intel's single-sourcing the 80386 chip, told us that "**IBM** has the right to manufacture the 386 and even change the microcode, and you can damn well bet they will, probably within the next couple of years." . . . **Texas Instruments** (Austin, TX) has stopped making its TI Professional but is offering owners of that machine an upgrade to the TI Business Pro, an IBM PC AT compatible that can be converted (with a new motherboard) to TI's System 1000 series of multiuser machines. TI will support Professional owners with service and parts for at least five years, said TI's Cindy Smith. She said TI is the first microcomputer company to "offer an alternative other than saying we're stopping production." If you're interested in trading in for a Business Pro, phone (800) 847-2787 or write to TI, 24510 Highway 290, Attn. TIPC Upgrade, Cypress, TX 77429. . . . **Dave Winer**, president of **Living Videotext**, offered this tip for someone in search of a hot new product. "A conferencing scheduling program for a network would be a hot idea," he said, "as would a slide-maker setting on a network, just like a LaserWriter does today." . . . The **Association of Shareware Professionals** has formed to help shareware developers market their products, broaden distribution, provide a forum for exchanging ideas, and "foster a high degree of professionalism" by setting standards for authors to follow. Cochairmen are Jim Button (PC File) and Bob Wallace (PC Write). You can contact ASP at 11058 Main St., Suite 225, Bellevue, WA 98006. . . . **Desktop publishing**, once a job for one per-

continued

son, is now becoming a departmental task, Aldus president **Paul Brainerd** said at a recent seminar on that subject. In many publishing situations, groups of people are working together on documents, he said. He also said that the real cost of desktop publishing is not hardware or software, but training. A common software system running on various hardware, though, would reduce those training costs, Brainerd said. . . . "We intend on putting **Paradox** in as many environments as possible," **Ansa** president **Ron Posner** told Microbytes Daily. "Specifically, we are looking at the Macintosh environment, Unix, and SQL." . . . **Generic Software** vice president Ken Goodman said the company will "test the waters" with CAD software for the Macintosh, releasing its $49.95 FirstCADD for the Macintosh in time for COMDEX in November. . . . **The Potomac Electric Power Company** is offering its customers in the Washington, DC area uninterruptible power supplies to help solve "dirty power" problems. According to PEPCO, the UPSs will provide from 5 to 15 minutes of power, enough time to save data gracefully. Leasing cost is $12 a month. . . . **Commodore Business Machines** is offering a special deal to schools: Buy three Amigas for the price of two. The educational discount can be applied to the A500, A1000, or A2000. . . . Calling it "a natural fit," **Atari** is going to start selling its MIDI-equipped ST line of computers in music stores. . . . **The Smithsonian Institution** and **American Interactive Media** will be distributing some Smithsonian publications as Compact Disc-Interactive programs. The first CD-I volume, scheduled for next year, will be based on a book called *Treasures of the Smithsonian* and will cover 300 of the museum's artifacts, including the Apollo 11 space capsule. . . . **Graphic Software Systems** (Beaverton, OR) is offering OEMs windowing software based on the **X Window** system (version 11) developed at MIT. Named

continued

al interactive environment, according to Holland.

The Hyperchannel connects the Cray to several networks of Apple Macintosh computers via a VAX-11/785, a VAX-11/780, and a Sun/2. The Macintoshes are linked to the VAXes and Sun/2 via AppleTalk in series with Ethernet. A converter system from Kinetics Inc. bridges Ethernet and AppleTalk. Users log into the Cray from a Macintosh via a micro/mainframe package from Pacer Inc. Once the user is logged in, the Macintosh performs as a remote terminal of the Cray. The Cray uses the Unicos operating system, which is Cray's licensed version of Unix Version V.

In addition to the Macintosh network, a Silicon Graphics system for high-speed animation is connected to the Cray via the Hyperchannel. Animation is primarily used to simulate high-speed video-interface scenarios on the Macintosh and future machines.

According to Holland, the system will soon include a VME board operating at 50 megabits per second, connecting a Macintosh II directly to the Cray. "Eventually, we'll have keyboards and mice connected directly," said Holland. Another objective is to have Ethernet talking directly to the Cray, thus bypassing the VAXes and Sun/2. "The aim is to get an Ethernet channel directly into the Cray without going into the Hyperchannel," said Holland, adding that "we want to get away from the morass of front ends." At present, about 200 users have access to the Cray and only about 10 use the system at one time. However, the system utilization is generally around 90 percent because of Apple's CPU-intensive graphics simulations.

Two full-time software engineers from Cray work at the Apple facility, in addition to a full-time maintenance engineer. Two separate soundproofed rooms contain three 440-volt power transformers and motor generators, two three-stage cooling water chillers, and a unit that pumps freon into the Cray's cooling jackets. A software system will automatically power down the Cray in the event of a cooling malfunction. A cooling tower, located outside the building, supplies water for the chillers.

Although Apple has yet to release a product fully simulated on the big machine, the Mac II's NuBus was verified on the Cray. Holland speculated that it will be about two years before the release of a product engineered and simulated from scratch on the Cray.

Neural Computing Not Just for the Very Rich

If you want to learn more about neurocomputers—computers designed according to models of how the brain handles information—and parallel processing, but are wincing at the $10,000-and-up price tags, here are some relatively inexpensive products that you might want to investigate. These products were all shown recently at the International Conference on Neural Networking in San Diego, California.

MacBrain is a Macintosh program from Neuronics (Cambridge, MA) for simulating neural networks. Matt Jensen, who developed the software, claims it's the only neural net simulation environment to sell for less than $10,000; in fact, it sells for $250. It's aimed at people beginning to explore neural networking, as well as those who already have a grasp on the technology.

"Our first target market is made up of the low-end, nontechnical people," said Jensen. "Primarily that includes students, grad students, psychologists, and noncomputer people working on fringe fields that have some overlap into neural-network theory and its applications. It's for the sort of people who don't want to get too heavily involved in mathematics but just want some idea of what this technology can do for them, and want some results they can see visually."

The version of the program for "hard cores" can best serve "as a simple prototyping tool," Jensen said. "It is very quick and easy to get things up and running and to adjust parameters interactively."

MacBrain runs on the Macintosh Plus, SE, or II. It contains an interpreter and paradigm shells and lets you create your own multiple paradigm shells. It is equipped to simulate adaptive resonance, the Delta rule, Boltzman machines, and Hopfield nets. An August update is set to support transputer-based boards. That version also offers two programming languages, one text-based and one graphics/icon-based, so people can do their own types of paradigms and rules.

If you are a developer looking to get involved with generalized parallel processing, you might want to check out the Parallon parallel-processing board from Human Devices (New

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GSS*X/386, it's a Xenix-based implementation for 80386-based machines. At press time, only an advance release was ready, but GSS said that the final edition will be ready by the end of the year and will support, among other things, EGA and VGA boards. . . . Only a game? **Strategic Simulations Inc.** reports that **George Bush** was elected president of the U.S. by a landslide in a simulation of the 1988 election. The company hosted a simulated election at the Consumer Electronics Show, using its newest game program, President Elect—1988 Edition. In the simulated contest, Bush won 499 electoral votes. Loser **Albert Gore**, senator from Tennessee, garnered 39 votes. And some say Bush is unelectable.

York, New York). The board uses eight 8-MHz NEC V20 microprocessors (each with 32K bytes of no-wait-state RAM) in a proprietary arrangement to produce eight 1-million-instructions-per-second processing nodes. The configuration supports multiple instruction; multiple data program execution, with a ninth V20 controlling interprocessor communications; PC interface; and data-acquisition functions via on-board programmable I/O ports. You can install up to eight boards (64 processors) in a single system.

Parallon will not run most existing PC software, but it can run parallel programs in the background while standard PC programs operate normally in the foreground. The Parallon Developer's kit lists for $1250 and includes a loader and monitor/debugger. A parallel C compiler is in the works, according to Human Devices.

Martingale Research (Allen, TX) has a hierarchical dynamic system called SYSPRO (which stands for system simulation program). Written in FORTRAN, SYSPRO lists for $995 and includes object code, code for data-file generation, a plotting program, utilities, a user's manual, and an hour of phone consultation. With it, you can develop networks of up to 100 neurons. SYSPRO Plus, which costs $1295, adds the source code for the back-propagation network, giving you nearly complete control of the model.

If you aren't ready to invest that much, Martingale also has a back-propagation network simulator for $275 and a demonstration package for a rock-bottom $75. In any event, you'll need an arithmetic coprocessor (8087 or 80287) and about 512K bytes of RAM (for 100-neuron models), along with some sort of graphics (EGA recommended). Graphics are not an absolute requirement, because the output is also available in ASCII for paper-and-pencil plotting.

Hecht-Nielsen Neurocomputer Corp. (San Diego, CA) sells a neurocomputer coprocessor board that fits into any PC AT-compatible slot. At $9500, the ANZA board treads the boundaries of "low cost," but it lets you design and create simulations of neural nets for use in such areas as pattern recognition, robotics, and database searching. The company said the card can implement a network with up to 30,000 neurons and 480,000 interconnections. At the conference, Hecht-Nielsen demonstrated a face-recognition system based on the ANZA board.

Campus Nets, Sharing Research Seen as Keys to Academic Computing

Establishing effective campus networks, developing instructional programs that are more than computerized page-turners, and sharing the results of research are the biggest challenges facing academic computing, according to participants at a recent university conference. Representatives from more than 30 schools gathered in Boston, at a conference sponsored by IBM's Academic Information Systems (ACIS) division, to discuss the state of computing in colleges. They also exhibited projects that demonstrate the use of microcomputers (IBM microcomputers) as tools for learning.

Jerry Latta, IBM's ACIS group director and a former physics teacher, predicted that we'll soon see "a major cultural change" in education, a change that will be caused by campus-wide networks and computer-based instruction. Latta said instructional software now being developed at "leading" universities is designed to enhance learning rather than to assume the teacher's role. He also said that if programs are to be effective learning tools, they have to be more than textbooks adapted to a computer screen. "This is not automated page-turning," Latta said.

IBM's ACIS program provides research funds and equipment to schools that Latta termed "leaders": Carnegie-Mellon, Cornell, MIT, University of Texas, UCLA, University of Florida, and others. Some participants at the conference, even though they benefit from endowments such as IBM's, expressed concern that only the better known universities get significant research funds, while other schools can barely stock their libraries.

Asked if there's a trend toward colleges that have and colleges that have not, Latta said the schools that get grants will share the results of their research with schools that lack such funding. This "fan-out effect" will spread the technology to schools with "modest budgets," Latta said. He mentioned the University of Wisconsin's Wisc-Ware program, a network for distributing instructional software, as one way in which technology is disseminated.

Some of the PC-based projects on display at the conference included a program to help people who have to work with toxic chemicals; Philo the Logician, intended to help students in introductory logic classes; tools for building expert systems; programs aimed at improving learning in large science-lecture classes; LAN-based courseware for students to read and critique each other's writing; an interactive phonetics lab; and programs for simulating molecular dynamics.

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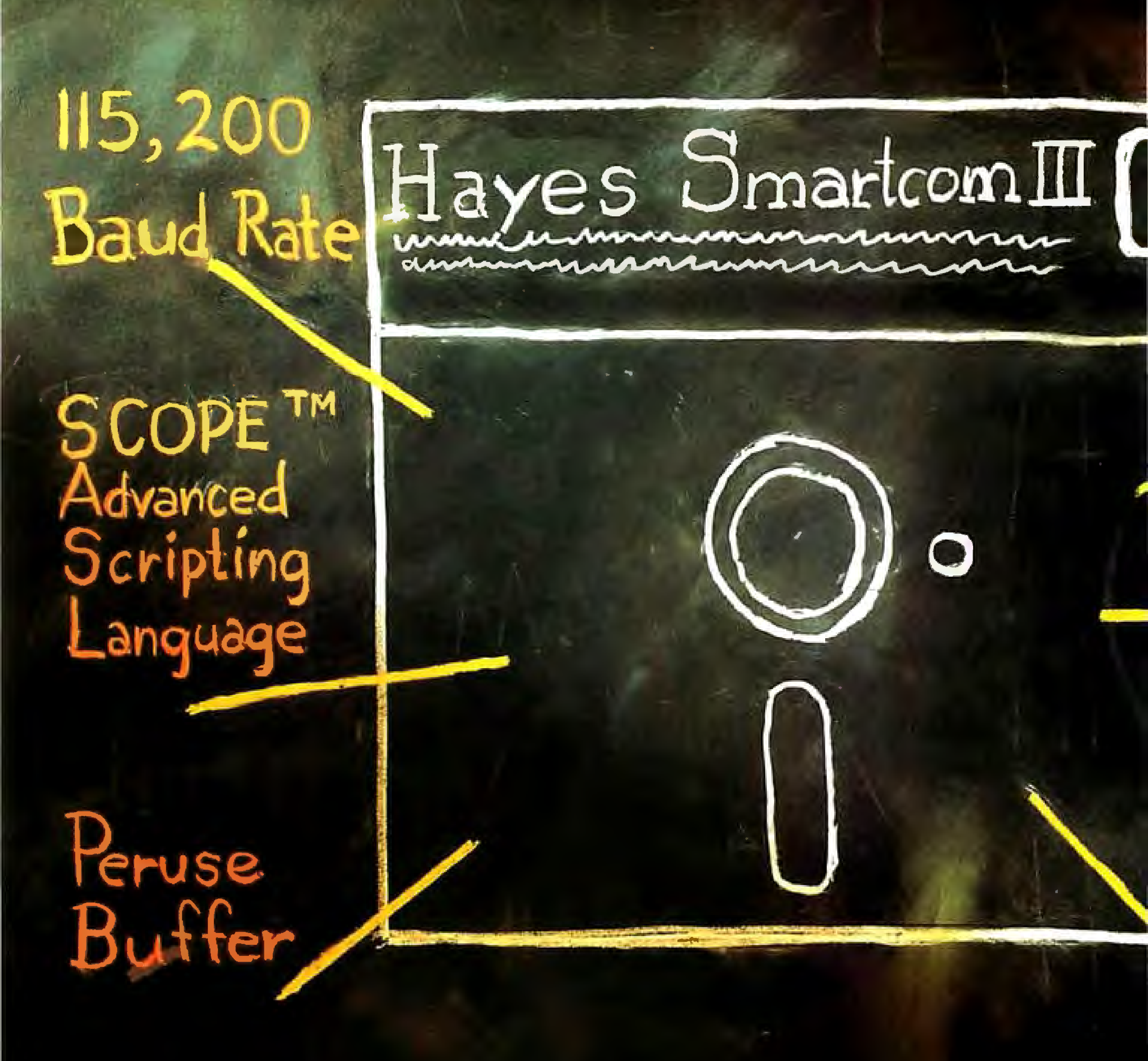


Smartcom III requires 512K memory and a hard disk, and runs on IBM PC-XT, AT and PS/2 family or compatible computers.

Two Programs Bundled with 1-megabyte Macs

Apple Computer recently showed us MultiFinder and HyperCard, two very impressive new software packages for 1-megabyte Macintoshes.

MultiFinder allows you to keep multiple applications ready for use and gives you limited multitasking, with almost perfect compatibility with existing Mac applications.

HyperCard uses the metaphor of "a stack of cards" (actually, a file full of graphic/text images) to provide a usable way of storing and cross-referencing data; it is also the foundation for what Apple calls *stackware*, user- and commercially produced applications that sit on top of HyperCard.

One of the most significant things about these two products is that they will soon be included with the purchase of any 1-megabyte or larger machine or motherboard upgrade, thus making both of them part of the standard Macintosh configuration. (Officials at Apple said that existing Mac users will be able to buy these products for under $50 each.)

MultiFinder is a new file that augments the existing Finder by allowing you to display multiple applications and switch between them by clicking in the appropriate window. Unlike Apple's Switcher program, MultiFinder shows each application's window on the same desktop.

We played with an alpha version of MultiFinder and found that at least 90 percent of the applications we tried behaved well with it. MultiFinder usually took between 2 and 5 seconds to switch applications and refresh the display.

MultiFinder also offers limited multitasking capability with applications designed for it. New code in the Mac's Event Manager steals control from an active application (when it is doing nothing) and passes it to inactive applications that can do some small part of their work and return it in under 100 milliseconds. The Event Manager can steal control from *any* Mac application, even existing ones, but new applications can be written to surrender control with less overhead.

MultiFinder will include a built-in background task that spools print jobs, thus freeing the Mac for other work (this feature was not available in the version we saw).

Apple personnel reported that numerous companies are working on both enhanced and new products that can use background time (including background terminal programs). They also said that future versions of MultiFinder will build toward full multitasking, but they had no details on this.

By most people's definition of the word, HyperCard is a new category of software. Though it has roots in previous Mac and non-Mac applications, HyperCard is as much a new *approach* to dealing with data as it is a product for doing so. Another way of looking at it is as the next and newest level of the Macintosh user interface. In fact, Apple personnel (who say that the company is getting out of the software business) were promoting HyperCard as a platform on which programmers can build commercial products—though they were quick to point out that HyperCard is also useful right out of the box.

HyperCard stores information (text, graphics, sound, animation, and—indirectly—anything else you can think of) in a stack file full of screen-size images called *cards*. Any card can point to any other card, even a card in another file on a shared file server. These links can already be present in a stack, or you can put them in yourself. With just a few simple mouse-based movements, you can "paste" into a card a dialog button that, when pressed, will take you to any card that you designate.

This brings us to another important aspect of HyperCard: the multiple levels at which it can be used. You can set HyperCard to run at a given level, which simplifies the menu bar accordingly.

At the first two levels, *browsing* and *typing*, you can look at stacks and modify and add cards. Many people will not get past these levels and will use supplied stack examples that function like phone lists, address books, appointment books, and similar applications.

The remaining three levels, *painting*, *authoring*, and *programming*, will attract some users into deeper and more fundamental levels of modifying a stack or creating a new one. At these levels, you can do things like change the size of a field, add a predefined button, and even specify exactly what a button does when you press it. HyperCard uses a simple but powerful English-like script language called HyperTalk to define a button's behavior.

Software developers can interact with HyperCard in a sixth way. By writing the appropriate programs, compiling them, and hiding them inside a stack file, a programmer can add new commands to HyperTalk, thus extending HyperCard to do things it was not explicitly designed to do. One example we saw was a cross-referenced geographic atlas; when we clicked on certain points on the screen, a laser-disk player that was connected to the Mac instantly displayed a satellite photograph of the area clicked on.

We have played with a beta version of HyperCard for several days and, so far, have found it fast, *very* useful, and a lot of fun. Look for a more detailed report on MultiFinder in the November BYTE and a report on HyperCard in the December issue.

—Gregg Williams and Tom Thompson

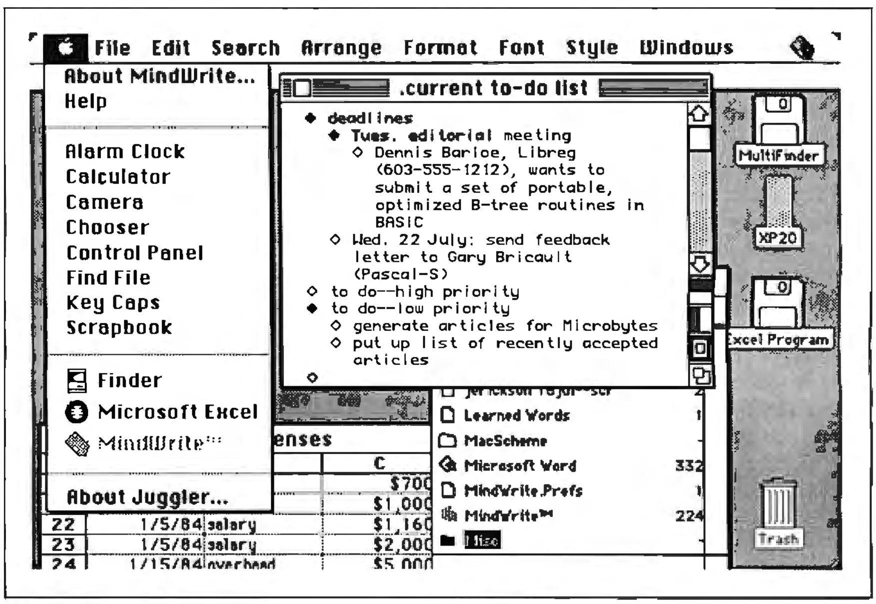


Figure 1: *Apple's new MultiFinder.*

PaintJet Prints in Color

Hewlett-Packard's PaintJet color graphics printer uses thermal ink-jet technology to produce text and graphics with a resolution of 180 by 180 dots per inch. It also prints near-letter-quality text at 167 characters per second.

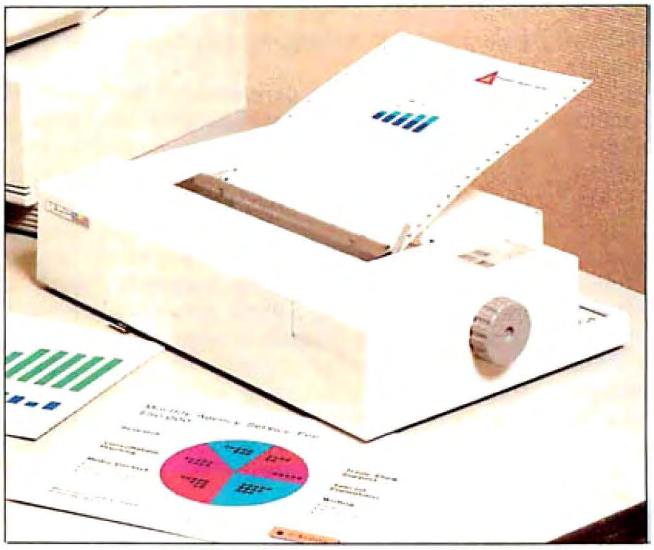
The printer mechanism holds four inks (black, yellow, magenta, and cyan) and mixes them to produce red, blue, and green. With the appropriate software, you can mix the three primary colors to produce 330 different shades and hues.

The PaintJet uses 60 nozzles to transfer the ink to the media. The nozzles, black or colored inks, and electrical printing elements come in disposable cartridges. HP rates the cartridge life at 1.1 million characters—about 1100 pages of text or 180 pages of color graphics.

You can use cut-sheet paper or single-sheet transparency film in the PaintJet in sizes up to 8½ by 11 inches. A full page of color graphics on paper takes approximately 4 minutes to print. A special mode, used for producing color transparencies, requires about 8 minutes.

The PaintJet measures 3.9 by 14.4 by 11.9 inches and weighs 11 pounds. Its noise level during printing is below 50 decibels. The printer is available with either serial, parallel, or HP-IB (IEEE-488) interfaces.

Price: $1395; black cartridge, $27.95; color cartridge, $34.95.
Contact: Hewlett Packard, 3000 Hanover St., Palo Alto, CA 94304, (415) 857-1501.
Inquiry 576.



HP's PaintJet produces up to 330 shades and hues.

Protected-Mode 286 and 386 Operating Systems

Extend MS-DOS with the OS/286 or OS/386 protected-mode operating systems. The systems run on top of DOS, using the same interface, so your DOS 3.x calls and BIOS functions are accessible. Device drivers and TSR (terminate-and-stay-resident programs) interrupt handlers written for DOS also run under OS/286 and /386.

OS/386 offers a 4-gigabyte address space and adds 32-bit performance to 386 systems, and you can customize it to give unmodified DOS programs up to 900K bytes, no matter how many TSRs, networks, or disk caches are installed. You can convert your 8086 assembly language programs to 16-bit (286) mode. On the 386, a 16-bit program runs two to three times faster than it would on the 286, the company reports. If you convert the program to 32 bits, it increases the speed another two to four times. Using the developer's toolkit, you can recompile programs written in C, Pascal, FORTRAN, or Common LISP.

The operating systems come with a kernel, linker, and symbolic debugger/command processor. Options include 16- and 32-bit compilers, High C, Professional Pascal, F77L FORTRAN, and a 32-bit assembler. The symbolic debugger acts as a command processor with command-line editing, a history mechanism, dynamic environment variables, and nesting of batch files.

Applications you develop with the 386 operating system are portable to other IBM PC-based 386 systems. Applications developed with OS/286 can be ported to compatible 286 and 386 systems.

To run the operating systems, you load them as device drivers at boot time. OS/386 uses two physical processors when they are present and requires an A.I. Architects HummingBoard, a Compaq 386, or a Chips and Technologies 386 Chipset or compatible with at least 1 megabyte of extended memory. For OS/286, you need an IBM PC AT or compatible with at least 1 megabyte of extended memory.

Price: $495 each.
Contact: A.I. Architects Inc., One Kendall Square, Suite 2200, Cambridge, MA 02139, (617) 577-8052.
Inquiry 577.

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If you want us to consider your product for publication, send us full information about it, including its price, ship date, and an address and telephone number where readers can get further information. Send to New Products Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Information contained in these items is based on manufacturers' written statements and/or telephone interviews with BYTE reporters. BYTE does not represent itself has having formally reviewed each product mentioned.

Unix Operating System

System V/386, a Unix operating system for the Intel 80386 microprocessor, includes optional development, word processing, and Streams networking packages. Source code is available. The operating system runs on any 386 machine, according to Microport.

Price: Two-user system, $199; development module, $499; text processing, $199; run-time system with all modules, $799; source code, $25,000. At press time, Microport had not set a price for the networking package.
Contact: Microport Systems Inc., 10 Victor Square, Scotts Valley, CA 95066, (800) 722-8649; in CA, (800) 822-8649.
Inquiry 578.

continued

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We make PCs better.

Inquiry 109

Snap Shot digitizes images for manipulation under Windows.

Snap Shot Does Windows

BioScan's Snap Shot lets you capture and digitize moving or static images from television cameras, VCRs, or laser disks (any RS-170 signal). The program supports real-time digitization to 256 gray levels at a resolution of 512 by 512 pixels. You can control the brightness and contrast of the video signal.

Before printing the image, you can crop, size, enhance, halftone, and preview your image under Microsoft Windows. The program directly supports Aldus PageMaker, or you can transfer bit-mapped images to any application through the Windows Clipboard or create TIFF files for high-resolution hard copy.

Three models of Snap Shot are available. The Model 10 includes software, a full-slot image-processing board, cables, and connectors. The Model 20 adds a 13-inch RGB monitor, and the Model 30 includes all of the above plus a monochrome video camera, a macro-zoom lens, cables, and a stand.

Snap Shot runs on IBM PC XTs, ATs, and compatibles with MS-DOS or PC-DOS 2.0 or higher, 512K bytes of RAM (640K bytes recommended), a Microsoft Mouse, and Microsoft Windows. Two floppy disk drives are required, and a hard disk drive is recommended.

Price: Model 10, $2250; Model 20, $2860; Model 30, $3570.
Contact: BioScan Inc., 4520 Union Bay Place NE, Seattle, WA 98105, (206) 523-5000.
Inquiry 579.

Transfer Data Between Incompatible Programs

Magic Mirror is a memory-resident program that lets you reformat and transfer data between incompatible programs.

You highlight data on your screen to store it on disk in a memory buffer limited only by your disk space. You can then call the data from the disk and format it for the program you want to send it to. You can store the formatting procedure in a library and reformat the data to be transferred to another program. After you reformat the data, you call up the target program and transfer the data. The data is sent as if it is coming directly from the keyboard, SoftLogic Solutions reports. The entire process takes only a few seconds.

Magic Mirror runs on IBM PCs and compatibles with MS-DOS or PC-DOS 2.0 or higher and 256K bytes of RAM. It occupies 48K bytes.

Price: $89.95.
Contact: SoftLogic Solutions Inc., One Perimeter Rd., Manchester, NH 03103, (800) 272-9900; in New Hampshire, (603) 627-9900.
Inquiry 580.

Use Existing Drives with your PS/2

Short for "external disk adapter," EDAPT from Flagstaff Engineering is an external disk drive interface package that lets you connect your existing 3½-, 5¼-, or 8-inch floppy disk drive to the IBM PS/2 computers.

EDAPT consists of a 2- by 2-inch connector that installs into the PS/2's second disk drive cavity, and a flat cable that runs from the card out to an existing drive. The package also includes a set of software device drivers and a power cable that uses the PS/2's 5- and 12-volt power supply.

The interface adapter delivers data at rates of 250 or 500 bits per second. The company claims it can be installed in less than 5 minutes.

Price: $99.
Contact: Flagstaff Engineering, 1120 Kaibab Lane, Flagstaff, AZ 86001, (602) 779-3341.
Inquiry 581.

Altos Combines 386 and Xenix V

Altos Computer Systems claims its 386 Series 2000 is the industry's first 80386-based system that runs the Xenix System V operating system. The Series 2000 is available in four configurations, all of which include an 80386 operating at 16 MHz, an 80387 coprocessor, and a 32K-byte instruction cache. Also standard is a 1.2-megabyte 5¼-inch floppy disk drive, a 60-megabyte streaming tape-backup unit, and an Altos V terminal.

The Model 2408S supports up to 20 users and includes 4 megabytes of RAM and a 65-megabyte ESDI (enhanced small device interface) hard disk drive. The 2417S has a 142-megabyte hard disk drive. Supporting up to 64 users, the Model 2417M includes 4 megabytes of RAM, a 142-megabyte hard disk drive, and the Multidrop cabling and transmission system that lets you connect up to 64 RS-232C devices to the system on a single cable. At the top of the line, the Model 2817M adds 4 more megabytes.

Any of the Series 2000 systems can be expanded to up to 16 megabytes of RAM in 2-, 4-, and 8-megabyte increments. A 320-megabyte hard disk drive and an uninterruptible power supply (UPS) for the system will be available by the end of the year. The UPS will fit as a pedestal base to the computer system and will come with software that provides power-fail/auto-restart services if the power failure lasts longer than the UPS's 3- to 5-minute rated life.

Price: $25,000 and up.
Contact: Altos Computer Systems, 2641 Orchard Parkway, San Jose, CA 95134, (408) 946-6700.
Inquiry 582.

continued

The Altos Series 200 runs Xenix and the 80386.

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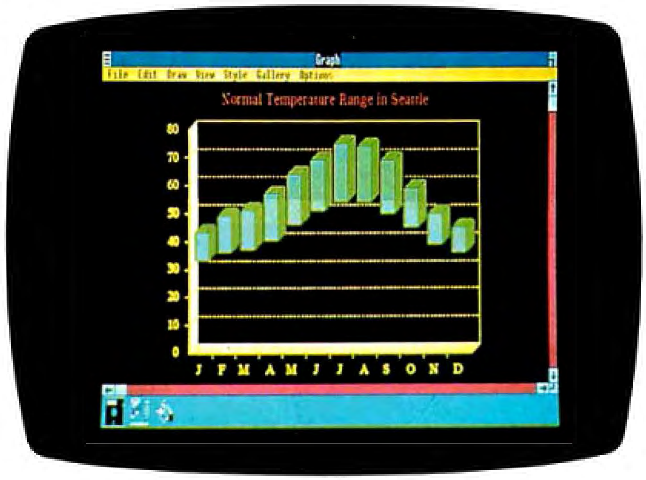

A three-dimensional bar chart created with Windows Graph.

Three-Dimensional Charting and Graphing

Windows Graph is a business graphics and charting program that is compatible with Microsoft Windows. From data files, you can create two- and three-dimensional charts and graphs of up to 34 by 34 inches, including area, bar, column, line pie, scatter, table, and combination charts. You can also place an unlimited number of charts on one page. A Folder is included, in which you can store custom graphs for later access.

The program features three-dimensional support for all chart types, and Microsoft's DDE (Dynamic Data Exchange) protocol is supported for linking data from one application to another. You can also link data to charts within Windows Graph to the data contained in a worksheet window and import data from a variety of spreadsheets. You can also create labels in the worksheet window and type and manipulate text interactively on the chart pages. Line and paragraph formatting and editing features enable you to place text in the graph area. When you modify the data in the worksheet, the program automatically updates the charts.

In creating three-dimensional views, you control the amount of depth and projection view. You can also change the location of the axes, add major and minor grids, and clarify legends.

In addition, Windows Graph is compatible with In*a*Vision and Windows Draw, and you can load charts into either program for further manipulation.

Windows Graph runs on IBM PCs and compatibles with at least 320K bytes of RAM, two floppy disk drives, a graphics card, a graphics monitor, and a printer. Micrografx recommends a hard disk drive and 512K bytes of RAM.

Price: $395.

Contact: Micrografx Inc., 1820 North Greenville Ave., Richardson, TX 75081, (214) 234-1769.

Inquiry 583.

Getting Personal with Laser Printers

General Computer's Personal LaserPrinter (PLP) takes up about as much desktop real estate as an Imagewriter and costs about half the price of an Apple LaserWriter. The PLP runs with the Macintosh Plus, SE, and II. A 1-megabyte RAM cartridge plugged into the printer lets you run it off the 512K-byte Macintosh.

Having only 4K bytes of ROM and a tiny RAM buffer, the PLP is essentially a "dumb" printer. It uses Macintosh QuickDraw routines to process the image and then writes print files into spool files on your disk.

Using a Ricoh 6000 print engine, the PLP prints at 6 pages per minute. It features three print modes: high-quality mode prints at resolutions of 300 dots per inch; draft mode prints at 72 dpi and provides a printout in seconds; and preview mode prints to screen, letting you see what the document will look like when printed.

The PLP comes with 13 LaserWriter fonts plus nine additional fonts. The fonts are defined in software as outlines, enabling you to scale, rotate, and manipulate the fonts without affecting output quality. The PLP does not support PostScript and can't be used on a local-area network.

General Computer claims the PLP's cartridge is good for 1500 copies, the drum cartridge is good for 20,000 copies, and the cleaner cartridge for 10,000 copies. A replacement drum cartridge with two cleaner cartridges are available for about $200.

Price: $2599; toner cartridge, $29.

Contact: General Computer Corp., 215 First St., Cambridge, MA 02142, (617) 492-5500.

Inquiry 584.

28-millisecond Drive for the Mac SE and II

The Rodime 450 RX is an internal 45-megabyte hard disk drive that's designed for the Macintosh SE and II. The company claims the drive has an average access time of 28 milliseconds.

An embedded SCSI controller is used in the drive because of space constraints. Rodime says it fully meets Apple's SCSI specifications. The controller handles all error correction and disk management. Built-in diagnostics identify and flag 28 different fault conditions in the drive, controller, or power supply. The 450 RX is fully arbitrating, which maximizes data throughput when you use multiple SCSI peripherals. You can connect up to seven additional SCSI peripherals through the drive's SCSI port.

The 450 RX includes FileGuard software for backing up data from the hard disk to floppies. You must have a dealer install the drive in the Macintosh II or SE. Its installation is identical to that of Apple's hard disk drives, requiring a supplied mounting bracket and a 50-pin connector.

Price: $1595.

Contact: Rodime Inc., Peripheral Systems Division, 29525 Chagrin Blvd., Suite 214, Pepper Pike, OH 44122, (216) 765-8414.

Inquiry 585.

Z80 Card Adds CP/M to PCs

MicroSolution's high-speed Z80 card lets you run CP/M programs on your IBM PC or compatible. The card requires a half-size 8-bit slot and has 64K bytes of RAM and an 8-bit Z80 processor that runs at 8 MHz with no wait states.

The Z80 card comes with the high-speed version of the company's UniDOS, a CP/M emulator that lets you create a complete Z80 CP/M version 2.2-compatible environment on your system.

Price: $195.

Contact: MicroSolutions Computer Products, 132 West Lincoln Highway, DeKalb, IL 60115, (815) 756-3411.

Inquiry 586.

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SYSTEMS

DG Upgrades Laptop

The Model 2T is Data General's latest incarnation of its Data General/One laptop computer. Weighing just under 12 pounds, the 2T adds a supertwist backlit LCD screen, a dual-speed Intel 80C88 running at both 4.77 MHz and 7.16 MHz, and removable batteries.

The standard model of the 2T has 512K bytes of RAM and a single 3½-inch floppy disk drive. You can upgrade the system's internal RAM in 256K-byte, 1-megabyte, or 2-megabyte increments, up to a maximum of 2.5 megabytes. A 3½-inch 10-megabyte internal hard disk drive is optional.

You can manually switch the supertwist LCD screen to a normal (nonbacklit) screen to conserve battery life. The system's nickel-cadmium rechargeable batteries are now removable and can power the 2T for up to 5 hours. In addition to the internal trickle-charger for the battery, an optional quick charge is also available. It fully recharges the batteries in 2 hours.

The 2T has both parallel and serial ports. Other available options include a Hayes-compatible 1200-bps modem, an interface card for an external 5¼-inch floppy disk drive, an 8087 coprocessor, a carrying case, and a car adapter. For software, the Model 2T comes with MS-DOS 3.2.

Price: $1695; with a hard disk drive, $2895.
Contact: Data General Corp., 4400 Computer Dr., Westborough, MA 01580, (800) 328-2436; in Massachusetts, (617) 366-8911.
Inquiry 587.

DG's upgraded Model 2T adds a supertwist backlit LCD.

Split-Personality System

Datamedia Corp.'s Colorscan/2 is a diskless workstation with a motherboard full of application-specific integrated circuits (ASICs), a V30 processor running at 8 MHz, and 768K bytes of zero-wait-state RAM. The system unit has a footprint of 15 by 10 inches and is just 2½ inches high. Not surprisingly, surface-mount technology is used extensively, and the Datamedia folks have taken several hints from IBM PS/2 designers with quick-disconnect components. The only cable goes to a cooling fan.

The Colorscan/2 can be a DEC VT-240–compatible terminal and a PC at the same time. You can hook up to an on-line system, such as a VAX, while working with a PC application at the same time. You switch between the terminal session and the PC by hitting a hot key. Since the Colorscan/2 has two RS-232C serial ports, you can also have an on-line session running under MS-DOS at the same time. As with the Macintosh, there's a Clipboard that lets you move data back and forth between VT-240 and PC modes.

The system's EGA chips are designed by Datamedia and provide a resolution of up to 800 by 480 on the 13-inch monitor, which is included. Characters display in a 10-by-10 pixel matrix. A custom ASIC also saves EGA registers and memory while in VT-240 mode. All VT-240 functions are stored in a 128K-byte ROM.

There's room inside for two add-in boards, as long as they aren't longer than 8 inches. You install all boards horizontally using 8-bit bus 90-degree adapters that are included with the unit.

Options include a long, narrow, battery-backed 2-megabyte RAM card that doesn't use either of the two expansion slots. And for those who choose not to go diskless, there's an expansion unit that sits vertically like a book and contains both a 3½-inch 1.4-megabyte floppy drive and a 3½-inch 20-megabyte hard disk drive. There's also a cardfile interface that accepts credit-card–size memory cards.

Price: $2000; 2-megabyte RAM card, $750; 3½-inch floppy/hard disk unit, $995; cardfile interface, $150.
Contact: Datamedia Corp., 11 Trafalgar Square, Nashua, NH 03063, (603) 886-1570.
Inquiry 588.

ON! System is Always On

The aptly-named ON! System doesn't have a power switch. In a departure from contemporary computer designs, the system stores all its built-in programs in RAM, with configurations available in either 2 or 4 megabytes.

Running an 8-bit Z80 processor with the ZRDOS operating system, the ON! System has built-in power-conditioning and backup power that the company claims will hold all data for up to 14 hours.

The built-in menu-driven software includes the NewWord word processor with a 65,000-word spelling checker and over 50 special utilities for file and system management. The system has an external 5¼-inch floppy disk drive that reads and writes data from over 40 disk formats, including MS-DOS.

The system unit has no moving parts, and, according to the company, doesn't require a cooling fan. Single parallel and RS-232C serial ports are standard, and the standard 14-inch monochrome display is available in green, amber, or white phosphor.

Price: $2895 with 2-megabytes of RAM; $3595 with 4 megabytes.
Contact: ON! Systems Inc., 27944 North Bradley Rd., Libertyville, IL 60048, (312) 680-4680.
Inquiry 589.

continued


Verbatim 6.6

PERIPHERALS

Low-Cost Buffer Gets Smaller

The new version of the MicroStuffer printer buffer measures approximately 5 by 6 inches—about half the size of its predecessor. The buffer has 64K bytes of RAM and works with all computers and most parallel-port printers. Installation is a simple matter of plugging it between your computer and printer.

MicroStuffer is totally transparent to the applications software. It shows buffer status with a flashing light on the front panel, which flashes faster as you fill the buffer. A "clear" push button clears the RAM, while a Repeat button lets you make multiple copies.

Price: $69.95.
Contact: Supra Corp., 1133 Commercial Way, Albany, OR 97321, (503) 967-9075.
Inquiry 590.

The new MicroStuffer printer buffer is compact and low-cost.

Up to a Gigabyte on the Mac II

Mirror Technologies' ProStation 1024 is a combination hard disk drive/tape-backup system designed especially for the Macintosh II, although it has a standard SCSI interface for use with any system so equipped. The system is available in hard disk configurations of 85, 172, 340, 680, and 1024 megabytes. The tape-backup part of the system is available in 40-, 120-, and 240-megabyte sizes. You can upgrade both the hard disk drive and tape-backup system to higher capacities.

The ProStation 1024 measures 6 by 17 by 18 inches and weighs about 45 pounds. Its surface color and texture match that of the Macintosh II, and it's designed to sit under the monitor. Mirror Technologies says a fully configured gigabyte system has an average track-to-track time of 17 milliseconds. The tape-backup system writes approximately 3.5 megabytes per minute on standard data cartridges. The unit has a locking on/off switch.

Software shipped with the ProStation includes Manager's SafetyNet, a program that performs a backup especially for file servers on the AppleShare network. Also included is Personal SafetyNet, which lets you back up your own files; AutoBack, a time-delay backup option; an Imagewriter spooler; and Think Technologies' LaserSpeed.

Price: $7995 and up.
Contact: Mirror Technologies Inc., 2209 Phelps Rd., Hugo, MN 55038, (612) 426-3276.
Inquiry 591.

New QMS Printer Supports PostScript

The QMS-PS 800 II is a new PostScript-based laser printer that prints 8 pages per minute using the Canon CXD print engine. The unit handles 500 sheets of input and 400 sheets of output and has a duty cycle of 10,000 copies per month. You can specify face-up or face-down paper output and use the dual-input bin for first sheet/ second sheet applications.

The 800 II has a megabyte of RAM for full-page graphics and text applications. Besides the PostSript page-description language, the printer also emulates the HP LaserJet Plus, HPGL (Hewlett-Packard graphics language), and Diablo printers. RS-232C, RS-422, and parallel interfaces are standard.

Price: $6495.
Contact: QMS Inc., P.O. Box 81250, Mobile, AL 36689, (205) 633-4300.
Inquiry 592.

Saba's Full-Page Reader

Saba Technologies' Page Reader is a full-page document reader that reads a page a minute into your computer while operating in the background. According to the company, the unit preserves the format of a scanned document, reading it into a wide variety of word-processing programs while keeping the same indentations, tabs, spaces, and columns as the original document.

The reader will also transfer columns of words and numbers into Lotus 1-2-3 and will read graphics into two graphics programs: PC Paint and PC Paintbrush. The reader has a built-in sheet feeder that lets it read stacks of up to five typewritten pages. Although Page Reader's software requires only 270K bytes of RAM, Saba recommends 640K bytes and a hard disk drive. To use the reader, you access the software with a hot key, tell it which word processor you're using, and press a key to activate the reader.

Price: $1299.
Contact: Saba Technologies Inc., 9300 Southwest Gemini Dr., Beaverton, OR 97005, (503) 626-7050.
Inquiry 593.

Bypassing the Power Supply

CPS (continuous parallel-power system) from Applied Research and Technology is an alternative power source for personal computers. The Co-Pilot 140 CPS supplies DC power directly to a computer by bypassing the computer's internal power supply and completely eliminating any switchover delays. According to the manufacturer, the battery system and the Co-Pilot will power a fully loaded AT-type computer for approximately 2 hours.

Under normal operating conditions, the computer power supply receives AC power from the 115-volt AC line and converts the AC to appropriate levels of DC. Simultaneously, the Co-Pilot is producing the same voltages, which are placed in parallel to the computer's. Should a power loss occur, the computer's power supply would begin to fail, and its DC levels would start to drop. But because the battery-backed Co-Pilot's DC levels are connected to the computer, the system's power needs are met.

The company says its parallel-power approach also eliminates the normal AC/DC/AC conversion inefficiencies associated with other backup and uninterruptible power supplies.

Price: $1495.
Contact: Applied Research and Technology Inc., 6400 Powers Ferry Rd., Suite 110, Atlanta, GA 30339, (404) 951-9919.
Inquiry 594.

continued

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Lawrence Oakley,
Business Computer Digest, 3/87

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Infoworld, April 27, 87

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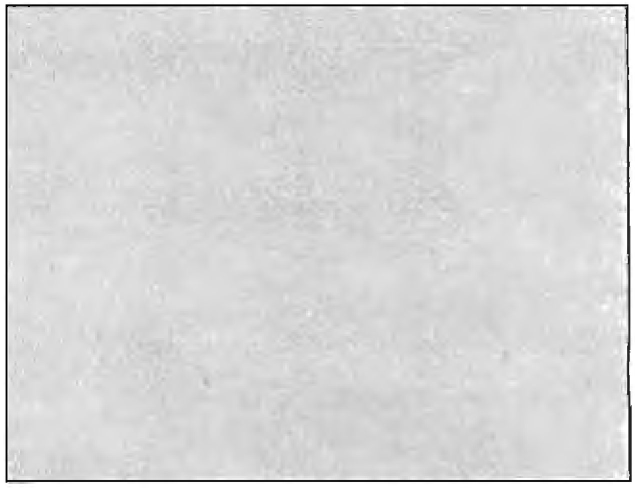
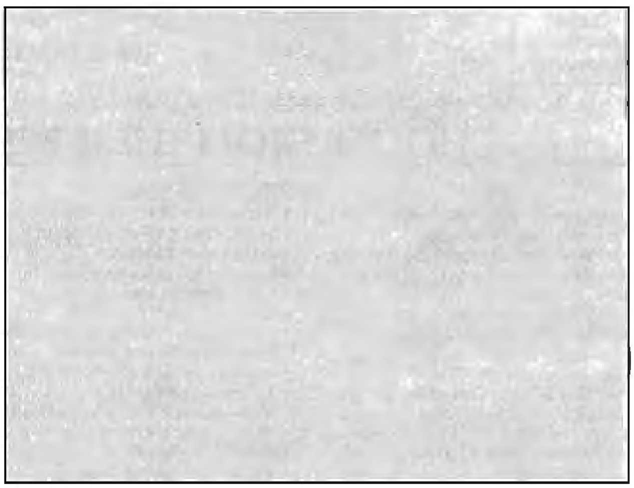
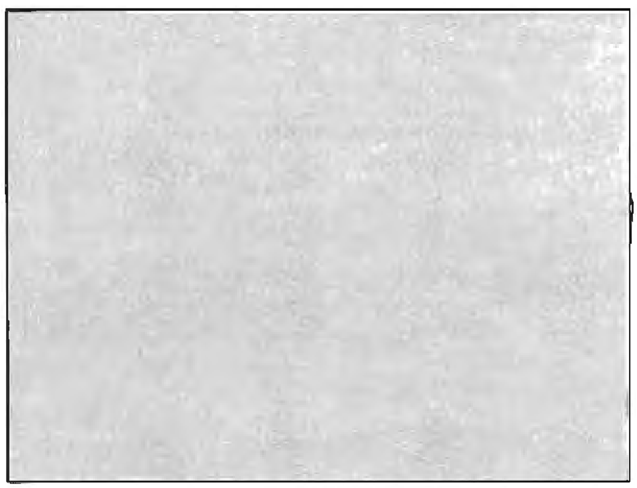


No integrated source-level debugging.



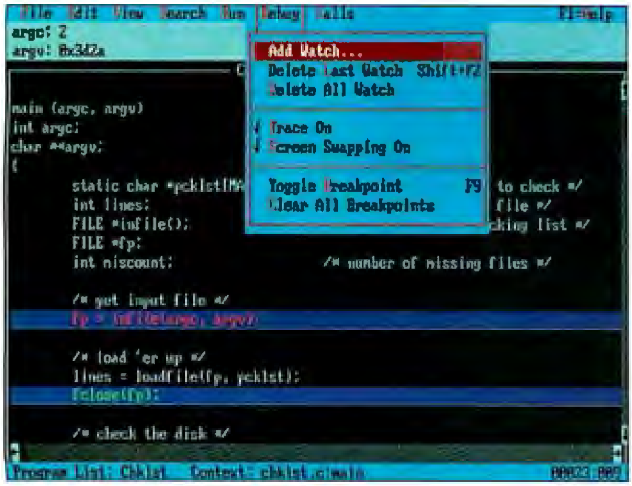
No graphics library.



No on-line help for the C language or library routines.

Life is not fair.

QuickC



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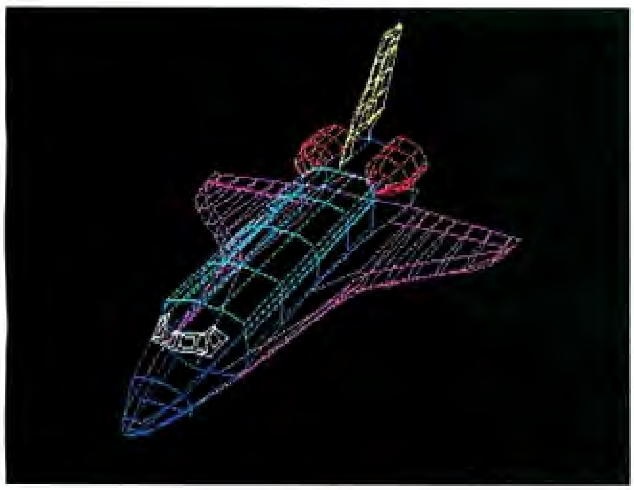

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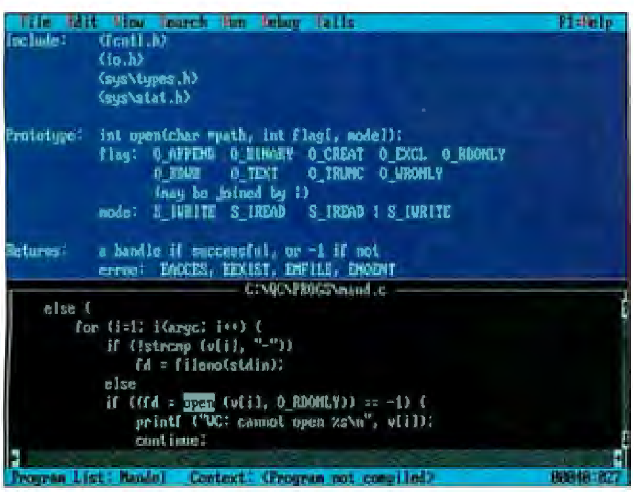

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Microsoft QuickC Compiler Feature Comparison

	Microsoft QuickC Version 1.0	Turbo C® Version 1.0
Debugger		
Integrated debugger and editor	Yes	—
Source-level debugging	Yes	—
Watch local & global variables	Yes	—
Set breakpoints	Yes	—
Stack tracing	Yes	—
Editor and Environment		
WordStar® compatible	Yes	Yes
Context-sensitive help for C language	Yes	—
Context-sensitive help for C functions	Yes	—
Brace, bracket & parenthesis matching	Yes	—
Mouse support	Yes	—
Support for EGA 43-line mode	Yes	—
Documentation		
Complete C language reference	Yes	—
Examples for every library routine	Yes	—
Compiler		
Completely Microsoft CodeView compatible	Yes	—
Automatic enregistering	Yes	Yes
Integrated MAKE		
Automatically generates .MAK file	Yes	—
In-memory MAKE compatible with stand-alone MAKE	Yes	—
Include file dependencies	Yes	Yes
Libraries		
Graphics library included	Yes	—
CGA & EGA and VGA support	Yes	—
Library source code available	Yes ($150)	Yes ($150)
Microsoft C Optimizing Compiler 5.0 compatible	Yes	—
Microsoft LINK vs. Turbo Link		
Links programs up to 640K	Yes	—
Supports overlays	Yes	—
Directory searching for library files	Yes	—

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Inquiry 182

ADD-INS

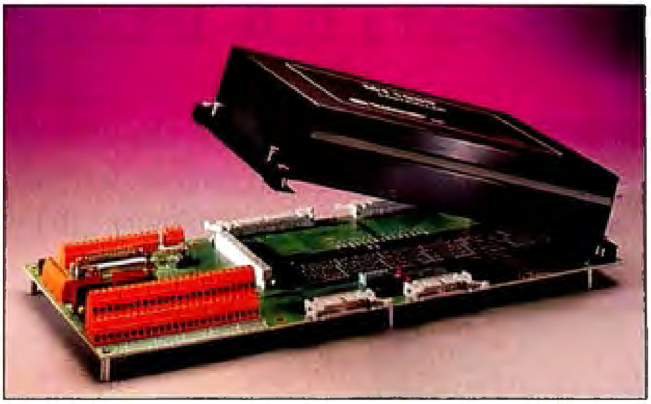
Turbo Pascal Controls Controller

The MT1000 is a single-board electronic controller designed for a wide range of control applications. According to Measurement Technology, it's the first controller to be programmed with Borland's Turbo Pascal, which has been enhanced on the MT1000 to include software interrupts that allow your program to respond in real time to external events.

Based on Hitachi's HD64180 CMOS processor, the MT1000 includes 64K bytes of battery-backed CMOS RAM, 128K bytes of user EPROM, 1K byte of EEPROM (electrically erasable), and a clock/calendar. Three RS-232C serial ports are included.

You can connect the MT1000 directly to a wide variety of sensors, as well as voltage and current input signals. It also has six frequency inputs that allow any frequency in the range of 50 hertz to 1 MHz to be automatically measured to .005 percent resolution within 20 milliseconds.

An optional floppy disk controller/256K-byte RAM card is available. The MT1000 requires a single 5-volt DC supply and typically consumes 5 watts of power.
Price: $1625.
Contact: Measurement Technology Inc., 1595 Central St., Stoughton, MA 02072-1694, (617) 344-6230.
Inquiry 595.



You can use Turbo Pascal to program the MT1000 controller.

12 MHz for your PC

Breakthru 286-12 from the Personal Computer Support Group replaces your PC, XT, or compatible 8088 processor with an 80286 processor running at 12 MHz. The Breakthru requires a half slot and has a multiconductor cable that plugs into the system's current processor slot.

The board has 16K bytes of cache memory and on-board logic for write buffering. The board can be slowed down via software control. Also included with the board is PCSG's Lightning disk-cache software.
Price: $595.
Contact: Personal Computer Support Group, 11035 Harry Hines Blvd. #207, Dallas, TX 75229, (214) 351-0564.
Inquiry 596.

Slotless Amiga Slot

The TimeSaver macro/clock for the Amiga 1000 plugs into the line between the computer and keyboard and attaches to the underside of your computer. The built-in replaceable lithium battery has a rated life of 12 to 18 months, and the unit automatically enters the date and time whenever you power-up or reboot your Amiga.

There's a built-in ROM with macros that contain shorthand versions of many CLI commands. It can be disabled if you desire. In addition, the TimeSaver has 7K bytes of RAM for programming macro keys, with a learn mode that remembers commands that you key in. You can also include any macro you select in a start-up/reboot routine.

TimeSaver has a command-line history buffer that stores your last 1024 characters of CLI commands, and a command-line editor for editing CLI commands. The unit also allows you to password-protect your Amiga, preventing its start-up until you enter your personal password.
Price: $79.95.
Contact: C Ltd., 723 East Skinner, Wichita, KS 67211, (316) 267-3807.
Inquiry 597.

Mighty Meg adds up to 14.5 Megabytes

Quadram's Mighty Meg is a memory-expansion board for IBM PC ATs and full compatibles that uses SIMMs (single in-line memory modules) to add up to 14.5 megabytes of RAM to your system, using a single 16-bit expansion slot.

The five available configurations for the Mighty Meg start at 512K bytes. You can expand the board incrementally up to 4 megabytes using 256K by 9 SIMM devices, or up to 14.5 megabytes using 1 megabyte by 9 SIMM devices.
Price: 512K bytes, $545; 14.5 megabytes, $4995.
Contact: Quadram, One Quad Way, Norcross, GA 30093-2919, (404) 923-6666.
Inquiry 598.

Two for the Toshiba

Multi-Tech Systems' MultiModem212TL is a plug-in card that fits into the expansion slot of the Toshiba T1100 Plus and T3100 laptop computers. The modem operates at both 300 and 1200 bps and is compatible with both the Bell 212A and the Hayes AT standards.

The MultiModem212TL measures 4.175 by 4.6 inches and interfaces with the internal Toshiba 60-pin bus. It includes two phone jacks and an on/off switch. The modem has a two-year warranty and is shipped with Multi-Tech's MultiComPC software on a 3½-inch disk.
Price: $299.
Contact: Multi-Tech Systems Inc., 82 Second Ave. SE, New Brighton, MN 55112, (800) 328-9717; in Minnesota, (612) 631-3550.
Inquiry 599.

Megahertz Corp.'s EasyTalk EMS is a multifunction card for the Toshiba T1100 Plus that includes a modem and 1 megabyte of RAM.

EasyTalk's memory conforms to the Lotus/Microsoft/Intel Expanded Memory Specification. Since the memory uses about 10 percent of the power of a disk drive, Megahertz says using EasyTalk's memory as a RAM disk can extend the laptop's battery power. An ultra-low-power memory option is available.

The modem component of the board is Hayes-compatible and operates at both 300 and 1200 bps. Crosstalk communications software is included with the modem.
Price: $899.95; low-power memory option, $200.
Contact: Megahertz Corp., 2681 Parleys Way, Suite 2-102, Salt Lake City, UT 84109, (801) 485-8857.
Inquiry 600.

continued

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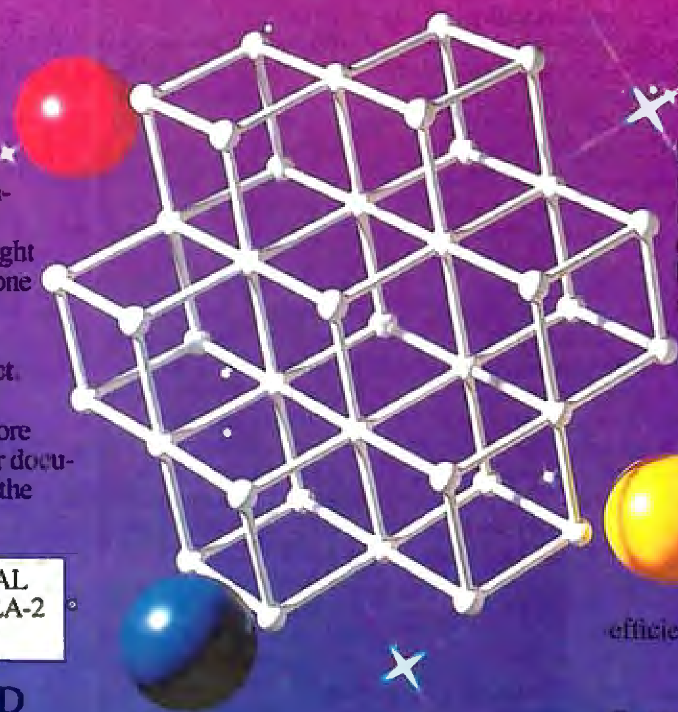

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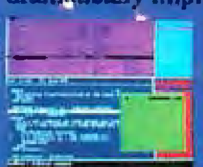

The Post Mortem Debugger analyzes the status of a program after it has terminated while the dynamic Run Time Debugger monitors the execution of a program with user-defined breakpoints. With their new, mouse based, multiple-window user interface these powerful debugging tools are a pleasure to use.

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Inquiry 158 for End-Users. Inquiry 159 for DEALERS ONLY.

SOFTWARE • PROGRAMMING LANGUAGES AND AIDS

AI Development Environment Incorporates Virtual Memory

Written in 386 native mode with virtual memory supported at the hardware level, PowerLisp lets you develop and run 60-megabyte applications on 3-megabyte 386 systems or 31-megabyte applications on IBM PC ATs.

MicroProducts reports that PowerLisp is the full implementation of Interlisp, originally written for use on a PDP-10. Common LISP features are also included, and Interlisp and Common LISP programs can be supported simultaneously. Interlisp functions can call Common LISP functions, and vice versa.

You can communicate between PowerLisp code and DOS applications executing in DOS memory. The program also has features that correct typos, entry errors, and programming errors. A static program analyzer lets you find and edit every place that calls a given function or refers to specific variables, objects, or properties. Editing features let you put breakpoints in functions as well as trace them; debugging facilities are built-in; and a utility is included that retains session history, enabling you to redo or undo commands.

Power-Ex, an optional expert-system shell, is derived from EMYCIN and ported to PowerLisp. The shell supports backward-chaining reasoning, confidence factors, case files, automated consistency checking, and English-language consultations. An IBM PC running Power-Ex can support rule bases of thousands of rules and can directly import knowledge bases developed using EMYCIN.

You can configure PowerLisp to operate in extended memory above the 640K-byte limit. The program comes in 286 and 386 versions, with the 286 version upgradable to a 386. MicroProducts reports that the 386 version is six times faster. To run the 286, you need an IBM PC or compatible with at least 2 megabytes of memory, a 30-megabyte hard disk drive, a CGA, EGA, or compatible graphics adapter, and MS-DOS or PC-DOS 3.0 or higher. To run the 386 version, you need a 386 system with at least 2 megabytes of memory, a 30-megabyte hard disk drive, a CGA, EGA, or compatible graphics adapter, and MS-DOS or PC-DOS 3.1 or higher.

Price: 286 version, $1195 or $1695 with 3-megabyte memory-expansion board; 386 version, $1695; Power-Ex, $500 (when purchased with the system).

Contact: MicroProducts Inc., 370 West Camino Gardens Blvd., Boca Raton, FL 33432, (800) 553-0777.

Inquiry 601.

TI Upgrades AI Development Tools

Texas Instruments has announced enhancements to its Personal Consultant Series of expert-system development tools. These include PC Scheme 3.0, Personal Consultant Easy 2.0, Personal Consultant Plus 3.0, two add-ons, and two run-time options.

PC Scheme 3.0 is an enhanced version of TI's implementation of Scheme, a lexically scoped dialect of LISP. Version 3.0 includes external language interfaces to C, Turbo Pascal, and others; random-file access and binary file I/O; and support for up to 2 megabytes of extended or expanded memory. An EMACS-like editor, EDWIN, lets you leave PC Scheme, execute a DOS-based program, and then return to PC Scheme. PC Scheme runs on IBM PCs, XTs, ATs, or compatibles with at least 320K bytes of RAM, two floppy disk drives or one floppy and one hard disk drive, and PC-DOS or MS-DOS 2.0 or higher. It also requires a minimum of 520K bytes to run EDWIN.

Personal Consultant Easy 2.0 is a utility designed to simplify the development of expert systems with up to 300 rules. The program offers a rule-entry language, an integrated window-oriented editor, regression testing, and rule tracing. Version 2.0 includes enhanced interfaces to external data, an enhanced knowledge-base listing, and forward-chaining capability, which can be completely forward- or backward-chaining. With version 2.0, you can also write as well as read DOS files and interface to dBASE III, Lotus 1-2-3, and ASCII text files.

The program runs on IBM PC ATs and compatibles with 640K bytes of RAM, a 10-megabyte hard disk drive, and MS-DOS or PC-DOS 2.0 or higher.

Version 3.0 of Personal Consultant Plus, an expert-system shell, can, like Easy version 2.0, read data from external DOS or ASCII text files, Lotus 1-2-3, and dBASE III. Plus 3.0 also offers delivery options, which enable expert systems developed with either Personal Consultant Plus or Easy to be delivered in LISP or C on DOS-based computers. Knowledge bases developed with Easy are upwardly compatible with Plus, according to TI.

Plus 3.0 is designed to take advantage of 80286- or 386-based systems. It provides extended knowledge-representation features and increased rule capacity, enabling you to develop larger and more complex applications than you can with Easy. Also, like Easy, Plus 3.0 is enhanced with external language interfaces to C and Turbo Pascal and expanded forward-chaining and frame control. Optional enhancements include the Images and PC Online programs.

Personal Consultant Plus 3.0 has the same hardware requirements as Easy 2.0.

Images and PC Online are optional add-on programs that run with Personal Consultant Plus. Images allows you to incorporate graphic images into your applications. It includes a set of interactive dials, gauges, and a selection of boxes to prompt you to input or display data. You can also use other graphics programs to create input forms, and you can display multiple images on the screen simultaneously.

PC Online supports data processing in batch mode. It lets you create process-monitoring systems that require little or no human interaction, TI reports. You can suppress screen output and notify the operator when information or action is required. PC Online also features reporting and trend-analysis capabilities.

Personal Consultant Plus runs on IBM PC ATs with at least 640K bytes of RAM and a 10-megabyte hard disk drive. You also need an EGA card to run Images.

One of the two run-time options for Personal Consultant Plus or Easy is C Delivery, available for DOS or Digital Equipment's VAX systems. C Delivery compiles the LISP-code knowledge bases into C source modules and links them with an inference engine and a window system, letting you deliver stand-alone or embedded applications on DOS-based systems.

Price: PC Scheme 3.0, $95; Personal Consultant Easy 2.0, $495; Personal Consultant Plus 3.0, $2950; Images, $495; PC Online, $995; C Delivery, $1995.

Contact: Texas Instruments Inc., Data Systems Group, P.O. Box 809063, DSG-150, Dallas, TX 75380-9063, (800) 527-3500.

Inquiry 602.

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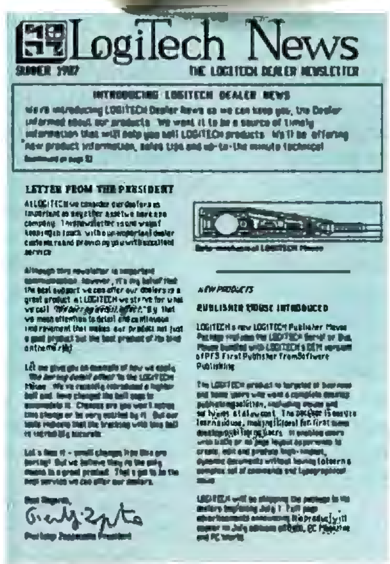
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Inquiry 160 for End-Users. Inquiry 161 for DEALERS ONLY.

SOFTWARE • SCIENTIFIC AND ENGINEERING

Engineering Model Analysis

Fujitsu's finite-element analysis program, Elm, enables you to test your three-dimensional structural designs for strength, safety, and performance. The program consists of an analysis module, ElmAnalysis, and integrated pre- and postprocessors, ElmPrelude and ElmEpilog.

ElmAnalysis performs static, eigenvalue, and response-spectrum analysis. The element library includes three-dimensional beam, truss, triangular, and quadrilateral shell elements, as well as two-dimensional 4-node and 8-node isoparametric elements.

The three dimensional finite-element analysis preprocessor, ElmPrelude, is menu-driven and replaces manual calculations and batch-mode data entry with a WYSIWYG (what-you-see-is-what-you-get) graphic approach to creating structural models. According to Fujitsu, you can display every feature of model composition through the use of colors and symbols (from element type, number, and rotation to boundary conditions). A Verify function enables you to display all the input data for a selected boundary condition or element.

The preprocessor includes pull-down menus, icons, and dialog boxes, and you use a mouse instead of the keyboard for data entry. Instead of looking up and keying in property values, you can use the industry-standard data supplied in the engineering libraries. If you want to perform your own batch-mode data entry rather than using ElmPrelude, you can use the free-format input scheme offered by ElmAnalysis.

ElmEpilog, the graphics postprocessor, is also menu-driven and lets you review and manipulate the output of ElmAnalysis with visual displays and printouts of the structure's undeformed shape, deformed shape, and mode shapes.

Elm is written in C and is also available in a two-dimensional version. Elm runs on IBM PCs, XTs, ATs, and compatibles with a 360K-byte floppy disk drive, at least 512K bytes of RAM, MS-DOS or PC-DOS 2.0 or higher, a 10-megabyte hard disk drive, and a numeric coprocessor. To use the pre- and postprocessors, you need a mouse, an EGA graphics board, and a monitor.

Price: $3990; two-dimensional Elm, $495.

Contact: Fujitsu America Inc., Engineering Products Dept., Information Systems Division, 3055 Orchard Dr., San Jose, CA 95134-2017, (408) 432-1300.

Inquiry 603.

Threaded Interpretive Language for Laboratories

SALT II, a threaded-interpretive language developed at the University of Chicago, has about 200 assembly language instructions that you can call and compile within a BASIC program.

SALT II includes graphics routines for plotting records, scrolling plots or records, and placing cursors on plots. It enables you to analyze records for regional maximum and minimum, average, slope, threshold detection, integration, differentation, and filtering. Other routines include expanded memory, transfer of numeric files to and from disk, laboratory interfacing, signal averaging, and background operations from BASIC. You can also add your own assembly language routines to the language.

The program supports every function of Tecmar's Labmaster interface board, including A/D, D/A, digital I/O, and timer/counter functions.

SALT II requires an IBM PC, XT, AT, or compatible with at least 256K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. You must also have a Tecmar Labmaster board for laboratory interfacing and a CGA for graphics.

Price: $75.

Contact: Sam Fenster, 5801 South Dorchester, Suite 12A, Chicago, IL 60637, (312) 702-1491.

Inquiry 604.

Drawing Chemical Structures on the Macintosh

DrawStructures contains 67 organic and biochemical structures, including all major classes of compounds and ring systems in object-oriented format for the Macintosh. Contained in PICT-format documents, you can use the structures as they appear, or modify them using MacDraw, MacDraft, or SuperPaint. Also included is a set of building blocks that can assist you in modifying or building your own structures in these environments.

Modern Graphics reports that DrawStructures does not work with CricketDraw, and SuperPaint accesses only 65 of the 67 documents.

The contained structures were created as object-oriented graphics, which you can resize without distortion or loss of resolution. You can use an Imagewriter, LaserWriter, or other PostScript device for output.

The program lets you copy and paste structures into other Macintosh programs, such as MacWrite. You can also incorporate text into the structures by using Imagewriter or LaserWriter fonts.

Price: $79.95.

Contact: Modern Graphics, P.O. Box 21366, Indianapolis, IN 46221-0366, (317) 253-4316.

Inquiry 605.

Neural-Network Demonstration Program

Awareness consists of four programs that demonstrate four neural-network algorithms. The programs are designed to teach you the properties of neural networks. The first program exhibits the computational capabilities of neural networks, such as association. The second program uses a generalized learning rule and demonstrates the exclusive OR (XOR) function, which you can use in learning context-sensitive signal processing. The third program is an example of a neural network that can produce solutions to combinatorial optimization problems. The fourth program deals with complicated problems, such as robotic control strategy.

The program runs on IBM PCs and compatibles with at least 256K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. It supports various graphics cards and the 8087 floating-point chip, which Neural Systems recommends.

Price: $130.

Contact: Neural Systems Inc., 2827 West 43rd Ave., Vancouver, British Columbia, Canada V6N 3H9, (604) 263-3667.

Inquiry 606.

continued

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Inquiry 162 for End-Users. Inquiry 163 for DEALERS ONLY.

SOFTWARE • BUSINESS AND OTHER

Training Your Musical Ear on the Commodore

Ear Training Tutor is a music software program that runs on the Commodore 64 and 128. The tutor drills you through more than 50 preset music lessons, playing musical intervals and triads in all inversions and asking you to name them.

First, you select what you want to be tested on. You can choose to follow the preset lesson structure, or you can design your own lesson parameters using only the specific intervals or triads that require further practice.

You can also choose whether to hear the intervals in ascending or descending order.

The program then plays the intervals or triads and asks you to identify what you hear. When you've answered correctly, the musical notation is displayed on-screen on both the grand staff and a music keyboard. A record-keeping routine keeps track of the lessons you've completed successfully. You can save complete drill text results to disk, including percentage correct and the specific interval/triad attempts and misses. You can also view current or past test results on-screen and send output to a printer.

The program is played through the on-board music chip of the Commodore 64 and 128, or you can hook it up to a Passport-compatible MIDI interface connected to any MIDI synthesizer or to your home stereo system speakers or headphones.
Price: $59.95.
Contact: MSB Music Software, 35 Hill St., Naugatuck, CT 06770, (203) 723-5275.
Inquiry 607.

Ear Training Tutor tests your knowledge of music.

Terminator displays dates and times around the world.

Clockwork Across the World

Terminator draws a line between night and day that moves across a world map in real time. The line position changes with the time of day, and its shape changes with the seasons. In determining the shape and position of the line, the program takes into account the declination of the Sun; the size of the Sun; the refraction caused by the Earth's atmosphere; and the equation of time, which computes the difference between solar and clock time.

You can view the changes by running Terminator in a variety of modes, from 2 minutes to 1 week. You can change modes every second or so, as fast as the program can compute the data that refreshes the screen, Trillium reports. You can display your local date and time along with times in up to 24 cities or time zones anywhere on the map.

You can edit Terminator's setup parameters by choosing to display other cities or time zones or by changing the program's initial values.

Terminator runs on IBM PCs or compatibles with a Hercules monochrome graphics adapter, a CGA or EGA, and at least 128K bytes of RAM.
Price: $30.
Contact: Trillium, 3770 Highland Ave., Suite 208, Manhattan Beach, CA 90266, (213) 545-8300.
Inquiry 608.

Decision Maker

Apian Software's Decision Pad helps you evaluate people, plans, and products. It combines elements of spreadsheet and rational decision theory in an interactive decision-making environment.

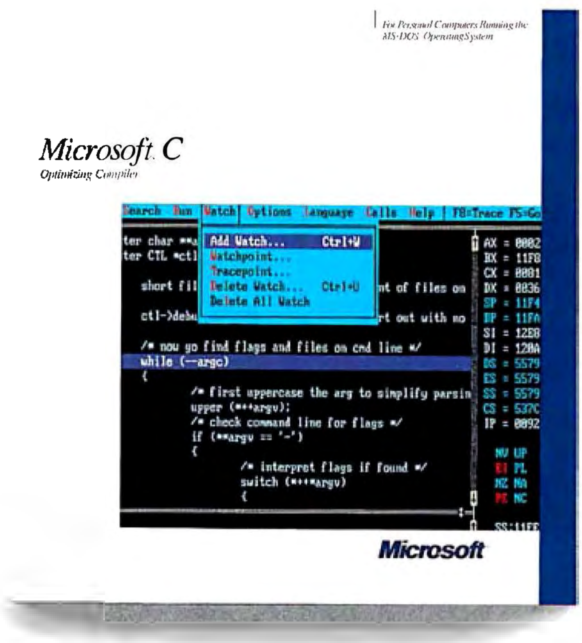
At the beginning of an evaluation, the program presents you with data-collection forms. You can choose up to 150 alternatives and preferences, and up to 60 criteria per alternative. Then you allocate each to its proper place, using 1- or 2-level weights and 20 positions. You can also incorporate opinions of other people and quantify them, and you can output reports at each step.

Decision Pad includes sample templates for personnel, purchasing, product-marketing, investment, and sales-presentation applications.

The program has Lotus 1-2-3-compatible file-import and -export capabilities, as well as ASCII export.

Decision Pad runs on IBM PCs and compatibles with at least 256K bytes of RAM and MS-DOS or PC-DOS 2.0 or higher. You also need a monochrome, CGA, EGA, or compatible display. A mouse is optional.
Price: $195.
Contact: Apian Software, P.O. Box 1224, Menlo Park, CA 94026, (415) 851-8496.
Inquiry 609.

C5.0 has three features professional programmers can't live without.



Speed.

Fast Execution Speed.

	Microsoft® C 4.0	Microsoft C 5.0
Sieve (25 iterations)	5.7	3.3
Loop	11.0	0.0*
Float	19.9	0.1
Dhrystone	22.8	19.1
Pointer	14.2	7.4

- New optimizations generate the fastest code:
  - —Inline code generation. NEW!
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- Fine tune your programs for even greater speed:
  - —Coding techniques for writing the fastest possible programs are included in the documentation. NEW!
  - —Segment Allocation Control:
    - —Group functions into the same segment to get faster NEAR calls. NEW!
    - —Specify which segments receive variables to yield faster NEAR references. NEW!
  - —Uses register variable declarations.
  - —Mix memory models using NEAR, FAR & HUGE pointers.

Benchmarks run on an IBM® Personal System/2™ *Time is negligible.

Speed.

Fast Compilation.
Fast Prototyping.

Microsoft C Version 5.0 includes QuickC,™ which lets you edit, compile, debug, and execute in an integrated environment. It's ideal for prototyping.

- In-memory compilation at over 10,000 lines/ minute. **NEW!**
- Built-in editor with parentheses, bracket and brace matching.
- Use the integrated debugger to animate through your program, add watch variables and set dynamic breakpoints. **NEW!**
- MAKE file is automatically generated for you. Simply indicate the modules you want to use, then MAKE recompiles and links only those modules that have changed. **NEW!**
- Full C 5.0 compatibility:
  - —Completely source and object code compatible.
  - —Emits CodeView®-supported executables.
  - —Identical compile/link command line switches.

And speed.

Fast Debugging.

Microsoft C Version 5.0 includes Microsoft CodeView, our source-level windowing debugger that lets you debug more quickly and thoroughly than ever before.

- Debug larger programs:
  - —Debug through overlays created by the Microsoft overlay linker. NEW!
  - —Expanded Memory Specification (EMS) support. NEW!
- Fast debugging through precise control of your program execution:
  - —Access source level and symbolic debug information from your Microsoft C, FORTRAN, and Macro Assembler programs. NEW!
  - —View your source code and assembly simultaneously.
  - —Watch the value of variables change as you execute.
  - —Set conditional breakpoints.
  - —Animate or single step through your program.
- CodeView brings you as close as you've ever been to your hardware:
  - —Swap between your code and output screens.
  - —Watch your registers and flags change as your program executes.

Microsoft

C 5.0 will be available soon. If you purchase Microsoft C 4.0 after June 1, 1987, we'll give you a C 5.0 upgrade. Free. For your free information packet, call:

(800) 426-9400.

0587 Part No. 098-048-615

EVENTS

September 1987

Remote Sensing Society Annual Conference: Advances in Digital Image Processing, Nottingham, England. Dr. P. M. Mather, The University of Nottingham, Nottingham NG7 2RD, England, (0602) 587611. *September 7–11*

Australian Computer Conference '87, Melbourne, Australia. ACC 87 Secretariat, Box 98, East Melbourne, Victoria, Australia 3002, (03) 416 1053. *September 8–11*

Capital Microcomputer Users Forum, Washington, DC. Jackie Voigt, 2111 Eisenhower Ave., Suite 400, Alexandria, VA 22314, (703) 683-8500 or (800) 638-8510. *September 9–10*

Robotic Systems in Aerospace Manufacturing, Fort Worth, TX. Lori Navalta, Technical Activities Division, Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48121, (313) 271-1500, extension 370. *September 9–11*

SOFTEACH: The Computer Products Training Forum, New York, NY and Atlanta, GA. Softsel, 546 North Oak St., P.O. Box 6080, Inglewood, CA 90312-6080, (800) 325-9189. *September 12–13 and September 19–20, respectively*

Euromicro 87: 13th Symposium on Microprocessing and Microprogramming, Portsmouth, England. Euromicro, Hengelosestraat 705, P.O. Box 545, 7500 AM Enschede, The Netherlands, (31) (53) 338799. *September 14–17*

Simulation Techniques for Personal Computers, Washington, DC. The George Washington University School of Engineering and Applied Science, Washington, DC 20052, (800) 424-9773; in Virginia, (202) 994-6106. *September 14–18*

1987 Electronic Printer and Publishing Conference, Miami, FL. Jean O'Toole, CAP International, One Snow Rd., Marshfield, MA 02050, (617) 837-1341. *September 14–18*

Software Licensing Agreements: Buying, Selling, and Protecting Rights, Princeton, NJ and Atlanta, GA. Ann Molinari, DTI, Lakeview Plaza, P.O. Box 2429, Clifton, NJ 07015, (201) 478-5400. *September 15 and September 22, respectively*

ICCC—ISDN '87: Integrated Services Digital Network, Dallas, TX. Jane Farthing, Bell Atlantic, 1310 North Court House Rd., Arlington, VA 22201, (703) 974-5435. *September 15–17*

Midcon/87, Chicago, IL. Dale Litherland, Director of Education, Midcon/87, 8110 Airport Blvd., Los Angeles, CA 90045-3194, (800) 421-6816; in California, (800) 262-4208. *September 15–17*

Computer Graphics: A Comprehensive Introduction, Palo Alto, CA. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., Culver City, CA 90231-3614, (800) 421-8166; in Canada, (800) 267-7014. *September 15–18*

Real-Time Operating Systems: A Hands-on Workshop, Los Angeles, CA and Washington, DC. Tom Watson, Integrated Computer Systems, 5800 Hannum Ave., Culver City, CA 90231-3614, (800) 421-8166; in Canada, (800) 267-7014. *September 15–18 and September 29–October 2, respectively*

Effective Skills for Technical Managers, Los Angeles, CA and Boston, MA. Marilyn Martin, Integrated Computer Systems, 5800 Hannum Ave., Culver City, CA 90231-3614, (800) 421-8166; in Canada, (800) 267-7014. *September 15–18 and September 22–25, respectively*

Visions '87 Computer Graphics Conference, Springfield, MO. Steve Finley, Department of Art and Design, Southwest Missouri State University, Springfield, MO 65804, (417) 836-5110. *September 18–19*

Interex HP 3000 Users Conference, Las Vegas, NV. Interex, Conference Department, 680 Almanor Ave., Sunnyvale, CA 94086, (408) 738-4848. *September 20–25*

Engineering Workstations Conference, Los Angeles, CA. Corporate Expositions Inc., P.O. Box 3727, Santa Monica, CA 90403. *September 21–23*

CD-ROM Expo, New York, NY. Dorothy Ferriter, 375 Cochituate Rd., P.O. Box 9171, Framingham, MA 01701-9171, (800) 343-6474; in Massachusetts, (617) 879-0700. *September 22–23*

Northcon/87 Electronic Show and Convention, Portland, OR. Dale Litherland, Director of Education, Northcon/87, 8110 Airport Blvd., Los Angeles, CA 90045-3194, (213) 772-2965. *September 22–24*

Integrated Voice/Data Communications and ISDN, Palo Alto, CA. Evelyn Black, Integrated Computer Systems, 5800 Hannum Ave., Culver City, CA 90231-3614, (800) 421-8166; in Canada, (800) 267-7014. *September 22–25*

Fourth Annual International Forum on Micro-Based CAD, Raleigh, NC. Gene Fernaro, C. C. Mangum Building, North Carolina State University, 3016 Hillsborough St., Raleigh, NC 27695-7902, (919) 737-2356. *September 23–25*

Writing Better Computer Software Documentation for Users, Atlanta, GA. Deidre Mercer, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *September 23–25*

Information Systems Perspectives Symposium, San Francisco, CA. GUIDE Headquarters, 111 East Wacker Dr., Suite 600, Chicago, IL 60601, (312) 644-6610. *September 27–30*

Defense and Government Computer Graphics Conference, Washington, DC. Defense and Government Computer Graphics Conference, P.O. Box N, Wayland, MA 01778, (617) 358-5356. *September 28–October 1*

Ninth Annual Electrical Overstress/Electrostatic Discharge Symposium, Orlando, FL. EOS/ESD Symposium, P.O. Box 14, Gillette, NJ 07933, (201) 522-4770. *September 29–October 1*

INFO '87: Information Management Exposition and Conference, New York, NY. Show Manager, INFO '87, 999 Summer St., Stamford, CT 06905, (203) 964-0000. *September 29–October 2* ■

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ASK BYTE

Conducted by Steve Ciarcia

Nothing's Too Good

Dear Steve:

I am trying to optimize the performance of the hard disks in some IBM PCs and compatibles. Some of them take much longer to read tracks than others do, and I think part of the problem may be due to an incorrect interleave factor.

I would also like to change the number of bytes per sector for some special storage problems I have, but I can't find any information on how to do this low-level formatting. Even though the disk-controller cards are made by different manufacturers, they are interchangeable. Where would I find out how to do low-level formatting for both hard disks and floppy disks? I don't mind doing it in assembly language.

Phil Mumma
Redwood City, CA

Be careful about changing things down deep in the hardware. Many things can go wrong if you're not absolutely certain about what you're doing.

First, you should use CHKDSK *to see how fragmented your files are. If the PC has to do a lot of seeks to get all the data, it'll take longer to read a file. Simply type* CHKDSK *.* *and read the report. Compare the results from running* CHKDSK *on two PCs with differing times and see if there's any relation between the degree of fragmentation and the speed. You'll need to do that in each subdirectory on the hard disk; files that aren't listed are contiguous.*

There are several utilities on the market that will defragment the files. Pick up a copy of PC Magazine *and look through the products in the disk optimizer category. I've used a public domain program called DOG (which stands for disk organizer) that I downloaded from CompuServe quite a while ago. It's a bit of a pain to use, but it works just fine. You can also download it from BIX.*

You'll need to defragment files on a regular basis. I do mine after every complete disk backup, so if anything goes wrong I've got the data ready to reload.

Once you've got all your files contiguous, see if the problem goes away. If it doesn't, only then will it be worthwhile to change the interleave factor. To do that, you need a low-level formatting program that works with the particular controller card you've got and that allows you to select an interleave factor. Where to get the formatter is a good question; for starters, try the folks who sold you the card, or try a computer club.

You'll have to back up everything on your disk before you reformat it. The default interleave is 6, and I suspect that you're kidding yourself if you try anything below 3. Remember that if an interleave factor is too low for the program, you have to wait for one complete disk rotation for each *sector that's read or written. This translates to a dramatic increase in time. The penalty for an interleave that's too high is relatively minor, so I bet you won't notice a significant change until you drop below the threshold and the time taken suddenly gets much worse.*

Don't even think *about changing the sector size! In principle this is easily done, but because it's so rarely attempted, the code in DOS to handle it hasn't been extensively tested. I've heard of several bugs in various versions of DOS that come to the fore when you try working with disks whose sector size you've altered.*

A better approach to the whole problem is to use the BUFFER= *statement in the CONFIG.SYS file to increase the number of DOS disk buffers. This will improve read performance quite a bit, particularly if you're doing random access to files. Sequential reads of all sorts won't improve much, simply because the buffers don't read far ahead. Writes won't improve at all because DOS writes through the buffer.*

You might want to look into add-on disk-caching products that improve DOS's buffering. I'm not convinced that they're worth it, but if you've got a critical application you should look into them.

If your data is read-only, it's an ideal candidate for a RAM disk. You can get EMS (expanded-memory specification) RAM boards with 4 megabytes for under $1000 nowadays, so the only delay you'll experience is loading the memory up in the morning.—Steve

Ear to the Ground

Dear Steve:

I have an amateur interest in both earthquakes and computers. For several years, I have been recording earthquakes from all over the world on a homemade seismograph. (A 1979 article in *Scientific American* described how to build one.) The seismograph is simple: a weighted pendulum with a magnet, suspended near a 10,000-turn coil. Voltages induced in the coil by the relative motion of the coil (resting on the earth) and the magnet (suspended and free to swing) are amplified by a 741 op-amp–based amplifier and are used to drive a Heathkit chart recorder. I have recorded earthquakes as far away as Alaska with this setup.

I'm writing to you for help in moving this setup into the computer age. I would like to eliminate the chart recorder (which costs a fortune in paper every month anyway), send the voltage from the amplifier into an A/D converter, and sample the digitized waveform at a healthy rate (say, 20 times per second) with my IBM PCjr.

I've read your Circuit Cellar article on parallel interfacing (July 1986 BYTE), and it explained nicely why someone here at work suggested that I'd probably need an 8255-5 as well as an ADC0809. However, no one that I know has been able to point me to any kind of usable circuit, much less get me instructions on how I might interface it to my computer.

I have located a company in Minnesota that sells a prototype add-on "sidecar"

continued

IN ASK BYTE, Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to

Ask BYTE
c/o Steve Ciarcia
P.O. Box 582
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Due to the high volume of inquiries, we cannot guarantee a personal reply, but Steve and the Ask BYTE staff answer as many as time permits. All letters and photographs become the property of Steve Ciarcia and cannot be returned.

The Ask BYTE staff includes manager Harv Weiner and researchers Eric Albert, Bill Curlew, Ken Davidson, Jeannette Dojan, Jon Elson, Roger James, Frank Kuechmann, Dave Lundberg, Tim McDonough, Edward Nisley, Dick Sawyer, Andy Siska, Robert Stek, Mark Voorhees, Steve Smith, and Charles Skiles.

Microsoft QuickBASIC 3.0's speed was verified by an indisputably independent test.

ess, returning to the editor at the offending | achievement for the price. ■

BASIC Benchmarks Comparison

	Turbo BASIC	QuickBASIC 3.0
Sieve:		
• 25 Iterations/1,899 Primes	3.241	3.023
Graphics: (Screen Mode 8 — EGA)		
• Draw 500 Circles	5.328	4.729
• Draw 3,200 Circles	11.422	5.051
• Draw 5,000 Boxes	10.598	5.988
• Draw 3,200 Vertical Lines	9.391	4.949
• Draw 20,00 Horizontal Lines	15.766	5.551
• Fill 200 Circles	7.689	6.431
Math:		
• Integer Math	4.284	4.230
• Floating Point, Single Precision	8.184	1.805
• Sines and Cosines (7,200)	15.599	4.887
• Single Precision EXP	13.731	3.742
Matrix Operations:		
• Borland's Test	0.714	0.055
• Microsoft's Test	34.328	4.781
• Bubble Sort (1,000 Integers)	2.856	2.477
File I/O:		
• Sequential (2,000 records)	21.696	7.531
• Random (2,000)	52.234	51.078
Text I/O:		
• Secreen Mode 0 (5,000 characters)	0.934	1.750
• Screen Mode 1 (5,000 characters)	9.447	9.008
• Screen Mode 2 (5,000 characters)	4.339	4.070

In the May 5, 1987 issue of *PC WEEK,* some interesting benchmarks were published. We won virtually all the tests, but one test in particular caught our attention: the competitor's. Now even they have to agree we're faster.

Microsoft® QuickBASIC 3.0 gives you the fastest execution speed. It also lets you write code faster. That's because you pick up speed working in an integrated programming environment which includes our unique integrated debugger.

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Microsoft

For a reprint of the article, just give us a call at (800) 426-9400. Benchmarks reprinted with permission of *PC Week.*

 *See specially marked packages for details. Offer valid only in U.S.A.

Inquiry 180 for End-Users. Inquiry 181 for DEALERS ONLY.

for the PCjr for $39. This board has a 60-pin connector that attaches to the PCjr but is otherwise unpopulated. What I'd like to do is wire-wrap the A/D circuitry onto this prototype board.

I had a chance to play with the IBM Data Acquisition and Control Adapter on a regular PC for a couple of weeks. During that time, I wrote some software to read the A/D adapter and display a time-varying voltage trace on the high-resolution graphics screen. Unfortunately, this card does not fit into the PCjr; besides, it costs over $1500 (it is packed with other functions, such as timers, D/A, and binary I/O). So my software is all set to go, but I have no hardware background on this stuff.

Can you help me out? I've tried all the sources I know of, without any luck.

Ted Blank
Wappingers Falls, NY

Actually, I think there's a more inexpensive way to do the deed—use the joystick input on your PCjr. Because the voltage output from the seismograph varies so slowly, you don't need a fancy A/D converter or all the complexity that goes along with it.

The joystick ordinarily works with a variable resistor between the input pin and +5 volts. The resistor determines the charging current for the timing capacitor. Anything that can stuff a suitable current into the capacitor will give pretty much the same results.

You probably already have a joystick, so there's no need to build a special cable that needs the funny Berg connector. Take the joystick apart and measure the voltages at either end of the x-axis potentiometer. One side will be at +5 volts, and the other (the input to the PCjr) will be somewhat lower. Because you need a ground connection, too, measure the voltages on one of the buttons: One side is ground, and the other is about +5 volts. (This would be simplified if I had a PCjr joystick reference manual handy.)

Next, the electronics for the seismograph:

The output of the amplifier circuit you have now is in the ballpark of 10 millivolts. What you need is a current in the range of 10 to 50 microamps. The solution is a voltage-to-current converter with a bit of amplification. The schematic in figure 1 diagrams something that should work. (Bear in mind that I haven't actually built this thing, so you'll have to do some fiddling to get it to work.)

To get the circuit calibrated, close the zero set switch and adjust the offset current potentiometer for zero volts at the wiper arm (you could use a switch there, too). Adjust the balance potentiometer for zero volts out of the 741.

Now enter the following BASIC program into your PCjr:

```
10 WHILE 0 = LEN(INKEY$)
20 PRINT STICK(0),STICK(1),
   STICK(2),STICK(3)
30 WEND
```

This will display the joystick input values

continued

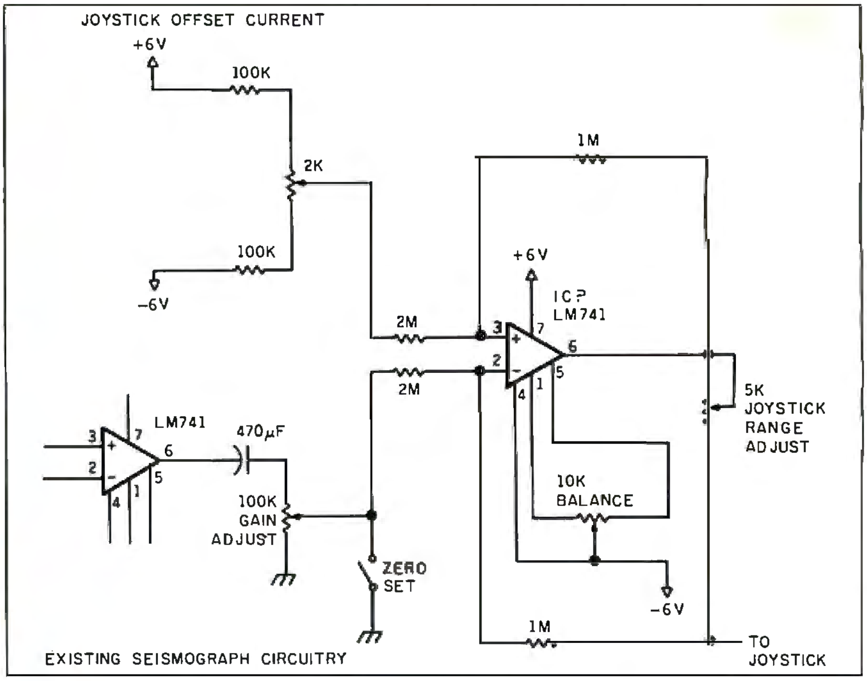


Figure 1: *Amplifier circuit for seismograph.*

so you can see what's going on. If you've got it wired up right, watch the first number (from STICK(0)*).*

Tap the seismograph so that you get a signal to play with and open the zero set switch. Set the range potentiometer to about midrange and adjust the offset potentiometer so that the minimum number is about +10 or so. Set the range port so that the maximum number is around +200. These two settings interact, so you'll need to twiddle both of them to converge on the right settings.

Eventually you should have a slight oscillation going, with reasonable joystick values coming back. Now you can establish some software-conversion factors that relate the numbers you get from the STICK( ) *function with the familiar values on the strip-chart recorder. I think you can use the PCjr and the recorder at the same time, but it's worth checking to make sure that the new circuitry doesn't load it down.*

The rest of the software is up to you.

Incidentally, some older 741 op amps suffer from what's known as "popcorn" noise: The output voltage abruptly bounces from one supply voltage to the other. If you're listening on a speaker, it sounds a lot like popcorn popping. If the output to this circuit shows unexplained spikes, try replacing the 741s with newer versions.—Steve

Squeaky Disk

Dear Steve:

The carbon brush on my 10-megabyte IBM hard disk drive squeaks. My dealer's service department fixed it once, but the squeak recurs. I called IBM and they want $565 to exchange the disk drive for a new one with a very short warranty.

I thought I might try a tiny amount of graphite lubricant. If this is inadvisable, please let me know. Any help you can give is appreciated.

Kenneth L. Kayser
Milwaukee, WI

You've got the right idea. Pull the drive apart and put the tiniest possible drop of lubricant on the brush.

The noise occurs because the rounded end of the spindle has worn a divot in the carbon brush. The divot catches on the spindle and oscillates at exactly the right frequency to make your hair fall out. The spring, of course, is a resonant, lightly damped structure.

You can also try bending the support spring a bit to move the divot off-center from the spindle. This will work until the spindle wears a divot in the new location, but that can take a long time. Eventually you'll wind up with several divots that merge into one pothole, and the problem will go away. Be careful when you've got the drive out. Do not rotate the spindle or the head actuator; the heads are in contact with the platters, and you will do irreversible damage if you move things around.

Resist the engineer's normal temptation to fiddle with the mechanical objects. Just do the job, put it back together, and count your change.

A little lubricant is better than a lot. Don't go hog-wild with a can of WD-40, the way you might under a hood with automotive troubles.—Steve

CIRCUIT CELLAR FEEDBACK

New on the Block

Dear Steve:

I'm very interested in building the projects you present in BYTE, but I'm 15 years old and the only computers I have access to are an AT&T PC 6300 and an Apple II+. Also, I don't know a thing about electronics. I want to learn, but I don't know where to start. Can you help?

Chris Mulberry
Golden, CO

We were all beginners once, so it's nothing to worry about. A good source of basic electronics books and **information** *is your local school or public library. Magazines such as* Modern Electronics *(available on most newsstands) publish much material useful to beginners.*

There are several good hardware-oriented books available on interfacing the Apple. These include:

Blankenship, John. The Apple House. *Englewood Cliffs, NJ: Prentice-Hall, 1984.*

Sather, James. Understanding the Apple II. *Chatsworth, CA: Quality Software, Computer Book Division, 1983.*

Sather, James. Understanding the Apple IIe. *Chatsworth, CA: Quality Software, Computer Book Division, 1985.*

Titus, Jonathan, et al. Apple Interfacing. *Indianapolis, IN: Howard W. Sams, 1981.*

Titus, Jonathan, et al. Microcomputer—Analog Converter Software and Hardware Interfacing. *Indianapolis, IN: Howard W. Sams, 1978.*

Uffenbeck, John E. Hardware Interfacing with the Apple II Plus. *Englewood Cliffs, NJ: Prentice-Hall, 1983. (This last book uses a different bus-connector-pin numbering than that used in the Apple manuals and every other Apple interfacing book. This can be confusing.)*

continued

In addition, Radio Shack has published a number of books by Forrest Mims; they are all excellent sources of information.—Steve

SB180

Dear Steve:

I'm interested in your articles on the construction of the SB180 computer and its peripheral boards, and I plan to build an SB180 myself. Unfortunately, I cannot afford the Micromint boards, so I will have to either use prototype boards or make my own printed circuit board. In view of the lower electrical quality of these homemade boards, and also to reduce the cost, I plan to use the 3-MHz 64A180 instead of the faster B version that you use. Will I have to change any components besides the processor and the crystal?

I have also been unable to find the FDC9266 floppy disk controller chip. Is there any other combination of more readily available chips that I could use to provide an equivalent interface?

Finally, the SB180FX offers some extra features that I would like to incorporate into my project, if possible. Since I am a relative beginner at electronic construction, I would welcome any advice you can give on the practical details of the construction of the SB180FX.

Jim Hawkins
Royston, England

There shouldn't be any problem with using the 3-MHz version of the HD6 in a home-built version of the SB180. As you suspect, the appropriate crystal should be the only required change; however, you might want to adjust some of the things developed with the 6-MHz unit in mind, such as the disk-access times.

The SMC9266 floppy disk controller chip is compatible with the industry-standard NEC 765A FDC and SMC's 9229 digital-data separator. My main reason for choosing the 9266 was to conserve circuit board space.

Building the SB180FX using point-to-point wiring would be impractical because of the difficulties in wiring the PLCC sockets and the problems associated with the 9-MHz clock speeds.
—Steve

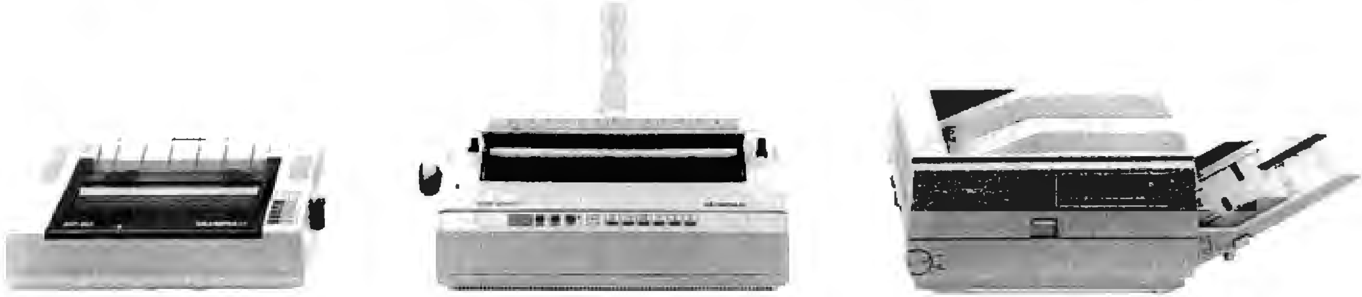
Expanding Term-Mite

Dear Steve:

I have some questions about the Term-Mite terminal board (January 1984 Circuit Cellar). I am using mine with an SB180. I've begun working with Echelon's graphics software and I'm looking for information on modifying the Term-Mite program.

continued

Dot, Daisy and Laser.



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OLYMPIA

The Competition

Advanced Engineering from Germany

744

I already know some of the things I would need: I could start with the source code for the Term-Mite, and then I would need a cross-assembler for the NS-455. Is a cross-assembler available from National Semiconductor, and will it produce code that can be burned into an EPROM?

In addition, I would like to add graphics characters. Can I add a full block and a hashed block, or are they already available?

I would also like to support windowing. With the Echelon window software, you have the ability to read the character at the cursor position and the ability to read a screen page. Are there any hardware limitations on performing either of these operations?

Cortney E. Smith
Tuba City, AZ

One of my Ask BYTE researchers, Jon Elson, has written a cross-assembler for the NS-455 chip. It's written in Turbo Pascal, which you can run on the SB180. You can reach him at 819 Marshall Ave., Webster Groves, MO 63119, (314) 962-6103.

You can implement the full block and the half-brightness block by displaying a space in reverse video and in half-intensity reverse video. Adding other characters requires the external character-generator feature, which disables half-intensity mode.

Windowing is certainly possible. All scrolling is done by copying character codes from one place in memory to another, and windowing just involves a few checks to keep the cursor in the correct window after linefeeds, wraparounds, and scrolling. When text scrolls off the top (or bottom) of the window, the bytes are just discarded.

The Term-Mite is almost completely software-driven, so you can accomplish almost anything with the right code. The Term-Mite source code is available from Micromint.—Steve ■

Between Circuit Cellar Feedback, personal questions, and Ask BYTE, I receive hundreds of letters each month. As you might have noticed, in Ask BYTE I have listed my own paid staff. We answer many more letters than you see published, and it often takes a lot of research.

If you would like to share your knowledge of microcomputer hardware with other BYTE readers, joining the Circuit Cellar/Ask BYTE staff would give you the opportunity. We're looking for additional researchers to answer letters and gather Circuit Cellar project material.

If you're interested, let us hear from you. Send a short letter describing your areas of interest and qualifications to Steve Ciarcia, P.O. Box 582, Glastonbury, CT 06033.

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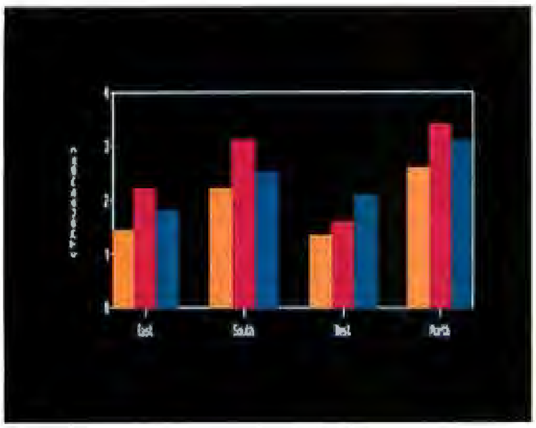
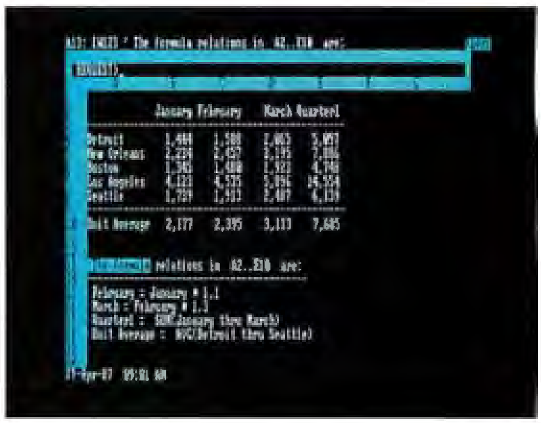
To get Lotus 1-2-3 to do all this more quickly and easily, we didn't make it more powerful.



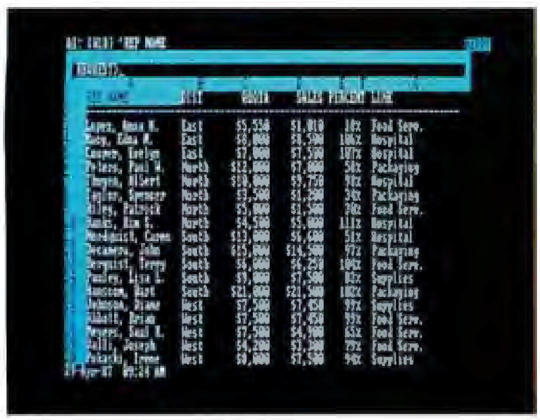
Lotus HAL doesn't change 1-2-3 or the worksheet. It makes things easier. For instance, to graph sales by district from January to March just request "graph Jan to Mar."

You can spend a lot of time setting up your spreadsheet. Summing up sales figures is a good example. With Lotus HAL, just request "total all rows" and 1-2-3 and Lotus HAL will create the formulas.

Say you want to extract just the information you want from a database. For example, you want to determine your top sales reps. Simply request "who has sales ≥ 8000."



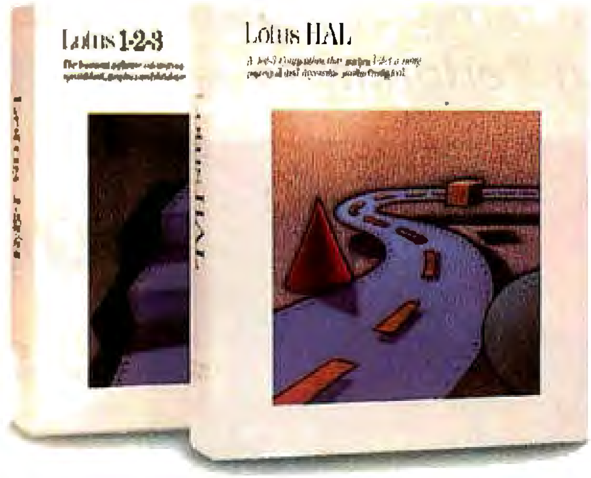
You may find yourself in the position of figuring out how a spreadsheet was built. Well, with ***Lotus*** *HAL, you simply request "list the relations in the sheet." And away you go.*



Do you find it hard to sort things by district or sales or any other criteria? Just request "sort by dist."

To create macros, well, you may not believe this. What you see here isn't a description of what's happening—it's the actual macro. See, we told you you wouldn't believe this.

We made you more powerful.



How? With Lotus HAL™—a Companion product for 1-2-3® that helps you take shortcuts, undo mistakes, link spreadsheets, use your own words for commands and basically get more out of 1-2-3 than ever.

So much more, that Computerworld has named Lotus HAL "Product of the Year."

The screens on the left will give you an idea of how easy it is to get more out of 1-2-3. And these are only a few of the enhancements and new features Lotus HAL brings to 1-2-3.

Lotus HAL gives you the ability to perform 1-2-3 tasks using simple English phrases—called, logically enough, "requests." This has advantages for all kinds of 1-2-3 users: the newer users will find that difficult tasks are now simplified; the more experienced users will find that many time-consuming tasks can now be performed in a fraction of the time.

In addition to this powerful capability, Lotus HAL also allows you to test assumptions, correct mistakes and simply change your mind with ease. Because through a special capability called "undo," Lotus HAL lets you reverse your last command—even retrieving a file before saving your work.

Besides all this, Lotus HAL gives 1-2-3 a number of other useful and powerful new features—like spreadsheet auditing and the ability to link cells or ranges between worksheets.

One obvious benefit of all this is that you save time. This is what led Business Software to say, "...(Lotus) HAL gives users the ability to move through 1-2-3 at least twice as fast."

And what does that savings in time mean to a business person? It means you're more powerful, more productive, more effective than ever before.

Make yourself more powerful, and buy yourself Lotus HAL. You'll find it at your Authorized Lotus Dealer, for just $150.* Or, you can call us directly at 1-800-345-1043 and ask for Product YS-1377, or ask for YS-1385 to receive more information about Lotus HAL. See? Everything with Lotus HAL begins with a simple request.

Lotus HAL

Requirements: Lotus HAL is a memory-resident program that requires 1-2-3 Release 1A, Release 2, or Release 2.01 for personal computers from IBM,** COMPAQ and AT&T, plus 1-2-3 certified compatibles; two disk drives; DOS 2.0 to 3.1; 512K RAM. Please refer to your 1-2-3 package or 1-2-3 documentation for appropriate hardware configurations and DOS requirements or consult your dealer. **Lotus HAL does not operate with 1-2-3 for IBM PCjr., or IBM PC Convertible or Release 1A for the IBM 3270 PC. When you purchase Lotus HAL directly from Lotus, take your first 30 days to try it. If after 30 days, Lotus HAL does not perform as described and you've purchased it directly from Lotus, we'll gladly give you a full refund.

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CD ROM 2:
OPTICAL PUBLISHING
Edited by Suzanne Ropiequet with John Einberger and Bill Zoellick
Microsoft Press
Redmond, WA: 1987
ISBN 1-555615-000-8
384 pages, $22.95

68000 ASSEMBLY LANGUAGE: TECHNIQUES FOR BUILDING PROGRAMS
Donald Krantz and James Stanley
Addison-Wesley
Reading, MA: 1986
ISBN 0-201-11659-6
402 pages, $24.95

SOFTWARE COMPONENTS WITH ADA: STRUCTURES, TOOLS, AND SUBSYSTEMS
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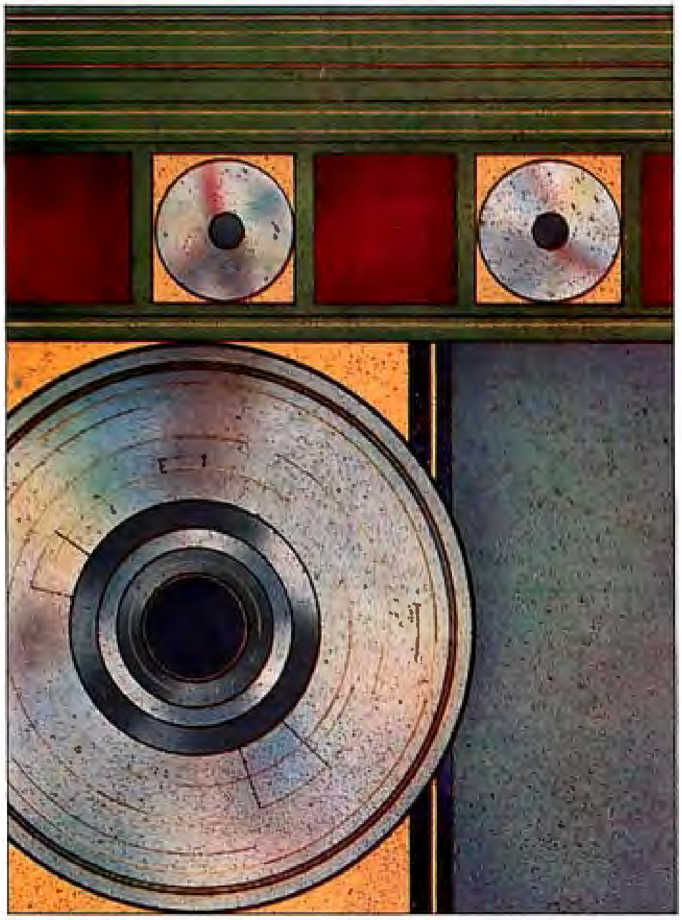
Benjamin/Cummings
Menlo Park, CA: 1987
ISBN 0-8053-0610-2
635 pages, $35.95



CD ROM 2: OPTICAL PUBLISHING

Reviewed by Paul E. Hoffman

Microsoft has long been a champion of emerging technologies, even if it has been a bit late in pushing them out the door. Last year, the company sponsored the first major conference on using compact optical disks (CDs) as read-only memory for computers. Microsoft also published the first major book on the new technology, *CD ROM: The New Papyrus* (reviewed in the October 1986 BYTE).

The articles in the first book covered a wide range of topics and expressed a general enthusiasm for the emerging CD-ROM technology. Many of the articles were introductory in nature and rarely went into much technical depth. The articles in *CD ROM 2: Optical Publishing* are more concrete and assume a greater background in storage concepts.

The articles are written by several different authors and compiled and edited by Suzanne Ropiequet, with assistance from John Einberger and Bill Zoellick. Though it contains many articles, this second volume lacks the variety and quantity of the first volume.

Two features of CD-ROM disks differentiate them from other removable data-storage media: They hold far more data, and they are read-only. The difference between a CD-ROM disk and a floppy disk is similar to the difference between a large book and a piece of paper. Like a book, the CD-ROM disk holds phenomenally more data, but it cannot be altered like a piece of paper can.

Optical Publishing treats the process of creating CD-ROM disks like book publishing. Instead of dwelling only on how computers can access CD-ROMs, the book spends a great deal of time explaining how standard computer concepts can be applied to the publishing industry. For example, a CD-ROM disk that has reference material on it is significantly more flexible than a book, even if the book has a great index. However, to be better than a book, the CD-ROM must have software support that's powerful and easy to use.

The book's orientation toward publishing makes it much easier to read than a technical book. It also conveys the big picture of CD-ROM: The data on the disks will be much more important than the computer controlling the disk reader. Although *The New Papyrus* had more interesting articles on information theory, *Optical Publishing* has more practical advice for people who intend to publish CD-ROM disks.

Responding to Users' Needs

The first couple of chapters quickly cover the background of CD-ROM and describe some of its potential applications. Editors Ropiequet, Einberger, and Zoellick provide an excellent technical summary of how data is read from a CD-ROM disk. Although this information is not necessary for someone preparing a CD-ROM disk, it is useful for an understanding of why you cannot simply give a disk producer a computer tape of files and expect a disk in return.

The next three chapters explain the underlying problems of preparing data for and retrieving information from CD-ROM disks. The editors detail the different methods for putting text on the disk. They also cover a much more interesting issue: how to read the information off the disk. This is followed by a chapter containing much more detail about methods for indexing and retrieving text on a disk, while the next chapter discusses index-

continued

Illustration by William Grant

ing and retrieving in database files.

These chapters make the process sound simple, probably dangerously so. As artificial intelligence researchers are discovering, people expect to see requested information in context. For instance, if a youngster using a CD-ROM for a report in school requested information on George Washington, and the first entry that was shown was about George Washington University, the student might think that the software processing his or her selection was not very smart. Since CD-ROMs can hold an incredible amount of information, the retrieval and indexing software must be more responsive to users' needs.

The material in these chapters presents an unfortunately limited view of the many indexing and retrieval methods that have been developed in the last 20 years. Although a few algorithms are listed, their advantages and shortcomings are glossed over. Important factors such as access times and disk space trade-offs are pretty much ignored, even though these can be explained in terms no more technical than the ones that were used earlier in the book to describe how bits are stored on CD-ROM disks.

Some Comparisons

Two chapters explore images and sound, respectively. The material about storing and processing graphics is much more detailed.

Even though the chapter on presentation systems covers the range in fairly good detail, it offers little guidance in selecting a data format for images. This is unfortunate, since there is a panoply of graphics standards from which to choose. To its credit, the chapter talks about many more side issues of image processing (such as compression, enhancement, and rasterization) than other sources of information.

The coverage of sound unfortunately does not include many side issues. Very little of the information relates to reproducing the audio data on different computers, or even how to store audio information in a general enough fashion for the CD-ROM disk to be of much use on more than one computer. This is indicative of the microcomputer industry's emphasis on visual over aural presentation.

Disk production was largely ignored in *The New Papyrus* but is covered in excellent detail in *Optical Publishing*. Chapter 10 presents an overview of the issues involved with getting data onto the disk, while Chapter 12 goes into the hows and whys of premastering and mastering the disk. These two chapters give the reader a solid idea of the intricacies of preparing data for CD-ROMs.

Thorny Issues

Probably the strongest chapter of *Optical Publishing* is Chapter 13, which covers a wide range of topics under the heading "Data Protection." Many early CD-ROM supporters waxed enthusiastic about putting entire encyclopedias, phone directories, and other reference books on a single CD-ROM, but they forgot a very important fact: The information in these works belongs to different people. This chapter goes into great detail about the legal issues involved in owning information and the format in which it is presented.

The sections on copyrights, trademarks, and trade secrets are also valuable to any print publisher considering putting its works on CD-ROM. Issues such as licensing information and property rights are also covered in detail. This chapter alone is worth the price of the book, especially for people who are wary of new information technologies.

Chapter 14 covers another thorny CD-ROM issue that is often ignored: updating CD-ROMs. Although it does not give many solid recommendations, it does raise interesting market-

continued


SYNC-UP
201C
SYNC-UP

ing questions about the data that is being sold. Such questions should be resolved before you commit to CD-ROM technology.

Real-World Examples

The last two chapters of the book are long, self-aggrandizing case studies about how two companies put together CD-ROM databases from existing microfiche products. The first article is about a card catalog product for libraries. The author reminds us over and over how innovative his company was for using CD-ROM and how wonderful the technology is. Unfortunately, he gives very little concrete information for someone studying the process of transferring information to CD-ROM. The second article, describing a medical information system, is a good summary of the book but presents almost no new information.

If the editors of *Optical Publishing* had included more articles in this section, readers would better understand the problems associated with converting to CD-ROM technology.

One-Sided Coverage

Although *Optical Publishing* covers a great deal of material well, it has some problems. A fair amount of boosterism pervades the articles. Although some of the negative features of CD-ROM are mentioned, they are seriously downplayed. While this book is a very good guide if you're interested in putting out a CD-ROM product, it is not very helpful if you're weighing CD-ROM against other competing technologies.

Part of the reason for this mostly one-sided coverage is probably that *Optical Publishing* is published by Microsoft Press, and Microsoft has invested a great deal of money and time in the CD-ROM effort. Since Microsoft has not backed other technologies (such as write-once optical disks), it is not surprising that alternatives do not get much coverage in the book.

Another reason for the boosterism is that most of the authors work for companies that help other companies produce CD-ROM disks. This could have been avoided by the collection editor, but the lead editor, Suzanne Ropiequet, works for Microsoft Press, and both the other editors work for companies that consult on CD-ROM. While the editors' credentials lend a certain amount of technical credence, they also call their bias into question.

For example, *Optical Publishing* makes dozens of references to the High Sierra Format (HSF) for information on CD-ROMs. In fact, Chapter 11 describes the format in great detail. Other formats are rarely mentioned, and most of the authors manage to put in a plug for HSF. Someone reading the book without reading other articles in the press wouldn't know that there are many other competing formats and that many manufacturers have adopted their own formats.

The emphasis on HSF (also called the HSG Proposal in the book) may be partially due to the fact that Microsoft is a member of the group that is creating the format. Although HSF has a good chance of becoming an accepted standard, the editors of this volume have performed a disservice to readers by not discussing other formats or the reasons why one might choose a nonstandard format.

Optical Publishing contains a wealth of good information and is an excellent companion to *The New Papyrus*. The articles are readable and often interesting. Although the book is flawed by a one-sided attitude toward this emerging technology, it is still worthwhile reading for most people who are interested in CD-ROM technology.

Paul E. Hoffman (2140 Shattuck Ave., Suite 2024, Berkeley, CA 94704) is a freelance writer and consultant. He has written five books about Microsoft products, including Microsoft Word Made Easy *(Osborne/McGraw-Hill, 1987).*

continued

68000 ASSEMBLY LANGUAGE: TECHNIQUES FOR BUILDING PROGRAMS

Reviewed by Adam Brooks Webber

Donald Krantz and James Stanley's *68000 Assembly Language* is a guide to writing programs for the Motorola 68000 family of microprocessors. The many examples included in the text are duplicated on an MS-DOS disk that comes with the book. According to the authors, the book is intended for people who have some experience with assembly language for another microprocessor and who want to make the transition to programming for the 68000. The category of prospective readers could be widened to include anyone who isn't either a 68000 expert or completely new to the concepts of machine-level programming.

Approach

This book is about generic 68000 programming, not about programming for the particular 68000-based computer the authors used. This means that the examples in the book, while helpful, cannot be used without modification on a Macintosh, an Amiga, or an Atari ST.

In general, *68000 Assembly Language* is pleasant to read; the tone is conversational in places. The serious-minded reader may find parts of the book too flip, but I found that the occasional humorous asides helped lighten what would otherwise have been a very dense technical work.

Reference Section

The book has two main sections. The first is a reference manual for the 68000. The authors describe the general architecture of the 68000, including the register set, memory map, and addressing modes. They group the instructions together according to function and explain each one individually. They introduce and compare several common techniques for parameter-passing, including those typically generated by compilers. Finally, Krantz and Stanley discuss the 68000's mechanism for exception handling (but without going into too much detail about the bus protocol).

The authors clearly know what they're talking about and generally have their facts straight, but the editing in the first section of the book is terrible. I found the frequent typographical, factual, and grammatical errors surprising—and what a reviewer finds surprising, an earnest student of the 68000 may find misleading. You may, for example, spend hours looking for another reference to the JNZ instruction mentioned on page 61, only to find no mention of it at all. You may rely on what you're told on page 10, that "When [a data register is] used as a destination, all condition codes excepting the extend flag are affected," which is not always true. To their credit, however, the authors recommend against using their book as a substitute for Motorola's reference manual. I concur.

Tutorial Section

The second section of the book is a 68000 programming tutorial. This is the real meat of the book, based on the very sound idea that people learn to write good code by reading good code. The authors proceed step by step through the development of a multiwindow text editor written completely in 68000 assembly language. They include the entire text of the editor in the book and on the accompanying disk. They provide several other examples in the same spirit: math routines, graphics routines, and a simple device driver. This is a great approach, and the book is worth buying just for the examples. The tutorial accounts for about two-thirds of the book's size and almost all its value.

continued

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The examples are not always typical of real-world applications of assembly language. In particular, few circumstances would convince a modern programmer to write an entire screen editor in assembly language. Typically, you might have a few key routines, originally implemented in some other language, that need to be hand-coded for speed. If this is the kind of application you have in mind, you may be disappointed in this book; it doesn't deal with tricks for squeezing every last cycle out of the machine. The examples are not at all sloppy, but they frequently favor readability and the ability to be modified over speed.

The Hardware

The authors' machine is an HSC PRO-68 card running in an IBM PC clone, which explains why the accompanying disk is MS-DOS-compatible. They claim, "We chose this system because it is generic enough so that any software we wrote with the exception of the I/O could be ported easily." Don't believe it. It was certainly a good idea to choose a generic machine just to avoid getting bogged down in the quirks of a big operating system, but there's no chance that the editor would be easy to port to a Macintosh or an Amiga.

In fact, the authors seem to have little or no experience with the popular 68000-based computers. The only area where this has handicapped them is in discussing the properties of different assemblers and linkers. They assume that some of the properties of their assembler (such as automatically optimizing short branches) are typical of all 68000 assemblers. Sadly, this is not the case. It is also not true that all 68000 linkers will handle the 16-bit references on which their examples depend. But these are minor problems; in the large picture, I think it is probably a good thing that the authors didn't opt for a machine-specific approach. The book is about 68000 programming; just keep in mind that you may also need a book on system-level programming for your particular computer.

Starting Point

While *68000 Assembly Language* is not a good 68000 reference and may be too generic to please some owners of 68000-based computers, its extensive, carefully explained examples make it worth reading.

It is clear that you can't learn to speak without hearing speech or to write English without reading it. I believe the same principle applies to the challenge of programming, and *68000 Assembly Language* is a good place to start.

Adam Brooks Webber is a software engineer at True BASIC Inc. (39 South Main St., Hanover, NH 03755).

SOFTWARE COMPONENTS WITH ADA: STRUCTURES, TOOLS, AND SUBSYSTEMS

Reviewed by Douglas Arndt

The cornerstone of software engineering is the concept of a disciplined approach to building ever-larger software systems. This means reusing software components that have been thoroughly tested and whose interfaces are well defined. Identifying and implementing these modular components is the subject of Grady Booch's latest work, *Software Components with Ada.*

Grady Booch is considered a pioneer within the Ada community. He lectures at Ada and software-engineering conferences, and he speaks from a great deal of experience. He is part of the original team that built the Rational Corp.'s software development environment—more than a million and a half lines of Ada

continued

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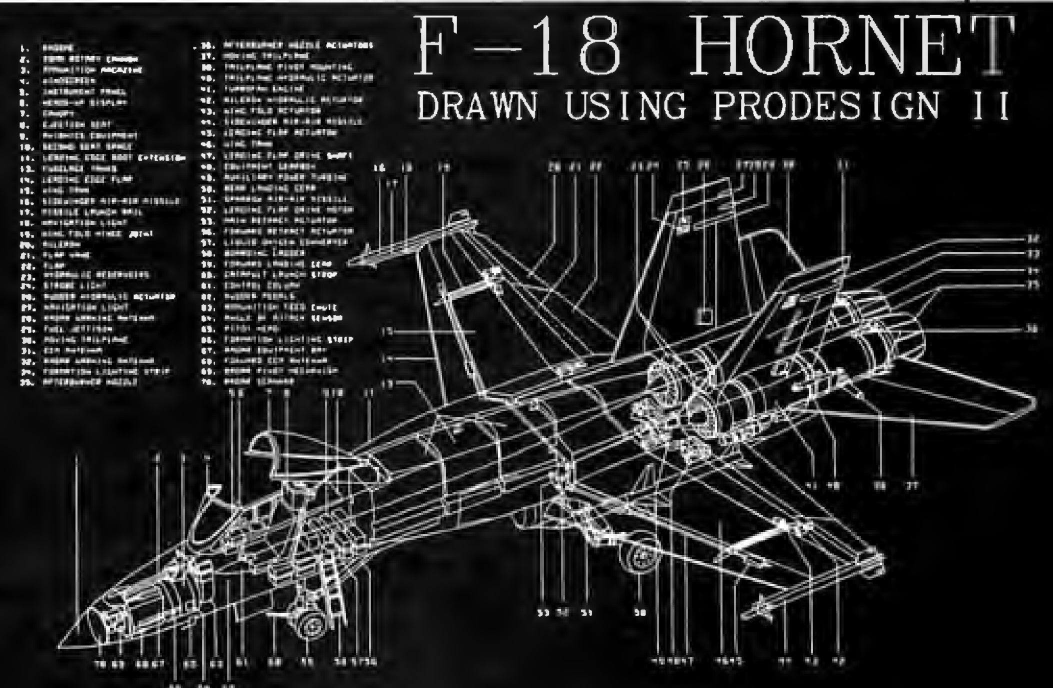


code, including a virtual-memory operating system. *Software Components with Ada* is a compendium of lessons learned over the past several years.

Software Reusability

Software Components with Ada is organized into four "packages" (the term is derived from an Ada feature that enforces encapsulation). Each package is segmented into chapters. The first package introduces such concepts as reusability, object-oriented development, and the characteristics of structures, tools, and subsystems. Booch describes how the application of these concepts is a superior approach to building software systems.

The theme of software reusability recurs throughout the book. Booch cites studies that conclude that only 15 percent of the code written on the average software project is "new." The rest has been written before, in some form or another, and could be reused. Hardware manufacturers have achieved orders of magnitude increases in productivity by adopting the component approach to engineering; software developers are just now beginning to catch up out of necessity.

In the first package, Booch reaches the conclusion that families of software components are necessary for the same reason that hardware vendors make many versions of the same microprocessor that vary according to power requirements, clock speed, price, and so on. Accordingly, he introduces a taxonomy he has developed to specify the various forms software components can take. The taxonomy separates components into data structures, tools, and subsystems. From there, the forms branch out until the lowest-level components are identified.

Data Structures Examined

In the second package, Booch explores the design and implementation of data structures. This section transcends other books on the subject because it takes the discussion of time and space behavior much further.

Each chapter in the second package describes a different data structure or class of structures. Still, the chapters are organized so that issues such as privacy, consistency, and concurrency can be isolated and examined.

In the third package, Booch shows how data structures are used to construct higher-level components that he categorizes as tools. In his taxonomy, tools are divided into the categories of utilities, sorting, searching (including pattern matching), and pipes and filters. Utilities are further separated into primitive, structure, and resource utilities. Booch designs and implements several examples.

Subsystems and the Law

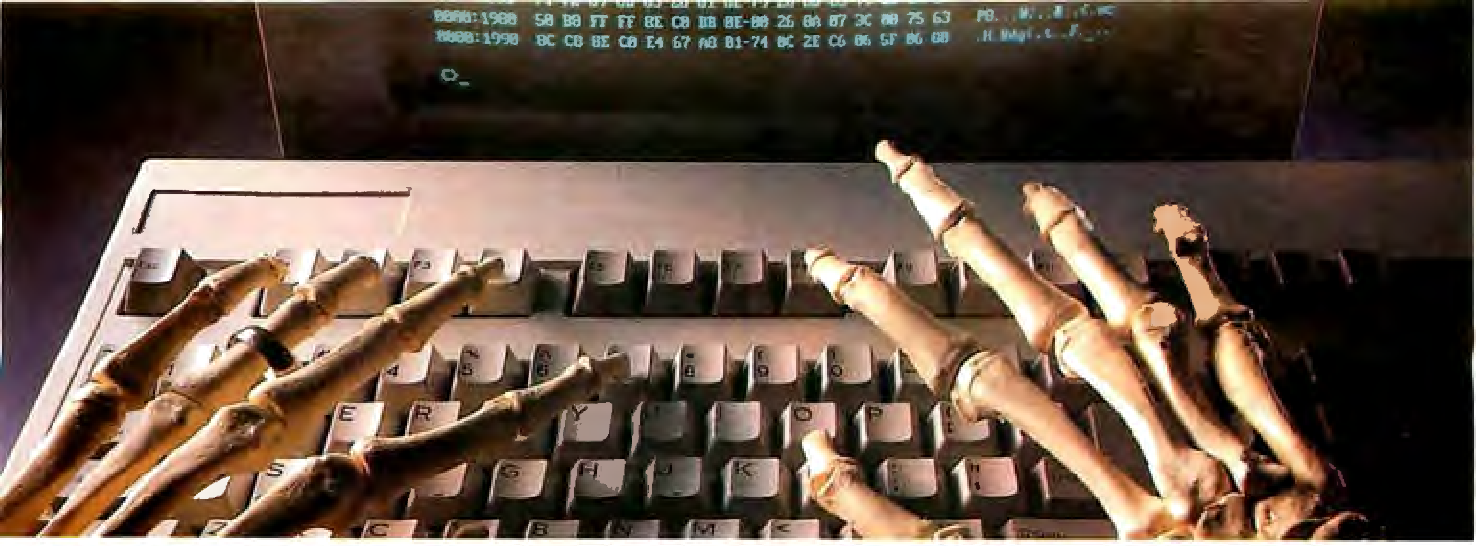
The fourth package is split into two chapters. The first concerns subsystems, which reside at the highest level of abstraction of software components. Booch describes the subsystem concept, along with its rationale and several technical and managerial issues. He cites several examples of applications at the subsystem level, including a windowing feature for user interfaces and the Space Shuttle Orbiter's flight computer operating system.

The last chapter, "Managerial, Legal, and Social Issues," covers such topics as how to identify reusable components, the techniques and problems associated with maintaining a large library of components, and how actual reuse affects the entire software development life cycle. Booch then moves on to the legal aspects of reuse.

Thorough and Applicable

In addition to being informative, *Software Components with Ada* is enjoyable to read. It is well-organized and written in a

continued



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relaxed, first-person-plural style. Booch makes appropriate and frequent use of pictograms to illustrate concepts and then follows up with fully coded examples. The book's 8½- by 11-inch format lets the code be spread across fewer pages. Each chapter concludes with a summary, a list of references, and a series of exercises for the reader.

Booch does not assume that the reader is familiar with data-structure theory. He patiently examines the motivation for each abstraction, usually associating each one with some model of reality. This approach increases the book's appeal as a textbook for classes in data structures, object-oriented design, or software engineering techniques.

Ada's Union with Design

Software Components with Ada is both a companion and a successor to Booch's influential first book, *Software Engineering with Ada* (Benjamin/Cummings, 1983, second edition 1986).

The connection between software components and Ada in both books is not just coincidental. Booch deftly describes the comfortable marriage between Ada and object-oriented design. While the concept of software components could be applied to most high-order languages, Ada was specifically designed to support the component paradigm. Ada offers the package structure, generics, separate compilation, a built-in tasking model, and a tightly controlled language definition (no subsets or supersets)—a nearly ideal combination for implementing reusable components.

Two Shortfalls

I have two significant concerns about the book's contents. The first is the issue of efficiency. Booch does not discuss the relative merits of iterative versus recursive operations on, for example, search operations or insertions into tree structures. He consistently chooses the recursive method because of its elegance and ease of implementation. Although both algorithms are linearithmic in nature, there is a significant penalty on most computer architectures for using the recursive method of insertion and lookup. The fact that Booch's methodology doesn't provide us with a way to differentiate between two algorithms that have similar or identical time behavior but different levels of efficiency is a problem that should be addressed.

The other thing that bothers me is that Booch seems to avoid the problem of handling limited private types (i.e., types for which no assignment operator is implicitly provided). Many of the structures in the book import only private types (for which assignment is implicit) as generic parameters but export limited types, creating incompatible interfaces. You can't have a queue of stacks, for instance, because the stack type is limited, and the queue package won't work with limited types. If you want a structure of some limited type, you must manage an access (pointer) type, adding a level of indirection and a lot of garbage-collection headaches. This approach is fine in small examples, but it is insufficient in large, complex systems. Booch acknowledges that this is a problem but offers no general solution.

A Software Component Standard

In the final analysis, these concerns do not diminish the impact the book should have on the software community. Booch pulls together many of the threads of traditional software theory and weaves them into a fabric that is altogether unique. I believe *Software Components with Ada* is destined to take its place on the reference shelf with the standard works of computer science. ■

Douglas Arndt (9427 East Third St., Tucson, AZ 85710) is a senior software engineer at Dalmo Victor and Singer. He is active in the Association of Computing Machinery's Special Interest Group on the Ada Programming Language (ACM SIGAda).

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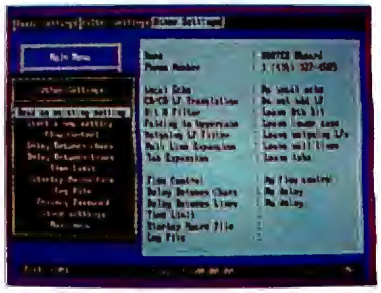

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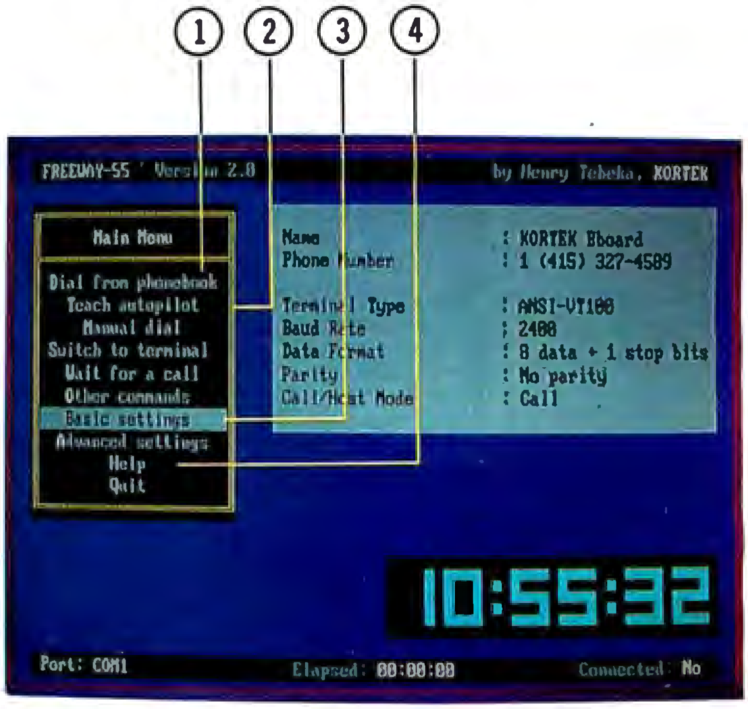

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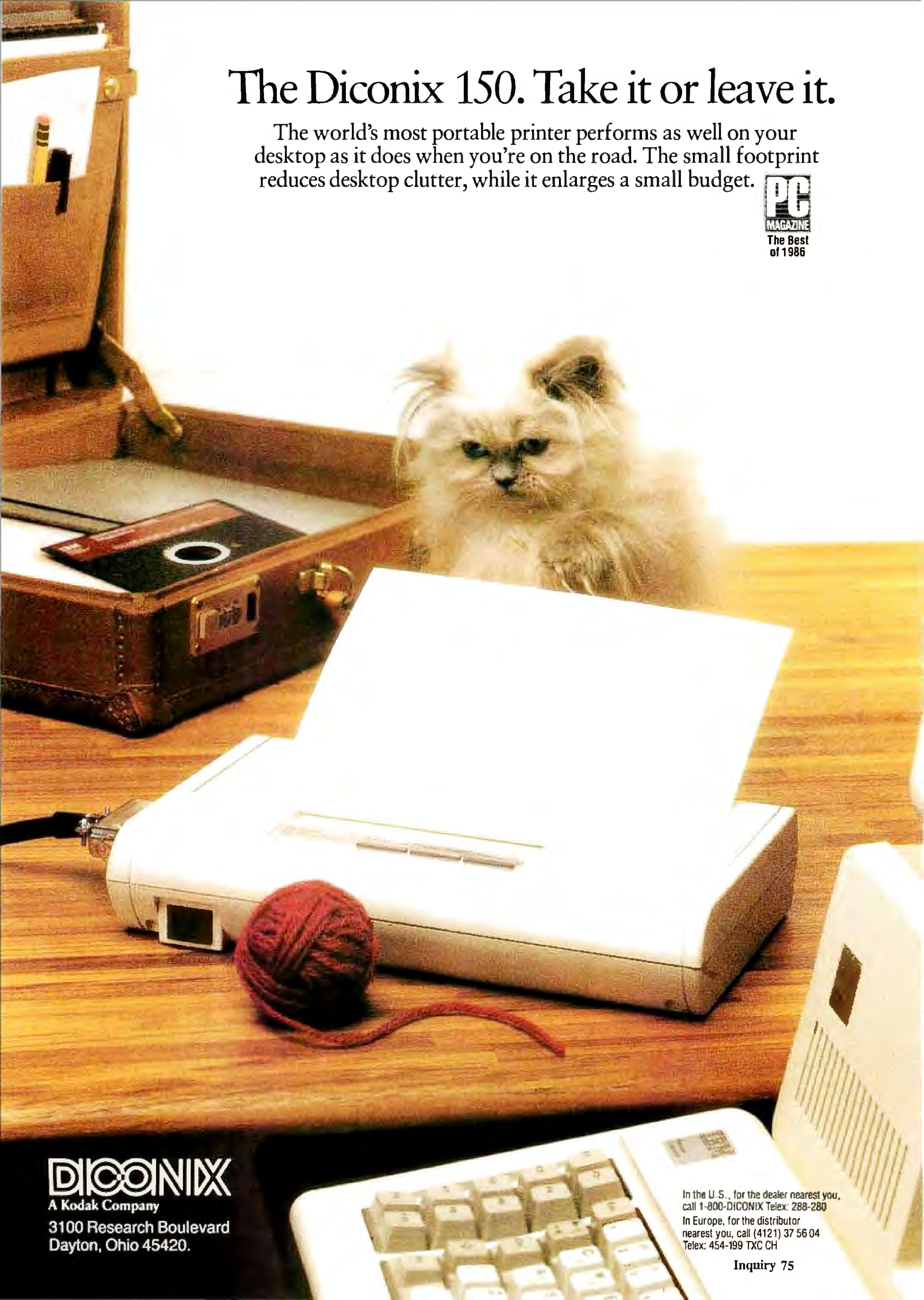
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Ray Duncan

A Programmer's Introduction to OS/2

Writing your first OS/2 application

OS/2 is Microsoft's multitasking, virtual-memory, single-user operating system for personal computers based on the Intel 80286 and 80386 microprocessors. Variously referred to in the press during the last two years as DOS 5, NewDOS, Advanced DOS, ADOS, and 286DOS, OS/2 is the first software product born of the Microsoft/IBM joint development agreement of August 1985.

OS/2 falls between Microsoft's MS-DOS single-tasking operating system and the Xenix multiuser, multitasking operating system. Although it is compatible with MS-DOS file systems and can run many existing MS-DOS applications, and although it has a hierarchical directory structure, I/O redirection, and some interprocess communication mechanisms similar to Xenix, it is neither an overblown MS-DOS nor a stripped-down Xenix. It is a completely new operating system designed to support high-performance, intensely interactive, "personal-productivity," and networking applications in a business environment.

The retail version of the basic OS/2 operating system will not reach users until early 1988, and the graphic user-interface layer (the protected-mode Windows/Presentation Manager) will arrive even later. However, to help programmers get familiar with the new system as quickly as possible and encourage the early port of existing applications to the new protected-mode environment, both Microsoft and IBM are directing earnest evangelical efforts at the software-development community. Both companies have announced an aggressive schedule of seminars for developers throughout the summer of 1987, and both have shipped software-development kits containing prerelease versions of the operating system and programming tools.

This article is the first in a series of three that will look at how to write programs to run under OS/2. The other articles will appear next month and in the Fall 1987 *Inside the IBM PCs* issue.

Key Features of OS/2

MS-DOS runs the 80286 processor in real mode, which is essentially an 8086-emulation mode. Even though the benefits of the 80286's higher clock rates and more efficient instruction set were not insignificant, both programmers and users found the persistence of the real mode's 1-megabyte-addressing limitation frustrating. OS/2 runs the 80286 in its preferred protected mode, with a physical address space of 16 megabytes and a virtual address space of 1 gigabyte. This use of protected mode has important implications for the structure of the operating system itself and for the design and operation of applications programs. (You can find a more detailed introduction to protected mode in Ross Nelson's article "A Protected-Mode Program for the PC AT" in the Fall 1986 *Inside the IBM PCs*, or in Intel's *iAPX286 Operating System Writer's Guide*.)

From the programmer's point of view, the key features of software development under OS/2 are a new application program interface (API), preemptive multitasking, interprocess-communication facilities, memory protection and virtual memory, dynamic linking, and compatibility with MS-DOS.

Application Program Interface

The OS/2 kernel provides about 200 services to applications programs executing under its control. Collectively they are referred to as the OS/2 API. You invoke all these services with *far calls* that are resolved at load time (see Dynamic Linking on page 104). Parameters—a mixture of values and addresses of values or structures—are pushed onto the stack prior to the call. A status code is returned in register AX: 0 if the function succeeded, or an error code if the function failed. Other returned values are placed in variables or arrays whose addresses were passed in the original call.

The OS/2 API functions fall into four major categories. DOSxxx calls are general services, including file and record I/O, device monitors, dynamic linking, multitasking, interprocess communication, memory management, timers, and internationalization support. VIOxxx calls display characters or strings with or without associated attributes, read back characters (and optionally, their attributes) from the display buffer, read or set cursor position and type, scroll up/down/left/right, set or get video mode, and put up or take down the pop-up window. KBDxxx calls are for keyboard status and input. MOUxxx calls read pointing-device position, status, and state of buttons; they also hide or reveal the pointer or set its shape.

A small subset of the above calls, known as the family API, has direct equivalents in MS-DOS function calls. OS/2 programs that restrict themselves to using the family API calls can be linked and bound in a special manner that lets them run in three environments: MS-DOS 2.x/3.x, the DOS 3.x compatibility box of OS/2, or protected mode under OS/2. Such programs are called *family*

continued

Ray Duncan is author of Advanced MS-DOS: Microsoft's Guide for Assembly Language and C Programmers, *Microsoft Press, 1986. He can be reached at P.O. Box 10430, Marina del Rey, CA 90295.*

The user's interface to OS/2's multitasking capabilities is simple.

apps or *bound apps*; the programming tools in the software-development kits are supplied in this form. (For more information on building family apps, see "Microsoft's New DOS," by Eva White and Richard Grehan in the June BYTE.)

The Windows/Presentation Manager offers applications programs another 500 or so functions that create, destroy, and control the appearance and size of windows, perform device-independent graphic output, put up and take down the pull-down menus, load resources, and so on. I'll ignore these for the present, except to note that when Windows/Presentation Manager is present, it replaces the system's default VIO and KBD routines with new services that let a well-behaved text application run in a window without its knowledge.

An interesting feature of the new OS/2 API is that it is equally efficient to call it from either a high-level language or from assembly language. Consider the function DOSSLEEP (probably the simplest useful function in the OS/2 API), which is called with a double-word value in milliseconds and suspends the caller's execution for the specified interval. The assembly-language form of the function call is

```
extern DOSSLEEP:far
    .
    .
    .
    push 0          ; push double value
                      1000
    push 1000       ; to sleep for 1
                      second
    call DOSSLEEP   ; transfer to OS/2
    or ax,ax        ; did call succeed?
    jnz error       ; jump if call
                      failed
```

To call an OS/2 API function from a C program, you simply declare it as far Pascal (i.e., parameters pushed left to right, the called routine clears the stack) and then invoke it directly:

```
extern unsigned far pascal
  DOSSLEEP(unsigned long);
.
.
status=DOSSLEEP(1000L);
```

The OS/2 C compiler generates the right code for the call automatically. There is no execution time or space penalty, there is no need for intermediate library functions to shift parameters around or pop them into registers before transferring to the operating system, and the source code is far more compact and readable than its assembly language counterpart.

Although the OS/2 API is a considerable architectural change from the familiar INT 21h of MS-DOS, it offers many significant advantages. The API lets OS/2 take full advantage of the 80286's ability to automatically copy parameters from the caller's stack to the receiving routine's stack. The API also enforces the separation between kernel and user-privilege levels by protected-mode call gates. The API might make subsequent conversion of applications for a true 32-bit 80386 version of OS/2 almost trivial, and it raises the possibility that the entire operating system and its applications could someday be ported to a processor with a non-Intel architecture, such as the Motorola 68020.

Preemptive Multitasking

Preemptive multitasking refers to the operating system's ability to allocate processor time between multiple tasks in a manner that is invisible to those programs. It is sometimes called time-slicing. A hardware interrupt, called the timer tick, which is generated by a programmable timer chip, lets the operating system regain control at predetermined intervals.

After updating the current date and time, control is transferred to a scheduler that maintains a list of the active tasks and their state. If the scheduler determines that the currently executing program has exhausted its time slice or that another program with a higher priority is ready to execute, the scheduler suspends (preempts) the current program and gives control to another program.

The user's interface to OS/2's multitasking capabilities is simple and easy to understand. A special supervisory program, called the session manager, lets you start up one or more copies of the system's command processor (CMD.EXE, the protected-mode counterpart of MS-DOS's COMMAND.COM). Each command processor and the programs that users launch from it are collectively termed a screen group and own a virtual screen buffer that receives all the output from the programs in that group. Users can cycle from one screen group to another with the aid of the session manager's hot key; when a screen group is brought to the foreground, its virtual screen buffer is mapped to the physical screen, and the programs in that group acquire control of the keyboard.

The programmer's view of multitasking under OS/2 is somewhat more complex and involves three types of system objects: screen groups, processes, and threads. Each screen group contains one or more active processes, and each process contains one or more active threads. The simplest case of a process is conceptually similar to a program loaded under MS-DOS: The process is initiated when the operating system allocates some memory, loads the necessary code and data from a disk file, and gives it control at an entry point specified in the file. Subsequently, the process can obtain and release other resources (such as access to disk files and additional memory), perform input or output, and spawn other processes by calls to the operating system. A process's membership in a screen group depends strictly on the membership of its "parent" process; similarly, any "child" processes that it creates will belong to the same screen group.

The OS/2 concept of threads is rather novel. A thread is a point of execution within a process and is associated with a stack, general register contents, and a state (i.e., waiting for some event, ready to execute, or executing).

Each process has exactly one thread when it is created, whose initial execution point is the entry point of that process. But that thread can create additional threads that then run asynchronously from the first and share ownership of all the processes' resources and "near data segments" (DGROUP).

Threads within a process can dynamically suspend, reactivate, and vary the priorities of one another and can perform input and output autonomously: Any necessary serialization of I/O is done within OS/2. Communication between threads is fast, since it is typically performed through shared data structures and does not need to involve operating system calls.

Interprocess Communication

OS/2 supports all the major methods of interprocess communication found in other multitasking operating systems. RAM semaphores are used for local signaling or resource synchronization between multiple threads in the same process. System semaphores that are called global objects can be used for signaling or resource synchronization between processes. Pipes, as in Unix, allow high-performance transfer of variable-length messages between closely related processes (usually a parent and its child processes).

Shared memory, named global memory segments, can be accessed by two or

continued

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Memory Protection and Virtual Memory

All the processors in the Intel 80x86 family generate memory addresses by combining the contents of a segment register (which you can think of as a base pointer) with an absolute or relative offset. On the 8086 or the 80286 in real mode, the value in a segment register is simply a paragraph address (a 20-bit physical address divided by 16). In protected mode, an additional level of addressing indirection is added. The value in a segment register is a selector, which is an index to an entry in a descriptor table that contains the base address and length of a memory segment, segment attributes (executable, read-only, or read/write), and privilege information. Each time a program makes a memory reference, the hardware accesses the descriptor table to generate the physical address and simultaneously checks to make sure that the memory access is valid.

Protected-mode addressing completely isolates tasks from one another. The descriptor tables themselves are not accessible by applications programs; only the operating system can manipulate them. If a program attempts to read or write a memory area that does not belong to it or calls an operating system routine to which it has not been given access, a hardware interrupt is generated that lets the operating system terminate the errant program. The combination of preemptive multitasking and memory protection contributes to a robust environment: There is little opportunity in protected mode for an ill-behaved program to bring the entire system down by going into a loop or writing on code or data owned by another program.

The flip side of the memory-protection coin is virtual memory. OS/2 can manage up to 16 megabytes of physical memory, but the amount of installed RAM is nearly irrelevant to the average applications program running in protected mode.

When the sum of the memory owned by active programs in the system exceeds the amount of physical memory, memory segments are rolled in and out from a swap file as needed (or just discarded and reloaded in the case of code or read-only data segments). This segment-swapping is accomplished by a module of OS/2 known as the memory manager, with the aid of the processor's hardware memory-protection mechanisms, and the process is completely invisible to applications programs. The theoretical limit on the amount of memory a program can own or share is around half a gigabyte, but the practical limit is the amount of physical RAM plus the swapping space available on the hard disk.

Dynamic Linking

The 80286's support for protected virtual memory makes it possible to place frequently used procedures, including most of the OS/2 and graphic user-interface services available to applications programs, into special files known as dynamic link (dynalink) libraries. The routines in these libraries can be shared by all the programs that require them and are not loaded from disk into physical memory until they are needed. Placing common procedures in dynalink libraries lets you alter, improve, or replace those routines without any change to the applications programs that invoke them.

The calls from a program to the routines in a dynalink library are resolved in two stages. The linker is informed that a particular external name is a dynalink routine by either an `Import` statement in the program's module-definition file or by finding a special "stub" record in an object-module library. It then builds the information necessary for deferred linking into the program's .EXE-file header: the names of the dynalink routines that are needed, the modules in which they will be found, and a list for each routine of all the addresses within the program where it is called. When you load the program for execution, the list of imported routines is examined, any external routines that are not already resident in memory are fetched from the disk, and the addresses within the calling program are fixed up appropriately. You can think of this as late binding.

Compatibility with MS-DOS

OS/2 provides upward compatibility and a smooth transition from MS-DOS at three levels: the user interface, the file system, and the DOS 3.x compatibility box.

The command-line interface of OS/2 version 1.0 is identical to that of MS-DOS, with the exception of a few new or enhanced commands, batch-file directives, and CONFIG.SYS file options. The session manager, which is triggered by a hot key and lets the user move from one screen group and command processor to another, is self-explanatory, and its use becomes natural very quickly. Adaptation to the Windows/PM, when it arrives, will also be easy: Its methods of operation and pull-down menus are quite similar to that of Microsoft Windows except that it uses overlapping rather than tiled windows, and you launch programs from a list of long, descriptive names rather than double-clicking on a filename in a disk-directory listing.

The file structure for both flexible and fixed disks—that is, the layout of the partition table, directories, file-allocation tables, and the files area—is exactly the same for the initial release of OS/2 as for MS-DOS. This means that you won't be escaping the 32-megabyte volume limit or the 8-character filename limit for some time yet. However, it does let developers exchange files and move back and forth between the two environments with a minimum of difficulty. OS/2's provisions for mountable file systems portend release from some of the historical MS-DOS limitations.

The DOS 3.x compatibility box is not a box at all, but a component of the OS/2 operating system that lets one "old" application designed for MS-DOS run at a time in the 80286's real mode alongside "new" protected-mode applications. Requests by the real-mode application for MS-DOS services are trapped by OS/2 and translated into API calls, switching back and forth between real mode and protected mode as necessary to perform I/O and other services. The user can determine how much memory will be allocated to the DOS 3.x box by an entry in the CONFIG.SYS file or disable it completely.

One disadvantage of the DOS 3.x box is that it makes the system vulnerable as a whole. Ill-behaved MS-DOS programs that manipulate the hardware directly or take over interrupt vectors can cause problems or even a hard crash—this is unfortunately the trade-off for being able to use the old programs at all.

A Simple OS/2 Application

An OS/2 application is built from two basic elements: source files that can be compiled or assembled into relocatable object modules and a module-definition file that describes the program's segment behavior (see figure 1).

In a traditionally trivial program that displays the message "Hello World!," the file `HELLO.ASM` contains the assembly language source code for the program (see listing 1). It looks similar to an equivalent MS-DOS program, with a few exceptions.

The directive `.286c` permits the as-

continued

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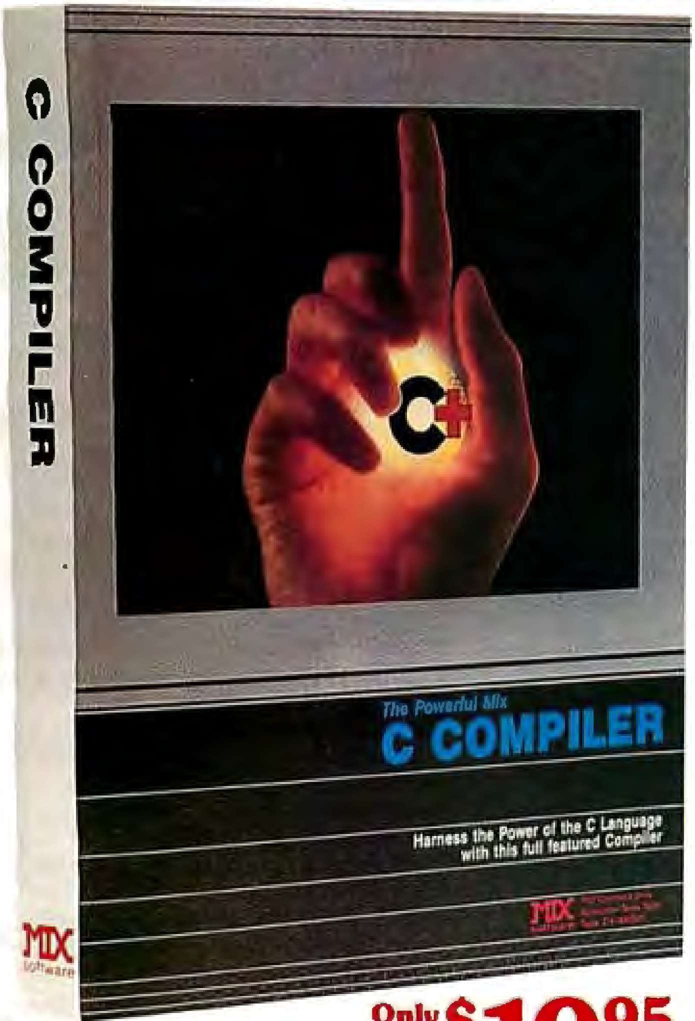

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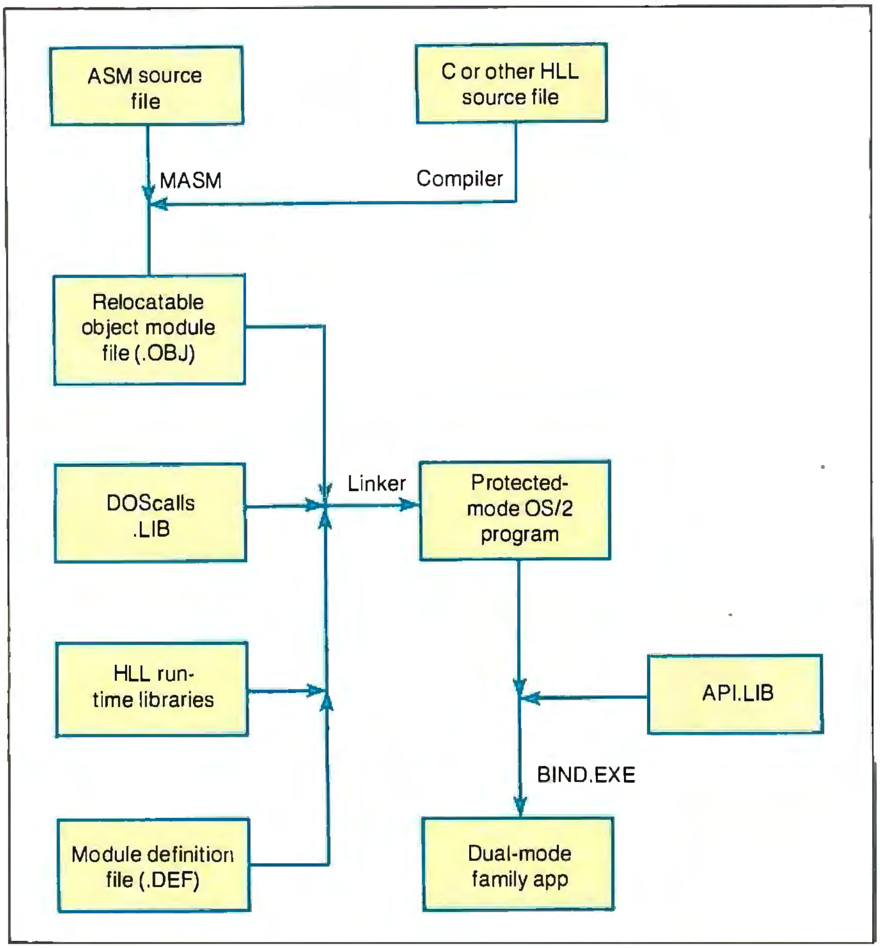

Figure 1: *The procedure for creating protected-mode and dual-mode, or "family," applications for OS/2.*

CS:IP	Points to the program's initial entry point
SS:SP	Points to the base of the program's stack
DS	Points to the program's automatic data segment (DGROUP)
AX	Contains the segment selector of the environment block
BX	Contains the offset of the command line at the end of the environment block

Figure 2: *Conditions at entry to a protected-mode OS/2 application.*

```
NAME HELLO                  ; executable name
PROTMODE                    ; protected mode only
DATA MOVABLE
CODE MOVABLE PURE
STACKSIZE 4096
```

Figure 3: *A module-definition file, HELLO.DEF, for the sample application file HELLO.EXE. Note that the stack size is declared here rather than in the HELLO.ASM file. If this were a C program, the heapsize would also be declared in this file.*

sembly of 80286 nonprivileged instructions that are not present in the 8086 instruction set. The handiest of these is the "push immediate" instruction, which saves time and space when you set up parameters for an OS/2 API call.

References to OS/2 API entry points are accomplished with EXTRN directives, assigning a far attribute to the external name. The assembler does not know anything about the nature of the procedure represented by the external name, but only that it has to generate an intersegment call to reach it and that the final address will be fixed up later.

The declaration of DGROUP with the group directive is mandatory. This is a "magic" name that specifies the application's automatic data segment, which also contains the default stack and heap. The _TEXT and _DATA segment names are simply conventions used by the Microsoft high-level language compilers. Unlike MS-DOS, OS/2 automatically initializes the DS register to point to DGROUP before it transfers control to the program's entry point (the other conditions at entry to a protected-mode application are summarized in figure 2). This is also reflected in the Assume directive that follows the segment declaration of _TEXT.

The remainder of the HELLO.ASM file contains nothing unexpected. Two calls to OS/2 services are demonstrated: DOSWRITE performs a synchronous write to a file or a device, and DOSEXIT terminates the application with a return code. DOSWRITE is the counterpart to MS-DOS's INT 21h function 40h, and DOSEXIT is comparable to MS-DOS's INT 21h function 4Ch. The last line in the source file is an end directive that defines the program's entry point in the usual manner.

The file HELLO.DEF (see figure 3) is the module-definition file for the program. It demonstrates only a few of the possible commands and options that can be used in this file. The name directive states that this is an executable program rather than a dynamic-link library (whose .DEF file would contain library instead).

Protmode signifies that the program will run in protected mode, while the lines beginning with code and data declare a few of the many possible segment attributes. The stack size for the program's initial thread of execution is defined by the stack directive; if this were a C program, an additional heapsize command would specify the initial size of the program's local heap.

Building the Application

To build the final executable program, you first translate the file HELLO.ASM to the relocatable object module HELLO.OBJ:

```
[C:\OS2\SOURCE\HELLO]
 MASM <Enter>

IBM Personal Computer MACRO
 Assembler Version 3.00
(C)Copyright IBM Corp 1981,
 1984, 1987
(C)Copyright Microsoft Corp
 1981, 1983, 1984, 1985, 1987

Source filename [.ASM]:
 HELLO<Enter>
Object filename [HELLO.OBJ]:
 <Enter>
Source listing [NUL.LST]:
 <Enter>
Cross-reference [NUL.CRF]:
 <Enter>
5506 Bytes symbol space free

0 Warning Errors
0 Severe Errors
```

The Microsoft segmented executable linker—the new linker supplied in the OS/2 software-development kit—combines the object module HELLO.OBJ with the module-definition file (HELLO.DEF), a library that contains special stub records for the OS/2 API dynamic links (DOSCALLS.LIB) and any applicable run-time libraries (none in this case) to create the protected-mode executable file HELLO.EXE:

```
[C:\OS2\SOURCE\HELLO] LINK
 <Enter>

Microsoft (R) Segmented-
 Executable Linker Version
 5.00.21
Copyright (C) Microsoft Corp
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Object Modules [.OBJ]: HELLO
 <Enter>
Run File [HELLO.EXE]: <Enter>
List File [NUL.MAP]: <Enter>
Libraries [.LIB]: DOSCALLS
 <Enter>
Definitions File [NUL.DEF]:
 HELLO <Enter>
```

You can also supply the assembler and linker with their parameters via the command-line or response files, or automate the process by means of a make file and the MAKE.EXE utility (see figure 4).

The output of the segmented executable linker is an .EXE file with the same structure as the .EXE files used in real-mode Windows—the so-called New.EXE

continued

Listing 1: *The source file HELLO.ASM for the sample application HELLO.EXE.*

```
        name    hello
        page    55,132
        title   HELLO --- print Hello on terminal
        .286c
;
; HELLO.EXE utility, demonstrating a simple assembly-language program for
; Microsoft OS/2.
;
; (C) 1986 Ray Duncan
;
stdin   equ     0   ; handle for standard input
stdout  equ     1   ; handle for standard output
stderr  equ     2   ; handle for standard error
        extern  DOSWRITE:far
        extern  DOSEXIT:far

DGROUP  group   _DATA

_DATA   segment word public 'DATA'

msg     db      0dh,0ah,"Hello Protected-Mode World!",0dh,0ah

msg_len equ $-msg

wlen    dw      ?       ; receives number of bytes written

_DATA   ends

_TEXT   segment byte public 'CODE'

        assume  cs:_TEXT,ds:DGROUP

print   proc    far

        push    stdout          ; file handle for standard output
        push    ds              ; long address of write buffer

        push    offset DGROUP:msg

        push    msg_len         ; size of write buffer
        push    ds              ; variable receives bytes written

        push    offset DGROUP:wlen

        call    DOSWRITE        ; transfer to OS/2
        or      ax,ax           ; test returned status
        jnz     error           ; jump if write failed

        push    1               ; terminate all threads
        push    0               ; return success code
        call    DOSEXIT         ; exit program

error:  push    1               ; terminate all threads
        push    1               ; return error code
        call    DOSEXIT         ; exit program

print   endp

_TEXT   ends

        end     print
```

```
hello.obj : hello.asm
 masm hello,hello,hello;

hello.exe : hello.obj hello.def hello
 link /map /line hello,,,doscalls,hello
```

Figure 4: *A make file for the sample application HELLO.EXE.*

format. The file has an elaborate header that contains the names of imported dynamic link routines and any attached resources and describes the locations, sizes, and attributes of the various segments within the file.

OS/2 uses the information in the header to allow for sharing of text segments between multiple instances of the same process, to discard and reload text (i.e., machine-code) segments and read-only data segments on demand, and to allocate the program's stack and heap, among other things.

Making a Family App

Since the HELLO.EXE file uses only the OS/2 functions `DOSWRITE` and `DOSEXIT`, both of which are members of the subset family API, it can be converted to a family app that runs in either the DOS 3.x compatibility box or in protected mode. To do this, you use the `BIND.EXE` utility and a special library named API.-LIB as follows:

```
[C:\OS2\SOURCE\HELLO] BIND
 HELLO.EXE API.LIB <Enter>
```

The output of this process is a new HELLO.EXE file that can run in either real or protected mode on an 80286 machine. To truly generalize this program and obtain a HELLO.EXE file that could run on any 80x86-based machine under MS-DOS or OS/2, you would have to replace all 80286-specific instructions in the source code with equivalent sequences that would run on an 8086/88. For example, you would need to replace the instruction

```
push msg_len
```

with

```
mov ax,msg_len
push ax
```

You can easily locate the 80286-specific instructions in a program by removing the `.286c` directive from the source file and reassembling it; each instruction that will not run on an 8086/88 processor will then be flagged as an error.

Coming Attractions

Next month, I will develop and discuss a more complex application that makes use of OS/2's sophisticated multitasking as well as its interprocess-communication services. ■

[Editor's note: *This article is adapted from Ray Duncan's book,* Advanced OS/2, *to be published by Microsoft Press in January 1988.*]

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Richard Grehan, Technical Editor

A Closer Look

Refinement of our benchmarks reveals some surprises about the relative speeds of 80386- and 68020-based machines.

BYTE started benchmarking the relative speeds of the new crop of 80386- and 68020-based machines within days of getting our hands on them. We presented the preliminary—and controversial—results in the July issue: The 80386-based machines were faster. We presented additional tests in the August issue, with much the same results.

However, our preliminary benchmark tests weren't ideal (some, in fact, contained outright errors, which I'll detail later). It's no small task to produce reliable benchmarks for systems with new architectures, especially when fundamental software-development tools (such as compilers) are few or in very early release.

So for this month's New Generation segment, I corrected problems in the original benchmarks and ran the improved code on the following lineup of hardware: the Mac SE, the Mac SE with General Computer's HyperCharger and Levco's Prodigy, the Mac II, the Arete 1100 supermicro, the Definicon DSI-780, the IBM PC AT, the IBM PS/2 Model 80, the Kaypro 386, the ALR 386/2, and the Compaq 386.

You will find statistics for most of these entrants in our July and August New Generation articles.

Levco's Prodigy for the Mac SE is a 68020 with a 68881 math coprocessor, both of which run at 16 MHz. It includes 1 megabyte of RAM. The Definicon DSI-780 is a coprocessor board for the IBM PC XT or AT (we plugged our DSI-780 into an 8-MHz AT) with a 16.67-MHz 68020 and 68881 and 4 megabytes of RAM. Both the Kaypro 386 and the ALR 386/2 use a 16-MHz 80386, but the ALR can accept a 10-MHz 80287 while the Kaypro (for reasons described later) could not use a math coprocessor.

The July issue also contains source code listings for the benchmarks. Listings are also available on BIX and BYTEnet, and on disk. (Order the July 1987 listings disk for the original benchmarks and the September disk for the corrected versions. See the card following page 256. For BYTEnet listings, see page 4.)

Sort and Float

Our Quicksort benchmark (SORT.C) was unreliable; it produced a list that was only "sort of" sorted. The cure was to change the outer `for` loop in the `quick()` function to read:

```
for (i=lo, j=hi, pivot=base[hi];
  i<j;)
```

I've simply changed the initialization portion of `j=hi-1` to `j=hi`. Recall that the Quicksort algorithm operates by dividing the array being sorted into pairs of partitions such that one partition contains all elements greater than or equal to a given number (the "pivot"), and the other contains all elements less than or equal to the pivot. These partition pairs are again subdivided, and the process continues until the number of elements in each partition is 1. This is where the old SORT.C bombed; since `j` had been initialized to `hi-1`, the termination expression `i<j` would not allow the `for` loop to execute.

All the times you see reported in tables 1a and 1b for the Sort benchmark were generated by the corrected program.

Next, we learned that optimizing compilers had a field day with the Float benchmark: I ran the original Float through MetaWare's 80386 HighC compiler and set its switches so I could view the 80386 assembly language that the compiler was generating. As it turned out, the compiler discovered that Float consisted of repetitious instructions and could be optimized if the results were kept in registers and simply moved into memory as required. The compiler resolved the last six multiply instructions into simple `MOVE` instructions.

To get around this, I recoded Float so that the loop enclosed only a single multiply and a single divide, and I boosted the loop count to 70,000 to make up for the six pairs of assignment statements I had removed. I also borrowed a technique from the Dhrystone benchmark and added code to factor out the looping time (by timing an empty loop and subtracting this value from the total elapsed time). Consequently, the new version of Float should give a better picture of the time it takes a math coprocessor to execute floating-point multiplications and divisions.

Flotsam and Jetsam

Running these benchmarks on such a diverse array of hardware gave me a chance to uncover all kinds of interesting tidbits:

• MetaWare's HighC compilers (I used two versions, one for generating 80286 code and one for generating 80386 code) provide a floating-point software switch that you can set to enable or disable the generation of in-line floating-point coprocessor code. They also come with two libraries: one that supports a math coprocessor, and one that performs floating-point operations using emulation code.

You would think that turning off the floating-point switch and linking with the emulation library would be enough to ensure that the .EXE file you were creating would ignore any floating-point unit (FPU) that might be present in the machine. Not so. There is an environment variable in MS-DOS called `NO87`, which you set according to whether or not you have a coprocessor on-board. The upshot is that even if you have created a program using the emulator library, when you run it on a machine with a coprocessor and the `NO87` variable set to a null value (i.e., you have executed the DOS command `SET NO87=`<return>), the program runs faster than if there was no coprocessor.

Clearly, the emulation library must be carrying coprocessor code with it, and the program brings this code into action if it finds an FPU. (Actually, this technique makes sense. It allows you to create code that runs on systems with or without FPUs; and if a system has an FPU, it gets a boost.) This means that you have to be careful about setting the compiler flag and the `NO87` variable when benchmarking. All the figures you see in table 1b for 80386 machines are from machines with an FPU (unless specified otherwise).

• To run the 80386 benchmarks, I executed the programs using Phar Lap's

RUN386 protected-mode environment (this is the only way you can run programs created by the 80386 version of the HighC compiler—see Matt Trask's review of 386|ASM/LINK 1.1e in the August BYTE). The latest version of RUN386 we had was 1.1e, and it simply locked up the Model 80. (The problem seemed to occur when RUN386 tried to load a benchmark program: The system would freeze and the hard disk access light would remain on.) When I reverted to an earlier version (1.1), it worked.

- The Kaypro 386 machine I tested had a socket for an 80387, but the machine refused to acknowledge an FPU when I plugged one in. The Kaypro uses Intel's 80386 motherboard, and there have been reports that Intel's board is incompatible with an 80387. Looks like there's some substance to those reports.
- I carefully followed Levco's instruction manual for installing the Prodigy board's accompanying software, but the installation disk's contents did not match what the manual led me to expect; specifically, a control desk-accessory file was missing from the floppy. Also, when I tried to run the RAM disk initialization (again, as outlined in the manual) a bomb box appeared. I finally discovered how to set up the Levco software by reading the "Get Info" information associated with the files on the floppy.

Table 1a: *Benchmark figures for 68020 machines. All Macintosh benchmarks were generated using Consulair's C compiler version 5.04; I used the 68020 flavor of this compiler for all Macs except the SE. The Arete came with its own compiler. On the DSI-780, I used Silicon Valley Software's C compiler version 2.0.*

Test	Mac SE	Mac SE with HyperCharger	Mac SE with Prodigy	Mac II	Arete	DSI-780
Dhrystone	574	2176	2380	2106	2710	3438
Fibonacci	263.54	71.60	71.45	83.72	69.86	47.89
Float	230.23	4.06	2.61	2.63	2.90	2.24
Savage	1921.00	8.86	5.22	5.42	24.70	5.65
Sieve	64.56	14.92	14.83	16.72	12.40	4.89
Sort	103.82	20.55	20.41	23.20	13.20	6.74

Table 1b: *Benchmark figures for 80386 machines. I used MetaWare's HighC 386 compiler version 1.3 on all machines except the AT, on which simply used the same compiler with no 80386 support. Phar Lap's 386|LINK was the linker (again on all machines except the AT, for which I used Microsoft's LINK version 3.51). I used RUN386 version 1.1e for the 80386 machines (as required by HighC) except for the Model 80—see text for the reason.*

Test	IBM PC AT 8-MHz 80287	Model 80 16-MHz 80387	Kaypro 386 No FPU	ALR 386/2 10-MHz 80287	Compaq 386 8-MHz 80287	Compaq 386 16-MHz 80387
Dhrystone	1590	3626	3271	3283	3748	3748
Fibonacci	126.22	57.26	64.65	64.66	53.12	53.11
Float	10.98	1.62	40.42	5.30	6.80	1.43
Savage	37.30	9.49	355.29	17.97	21.53	8.95
Sieve	24.60	6.45	6.81	7.41	5.99	5.98
Sort	43.17	7.74	8.35	8.55	5.58	5.58

Results

First of all, it's easy to see that if your application is floating-point-intensive, then no matter which processor you choose, for heaven's sake, get a math coprocessor. The cost of coprocessors is still a bit high (often as much as or more than the CPUs that run them—as of this writing, you'll pay around $300 for an 8-MHz 80287 and $200 for a 12-MHz 68881). But if processing time is money, the coprocessor could easily pay for itself.

In the 68000/68020 arena, it's Definicon's DSI-780 that appears to win out. I say "appears" because the C compiler used with the Definicon board (Silicon Valley Software's C compiler) is necessarily different from the one I used on the Macintoshes (Consulair) and the Arete (its C compiler comes with Unix). Therefore, it is difficult to tell how much of the Definicon's advantage to attribute to the compiler. (Here's an example of a similar case: I also compiled the benchmarks using Lightspeed C version 2.01 on the Mac SE with Prodigy installed. Lightspeed C turned in figures that were 10 percent to 15 percent faster than Consulair's 68020 compiler—except for the floating-point benchmarks, which makes sense once you discover that Lightspeed C does not recognize the 68881.)

If money's no object and you're out for raw power, a Compaq 386 with an 80387 installed is your best bet in 80386-land. The figures for the 80386 systems are probably more meaningful than those for the 680x0 machines, since I was able to run the same .EXE files on all the 80386 systems. (Of course, I couldn't do this for the AT; even so, at least the compiler on the AT was from the same company as the 80386 compiler—MetaWare.)

Overall, it appears that—and I know I'll catch a lot of flak for this—the 80386 machines outperform the 68020 machines. Of course, the reasons for this could well go beyond the possibility that one processor is simply faster than the other; I'm using different C compilers, the hardware is different, the software I've used represents only a tiny subset of all the applications users can expect to run, and so on. But let's look at some facts: The C compilers I used were the only shipping 68020 and 80386 compilers available at the time I ran these benchmarks (Manx's Aztec C 68020 compiler might be shipping by the time this issue reaches press, as might Computer Innovations' C86+ 80386 compiler—we'll include these in future New Generation stories), so, for now, these are the compilers available to you for your development work. Also, it makes no sense to benchmark the processors independently of the systems that incorporate them: You don't buy just a processor, you buy a complete system—and the systems I tested are the same ones you can buy. So what we're looking at are the hardware and software configurations that the world has made available to you so far. ■

[Editor's Note: *The table in this article is a condensation of a vast array of benchmark figures that were compiled. For the complete set of figures—especially if you're interested in floating-point performance without an FPU—see the supermicro.benchmark topic on BIX.*]

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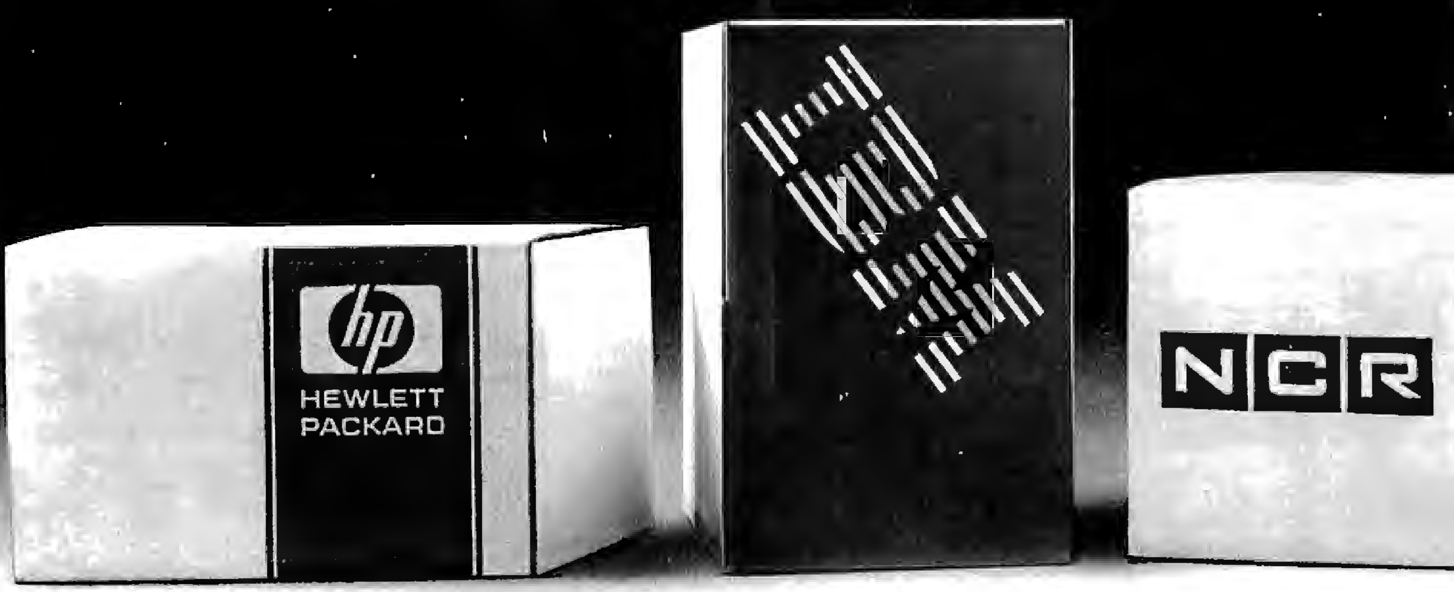

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Steve Ciarcia

Part 1: AT Basics

Build the Circuit Cellar AT Computer

New chip technology lets Steve put an AT on a card

The personal computer industry can best be described as competitive and fast-moving. Hundreds of manufacturers around the world are turning out IBM PC, XT, and AT clones, as well as board products for those who wish to mix and match to build a desktop computer. Heavy competition forces these manufacturers to continually bring out higher performing products that are less expensive than their competitors' products. Talk about a dog-eat-dog business!

Ordinarily, given such market volatility, I would not stick my neck into the "clone wars," but I just couldn't pass up the opportunity to show some new technology that would one-up all these companies. The two-part project starting this month uses a set of four high-integration ZyMOS ICs that contain most of the peripheral chips needed to build an IBM PC AT. Using this advanced technology, I will present a faster, smaller, and more efficient 100 percent compatible AT CPU board called the CCAT (Circuit Cellar AT). With the addition of Award Software's AT BIOS, the CCAT and your imagination can configure an unbeatable (should I say uncloneable?) 80286 computer system.

Technology to the Rescue

The ZyMOS POACH (which stands for PC on a chip) set is really an ASIC (application-specific IC) set that was originally developed to show just how much could be integrated on one 230-pin chip (it contained 22,000 logic gates). Eventually, it was divided into more cost-effective 84-pin devices (see photo 1).

ZyMOS uses standard-cell CHMOS (complementary high-speed metal-oxide semiconductor) technology for its ASIC products. Some methods for developing ASICs are gate arrays, programmable logic arrays, and standard-cell technology, to name a few. Standard-cell technology produces chips that are highly integrated (they can squeeze 25,000 logic gates on a single device) but also very efficient in their use of silicon area.

Gate arrays are essentially a mass of predefined gates that are interconnected by the designer, but that most often leave a lot of unconnected gates and waste silicon. The standard-cell approach uses just the logic elements the designer requires. The result is higher densities of utilized gates requiring smaller die size. Less silicon means lower cost per device.

Standard cells are predefined logic units that correspond to commercially available devices like inverters, AND gates, flip-flops, and more complex parts (like the 82xxx peripheral chips used in the IBM PC AT).

A chip designer developing an IC first lays out a schematic, just as for any project. Such a schematic typically contains off-the-shelf components like 8254 counter-timers, 7474 flip-flops, 7408 AND gates, and 7432 OR gates. Next, the designer enters this schematic into a computer using specialized graphics soft-

continued

Photo 1: *This section of the Circuit Cellar AT circuit board shows the POACH (PC on a chip) integrated circuits.*

Steve Ciarcia (pronounced "see-ARE-see-ah") is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, and product development. The author of several books on electronics, he can be reached at P.O. Box 582, Glastonbury, CT 06033.

ware that generates a file called a *net list* (Circuit Cellar projects are currently done on Schema).

The net list defines which logic elements from a library of standard cells are needed and how those cells are interconnected. The net list is input to a logic simulator, which the designer uses to debug the design, and then fed to a program called a *router*. The router actually lays out the final chip, transistor by transistor. Sounds easy! It's not—it's just easier and faster with the computerized tools. Even so, it took seven months to develop the four-chip POACH set used in the CCAT.

Understanding the AT's Design

Before we look closely at the POACH chips and the CCAT, we should get some understanding of the IBM PC AT motherboard's design so we can better understand what it is that we are trying to improve. The AT is an Intel 80286 16-bit microprocessor design that can optionally support the 80287 math coprocessor for fast floating-point operations. It also uses an Intel 8742 microcontroller as a keyboard processor.

In addition to the processors, the AT uses 10 VLSI peripherals that work in

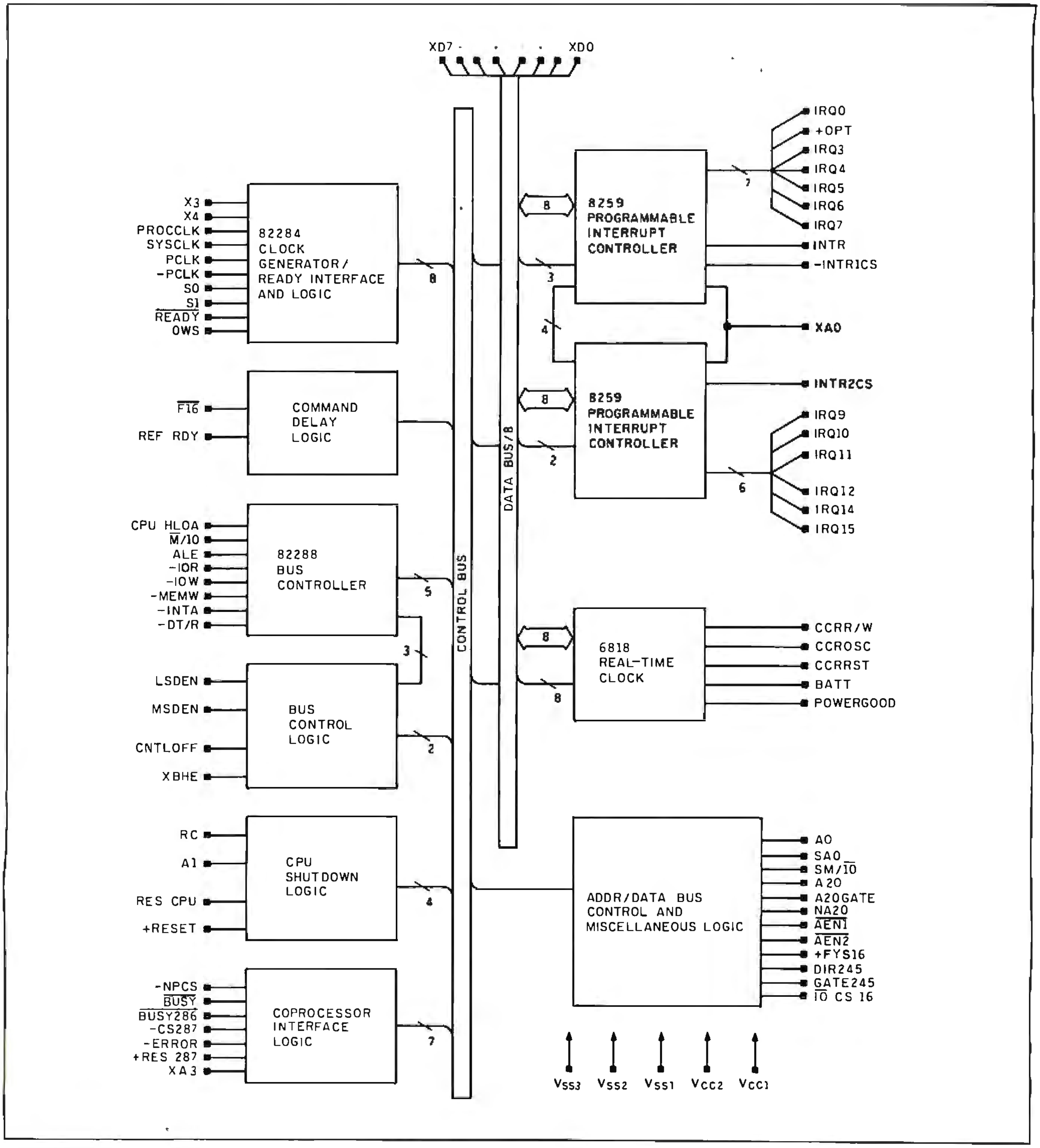

Figure 1: *The block diagram of the internals of POACH1.*

conjunction with the 80286 to perform functions like bus timing, interrupt control, and direct-memory-access operations. These devices integrate much necessary logic that a designer would ordinarily have to build up from primitive logic functions to get a design to perform properly. They are the building blocks that, with integrated microprocessors, have shrunk the computer's physical size and made prices affordable.

The peripherals in the AT include two 8259A programmable interrupt controllers, an 82284 clock generator and ready interface, an 82288 bus controller, a 6818 clock/calendar/RAM, two 8237A DMA controllers, a 74LS612 memory mapper, an 8284 clock generator, and an 8254 programmable interval timer.

The interrupt controllers sort out and prioritize interrupt requests to the microprocessor. Each interrupt controller can handle up to eight interrupts, but Controller-2 (CTLR2) interrupts are directed through CTLR1, which uses up one of CTLR1's interrupt lines. Interrupt requests (IRQ) are mapped as shown in table 1. The 82288 and 82284 perform general system clocking, some decoding of 80286 control signals, and bus-control functions in the AT.

The 6818 contains the clock/calendar and 64 bytes of CMOS RAM. The clock function uses 14 bytes of the RAM to hold time and date data. The rest of the RAM holds the system's configuration information, like the type of floppy and hard disk drives and low- and high-memory bytes. The 6818 is kept alive when the machine is powered down with battery power and a continually running clock frequency.

The two 8237As provide seven DMA channels. DMA CTLR1 supports 8-bit data transfers between 8-bit I/O adapters and 8- or 16-bit system memory. Data transfers can occur throughout the 16-megabyte address space in 64K-byte blocks. DMA CTLR2 supports 16-bit data transfers between 16-bit I/O adapters and 16-bit memory and can perform data transfers in 128K-byte blocks throughout the full 16-megabyte address range. Since the DMA controllers generate only 16-bit addresses, the system uses the LS612 memory mapper to extend the addressing to 16 megabytes.

A 14.318-megahertz crystal drives the 8284 clock generator. The 14.318-MHz clock is routed directly to the expansion slots.

The 8254 programmable interval timer provides 16-bit counters on three independent channels. Channel 0 produces the system timer signal (18 ticks per second), channel 1 generates the dynamic RAM-refresh request, and the system uses channel 2 for the speaker's tone generator.

Table 1: *Request mapping for the interrupt controllers on the CCAT.*

CTLR1	CTLR2	
IRQ0		Timer output 0
IRQ1		Keyboard (output buffer full)
IRQ2		Interrupt from CTLR2
	IRQ8	Clock/calendar/RAM
	IRQ9	Software redirected to INT 0AH (IRQ2)
	IRQ10	Reserved
	IRQ11	Reserved
	IRQ12	Reserved
	IRQ13	Coprocessor
	IRQ14	Fixed disk controller
	IRQ15	Reserved
IRQ3		Serial port 2
IRQ4		Serial port 1
IRQ5		Parallel port 2
IRQ6		Disk controller
IRQ7		Parallel port 1

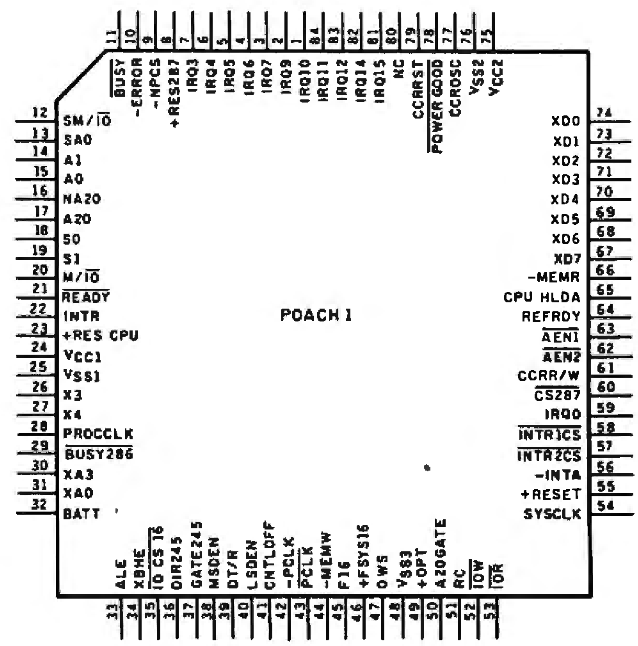

Figure 2: *A pin-out diagram for the POACH1 chip.*

You should begin to see some of the characteristics of the AT emerging. It is a 16-bit interrupt-driven system with DMA capability for fast memory data transfers. The PC's speaker is still there to prompt you with those annoying beeps and to add some dimension to game playing. And we've added a real-time clock to keep track of time and date.

If we tack on 512K bytes of DRAM and a couple of ROMs to hold the BIOS, the system starts taking form. It would be great if we could stop here, with about 43 chips making up the system. But we have to glue all this together and provide a means for the processor to talk to memory and the outside world—so we have address and data buses.

The AT has a number of address and data buses, with many buffers, latches, and multiplexers separating the individual buses. In fact, it has *five* distinct buses: local, system, X, memory, and L address. (The first four have both address and data components.)

continued

The local address and data buses are tied directly to the 80286 and 80287. Twenty-four address lines and 16 data lines form the heart of the AT. The address lines are latched by three LS573s that buffer the local address bus from the system address bus. Because the 80286 can do word and byte data transfers, and word transfers need not be aligned, the AT data-bus interface has to differentiate between the high-bus byte and the low-bus byte. ("Aligned" refers to the fact that the word address is even, that is, A0 = 0).

If the system has to transfer a word over the bus to an odd address location, it requires two bus cycles—one to transfer the low byte and one to transfer the high byte (this is a nonaligned word transfer). The local data bus is separated from the system data bus by an LS245 buffer and an LS646, which not only buffers but also has a latch function.

The system address and data buses are the primary ones in the AT for both memory and I/O transfers, including the interface to the AT's expansion slots. The sys-

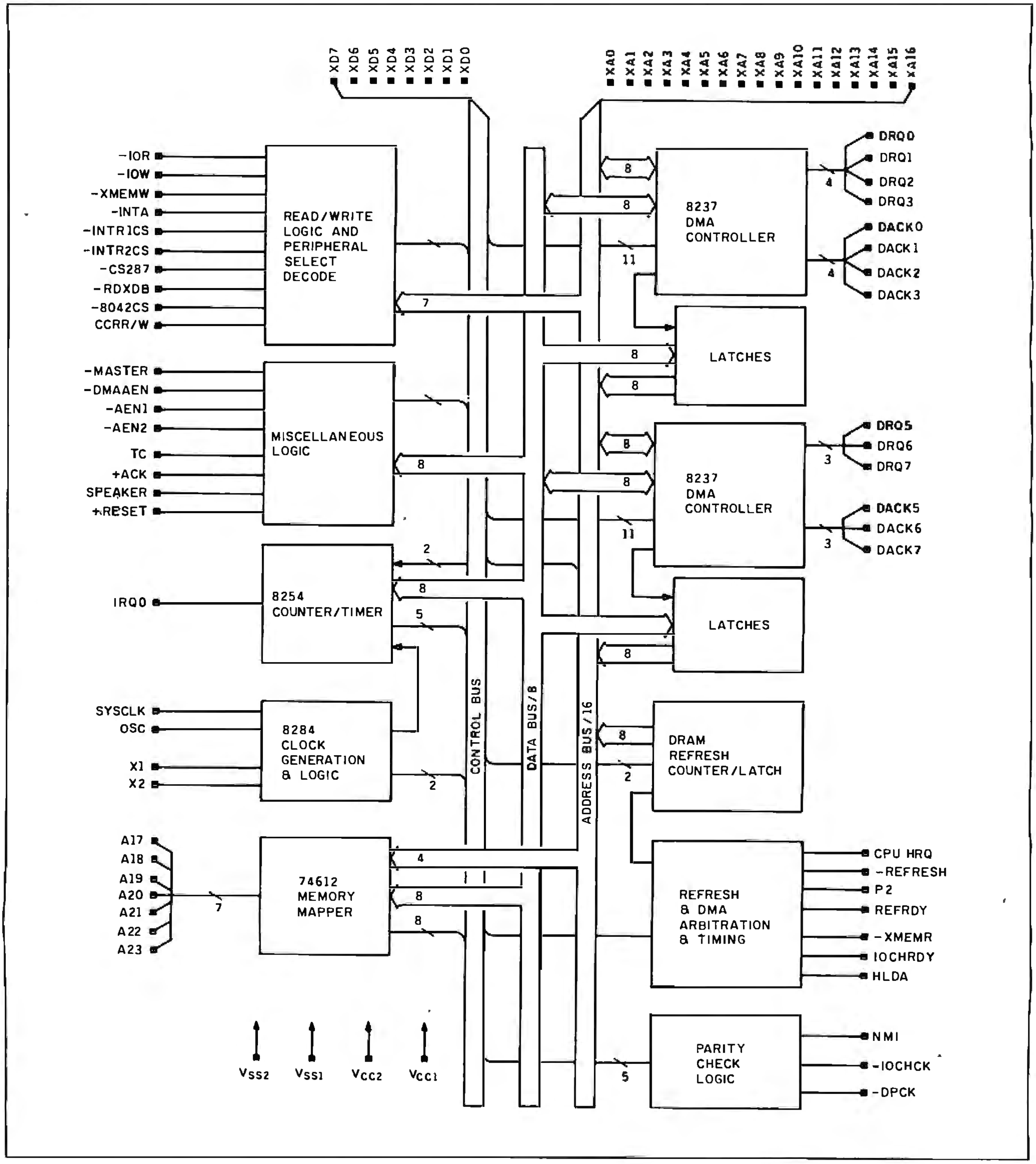

Figure 3: *The block diagram of POACH2.*

tem address bus is a latched 20-bit (SA0 through SA19) version of the 80286 local address bus. The system data bus maintains the low-byte and high-byte reference. The AT performs 16-bit transfers for memory and expansion data, but it does 8-bit data transfers for the X bus (which the AT motherboard uses to communicate with the 80286 peripheral chips).

The X address bus is a 17-bit bus that you can think of as private to the motherboard. The system uses this bus to address ROM (where the BIOS is kept) and motherboard I/O, as well as to generate addresses for DMA- and RAM-refresh operations. It is separated from the system address bus by LS245s.

The X data bus interfaces to functions like DMA controllers, interrupt controllers, the keyboard processor, and the clock/calendar/RAM hardware. Although the system uses the X address bus to select ROM data, this data is fed to the processor via the memory data bus, not the X data bus.

The memory address and data buses apply to DRAM on the motherboard. The 9 address lines (MA0 through MA8) of the memory address bus are a multiplexed version of 18 system-address lines. The memory data bus is a 16-bit motherboard bus that interfaces both DRAM and ROM.

The L address bus, hangs like an appendage off the local address bus. It is an unlatched 7-bit (LA17 through LA23) address that is always available except when an I/O processor gains control of the system. The L address bus gives the AT a 16-megabyte address range.

Complicated? You bet! We've just added 83 ICs for buffering, additional logic, and glue to tie the system together. This brings the total IC count for a 512K-byte system to 126 packages. Now you can see why the motherboard is approximately 14 inches square!

Microcomputers did not always have big motherboards. Originally, when they were much simpler, they used passive backplanes, with the processor board plugged into one of the backplane slots. Chip count and board size have an obvious effect on the cost of the system. That's where the new high-integration chips play such an important role.

The POACH Set

The engineers at ZyMOS partitioned the motherboard's logic into a set of 84-pin ICs. Two chips, POACH1 and POACH2, contain *all* the 82xxx-series peripherals and also some key logic. POACH1 is primarily responsible for system clocking and bus control (see figures 1 and 2). It contains the 8259A interrupt controllers, the 82284 clock generator and ready interface, the 82288 bus controller, and the 6818 clock/calendar/RAM. All the buffers and latches in the system are controlled by POACH1.

POACH2, shown in figure 3, controls the X address bus for DMA and refresh operations. It contains the two DMAs, the 74LS612 memory mapper, refresh logic, the 8284 clock generator, and the 8254 programmable interval timer. Figure 4 shows POACH2's pin-out diagram.

The buffers, latches, and remaining logic are in POACH3, the buffer chip. (I haven't provided a block diagram for POACH3 since it's simply a mass of uninteresting discrete logic.) POACH3 is mode-programmable, and we've used two in the CCAT, one for address buffering and the other for data buffering. I'll refer to the device set for address-buffering mode as POACH3-A and the device set for a data buffer as POACH3-D.

The AT POACH set brings the total IC count for a 512K-byte AT-compatible motherboard equivalent down to 23 IC packages and two SIMMs (single in-line memory modules).

Ultimately, our design is intended to be totally IBM compatible, with certain key advantages. Using the POACH chips, we can squeeze the whole motherboard into an AT expansion board with room to spare and build a system on a passive backplane. Since all the usual power-hungry ICs are now incorporated in the POACH devices (the four-chip set needs less than 100 milliamperes), we will also be able to construct a low-power AT.

The POACH set brings the total chip count for a 512K-byte AT compatible down to 23 IC packages and two SIMMs.

Next Month

I'll complete this project with a full schematic and a detailed description of the Circuit Cellar AT computer. ■

The CCAT was a joint venture, and I'd like to note the contributions and help from ZyMOS, Micromint Inc., Award Software Inc., and the Circuit Cellar research staff. In addition, I'd like to personally thank Bob Andrews, Jeff Bachiochi, and Jeff Remmers for their efforts.

Editor's Note: Steve often refers to previous Circuit Cellar articles. Most of these past articles are available in book form from BYTE Books, McGraw-Hill Book Company, P.O. Box 400, Hightstown, NJ 08250.

Ciarcia's Circuit Cellar, Volume I covers

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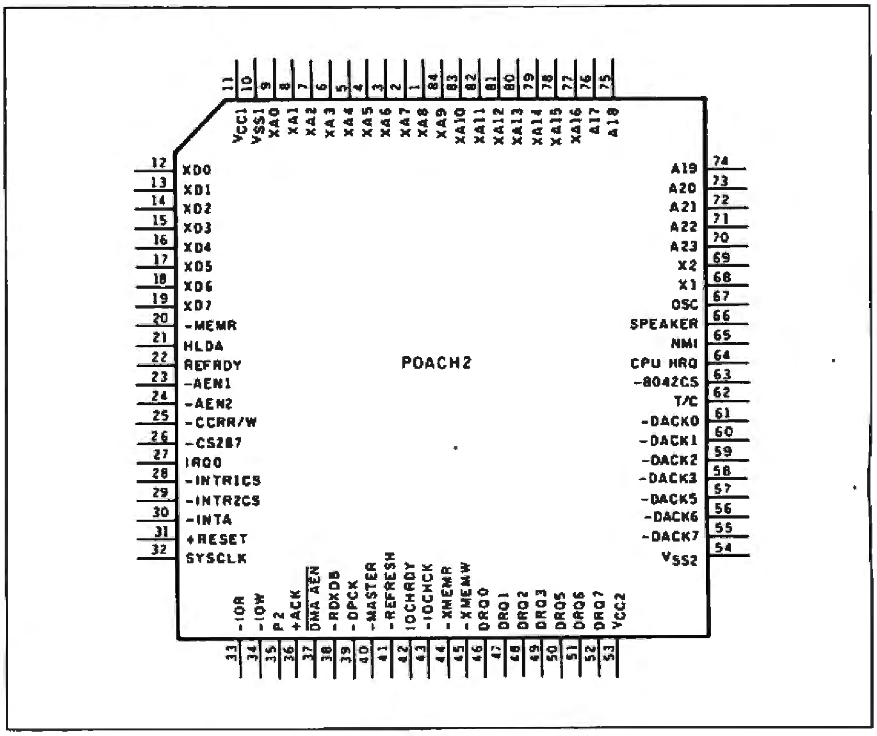

Figure 4: *POACH2's pin-out diagnn.*

articles in BYTE from September 1977 through November 1978. *Volume II* covers December 1978 through June 1980. *Volume III* covers July 1980 through December 1981. *Volume IV* covers January 1982 through June 1983. *Volume V* covers July 1983 through December 1984.

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To be included on the Circuit Cellar mailing list and receive periodic project updates and support materials, please circle 100 on the Reader Service inquiry card at the back of the magazine.

Hanna Oktaba and René Berber

Crafting Reusable Software in Modula-2

Careful program design results in safe, reusable program libraries

Programmers are constantly being called upon to produce more and more software, and their productivity continues to be an increasingly pressing problem. One way to boost programmers' productivity is to design reusable software—software that is standardized in some way so that the programmer can use it in a later situation instead of writing new but similar code. If you begin designing your programs in a way that produces small, reusable units of code, you will eventually build up a library of code modules that you can draw from to speed up the design and coding of new programs.

Unfortunately, software seems to resist efforts to make it more manageable. Sorting a set of strings, for example, is different enough from sorting a list of numbers that writing new code from scratch seems simpler than trying to adapt an existing routine. One way to make software reusable is to try to separate the algorithm from the data structures it uses. If you can do this, you need to design, code, and debug the algorithm only once, adding only a few data-related routines to implement the algorithm in a new context.

In the case of a sorting routine, you would try to design it so that it takes as parameters an array of objects to be sorted and a procedure that defines which of two elements comes before the other. This is called *parameterized programming* because the elements that distinguish one occurrence of the routine are passed as parameters to it.

To support parameterized programming, a programming language needs to provide you with certain facilities. An article by Joseph Goguen (see reference 1) lists those facilities and explains how they are used. Such languages include Ada, with packages and generic packages; C, with the use of libraries; and Modula-2, with its modules and opaque-type declarations.

Modula-2 and Reusable Software

The programming language Modula-2 (see reference 2) has several constructs that support the crafting of reusable software. This language is readily available on many microcomputers, and for that reason we think it is important to promote its use for the design of reusable software.

In Modula-2, the basic concept of a *module* is, in an intuitive way, used to encapsulate pieces of software that make a logical unit in themselves—for example, an I/O package. There are several kinds of modules: program modules, local modules, and library modules. From here on, we will refer only to library modules.

Library modules are made out of two parts: a *definition* part and an *implementation* part. [Editor's note: *Since these units of code begin with the phrases* `DEFINITION MODULE...` *and* `IMPLEMENTATION MODULE...`, *they too are called modules, but we will use the word "part" wherever possible to refer to these two parts that, together, completely define a library module.*] The definition part contains a description of everything a module exports. This includes any constants or variables, the data types manipulated by the module, and the procedures that operate on them. A procedure description shows only its name, the name and type of its formal parameters, and, if it returns a value, the data type it returns.

The implementation part contains the implementation details (i.e., the actual code) of the procedures described in the definition part. It also contains auxiliary procedures, variables, module-initialization code, and anything not exported but needed for the implementation. Sometimes the definition part declares, but does not define, data types (which are called *opaque* types because client modules cannot "see" the implementation details). In such a case, the implementation part defines the opaque type, but the details of the data structure are restricted to the implementation part itself.

Several concepts of Modula-2 promote the design methodology of reusable software. The most important are:

- *Separate compilation of modules.* This permits the creation of module libraries, ready to be reused as many times as needed. Also, the structure of Modula-2 lets you change and recompile the implementation part of a module without recompiling its definition part or any other library modules that depend on it.
- *Import lists.* These allow modules to use exportable procedures and data structures from other modules. This lets you use modules as building blocks in the construction of complex systems.
- *Opaque types.* When a module contains an opaque data type and all the proce-

continued

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dures needed to manipulate it, client modules can manipulate variables of that data type without knowing how the data is represented internally. To create reusable software via parameterized modules, you define an opaque data type and then create a generic routine that passes as arguments the procedures that will tell the routine how to interact with the data type. (In the case of the sorting example, you would pass a procedure that would tell the generic sort routine how to judge which of two elements comes first.)

• *Procedure types.* Modula-2 allows variables to hold values of type "procedure," thus allowing procedures to be passed as argument variables into another procedure.

• *Open arrays.* A program can pass an open array by name into a procedure without knowing its size at compile time. (Pascal, for example, can't do this.) This capability increases Modula-2's flexibility in writing procedures to manipulate arbitrary arrays of data.

Design Methodology for Parameterized Modules

You can use the following steps to create a parameterized module. As with any programming methodology, this is not a fixed procedure to follow, but it includes the important points you should look out for, and, with some experience, you would use to create reusable software.

• Analyze the system you are designing to see if any of its parts might be useful in other systems. If this is so, you have found a reusable part.

• See if you can design the reusable part so that it can pass the data type and, if possible, the procedures that manipulate it as parameters. An example of this is a FIFO (first-in/first-out) queue handler in which the type of elements manipulated is a parameter to the module. In such a case, you can change the type of elements stored in the queue without altering the operations that store or take out elements.

• To build the reusable package, define two modules: one for the opaque definition of the new data type and the procedures that manipulate it, and another for the procedures that use the new data type opaquely to get the real work done. (Remember that each of these modules will have both definition and implementation parts.) The definition part of the second module needs only to import the opaque data type and the procedures associated with it.

• The opaque data type and its procedures are actually defined in the implementation part of the first module. This implementation either defines the data type (if you use it here only) or imports it from another module (if you make it available to other modules as well). In either case, you should actually implement the opaque data type visible outside the first module as a *pointer* to the data type that you need.

Both parts of the second module, along with the definition part of the first module, can be compiled and stored in a library of reusable modules. When a similar application arises that needs the same operation performed on a different data type, then you can reuse these modules; you will need to rewrite only the implementation part of the first module (i.e., the opaque data type and its procedures).

An Example

To illustrate how to apply this method, let's analyze an example that follows all the steps just described.

Suppose you are designing a file system, and one of the operations your clients require is sorting file descriptors of disk directories alphabetically by filename. After some thought, you realize that the sort operation is general enough to apply to several situations; in particular, to finite sequences of any data type, as long as the data type has defined for it an ordering operation "<=", and this operation satisfies the properties of *total order* (see the comments of listing 1 for a definition of total order). From this, you decide that you can parameterize your sort operation using an arbitrary data type (let's call it `ElemType`) and a procedure called `compare` that implements the "<=" function.

Now, to do the actual programming in Modula-2, you must first code the definition part of the module that describes the formal type parameter `ElemType` and the `compare` procedure. Let's call this module `SortElemType`; listing 1 shows its definition part. [Editor's note: *Enhanced, ready-to-run versions of listings 2, 3, 5, 6a, and 6b are available under the names SORT.DEF, SORT.MOD, SORTTEST.MOD, SORTELEM.DEF, and SORTELEM.MOD on disk, in print, and on BIX; see the insert card following page 256 for details. These programs run under version 2.0 of Logitech's Modula-2. Listings are also available on BYTEnet; see page* 4.]

The definition module of `SortElemType` provides an interface for a sort module, declaring `ElemType` as the data type to be manipulated. By making this an opaque type, you can isolate its actual definition to the implementation part of this module. `ElemType` is followed by the description of the `compare` procedure, which is a Boolean relation that gives the ordering over elements of type `ElemType`. Unfortunately, there are no tools in Modula-2 definition modules to express what a procedure does, so we have documented this in a comment statement.

Next, write the definition part of `Sort`, the module that gets the real work done using the data type `ElemType` (see listing 2). Note that this module imports both `ElemType` and `compare` and exports `QuickSort`, an implementation of the algorithm developed by C. A. R. Hoare. [Editor's note: *Compilers that implement the most recent definition of Modula-2 as defined in reference 2 do not need to use `EXPORT QUALIFIED` statements in definition modules; if they are included, they are treated as comments.*] The procedure's formal parameter is an open array, which makes it possible for it to sort arrays of different sizes.

Listing 3 is the implementation part of the `Sort` module; the implementation of `QuickSort` is adapted from Nicklaus Wirth's recursive implementation (see reference 3). All the `QuickSort` procedure does is define a local procedure, `Sort`, and then call it. Modula-2 uses the built-in function `HIGH(A)` to find the upper bound of the open array A. Just because the formal array argument A is indexed from 0 to `HIGH(A)` (open arrays *must* be indexed in this way), the actual array given to `QuickSort` is not restricted to that set of index limits.

The two definition parts and this implementation part in listings 1 through 3 comprise our reusable sort module. You can compile them (doing the definition modules first) and store them together for later use.

Now, getting back to the task of sorting the list of files alphabetically by name, you need to code the implementation part for the `SortElemType` module (see listing 4). In this module, you must either specify or import the actual data type needed and implement the `compare` procedure used to define the alphabetic ordering.

This implementation defines `ElemType` as a pointer to records of type `FileDescr`; if you don't import `FileDescr` from another module (as it is not here), then this module is the only part of the system that knows what constitutes the manipulated data.

Procedure `compare` expresses the "<" relation of descriptors, taking into account the alphabetical order of its field, `name`. The procedure `StringComp`, which properly belongs to a module that implements string operations, is an auxiliary function used to compare any two strings. In it, you see again the use of open arrays as formal parameters, conforming to the agreed-upon convention in Modula-2 of the data type "string" as an array of any number of characters with a lower index of zero.

continued

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Listing 1: *The definition part of the* `SortElemType` *module. This module defines the new opaque data type (*`ElemType`*) and the procedure that operates on it (*`compare`*).*

```
DEFINITION MODULE SortElemType;

 EXPORT QUALIFIED ElemType, compare;
 TYPE   ElemType;   (* pointer to any data type *)

 PROCEDURE compare (x, y: ElemType): BOOLEAN;
  (* compare(x,y) implements: x < y
  defined as NOT (y <= x), for ascending order;
  and if descending order is desired
 compare(x,y) should implement: x > y
   defined as NOT (x <= y);
  where "<=" denotes a binary relation that must satisfy
  the total order properties:
  1. x <= x
  2. x <= y AND y <= x ==> x = y
  3. x <= y AND y <= z ==> x <= z
  4. x <= y OR y <= x for every x, y
 *)

 (* ... and other operations to manipulate the data *)

END SortElemType.
```

Listing 2: *The definition part of the* `Sort` *module. This module defines the procedure that sorts an array of items of type* `ElemType`.

```
DEFINITION MODULE Sort;
 FROM SortElemType IMPORT ElemType, compare;
EXPORT QUALIFIED QuickSort;

PROCEDURE QuickSort (VAR A: ARRAY OF ElemType);
 (* Input: an array A filled with data
  Output: same array sorted.
  Requires that ElemType has a total order
  relation named "compare".
 *)
END Sort.
```

Listing 3: *The implementation part of the* `Sort` *module. This module implements the sorting procedure defined in listing 2.*

```
IMPLEMENTATION MODULE Sort;

  FROM SortElemType IMPORT ElemType, compare;

 PROCEDURE QuickSort (VAR A: ARRAY OF ElemType);

  PROCEDURE sort (l, r: INTEGER);   (* N. Wirth, '86 *)
   VAR i, j : INTEGER;
    x, w : ElemType;
 BEGIN
  i:= l; j:= r;
  x:= A[(l + r) DIV 2];
  REPEAT
   WHILE compare(A[i],x) DO INC(i) END;
   WHILE compare(x,A[j]) DO DEC(j) END;
   IF i <= j
    THEN w:= A[i]; A[i]:= A[j]; A[j]:= w;
    INC(i); DEC(j)
   END
  UNTIL i > j;
  IF l < j THEN sort(l,j) END;
  IF i < r THEN sort(i,r) END
 END sort;

 BEGIN
  sort(0,HIGH(A))
 END QuickSort;
END Sort.
```

Listing 4: *The implementation part of the* `SortElemType` *module. This module, which is the only one that must be rewritten to handle a different kind of sort operation, gives the implementation details of the opaque data type* `ElemType` *and the* `compare` *procedure.*

```
IMPLEMENTATION MODULE SortElemType;

 (* FROM FileDescriptor IMPORT FileDescr;
  (used instead of definition below
  when the data has already been defined)
 *)

 CONST  EOS = 0C;      (* end-of-string character *)
 TYPE   ElemType = POINTER TO FileDescr;
  FileDescr = RECORD
   name : ARRAY[0..8] OF CHAR;
   ext : ARRAY[0..3] OF CHAR;
   size : ARRAY[0..10] OF CHAR;
   date : ARRAY[0..8] OF CHAR;
   time : ARRAY[0..6] OF CHAR
  END;

 PROCEDURE compare (x,y : ElemType): BOOLEAN;
 BEGIN
  RETURN StringComp(x<.name,y<.name)
  END compare;

 PROCEDURE StringComp (s1, s2: ARRAY OF CHAR): BOOLEAN;
  (* returns s1 < s2 *)
   VAR i, max : CARDINAL;
 BEGIN
  i:= 0; max:= HIGH(s1);
   WHILE (i < max) & (s1[i] = s2[i]) DO
    IF s1[i] = EOS
    THEN RETURN FALSE     (* s1 = s2 *)
    ELSE INC(i)
   END
 END;
 RETURN s1[i] < s2[i]
 END StringComp;

END SortElemType.
```

Listing 5: *The skeleton of a program used to test the generic sort module defined by listings 1 through 4.*

```
MODULE SortTest;
  FROM SortElemType IMPORT ElemType;
  FROM Sort IMPORT QuickSort;
   (* other imports here *)
CONST   N = 100;
VAR     a : ARRAY [1..N] OF ElemType;
```

```
BEGIN
  (* fill up the array with pointers to file-descriptors *)
 QuickSort(a);

 (* according to the output specification of QuickSort
 we now have the array "a" sorted. Add more code here
 to confirm that array a has been sorted correctly.
 *)

END SortTest.
```

Listing 6: *Expanding the generic module to handle new situations. With redefined definition* **(a)** *and implementation* **(b)** *parts of the* SortElemType *module, the user of the final program can choose which of two fields to use in sorting the list of records. Note that this method still restricts the programmer to sorting a single given data type.*

a

```
DEFINITION MODULE SortElemType;

  EXPORT QUALIFIED ElemType, compare, select, optionMenu;
  TYPE ElemType;    (* as before *)

  PROCEDURE compare (x, y: ElemType): BOOLEAN;
   (* as before *)

  PROCEDURE select (option: CARDINAL);
   (* used by user to select desired comparison
     procedure, a default is provided until the user
     changes it *)

  PROCEDURE optionMenu;
   (* displays on the screen the available options
  *)

END SortElemType.
```

b

```
IMPLEMENTATION MODULE SortElemType;

  (* ... same type declarations *)
 VAR  comp : PROCEDURE (ElemType,ElemType): BOOLEAN;

 PROCEDURE compare (x, y: ElemType): BOOLEAN;
  BEGIN               (* call the procedure currently *)
   RETURN comp(x,y)     (* assigned to "comp" *)
 END compare;

 PROCEDURE select (option: CARDINAL);
 BEGIN
  CASE option OF           (* compare by : *)
    1 : comp:= compName; (* file-names *)
   |2 : comp:= compExt    (* extension *)
   ELSE comp:= compName  (* default *)
  END
 END select;

 PROCEDURE optionMenu;
 BEGIN
    WriteString("options:"); WriteLn;
   WriteString(" 1 to sort by file-name"); WriteLn;
   WriteString(" 2 to sort by extension"); WriteLn;
    WriteString(" the default is 1, any other is taken as
1");
   WriteLn; WriteLn
 END optionMenu;

PROCEDURE compName (x, y: ElemType): BOOLEAN;
  (* ... as compare before *)

PROCEDURE compExt (x, y: ElemType): BOOLEAN;
BEGIN
 RETURN StringComp(x<.ext,y<.ext)
END compExt;

  (* more procedure implementations go here *)

BEGIN (* to initialize the module *)
 comp:= compName     (* default *)
END SortElemType.
```

Listing 7: *An unsafe method that allows a generic routine to work with different data types. Listings* **(a)** *and* **(b)** *sketch out the structure of the definition and implementation parts, respectively, of a new generic sort module called* Gsort. *Listing* **(c)** *shows how a comparison routine handles the conversion of a pointer (i.e., an address) to the data it points to. This method is unsafe because a programmer may accidentally use the wrong comparison operation for a given data type, and the compiler will not know that an error has been made.*

a

```
DEFINITION MODULE GSort;

   FROM SYSTEM IMPORT ADDRESS;
   EXPORT QUALIFIED QuickSort;

   TYPE COMPROC = PROCEDURE (ADDRESS,ADDRESS): BOOLEAN;

   PROCEDURE QuickSort (VAR A: ARRAY OF ADDRESS; compare:
   COMPROC);

END GSort.
```

b

```
IMPLEMENTATION MODULE GSort;

 FROM SYSTEM IMPORT ADDRESS;

 PROCEDURE QuickSort (VAR A: ARRAY OF ADDRESS; compare:
 COMPROC);

 PROCEDURE sort (l, r: INTEGER);    (* N. Wirth, '86 *)
  VAR  w, x: ADDRESS;

 (* the rest as before *)

END GSort.
```

c

```
PROCEDURE compName (x, y: ADDRESS): BOOLEAN;
   VAR  xt, yt : POINTER TO FileDescr;

BEGIN
   xt:= x;   (* convert (implicitly) ADDRESS to *)
   yt:= y;   (* have access to the RECORD fields*)
   RETURN StringComp(xt^.name,yt^.name)
    (* xt^.name gets the name field of the record
    pointed to by xt
    *)
END compName;
```

Pointers are handy to use, since the algorithm can move them easily.

After compiling listing 4, you are ready to use the Sort and SortElemType modules, which are now configured to sort a list of filenames alphabetically. Listing 5 shows the skeleton of a program that uses these modules to perform this sort. You should keep this program as a test of your sort library.

A More Versatile Implementation

At this point you may ask, "What happens if I want to sort both by name and by extension? I can't have two different SortElemType implementations in the same program."

Since you want to do several compare operations on the same data type, you can solve this problem by changing the SortElemType. You must change the implementation of compare so that it returns the proper value based on your choice of sort type (see listings 6a and 6b). You can do this in Modula-2 by declaring a variable of a procedure type; that is, a variable whose value is a Modula-2 procedure.

In listing 6b, the variable comp represents any element of the class of functions that have two parameters of type ElemType and a return value of type BOOLEAN. You can assign any such procedure to the variable comp with the statement comp := procname.

This is, in fact, what the select procedure does; it lets you choose between the available procedures (shown, if necessary, by the optionMenu procedure). Notice that since comp is not exported in the definition part of this module (see listing 6a), it can only change value inside this implementation module and is safe from tampering by any other module. Another point is that you must initialize comp to some value, and you do this in the initialization part of the module (the last three lines of listing 6b).

In this example, we generalized a module to allow a program to sort its records on different fields. By introducing other procedure-type variables, you could provide other kinds of control, such as selecting one of several sorts to use, changing the order of sorting, or other such modifications.

This change in the SortElemType module does not affect the Sort module, and its access to the type and comparison procedure are the same as before. But you still have to recompile Sort because it imports a module whose definition part has been redefined (SortElemType).

Some people may criticize the use of the exported function compare as inefficient; after all, it does nothing but call comp, and you could save time by exporting comp and using it instead of compare. The reason for this particular way of coding is safety: By encapsulating comp, you can change it only inside this module. Exporting it, however, makes the program somewhat unsafe because you could conceivably change it from the outside.

The point here is that you have traded efficiency for safety, which Liskov and Guttag (see reference 4) say is sometimes necessary. When a module is intended to be used by anyone, they say, then you should opt for safety; if only you use it, then you can take chances and try to gain some efficiency. (We found the improvement to be less than 1 percent in running time, measured using sample runs with 100 file descriptors.)

Unsafe Generic Modules

The reusable packages that are built following the method just shown have a disadvantage that will surface if somebody wants to sort different data types in the same program—it can't be done. This shortcoming arises from the fact that the implementation of the formal parameter module (the implementation part of SortElemType) is, at the same time, the actual parameter instantiation (the module in which ElemType is defined). Since there can be only one implementation of any module in a program, you are limited to one instantiation, or definition, of ElemType.

You can get around these restrictions by using the low-level facilities of Modula-2. In doing so, however, you will lose some of the protection against error that Modula-2 normally provides. Listings 7a and 7b show how to build a generic sort without using a formal parameter module like SortElemType.

In listings 7a and 7b, the array of pointers has been replaced by an array of type ADDRESS, the elements of which are compatible with *any* pointer type. Pointers are convenient to use, since the algorithm can move them easily.

The alternative of using actual data, probably structured, results in an expensive operation: You must move the data word by word. Notice that, in listing 7a, QuickSort now sorts an array of addresses instead of ElemTypes. Also, compare is now a procedure variable of type COMPROC (which is any procedure that takes two addresses for arguments and returns a Boolean value).

When you use this method, you must declare that all the arrays you will sort are arrays of elements of type ADDRESS. The specific comparison routine for a given array must then use implicit- or explicit-type transfer to access the actual data (which is pointed to by the array elements of type ADDRESS) and return the correct value. Listing 7c shows how you would rewrite compName to work within this scheme.

This generic module allows you to use any number of data types and their respective comparison procedures in the same program. The reason we call this implementation unsafe springs from the definition of compare, which is any procedure that receives two addresses and returns a Boolean value. If you mistakenly send an array with one type of data and a function that compares another kind of data, the compiler will not catch your error and the program may give wrong answers or even cause the system to crash. Nevertheless, if your program needs to sort more than one data type, this is an approach you can use—but carefully!

Benefits of Reusable Software

The methodology described in this article is only one of a number of ways to obtain reusable modules; see references 5 and 6 for other approaches. With these and other such methods, you gain two important things: productivity, by reducing the effort you spend programming, debugging, and testing those modules already coded as generic; and reliability, by building new software on existing modules that you know work properly.

These benefits make the work expended in designing the module this way well worth it. ■

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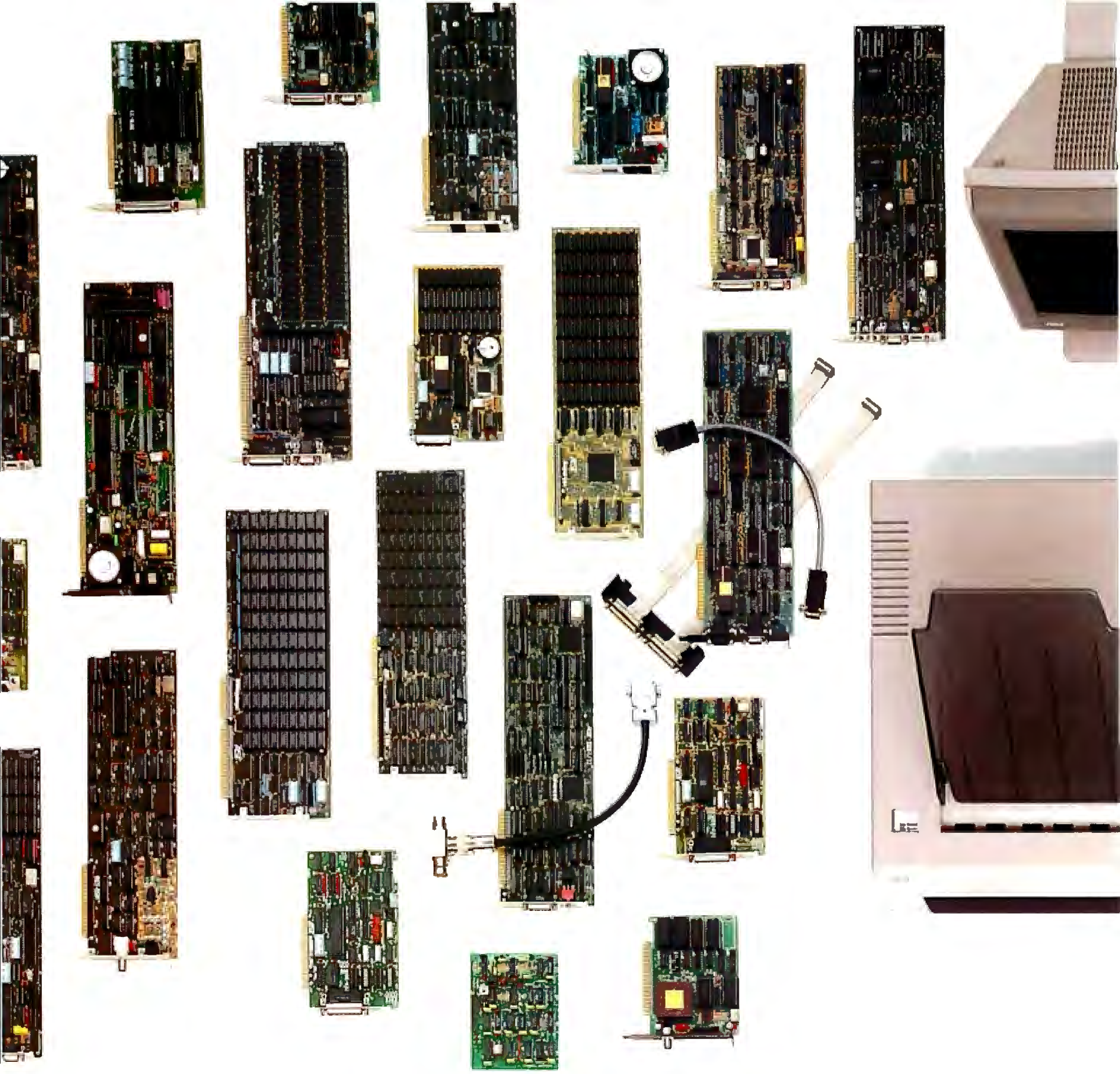

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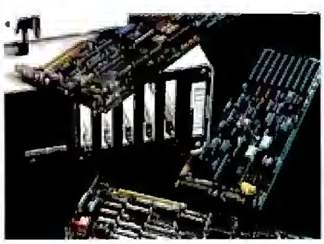

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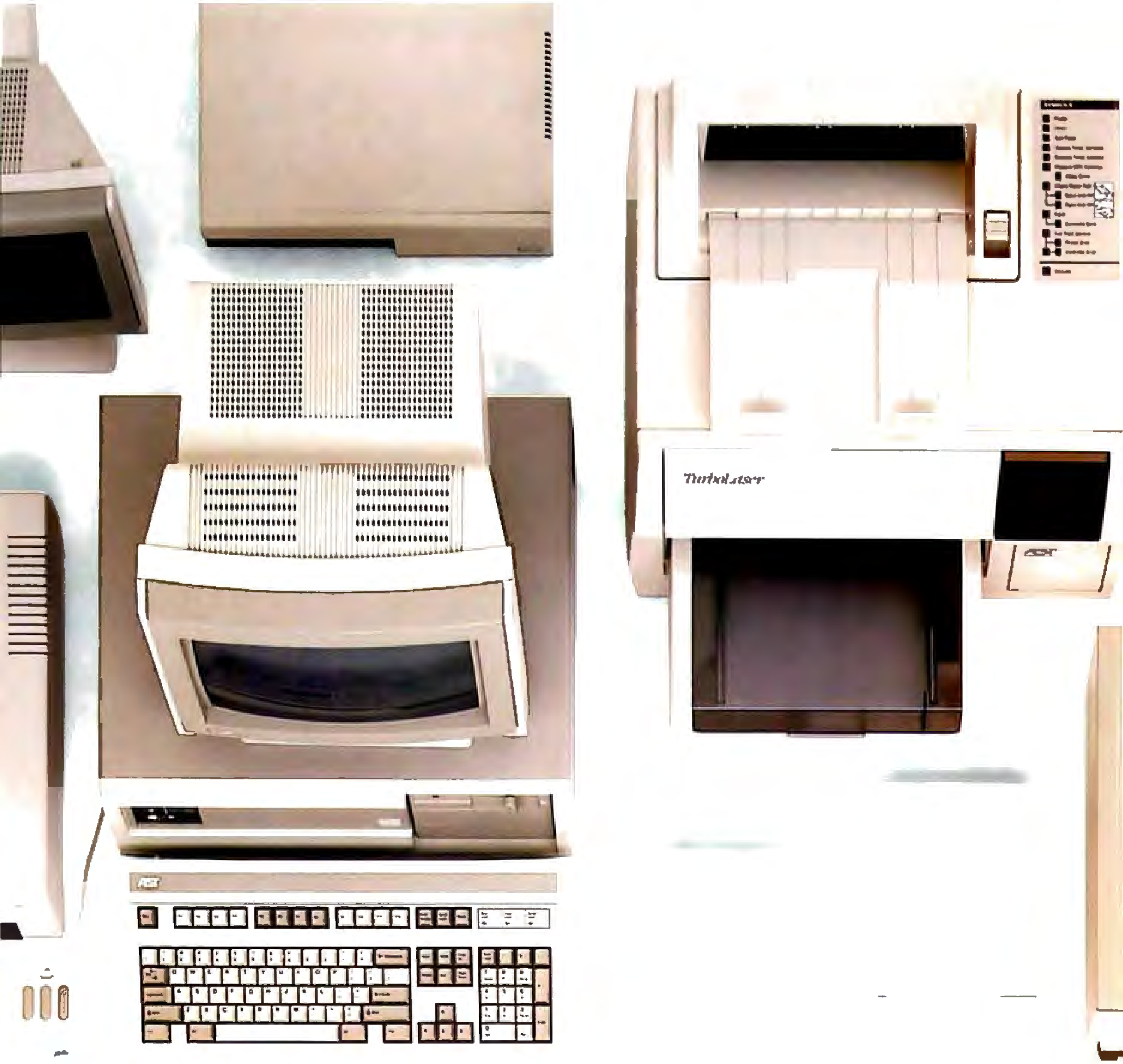

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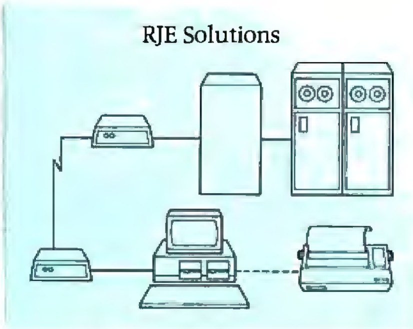

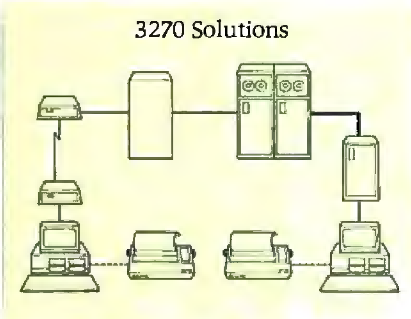

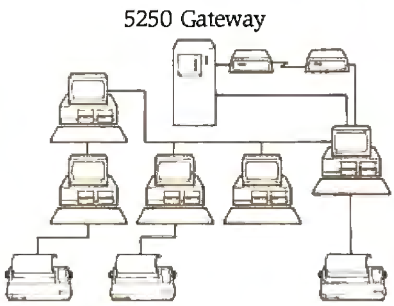

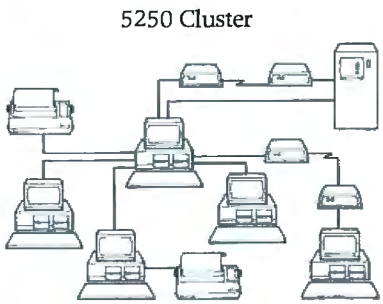

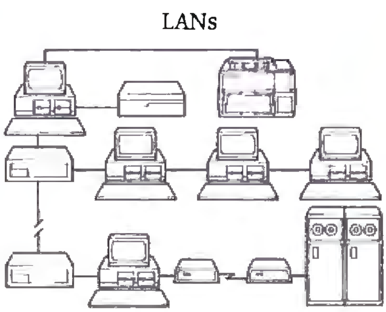

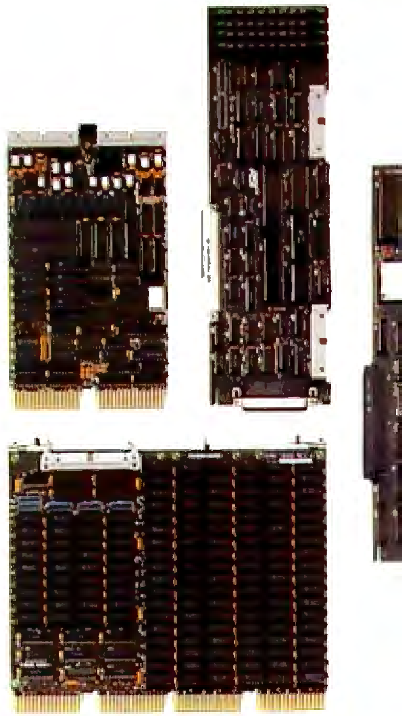

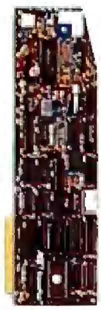

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Michael J. Sorens

Teaching Old Screens New Tricks

Create fancy screen displays for your homegrown programs

Have you ever wondered how the big software packages make those flashy screen displays? You could always purchase a screen-management program, but for those who enjoy doing it themselves, I will provide some insight and a few easy techniques for creating fancy displays on your IBM PC.

You can manipulate bold (or bright), underlined, reverse, or blinking characters on your monochrome monitor. (The techniques can easily be adapted to work with a color monitor.) I will not address the use of graphics boards or adapters, and I have limited my graphics discussion to the standard graphic character set, ASCII codes 128 through 255, which is sufficient for making borders, windows, and other shapes on the screen.

Screen Writing

There are two approaches to creating displays: screen writing and memory writing. Screen writing involves writing sequences of characters, including special control characters, to the screen. The control characters manipulate the screen.

Chapter 2 of the DOS 2.10 technical manual describes "extended screen and keyboard control." For example, consider designing your DOS prompt so that it shows the current path, followed by a > and a space, but having it displayed in bright letters. Here's the prompt command that you'd need:

```
prompt $e[1m$p$g$e[0m $a
```

Let's dissect this command piece by piece. The dollar sign ($) characters are documented under the prompt command. The `$e` is an escape character (ASCII 27), `$p` is the current path, `$g` is the > symbol, and `$a` is undefined, but it is used to force a space after the >. To print bright characters on the screen, it is necessary to write an escape character followed by `[1m`. To restore dim characters, you use an escape character followed by `[0m`. Put the pieces together as shown, and you get the effect described above, except for one thing: You must include a device driver, called ANSI.SYS, in your CONFIG.SYS file.

If you do not have a CONFIG.SYS file, create a text file with that name and keep it in your root directory. For our purposes, all it needs is this single line: `DEVICE = ANSI.SYS`. This causes the screen to have some smarts; rather than printing some textual representation of an escape character (my machine prints an arrow), it executes the escape character as a screen-control function.

After you add this line to the CONFIG.SYS file, reboot your computer so that the device driver will take effect. Then the DOS prompt appears as described above.

To create bright letters inside a program, the technique is essentially the same. I'll use Turbo Pascal for the programming examples, but the names should be suggestive enough for you to readily adapt the code to your favorite language.

The code shown in listing 1 first defines three constants. Then, the `writeln` statement displays the list of things inside the parentheses in the order shown. This will cause string 1 to appear in bright text, while string 2 will appear in dim text (see code fragment A). Other characteristics, such as blinking, reverse, colored, and underlined text, can also be printed in this way once we know the appropriate codes. Note, however, that once an escape sequence is printed, all subsequent output will appear in the specified style until a new escape sequence changes it.

Note one additional prerequisite when using a programming language: You must direct the output specifically to the standard output device—not to the screen. This may seem perplexing because, by default, the standard output device *is* the screen. But the screen is not always the standard output device. In Turbo Pascal 3.0, for example, `writeln` will not work unless you first use the `{$Pn}` compiler directive (where `n` is some integer larger than zero) to indicate that all `writelns` should go to the standard output device.

Now let's examine a framework for easily changing from one style of text to another, rather than laboriously using the escape codes. I've used Turbo Pascal for the examples. First, let's establish the definitions as shown in code fragment B. Pascal lets you create new types. The first declaration enables you to create variables of type `ScreenStyle`, which can have only one of the five values shown. The second declaration allows you to create variables of type `ShortString`, which are just strings whose maximum length is 25 characters. I will now introduce two routines, `SetOneStyle` and `SetTextStyle`, which return strings of control sequences, such as an escape character followed by `[1m`.

`SetOneStyle` returns a string that forces a single text style, while `SetTextStyle` returns a string that can be a combination of one or more styles, such as underlined and boldfaced characters. To

continued

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create a string that initiates blinking characters, for example, you call SetOneStyle(BlinkText). This returns a text string with embedded control characters. In other words, you can assign the returned value to a variable; let's call it BlinkString.

```
BlinkString :=
  SetOneStyle(BlinkText);
```

We can then display BlinkString just as we displayed control codes above:

```
write(BlinkString);
```

or, if there is no reason to store the result of SetOneStyle in BlinkString, we can print the function result directly:

```
write(SetOneStyle(BlinkText));
```

Both write statements achieve identical results. (The difference between write and writeln, by the way, is that the latter will terminate a line and start a new line.)

You can use the routine SetTextStyle to create combinations of styles. The generalized control-string format is an escape character followed by [#;...;#m, where you can use more than one code between the [and the m. Each # character represents a style code. The ... indicates that you can repeat these style codes. You must separate each pair of codes by a semicolon, and an m must terminate the sequence. SetTextStyle requires two input parameters: a desired style code and an existing style string. The new style code is added to the existing style string so that it maintains the above format (see code fragment C).

You set the local variable CodeChar depending on the value of the style parameter with the case statement. Then you assign a value to the function. If the ExistingString is empty, you just create a standard escape string, such as [5m. Otherwise, you need to chop off the m, add the ; separator, add the new code, and then tack on the m at the end.

In SetOneStyle (see code fragment D), you first create a string to set the screen back to normal, regardless of its previous condition. If you are actually requesting something other than "normal," then you concatenate the second code by a second call to SetTextStyle as shown in code fragment D.

You can intermix the different text styles freely, for the most part, so you must take some care in creating escape sequences. If you write an escape sequence for blinking text, as shown above, and then later write an escape sequence for reverse text, you will actually get reversed blinking text, because you have not turned off the blinking effect. It is best to use some type of flag to keep track of the current styles. To change a style, then, the necessary steps are to modify the flags to get the condition you want, send an escape sequence to turn off all effects, and send an escape sequence to establish all effects specified by the flags.

Code fragment E is a routine for managing a set of Boolean flags so that you can examine the current style of your screen by checking the set of corresponding flags. The flags are Boolean variables called Bold, Blink, Underscore, and Re-

Listing 1: *Code fragments used to generate screen attributes.*

Code fragment A

```
const
 BrightControl = "[1m';
 DimControl = "O[m';
 ESC = #27; . . .
 writeln(ESC, BrightControl, string1,
 ESC, DimControl, string2);
```

Code fragment B

```
type
 ScreenStyle = (BoldText, BlinkText, UnderscoreText,
 ReverseText, NormalText);
 ShortString = string[25];
```

Code fragment C

```
function SetTextStyle(
 Style: ScreenStyle; {the desired text style}
 ExistingStyle: ShortString {the control string to modify}
 ): ShortString;
 var CodeChar: char;
 TextStyle: ShortString; begin
 case style of
  BoldText: CodeChar := "1';{the magic numbers}
  BlinkText: CodeChar := "5';
  UnderscoreText: CodeChar := "4';
  ReverseText: CodeChar := "7';
  NormalText: CodeChar := "0';
  else writeln ("Internal error in SetTextStyle');
  end { case };
 if (ExistingStyle = '') then
  SetTextStyle := chr(27) + '[' + CodeChar + 'm'
 else SetTextStyle :=
  copy(ExistingStyle, 1, length(ExistingStyle)-1) + ';' +
 CodeChar + 'm';
 end;
```

Code fragment D

```
function SetOneStyle(Style: ScreenStyle): ShortString;
var CodeStr: ShortString; begin
 CodeStr := SetTextStyle(NormalText, '');
 if (style = NormalText) then SetOneStyle := CodeStr
 else SetOneStyle := SetTextStyle(style, CodeStr);
end;
```

Code fragment E

```
function RefreshStyles: ShortString;
var CodeStr: ShortString;
begin
 CodeStr := SetTextStyle(NormalText, '');
 if bold then CodeStr := SetTextStyle(BoldText, CodeStr);
 if blink then CodeStr := SetTextStyle(BlinkText, CodeStr);
 if under then CodeStr := SetTextStyle(UnderscoreText, CodeStr);
 if reverse then CodeStr := SetTextStyle(ReverseText, CodeStr);
 RefreshStyles := Codestr;
end;
```

Code fragment F

```
write(SetOneStyle(Reverse));
DrawBorders;
{user defined routine}
write(RefreshStyles);
```

verse, which keep track of the four named styles. Suppose you want to create a border in reverse characters while not interfering with the rest of the display. You need to write a control string to turn on the reverse-character style before you start drawing the border, and then you must write a control string to restore the screen state so that the subsequent text will be displayed in the same style combination as it was before you turned on the reverse characters.

`RefreshStyles` (see code fragment E) will first turn all styles off and then reactivate any that are supposed to be on. Thus, in order to draw your reverse border, you first set the screen to reverse style, draw the borders, and then refresh the styles. It's fine to change the style without adjusting the flags in this instance, since you will be refreshing the state to agree with the flags before you do anything else. The code might look like that shown in code fragment F.

For drawing a window, characters in the ASCII range 176 through 223 are appropriate. They provide an appealing screen display for many applications. The techniques described so far can create specific strings of text with a lot of flexibility. For entire screen design, however, memory writing is more appropriate.

Code fragment G

```
type ScreenChar =
 record
 Value: char; {actual character}
 Style: byte; {text style}
 end;
```

Code fragment H

```
 const Count= 10;
 var Asterisks: array [1..count] of ScreenChar;
 procedure CreateAsterisks;
 begin
 for i := 1 to count do begin
 asterisks[i].value := "*';
 asterisks[i].style := $87; {hexadecimal notation}
 end;
 move(asterisks, destination, Count * 2);
end;
```

Code fragment I

```
const Count= 10;
  TwiceCount = 20;
 var Asterisks: array [1..TwiceCount] of byte;
 procedure CreateAsterisks;
begin
 for i := 1 to count do begin
 asterisks[(2*i)-1] := ord("*');
 asterisks[(2*i)]:= $87;
 end;
 move(asterisks, destination, TwiceCount);
end;
```

Code fragment J

```
const ScreenSize= 2000;
ScreenBytes = 4000;{twice ScreenSize} LineSize= 80;
type ScreenImage = array[1..TotalLines, 1..LineSize] of ScreenChar;
 BlockImage= array[1..ScreenBytes] of ScreenChar;
var Lines: ScreenImage absolute $B000:0;
 Screen: BlockImage absolute $B000:0;
```

Code fragment K

```
procedure CreateAsterisks;
begin
 for i := 1 to count do begin
 Screen[origin + i].style := $87;
 Screen[origin + i].value := "*';
 end;
end;
```

Code fragment L

```
procedure ShowHelp;
var ScreenCopy: BlockImage;
begin
 fillchar(ScreenCopy, ScreenBytes, ' '); {blank out array}
 for i := 1 to HelpSize do
 for j := 1 to length(HelpLines[i]) do begin
 ScreenCopy[i,j].value := HelpLines[i,j];
 ScreenCopy[i,j].style := HelpStyles[i];
 end;
 move(ScreenCopy, Screen, ScreenBytes); end;
```

Code fragment M

```
 var MonoScreen: ScreenImage absolute $B000:0;
 ColorScreen: ScreenImage absolute $B800:0;
 Monitor: ScreenImage;
```

Code fragment N

```
 if (VideoCode = 7) then Monitor := addr(MonoScreen)
 else Monitor := addr(ColorScreen);
```

Memory Writing

The memory-writing method is somewhat more low-level, but you can create very fast screen displays with it, and you do not need the ANSI.SYS driver in your CONFIG.SYS file. I'll limit my discussion to the IBM PC monochrome monitor, as in the previous section; you can implement colors by simply adding more flags and more style choices.

The IBM PC display screen is memory-mapped at address B000:0000 for monochrome displays (segment B000, offset 0) and at B800:0000 (segment B800, offset 0) for color displays. Writing data into memory at the address of the screen will show that data on the display. Since there are 25 lines of 80 characters each, the screen occupies exactly 4000 bytes of contiguous memory. Each screen character is represented as a 2-byte entity. You will need a record structure that can easily access memory locations, like that in code fragment G.

This creates a new data type consisting of a character called `Value` followed by a byte called `Style`. Bytes and characters are actually the same thing, but you can refer to them differently. If you define a variable `Spot` of type `ScreenChar`, then you can refer to the two components of `Spot` as `Spot.Value` and `Spot.Style`. For a single character, the two bytes of `ScreenChar` represent the character and the text style, in that order. If you have a tool that lets you examine memory, take a look. The hexadecimal codes for the different styles are shown in table 1.

This means that you can modify your screen manually if your favorite language has a fast, efficient procedure for moving blocks of memory around. Turbo Pascal, for instance, has the move procedure: `move(source, destination, count)`, wherein you move the specified number of bytes (`count`) from the source to the `destination`. As an example, let's

continued

Table 1: *Hexadecimal codes for text functions.*

Normal (low intensity)	07
Bold (high intensity)	0F
Underline	01
Blink	87
Reverse	70

Table 2: *Bit settings within the style codes. An X indicates a "don't care" condition.*

Bold	XXXX	1XX1
Underline	X000	X001
Blink	1XXX	XXXX
Reverse	X111	X000

create a field of 10 blinking asterisks. Two equivalent versions are shown in code fragments H and I. The version shown in code fragment H uses Pascal record structures and is more readable. Note that you use the destination variable without yet defining it. If your language of choice does not have records but has arrays, you can achieve the same effect, but the calculations look a little more complicated, as shown in code fragment I.

Using either definition, you first create a string of asterisks interleaved with a string of style codes. Then you move the coded asterisk string to your destination. But where is the destination? Recall that the display screen consists of 2000 character records located at a specific address. Thus, you need to be able to talk about absolute memory locations. Turbo Pascal allows you to declare variables absolutely, as shown in code fragment J.

Here you have created two different representations for the screen, both representing the same memory locations. `Lines` is set up as a two-dimensional array of lines and columns, while `Screen` is just a single array of screen characters. Both variables are located at the same specified address, exactly overlaying the location of screen memory. You can use some offset into the `Screen` array as your destination in `CreateAsterisks`. Actually, you can eliminate the move by using the `Screen` array directly (see code fragment K).

The new routine allows you to write directly to the screen as if it were memory. You need to set the variable `origin` to some appropriate value between 1 and (2000 `count`). The representations above allow you to access the screen memory as either individual bytes or as whole lines. Thus, rather than accessing something in the *i*th position of line *n* by saying `Screen[(n * LineSize) + i]`, you can just use `Lines[n,i]`.

For incredibly fast displays, you can build up a copy of the screen somewhere in memory, setting whatever text-style attributes you like, and then executing a block move to transfer the data to the screen instantly.

Suppose, for example, that you have an array of strings that you want to print, perhaps a help screen. Let's call this array `HelpLines` and fill a copy of the screen, called `ScreenCopy`, with these strings, and then move the copy to the display for an instant picture update. Also, let's use a second array, `HelpStyles`, which contains style codes for each corresponding string in `HelpLines` (see code fragment L).

This procedure allows us to mix reverse lines, bold lines, and so on, on the same screen. How about combining effects, such as blinking and reverse text? For this you need more "magic numbers." Table 2 shows how the different codes can and cannot be combined. The representations show the bit settings within the style byte. To achieve a certain style, set the ones and zeros shown. The X terms can be either zeros or ones.

Those familiar with digital logic will recognize the X terms as "don't care" terms. Hence, to create a bold character, you can use the code 0F, 5F, FF, or 09. However, be careful; 09 also fits the pattern for underlining, so both styles will appear. Table 1 shows, for example, that you cannot mix reverse characters with underlined ones, since the low-order bit of the reverse style is a 1, while that of underlined style is a 0.

Table 3 shows the useful combinations in both hexadecimal and binary. These are like a set of mnemonic constants for use in a program. Finally, let's see how to make a program flexible enough for it to recognize and act upon the difference between a monochrome monitor and a color monitor. Buried obscurely in some portion of memory is a single integer that can tell you what type of monitor you have. So you define an absolute variable:

```
var VideoCode: integer absolute
$0040:$0049;
```

Table 3: *Some useful combinations of attribute codes, shown in binary and hexadecimal.*

Normal	0000 0111	07
Bold	0000 1111	0F
Underline	0000 0001	01
Blink	1000 0111	87
Reverse	0111 0000	70
Bold and underline	0000 1001	09
Bold and blink	1000 1111	8F
Underline and blink	1000 0001	81
Blink and reverse	1111 0000	F0
Bold, underline, and blink	1000 1001	89

If this value is a 2 or a 3, the display is color; if it's a 7, the display is monochrome. Other values may or may not have any significance.

Now you can tell what type of display you have. How do you use this information? Modify the previous definition of Screen, renaming it MonoScreen, and add two more definitions (see code fragment M).

Somewhere in your program initialization, you need to set up the Monitor variable for use by the rest of the program, as shown in code fragment N.

The addr function returns the address of the specified variable. From that point on you no longer need to worry about what type of display screen you have. All references to it, however, must be through the pointer variable, Monitor. Thus, instead of using Screen[n], you use Screen^[n] in the code.

Custom-Made

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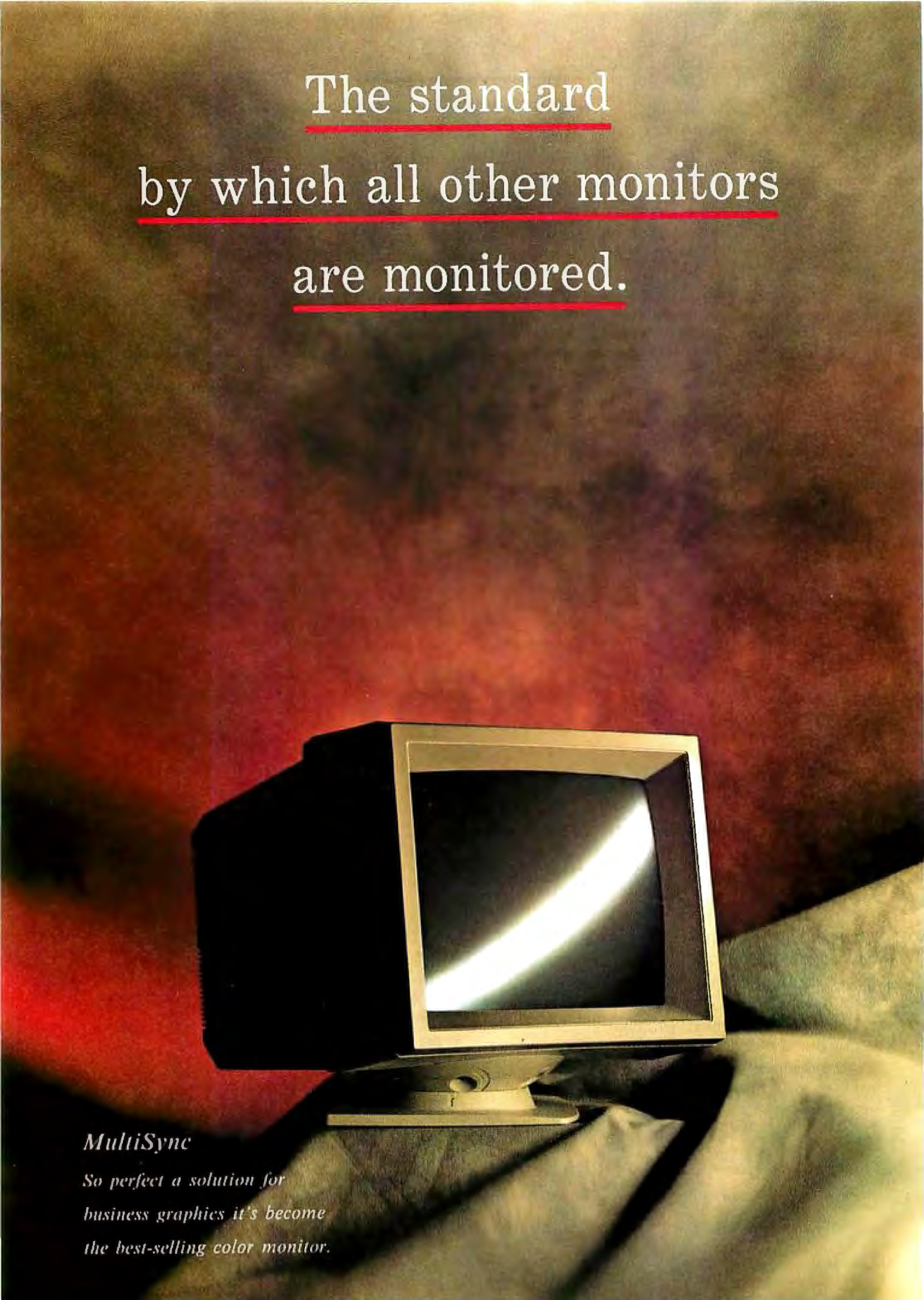
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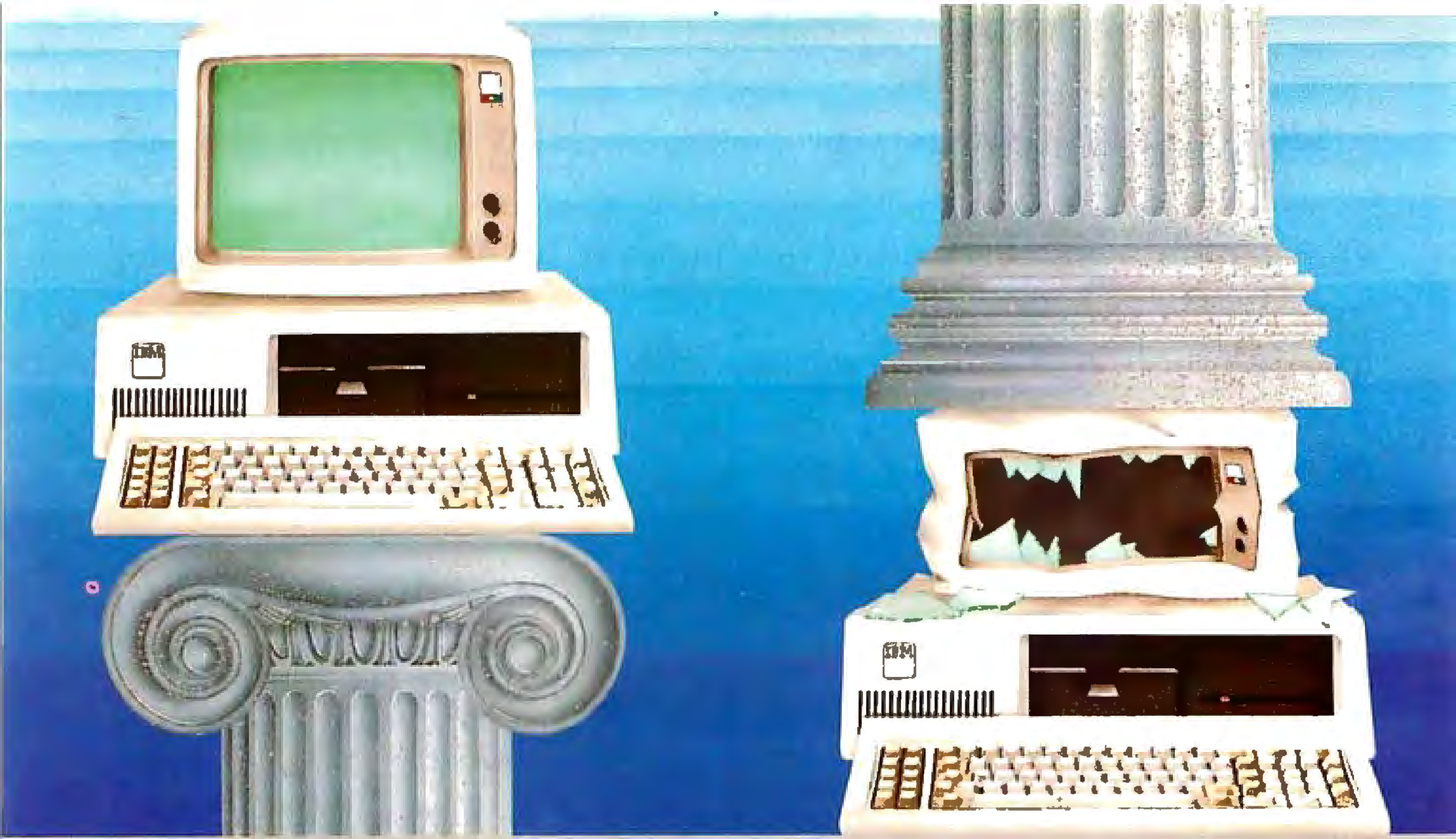

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Bart Kosko

Constructing an Associative Memory

This simple nonlinear neural network runs on your PC

From the earliest days of behaviorist psychology, scientists have believed that the associative structure of learning resides in the neural microstructure of organisms. But where do memorized patterns reside? Do we encode *Gone With the Wind* in a cell or do we somehow superimpose it on or between several cells? How is the ability to fix a flat tire or to play the *Moonlight Sonata* stored in memory? How do we learn the color green from green things, or triangularity from triangles? How do asynchronous neurons keep any pattern, such as a phone-number, reverberating in short-term memory long enough for us to learn it?

An associative memory is a mapping from data to data, a mathematical abstraction from the familiar associative structure of human and animal learning. We associate behavioral responses with sensory stimuli, effect with cause, like character with like faces, breakfast with sizzling bacon. An associative memory is parallel distributed—as in a neural network, for example—when it memorizes data by superimposing it on the same memory medium.

I will show you how to construct the simplest nonlinear neural-network associative memory—called a BAM (bidirectional associative memory)—that recalls or content-addresses stored associations (x, y) by minimizing a system "energy" (which I will define mathematically later). The BAM is a two-layer feedback network of interconnected neurons. Each neuron a_i in layer or field F_A is totally connected by "synapses" to every neuron b_j in field F_B, and vice versa, and no neurons are connected within a field. Associations (x, y) are stored by placing them at local energy minima. Input patterns tend to map into the most similar stored association as the input "rolls" into the nearest energy minimum.

In a BAM, and in most neural networks, patterns are stored in the edges, or synapses, between the neurons. The stable reverberation of patterns across fields of neurons—produced by a BAM energy minimum or other network mechanism—constitutes short-term memory. STM reverberations gradually seep pattern information into long-term memory (LTM), the synapses between the neurons.

Modern computers store everything in single "cells." Brains almost certainly do not. Computers learn by rote, not by example. Computers excel at high-speed serial computation but fail at real-time pattern recognition. Brains do the opposite. Computers implement precise algorithms through the synchronous operation of their cells. Brain cells operate asynchronously as a nonalgorithmic dynamic system, which presumably can be approximated with a system of nonlinear difference or differential equations. In short, a computer is a breed of adding machine. A brain is more akin to a market economy, a galactic system, or a swarm of atomic particles.

Now we have hardware devices, called neurocomputers, that behave like brains but look like computers or coprocessors. Neurocomputers are electrical or optical implementations of neural networks. Neural networks are programmable dynamic systems. Neurocomputers are the engineering by-product of the science of artificial neural systems (ANS), which seeks to explain mind and brain as programmable dynamic systems and rests on the mathematical information-processing principles of neural-network models. Associative memories are fundamental computing structures of ANS and can be naturally implemented on neurocomputers. You can simulate small-scale associative memories, such as BAMs with few neurons, on digital computers with little effort.

The Benefits

Associative neurocomputing has two major benefits that underlie the current surge of ANS interest in industry, academia, and government. First, ANS devices can store large numbers of complex patterns—speech templates, visual scenes, robot movements, spatiotemporal behavior, social behavior, and so on. Second, ANS devices can classify new patterns to stored patterns quickly. Roughly speaking, neurocomputing devices classify patterns at a speed independent of the number of patterns stored. They immediately map input patterns to the nearest stored patterns. However, if they store too many patterns, classification accuracy degrades.

These two properties of neurocomputing resemble our ability to recognize familiar faces, aromas, and melodies at age 5 and at age 50 with roughly the same rapidity. We say the lawyer is quick on her feet if she accurately associates live testimony with obscure case precedents. We frequent the mechanic or physician who accurately diagnoses problems on the spot. We marvel at the cocktail-party pianist who plays from

continued

Bart Kosko was organizer of the IEEE First Annual International Conference on Neural Networks (ICNN-87) and is on the editorial board of Neural Networks. He received his masters in mathematics from the University of California at San Diego and his Ph.D. in electrical engineering from the University of California at Irvine. Dr. Kosko can be reached at Verac, 9605 Scranton Rd., San Diego, CA 92121.

Computers suffer from an inherent direct relationship between pattern number and search time: More patterns means a longer search.

memory any tune upon request.

On the contrary, computer search time always depends on the number of stored patterns or templates. Computers suffer from an inherent direct relationship between pattern number and search time: more patterns, longer search. This is why they fail at real-time pattern recognition. And it is arguably why artificial intelligence researchers, after more than 20 years, have failed to build real-time pattern recognizers and sensory processors on serial or parallel computers.

Bidirectional Associative Memories

A BAM stores and recalls associations (A_i, B_i) that are learned by summing correlation matrices. This procedure superimposes the patterns to be learned on the same memory medium, much as data pairs can be superimposed on a hologram (as in optical BAMs). Recall that the encoding procedure places the associations (A_i, B_i) at or near system energy minima. Each set of associations sculpts its own energy surface over the BAM state space. Associations are placed on the energy surface like rocks on a rubber sheet. Geometrically, it is clear that the number of energy minima does not affect the speed with which an input pattern rolls down the energy surface into a particular local minimum. Hence, no matter how big the BAM (whether it consists of 10 neurons or 10 billion neurons), it immediately converges to the nearest minimum.

The BAM is a two-field network of symmetrically interconnected neurons, as shown in figure 1. There are n neurons in $F_A = \{a_1, \ldots a_n\}$ and p neurons in $F_B = \{b_1, \ldots, b_p\}$.

Each neuron is a simple nonlinear function. It transforms the sum of weighted input signals into a single output signal. In the simplest case, the output is binary, 1 or 0 (in general, a neuron's output signal continuously varies from 0 to 1). Stephen Grossberg of Boston University has proven mathematically that to accurately store and process distributed information in a neural network, this signal function must be a sigmoid or S-shaped function, such as $(1 + e^{-x})^{-1}$, and, indeed, the average firing frequency of real neurons is sigmoidal. The threshold function of a binary neuron is the limiting case of a steep continuous sigmoid function. This article assumes that the neurons in F_A and F_B are binary.

Each neuron turns on or off according to a threshold law. If the input to a neuron is positive, it turns on; if negative, off. When the input equals zero (threshold), the neuron maintains its current state; it stays on if it is on, and off if off. The larger the threshold, the fewer the neurons that can turn on. Increasing the threshold of all neurons in a field in effect increases the competition within the field for activation.

If all neurons in a field apply the threshold law to their inputs simultaneously, the BAM is operating synchronously. Otherwise, it operates asynchronously, simulating a collection of independent, randomly operating neurons. For simplicity, you can assume synchronous operation. For instance, if six neurons in F_A receive the vector of inputs (6 −4 −1 8 −3 10), then the new F_A state is (1 0 0 1 0 1)—only neurons a_1, a_4, and a_6 turn on.

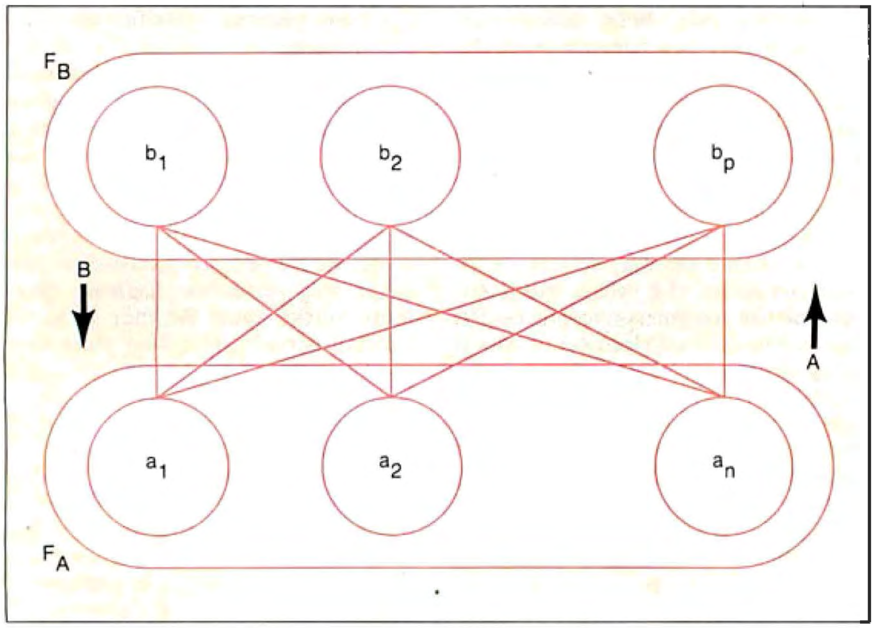

Figure 1: *Topology of a BAM, showing the two fields of neurons connected by synapses.*

BAM Encoding

Encoding is learning. A neural network learns by modifying the synapses between its neurons. In a BAM, all synaptic information is contained in an n-by-p connection matrix M. Every matrix M between F_A and F_B produces a stable BAM. All inputs quickly map to a pattern of stable reverberation. But different connection matrices encode different (A, B) associations as stable reverberations.

A BAM encodes a particular set of associations $\{(A_1, B_1), \ldots, (A_m, B_m)\}$ by summing bipolar correlation matrices. This is an example of Hebbian, or correlation, learning. You can also interpret this method of encoding as Grossberg reciprocal outstar coding, in that each neuron in F_A and F_B fans out its output along modifiable pathways. The encoding scheme tends to place distinct associations (A_i, B_i) at or near local energy minima—provided you don't encode too many associations. You cannot reliably encode (store) and decode (recall) more patterns than the number n of neurons in field F_A or the number p of neurons in F_B, whichever is less; that is, given that you have m patterns, $m < \min(n, p)$. One way or another, the number of neurons in every neural network, artificial or biological, limits its storage capacity.

Bipolar vectors or matrices are binary vectors or matrices with −1s replacing 0s. The bipolar versions of the binary patterns $A_1 = (1\ 0\ 1\ 0\ 1\ 0)$ and $B_1 = (1\ 1\ 0\ 0)$ are $X_1 = (1\ -1\ 1\ -1\ 1\ -1)$ and $Y_1 = (1\ 1\ -1\ -1)$. In general, X and Y will denote the respective bipolar version of the binary vectors A and B. It can be shown that BAM correlation encoding improves if bipolar vectors and matrices are used instead of binary vectors and matrices.

The BAM encoding scheme converts each binary pair (A_i, B_i) to a bipolar pair

continued

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upset perturbed tired
tedious overwhelmed miffed
dizzy defeated agitated
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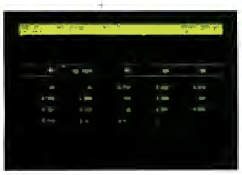

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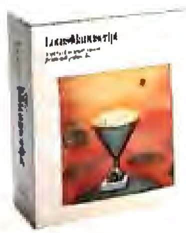

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(X_i, Y_i), converts each bipolar pair to a bipolar correlation matrix $X_i^T Y_i$, and then adds up the bipolar correlation matrices $M = X_1^T Y_1 + X_2^T Y_2 + \ldots + X_m^T Y_m$ where the column vector X_i^T is the vector transpose of the row vector X_i. For example, if $X = (1\ -1)$, then

$$X^T = \begin{pmatrix} 1 \\ -1 \end{pmatrix}.$$

A special case of the BAM occurs when $F_A = F_B$ and all $A_i = B_i$. Then $M = M^T$ and the BAM collapses to symmetric unidirectional associative memory that stores the single patterns A_i in local energy minima. (The general continuous version of the symmetric unidirectional associative memory is known as the Cohen-Grossberg autoassociator; the special binary version is known as the Hopfield model.) Let's assume the general case where F_A and F_B are distinct.

Suppose you want to find the BAM that encodes the two binary associations

$A_1 = (1\,0\,1\,0\,1\,0)$ $B_1 = (1\,1\,0\,0)$,
$A_2 = (1\,1\,1\,0\,0\,0)$ $B_2 = (1\,0\,1\,0)$.

Note that this example does not strain the memory capacity, since $2 < \min(6, 4)$. Convert these binary pairs to bipolar pairs:

$X_1 = (1\ -1\ 1\ -1\ 1\ -1)$
$Y_1 = (1\ 1\ -1\ -1)$
$X_2 = (1\ 1\ 1\ -1\ -1\ -1)$
$Y_2 = (1\ -1\ 1\ -1)$.

Convert these two bipolar vector pairs to two bipolar correlation matrices:

$$X_1^T Y_1 = \begin{pmatrix} 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ -1 & -1 & 1 & 1 \end{pmatrix}$$

$$X_2^T Y_2 = \begin{pmatrix} 1 & -1 & 1 & -1 \\ 1 & -1 & 1 & -1 \\ 1 & -1 & 1 & -1 \\ -1 & 1 & -1 & 1 \\ -1 & 1 & -1 & 1 \\ -1 & 1 & -1 & 1 \end{pmatrix}.$$

Note that the jth row of the ith correlation matrix $X_i^T Y_i$ is simply Y_i multiplied by the jth element of X_i, and that the jth column is simply X_i multiplied by the jth element of Y_i. So correlation matrices can be written down directly when given bipolar associations. Then M is given by $M = X_1^T Y_1 + X_2^T Y_2$:

$$M = \begin{pmatrix} 2 & 0 & 0 & -2 \\ 0 & -2 & 2 & 0 \\ 2 & 0 & 0 & -2 \\ -2 & 0 & 0 & 2 \\ 0 & 2 & -2 & 0 \\ -2 & 0 & 0 & 2 \end{pmatrix}.$$

This synaptic matrix encodes my particular computational problem; namely, storing (A_1, B_1) and (A_2, B_2) in a parallel distributed network. The matrix element m_{ij} indicates the symmetric (distance-dependent) synapse between neurons a_i and b_j. The synapse is excitatory if $m_{ij} > 0$, inhibitory if $m_{ij} < 0$. (Try drawing the BAM network topology obtained with this matrix M.)

You can erase association (A_i, B_i) from M by adding $-X_i^T Y_i$ to M. This is equivalent to encoding (A_i, B_i^c) or (A_i^c, B_i), where the superscript c denotes complement. The complement of (0 1 1 0 0), for instance, is (1 0 0 1 1). This is true because you obtain the complement of a bipolar vector by multiplying the vector by -1. A little thought then shows that when you encode (A_i, B_i) in M, you encode (A_i^c, B_i^c) in M as well, and vice versa.

The BAM energy E of association or state (A_i, B_i) is $-A_i M B_i^T$. In the example, $E(A_1, B_1) = E(A_2, B_2) = -6$. (In upcoming examples, you'll see that the BAM encoding algorithm placed (A_1, B_1) and (A_2, B_2) in local energy minima.)

BAM Decoding

BAM decoding is associative recall. Say an input pattern A is presented to BAM field F_A. The n neurons across F_A are turned on or off according to whether the corresponding binary values of A are 1 or 0. Each neuron a_i in F_A fans out its binary value across the p pathways as if pouring water into a pipeline system. The synaptic value m_{ij} multiplies, or "gates," the binary value a_i. Each neuron b_j in F_B receives a fan-in of input products $a_i m_{ij}$ from each of its n synaptic connections; b_j then behaves as an OR gate, since any neuron in F_A can activate it. Neuron b_j sums its input across all connections, $a_1 m_{1j} + a_2 m_{2j} + \ldots + a_n m_{nj}$, then thresholds this sum to generate its output binary signal. If the input sum exceeds b_j's threshold, which I assume is 0, then b_j's output is 1. If it is less than threshold, b_j's output is 0. If it equals threshold, b_j maintains its current state. Neuron b_j then fans out its output signal across the n pathways m_{ij} to each neuron a_i in F_A. This means F_B uses the transpose memory M^T to send information, while F_A uses M.

Each a_i then generates its binary signal from all its summed inputs and sends it back to F_B. And round and round the BAM goes. Fortunately, it is a mathematical theorem that the BAM always rapidly converges, so it will not oscillate chaotically forever. (Exercise: Show that a state change in F_A or F_B and the threshold signal law forces the energy E to decrease, and that E cannot decrease forever. This is sufficient to prove that any matrix M

continued

Listing 1: *Pseudocode for a BAM demonstration program written in BASIC.*

```
Step 1. For all i,j clear M(i,j), A(i), B(i). This is an initialization step.
Step 2. Get input into A( ) and B( ) for an association to be learned.
        The input will have only two possible values, 0 or 1.
Step 3. Learn the desired input association.
         a. Build X(i) for A(i) where X(i)=-1 if A(i)=0
          and X(i)=1 if A(i)=1;
         b. Build Y(i) from B(i) where Y(i)=-1 if B(i)=0
          and Y(i)=1 if B(i)=1;
         c. For all i,j, build M(i,j) = M(i,j) + X(i) * Y(j).
Step 4. If there is another association to learn, go to step 2.
Step 5. Input a new A( ) and B( ) to be run on the network.
        The input for each element will have the values 0 or 1.
Step 6. Run the A to B iteration of the network.
         a. The new B(j)=1 if the sum of A(i) * M(i,j) for all i
          is greater than the 0 threshold;
         b. The new B(j)=0 if the sum of A(i) * M(i,j) for all i
          is less than the 0 threshold;
         c. The new B(j) is unchanged if the sum of A(i) * M(i,j)
          for all i is equal to the 0 threshold.
Step 7. Run the B to A iteration of the network.
         a. The new A(i)=1 if the sum of B(j) * M(i,j) for all j
          is greater than the 0 threshold;
         b. The new A(i)=0 if the sum of B(j) * M(i,j) for all j
          is less than the 0 threshold;
         c. The new A(i) is unchanged if the sum of B(j) * M(i,j)
          for all j is equal to the 0 threshold.
Step 8. Repeat steps 6 and 7 until there are no changes in A( ) and B( ).
Step 9. Display the results.
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produces a stable BAM.)

BAM decoding is easier done than said. Returning to the example, let's see if the memory matrix M actually stores the pairs (A_1, B_1) and (A_2, B_2). You do this by presenting A_1 to the BAM and observing whether (A_1, B_1) is recalled. If it is, then either A_1 or B_1 will recall (A_1, B_1). Repeat this test for A_2 and B_2.

Vector-matrix multiplication summarizes BAM forward and backward information flow. Forward flow proceeds through M, and backward through M^T. The row vector $A\,M = (4\ 2\ {-2}\ {-4})$ is the vector of fan-in inputs received by F_B. The threshold-signal law then yields $(4\ 2\ {-2}\ {-4}) \rightarrow (1\ 1\ 0\ 0) = B_1$, since you are synchronously updating all neurons in F_B. So A_1 evoked B_1. B_1 then sends an M^T-filtered vector of signals back to F_A: $B\,M^T = (2\ {-2}\ 2\ {-2}\ 2\ {-2}) \rightarrow (1\ 0\ 1\ 0\ 1\ 0) = A_1$. If you now push A_1 through M again, B_1 results, which again evokes A_1, and so on forever. Thus, the short-term-memory pattern (A_1, B_1) reverberates across the BAM. It is a stable equilibrium point of the dynamic system. Put another way, both A_1 and B_1 recall the stored association (A_1, B_1). Similarly, $A_2 M = (4\ {-2}\ 2\ {-4}) \rightarrow (1\ 0\ 1\ 0) = B_2$, and $B_2 M^T = (2\ 2\ 2\ {-2}\ {-2}\ {-2}) \rightarrow (1\ 1\ 1\ 0\ 0\ 0) = A_2$. So (A_2, B_2) is also stored as a stable point. An instructive exercise would be to see how many synapses in M you can remove or change without affecting these stable reverberations.

The BAM is error-correcting. Partial or noisy patterns tend to recall complete patterns. For example, the input $A = (0\ 1\ 1\ 0\ 0\ 0)$ is just A_2 perturbed by 1 bit. Then $A\,M = (2\ {-2}\ 2\ {-2}) \rightarrow (1\ 0\ 1\ 0) = B_2$, and thus A evokes the resonant pair (A_2, B_2). Note that (A, B_2) has energy $E(A, B_2) = -4 > -6 = E(A_2, B_2)$, evidence that the BAM encoding procedure placed (A_2, B_2) at a local energy minimum.

Suppose you add the new association (A_3, B_3) to the BAM memory M, where $A_3 = (1\ 1\ 0\ 0\ 1\ 1)$ $B_3 = (0\ 1\ 1\ 1)$. This strains the BAM's storage capacity but does not exceed it. Geometrically, when you store only a few association patterns (A, B), each forms a large basin of attrac-

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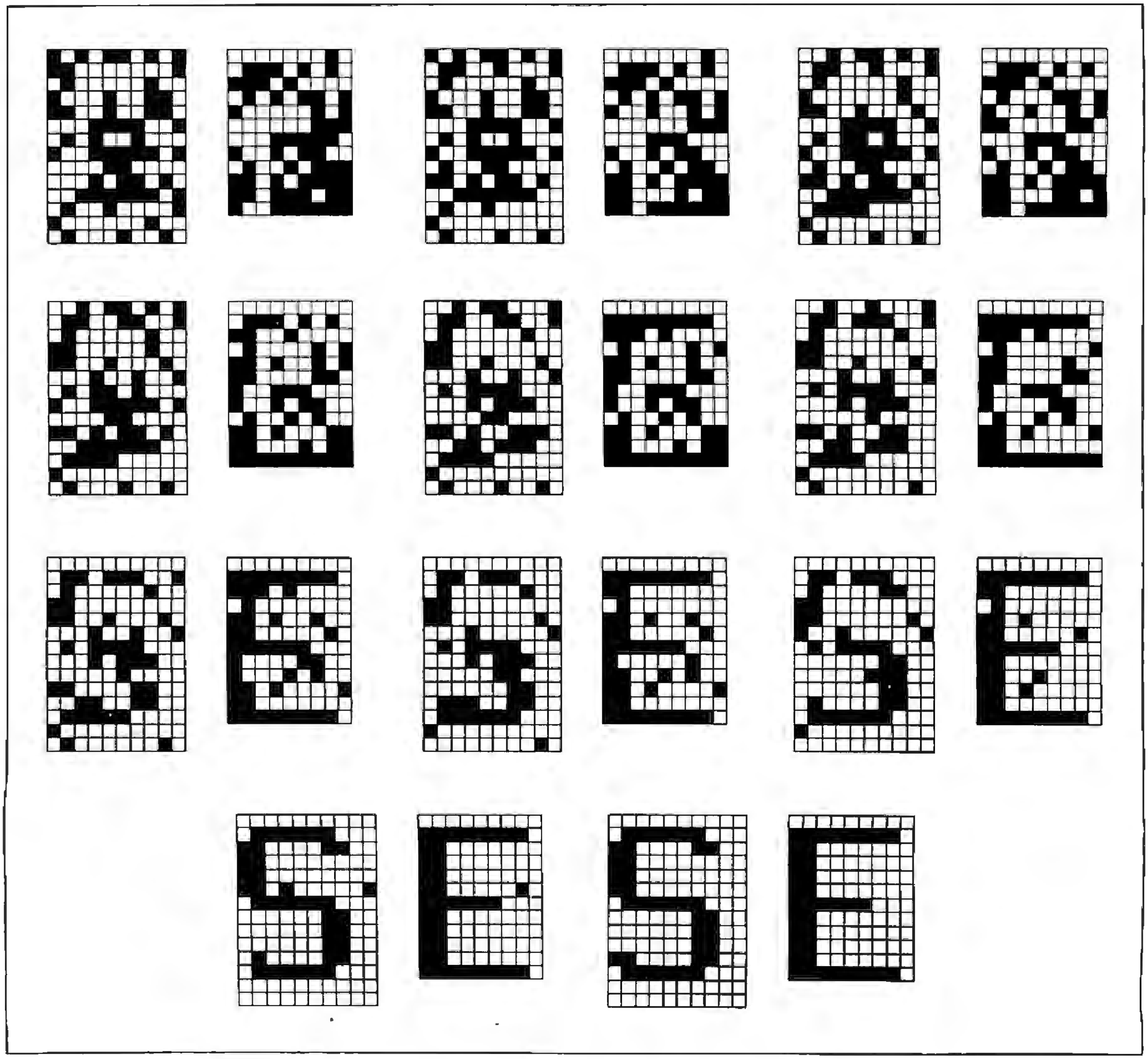
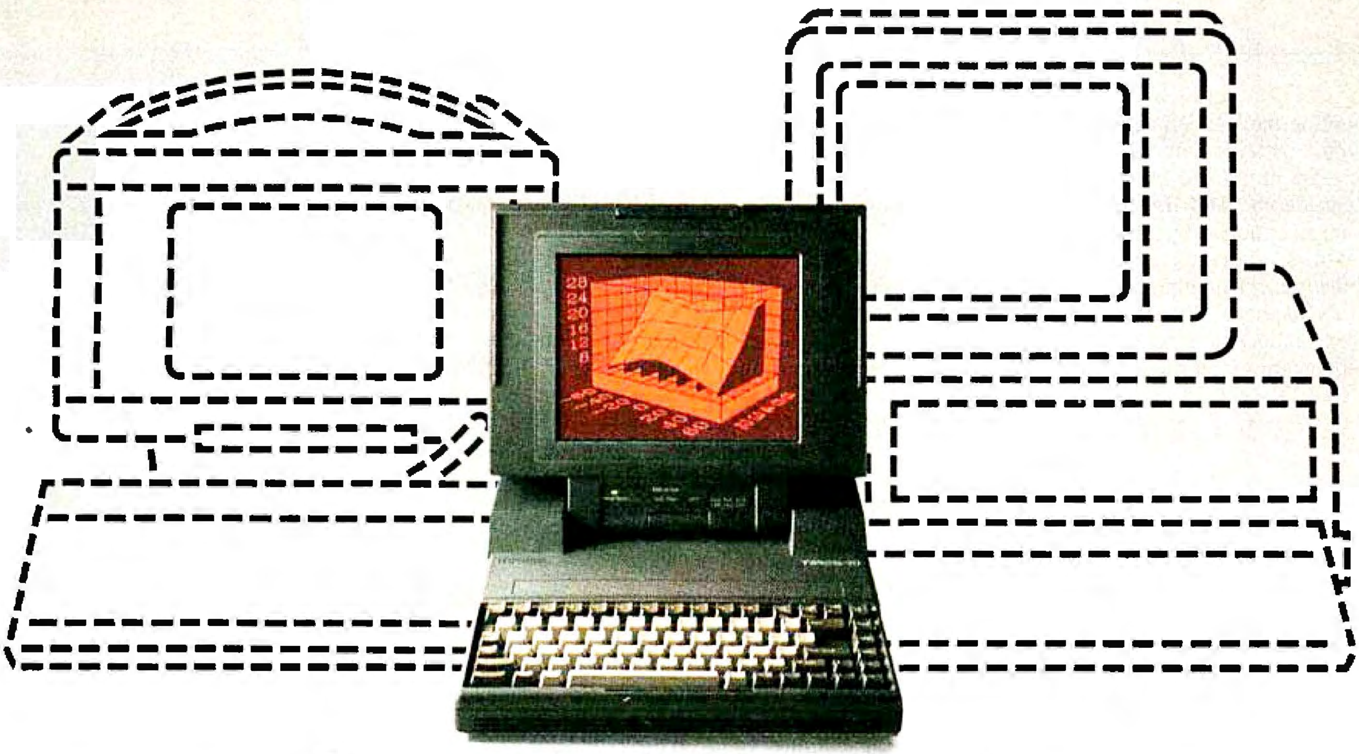


Figure 2: *Asynchronous recall in a BAM consisting of two fields of neurons, one containing 140 neurons and another containing 108 neurons.*



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Toshiba America, Inc., Information Systems Division tion in the BAM state space. As you add more patterns to the BAM, the basins increase in number but shrink in diameter and depth. The BAM recognizes fewer input patterns by stored associations. Worse, spurious attractor basins can emerge, causing misclassification. When this happens, the BAM experiences a type of déjà vu, since it remembers something it never learned.

In this case, the new memory $M = X_1^T Y_1 + X_2^T Y_2 + X_3^T Y_3$ is given by

$$M = \begin{pmatrix} 1 & 1 & 1 & -1 \\ -1 & -1 & 3 & 1 \\ 3 & -1 & -1 & -3 \\ -1 & -1 & -1 & 1 \\ -1 & 3 & -1 & 1 \\ -3 & 1 & 1 & 3 \end{pmatrix}$$

When you retest to see if (A_1,B_1) and (A_2,B_2) are still stable points, you'll find that they are, since $E(A_1,B_1) = E(A_2,B_2) = -6$. To test A_3, $A_3 M = (-4\ 4\ 4\ 4) \rightarrow (0\ 1\ 1\ 1) = B_3$, and $B_3 M^T = (1\ 3\ -5\ -1\ 3\ 5) \rightarrow (1\ 1\ 0\ 0\ 1\ 1) = A_3$. So (A_3, B_3) is also a resonant stable point, but with energy that's twice as small, namely, $E(A_3, B_3) = -12$. Since (A_3, B_3) is a deeper basin, you can expect it to attract and classify more patterns. The unit input (1 1 1 1 1 1), which is 1 bit closer to A_3 than to A_1 or A_2, recalls (A_3, B_3). But if you flip the last bit, the new input (1 1 1 1 1 0) misclassifies to a spurious association (A, B), where A = (1 1 1 0 1 0) and B = (1 1 1 0), also with energy $E(A, B) = -6$. Such misclassification reflects that you have almost overstuffed the BAM memory matrix M.

If you'd like to experiment with the above algorithm, Duane DeSieno, Rod Taber, and Joel Davis have provided programs in BASIC, Pascal, and C. [Editor's note: *These programs are available on disk, in print and on BIX; see the card following page 256 for details. They are also available from BYTEnet listings; see page 4.*] Listing 1 shows pseudocode for the BASIC program.

Asynchronous BAM Recall

Figure 2 illustrates asynchronous BAM recall. Field F_A contains n = 10 x 14 = 140 neurons. F_B contains p = 9 x 12 = 108 neurons. Both vector fields are arranged as binary matrices to help the eye detect interesting spatial patterns. The BAM stores the three alphabetic associations: (M, V), (S, E), and (G, N). A 40 percent noise-corrupted version (99 bits randomly flipped) of (S, E) is presented to the BAM. Figure 2 shows 11 snapshots of the asynchronous recall process. At each clock cycle, roughly six randomly chosen neurons are allowed to make update (state-change) decisions. This is a cross-sectional approximation of a stochastic neural process—a set of independent neurons, each randomly updating in time.

Different random-update choices produce different asynchronous-recall trajectories. In this BAM, most trajectories recall the desired nearest stored association, since the memory capacity is not strained and the spatial patterns all differ significantly. In figure 2, (S, E) is perfectly recalled, as the neurons independently proceed from local chaos to global order—without any neuron aware of its global effects. The anarchical neurons are guided as if by an invisible hand to correct global system errors without knowing that such errors have occurred and need to be corrected.

Finally, BAMs are perhaps best implemented in optics, with photons instead of electrons. Neurons in fields F_A and F_B can be totally interconnected to each other with simple lenses. Using resistors to interconnect amplifiers is much more difficult, space consuming, and expensive. Unlike electrical pathways, optical-interconnect beams can pass through one another without interference. ■

For More Information

Associative-memory literature is mathematical, interdisciplinary, and vast. McCulloch and Pitts introduced the first Boolean switching-function neurons in 1943. Kohonen largely pioneered the study of correlation-matrix memories. His 1984 book is a standard in the field. Steinbuch put forth the idea of stable points in crossbar associative networks in his 1961 "learning matrix."

Amari et al first made the rigorous connection between associative networks and thermodynamics. Hopfield next made the connection between stable points and energy minima by establishing an isomorphism between symmetric binary networks and the Ising spin-glass model of ferromagnetism in statistical mechanics. Grossberg et al have proven all of the above and more with rigorous mathematics. With Carpenter, Grossberg developed the adaptive resonance model that, in some sense, an adaptive BAM approximates.

Grossberg's 1982 and 1987 volumes are the Old and New Testaments of neural networks—read them. I developed the BAM and have extended it to real-time unsupervised learning. The 1986 volumes of Rumelhart and McClelland provide an accessible introduction to neural networks from a cognitive-science perspective.

FOR FURTHER READING

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Andrew M. Rockett and John C. Stevenson

Karmarkar's Algorithm

A method for solving large linear programming problems

[Editor's note: *This is easily the most mathematically advanced article we've done in BYTE. Readers might remember Andrew Rockett and John Stevenson as two of the three authors of a two-part article (August and September 1980 issues) on Khachiyan's algorithm, another algorithm for linear programming that turned out to be sound in theory but unusable in practice.*

Here is my attempt to summarize the important points this article makes. First, it describes Karmarkar's algorithm, how it works, and why it's valid in the theoretical sense. It does not, *however, include a modification of the algorithm (included in Karmarkar's original paper) that makes its implementation feasible for large problems being solved on mainframe computers.*

Second, the classic simplex method for solving linear programming problems differs from Karmarkar's algorithm in that the former stops when it has found the absolute best solution, while the latter stops when it finds an answer that is a set factor better than the initial guess; this is assumption (C) of problem type (4) in the section "Karmarkar's Restricted Problem." This means that the choice of the initial guess greatly influences the accuracy and validity of the final answer.

Third, Karmarkar's algorithm does not directly solve linear programming problems. Instead, it attempts to minimize a given function (called the objective function*) within an* n*-dimensional "triangular" region called a* simplex. *(See "Concepts from Linear Algebra" on page 147 for more detailed definitions.) It turns out that we can map the problem space of the linear programming problem (which is called an* n-dimensional orthant*) into a simplex, solve the problem using Karmarkar's algorithm, then get the final answer by mapping the solution back into the orthant that represents the original problem. (Figure 4 shows a geometric representation of how the orthant maps into the simplex.)*

Figures 2 and 3 show a geometric visualization of how Karmarkar's algorithm works. In figure 2, we start with the point $\mathbf{a}_0$ *in the center of the circle, knowing that the solution is at one of the endpoints of the line it's on. The first part of Karmarkar's algorithm takes us to a better approximation to the answer,* $\mathbf{x}^{(1)}$, *which lies between* $\mathbf{a}_0$ *and one of the two points at the intersection of the line* $\mathbf{a}_0$ *is on and the inscribed circle. (In general, we will use lowercase boldfaced letters to indicate column vectors only, while uppercase boldfaced letters will indicate matrices of arbitrary size; scalars will be italicized.) Karmarkar's theorem proves that, by limiting your step to one-fourth the size of the "step" that is possible at this point, you can guarantee* under all circumstances *a certain minimum improvement. This is discussed under "The Main Theorem."*

Figure 3 shows how Karmarkar's algorithm iterates from one approximation to the next. A "better" point $\mathbf{x}^{(k)}$ *is projected into the* $\mathbf{a}_0$ *center of another simplex (triangular region). The work of figure 2 is repeated in this second simplex, and the better approximation it produces,* $\mathbf{a}^*$, *is then mapped back into the first simplex, resulting in a still better approximation,* $\mathbf{x}^{(k+1)}$. *This process is repeated a given number of times to get the final approximation,* $\mathbf{x}^{(m)}$, *which is then transformed into the original orthant to get the final result.*

It turns out that you can calculate the number of iterations, m, *needed to improve the initial estimate by the factor desired (see "The Main Theorem" below for the equation for* m). *If, after* m *iterations, the calculated results don't show the desired improvement, the problem is infeasible and has no solution.*

"Nonzero Objective Functions" and later sections describe strategies for taking away certain restrictions that limit the problems Karmarkar's algorithm can solve. These sections also discuss the problem of feasibility and the use of Karmarkar's algorithm in real-world situations.]

—Gregg Williams, Senior Technical Editor

In the fall of 1984, a new mathematical technique briefly became front page news. The *New York Times* called it a "breakthrough in problem solving," while *Time* magazine described a "major math breakthrough" in an "abstruse branch of mathematics known as linear programming." The method was devised by Nerendra K. Karmarkar at AT&T's Bell Laboratories in New Jersey. Unlike Khachiyan's algorithm, another new way of solving linear programming problems, Karmarkar's algorithm had already demonstrated its worth: An article in the September 21, 1984, issue of *Science* reported that an implementation of the algorithm outperformed one implementation of the classic simplex method by a factor of over 50 on medium-scale problems of 5000 variables.

In this article, we shall place Karmarkar's algorithm in the context of linear programming theory relative to the simplex method, given both geometric and algebraic descriptions of the procedure and an indication of why it works. Then we will explain how to reduce a general linear programming problem to the restricted form actually solved by Karmarkar and mention

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some implementation considerations. Our presentation is based on Karmarkar's paper "A New Polynomial-Time Algorithm for Linear Programming" (*Combinatoria*, vol. 4, 1984, pages 373-395). We will illustrate several points with example problems and BASIC programs that solve them.

LP Problems and the Simplex Method

By a linear programming (LP) problem we mean a problem of the form

(1) minimize $\mathbf{c}^T\mathbf{x}$
subject to $\mathbf{Ax} \geq \mathbf{b}$ and $\mathbf{x} \geq \mathbf{0}$

where **c** and **x** are vectors in R^n, **A** is an m by n matrix, and **b** is a vector in R^m. The objective function is $\mathbf{c}^T\mathbf{x}$, and the conditions $\mathbf{Ax} \geq \mathbf{b}$ and $\mathbf{x} \geq \mathbf{0}$ are the constraints. Given (1), there is a corresponding maximization problem called the dual problem:

(2) maximize $\mathbf{b}^T\mathbf{y}$
subject to $\mathbf{A}^T\mathbf{y} \leq \mathbf{c}$ and $\mathbf{y} \geq \mathbf{0}$

The solutions of these problems are related, as you can see by noticing that $\mathbf{b}^T\mathbf{y} \leq (\mathbf{Ax})^T\mathbf{y} = \mathbf{x}^T(\mathbf{A}^T\mathbf{y}) \leq \mathbf{x}^T\mathbf{c} = \mathbf{c}^T\mathbf{x}$. So the maximization problem seeks to increase $\mathbf{b}^T\mathbf{y}$ as much as possible, while the minimization problem seeks to decrease $\mathbf{c}^T\mathbf{x}$, which is always greater than or equal to $\mathbf{b}^T\mathbf{y}$. Consequently, if a solution can be found, it must occur when $\mathbf{b}^T\mathbf{y} = \mathbf{c}^T\mathbf{x}$.

The *simplex method* is a linear programming algorithm that solves both the original problem and the dual problem at the same time. To apply the simplex method to problem (1), first we rewrite the problem as

(3) minimize $\mathbf{c}^T\mathbf{x}$
subject to $\mathbf{Ax} = \mathbf{b}$ and $\mathbf{x} \geq \mathbf{0}$

where now the vector **x** is in R^{n+m}. The m additional components are called *slack variables* since each of the m inequalities in the original constraint $\mathbf{Ax} \geq \mathbf{b}$ requires one slack variable $s_k \geq 0$ to transform the kth inequality $\mathbf{A}_k\mathbf{x} \geq b_k$ into an equality $\mathbf{A}_k\mathbf{x} - s_k = b_k$. The vector **c** and the matrix **A** of (3) are obtained from those of (1) by extending the old **c** with m zeros and by adjoining $-\mathbf{I}_m$ to the old **A**. Although (3) at first seems to be a trivial reformulation of (1), it is not, since the m slack variables are closely related to the variables we called **y** in the dual problem (2). Moreover, we now know a basic point $\mathbf{x}^{(0)}$ that satisfies $\mathbf{Ax} = \mathbf{b}$ in (3), since $\mathbf{x}^{(0)}$ can be obtained by setting $\mathbf{x}^{(0)}_k = 0$ for $k = 1, \ldots, n$ and $\mathbf{x}^{(0)}_{k+n} = -\mathrm{b}_k$ for $k = 1, \ldots, m$. [Editor's note: $\mathbf{x}^{(0)}$ *is an $(n+m)$−dimensional vector of $R^{(n+m)}$; the superscript (0) is used to denote that it is the first true value of an iterated sequence of points* $\mathbf{x}^{(0)}, \mathbf{x}^{(1)}, \mathbf{x}^{(2)}, \ldots$. *The kth component of this vector is the value* $\mathbf{x}^{(0)}_k$.] If $\mathbf{x}^{(0)} \geq \mathbf{0}$, it is called a *basic feasible point,* since it satisfies the constraints of (3).

"Stage one" of the simplex method transforms a basic point into a basic feasible point, then "stage two" moves to successively better (in terms of the objective function) basic feasible points until the minimum of the objective function is reached. Since there are a finite number of basic feasible points, the simplex method will either find the solution or detect the nonsolvability of the problem in a finite number of steps. Unfortunately, the number of basic feasible points increases rapidly as the number of variables increases, and it is possible to construct problems that trick the simplex method into visiting almost all possible basic feasible points before reaching the optimum point. (See the version of the "Klee-Minty problem" included in Part 2 of our article on Khachiyan's algorithm in the September 1980 BYTE.)

Thus the worst-case performance of the simplex method is exponential in n, the number of variables. We shall write this as $O(e^n)$; the Bachmann-Landau order notation $f(n) = O(g(n))$ means that

$$\lim_{n \to \infty} \left| \frac{f(n)}{g(n)} \right| \leq K$$

where K is a constant independent of n. Put another way, for large n if you double the size of the problem, the running time will be multiplied by e^n, and e^n gets large very fast!

In spite of the worst-case performance, the simplex method has worked well in practice. Since most computer implementa-

continued

Concepts from Linear Algebra

If **x** is a column vector in the n-dimensional real vector space R^n, then the transpose of **x** is the row vector $\mathbf{x}^T = (x_1, x_2, \ldots, x_n)$. The vector **e** is the special vector such that $\mathbf{e}^T = (1, \ldots, 1)$. We shall write $\mathbf{x} \geq \mathbf{0}$ when $x_k \geq 0$ for $k = 1, \ldots, n$. Then the positive n-dimensional orthant $P_+^n \subset R^n$ consists of all $\mathbf{x} \in R^n$ with $\mathbf{x} \geq \mathbf{0}$. The length of the vector **x** will be denoted $|\mathbf{x}|$.

Given a vector $\mathbf{x} \in R^n$, the diagonal matrix of **x** is the n by n matrix $\mathbf{D} = \mathbf{D}(\mathbf{x})$ consisting of the elements of **x** down the diagonal and zeros everywhere else. $\mathbf{D}(\mathbf{e})$ is called the (n-dimensional) identity matrix and will be denoted by $\mathbf{I}_n$. The inverse of a square matrix **A** is $\mathbf{A}^{-1}$ and $\mathbf{AA}^{-1} = \mathbf{A}^{-1}\mathbf{A} = \mathbf{I}_n$.

The solutions of a homogeneous system of linear equations $\mathbf{Ax} = \mathbf{0}$ form a linear subspace $\Omega = \{\mathbf{x} \mid \mathbf{Ax} = \mathbf{0}\}$ of R^n that contains the origin and is of dimension less than n if the matrix A is not trivial. The solutions of an inhomogeneous system of linear equations $\mathbf{Ax} = \mathbf{b}$ are translates of the solutions of the corresponding homogeneous equation since, given any particular solution $\mathbf{x}_0$ with $\mathbf{Ax}_0 = \mathbf{b}$, then for any **x** with $\mathbf{Ax} = \mathbf{0}$ we see that $\mathbf{A}(\mathbf{x}_0 + \mathbf{x}) = \mathbf{b}$.

The n-sphere S^n is contained in R^{n+1} and is $\{\mathbf{x} \mid \Sigma x_i^2 = 1\}$. Thus S^0 consists of the two points $+1$ and -1 on the real line R, S^1 is the unit circle in the plane R^2, and S^2 is the "usual" sphere in the three-dimensional space R^3.

Similarly, the n-simplex Δ^n is contained in R^{n+1} and is $\{\mathbf{x} \mid \Sigma x_i = 1 \text{ and } \mathbf{x} \geq \mathbf{0}\}$. Thus Δ^0 is the point $+1$ on the real line, Δ^1 is the diagonal line segment from (0,1) to (1,0) in the plane, and Δ^2 is the triangle in R^3 connecting (0,0,1), (0,1,0) and (1,0,0) (see figure 1 for an example). The center of the n-simplex will be denoted by the vector $\mathbf{a}_0$ such that $\mathbf{a}_0^T = (1/(n+1), \ldots, 1/(n+1))$.

tions use finite-precision arithmetic, the possibility of "cycling" due to degeneracy is practically eliminated because of the perturbation caused by round-off errors while proper scaling of the initial problem removes the pitfalls of the Klee-Minty problem. (As far as we are aware, all known Klee-Minty problems depend on scaling tricks to create their effect.)

Karmarkar's Restricted Problem

Karmarkar's algorithm does not solve the linear programming problems (1), (2), or (3) but rather the restricted problem

(4) minimize $\mathbf{c}^T\mathbf{x}$
subject to $\mathbf{x} \in \Omega \cap \Delta^n$

where $\mathbf{c}, \mathbf{x} \in R^{n+1}$ and $\Omega = \{\mathbf{x} \mid \mathbf{Ax} = \mathbf{0}\}$ is the solution space of a homogeneous system of linear equations and Δ^n is the n-dimensional simplex contained in R^{n+1} (see the text box "Concepts from Linear Algebra."). We shall make three assumptions about problem (4):

(A) the minimum value of the objective function is zero;
(B) the problem is feasible and the center $\mathbf{a}_0$ of the simplex Δ^n is a feasible point (i.e., $\mathbf{a}_0 \in \Omega$); and
(C) a termination parameter $q > 0$ is given, and we will accept the problem as solved when we obtain a feasible point $\mathbf{x}$ with

$$\frac{\mathbf{c}^T\mathbf{x}}{\mathbf{c}^T\mathbf{a}_0} \leq 2^{-q}.$$

Minimizing the Objective Function

Suppose we wish to minimize $\mathbf{c}^T\mathbf{x}$ where $\mathbf{x}$ is on a sphere S centered at a point $\mathbf{a}$. Since the solutions of $\mathbf{c}^T\mathbf{x} = 0$ are the vectors $\mathbf{x}$ that are perpendicular to the vector $\mathbf{c}$ at the origin, the solutions of $\mathbf{c}^T\mathbf{x} = K$ form a family of lines parallel to the solutions of $\mathbf{c}^T\mathbf{x} = 0$. If $K > 0$ the displacement is in the direction of $\mathbf{c}$, while if $K < 0$ the displacement is in the opposite direction. It now becomes clear that the point on S that minimizes $\mathbf{c}^T\mathbf{x}$ is $\mathbf{x}'$, the intersection of the circle with the vector $-\mathbf{c}$ drawn from the center $\mathbf{a}$ (see figure A).

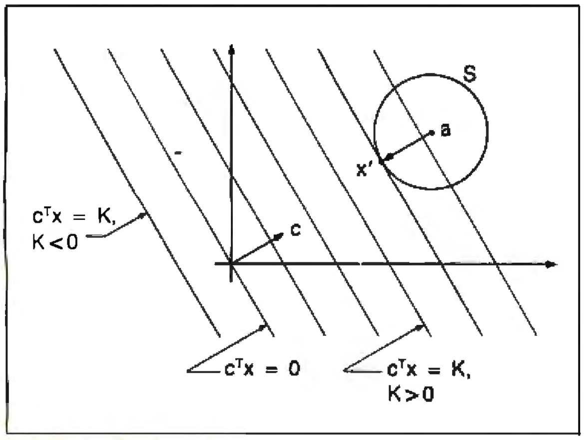

Figure A: *Finding a point on the circle S that minimizes* $\mathbf{c}^T\mathbf{x}$.

After we have investigated Karmarkar's solution of this problem, we shall show how to transform the general problem (3) into a problem of the form (4) and how to deal with assumptions (A) and (B). Assumption (C) is inherent in any calculation that uses finite-precision arithmetic.

To make our discussion less abstract, consider example 1 as an instance of problem (4):

Example 1: minimize $(3\ \ 3\ -1)\mathbf{x}$
subject to $\mathbf{x} \in \Omega \cap \Delta^2$
where $\Omega = \{\mathbf{x} \mid (2\ -3\ \ 1)\mathbf{x} = 0\}$ and
$\mathbf{x} \in R^3$

We have sketched the region $\Omega \cap \Delta^2$ for this problem in figure 1. Since the objective function (the one being minimized) is linear and the region $\Omega \cap \Delta^2$ is a line segment, if the function is not constant on the region, then the minimum must occur at one endpoint or the other. At $(3/5, 2/5, 0)^T$ the value of the objective function is $(9/5 + 6/5 - 0) = 3$, while at $(0, 1/4, 3/4)^T$ the value is $(0 + 3/4 - 3/4) = 0$ and assumption (A) of problem (4) is satisfied. Since the center point $\mathbf{a}_0 = (1/3, 1/3, 1/3)^T$ has $\mathbf{Ax} = (2(1/3) - 3(1/3) + 1(1/3)) = 0$, it is a member of Ω, and assumption (B) is fulfilled.

We have a problem in which the region is bounded (by the simplex Δ^n), an interior point is known, the solution is known to be on the boundary, and an approximate solution will be satisfactory if it is within a preset tolerance of the desired value.

The Initial Step

Since $\mathbf{a}_0$ of the simplex does not meet assumption (C), we cannot accept it as a solution to example 1. We must find a new point satisfying both assumptions (A) and (B) that gives a smaller objective function value. Karmarkar uses the objective function to find the best direction to move from $\mathbf{a}_0$ as follows. Since $\mathbf{c} \in R^{n+1}$ does not give a direction in the lower dimensional region $\Omega \cap \Delta^n$, $\mathbf{c}$ is projected orthogonally onto the region; this projected vector $\mathbf{c}^*$ then points in the direction opposite to the one we want (since we are minimizing, not maximizing). Since it suffices for the algorithm to move from interior point to interior point, Karmarkar further simplifies the problem by minimizing as follows: Inscribe a sphere in Δ^n centered at $\mathbf{a}_0$; then the intersection of this sphere with Ω will again be a sphere of a lower dimension (because Ω is a subspace of R^{n+1}, and $\mathbf{a}_0$ is both the center of the sphere and in Ω). But then this minimization problem is trivial (see the text box "Minimizing the Objective Function"), and we have found a point to which we should move. For technical reasons that provide a guaranteed minimum improvement (see "The Main Theorem" on page 150), Karmarkar does not move as far as possible on each step and effectively uses a smaller sphere than the inscribing one we have described.

In figure 2 we indicate this process as applied to example 1. Since both our example and drawing are contained in three dimensions, the final sphere in $\Omega \cap \Delta^2$ is of dimension 0 (two points), which makes the sketch rather trivial. However, this final sphere is two dimensions less than the simplex, and this is the case in general.

The General Iteration Step

If we call the initial point $\mathbf{x}^{(0)}$ (so that $\mathbf{x}^{(0)} = \mathbf{a}_0$ and the result of the initial step is $\mathbf{x}^{(1)}$), then we must describe the construction of $\mathbf{x}^{(k+1)}$ from $\mathbf{x}^{(k)}$ for $k > 0$. Each of these points is interior to $\Omega \cap \Delta^n$, and $\mathbf{x}^{(k+1)}$ is obtained from $\mathbf{x}^{(k)}$ in a manner similar to the initial step. Karmarkar applies a projective transformation from Δ^n to itself that moves $\mathbf{x}^{(k)}$ to the center $\mathbf{a}_0$ and fixes the corners of the simplex. But now the initial step method can be applied to find a better point in the transformed simplex, and

continued

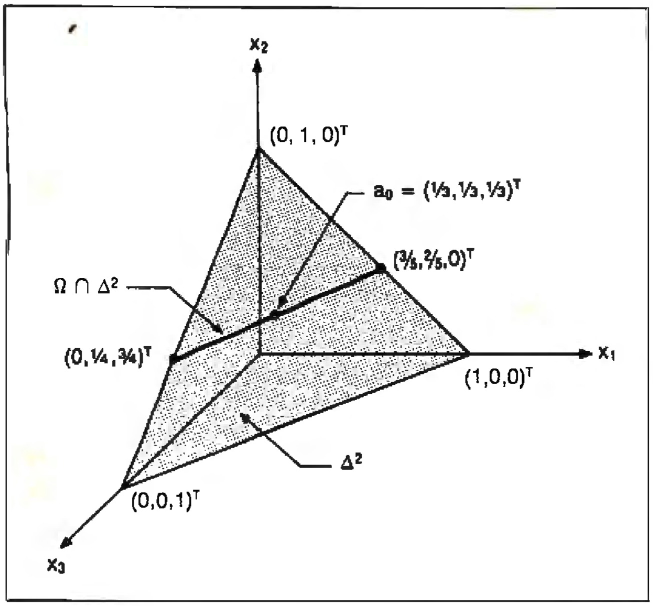

Figure 1: *The region of example 1. The region $\Omega \cap \Delta^2$ is the intersection of the subspace of $\mathbf{R}^3$ and the two-dimensional simplex Δ^2. In example 1, $\Omega = \{\mathbf{x} \mid (2\ {-3}\ 1)\mathbf{x} = \mathbf{0}\}$ is a plane passing through the origin and intersecting Δ^2 in the line segment from $(0, 1/4, 3/4)^T$* to $(3/5, 2/5, 0)^T$.

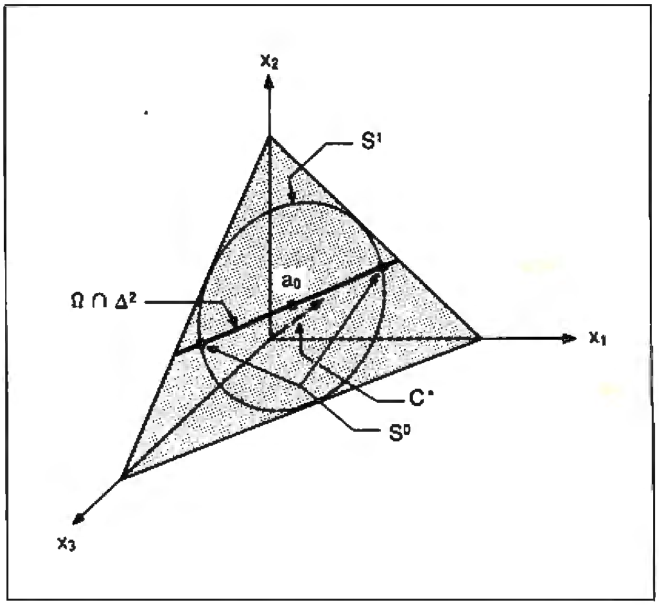

Figure 2: *The initial step. The vector $\mathbf{c}^*$ is obtained by an orthogonal projection of $(3, 3, -1)^T$ onto the region $\Omega \cap \Delta^2$; it goes behind the $x_1 - x_2$ plane. We show the inscribed one-dimensional sphere S^1 centered at $\mathbf{a}_0$ (the center of the circle). Its intersection with Ω is the lower dimensional sphere S^0, also centered at $\mathbf{a}_0$. Karmarkar's algorithm selects as the next point the point $\mathbf{x}^{(1)}$ part way toward the minimizing point on S^0.*

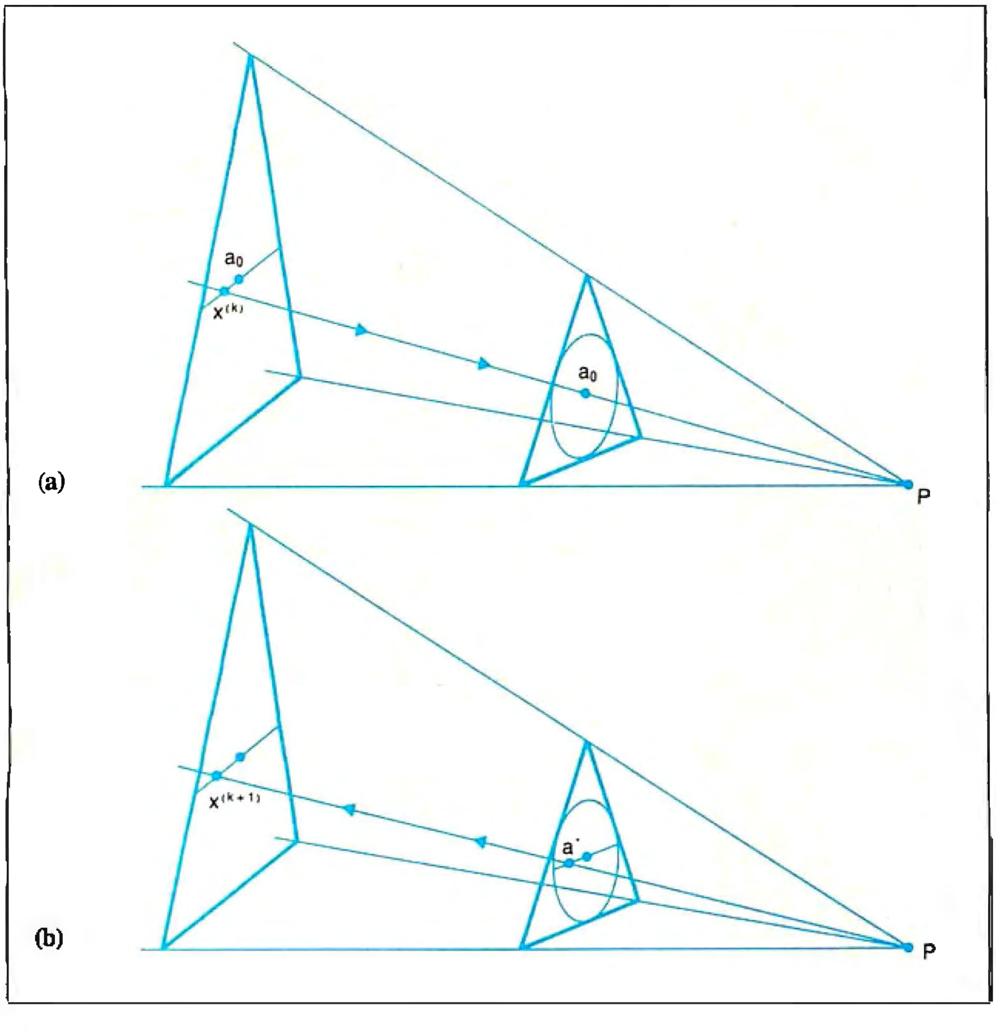

Figure 3: *The general step: a projective transformation. To visualize a projective transformation from Δ^2 to itself, we imagine two separate simplexes of different sizes and orientations such that the lines joining the corresponding vertices all intersect at a common point* **P** *and the image of $\mathbf{x}^{(k)}$ in the first (left) simplex is $\mathbf{a}_0$ in the second simplex (figure 3a). After optimizing in the second simplex, the solution points* $\mathbf{a}^*$ *and* **P** *determine a line that intersects the first simplex at $\mathbf{x}^{(k+1)}$ (figure 3b). Connoisseurs of projective geometry will recognize this sketch as one portion of the proof of Desargues's theorem.*

then $\mathbf{x}^{(k+1)}$ is found by reversing the transformation to return to the original simplex.

In figure 3 we show how such a projective transformation can be constructed for example 1. We can see that for this example, the $\mathbf{x}^{(k)}$s move nearer and nearer to the actual solution point on the boundary. Since $\mathbf{x}^{(k)}$ is sent to $\mathbf{a}_0$ by the transformation, the line segment from $\mathbf{x}^{(k)}$ to (0, 1/4, 3/4), the desired boundary point, is stretched at each iteration, and the next $\mathbf{x}^{(k+1)}$ moves closer to the boundary point but never reaches it. Thus assumption (C) is an essential feature in that it ensures an end to Karmarkar's method.

It is worth noting that since the algorithm returns to the initial region at each step, round-off errors will not accumulate. The method is stable in that, should an $\mathbf{x}^{(k)}$ be outside $\Omega \cap \Delta^n$ from numerical error, the algorithm can continue as soon as $\mathbf{x}^{(k)}$ is revised to be feasible again.

An Algebraic Description

We will now make our geometric description precise by giving algebraic formulas for various parts of the process. Suppose we have $\mathbf{x}^{(k)}$ and we want to find $\mathbf{x}^{(k+1)}$.

First we need a projective transformation $T: \Delta^n \rightarrow \Delta^n$, which sends $\mathbf{x}^{(k)}$ to $\mathbf{a}_0$. Let $\mathbf{D} = \mathbf{D}(\mathbf{x}^{(k)})$ be the diagonal matrix of $\mathbf{x}^{(k)}$ and let $T(\mathbf{x})$ be $\mathbf{D}^{-1}\mathbf{x}/\mathbf{e}^T\mathbf{D}^{-1}\mathbf{x}$. Since $\mathbf{D}^{-1}\mathbf{x}^{(k)} = \mathbf{e}$ and $\mathbf{e}^T\mathbf{D}^{-1}\mathbf{x}^{(k)} = \mathbf{e}^T\mathbf{e} = n+1$, we see that $T(\mathbf{x}^{(k)}) = \mathbf{a}_0$. To show that T is a projective transformation, it suffices to show that T takes lines to lines.

Notice that $T(\mathbf{x})$ is really $\mathbf{D}^{-1}\mathbf{x}$ together with a normalization so that $T(\mathbf{x})$ remains in Δ^n. Since $\Omega = \{\mathbf{x} \mid \mathbf{A}\mathbf{x} = \mathbf{0}\}$ is an affine space and projective transformations preserve affine spaces, $\Omega' = T(\Omega)$ is an affine space. Ω' is also the null space of $\mathbf{AD}$ since $\mathbf{A}\mathbf{x} = \mathbf{0}$ if and only if $\mathbf{AD}(T(\mathbf{x})) = 0$ (to see this directly, just put in our definition of $T(\mathbf{x})$ and notice that $\mathbf{D}\mathbf{D}^{-1} = \mathbf{I}_{n+1}$). [Editor's note: *An* affine space *is more general than a vector space in that it does not possess the conventional measures of distance and angle. A* null space *is the subspace of a vector space whose vectors are mapped by a given linear transformation into the zero vector.*]

Let $\mathbf{B}$ be the matrix $\mathbf{AD}$ augmented with a bottom row of ones (i.e., $\mathbf{B}$ will define $\Omega' \cap \Delta^n$ since $\Omega' \cap \Delta^n$ is Ω' together with the condition that the sum of the components of the vector is 1).

Let

$$\mathbf{c}_p = (\mathbf{I}_{n+1} - \mathbf{B}^T(\mathbf{B}\mathbf{B}^T)^{-1}\mathbf{B})\mathbf{D}\mathbf{c}$$

be the projection of $\mathbf{c}$ onto the null space of $\mathbf{B}$.

Since the radius of the largest inscribed sphere in Δ^n is $r = 1/\sqrt{(n+1)n}$ we can improve our objective function by moving a distance no more than r (which guarantees feasibility) from $\mathbf{a}_0$ in the direction $-\mathbf{c}_p$. Karmarkar introduces a parameter α between 0 and 1 (α can be set equal to 1/4) and moves the length αr from $\mathbf{a}_0$ in the direction that decreases the value of the objective function to find his new point

$$\mathbf{a}^* = \mathbf{a}_0 - \alpha r(\mathbf{c}_p/|\mathbf{c}_p|)$$

and then we set $\mathbf{x}^{(k+1)} = \mathbf{D}\mathbf{a}^*/\mathbf{e}^T\mathbf{D}\mathbf{a}^*$ so that $\mathbf{x}^{(k+1)}$ is in $\Omega \cap \Delta^n$ and $T(\mathbf{x}^{(k+1)}) = \mathbf{a}^*$.

The BASIC program in listing 1 carries out this calculation for example 1 and arrives at the solution $(\mathbf{x}^{(19)})^T = (0.0003, 0.2501, 0.7497)$ with the termination parameter $\mathbf{c}^T(\mathbf{x}^{(19)})/\mathbf{c}^T\mathbf{a}_0 < 0.001$. The exact solution is (0, 0.25, 0.75).

The Main Theorem

We now have an algorithm, some nice pictures, and an example that the algorithm appears to solve. The only problem is that as yet there is no reason to suppose that the algorithm succeeded for any reason other than sheer luck. Projective transformations

continued

Listing 1: *This BASIC program, KAREX1, is written in a version of Microsoft BASIC that should run on most microcomputers. It solves the problem given as example 1 in the text.*

```
200 '
202 ' N is number of unknowns and K is the
    number of equations
204 '
206 N = 3 : K = 1
208 '
210 K1 = K + 1 : K2 = 2*K1
212 DIM AO(N), XOLD(N), XNEW(N), CC(N), CP(N), A(K,N),
   B(K1,N), B1(K1,K2), B2(N,K1), B3(N,N)
214 '
216 ' CC is for the objective function
218 ' B1, B2 and B3 are used for the computation of CP
220 ' R and C are "row" and "column" indices
222 '
224 ' Initially, set XNew = AO, the center of simplex
226 '
228 FOR C = 1 TO N: AO(C) = 1 / N : XNEW(C) : AO(C)
    :NEXT C
230 '
232 ' T is the tolerance
234 '
236 T = .001
238 '
240 ' ALPHA is usually set equal to 1/4
242 '
244 ALPHA = .25
246 '
248 ITERATION = 0
250 '
252 ' Data for constraint matrix A
254 '
256 DATA 2, -3, 1
258 '
260 FOR R = 1 TO K:FOR C = 1 TO N:READ A(R,C):NEXT C:NEXT R
262 '
264 ' Data for objective function CC
266 '
268 DATA 3, 3, -1
270 '
272 FOR C = 1 TO N:READ CC(C): NEXT C
274 '
276 ' Set initial Value to value at center of simplex...
278 '
280 V = 0 : FOR C=1 TO N: V = V + CC(C)*AO(C) :NEXT C: VNEW = V
282 '
284 ' Now we can begin the MAIN ITERATION process...
286 '
300 WHILE VNEW / V > T
301 '
302 PRINT USING "####";ITERATION;:
    FOR C=1 TO N: PRINT USING
    "###.####";XNEW(C); :
    NEXT C : PRINT USING
    "###.#######";VNEW / V
303 '
304 ITERATION = ITERATION + 1
305 '
306 ' Put Xnew into Xold
307 '
308 FOR C = 1 TO N : XOLD(C) = XNEW(C) : NEXT C
309 '
310 ' Construct the matrix B
311 '
312 FOR R=1 TO K:FOR C=1 TO N:B(R,C)=A(R,C)*XOLD(C):
    NEXT C:NEXT R
```

continued

```
313 FOR C = 1 TO N : B(K1,C) = 1 : NEXT C
314 '
315 ' Zero matrices to be used in computations...
316 '
317 FOR R=1 TO K1 : FOR C=1 TO K2 : B1(R,C)=0 NEXT C : NEXT R
318 FOR R=1 TO N : FOR C=1 TO K1 : B2(R,C)=0 NEXT C : NEXT R
319 FOR R=1 TO N : FOR C=1 TO N : B3(R,C)=0 : NEXT C : NEXT R
320 FOR C=1 TO N : CP(C) = 0 : NEXT C
321 '
322 ' Find BBT and put in B1
323 '
324 FOR R = 1 TO K1 :
      FOR C = 1 TO K1 :
       FOR I = 1 TO N:B1(R,C)=B1(R,C)+B(R,I)*B(C,I): NEXT I:
      NEXT C :
     NEXT R
325 '
326 ' Adjoin an identity matrix to BBT
327 '
328 FOR I = 1 TO K1 : B1(I,I+K1)=1 : NEXT I
329 '
330 ' Row reduce BBT|I
331 '
332 FOR R = 1 TO K1
333  IF B1(R,R) <> 0 THEN 338
335   I =<R + 1
335    IF I> K1 THEN PRINT"Error! BBT is SINGULAR!":
       GOTO 400
336    IF B1 (I,R) = 0 THEN I = I+1 : GOTO 335
337    FOR C = 1 to K2 : SWAP B1(R,C),B1(I,C) : NEXT C
338 FOR I = R+1 TO K1 :
       Z = B1(I,R) / B1(R,R):
       FOR C=1 TO K2:B1(I,C)=B1(I,C)-Z*B1(R,C): NEXT C
      NEXT I :
339 NEXT R
340 '
341 ' Now back substitute to finish it...
342 '
343 ' FOR R = K1 TO 2 STEP -1 :
       FOR I = R-1 TO 1 STEP -1 :
        Z = B1(I,R)/B1(R,R) :
        FOR C = R TO K2 :
         B1(I,C)=B1(I,C)-Z*B1(R,C):
         NEXT C :
       NEXT I :
      NEXT R
344 '
345 Remember to make diagonal entries 1s
346 '
347 FOR R=1 TO K1 :
      Z = B1(R,R) :
      FOR C = 1 TO K2 : B1(R,C) =B1(R,C) / Z :
      NEXT C :
     NEXT R
348 '
349 ' BBT Inverse is now in B1 in columns K1+1 to K2
350 '
351 ' Now multiply BBT Inverse by BT and put in B2
352 '.
353 FOR R = 1 TO N :
      FOR C = 1 TO K1 :
       FOR J = 1 TO K1:B2(R,C)=B2(R,C)+B(J,R)*B1
         (J,C+K1):
       NEXT J :
      NEXT C :
     NEXT R
354 '
355 ' Take THAT and multiply by B and put in B3
356 '
357 FOR R = 1 TO N:
      FOR C = 1 TO N :
       FOR J = 1 TO K1:B3(R,C)+B2(R,J)*B(J,C): NEXT J:
      NEXT C :
     NEXT R
358 '
359 ' Find I-B3 by subtracting 1s on diagonal and
     changing signs
361 '
362 FOR R = 1 TO N : B3(R,R) = B3(R,R) - 1 : NEXT R
363 FOR R=1 TO N:FOR C=1 TO N:B3(R,C) = -1*B3(R,C): NEXT
     C:NEXT R
364 '
365 ' Multiply by D
366 '
367 FOR R=1 TO N:FOR C=1 TO N:B3(R,C)=B3(R,C)*XOLD(C):
     NEXT C:NEXT R
368 '
369 ' Find projection of CC and call it CP
370 '
371 FOR R=1 TO N:FOR C=1 TO N:CP(R)=CP(R)+B3(R,C)*CC(C):
     NEXT C:NEXT R
372 '
373 ' Find length of CP and the normalized CP
374 '
375 AA = 0
376 FOR C=1 to N : AA = AA + CP(C)*CP(C) : NEXT C
377 AA = SQR(AA) : FOR C=1 TO N : CP(C) = CP(C) / AA : NEXT C
378 '
379 ' Find a*, project back to get new X...
380 '
381 AA = SQR(N*(N-1)) / ALPHA
382 FOR C=1 TO N : XNEW(C) = (AO(C) - CP(C) / AA)*XOLD(C)
     : NEXT C
383 '
384 ' And remember to divide by "size" of new X to
385 ' complete the projective transformation back to
386 ' the original simplex
387 AA = 0
388 FOR C=1 TO N : XNEW(C) = XNEW(C) : NEXT C
389 FOR C=1 TO N : XNEW(C) = XNEW(C) / AA : NEXT C
390 '
391 ' Find objective function Value at NEW point X
392 '
393 VNEW = 0
394 FOR C=1 TO N : VNEW = VNEW + CC(C)*XNEW(C) : NEXT C
395 '
396 WEND ' End of main iteration loop...
397 '
398 PRINT:PRINT"Tolerance reached:
     Vnew / Vinitial = "; VNEW / V:PRINT
399 PRINT USING "####"; ITERATION; :
     FOR C=1 TO N:PRINT USING "###.####";
     XNEW(C); : NEXT C : PRINT USING
     "####.#######";VNEW / V
400 END
```

do not preserve linear functions such as the objective function of the problem. Karmarkar's main result is the association of a "potential function" with the objective function, and then a proof that his algorithm reduces the potential function by a guaranteed amount with each iteration, and then a proof that the reduction of the potential function is equivalent to reduction of the ratio $\mathbf{c}^T\mathbf{x}/\mathbf{c}^T\mathbf{a}_0$. While an exposition of these proofs is beyond the scope of this article, we shall state his principal result and show how the reduction in $\mathbf{c}^T\mathbf{x}/\mathbf{c}^T\mathbf{a}_0$ then follows.

Given the objective function of problem (4), let the corresponding potential function $f(\mathbf{x})$ be

continued

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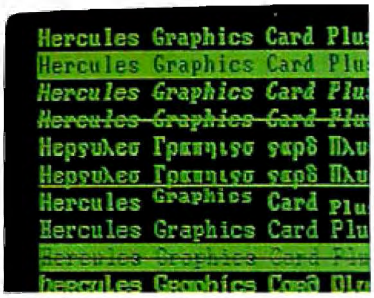

RamFont lets most popular word processors display italics, subscripts, superscripts, foreign languages, different font styles and symbols etc. at lightning speed.

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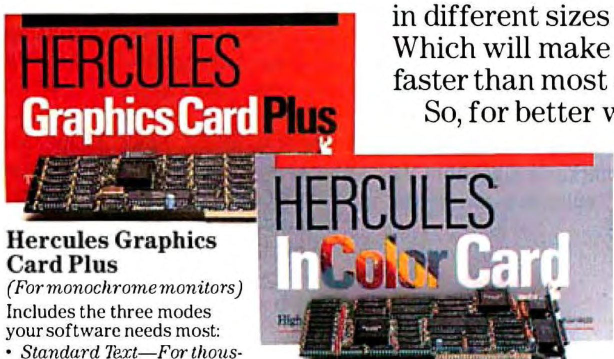

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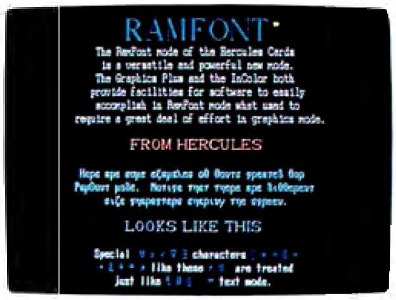
Programs like Design Enterprise's Alexander use it to display symbols (musical notes and foreign languages) which, before RamFont, were possible only in the much slower graphics mode. Other programs including Nota Bene, WordMARC, and Qalam all have optimized displays with RamFont.



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$$(5) \qquad f(\mathbf{x}) = \sum_{i=1}^{n+1} \ln(\mathbf{c}^T\mathbf{x}/\mathbf{x}_i)$$

where $\ln(r)$ is the natural logarithm of the real number r and x_i is the ith component of the $(n+1)$-dimensional point $\mathbf{x}$. Karmarkar considers this potential function under the projective transformation T and shows that, in the transformed space $\Omega' \cap \Delta^n$, the point that minimizes $(\mathbf{Dc})^T(T(\mathbf{x}))$ on the inscribed sphere of radius αr either gives a value of zero or has reduced the transformed potential function by at least $\delta > 0$ where the constant δ depends on α. In particular, if $\alpha = 1/4$ then $\delta \geq 1/8$. Then applying the inverse transformation, he obtains

Karmarkar's theorem: Either (i) $\mathbf{c}^T\mathbf{x}^{(k+1)} = 0$ or (ii) $f(\mathbf{x}^{(k+1)}) \leq f(\mathbf{x}^{(k)}) - \delta$ where δ is a constant depending on α, and if $\alpha = 1/4$, then $\delta \geq 1/8$.

Suppose the algorithm has run for m iterations and $\mathbf{c}^T\mathbf{x}^{(m)} > 0$. How close to the solution have we come? Applying the theorem repeatedly, we have $f(\mathbf{x}^{(m)}) \leq f(\mathbf{x}^{(m-1)}) - \delta \leq \ldots \leq f(\mathbf{x}^{(0)}) - m\delta$. Since $\mathbf{x}^0 = \mathbf{a}_0$, we have

$$\sum_{i=1}^{n+1} \ln(\mathbf{c}^T\mathbf{x}^{(m)}) - \ln(\mathbf{x}^{(m)}{}_i)) \leq \sum_{i=1}^{n+1} \ln(\mathbf{c}^T\mathbf{a}_0) - \ln(1/(n+1))) - m\delta$$

so

$$(n+1)\ln(\mathbf{c}^T\mathbf{x}^{(m)}) - \sum_{i=1}^{n+1} \ln(\mathbf{x}^{(m)}{}_i) \leq (n+1)(\ln(\mathbf{c}^T\mathbf{a}_0) + \ln(n+1)) - m\delta$$

which gives us

$$(6) \qquad \ln\left(\frac{\mathbf{c}^T\mathbf{x}^{(m)}}{\mathbf{c}^T\mathbf{a}_0}\right) \leq \ln(n+1) + \frac{1}{n+1} \sum_{i=1}^{n+1} \ln(\mathbf{x}^{(m)}{}_i) - \frac{m\delta}{n+1}$$

Because $\mathbf{x}^{(m)}$ is in the interior of Δ^n, all of the components of $\mathbf{x}^m$ are $0 < x^{(m)}{}_i < 1$ and so the term $\Sigma \ln(x^{(m)}{}_i)$ is negative. Thus

$$\ln \frac{\mathbf{c}^T\mathbf{x}^{(m)}}{\mathbf{c}^T\mathbf{a}_0} < \ln(n+1) - \frac{m\delta}{(n+1)}$$

The equation

$$m = \frac{(n+1)(q+\ln(n+1))}{\delta}$$

gives us the number of iterations of Karmarkar's algorithm we need to calculate. To see that this is true, substitute m into the last inequality, which eventually becomes

$$\ln \frac{\mathbf{c}^T\mathbf{x}^{(m)}}{\mathbf{c}^T\mathbf{a}_0} < -q.$$

Exponentiating both sides and noting that $e^{-q} < 2^{-q}$ for $q < 0$, we get

$$\frac{\mathbf{c}^T\mathbf{x}^{(m)}}{\mathbf{c}^T\mathbf{a}_0} < e^{-q} < 2^{-q},$$

which is equivalent to condition (C) of Karmarkar's restricted problem, problem (4). The above definition for m leads us to approximate the number of iterations of Karmarkar's algorithm as $O((n+1)(q+\ln(n+1)))$.

Nonzero Objective Functions

We now turn to the assumptions we made about problem (4). Assumption (A) was that the minimum of the objective function was zero. Let us now suppose that the minimum is not zero but some other number M. How can we regain assumption (A)? Since $\mathbf{x} \in \Delta^n$, $x_1 + \ldots + x_{n+1} = 1$ and multiplication by M gives $M = M(x_i + \ldots + x_{n+1})$. Now we can make the objective function homogeneous by considering instead

$$\mathbf{c}^T\mathbf{x} - M\mathbf{x} = (\mathbf{c} - M\mathbf{e})^T\mathbf{x}$$

since the minimum of this function is zero.

As an example, let us alter example 1 by changing only the objective function:

Example 1a: minimize $(1\ 1\ 0)\mathbf{x}$
subject to $\mathbf{x} \in \Omega \cap \Delta^2$
where $\Omega = \{\mathbf{x} \mid (2\ {-3}\ 1)\mathbf{x} = \mathbf{0}\}$ and $\mathbf{x} \in R^3$

(This retains the region $\Omega \cap \Delta^2$ of example 1.) The minimum still occurs at $(0, 1/4, 3/4)^T$, but instead of 0 it is now 1/4. The alteration discussed above gives the new objective function

$$(1\ 1\ 0)\mathbf{x} - (1/4)\mathbf{x} = (3/4\ 3/4\ {-1/4})\mathbf{x}$$

which has a minimum value of 0.

Reduction to the Restricted Problem

Actually, example 1a came from a problem of the general form (3). Let us see how the reduction of problem type (3) to type (4) was carried out for the example problems before we consider the reduction method in general. Consider the problem

Example 1b: minimize $(1\ 1)\mathbf{x}$
subject to $(2\ {-3})\mathbf{x} = -1$ (where $\mathbf{x} \in P_+^2$)

and the sketch of the constraint region in figure 4. Notice that the minimum occurs at $(0, 1/3)^T$ and that $(1, 1)^T$ is an interior feasible point. We construct a projective transformation T from P_+^2 to Δ^2 as follows:

$$X_1 = x_1/(x_1 + x_2 + 1)$$
$$X_2 = x_2/(x_1 + x_2 + 1)$$
$$X_3 = 1/(x_1 + x_2 + 1)$$

where lowercase x components are for the vector of P_+^2 while uppercase X components are for the vector in Δ^2 (which requires three components since $\Delta^2 \subset R^3$). This transformation sends $(0, 1/3)^T$ to $(0, 1/4, 3/4)^T$ and the feasible point $(1, 1)^T$ to $(1/3, 1/3, 1/3)^T = \mathbf{a}_0 \in \Delta^2$. Since X_3 approaches 0 as $x_1, x_2 \to \infty$, we see that $X_3 = 0$ corresponds to "infinitely large" values for x_1 and x_2 in the far reaches of P_+^2. Thus T has taken the unbounded region P_+^2 and compressed it into the bounded simplex Δ^2.

What happens to the straight line $(2\ {-3})\mathbf{x} = -1$? Since $x_1 + x_2 + 1 \geq 1$ for $\mathbf{x} \in P_+^2$, we can rewrite the original constraint $\mathbf{Ax} = \mathbf{b}$ as

$$\frac{2x_1 - 3x_2}{x_1 + x_2 + 1} = \frac{-1}{x_1 + x_2 + 1}$$

which is the same as $2X_1 - 3X_2 + X_3 = 0$. With this done, we have reduced example 1b (of type (3)) into a problem of type (4). (Notice that the image of the half-line region in P_+^2 is a line segment in Δ^2 as we would expect, since T is a projective transformation.)

The reduction described in the previous paragraph is generalized easily. Suppose we have any problem of type (3) and an interior feasible point $\mathbf{a} \in P_+^n$ (so that $\mathbf{Aa} = \mathbf{b}$). Let $T: P_+^n \to \Delta^n \subset R^{n+1}$ be given by

continued

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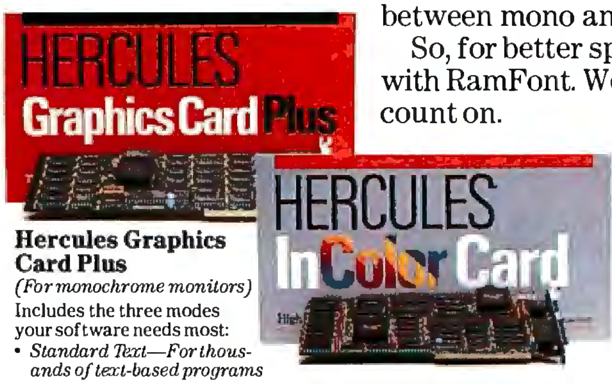

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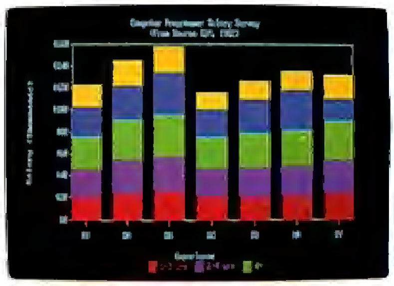

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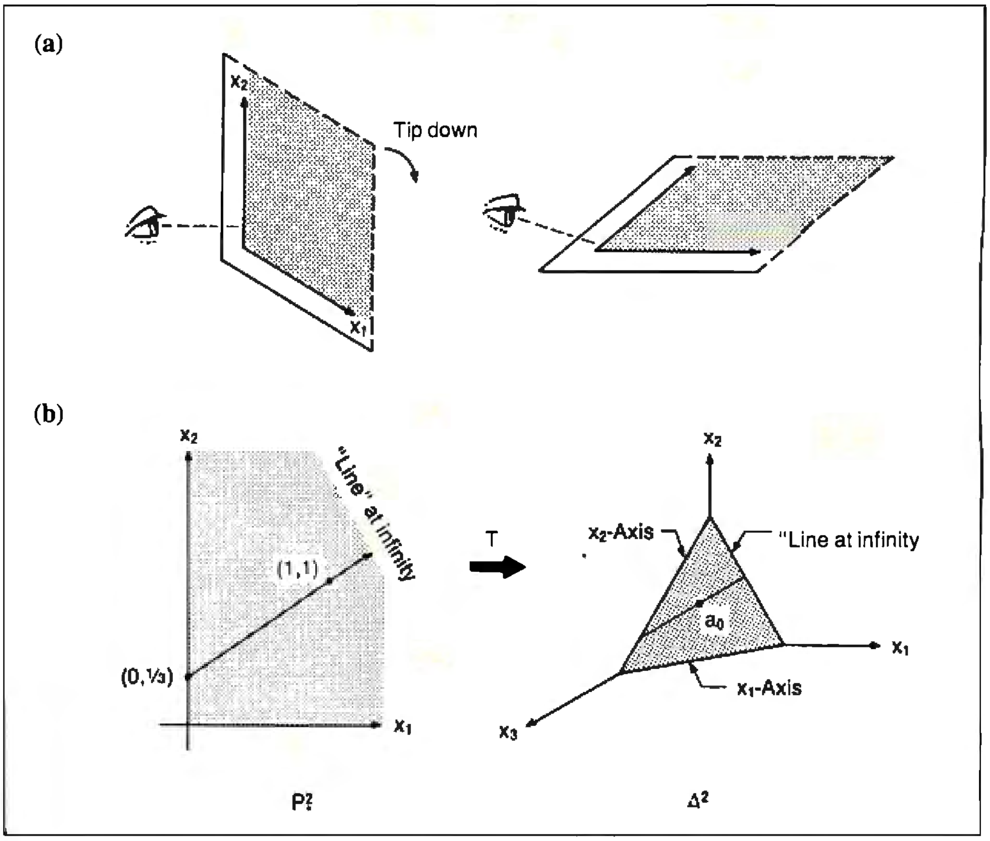
Figure 4: *Reduction to the restricted problem. The projective transformation T sending P_+^2 (the "first quadrant") to Δ^2 can be visualized as follows: Imagine tipping the sketch of P_+^2 so that "infinity" dips down to the horizon* (**a**). *What you now see is a triangle bounded by the two axes and the horizon line or "line at infinity"* (**b**).



$$(7)\quad X_k = \frac{x_k/a_k}{(x_1/a_1) + \ldots + (x_n/a_n) + 1} \quad \text{for } k = 1, \ldots, n;$$

and

$$X_{n+1} = \frac{1}{(x_1/a_1) + \ldots + (x_n/a_n) + 1}$$

where, as in the example, lowercase components are for the vector in P_+^n while uppercase components are for the vector in Δ^n (which requires $n+1$ components since $\Delta^n \subset R^{n+1}$). As in the example, the system of equations $\mathbf{Ax} = \mathbf{b}$ in problem (3) is transformed into a homogeneous system as required by problem (4) since we have the additional component X_{n+1}, which can be used to eliminate the constant terms in the constraints of (3). Moreover, assumption (B) is satisfied since T sends the feasible point $\mathbf{a}$ to the center $\mathbf{a}_0$ of the simplex Δ^n.

It remains for us to explain two things: first, how the interior feasible point can be found (since it is essential for the construction of the transformation T); and second, what to do if the minimum of the objective function is not known.

Feasibility Problems

Given a system of equations $\mathbf{Ax} = \mathbf{b}$ as in problem (3), we wish to find a solution $\mathbf{a}$ in the interior of P_+^n. Let $\mathbf{x}_0 = \mathbf{e}$ (so $\mathbf{x}_0$ is in the interior of P_+^n) and let $\mathbf{b}_0 = \mathbf{Ax}_0 - \mathbf{b}$. If $\mathbf{b}_0 = \mathbf{0}$, then $\mathbf{x}_0$ is feasible and we are done, so let us suppose that $\mathbf{b}_0$ is not zero. We introduce an artificial variable λ and consider the problem

$$(8)\quad \begin{array}{l} \text{minimize } \lambda \\ \text{subject to } \mathbf{Ax} - \mathbf{b} = \lambda \mathbf{b}_0 \\ \text{where } \mathbf{x} \geq 0 \text{ and } \lambda \geq 0 \end{array}$$

But $\mathbf{x} = \mathbf{x}_0$ and $\lambda = 1$ is a feasible point for (8), and this problem is of the form (3). If the minimum of λ is zero, then we have solved $\mathbf{Ax} - \mathbf{b} = 0$, and we have a feasible point for problem (3). Of course, if there is no feasible point to be found, then problem (3) has no solution anyway.

Since the feasibility problem corresponding to example 1b is rather trivial, let us consider a slightly larger problem that might come from a problem of the form (1). The four inequalities

$$\begin{array}{lll} x_1 & & \leq 3 \\ x_1 & & \geq 2 \\ & x_2 & \leq 5 \\ & x_2 & \geq 4 \end{array}$$

form the boundaries of a 1-by-1 unit square in P_+^2 whose upper left corner is $(2, 5)^T$.

If we introduce four (nonnegative) slack variables, we can rewrite these inequalities as equalities:

$$\begin{array}{llllllll} x_1 & & + s_1 & & & & = 3 \\ x_1 & & & - s_2 & & & = 2 \\ & x_2 & & & + s_3 & & = 5 \\ & x_2 & & & & - s_4 & = 4 \end{array}$$

We now have a problem in P_+^6. Setting $\mathbf{x}_0 = \mathbf{e}$ and $\mathbf{b}_0 = \mathbf{Ax}_0 - \mathbf{b}$, we find that $\mathbf{b}_0^T = (-1, -2, -3, -4)$, so our problem can be rewritten as

Example 2a:

$$\text{minimize } (0\;0\;0\;0\;0\;0\;1)\mathbf{Y}$$

$$\text{subject to } \begin{pmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & -1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 & 1 & 0 & 3 \\ 0 & 1 & 0 & 0 & 0 & -1 & 4 \end{pmatrix} \mathbf{Y} = \begin{pmatrix} 3 \\ 2 \\ 5 \\ 4 \end{pmatrix}$$

$$\text{and} \quad \mathbf{Y} \in P_+^7$$

continued

Here $y_1, \ldots, y_6$ correspond to $x_1, \ldots, x_6$ and y_7 to λ. But this problem is similar to example 1b, and we can apply the projective transformation $T{:}P_+^7 \rightarrow \Delta^7 \subset R^8$ given by

$$Y_k = \frac{y_k}{y_1 + \ldots + y_7 + 1} \quad \text{for } k = 1, \ldots, 7; \text{ and}$$

$$Y_8 = \frac{1}{y_1 + \ldots + y_7 + 1}$$

(using our usual notation) to obtain a problem in the form of problem (4):

Example 2b:
minimize (0 0 0 0 0 0 1 0)Y

$$\text{subject to} \begin{pmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 1 & -3 \\ 1 & 0 & 0 & -1 & 0 & 0 & 2 & -2 \\ 0 & 1 & 0 & 0 & 1 & 0 & 3 & -5 \\ 0 & 1 & 0 & 0 & 0 & -1 & 4 & -4 \end{pmatrix} \mathbf{Y} = 0$$

and $\quad \mathbf{Y} \in \Delta^7$

After this problem is solved by Karmarkar's algorithm, the inverse projective transformation must be applied to return to our original coordinates in P_+^7. Of course, we are interested only in the first two coordinates; the rest are the four slack variables and the artificial variable.

The BASIC program KAREX2 carries out this calculation for example 2 and arrives at the solution $x_1^{(26)} = 2.46123$ and $x_2^{(26)}$ 4.42794 with a tolerance of 0.001. [Editor's note: *See the end of the article for more information on KAREX2 and KAREX3. These two programs are minor variations on listing 1.*]

An Infeasible Problem

Suppose example 2 were not feasible. How would we have discovered this using Karmarkar's algorithm? From equation (6) we saw that if the algorithm is carried out m times, the ratio $\mathbf{c}^T\mathbf{x}^{(m)}/\mathbf{c}^T\mathbf{a}_0$ must be no more than a certain size. Thus given the q from assumption (C) of problem (4), we can calculate in advance the maximum number of iterations we will run the algorithm. If after that many iterations we do not have an answer within the required tolerance, then our system of equations is not feasible.

For example, let us alter the situation of example 2 to require $x_1 \geq 3$ and $x_1 \leq 2$ instead of $2 \leq x_1 \leq 3$. Proceeding as before, we obtain

Example 3:
minimize (0 0 0 0 0 0 1 0)Y

$$\text{subject to} \begin{pmatrix} 1 & 0 & -1 & 0 & 0 & 0 & 3 & -3 \\ 1 & 0 & 0 & 1 & 0 & 0 & 0 & -2 \\ 0 & 1 & 0 & 0 & 1 & 0 & 3 & -5 \\ 0 & 1 & 0 & 0 & 0 & -1 & 4 & -4 \end{pmatrix} \mathbf{Y} = 0$$

and $\quad \mathbf{Y} \in \Delta^7$

The BASIC program KAREX3 attempts to solve this problem in the same manner that KAREX2 solved example 2, but we have added a "failure" detection routine: At the end of each iteration, the program tests inequality (6) and ends if it does not hold. We decided to use inequality (6) in our example rather than the later inequality Karmarkar used to estimate the number of iterations because dropping the $\Sigma \ln(x_k^{(m)})$ terms results in a rather large overestimate of the number of steps needed. The program fails at iteration 26 where $x_1^{(26)} = 1.81118$ and $x_2^{(26)} = 3.02786$.

continued

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Solving an LP Problem

Now we can put all these pieces together and explain how to solve the linear programming problem (3). One way would be to rewrite the problem as a (giant) feasibility problem (as we described for Khachiyan's algorithm) and then proceed to solve it. While this way of solving a linear programming problem looks nice, it defeats the advantage of Karmarkar's approach: the use of the objective function as a gradient to find the "best" direction to move.

Karmarkar's solution is as follows: First, find a feasible point in the interior of P_+^n. If no point can be found, then there is no solution to the problem and we are finished. Given a feasible point, construct the transformation (7) and reduce the problem to the restricted form (4) with assumptions (B) and (C) fulfilled.

Now we must deal with assumption (A). If the actual minimum is known, we can proceed as before by altering the objective function (as we did with example 1a). But what if the minimum value is unknown? We can at least put upper and lower bounds, say u_0 and l_0, on it (these may be ridiculous overestimates, but since the objective function is a linear function on a bounded region, such bounds must exist). Now divide the difference between these bounds into thirds and set $l_1 = l_0 + (u_0 - l_0)/3$ and $u_1 = l_0 + 2(u_0 - l_0)/3$. If we pretend that the minimum actually is l_1 and run the algorithm (modified so that if it finds a point $\mathbf{x}^{(m)}$ with $\mathbf{c}^T\mathbf{x}^{(m)} < 0$ then it backtracks along the line segment to $\mathbf{x}^{(m-1)}$ to find the point with $\mathbf{c}^T\mathbf{x} = \mathbf{0}$ and returns this value as $\mathbf{x}^{(m)}$), we will find out whether or not the real minimum is between l_0 and l_1. If it is, we have new upper and lower bounds and we can repeat this process; if it is not, we can pretend that u_1 is the minimum and try again. Either way, the range between the upper and lower bounds is reduced by either 1/3 or ⅔ each time. In this way, we can zero in on the actual minimum of the objective function very quickly.

Some Implementation Comments

As you may have noticed, we have used $\mathbf{a}_0 = \mathbf{e}$, the unit vector, in our examples; this was done only to simplify the arithmetic. The projective transformation $T{:}P_+^n \rightarrow \Delta^n$ in equation (7) is defined for any point $\mathbf{a}$ in the interior of P_+^n; clearly, the more "intelligent" your choice of $\mathbf{a}_0$, the quicker Karmarkar's algorithm will find the solution.

Karmarkar's estimates of the relation between the α and δ were crucial to the proofs of his theorems. Since the feasible point used as the initial point in his algorithm is arbitrary, it is clear that as a practical matter, α may be allowed to vary from step to step. One may choose α so that each successive approximation to the solution remains feasible and interior to Δ^n. You are invited to experiment with various αs in the example programs we have included.

While we have touched on the issue of complexity, our discussions have been far from complete. It is difficult to compare the simplex method and Karmarkar's algorithm since the work involved within each of their respective steps is different. The main bottleneck in Karmarkar's algorithm is the matrix inversion step needed for the orthogonal projection of $\mathbf{c}$ to $\mathbf{c}_p$. In our sample programs, we have made no attempt at speed: We find $(\mathbf{BB}^T)^{-1}$ by brute force row reduction of $\mathbf{BB}^T|\mathbf{I}_{m+1}$. Karmarkar also describes a modified algorithm in which the computations in the $(k+1)$th step use those of the kth step, and he is able to reduce the arithmetic operations required for each step from $O(n^3)$ to $O(n^{2.5})$. Readers interested in this modification should consult Karmarkar's original paper (cited at the beginning of this article). ■

[Editor's note: *The source code for KAREX1.BAS, KAREX2-.BAS, and KAREX3.BAS is available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet; see page 4.*]

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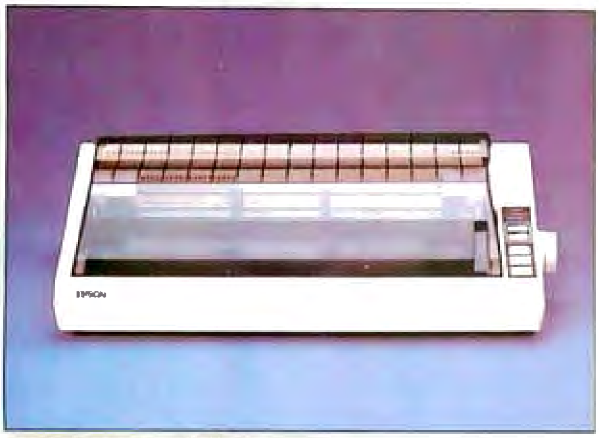

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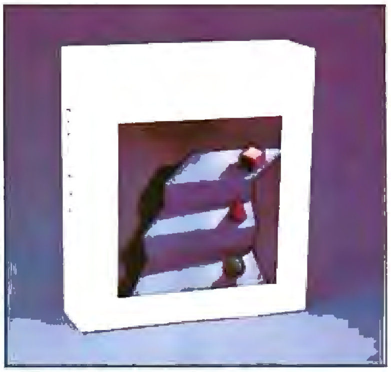

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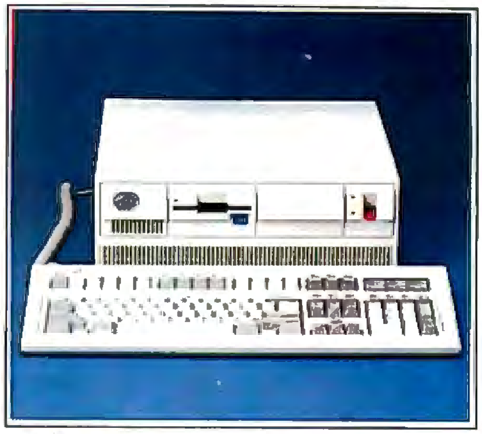

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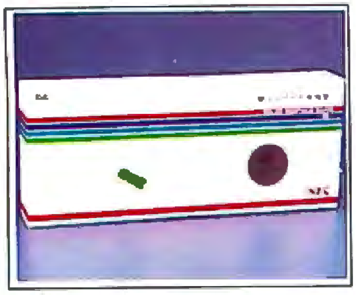

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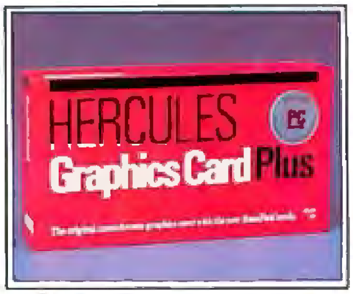

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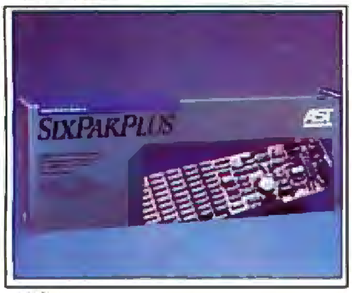

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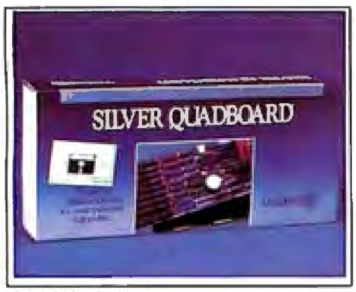

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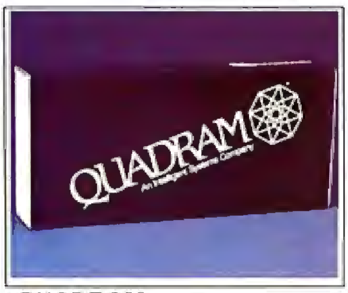

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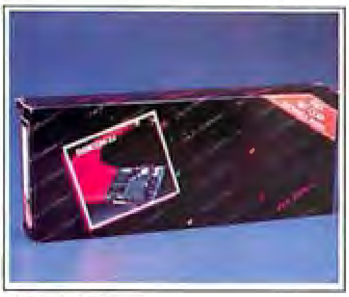

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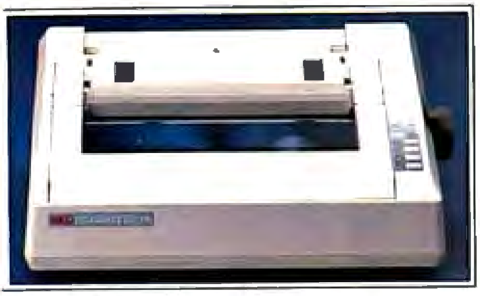

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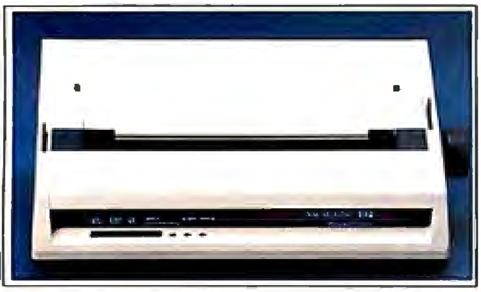

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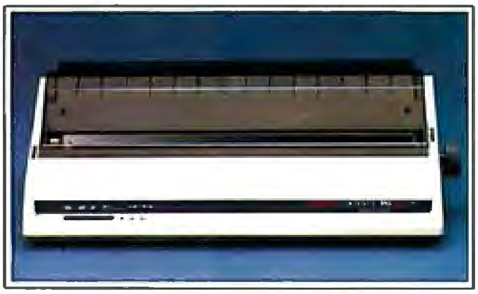

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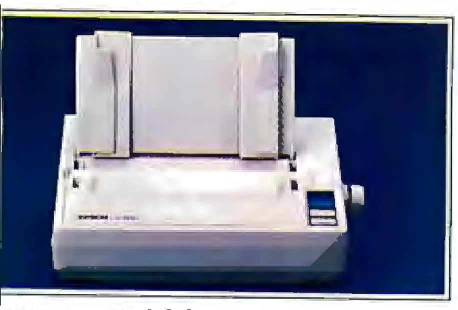

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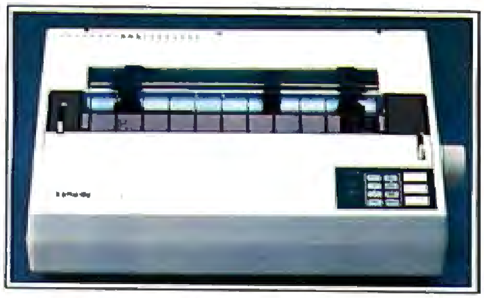

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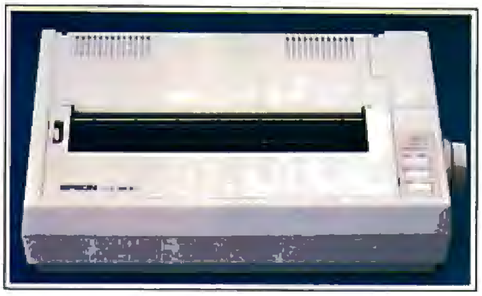

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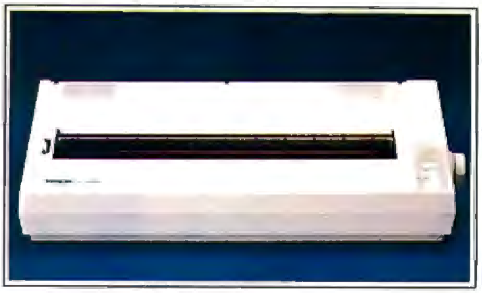

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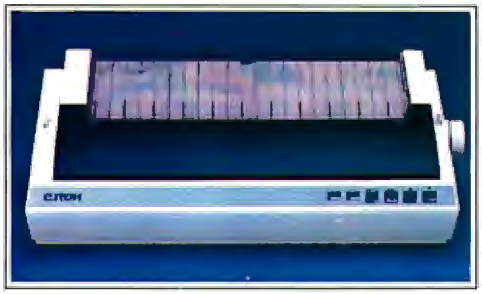

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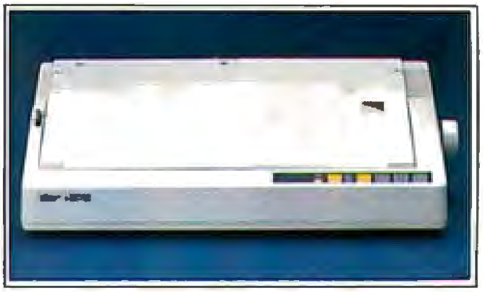

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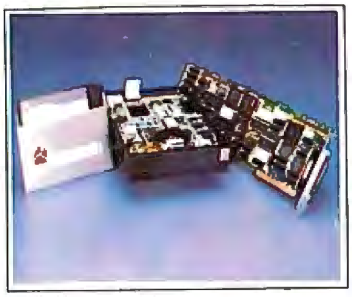

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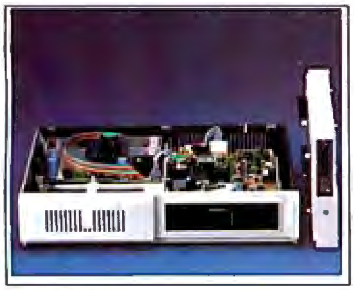

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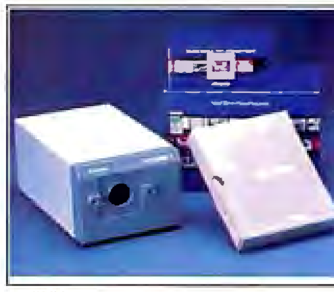

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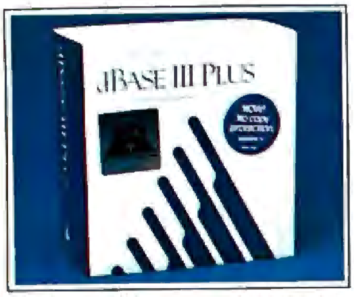

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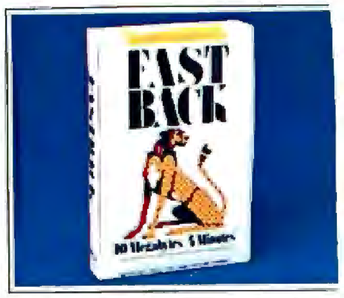

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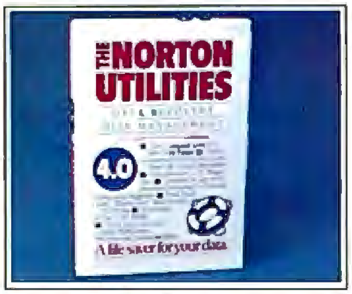

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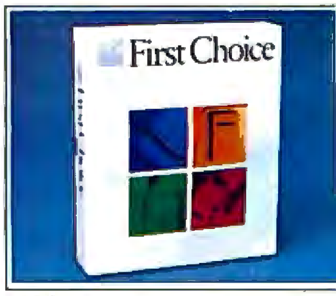

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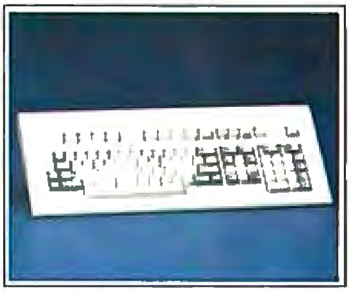

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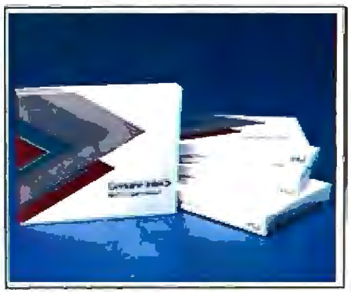

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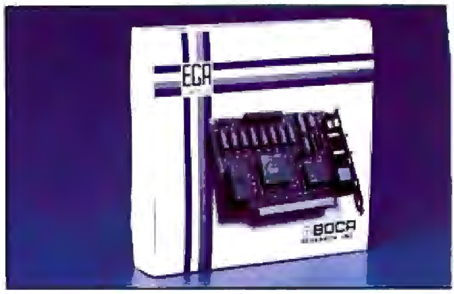

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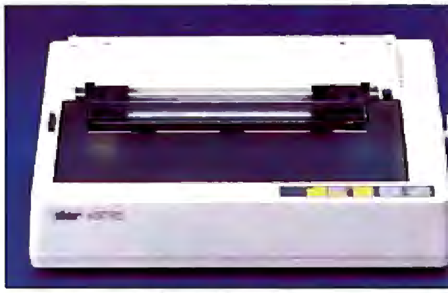

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Printer Technologies

Introduction

Printer Technologies

The values by which we measure printers are easily understood and yet imprecisely defined. *Speed* is easiest to measure in characters per second, but that approach has little value to users, who are more interested in pages per minute, a value that can't be derived simply from a printer's maximum rate. But measures of throughput require agreement on what constitutes a representative document.

Quality doesn't lend itself to precise definition either. Each level of printing—draft, near-letter-quality, and letter-quality—has its own separate criteria. Furthermore, each different technology tends to have its own set of standards.

Even *cost* comparison is not always straightforward. Increasingly, printers have optional font cards or cartridges and software that may affect cost. With page printers, the addition of memory to a system may make cost comparisons misleading, and the presence or absence of on-board intelligence, in the form of a controller, can also confuse cost comparisons.

In this collection of articles, we've tried to help define the issues more precisely by explaining exactly what goes into the various technologies. Rick Cook's article, "Page Printers," brings out some important distinctions and limitations of laser, liquid-crystal-shutter, and light-emitting-diode designs. He explains why these units are so expensive and what it will take to bring their costs down.

In "Color Printing," Naomi M. Luft describes the subtractive color process and the various ways we have of currently getting living color on paper. This article also includes a text box entitled "Plastic Ink," which describes a new implementation of the ink-jet technology.

Lars Jansson takes an original and direct approach to the question of "Print Quality." He explains the factors affecting print quality and proposes a set of objective measurements. Dick Pountain puts aside his regular column this month to discuss the conversions necessary to make rasterized images from vector information in "Vector-to-Raster Algorithms."

Turning to more traditional printer designs, three short engineering close-ups give an insider's view of how dot-matrix-impact, thermal-transfer, and other designs continue to be refined. "Taming the Hot Heads" by Keith B. Davenport shows how careful engineering and CAD have helped to maximize print-head efficiency and reduce the heat buildup that comes with fast printing. Mark Hohneker summarizes an alternative approach to standard dot-matrix-impact designs in "Matrix-Line Printing," and Julio Guardado describes another increasingly important technology in "Color Thermal-Transfer Printing."

Two additional engineering close-ups deal with page printers. In "Designing a High-Speed Page Printer Controller," Phil Ellison describes what is involved in making a page printer controller in order to maximize throughput. On an even more detailed level is Bert Douglas's article, "Strip-Buffer vs. Full-Page Bit-Map Imaging."

One aspect of printer technology we don't cover in this section is speed—how to measure and define it. Instead, we will conclude this introduction with a summary of a proposed new standard for measuring speed.

According to a draft version of the European Printer Performance Test (EPPT), 11 major printer manufacturers in Europe worked to develop the specification for measuring true print speed or throughput. The specification is intended for use with all printer designs (i.e., dot-matrix, daisy-wheel, ink-jet, thermal-transfer, and laser). The standard does not deal with measurements or criteria for measuring quality, character fonts, and so forth. However, it does provide a descriptive system for defining the various quality levels so that, for example, draft printing and letter-quality printing speed become objective terms.

The hope of the original group of 11 manufacturers is that the proposed standard will be adopted or at least incorporated into an official standard by the European Computer Manufacturers Association (ECMA) and the American National Standards Institute (ANSI). The test is designed for use only with printers that support European languages.

The tests are divided into performance tests and endurance tests. For the performance tests, the data patterns are printed five times. For the endurance tests, data patterns are printed repeatedly for 1 hour. The tests are (a) a letter test using a standardized letter; (b) a spreadsheet test using a 132-character-per-line spreadsheet; and (c) a graphics test, consisting of two vertical lines and two triangles, made up strictly of bit-image information.

The draft version of the EPPT runs 14 pages plus appendixes. It is a precise and well thought-out standard and, if adopted, will do much to eliminate the current confusion regarding advertising and specification of printing speed. For further information on the proposed EPPT, you can write to Alan Clemmetson, Dataquest U.K. Ltd., 13th Floor, Centre Point Bldg., 103 New Oxford St., London WC1A 1DD, U.K.

—George A. Stewart and Jane Morrill Tazelaar, Technical Editors

Color Printing

A balancing act among price, performance, and print quality

Naomi M. Luft

IN COLOR PRINTING, you get what you pay for. The key word, and one I will use many times, is *trade-off*. You pay for higher resolution with longer processing and printing times. To get higher speed, you pay—and pay. To get more color choices, you trade effective print resolution. And the list goes on. But the list of available color-printing technologies also goes on; the current total is six.

In order of current popularity, these six basic color-printing technologies are pen and electrostatic plotters, and thermal-transfer, ink-jet, serial dot-matrix, and electrophotographic (color laser) printers. The vector-oriented pen plotters are by far the most popular, largely because they are flexible. They "write" with varied-color pens on various media and have a large base of existing software. However, raster-based competitive technologies are gaining ground by offering faster print speeds, superior text printing, and compatibility with the emerging world of digital imaging.

Unlike pen plotters, raster-based printing systems must perform several electronic image-creation functions, including combining basic colors under software control, precisely overlaying colors to get shades, and interpreting a rasterized bit stream rather than vector commands. Although each color-printing technology handles these required functions differently, some basic principles are common to all.

Generating Colors

The most familiar example of a raster-based product that produces a variety of shades through color mixing is the television set. The color "model" used for producing colors on TVs, and the closely related color computer monitors, is RGB: Three light sources (red, green, and blue) generate the color within the monitor. The presence of all three colors creates white, while their absence results in black. Red, green, and blue are sometimes called the *additive* colors.

Printing systems usually do not use the RGB model because the colors are strong and opaque and therefore do not combine well. Instead, the complementary model, CMY (cyan, magenta, and yellow), is customary. Cyan, magenta, and yellow are referred to as the *subtractive* primaries because they create color by subtracting a particular color of light reflected off a white page. Cyan is the absence of red, magenta the absence of green, and yellow the absence of blue. You can combine these three colors to create the additive colors (red, green, and blue), as well as black (see figure 1). (Since this combined black often appears brown, many printers are also configured with a "true" black as a fourth color.)

The process of combining colors is mechanically tricky and represents a technical challenge for all printer technologies. With the exception of ink-jet, all color printers separate the printing function for each of the subtractive colors, overlaying the colors in several passes. Thus, registration is critical to ensure that each pixel lines up precisely with the corresponding pixel from a previous pass. In moving-head (serial) printing systems, such as serial dot-matrix and some thermal-transfer printers, the print head traverses the same line repeatedly until it has printed all the colors, then the paper moves to the next line. Page-oriented systems, such as fixed-head thermal-transfer, electrostatic, and electrophotographic printers, print the entire page in one color before going to the next color.

Mixing Colors

Processing color separations and overlaying pixels become even more complex when an application requires more than the seven basic colors shown in figure 1. In general, printers lack the flexibility of computer monitors, which can vary shades under software control by varying the intensity of the electron beam. The only printing technology to achieve shading by varying the electrical signal is *dye sublimation*, an emerging subset of thermal-transfer printing that creates near-photographic-quality output. The more common approach to printing shades of the basic colors is *dithering*.

The dithering process generates shades of gray by mixing black with various percentages of white. Rather than treating each pixel as a single dot, systems that employ dithering combine dots into a matrix to create intermediate color values. Figure 2 shows how, in a 2-by-2 matrix,

continued

Naomi M. Luft is a senior research analyst specializing in nonimpact printing technology at Datek Information Services, P. O. Box 68, Newtonville, MA 02160.

you can combine the two basic values, black and white, into five shades.

In color systems, the range of shades increases substantially with a 2-by-2 matrix. Each subtractive color can have five intensity levels that can in turn be overprinted, thereby generating up to 125 different shades (5 by 5 by 5, with the three multiples representing the three subtractive colors). The possibilities increase as the matrix size increases. In a 3-by-3 matrix, each color can have 10 intensity levels, so you can achieve 1000 shades of color. Dithering patterns exist in the application software, the printer-resident firmware, or a combination of both.

You make trade-offs, however, in this method of increasing the number of colors. Dithering is effective only in relatively high resolution systems in which individual dots are barely distinguishable and, consequently, a matrix of dots is small enough to appear as a single picture element, so the color shade appears spatially integrated to the eye. The matrix structure effectively reduces the printer's resolution. For example, if a 200-dot-per-inch printer generates 125 shades using a 2-by-2 matrix, its effective resolution is reduced by that factor of 2 to 100 dpi. For 1000 colors (the 3-by-3 matrix), the effective resolution is reduced by a factor of 3 to 67 dpi. Therefore, when you need the highest possible resolution, you need to restrict your choices to the seven basic colors. Dithering is especially useful for shading large areas like pie charts in business graphics.

Two alternatives to dithering maintain printer resolution while they expand the number of color shades. One approach, used in commercial printing, is to vary the size of the dot in a technique called *halftoning*. Because it is difficult to control dot size with existing printer technologies, only a few specialized systems have taken this approach; most of them use ink-jet technology.

Another approach is to use ink or ribbons with more than three subtractive colors, ideally, two intensity levels for each subtractive primary. With six colors plus black, you could generate 216 colors per picture element without losing any resolution. The disadvantages of this approach are that the costs of hardware and supplies increase while throughput rates decline, since you need to either make more passes or distribute hardware resources, such as ink-jet nozzles, between more colors.

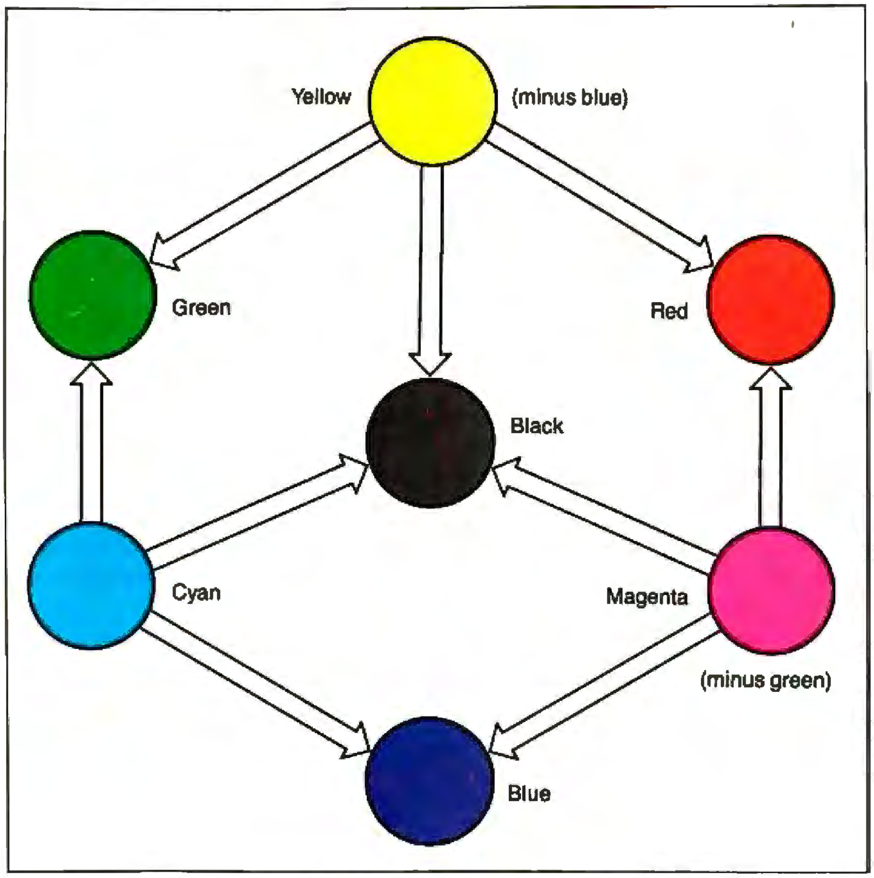

Figure 1: *This diagram shows the actual subtractive colors: cyan, magenta, and yellow. The other colors—red, blue, green, and black—were formed by combining these colors; that is, the yellow and magenta together form the red shown here, and so on. The brownish black is a combination of CMY and illustrates why many printer manufacturers add a true black to their colors.*

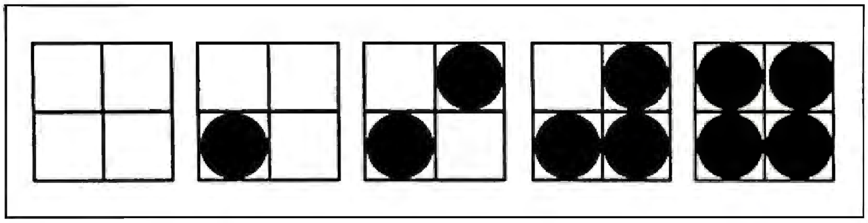

Figure 2: *Dithering generates shades of gray by mixing black and white. Treating each dot as a 2-by-2 matrix lets you combine black and white into five shades: 100 percent white, 25 percent black and 75 percent white, 50/50, and so on. You can employ a similar scheme with colors, greatly increasing the number of available colors but also decreasing the final resolution.*

Setting Up Your System

With the exception of pen plotters, all current color printers are raster-based; that is, the image is decomposed into scan lines and then reconstructed during printing. Since most software defines graphics in terms of vectors, graphics systems have an algorithm to convert vector commands into a matrix for display on the raster-based monitor; you can use this same matrix to print the image (see "Vector-to-Raster Algorithms" by Dick Pountain on page 177). Again, trade-offs are involved in choosing various print matrices.

Three basic configuration choices exist: You can attach a printer directly to the monitor's screen buffer, which holds a bit map of pixel information; a printer can share the video signal with the monitor; or you can convert the computer's vector information into a printer-compatible raster image via software or dedicated hardware.

The first two choices are "screen-dump" methods that let you bypass the need for software drivers and generate quick hard copies of screen information. The information is transferred one for one from the computer to the hard-copy device; therefore, whatever is on the

continued

screen will appear exactly the same way on the printer. However, the printer usually has a higher resolution than the system monitor. Thus, when you transmit the pixels to the printer and print them at full resolution, the printed image becomes much smaller than the displayed image was. For example, a 640- by 480-pixel image on the screen printed at 200 dpi becomes a 3.2- by 2.4-inch printout. Systems usually compensate by assigning multiple print dots to each screen pixel to get a larger image. Since this method doesn't take advantage of the printer's higher resolution, the "jaggies" (visible stairstepping) from the screen also appear on the printout.

The third approach, converting vectors to raster information specifically for the printer, has the advantage of not limiting the image to the size of the monitor's screen buffer; printing can take place at full resolution. The trade-offs are in price and performance. Because the system must manipulate many more bits of information, this approach is both processing- and memory-intensive, which adds to the expense and can result in low throughput rates.

Vector-to-raster conversion can take two approaches: software- or hardware-based. Some systems generate raster data in host software and transmit a bit map to the printer via the standard printer interface. The main disadvantage of this software-based method is that it ties up the host during image processing. More advanced systems frequently use dedicated hardware processors that are optimized for this conversion function. The configuration possibilities include an external box, an add-in card, and a printer-resident controller. Add-in cards can cost as little as $600, while the higher-performance rasterizers can run over $6000, a hefty price now that most high-end color printers cost under $10,000. In addition, you need software drivers to link applications with each specific output device.

I want to look at the operating principles and performance trade-offs of the six color-printing and -plotting technologies currently available. Figure 3 illustrates how these technologies compare in price and performance.

Pen Plotters

To date, pen plotters have been the most popular color-output devices. Widely used in technical applications such as CAD/CAE, they can produce output up to E-size (34 by 44 inches). Office applications, such as business graphics and presentation materials, increasingly use plotters. Desktop models for A- and B-size drawings are available for under $2000, and software drivers in numerous packages support them. On the systems level, pen plotters are less complex and less expensive than many other printers because they can interpret software directly in terms of vectors and, thus, don't need vector-to-raster conversion.

Mechanically intensive devices, pen plotters require that various pens and output media (paper, transparencies, vellum) move under software control, so that the pens can actually write to generate a graphic and associated text. Plotting involves combining *x* and *y* motions to execute vector commands (e.g., to draw a line between two points or a circle around a point). You change colors by mechanically switching pens typically held in a carousel or bank along the side of the plotter. The number of pens ranges from 2 to more than 10.

Plotters fall into three basic groups: flatbed, drum, and hybrid. All three have a carriage bar along which the pen moves to draw along one axis (say, the *x* axis). They differ in how they achieve pen motion in the *y* direction. *Flatbed* plotters hold the paper stationary while the pen moves in the *y* direction; the size of the flatbed creates the limit on output size. For applications that require output-size flexibility, you would use a drum or hybrid model. *Drum* plotters move the paper back and forth using a rotation drum to achieve motion in the *y* direction. *Hybrid* plotters similarly move the paper to achieve *y* movement; however, they hold it between friction rollers, are much smaller than drum plotters, and have no mechanism for rolling up long plots.

Available pen plotters offer varying levels of plotting accuracy and speed. High-level systems have resolutions to 0.001 inch, meaning that they can mechanically place dots that close to each other. Another measure of accuracy is repeatability, or how precisely the plotter

continued

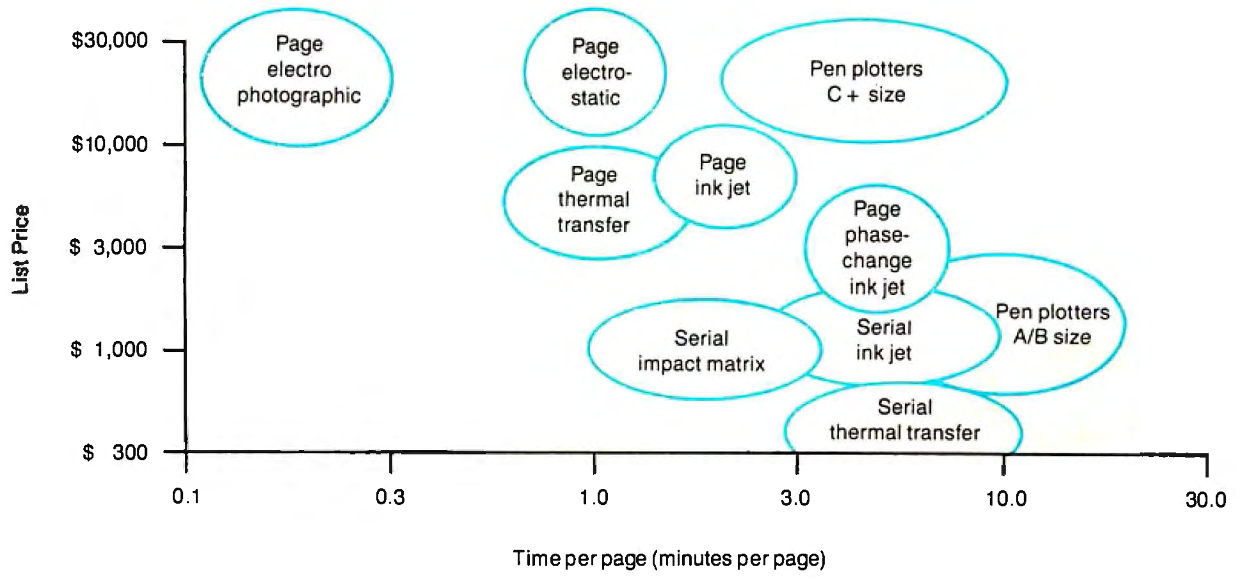

Figure 3: *A price/performance comparison of color-printer technologies.*


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can return to a specific point again and again. Although the pens can move several inches per second, effectively, pen plotters are the slowest color technology. Desktop-size plotters can take 3 to 6 minutes for simple business graphs and up to 20 minutes for more complex plots with large area fills.

Electrostatic Plotters

Electrostatic technology was the first raster-based output method widely used for printing color graphics, particularly in technical environments. Its primary advantages over pen plotting are its improved speed, quiet operation, and suitability for unattended operation. Like pen plotters, some electrostatic plotters are capable of large-format output. However, electrostatic plotters are among the most expensive color printers available, with B-size products costing between $12,000 and $14,000, and larger-format plotters ranging from $40,000 to $100,000 or more. In addition, you must use a special dielectric coated paper.

Electrostatic plotters operate by passing dielectric paper under a fixed-page-width electrostatic head that consists of a line of individual styli. Voltage is selectively applied to the individual styli, placing a charge on the dielectric paper and creating a latent image. Then the paper passes through a bath of liquid toner, and the charged areas attract toner particles. In a color system, this charging and toning process takes place several times (three if you use CMY, four if you add a separate black); the toner bath is different for each color. As a result, this technology is mechanically complex. Figure 4 is a schematic of an electrostatic plotter by Benson Inc.; this plotter is unique in that it has multiple heads as well as multiple toner baths so you don't need to rewind the paper between colors.

One advantage of electrostatic plotters is their high-resolution output. Several systems exist with 400-dpi resolution, which improves output quality, especially when you need a large number of colors (due to the trade-offs between dithering and resolution). Some plotters also have a lower-resolution mode for proofing or plotting at higher speeds; 400 dpi is relatively slow in terms of processing time and paper-indexing rate.

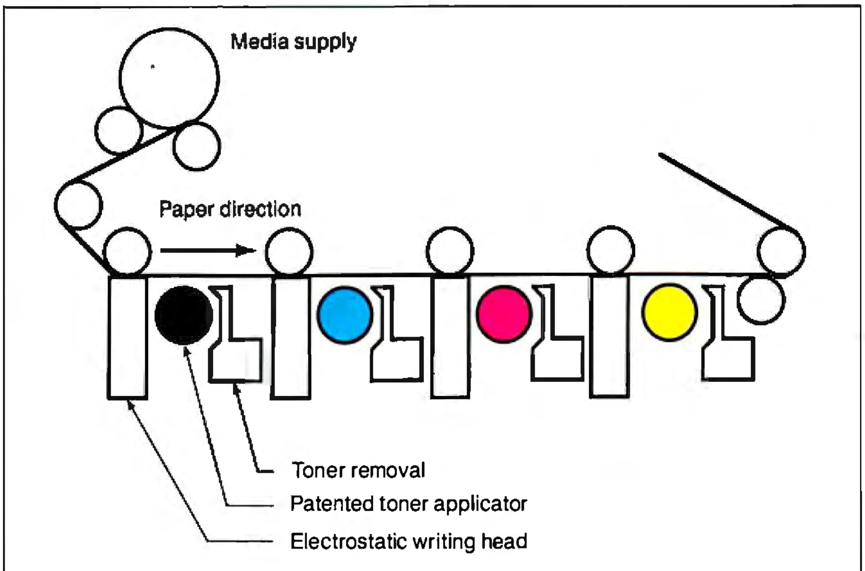

Figure 4: *Schematic of an electrostatic plotter by Benson Inc. Note that this plotter has multiple electrostatic heads as well as multiple toner baths so that the paper makes only a single pass and needs no rewinding between colors.*

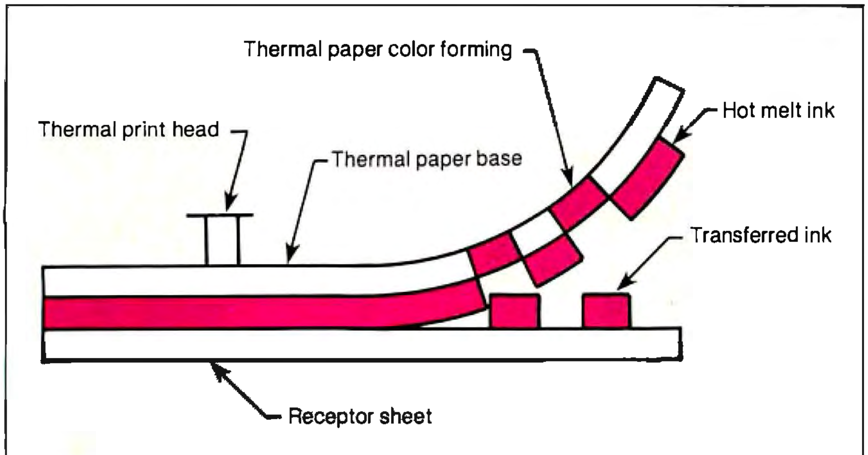

Figure 5: *How thermal-transfer printing works. To print in color and on plain paper, you use a ribbon composed of blocks of the subtractive colors, which you overprint to obtain the various colors.*

Thermal Transfer

Thermal-transfer printers come in two varieties: serial (moving-head) printers and fixed-head page printers. Although both types lay down color similarly and require the same kind of media, they vary significantly in price. The serial printers, usually appealing to home users, cost less than $300. The page-oriented systems, primarily used for engineering output (in many cases for proof copies, due to output-size limitations) and some new applications such as presentation graphics, cost between $4500 and $10,000. Thermal-transfer printing is particularly effective for area fills, since the density of the graphic does not affect print speed in page systems.

Three key elements compose thermal-transfer printing: a thermal head, a ribbon, and paper. The thermal head consists of a set of resistive elements that selectively heat up when an electrical current is applied. Direct-thermal printers, in which the head causes a specially treated paper to darken, have used these heads for a long time. Thermal-transfer printing inserts a wax-coated ribbon between the head and paper. The ribbon is heated from behind, the wax-based ink coating melts, and the image is transferred to the paper (see figure 5). Using a ribbon lets the thermal head print on plain paper and in color.

Like electrostatic plotters, thermal-transfer printers produce color prints through multiple passes of the subtractive primaries. In both serial and fixed-head configurations, the thermal-transfer ribbon has blocks of each subtractive color. In serial printers, these blocks are the same length as the print line: The head traverses the line with one color and then goes back to the beginning of the same line to overprint it with another color, and so on. The print mechanism indexes

continued

While ink-jet printing is conceptually very attractive, it has a number of problems.

to the next print line only after all three or four colors have printed and the ribbon has progressed to a new block of the first color. In fixed-head page printers, the color blocks are page-size. You must pass the whole page under the head several times, usually by backing the paper up and refeeding it, an approach that offers a registration challenge. The size of these ribbon blocks effectively limits the size of a printed page.

Thermal-transfer printing has several advantages: The serial printers offer the least-expensive color output currently available, while the page printers offer relatively fast print speeds (some systems can print a page in less than a minute), high resolution (the majority of printers now have 200- or 300-dpi resolution), and reliability. The disadvantages of thermal-transfer technology include the cost of supplies (the ribbons are expensive, and most systems require special "plain" paper with a very smooth finish) and print quality (some users object to the shiny crayon-like output).

Ink-Jet

Ink-jet is the only raster-based technology that prints color in a single pass. This is possible because ink-jet heads have multiple ink nozzles, with at least one per subtractive color. Having several nozzles per color increases overall throughput speed. Because of the need for extensive "plumbing" (connecting nozzles to multiple ink sources), ink-jet printers tend to be more costly than thermal-transfer printers for a given performance class, ranging in price from $700 to about $6000. In addition, early systems were plagued with reliability problems, such as clogged nozzles from dried ink, which gave the technology a bad name. Figure 6 is a schematic of an early-model ink-jet printer from Advanced Color Technology.

Ink-jet printing is a true noncontact technology. A print head generates individual ink droplets and propels them to the paper, creating characters and patterns (see photos 1a to 1d).

Three basic classes of ink-jet printers exist: continuous-jet, drop-on-demand, and phase-change. *Continuous-jet* printers employ a stream of ink droplets (typically more than 50,000 per second) issued from print nozzles under pressure. A charge is selectively applied to the droplets, and, depending upon the desired configuration, some droplets are deflected toward and others away from the page. *Drop-on-demand* printers are simpler, forming droplets in the nozzles and ejecting them through appropriate timing of electr nic signals. Some systems use piezoelectric crystals that constrict the nozzle; others use small heating elements that cause the ink to temporarily boil and be ejected. An even more elaborate use of heat exists in *phase-change* ink-jet printing. This method liquefies solid ink pellets, ejects them from the print nozzles, and "freezes" them on the paper surface without their *wicking*, or bleeding, into the paper. Phase-change ink-jet printing is uncommon (see the text box "Plastic Ink" on page 174).

While ink-jet is conceptually a very attractive technology and offers good color with moderate supply costs, it has a number of problems. You pay a comparative-

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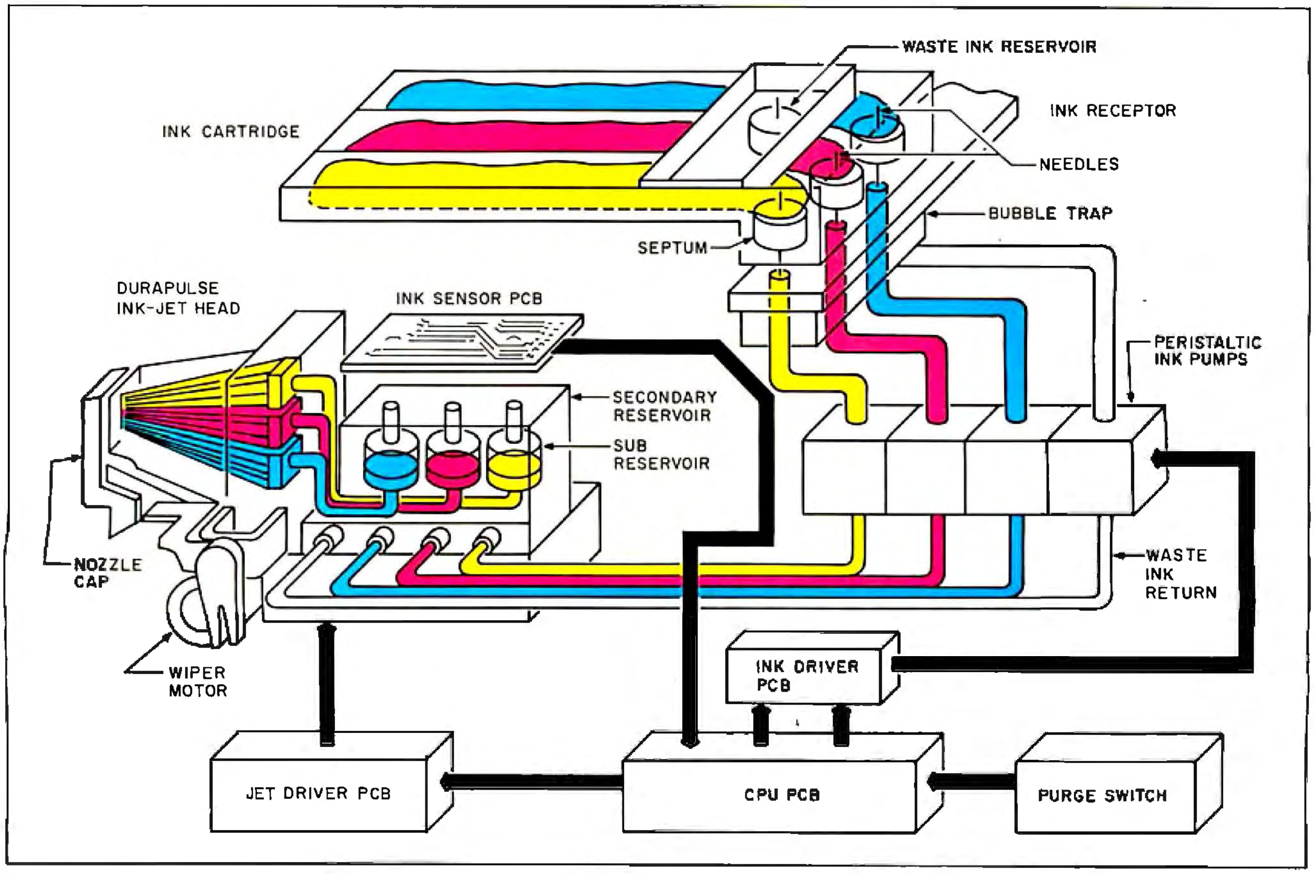

Figure 6: *Schematic of a color ink-jet printer from Advanced Color Technology. This is a diagram of an early model but shows the system's complexity and the kind of plumbing it requires.*

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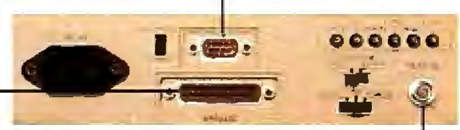

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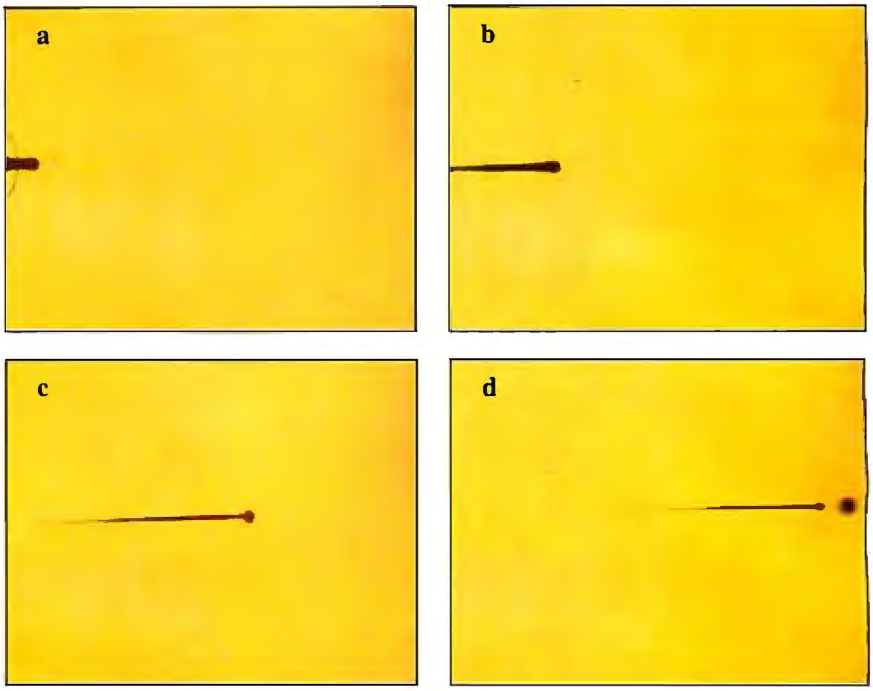

Photo 1: *This sequence of photos shows a drop of ink emerging from the print head of the Hewlett-Packard PaintJet color-graphics printer.* **(a)** *At 25 microseconds, the ink jet is about 0.3 mm long and is still coming out of the nozzle. About half of its length is shown. Note the circular orifice; the ink is going from left to right.* **(b)** *At 45 μs, the head of the ink jet has formed and is almost ready to separate from the rest of the ink jet. The tail of the jet is just now exiting the nozzle. The total jet length is about 0.7 mm.* **(c)** *At 85 μs, the entire jet is shown and is about 0.73 mm long. The head of the jet is about 1.0 mm from the nozzle and has separated from the rest of the ink jet (note the formation of a circular form at the right end of the jet).* **(d)** *At 125 μs, the tail has broken up into separate drops, and the head is about to hit the paper. The drops behind the head are moving quickly and hit the same spot on the paper as the head, creating a single dot.*

ly high price for a product of questionable reliability, you need special paper to reduce ink wicking (phase-change ink being the exception), and throughput is generally slow (up to four minutes per color page).

Serial Dot-Matrix

For office use, serial dot-matrix printers are the most popular. However, they have had a limited presence in color applications, even though an increasing number of them have color capabilities. While most configurations are suitable for business graphics or emphasizing text, few can act as a pen-plotter replacement and produce presentation-quality output.

Serial dot-matrix printing is an impact technology. Wires in a print head are fired, striking the ribbon, which releases ink on the paper as the head traverses the print line. As in serial thermal-transfer printing, all colors are overlaid on each print line before moving on to print the next line. Unlike their thermal-transfer counterparts, however, most serial dot-matrix ribbons have horizontal stripes of the colors that run the length of the ribbon. The system switches colors by mechanically shifting the ribbon up and down. Most serial dot-matrix printers use CMY, but a few use RGB.

Using serial dot-matrix technology for color printing has some favorable points. It is an established, reliable technology, using low-cost supplies, that offers true plain-paper printing and convenient monochrome operation. The technology does have its shortcomings, however. Hard copy is limited to paper; workable transparencies are generally unavailable. When you need area fills, the output tends to streak, and the color lacks brilliance. In addition, the diameter of the wires in the print head limits the potential resolution; most wires are between 0.007 and 0.014 inch.

Color Electrophotography

An electrophotographic printer is essentially a color copier used as a computer printer. Use of electrophotography for color printing is on the verge of becoming a reality. You could convert a color copier into a computer printer by fitting it with a

continued

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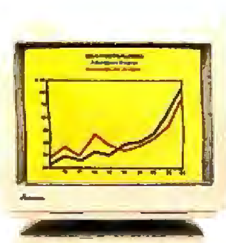

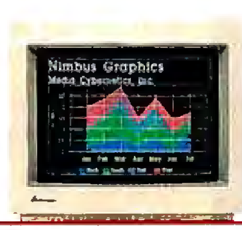

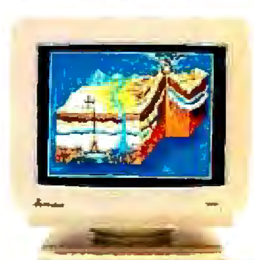

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Plastic Ink

Jane Morrill Tazelaar

Plastic ink? It sounds strange to me, too, but Thermo Jet, an ink-jet technology from Howtek Inc. in Hudson, New Hampshire, uses plastic ink in a combination of phase-encoded and drop-on-demand printing to produce an output similar to embossing with a fantastic variety of colors and attention to detail. The printer surrounding this technology is Howtek's Pixelmaster. It can print digitized images of photographs—you need another unit to do the digitizing—and the "printed" output appears similar to an original painting of the scene. There's almost a three-dimensional quality to it.

Thermo Jet is by no means limited to reproducing photographs. Business graphs are crisp, clean, and clear. Logos resemble those you find on expensive stationery—raised, embossed, shiny, very professional. They look like originals, and indeed they are. Print quality is astounding; it resembles the kind you find on wedding invitations—raised, embossed, high-quality.

How Does It Work?

One of the major problems with many ink-jet printers is the tendency of the ink's solvent to evaporate, leaving dried ink clogging the jets. Plastic ink is loaded dry and serves as its own carrier, so there is no solvent to evaporate; hence, no clogging. Other ink-jet problems include the way in which ink tends to "bleed" into the paper it is being sprayed on before it dries and the way it smudges if you touch it before it's dry. Plastic ink eliminates these problems because it solidifies immediately on contact with the paper.

Plastic ink is solid at room temperature and has a melting point well above it. Within the Pixelmaster printer, the ink remains in a liquid state because it is kept in a reservoir that is heated to a temperature above the ink's melting point. The print head is also heated. Thus, while the ink remains in the printer, it is liquid. As soon as it leaves that heated environment—conventional piezoelectric crystals apply pressure on the reservoir, expelling the ink through the jet "on demand"—the ink cools and returns immediately to its natural solid state, producing a high-quality, slightly raised output. The solid plastic inks are clean and easily inserted through shape- and color-coded receptacles in the Pixelmaster.

The Pixelmaster Printer

The Pixelmaster comes in two configurations. The Pixelmaster I has 8 jets for each color (black, cyan, magenta, and yellow) and prints a full page of information—either multicolor or black only—in approximately two minutes. The Pixelmaster II comes with 20 black jets and 4 jets for each of the other three colors. It prints a page of black-only text in 30 seconds and a page of color in 4 to 5 minutes. Retail prices for either configuration start at $4495.

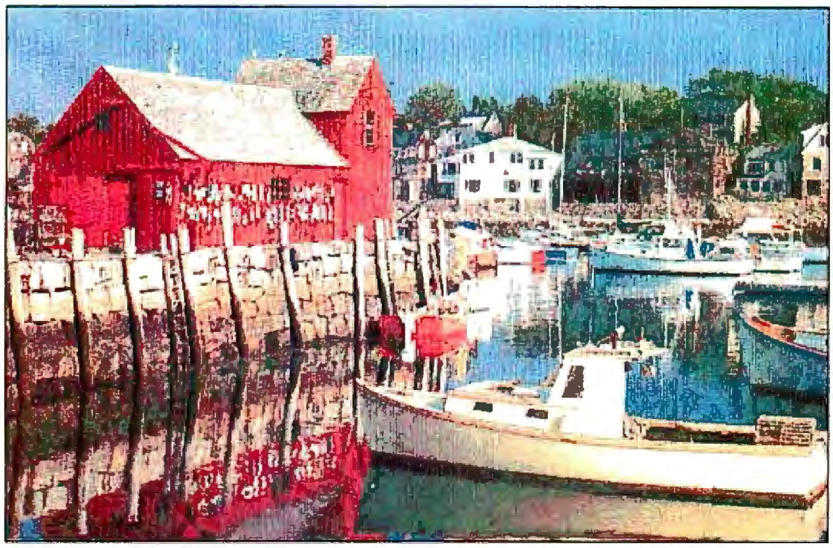
At 240 by 240 dpi by four colors of ink, the Pixelmaster can place as many as 21.5 million dots on an 8½- by 11-inch piece of paper. It can generate up to 64 levels of each of the RGB colors (converted to CMY via proprietary software) for a total of over 250,000 possible color shades. These numbers help to explain the beautiful realism it attains (see the photos). In addition to magnificent colored reproductions, the Pixelmaster can print four-color separations, one color per page, and mirror images, used to produce transparencies.

The Pixelmaster is limited in output size; although geared to office use and supporting letter and A4 paper sizes, it does not support legal and B5 paper sizes. However, it does provide the other normal abilities of an office printer: You can vary lines per inch, page length (within stated limits), margins, number of copies, and so forth. You can integrate all kinds of color images and text on any standard office paper. You can vary the color and thickness of your "pen" and generate truly solid area fills. And you can emulate LaserJet raster-graphic densities. You can print text, fonts, and special characters in a variety of type styles and sizes by inserting the appropriate font card, and reference as many as 120 different fonts or symbol sets at one time, all on a single page if you wish.

The Pixelmaster contains 32 ink jets mounted on a round print head that rotates on an axis concentric to the curved platen. Vertical motion tabs pick up a single sheet of paper from the holder and wrap it into a semicircle around the print head. A slight vacuum holds the top of the sheet against the platen, and the paper moves smoothly past the rotating print head. Since the paper remains at a fixed distance and angle from the ink jets—print-head rotation and paper lift are synchronized—each jet can be aimed and timed to accurately place ts of ink on the paper.

An easily

Controller (I C), a single-board computer built around a 68000 microprocessor with between 512K bytes and 4.5 megabytes of RAM (in 2-megabyte increments), d



Digitized images of photographs produced by Howtek's Pixelmaster printer using Thermo Jet technology and plastic ink.

ing controller to contain numerous protocols such as page-description languages, emulations of protocols for existing printers, or custom protocols developed for specific vertical applications. You can also add optional hardware interfaces, such as IEEE488, SCSI, and Ethernet. Currently, Howtek supports two protocols: Hewlett-Packard's HPGL and HPPCL LaserJet protocols. PIC cards have also been configured to support Centronics, RS-232C, or GPIB physical communication interfaces.

The print engine in the Pixelmaster includes a slant processor, one of six custom Howtek LSI chips, which transforms the PIC's scan-line data into ink-jet commands. This chip also controls the ink-monitoring and control systems and the heater—an approach that greatly simplifies the software needed to drive the printer.

In All Honesty

I haven't seen the Pixelmaster in operation, and I won't pretend that I have. I am told that using it is as simple as loading the paper and pushing the right buttons. I am told that it runs very quietly. I believe the people at Howtek, but you can't prove these things by me.

What I will stand up and shout about, however, is the most exciting output I have ever seen from an office printer: pictures that seem almost touchable, print quality that is indeed touchable, and brilliant detail and color quality. Plastic ink may sound like a strange idea, but in the world of ink-jet printing, it might turn out to be sheer genius.

data-controlled light source—a laser for a color laser printer. The first such system will probably be available in early 1988. Initial price estimates range from $20,000 to $25,000; this is comparable to electrostatic plotters.

Electrophotography is a plain-paper technology; rather than imaging directly on paper as electrostatic plotting does, light exposure creates a charge on a photoconductive drum. These latent images are toned (usually with a dry toner); then the toner is transferred to the paper and fused. In some cases, an intermediate, nonconductive surface receives each color layer before finally transferring it to the page.

Much of the excitement about the potential of color laser printers is based on the tremendous success of their monochrome counterparts. As some prices have dipped below $2000, these page printers have become an accepted office output device. Experts expect color laser printers to share some of the positive attributes of the current laser offerings and thereby bring color out of specific application niches. Print resolution will be high, probably the 300 dpi that is standard for page printers, and therefore compatible with office-oriented software in monochrome mode. The cost of supplies should be low. And while speeds are likely to be below 10 pages per minute for color output, monochrome pages should run at 20 to 30 ppm.

A Balancing Act

While the growth of color printing has been slower than expected, it is not for lack of color-printing technologies. The task for color-printer manufacturers now is refining those technologies so that you don't lose resolution when you want a large variety of colors, you don't have to take a slow printer in order to get one you can afford, and you can use any sort of paper or transparency that you want with any sort of printer that you have. But this is still in the future. For the present, you must balance price, performance, print quality, and other factors in choosing a color printer or plotter. ■

FOR MORE INFORMATION

The issues discussed in this article and the potential for color in a variety of environments are treated in detail in a new market study by Datek Information Services entitled *High End Color Printers for Emerging Applications*. For more information on this and other Datek reports, write Datek at P. O. Box 68, Newtonville, MA 02160, or call (617) 893-9130. Datek is a research and publishing firm providing focused newsletters, reports, and seminars for the electronic-imaging industries.

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Vector-to-Raster Algorithms

Disguising the more intuitive vector information as raster data

Dick Pountain

FROM CRTS TO printers, the world of personal computers contains a multitude of raster devices trying to express vector information. While programs specify formulas, curves, and objects, most of the visual output devices that personal computers use (except the pen plotter) must translate that information into the sequence of dots, or pixels, that a raster device can portray. (While dots refer to printed output and pixels to screen output, there is no difference between the two in terms of raster imaging. Therefore, I shall use the word *dots*, where applicable, to focus on printing, while the word *pixels* would be equally correct were I to focus on displays.)

Made for TV

The archetypal raster device is the television CRT. Even the word *raster* comes from television technology, where it describes the two-dimensional array of horizontal scan lines traced by a flying dot of light as it creates a TV picture (a process called *raster scanning*).

A raster device produces an image by scanning each horizontal line and generating the sequence of dots that it finds, thereby building up a whole picture. The exact sequence of dots is calculated from information found in the operating software. Since raster images consist of separate dots, a raster device can't draw continuous lines like a vector device can. If you have sufficient resolution and slightly overlapping dots, you can maintain the appearance of continuity most of the time, but diagonal lines inevitably contain an element of "jagginess."

Most personal computers use a raster CRT as their primary output device. Some portables use liquid-crystal, gas-plasma, electroluminescent, or other types of flat-screen displays, but you can still categorize them as raster displays although technically they don't produce their displays with a flying dot. What they do have in common is a picture composed of individual pixels, arranged in lines drawn one after the other.

Most of the printers for personal computers are also raster devices. Laser printers print lines of dots in sequence to build up an image on the paper. Most dot-matrix printers have the ability to print both in bit-image mode, a raster process, and in character mode. The daisy-wheel printer is one exception; it prints only whole characters, can't draw arbitrary lines, and gives you no access to the individual dots.

Creating a Good Disguise

Since raster devices are so widespread and vector devices relatively rare, why bother to make the distinction? Because the kinds of data structures and algorithms you need to program the two are fundamentally different. More important, vector representation is much more intuitive to the human mind and far more flexible in use. As so often happens in computing, we are faced with a paradox: We wish all output devices were vector-oriented, but they tend to be raster-oriented. A lot of programming effort goes into disguising the latter as the former.

For example, the natural way to specify a circle would be to provide the coordinates of its center and its radius. A raster display will have none of this; it understands only a sequence of dots on each line. It doesn't care which of these dots fall on the circle and which don't.

The vector description is not only more natural, it is also more flexible and economical. You can represent a circle, at its simplest, with three numbers (*x*, *y*, and *radius*). If you need to move the circle, ideally all you must do is change the values of *x* and *y*. However, to a raster device, moving the image changes everything, as each dot on the circle will be in a different place.

Some personal computers that support graphics include a BASIC command to draw a circle on a raster device from a vector representation. But at some lower level, either in the BASIC interpreter itself or in the operating system, software is working away furiously to convert this vector representation into a pattern of dots suitable for the raster device, a process called *rasterization*. The special algorithms employed by this process are often called *vector-to-raster* or *scan-conversion* algorithms.

Laser printers increasingly incorporate their own intelligence and rasterization routines, and the performance of their conversion algorithm can have a crucial affect on their speed. Laser-printer ras-

continued

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terization can take a lot of processing time because the resolution is more than 10 times that of a typical CRT screen. Many current laser printers contain a processor chip at least as powerful as the CPU in the computer to which they are connected. The use of custom hardware for rasterization is also increasing (see "Designing a Raster-Image Processor" by Jon Barrett and Kirk Reistroffer in the May BYTE).

With a Little Bit

Raster devices that can produce arbitrary graphics images (as opposed to just characters) are usually "bit-mapped." This means that every pixel or dot in the raster image is represented by a bit in computer memory. For example, in a bit-mapped CRT display, the whole screen image is stored as a sequence of bits in an area of computer memory reserved for this purpose, called the display buffer.

The display buffer is accessible not only to the CPU but to a video-controller chip that scans through it at short intervals (60 times per second for most U.S. screens) and translates every 1 bit into a lit pixel on a scan line on the screen. In a laser printer, the bits are used to alter the intensity of the scanning laser beam that creates the paper image.

The process of generating an image now becomes the process of writing the correct pattern of bits into the display buffer. Unfortunately, this is not as straightforward as it seems, for two reasons. First, as a rule, CPUs don't access single bits; instead, they access 8-bit bytes or 16- or 32-bit words. Thus, within memory you must group together the dots making up an image in a manner that bears no relation to the image but is dictated solely by the CPU's word length. Dots that logically belong to the same image may be spread across many memory words.

Second, the display buffer consists of one long sequence of bytes (or words), whereas the output is composed of a number of separate scan lines. Two dots that are *vertically* adjacent on the output may be widely separated in the display buffer.

In addition, many manufacturers have devised complex mappings between the display buffer and the raster device; for example, some intersperse color information with bit-mapped data in the same buffer or store scan lines in a different order from that on the output. I shall consider only simple monochrome bit maps, where each bit corresponds exactly to one dot. Some color devices use a number of such simple bit maps, called *bit planes*, to represent the different color components—red, green, blue, and gray—of a colored image, and my observations apply equally to these.

Dissecting Objects into Bit Maps

How can you translate an object described geometrically (e.g., a line or a polygon) into a bit map? The tension between the two ways of representing an image, as an object or as a bit map, runs through all of graphics programming. For example, MacPaint is a bit-mapped drawing program; it turns every picture you draw directly into a bit map.

On the other hand, MacDraw is an object-oriented program; it stores a picture as a set of data structures containing geometric descriptions of the various image components. MacDraw constructs a bit map only when it displays or prints the picture. Thus, you have more flexibility in altering a MacDraw image than you do in modifying one from MacPaint.

In an object-oriented program, each component is a separate object that you can move as a whole, alter in size, or rotate to any angle. The ideal in graphics programs from CAD/CAM to desktop publishing is to keep the data geometrical (and, therefore, flexible) as long as possible, converting to the relatively inflexible bit map only at output time. As well as consuming a lot of processing time, rasterization causes an irreversible loss of information; it is difficult indeed to extract geometrical information from bit-mapped images. You can, however, manipulate them to some extent with the `BitBLT` operation.

The Plot Thickens

The most primitive operation on a raster device is plotting a single point at an arbitrary location, expressed in device coordinates (the number of dots by the number of scan lines). However, even this operation is not trivial. You must convert the device coordinates to the memory address of the appropriate word and then set the correct bit within that word using logical masking operations. To make things worse, you often have to count from the wrong end of the word to find the correct bit, a *bit-reversed* format:

```
dot   0 1 2 3 4 5 6 7
      x x x x x x x x
      7 6 5 4 3 2 1 0   bit
```

Listing 1 contains `Plot`, a pseudocode algorithm for plotting, which assumes the bit-reversed format. [Editor's note: *This article uses the following conventions: square brackets, [x], mean "the contents of memory location* x"*;* ^ *means "raised to the power"; and the logic operators* OR, AND, *and* NOT *are bit-wise operations rather than Boolean ones. All the algorithms given are in pseudocode.*]

In practice, you wouldn't actually employ multiplication and division as I have in listing 1. A plotting routine must be as fast as possible, since printing ultimately depends on it, and it will be executed billions of times. You should always write it in machine code and optimize it using every trick your instruction set offers.

You should also replace all the multiplication, division, and power operations with logical left and right shifts. For example, if your word length is 8 bits and you have 640 dots per line, you want a routine that operates like `FasterPlot` (see listing 2). A faster, but more hardware-specific, solution would be to eliminate *y* coordinates from the calculation by precomputing the address of every scan line on the device and storing them in a lookup table.

Listing 1: `Plot`, *a pseudocode algorithm for plotting a single point at an arbitrary location.*

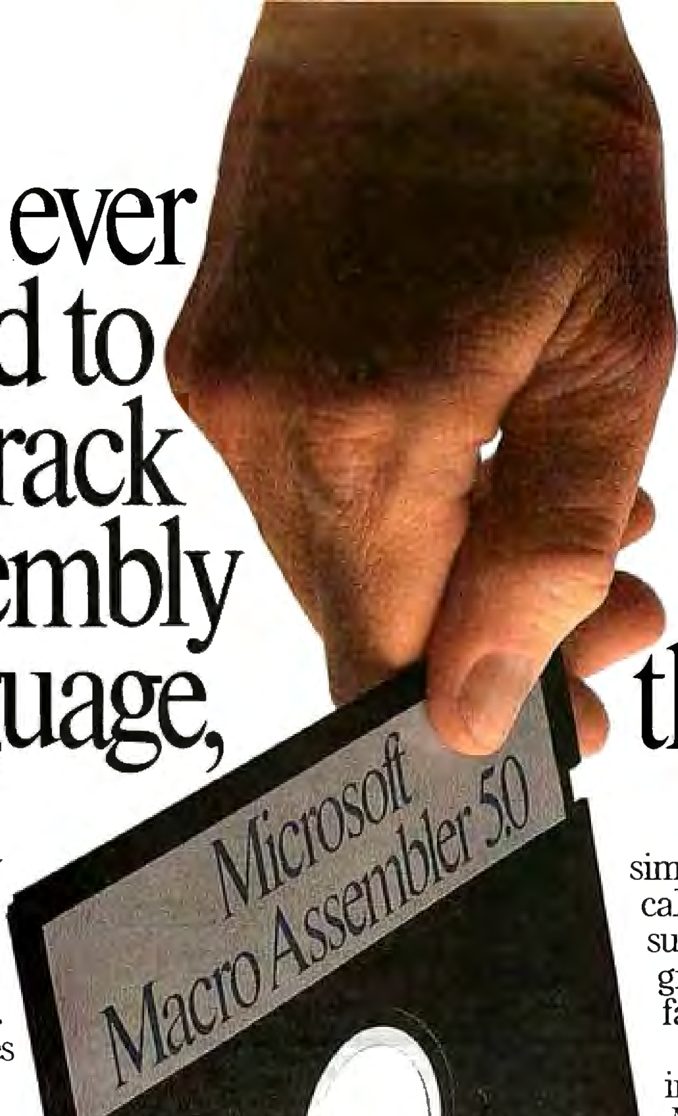
```
Program Plot(X,Y)
Address    <- BufferStartAddress + QUOTIENT((X +
              Y * PixelsPerScanline) / BitsPerWord)
BitNumber  <- (BitsPerWord - 1) - REMAINDER((X +
              Y * PixelsPerScanline) / BitsPerWord)
Mask       <- 2 ^ BitNumber
[Address]  <- [Address] OR Mask
```

Listing 2: `FasterPlot`, *a more efficient version of listing 1.*

```
Program FasterPlot(X,Y)
Address    <- BufferStartAddress + (X SHIFTR 3) +
              (Y SHIFTL 6) + (Y SHIFTL 4)
Mask       <- 128 SHIFTR (X AND 7)
[Address]  <- [Address] OR Mask
```

continued

If you ever wanted to take a crack at assembly language, now's the time.



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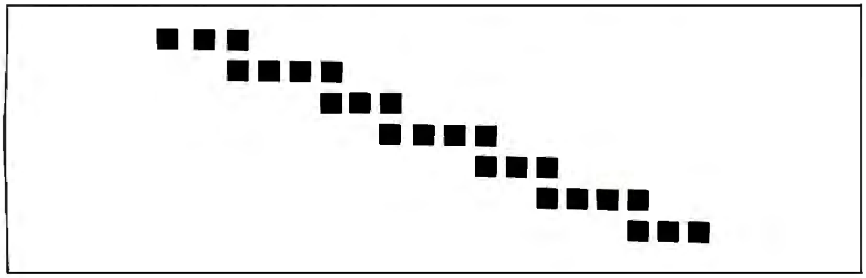

Figure 1: *The staircase effect achieved when you try to plot a straight diagonal line on a raster device.*

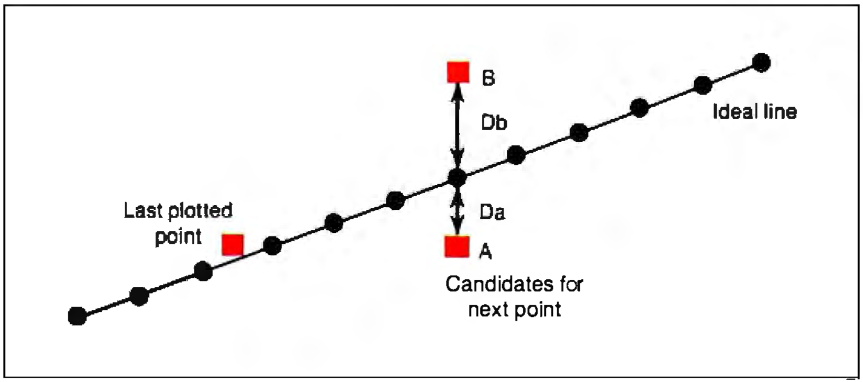

Figure 2: *A diagram of Bresenham's method for determining which point to plot next to come closest to the ideal of a particular line.*

Listing 3: `BresenhamLine`, *a pseudocode algorithm for an abbreviated and limited version of Bresenham's line algorithm.*

```
Program BresenhamLine(X1,Y1,X2,Y2)
DeltaX <- X2-X1
DeltaY <- Y2-Y1
Error  <- 2 * DeltaY - DeltaX
X      <- X1
Y      <- Y1
FOR Count FROM 1 TO DeltaX
   IF   Error > 0
   THEN Y <- Y+1
        Error <- Error + 2 * (DeltaY - DeltaX)
   ELSE Error <- Error + 2 * DeltaY
   ENDIF
   X <- X+1
   Plot(X,Y)
```

Listing 4: `HorizLine`, *an algorithm for horizontal lines in pseudocode.*

```
Program HorizLine(X1,X2,Y)
FirstAddress    <- BufferStartAddress + (X1 SHIFTR 3) +
                   (Y SHIFTL 6) + (Y SHIFTL 4)
LastAddress     <- BufferStartAddress + (X2 SHIFTR 3) +
                   (Y SHIFTL 6) + (Y SHIFTL 4)
FirstMask       <- 255 SHIFTR (X1 AND 7)
LastMask        <- NOT (255 SHIFTR (X2 AND 7))
[FirstAddress]  <- [FirstAddress] OR FirstMask
FILL FROM FirstAddress+1 TO LastAddress-1 WITH 255
[LastAddress]   <- [LastAddress] OR LastMask
```

For screen applications, you may want a second version of `Plot` that replaces the `OR` operation on the `Mask` with a bit-wise `XOR`. This produces the effect of plotting a black pixel on white areas and a white pixel on black areas, while replotting the same point erases it. You can use drawing routines based on this primitive to draw over any image and then restore the previous image; this is one way to provide a screen-cursor symbol or a rubber-band box for grabbing screen areas.

Once you can plot a point, you need a routine that can draw lines. Line plotting on a raster device bears little resemblance to geometry, where $y = Mx + C$ (M being the slope and C a constant). Instead of plotting in continuous two-dimensional space, you are trying to plot onto a grid of discrete points.

You cannot, in general, plot a straight diagonal line on a raster device; you can only approximate it with a series of steps resembling a staircase (see figure 1). You can use the geometrical formula by computing $y = Mx + C$ for each x (in floating-point arithmetic) and then rounding the value of y to the nearest integer, but it's too slow for practical use.

True raster-line algorithms calculate which of the available dots (from the grid of discrete points) fall closest to the ideal straight line between the two points. To achieve maximum speed, these algorithms avoid multiplication and division. The best are incremental algorithms, where you compute each step from the preceding one.

Bresenham's Line Algorithm

The most widely used raster line algorithm today is Bresenham's line algorithm, discovered by J. E. Bresenham, an IBM researcher, in 1965. This algorithm maintains an error term whose value is proportional to the deviation of the points from the ideal line. If a point has just been plotted, in general, two possible choices exist for the next point (*A* and *B* in figure 2), and one of them will be nearer to the ideal line than the other.

Bresenham's error term is proportional to $(Da - Db)$, the difference in distances from the ideal line. In figure 2, *A* is closer to the line; since $Da < Db$, the error term is negative, and you need to increment only the x coordinate, resulting in a horizontal line segment. If the error term is positive, *B* is closer to the line, and you increment both the x and the y coordinates, resulting in a step (both a horizontal and a vertical line segment).

Bresenham devised an algebraic derivation of the error term so it can be calculated incrementally, using only integer addition, subtraction, and multiplication by 2 (replaced in practice by a left shift).

See BresenhamLine in listing 3. (For space reasons, I have confined myself to a line with an uphill slope of less than 45 degrees; a more generalized version of the algorithm examines the relative magnitudes of $x1$, $y1$, $x2$, and $y2$ and swaps variables appropriately.)

The only true straight lines you can draw on a raster grid are horizontal lines, vertical lines, and the 45-degree diagonal line (which is at an actual 45 degrees only if the device has a square aspect ratio). These special cases are easier to plot, and so they often have their own separate routines that run faster than the general case. For example, horizontal lines occupy contiguous addresses in the bit map; thus, you can plot them noniteratively using a fast memory-fill instruction.

The only trick lies in masking the partial bytes that may occur at either end of the line. Assuming the same hardware characteristics as FasterPlot, HorizLine (see listing 4) ignores the line less than eight dots long that falls within 1 byte; in that case, you should use both FirstMask *and* LastMask. (Listing 5 contains VertLine, a routine that plots vertical lines.)

You can now combine these horizontal and vertical line routines into a fast box-drawing routine, Box, which you could use, for example, to print forms on a laser printer (see listing 6). In a similar fashion, you could use the general-purpose line routine, BresenhamLine, to write a *polyline* routine that draws a polygon from a list of coordinate pairs that describe its vertices.

Going Around the Bend

You can draw curved lines using just the polyline routine, as a sufficient number of short line segments can approximate a curve; for example, a regular polygon with a sufficient number of sides can approximate a circle. A *sufficient number* is that number that reduces the length of a side to a single dot, for this is as near to a true curve as a raster device can come.

Circles and ellipses are so useful that it's practical to have a fast routine especially for drawing them. The equation for a circle of radius, r, about the origin, 0,0, is $x^2 + y^2 = r^2$. However, plotting this equation directly using floating-point arithmetic and rounding is impractical; the square-root calculation is too slow. Instead, you can use an error term whose value is proportional to $x^2 + y^2 - r^2$ and choose the points that minimize this error.

As in Bresenham's line algorithm, algebraic rearrangement lets you use only simple integer calculations. J. Michener's algorithm is a variation on Bresen-

continued

Listing 5: VertLine, *a pseudocode algorithm for vertical lines.*

```
Program VertLine(X,Y1,Y2)
FirstAddress    <- BufferStartAddress + (X SHIFTR 3) +
                   (Y1 SHIFTL 6) + (Y1 SHIFTL 4)
LastAddress     <- BufferStartAddress + (X SHIFTR 3) +
                   (Y2 SHIFTL 6) + (Y2 SHIFTL 4)
Mask            <- 128 SHIFTR (X AND 7)
FOR Address FROM FirstAddress TO LastAddress STEP 80
   [Address]    <- [Address] OR Mask
```

Listing 6: Box, *a method for drawing a box using horizontal lines (listing 4) and vertical lines (listing 5).*

```
Program Box(X1,Y1,X2,Y2)
HorizLine(X1,X2,Y1)
VertLine(X2,Y1,Y2)
HorizLine(X1,X2,Y2)
VertLine(X1,Y1,Y2)
```

Listing 7: Circle, *a pseudocode version of Michener's algorithm for drawing a circle.*

```
Program Circle(CtrX,CtrY,Radius);
X <- 0
Y <- Radius
Error <- 3 - 2 * Radius
WHILE X =< Y {generate 8 points from one X and Y}
  Plot(CtrX+X,CtrY+Y)
  Plot(CtrX+X,CtrY-Y)
  Plot(CtrX-X,CtrY+Y)
  Plot(CtrX-X,CtrY-Y)
  Plot(CtrX+Y,CtrY+X)
  Plot(CtrX+Y,CtrY-X)
  Plot(CtrX-Y,CtrY+X)
  Plot(CtrX-Y,CtrY-X)
  IF Error > 0
  THEN Error <- Error + 4 * (X-Y) + 10
    Y <- Y-1
  ELSE Error <- Error + 4 * X + 6
  ENDIF
  X <- X+1
ENDWHILE
```

Listing 8: FilledCircle, *a modification of listing 7 that fills the circle as it is drawn.*

```
Program FilledCircle(CtrX,CtrY,Radius);
X <- 0
Y <- Radius
Error <- 3 - 2 * Radius
WHILE X =< Y
  HorizLine(CtrX-X,CtrX+X,CtrY+Y)
  HorizLine(CtrX-X,CtrX+X,CtrY-Y)
  HorizLine(CtrX-Y,CtrX+Y,CtrY+X)
  HorizLine(CtrX-Y,CtrX+Y,CtrY-X)
  IF Error > 0
  THEN Error <- Error + 4 * (X-Y) + 10
    Y <- Y-1
  ELSE Error <- Error + 4 * X + 6
  ENDIF
  X <- X+1
ENDWHILE
```

ham's: To gain speed, you compute only one-eighth of the points on the circle, the 45-degree slice from 12:00 to 1:30; the rest is deduced on the grounds of symmetry (see `Circle` in listing 7). Again, you would actually implement the multiplications as left shifts.

Curve-fitting algorithms can be used to handle arbitrarily curved lines. However, these are usually reserved for sophisticated CAD/CAM systems and are not yet routinely implemented on laser printers or other personal computer raster devices. The principle of a curve-fitting algorithm is to roughly sketch out a path by plotting a number of guide points and then fitting to them the nearest curve the algorithm can find using pieces from different cubic curves. Cubic curves take the form $y = A*x^3+B*x^2+C*x+D$ and have the happy property of fitting together smoothly where they join.

A typical application for a curve-fitting algorithm would be smoothing the wire-frame drawings of aircraft or car designs on a CAD workstation. (For a fuller account of Bézier and B-spline methods for curve fitting, see "Free-Form Curves on Your Micro" by Steve Enns in the December 1986 BYTE.)

Fill It Up, Please

Once you can draw boxes, polygons, and circles, you want to be able to fill them with a solid color. The fastest way is to do it when you are drawing the original shape, for that's when the coordinates of each point on the shape are available. For example, you could modify `Circle` (see listing 7) into `FilledCircle` (see listing 8) by drawing horizontal lines between symmetrical pairs of points, instead of just plotting them.

A filled box is similarly produced from a sequence of horizontal lines. Filled polygons, however, present more of a challenge; you must find the points at which each horizontal scan line intersects with the edges of the polygon. If you are drawing a concave polygon, there may be more than two such points for some lines. The resulting algorithms are complex and involve keeping sorted tables of the intersection points and the polygon edges.

Filling arbitrary outlines after they have been drawn is a difficult process, but one that an interactive drawing program might require. Once you have drawn a shape, information about its outline exists only in the bit map; extracting that information is painful. You must write a routine that reads the value of a dot from the bit map, the exact reverse of `Plot`, so that you can detect the edges of the region to be filled. `IsSet` (see listing 9) returns the value "true" if the point x,y is turned on and "false" if it is not (i.e., if the dot has the background color).

The simplest fill algorithm is the flood fill, which is more common in screen applications. It searches in all directions from a chosen start point for pixels that are not set and then sets them; the process resembles water flooding across a floor. Filling stops when the flood reaches the boundary of the shape. That boundary must consist of an unbroken chain of set pixels; if it has any holes, the flood will leak out and fill the area around the shape, a common experience for users of drawing software. The algorithm is most clearly expressed in the recursive form shown in `FloodFill` (see listing 10).

`FloodFill` examines the four nearest neighbors of each point: left, right, up, and down. In topological terms, it fills a 4-connected region. You could easily expand it to examine eight neighbors (including the diagonally adjacent pixels), but this expansion can cause the flood to leak through boundaries drawn using any variant of Bresenham's line algorithm, since they have "holes" in the diagonal directions (see figure 3).

This recursive flood fill uses an enormous amount of stack space when you run it over sizable areas on a high-resolution device. Iterative versions that overcome this problem are less elegant; they identify horizontal "runs" of pixels to be

Listing 9: `IsSet`, *a pseudocode routine to determine whether a particular bit in a bit map is a 0 or a 1.*

```
Function IsSet(X,Y)
Address  <- BufferStartAddress + (X SHIFTR 3) +
            (Y SHIFTL 6) + (Y SHIFTL 4)
Mask     <- 128 SHIFTR (X AND 7)
Value    <- [Address] AND Mask
IF Value  = 0 THEN RETURN FALSE
  ELSE RETURN TRUE
```

Listing 10: `FloodFill`, *a pseudocode algorithm in recursive form that floods an area in order to fill it.*

```
Program FloodFill(X,Y)
WHILE NOT IsSet(X,Y)
  Plot(X,Y)
  FloodFill(X-1,Y)
  FloodFill(X+1,Y)
  FloodFill(X,Y-1)
  FloodFill(X,Y+1)
ENDWHILE
```

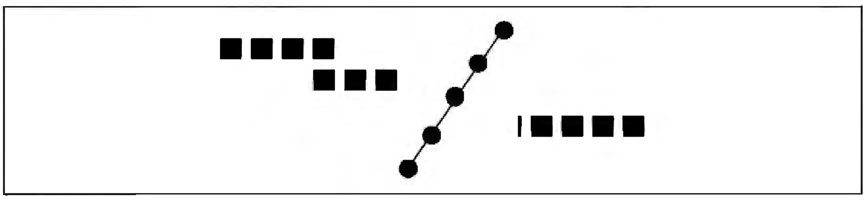

Figure 3: *This shows how a flood fill can leak through the "holes" in a diagonal line.*

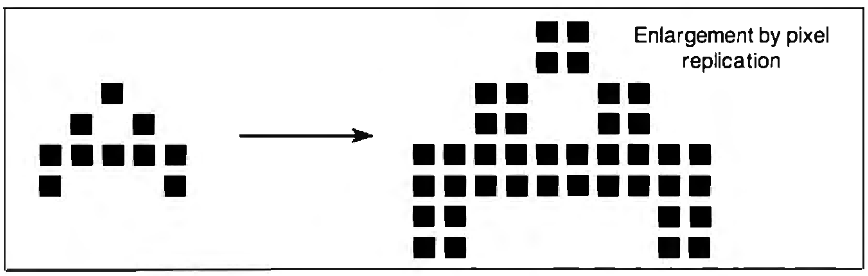

Figure 4: *This shows the only method of enlarging a character stored in bit-mapped form—pixel replication.*

filled by searching along each scan line to find where it intersects with the boundary.

What a Character!

The drawing primitives we have seen can produce text characters on a raster device, but this is not usually the primary method of displaying text. It's far too slow to draw a letter *A* using line- and maybe curve-drawing primitives every time you press the *A* key. Instead, on "soft" systems like the Macintosh, Amiga, and most laser printers, characters are normally stored in nonvisible RAM as a set of bit maps that make up a complete font and then copied to the display buffer as needed. If you have a character-only device, the font lives in ROM, and the display hardware copies it directly.

More sophisticated typesetting systems employ a two-stage process. They store the fonts as vector descriptions and then convert them to bit maps in font memory, using algorithms like those above. From font memory, the bit maps can be copied to the display buffer on demand. The advantage of this approach is that you can produce different sizes and styles of characters from the same description by applying geometric transforms—you might slope a font to italicize it—while preserving the display quality.

Donald Knuth's METAFONT is an example of a system that describes typefaces geometrically in terms of curved segments. The PostScript page-description language can also compute bit maps from mathematically described fonts.

By contrast, fonts that are stored solely in bit-mapped form are relatively inflexible. You can enlarge them only by the crude process of replicating the dots (i.e., by printing two or four dots for each one in the original character). This has the profound disadvantage of magnifying the jaggedness of the original in proportion and leads to unsightly characters in the larger point sizes (see figure 4). The alternative is to store a separate font bit map for each point size, which uses a lot of memory. (Transforming bit-mapped characters is limited to rotation in multiples of 90 degrees.)

Bit Blitting

The operation used to copy characters to the display buffer has become famous as the `BitBLT` or Blit operation, short for bit boundary block transfer. The basic Blit operation copies the bits that represent a rectangular area of dots from one place (the source) to another (the destination) in memory.

The source and destination may both lie in the display buffer, or the source may lie elsewhere, such as in font memory. Dots need not be aligned on word boundaries, hence the bit-boundary tag; therefore, much of the algorithm is concerned with masking out parts of bytes that fall outside the source or destination rectangles. It must also cope with the various cases where the source and destination rectangles overlap (they might even be the same rectangle).

The most general form of Blit can combine the source and destination rectangles using logical operations rather than simply copying, for example, *source* `XOR` *destination*. With it, you can obtain many special effects, such as characters with transparent backgrounds or characters overprinting each other, perhaps, for accents. (For a good description of the use of the `BitBLT` operation in kerning characters for a laser printer, see "Designing a Raster-Image Processor" in the May BYTE.)

`BitBLT` is, in theory, a general operation that can serve as the sole graphics primitive in a system (it was used this way by its inventors, the Smalltalk team at the

continued

Xerox PARC). It does not belong to the class of conversion algorithms that are the subject here, because it is an operation *on* bit maps rather than a producer *of* bit maps.

However, far from being a rival to scan conversion, `BitBLT` is highly complementary. An image that has been scan-converted to a bit map can be moved around using `BitBLT` to save having to draw it again, as with font characters.

`BitBLT` is the best way to scroll a screen, for example, by copying the whole screen one line upward and then erasing the bottom line by `XOR`ing it with itself or by copying in the next image line. The `BitBLT` operation is also good for creating overlapping windows and simulating the movement of objects on the screen. However, it is not a good way to draw arbitrary lines and curves or to fill arbitrarily shaped areas.

Blitting large areas can consume a lot of processing time, and there is an increasing tendency to implement `BitBLT` directly in hardware, as in the Amiga's blitter chip and graphics coprocessors like the TMS34010. The latter chip also supports scan-conversion primitives to draw lines and fill areas.

A Raster in Vector Clothing

The ideal computer output device would allow randomly oriented lines and areas to be drawn directly by merely specifying their display coordinates. However, in the real world, we have to simulate such a device using cheaply available raster-scan devices like the television CRT tube and the dot-matrix printer.

A lot of ingenuity has been expended on the algorithms necessary to make this simulation work efficiently, but the user and the high-level-language programmer seldom see the complexity of vector-to-raster conversion, because it is taken care of in the operating system, language compiler, or even by the hardware.

The field of vector-to-raster conversion is by no means yet closed. New algorithms for polygon filling are still being discovered, and the application of `BitBLT` to multicolor displays is a recent development. As laser-printer technology advances into color, antialiasing (i.e., disguising jagged lines by shading the edges with varying-intensity dots) promises to become a hot topic. ■

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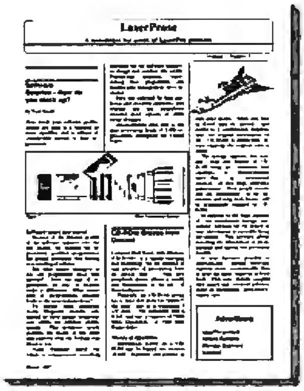

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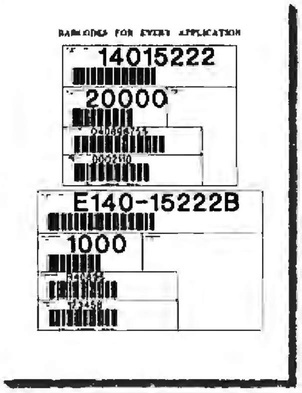

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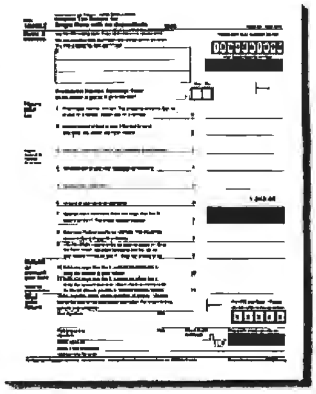

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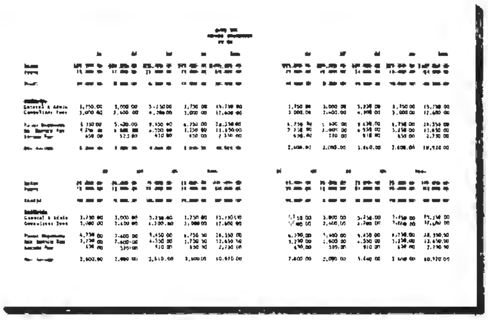

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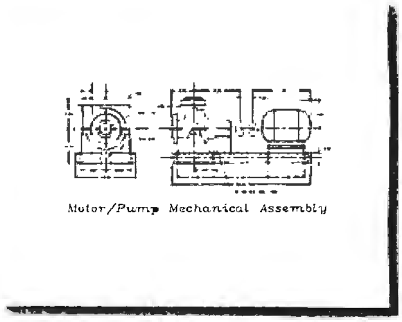

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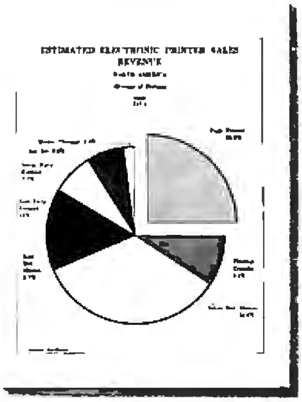

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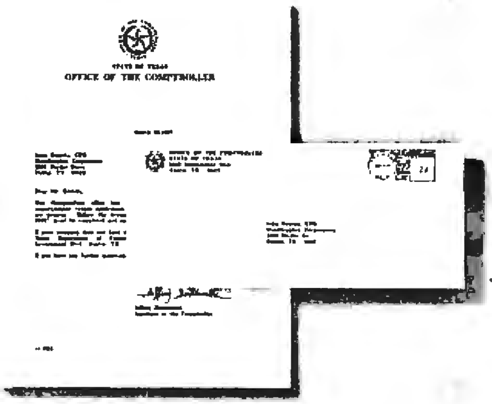

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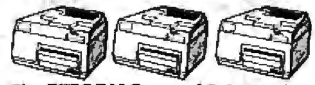

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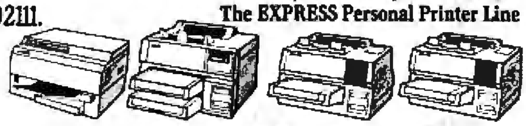

LaserPro Shared Resource Printers

Page Printers

New technologies help laser printers and their cousins cost less and produce better results

Rick Cook

TODAY'S PAGE PRINTERS have two problems. The first is obvious: price. At a time when a very good printer costs less than $1300 and a less capable unit can sell for under $200, laser printers start at $1700 and go up quickly.

The second problem is resolution. For traditional computer-printing jobs, the 300-dot-per-inch resolution of current-model page printers is more than adequate. However, the advent of page printers has spawned new applications—notably, desktop publishing—where 300 dpi is not always good enough. Traditional graphics-reproduction methods for typesetting and photography use resolutions of 1000 to 2400 dpi.

Help is coming on both fronts, thanks to new technologies such as LED, liquid-crystal-shutter, and ion-deposition imaging, and to traditional market forces such as volume production and changes in the design philosophy regarding printer intelligence. In this article, I'll survey the present technology and look at some of the developments that promise to make page printers even more powerful and versatile and, in some cases, less expensive.

How a Page Printer Works

Most page printers use electrostatic forces to create a page image from rasterized digital information and to transfer that image in the form of toner onto a piece of paper.

The heart of an electrostatic page printer is a drum or belt coated with a photoelectric substance that develops a positive or negative charge in response to light. The usual coatings are selenium and some organic compounds. A beam of light (or an array of individual light sources) "writes" an image onto the drum one row of dots at a time (see photo 1). As each row of dots is written out, a stepper motor advances the drum by one row and the light source writes out the next line of the image.

The result is a 1000-volt electrostatic image of the page on the drum, against a background potential of about 100 V. As the drum rotates, it passes over a reservoir of toner, finely divided particles of an organic compound that is susceptible to static charge. The charged areas on the drum attract and hold the toner. The toner-laden image on the drum is then brought into contact with a sheet of paper that has been charged to an even higher potential, usually about 2000 V, by means of a corona mechanism. The toner jumps to the paper in the same way that bits of lint will jump up and cling to a vinyl comb. Heated rollers fuse the toner to the paper to produce the finished page, and the paper-handling system passes it to the output tray.

After transferring the image onto paper, the drum rotates past a discharge wire to eliminate any remaining charge. Then a scraper assembly removes the last traces of toner, leaving the drum clean and ready to receive the next image.

Figure 1 illustrates the entire system (for a laser printer) schematically, but don't be misled: The process is not simple. A good laser printer is a tightly coupled system of electronic, chemical, optical, and mechanical parts. This intricacy and interaction of technologies is largely responsible for the laser printer's high cost.

Consider just one element: the image drum (or belt, in some designs). The drum must rotate smoothly, precisely, and concentrically. If it is out of round or mounted eccentrically, the light will be out of focus on the surface at some points, and any spot of toner left at that point will be too large. Furthermore, if the drum does not advance smoothly and accurately, the rows of pixels will be blurred or misplaced. Getting the required precision from the drum movement takes a good stepper motor, quality bearings, and a drum manufactured to close tolerances.

Because these active elements have to be so closely matched, manufacturers buy them as preassembled "engines" from one of the OEMs, such as Canon, Ricoh, and Kyocera. The end-product manufacturers then add a controller, a paper-handling mechanism, and other components to make a complete printer.

Kinds of Page Printers

Laser printers were the original page printers and are still the most widely used variety. They have been available for about 10 years, starting on printers for large computer systems and filtering down to microcomputers. Today, laser-printer technology is widely available and

continued

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generally well-understood.

These printers use a laser beam to write the image onto the drum. The laser isn't aimed directly at the drum. Instead, it is aimed at a rotating mirror, usually with 8 to 16 faces, that scans the beam across the face of the drum, turning on and off according to the digital information coming from the rasterized image. The controller synchronizes the scanning beam and the drum-advance motor with the flow of rasterized information.

Small laser printers that produce fewer than 10 pages per minute generally use a laser diode to produce the beam. Faster printers use a more powerful helium-neon or argon laser; the power of the beam determines how quickly the laser can charge the individual points on the drum.

Compared to other kinds of page printers, the biggest design challenge associated with laser printers is their optical system. To work properly, the laser printer's beam must be equally strong and precisely focused at every point along the scan line. It must also be aligned with the drum and synchronized with its rotation.

Any scanning beam is subject to what are called cosine-fourth losses, named for the function that describes them. (The losses are proportional to the fourth power of the cosine of the angle between the beam and the scanned surface.) As a result of these losses, the beam is weaker and more diffuse at the edges of the scan than at the center. Laser printers use a complex lens system designed to compensate for these losses. Likewise, the faces of the rotating mirror need to be precisely aligned and perfectly flat. Any irregularity will cause misalignment of a row of pixels.

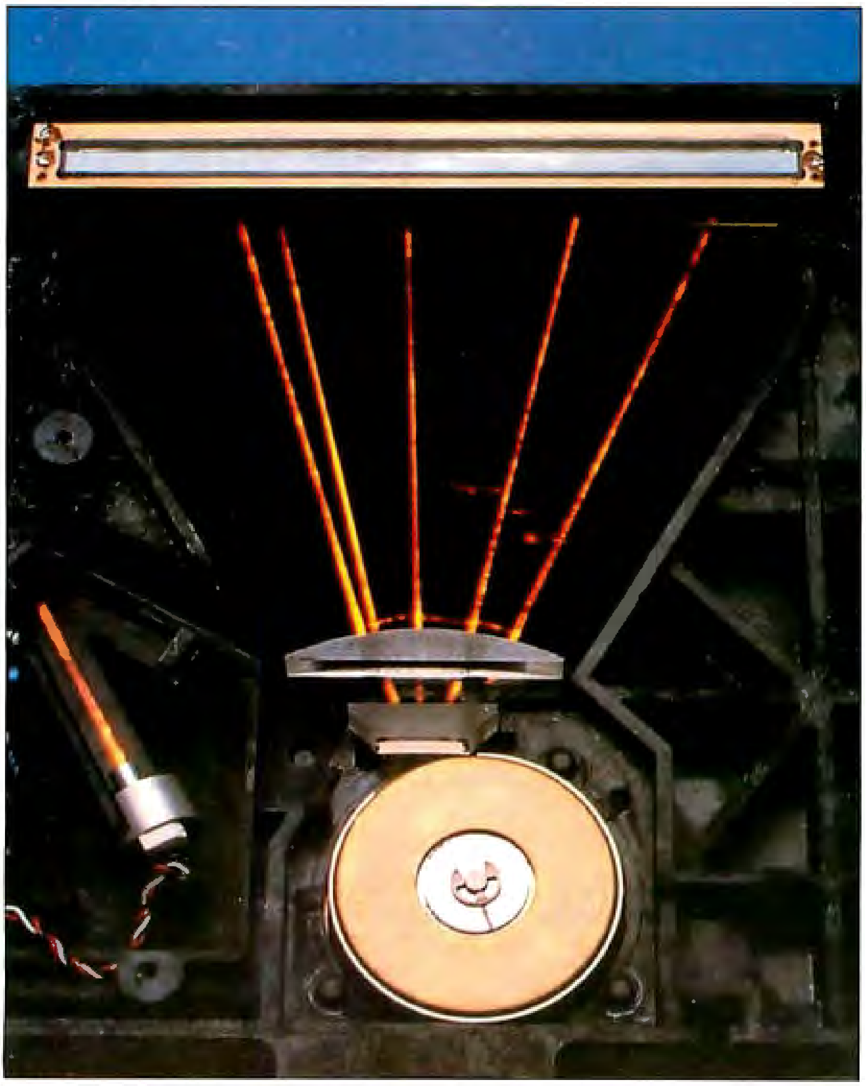

Photo 1: *Inside a laser printer. This photo was taken using timed exposures on a laser phosphor card, creating a visible trace of the invisible infrared beam. (Photo courtesy of Xerox Corp.)*

Finally, the optics have to be held in precise alignment with the drum and each other. Vibration or misalignment can ruin a laser printer's print quality. (This is one of the reasons laser printers are so heavy, but transformers needed to produce the high voltages also contribute weight.) If a laser printer's optical system gets knocked out of alignment, it is not simple to repair; the unit generally has to go back to the manufacturer.

Although the laser-beam design is the most common approach to writing an image on the electrostatic drum, other designs are available and offer certain advantages. One type of page printer uses a row of LEDs, one for each pixel in the row, to write the image to the drum. Datasouth now offers an LED printer (the Pagewriter 8, $2995) based on an NEC print engine.

LED engines are made by NEC and Sanyo at the low end (less than 10 ppm), Kentek and Agfa at the medium range (more than 12 ppm), and Kodak at the high end (up to 92 ppm).

A third variation is the LCS printer, which has a row of liquid-crystal "shutters" in place of the diodes. A powerful fluorescent bulb provides the light, and pulses of electricity open and close the shutters to write the image. Taxan sells an LCS printer (the Crystaljet, $3495). Figure 2 shows an LCS print head.

Because LED and LCS printers use fixed, multiple light sources rather than scanning a beam across the drum, they are optically simpler than a laser printer. Alignment is easy to maintain, and you can replace the print bar (the part that holds the LEDs or LCSs) in the field in a few minutes.

This optical simplicity is somewhat offset by the need to drive each light source individually, which increases the electronic complexity. Most LED and LCS printers multiplex the control signals to cut down the number of signal lines. However, this means that all the light sources cannot be on at once—the printer has to write different sections of the scan line at different times. In some designs, the light bar is mounted at an angle to the drum's rotation to let it write to only part of the drum at once.

In both LED and LCS printers, the number of elements in the print bar determines the resolution. The difficulty of packing the light elements densely enough to achieve high resolution is one of the reasons LED and LCS printers came later than laser printers. In the case of LED printers, the devices must be packed onto LSI chips. For instance, the NEC engine in the Datasouth LED printer uses LEDs built on chips with LSI technology, 128 LEDs per chip. In the

LCS printers, the shutters had to be much smaller than previous applications had demanded (see photo 2).

The LCS design poses an additional problem: The heat from the light source tends to distort the cells in the array. The solution has been to minimize the light intensity and to engineer the print bar to handle the strain.

A close relative of electrostatic printers is the ion-deposition printer, which uses a beam of charged particles (ions) rather than a beam of light to write the image on the drum.

Like LED and LCS printers, an ion-deposition printer uses a row of elements to write to the drum. The elements are conceptually similar to a triode vacuum tube with ions flowing from cathode to anode, regulated by a grid. Unlike other page printers, these printers do not use heat to fuse the toner to the paper. The drum is much harder than the light-sensitive ones used in laser, LED, and LCS printers, making it feasible to cold-fuse the toner particles onto the paper by means of a pressure roller. As a result, the printer generates less heat. Figure 3 is a schematic illustration of the ion-deposition design.

Ion-deposition technology offers a number of advantages in medium-to-high-speed printers, most notably durability. In a laser printer, 500,000 copies per drum is considered excellent performance, and some printers will do only 15,000 copies before the drum needs replacement. By contrast, C.Itoh claims that the drum on its ion-deposition printer will print between 1 and 3 million copies before it must be replaced. These printers have fewer moving parts than laser printers—contributing to the design's reliability.

Moreover, the drum's hardness lets it stand up to harder scraping than is possible with an electrostatic drum. More of the excess toner particles are removed, resulting in fewer "freckles" on the pages.

Ion-deposition printers are basically volume devices. Although the technology could be used in a desktop printer, it tends to be more expensive in low-volume applications than electrostatic systems. Furthermore, because the rollers have to press the toner onto the paper, ion-deposition print has a shiny ("calendered" is the technical description) look that some people find objectionable.

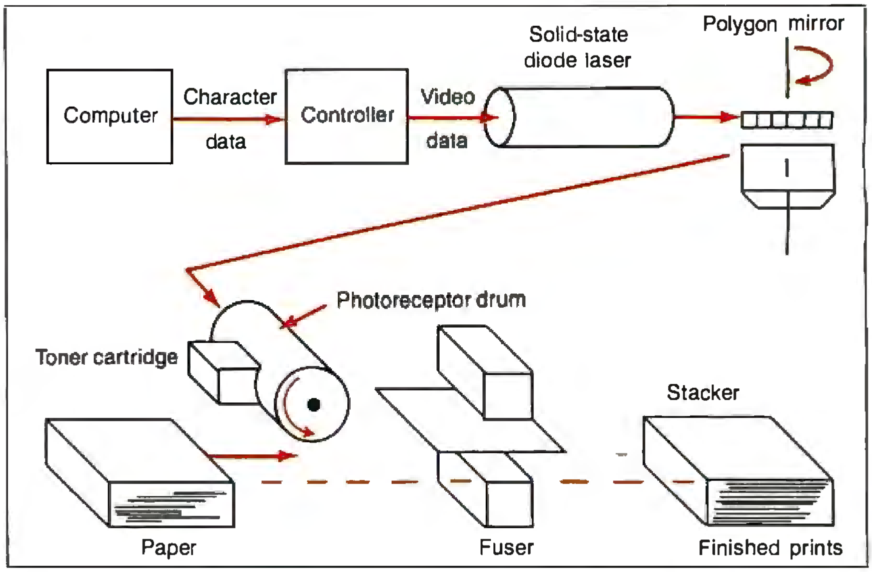

Figure 1: *A schematic diagram of a laser printer. Raster-scanned light from a laser is deflected by a mirrored cylinder to expose the surface of a photoreceptor drum. The charged areas attract toner to the drum, which is then transferred to paper and fused on by heat.*

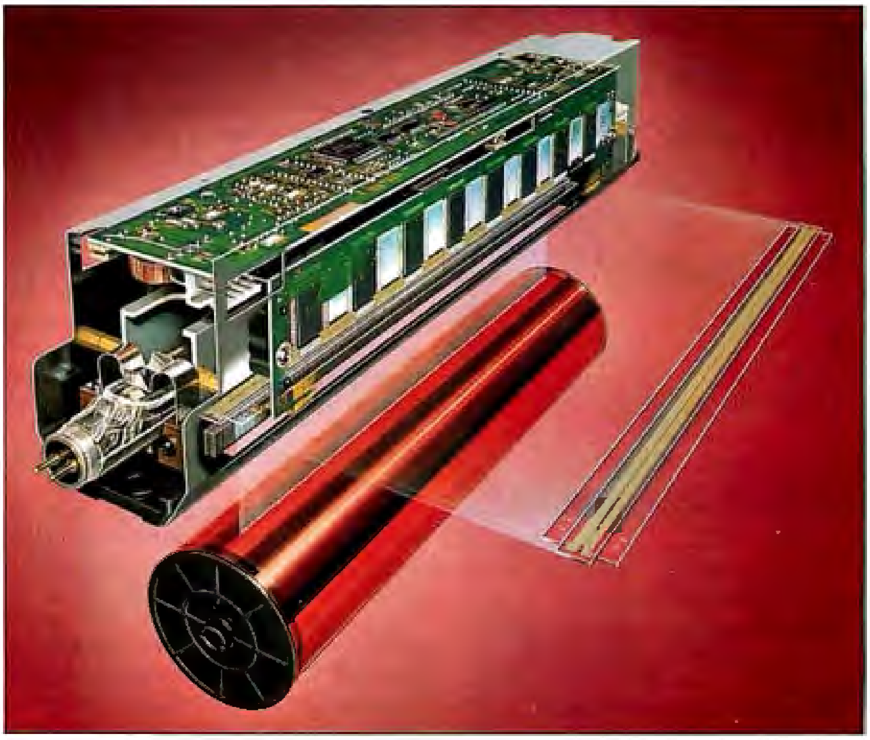

Figure 2: *The print-head assembly of an LCS printer. The fluorescent bulb in the head provides light to the shutters, which open and close according to commands from the controller, charging selected dots on the photoreceptor drum. (Figure courtesy of Taxan USA Corp.)*

Cutting Costs

One way to cut the cost of page printers is to build a lot of them. As production increases, economies of scale set in and the cost of making a page printer drops. Copiers are made in much larger numbers than laser printers, one of the main reasons a plain-paper copier sells for half the price of a laser printer.

Other page-printing technologies, such as LED and LCS, can also push down prices. Currently, LED and LCS printers are no cheaper than laser printers. But laser printers have been made for longer and in larger volumes than LED and LCS designs. Manufacturers claim LED and LCS prices will drop as they move farther along the learning curve and production increases.

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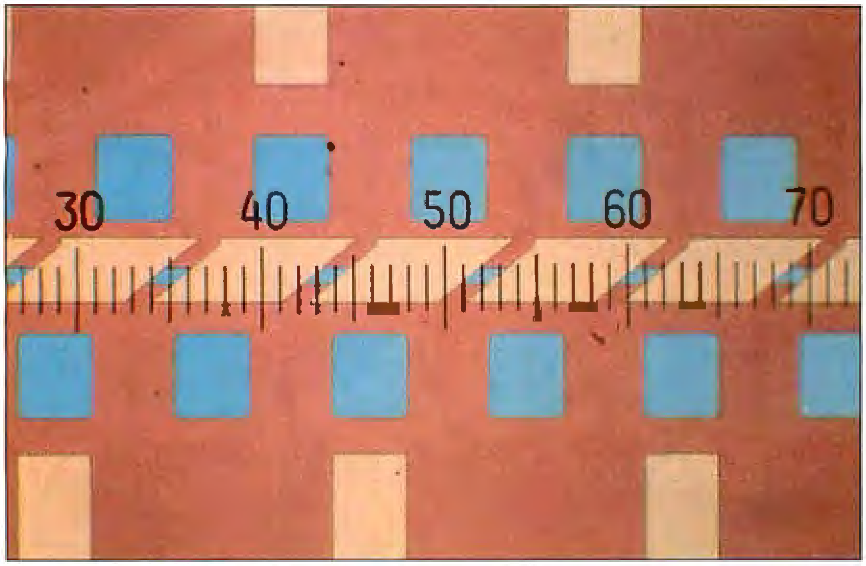

Photo 2: *A photomicrograph of part of a shutter array on an LCS print head. (Photo courtesy of Taxan USA Corp.)*

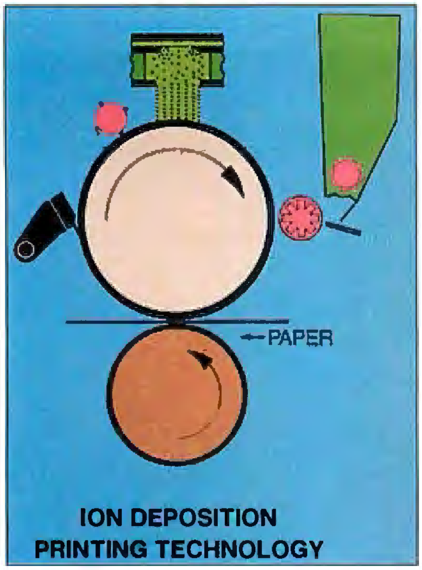

Figure 3: *A schematic diagram of an ion-deposition printer. A modulated ion source (top) similar to that in a triode electron tube generates the ions, which are directed onto the drum, forming a latent image. The image attracts toner from the cartridge, which then is pressure-fused onto paper passing between the drum and a pressure roller. (Figure courtesy of C. Itoh Electronics Corp.)*

The declining cost of electronic components, especially RAM, helps, but so much of a printer is electromechanical that prices probably won't drop as rapidly as they have for computers.

Another way to cut the cost of a page printer is to reduce its intelligence. Moving the rasterizing and image-storage components from the printer to the computer reduces the cost of the printer significantly. The amount of actual savings to the user depends on whether the computer's main processor and memory are used to control the printer, or whether a full-featured computer-on-a-board must be added through an expansion slot. For example, Atari's $1500 SLM-804 laser printer uses a separate controller box between the printer and the computer. Apple is also reportedly taking this tack (i.e., taking the intelligence out of the printer) with its new design for a laser printer that will supposedly list for between $2000 and $2500. IBM's Personal Pageprinter ($2199) uses a similar approach.

On the negative side, when the computer handles the control functions, a complete bit map of the page must be passed to the printer for every copy of the page printed. Without a fast communications channel, printing will be slow. Some companies, such as Electronic Form Systems and TallTree, use a video interface to keep the speed up. IBM's Personal Pageprinter uses a video interface. The least expensive way is to use a serial or parallel interface and just accept the slower speed.

Increasing the Resolution

Aside from lower cost, what users want most from a page printer is higher resolution.

At 300-dpi standard resolution, the page printer falls in an uncomfortable middle ground. The quality of text and graphics on a 300-dpi page printer is superior to that from other kinds of computer printers but not as good as the typeset material found in books and magazines. Traditional typefaces can only be approximated on a 300-dpi device (see the text box "Page Printer Typography" on page 194). In particular, halftone images suffer on a page printer (see the text box "A Gray Area for Page Printers—Photography" on page 192).

The minimum resolution on typesetters today is about 1200 dpi. If inexpensive page printers could print at that resolution, they would be much more useful. In fact, doubling the current resolution to 600 dpi would be good enough to handle most graphic-arts jobs. Book-quality work printed on coated stock would still be out of reach.

In the next 24 months, you will probably see a number of 600-dpi desktop page printers. But, for a variety of reasons, they will cost much more than the 300-dpi models.

As a printer's resolution increases, so does its cost of manufacture. The individual dots have to be made smaller, and their placement must be more precise. This is true for both vertical and horizontal resolution.

Increasing horizontal resolution requires better optics, especially on laser printers, because the effects of the cosine-fourth losses become more significant; at higher speeds and densities, the power level is more critical. Increased resolution also requires more precise control of the light source. On a laser printer, that means more accurate mirrors and more precise scanning. LED and LCS printers need more elements in the print bar and the ability to turn the elements on and off more quickly.

The accuracy of the drum-advance mechanism basically determines vertical resolution, since the drum must advance by one pixel for each new row of pixels. That means a better stepper motor and other components, as well as more precise electronic control.

Another consideration is the size of toner particles. Generally speaking, the smaller the average size of the toner particles, the higher the printer's resolution can be. However, the smaller the particles, the harder they are to control. A page printer is basically an electrostatic material-handling system where the material handled is toner. Ideally, there should be no charge anywhere except where the printer puts it, there should be no attraction among toner particles, and the particles should not move except in response to applied static fields.

In practice, however, toner particles are attracted to each other, they adhere to the drum, and they are influenced by stray electrostatic forces within the

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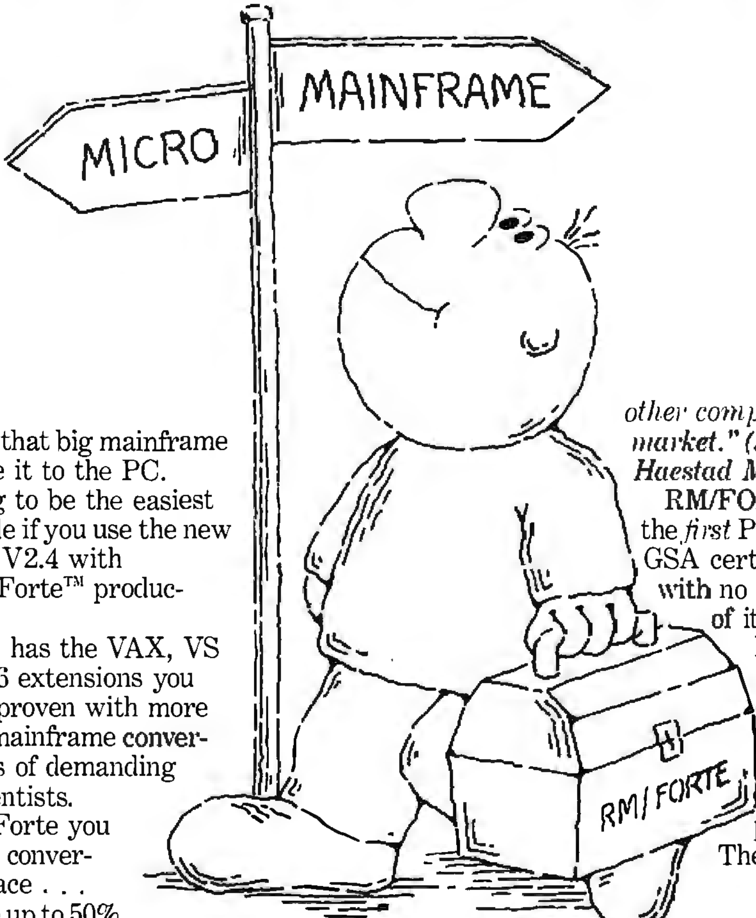

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A Gray Area for Page Printers—Photography

Photographs are a challenge for today's page printers. While text printed at 300 dpi might look beautiful to the casual observer, photographs rendered at the same resolution are decidedly second-rate. The reason for this is best summed up in two words: continuous tones.

The typical black-and-white photograph consists of continuously varying tones of gray. An artist attempting to copy a black-and-white photo can re-create the grays by mixing varying amounts of black and white paint on a palette. Of course, that solution isn't feasible in mechanical reproduction systems such as printing presses, which work with only one shade of ink. Because of this fundamental limitation, photographs and other continuous-tone images must go through a process known as screening before they can be mass-printed.

Photographic Screening

In the screening process, a grid of dots or lines called a screen is placed over the photograph, and a new photograph is made. The resulting *halftone* has no gray tones; instead, the gray regions are approximated by means of black dots that vary in size and shape. The density of the screen (i.e., the number of dots or lines per inch) along with certain other factors determines how well the halftone reproduces the original's gradual changes in tone: Higher density allows more gradual changes. Newspaper-quality halftones are typically made with an 85-line screen (i.e., 85 dots or lines per inch); magazine-quality uses a 100- or 133-line screen.

Digital Approaches

The same process can be simulated on a computer. First, the photo is digitized. A scanner moves across the photo just as a print head moves across a page, but, instead of printing, it reads the gray level of the image at fixed intervals. Each sample reading is stored as a number in a given range.

To reproduce the digitized image, the computer creates a bit image made up of small two-dimensional cells. The sampled gray levels are mapped into these cells. To reproduce a gray level from the digitized image, a corresponding percentage of pixels within that cell are turned on. For instance, if an 81-dot region is to have a gray level of 25 percent, 20 of the dots inside the cell are turned on.

Figure A: *A Laserport simulation of a 100-line screen, based on a digitized photo provided by Adobe Systems.*

Resolution vs. Shading

To allow for smoothly varying tones, small cells are needed (just as with the small dots in the halftone screens). But the smaller the cell, the fewer dots can be placed inside it. This, in turn, limits the number of discrete shades that are possible within a cell.

For instance, to approximate a 75-line screen requires 75 cells per inch. At 300 dpi, a page printer can place just 16 (i.e., 4 by 4) dots inside such a cell, yielding only 16 possible gray levels. Note that the resolution is now 75 cells per inch—the image will have only 75 discrete regions per inch, instead of the 300-dpi resolution when only two gray levels, black and white, are represented.

Some printers come with software to accomplish this kind of halftone simulation. Adobe Systems' PostScript, the PDL used in Apple's LaserWriter and certain other models, provides `screen` for setting the cell size, `setscreen` for controlling the method of filling pixels inside each cell, and `settransfer` for applying further transformations to the gray level inside each cell.

The net result of this software-simulated halftoning still falls short of the result of true photographic halftoning. The problem is the shape of the dots.

If you examine a printed photo under a magnifier, you will find that the shape of the dots varies depending on their surroundings. This is especially true along edges where the dots tend to elongate in the direction of the edge. This makes edges stand out much more clearly. Since edge definition is vital to perceived sharpness, the result is a major improvement in effective image quality.

Page printers generally cannot vary the shape of their smallest dot, and thus, at the lowest level, they cannot duplicate the effect of the photographic halftone. At a higher level—the cells made up of dots—page printers can vary the way the cell is filled in, but this approach operates at the expense of resolution.

One solution to this problem is to use a higher-resolution laser printer, so that the cells can be smaller and still represent a large number of discrete gray tones. This is effective but also expensive.

Smaller Dots

DP-Tek (Wichita, Kansas) has taken a more direct approach to the dot-shape problem. The company manufactures a Canon-engine controller called Laserport. Laserport combines a software package (for simulating the halftone process as explained previously) and a custom controller that actually varies the shape of the laser's dots.

DP-Tek claims that the Laserport controller can produce the equivalent of a 100-line screen print on a standard Canon print-engine laser printer, when driven by an IBM PC AT or comparable computer. (Figure A is a Laserport simulation of a 100-line screen, using as input a digitized photograph provided by Adobe Systems.)

According to DP-Tek, the Laserport system is based on two elements: the controller's ability to produce dots in any needed shape and the company's rasterization process, which mathematically models the effects of screening a photograph.

DP-Tek originally developed the system because it had to put in a system to prepare a computerized Multiple Listing Service book. The books show real-estate agents the houses available for sale in a particular area and usually include a photograph of the house as well as the description. Because the books are updated frequently and issued in fairly small print runs, this was an ideal application for a laser printer—except for the photographs.

"The computer industry has always used standard graphics techniques," says Alan Frazier, DP-Tek's president. "We took the same approach at first, but we couldn't get a satisfactory quality level. Finally, we spent a lot of time looking at dots."

According to Frazier, one of the most important parts of developing the system was modeling what happens when a photograph is screened; in other words, when light is reflected through a variable-density screen from an image. The development work was done on AT-class computers in C and Pascal and later optimized and converted to assembly language for run-time packages. This was combined with a proprietary controller that can vary the shape of dots.

The company is closemouthed about the details of the process. All Frazier will say about the way the controller works is that "in electronics, states are rarely purely on or off." Presumably, the controller varies the intensity of the printer's laser beam and/or the scan rate and drum-rotation rate to vary the shape of the dots. Figure B is an enlargement of a 300-dpi test pattern produced by Laserport, showing the system's ability to vary the dot size over a wide range.

The controller fits in the computer's case and works with the printer's resident controller. When the printer is printing text or graphics, the Laserport controller stays in the background. When it has to print a photograph, the Laserport controller handles it. The company claims that Laserport is transparent to the software that works with the laser printer.

The Laserport software includes drivers for the printers, modeling software to duplicate the effects of screening a photograph, and a set of high-level picture-printing commands. To print a picture, the user or the application program must tell Laserport where the picture is to go on the page and the name of the file containing the picture image.

The DP-Tek controller is sold to OEMs for incorporation into their systems. One customer is Chorus Data Systems of Merrimack, New Hampshire, which uses it with its Photobase graphics database.

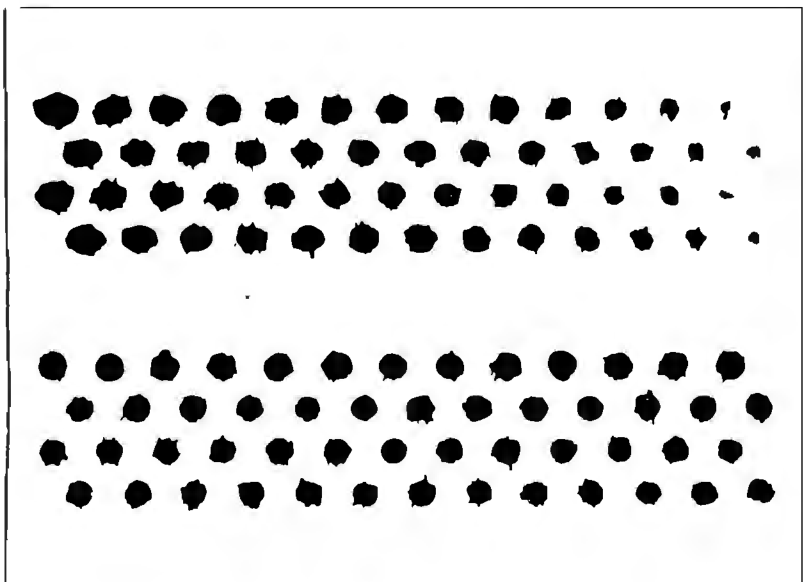

Figure B: *An enlargement of a 300-dpi test pattern produced by Laserport, showing the system's ability to vary the dot size over a wide range.*

Page Printer Typography

Laser printers are producing a revolution in typography. Type designers are adapting existing type styles to laser printers and designing new type styles to capitalize on the strengths of image printers and minimize their weaknesses.

The first mechanical composing machines, such as the Linotype, provoked a similar revolution when they appeared in the 19th century. The rigid mechanical spacing of the letters and the limited number of characters available in typesetter magazines forced designers to modify their type families. For example, italic fonts tended to become wider to match the spacing of regular fonts.

Phototypesetting precipitated another, smaller revolution in the 1950s. Rather than handcrafting each font in its own point size, typographers could design a single font and then use optics to produce a range of smaller and larger fonts. In some cases, the substitution of optics for hand design has resulted in a lowering of typographic quality.

The onset of digital type in the 1970s and 1980s has brought with it the promise of a return to the high art of typography. Having characters stored digitally brings all the power of CAD to the hands of the type designer. Page printers have brought the world of digital type to the personal computer desktop.

Typefaces and Fonts

Type is classified according to families. A family is a group of alphabets that are stylistically related. Within each family are several typefaces—alphabets sharing the same characteristics. Times Roman, Times Roman Bold, and Times Roman Italic are all members of the same type family. Typefonts are examples of a typeface in a particular type size. For instance, 24-point Times Roman Bold is a font, but Times Roman Bold is a face, a member of the Times Roman family. What computer people commonly call a typefont on a laser printer is really a typeface, since it comes in several different sizes.

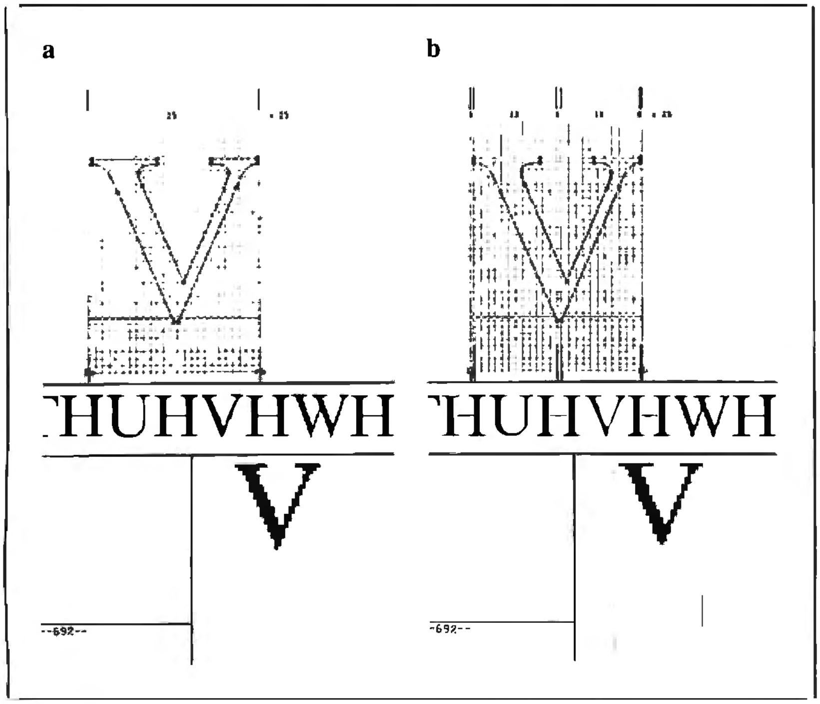

Figure C: *Examples of typographic designs that are hard to duplicate on a 300-dpi page printer:* **(a)** *Before optimization: Note the uneven base-alignment of* U, V, *and* W, *caused by the slight descent of the curved and pointed bottoms of the characters.* **(b)** *After optimization: Bitstream's Fontware corrects for the variations by moving the outlines. These corrections will be made automatically until the point size is large enough to allow the resolution to be aesthetically displayed. (Figures C, D, and E are courtesy of Bitstream Inc.)*

The distinction between typeface and typefont is important because there is more to the different fonts in a face than enlarging and reducing the type. This is especially true with laser printers.

Low-Resolution Typography

A type designer working for laser printers has two interrelated problems. Figure C illustrates them.

The first one is that some faces don't work well at 300 dpi. For instance, a face with slight angles in its long strokes will cause trouble. The classic example is Optima, a face with gently slanting verticals. At 300 dpi in common book sizes, this produces a jarring break in long verticals, such as the stem of a *d* or an *l*. Italics from many families give designers trouble for the same reason.

The lower resolution can interfere with subtle features of typefaces. Garamond, a common book face, has cups at the top and bottom of many strokes. At 300 dpi, those cups are hard to reproduce in common font sizes.

The second problem is that, even in fonts that are adaptable to laser printers, the coarser resolution requires adjusting the letter shapes. For example, in many faces, the points of the *w* and *v* extend slightly below the baseline. At 2000 dpi, this looks elegant. At 300 dpi, the extension becomes crude and jarring.

A related consideration is font size. Relative letter spacing and weight (i.e., thickness of strokes) tend to change with the size of the font. Details that cannot be reproduced in small sizes are important in larger sizes; without them, the type looks wrong. Similarly, spacing that is appropriate for small sizes is often too loose in larger sizes.

This is nothing new. Type designers have always had to adapt fonts to the method of typesetting. But today's bit-image printers require more adaptation than previous innovations.

The correct, but not universally practiced, process of adapting a typeface to a laser printer starts with an idealized version of the face at very high resolution. This is as close to the original type design as possible, without any compromises for reproduction or resolution. Typically, before a type foundry begins adapting a typeface, a type designer must "clean up" the letterforms to correct for adaptations that were made for the sake of other typesetting processes.

Once the idealized face is in hand, the

designers can begin adapting the face for different fonts.

A laser printer complicates this process because the resolution is so low. Information is lost when letters are reduced without any increase in resolution. For instance, a serif might disappear in the smaller typefonts, or a thin stroke may become exaggerated. As a result, type design for laser printers is in part a matter of trompe l'oeil. The eye must be fooled into believing features are present that actually aren't. The question facing the type designer is: Which information can be lost without distorting the letter too much? In one case, it might be better to compress a letter. In another, the stroke might be widened or a serif might be omitted.

One common adjustment is to increase or decrease the width of the strokes (vertical lines) so they coincide with a pixel column. Curves are less of a problem because the pixels of a curved line naturally fall on different scan lines, and the roughness can be made to average out. The extreme points of curves must coincide with pixel columns or they will become flat or pointed.

If you examine an enlargement of a laser-printed font, you will often find dots that don't seem to belong. An *r* might have a dot that appears too high in the curved stroke, or a *d* might have a dot almost floating inside the enclosed space. Actually, these "excess" dots are carefully placed to add weight or thickness at critical points and trick the reader's eye into seeing elements or details that are not there (see figures D and E).

The scaling is typically done algorithmically, at least in part. Type foundries usually have proprietary algorithms to change letter shapes as they enlarge and reduce their basic designs.

Once the face has been enlarged or reduced, a type designer usually optimizes it to make the font look as good as possible. This can involve not just resolution and size; it can also depend on the nature of the printer that will output the type. For instance, not all bit-image printing engines have the same ability to reproduce thin lines. The amount of optimization that is done depends on how well the algorithm represents the face in the new font and how much money the customer is willing to spend to get it right.

Adobe's PostScript PDL and Bitstream's Fontware system include algorithms for sizing faces effectively.

Bitstream has automated much of the design process with a program. Originally written in LISP on a Symbolics LISP machine, it is an expert system that chooses the best adjustments when scal- face based on the rules used by Bitstream's type designers. Bitstream offers Fontware to OEMs so they can scale and fine-tune faces for their equipment themselves. The company plans to offer a run-time package to do the scaling on the laser-printer controller or the computer driving it. Hardware and software OEMs will be able to adapt the package to their equipment or software to give their users the same kind of control over their fonts. If a user needs a 22-point font, he or she can get something optimized for 22 points, not something designed for 24 points and scaled down.

Despite the problems involved in adapting faces to bit-image printers, there is only limited interest in designing faces, especially for 300-dpi printers.

Matthew Carter, vice president of design at Bitstream, is adamant that good type is good type; it doesn't change over the centuries. Garamond, a very popular face today, was designed about 400 years ago. It is a mistake to discard one face and design a new one just to accommodate the limitations of a new technology, Carter claims, because the technology will have improved enough to handle the standard face before the new face catches on.

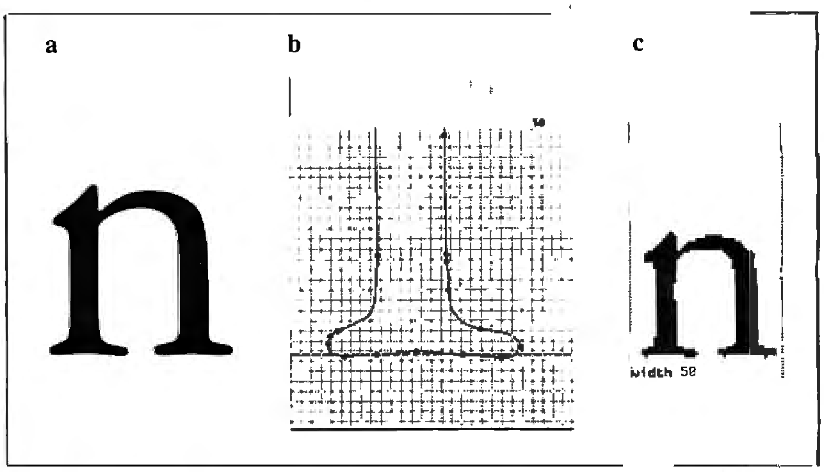

Figure D: *Some type styles are not representable at resolutions below 800 dpi. The lowercase* n *(detail* **a***) from Garamond #3 has wavering strokes and serif features that cannot be fit to conform to the grid (detail* **b***). To get the effect of a finely wrought typeface using 300 dpi, designers often trick the eye by adding dots where they don't belong (detail* **c***).*

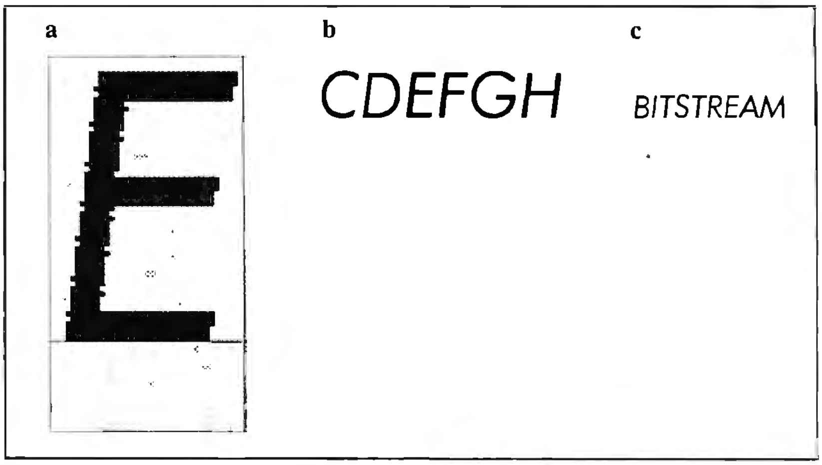

Figure E: *Characteristics of some type styles are representable with manual corrections by designers working directly with the output technology. The uppercase* E *of Futura is enlarged at 12 times actual size (detail* **a***) to show the serrated edge of the sloped vertical. At twice actual size (detail* **b***), the serrations are still visible; but at actual size (detail* **c***), the letters appear smooth and consistent.*

No one kind of page printer is going to give users everything they want. There are too many basic conflicts and trade-offs.

printer. The particles seep into other parts of the printer. All these effects get worse as the toner particles get smaller.

The traditional solution is to use a wet toner in which the particles are suspended in a liquid. This method is used by high-resolution electrostatic printers like laser phototypesetters, but it is messy and adds complications of its own. New toner formulations and better toner-manufacturing processes are another possible approach.

The paper becomes a factor as resolution increases. One of the reasons laser phototypesetters achieve such high resolution is that their output is printed on very glossy stock. The smooth surface makes fine detail possible. But the quality of paper supplied to most office page printers isn't nearly as smooth; thus, the page printer's output isn't as good at comparable resolutions. Apart from the cost of ultrasmooth paper, the paper-handling mechanisms used in desktop page printers depend on the surface roughness of the paper to get a grip. Paper on very smooth stock requires different, more complicated methods, such as vacuum gripping.

As resolution increases, the electronic components of the printer become more expensive. Doubling the resolution to 600 dpi from 300 dpi means quadrupling the amount of RAM needed to store a page image—to 5 megabytes from 1.25 megabytes (unless the controller design is changed; see the article entitled "Designing a High-Speed Page Printer Controller" by Phil Ellison on page 225). Furthermore, the controller must either work twice as fast to lay down twice as many dots per scan line in the same time or slow down the laser beam, increasing the time required to print a page. While the electronics costs don't increase in proportion to the mechanical costs, the increases are significant.

Intrinsically, there is no reason a desktop page printer cannot match the resolution of phototypesetters—if the buyer is willing to pay the price. For example, Varityper now makes a small 600-dpi laser printer that costs about $18,000.

Some phototypesetting machines are basically specialized laser printers, but they are even more expensive.

One factor holding back the development of high-resolution personal desktop page printers is that the manufacturers aren't sure that enough users are willing to pay the price. So far, the small page printer market has been highly price-sensitive, and the makers aren't sure most users will pay for higher resolution. Varityper's printer, for instance, is aimed at the typesetting market.

The Coming Printers

No one kind of page printer is going to give users everything they want. There are too many basic conflicts and tradeoffs. Instead, you will probably see a range of desktop page printers with different mixes of price and features.

At the low end will be inexpensive 300-dpi printers with print speeds of 5 ppm or less and street prices between $500 and $1000. These printers will rely on the computer's processor and memory for control. Due to memory constraints, they will probably not be able to print full-page graphics and will not use a page-description language (PDL). They will probably be limited to 8½- by 11-inch paper and might handle only certain weights of paper. You might see the first of these by the end of the year, although the very inexpensive examples are probably two years off.

The next group of printers will offer higher print speeds and more features for a higher price. They will include a PDL, full-page graphics, more flexible paper-handling, and a variety of bells and whistles. These printers will probably start at about $1200 and run up to $5000 or more, depending on features. These printers are essentially refined versions of today's page printers. In that sense, they are already available.

Above that will be the high-resolution page printers. Except for their 600-dpi resolution, they will be much like the preceding group of printers. Prices for high-resolution printers will probably start at around $5000. It will be at least a year, more likely two, before these desktop high-resolution page printers appear.

Finally, there will be desktop color page printers (see the article entitled "Color Printing" by Naomi M. Luft on page 163). These will probably come in at around $10,000 and won't be available for at least two years.

One thing is certain. Users want fast, quiet, high-resolution printing. That being the case, page printers of all sorts are going to proliferate for the rest of the decade. ■

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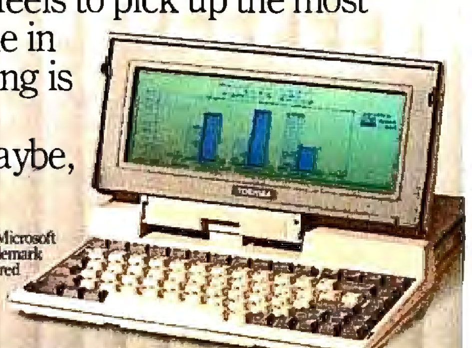

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Print Quality

The factors influencing print quality and ways to measure it

Lars Jansson

WHAT IS GOOD print quality? The easy answer is a subjective one: Good print quality is whatever most people consider it to be. However, for a printer manufacturer, that answer is not good enough.

Over the past year, engineers at Facit have been working on a set of objective definitions for print quality. We have also developed a measurement system that rates a print sample over a wide range of performance values relating to print quality. The ultimate goal is to rate printer technologies, as well as commercial printers, on the basis of print quality without relying on subjective, variable human judgments.

From a technical point of view, perfect print quality entails the ability to put a message at an exact position on a piece of paper without distortion. The message can be a complete image; it is then called graphics. You can divide such an image into graphics primitives—line, arc, and dot. Alternatively, a message can consist of text, which can be further broken down into text primitives—alphanumeric characters. The alphanumeric primitives are far more complex than the graphics primitives; each letter or number is a graphics image in its own right.

In any system that does not produce fully formed characters, the symbols are built up from dots. (This includes dot-matrix-impact, thermal, laser, ink-jet, and similar printers.) Thus, we start with some fundamental questions about dots. What are the properties of a dot? What are the properties of a system for putting dots on paper? And what are the properties of a symbol composed of dots? Answering these questions gives us a good start on defining and measuring print quality.

Design Considerations

A dot has size, shape (normally round), and color or gray level (in an ideal black-and-white system, a dot is black or it doesn't exist at all). When we transfer a dot to paper, its size changes and its shape is no longer what it was supposed to be—distortion enters the picture. But before printing, and from a design standpoint, size and shape are important parameters.

When we want to place a dot on paper, the first question is: On what positions horizontally and vertically is it possible to put a dot? In other terms, what position-grid or matrix do we have? The next question is: How close to one dot can we place another? Most printers cannot actually use horizontally adjacent grid positions due to compromises between speed and resolution.

For example, a typical character matrix in a 9-pin dot-matrix printer has 12 horizontal grid positions in each $\frac{1}{10}$ inch. But what is the actual resolution available for character generation? The last three of the positions make up the intercharacter spacing; therefore, the character matrix is actually 9 by 9. But if we place a dot on the first position, that pin typically cannot use the second position because the electromechanical system takes time to stabilize before it can fire again. Thus, the closest allowable spacing, or the horizontal resolving power, for dots on a line is $\frac{2}{12}$ inch, not $\frac{1}{12}$ inch as the character matrix might suggest.

In the vertical dimension, the resolution is the same as the vertical spacing of pins on the print head. Improving the resolution beyond these design limitations requires multipass techniques: After the first print pass, the paper or the print head is offset by a small amount horizontally or vertically and prints the line again.

Next, consider the readability of dots, lines, and arcs. What happens when we place a number of dots in line? How close do they have to be to generate a good line and not just dot, dot, dot?

Figure 1a shows that a 30 percent overlap with regard to diameter and grid position gives a decent line. But is that the whole story? If the dots are square or rectangular, which is common for thermal-transfer techniques, overlap is not necessary—at least not for horizontal and vertical lines.

Diagonal lines present another problem, shown in figure 1b. This figure shows that dot overlap alone does not give the complete picture. Figure 2 illustrates a more refined measurement, the *blank-area factor*.

Mathematically, the blank-area factor is the ratio of the blank (unprinted) area to the total area of the ideal line. In the case of circular dots printing a straight line, it

continued

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is sufficient to calculate one-quarter of the area over a span of two overlapping dots:

$$\frac{A}{4} = \int_0^{S/2} [f(x) - g(x)]dx$$

$$= \int_0^{S/2} \left[\frac{D}{2} - \sqrt{\left(\frac{D}{2}\right)^2 - x^2}\,\right]dx$$

$$= \frac{SD}{4} - \left[\frac{SD}{8}\sqrt{1 - \left(\frac{S}{D}\right)^2} + \frac{D^2}{8} \arcsin \frac{S}{D}\right]$$

$$A = SD - \frac{1}{2}\left[SD\sqrt{\qquad\quad D} + D^2 \arcsin \frac{S}{D}\right]$$

where D = the print wire diameter, S = the distance between print positions (center to center), $f(x)$ = the shape of the ideal line to be printed, and $g(x)$ = the shape of the print wire.

The blank-area factor is given by

$$\frac{A}{SD} = 1 - \frac{1}{2}\left[\sqrt{1 - \left(\frac{S}{D}\right)^2} + \frac{D}{S} \arcsin \frac{S}{D}\right].$$

Generally, the greater the overlap, the smaller the blank-area factor will be. But, when we use the above equation for varying degrees of overlap, we discover a point of diminishing returns somewhere between 10 percent and 30 percent, at least when round print wires are used (see table 1).

Of course, printer symbols don't consist just of straight lines. Arcs—circles or partial circles—are crucial in the design of most typefaces. Unfortunately, in the case of arcs, minimizing the blank-area factor requires a higher degree of dot overlap. Furthermore, these arcs demand as much from the vertical resolution as from the horizontal, while in most matrix printers, the vertical resolution is often just half as good as the horizontal. The solution to this design challenge tends to be expensive.

Minimizing the Blank-Area Factor

If we can achieve good print quality by having a small blank-area factor, how do we then get one? One answer is obvious—a dense matrix and small dots. Wefind this in laser printers with a resolution of 300 by 300 dots per inch and a dot size of about 0.1 millimeter. However, impact-matrix printers have a limit to the dot size: pins of 0.1-mm diameter will pass right through the ribbon without touching. The minimum practical dot size seems to be 0.2 mm, which we find in 24-pin print heads.

A small dot causes a new problem: Reproducing the vertical lines or stems of most characters requires printing at least two adjacent dots, which slows down printing and also affects the blank-area factor.

With this in mind, we must look for a different dot shape, one that gives a better blank-area factor and does not require two dots to make a vertical line. Figure 3a shows the result (enlarged and idealized) of using a semielliptical dot that is 0.2 mm vertical and 0.34 mm horizontal. If a print head can accommodate elliptical pins, this approach looks promising.

Typographic Ideals

What is the property of a symbol?

If we restrict ourselves to alphanumerics and allow full freedom for aesthetic considerations, we can avail ourselves of 500 years' worth of typesetting and font design. So why reinvent the wheel by doing our own typefaces? Unfortunately, we do not have full freedom, particularly not in matrix printers. Given the limitations of a particular matrix, it can be extremely difficult to adapt a set of characters that was originally defined in terms of continuous lines. It is often much easier and more successful to design an attractive set of characters specifically for one printer's limitations. So we're back to fundamentals of typeface design.

What then is the most important property of a symbol? If we can't read it, it doesn't matter how pleasing it is to the eye, so readability is number one. What is readability, and what distinguishes one character from the other?

Figure 3b tells you that the upper part of lowercase letters gives much more readability information than the lower part. (Try reading each half with the other half blocked from view.) In particular, the intersection between stem and body gives a lot of information—distinguishing between b and d, for example.

Most of the characters in the roman alphabet consist of one or more lines created without lifting the pen from the paper. Some characters also have diacritical marks, but, even for those characters, the major portion is a continuous line. What distinguishes one line from another is the varying line width and, in some cases, the serifs used at the end of the line.

We have a dilemma. Typographic art requires a fine grid, small dots, and, very often, thick lines. On the other hand, print speed requires either a coarse grid or, in a fine grid, the allowance to skip over one or several positions after printing a dot. The cost of technology limits the position accuracy, dot frequency, and dot size. It is not possible to satisfy all these quality and speed requirements at the same time. Already, at the design stage, we have to make compromises.

After designing the ideal grid and selecting a dot size, dot shape, and character shape, we can print symbols on paper. But the result on paper is far from what we envisioned. Misalignment and skewing appear, with respect to lines and even with respect to character cells. The characters themselves do not look as designed. Ink appears where it is not supposed to be and none, or very little, where it is supposed to be. Why is this so, and how do we measure the departure from the ideal?

Measurement System

To objectively and efficiently perform all the measurements and their related calcu-

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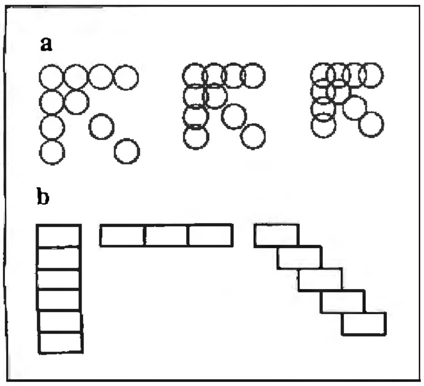

Figure 1: (a) *Effects of varying degrees of dot overlap on the clarity of lines with circular dots.* (b) *Rectangular dots require no overlap for horizontal vertical lines.*

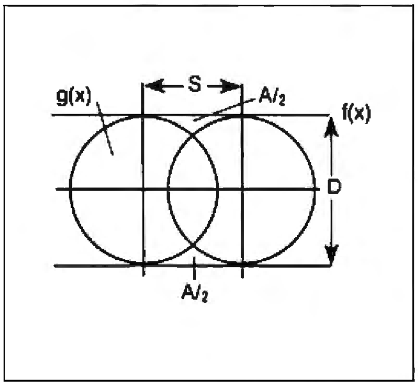

Figure 2: *The blank area* A *is a function of dot diameter* D, *overlap* S, *the shape of the line f(x), and the shape of the dot* g(x).

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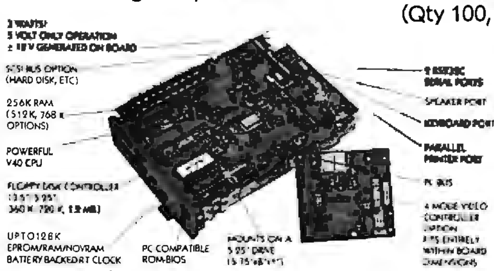

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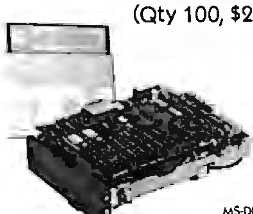

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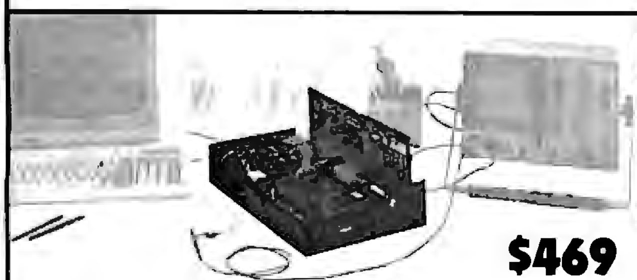

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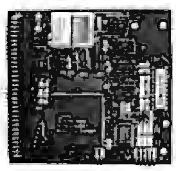

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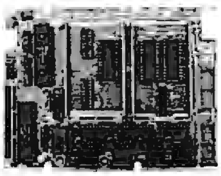

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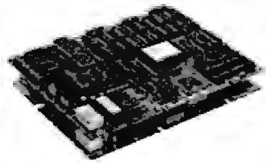

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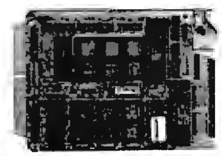

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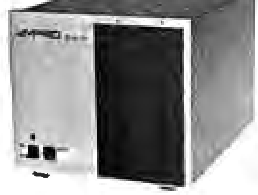

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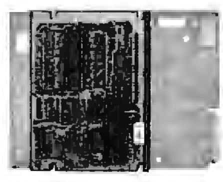

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lations, we use an image-processing system from the Swedish company ContextVision (see figure 4).

First, we take a carefully planned print sample, enlarge it, and convert it into a digitized gray-scale image. Photo 1 shows an original and its digitized counterpart. Now that the print sample is in digital form, we have access to a powerful array of image-processing operations.

The first operation is to divide the image into meaningful regions—characters or dots, depending on what we're measuring. Briefly, the system uses a threshold level to sort out the pixels that belong to the background from the ones that belong to the character or dot. Photo 2, produced with the ContextVision system, is a histogram showing the frequency of intensity levels. Table 2 lists some of the results of the image analysis.

Position Deviation

One way to measure position deviation is simply to measure the distances between characters on a row of identical characters and calculate the variance. However, numerical cancellation tends to reduce the validity of the measure. A better way is to measure the deviation of each character from its ideal location, using as a reference point the character's center of gravity, as shown in figure 5.

Position variance is defined as

$$v_x = \frac{1}{n-1}\sum_{i=1}^{n}(d_i - \bar{a})^2$$

$$= \frac{1}{n-1}\left[\sum_{i=1}^{n} d_i^2 - n\bar{a}^2\right]$$

and the position deviation is

$$SV_x = \sqrt{V_x}\ ,$$

where d_i = the distance between a printed and an ideal character, n = the number of distances measured, and $\bar{a}$ = the mean value of the distances d_i.

Edge Sharpness

Good printing should be crisp and clear; the edges of characters should be very well defined. Reality, once again, tells you that this is not the case. Under magnification, the edges appear as shown in photo 3.

One way to measure edge sharpness is to plot the darkness of a character as a function of distance across one of its component stems and then to measure the

continued

Table 1: *At around 30 percent overlap, the blank-area factor becomes small enough, and further increases in overlap are not significant.*

Overlap (%)	S/D	Blank-area factor
0	1.0	0.2146
10	0.9	0.1600
30	0.7	0.0891
50	0.5	0.0434

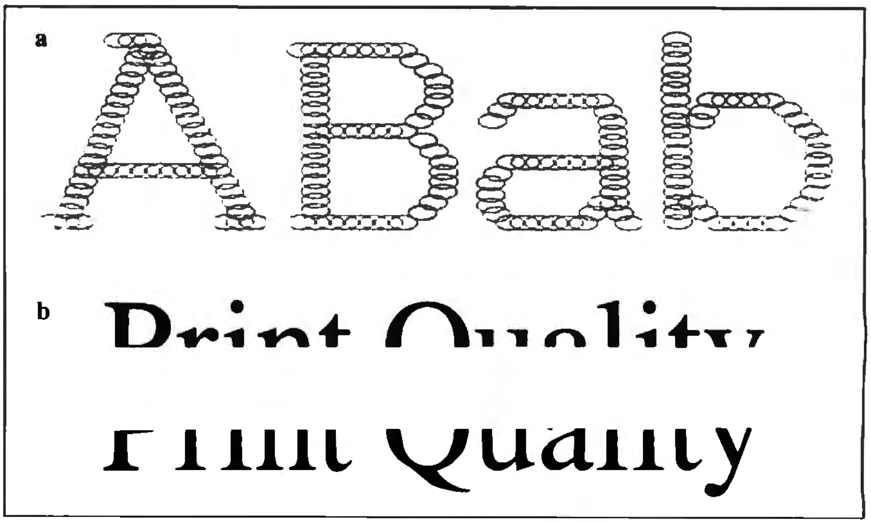

Figure 3: (a) *Elliptical dots reduce the blank-area factor without as much overlap as circular dots.* **(b)** *The top part of roman letters conveys more information than the bottom; try reading each half with the other blocked from view.*

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width of the edge—the portion of the character where the intensity falls from 90 percent to 10 percent (see figure 6). This measurement is repeated along the perimeter and is normalized by dividing the sum by the number of samples.

Edge Roughness

Before a character—and, on a lower level, a dot—is printed, its edge is straight or slightly curved. In the printing process, this property is lost and edge roughness appears instead (see photo 4).

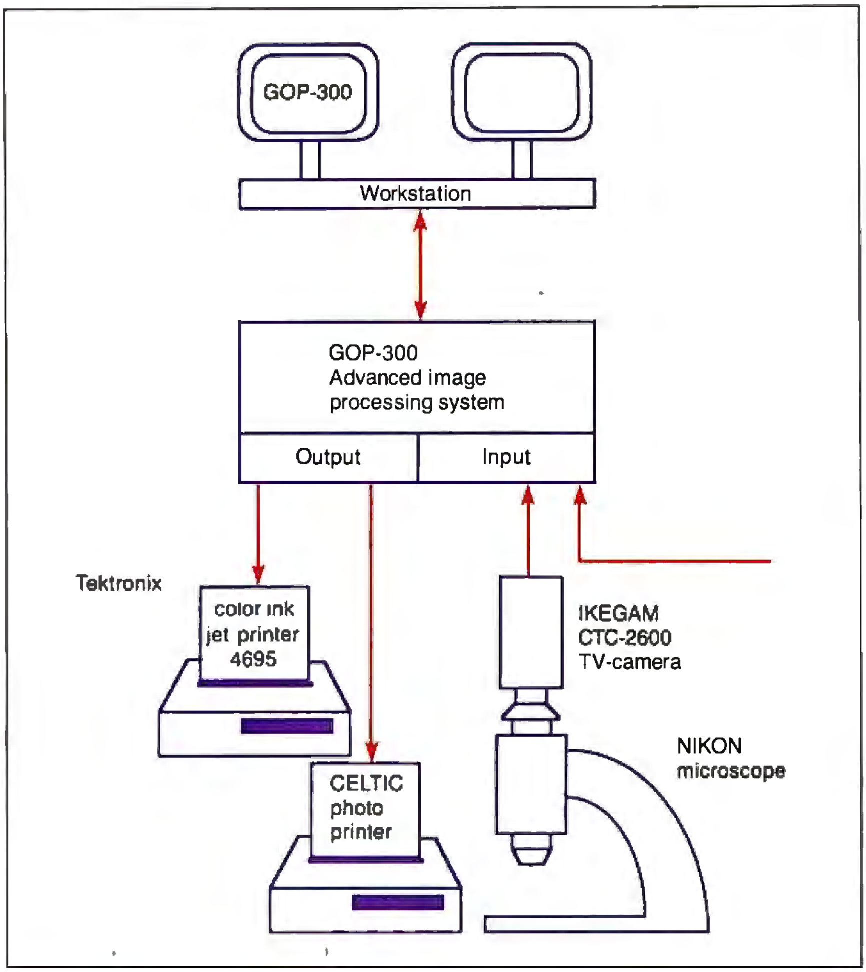

Figure 4: *Schematic diagram of the ContextVision image-processing system Facit uses to make objective print-quality measurements.*

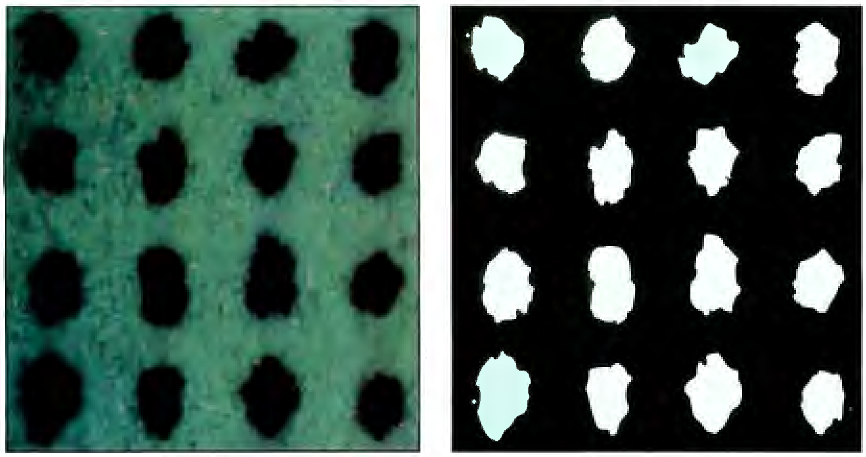

Photo 1: (a) *The original printed test pattern and* **(b)** *its digitized counterpart (with colors reversed).*

Edge roughness is thus defined as the distortion that comes from small local errors in the edge line; note that this attribute is distinct from the global shape deviations described below.

To measure roughness, we use the fact that the perimeter of a character with a rough edge is longer than the one of a character with a smooth edge. Using image processing, we smooth the perimeter and then compare the perimeters before and after smoothing. Roughness is thus defined as the ratio of the original perimeter to that of the averaged object.

Edge Orientation Variance

An interesting property of edge roughness is the variation of the orientation of roughnesss around the edge. By measuring the direction as well as the magnitude of roughness for every point around the perimeter, we can understand some of the reasons for the edge roughness. For example, depending on the roughness orientation, we may be able to deduce that a print wire is oscillating or out of alignment or that power distribution is uneven over the wire matrix. Our image-processing system includes a special operator that produces an image in which the brightness of each pixel corresponds to the confidence that an edge is present and the color corresponds to the direction of that edge (see photo 5).

Shape Deviation

A large global error in a character (e.g., a bent stem in the letter T) is defined as shape deviation. Shape deviation is measured over a set of, say, 100 duplicate characters by superimposing the characters on each other. You can measure the "fuzziness" of the edge by calculating the statistical variance between pixels located at the same place on the different characters and then summing these variances. (Note that the pixels I'm referring to exist inside the image-processing system and are much smaller than the print dots.)

Gray-Level Variance

The gray-level variance measures how uniform the blackness of the character is. Ideally, the gray-level variance should be zero, or at least very small. Gray-level variance is calculated as follows:

$$v = \frac{1}{n-1} \sum_{i=1}^{n} (x_i - \overline{x})^2$$

$$= \frac{1}{n-1} \left[\sum_{i=1}^{n} x_i^2 - n\overline{x}^2 \right]$$

where x_i = the gray level of each pixel in the character, n = the number of pixels in the character, and $\overline{x}$ = the mean value of the gray level x_i.

This measurement applies to entire pages as well as to characters. In the case of characters, we measure the gray level of each pixel and calculate the result. To get the gray level of a page, we perform the same calculation a second time, using the mean value of the characters' gray level as measurement data.

Interpreting the Data

Now that we have an objective measurement tool for print quality, how do we apply it? Looking over the different attributes, it seems that we have been measuring badness rather than goodness of printing. Does this negative orientation let us make positive comparisons be-

continued

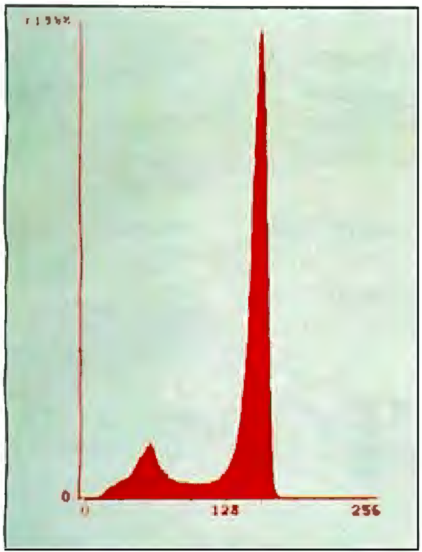

Photo 2: *Histogram of the gray-scale image of photo 1.*

Table 2: *The statistical results from the image-processing analysis. (Roundness in the ContextVision system is the integration of the shortest distance to the edge per pixel for all pixels within the dot, for all dots within the sample. D_{max} is the length of the longest axis through the center of gravity for each dot in the sample. Angle is the angle of the longest axis.)*

		arithmetic mean	standard deviation
Area	(mm^2)	0.091	0.0123
Mean diameter	(mm)	0.340	0.0229
Roundness	(CTX)	1.585	0.1427
Perimeter	(mm)	1.395	0.1307
D_{max}	(mm)	0.430	0.0466
Angle	(deg)	90	12.3
Satellites	4		
Measured objects	16		
Contrast (obj/bkn)	0.40		

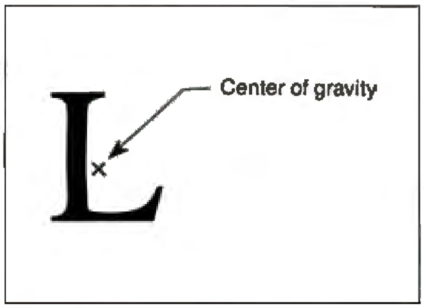

Figure 5: *A character's "center of gravity" is used as a reference point in calculating position variance.*

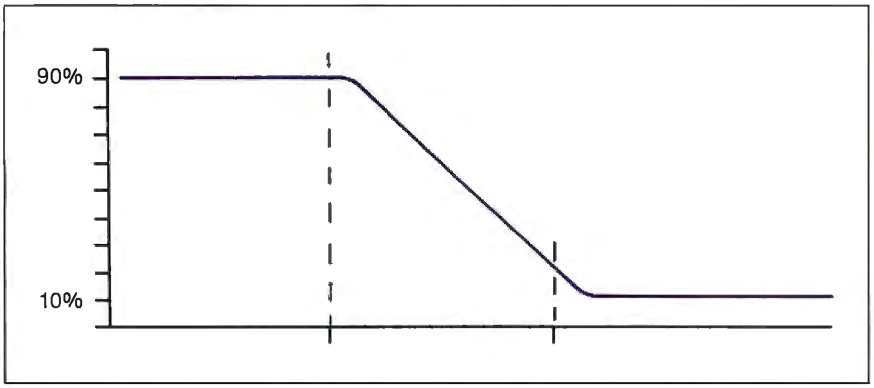

Figure 6: *The gray level of a character is plotted as a function of distance. The area between 90 percent and 10 percent intensity corresponds to the fuzzy edge of the character. In sharp, clear printing, this region is minimized.*

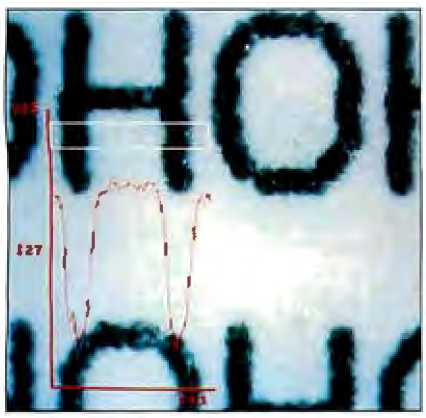

Photo 3: *Edge sharpness is measured within the white border. The red graph shows the rate of fall off from black to white.*

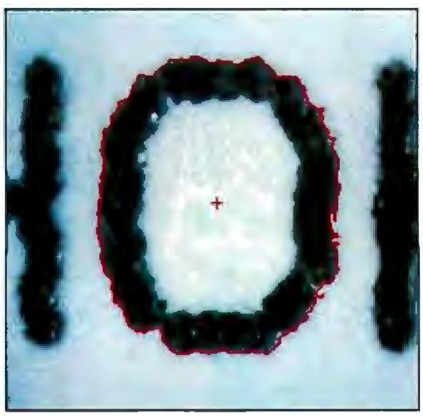

Photo 4: *To measure edge roughness, we compare the perimeter of the original object to the perimeter of a smoothed version.*

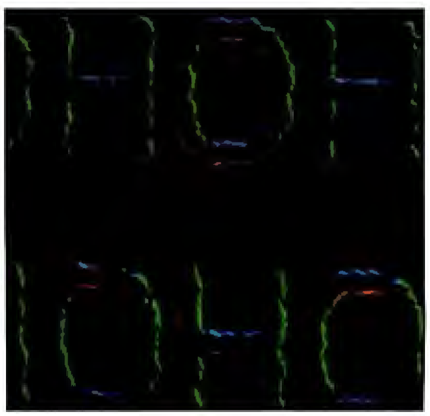

Photo 5: *Different colors represent different orientations of edge roughness in this computer-enhanced representation.*

What users perceive as bad print quality relates directly to certain measurable attributes: smearing (and its inverse, voids), shape, and dot density.

tween different print samples?

To make the leap from laboratory measurements to inferences about perceived quality, we must calibrate our measuring tool against the subjective opinions of a wide variety of users. In other words, we need to know the relationship between objective measurements like *position deviation*, *shape*, and *dot density*, and wine-tasting terms such as *crisp*, *clear*, and *pleasing*. To go one step further, can we use our objective measurements to define, once and for all, the various print-quality levels: draft, correspondence, near-letter quality, letter quality, and whatever we wish to call the next quality level?

At Facit, we have much more research to do on these issues, but preliminary work reveals some useful information.

What users perceive as bad print quality relates directly to certain measurable attributes: smearing (and its inverse, voids), shape, and dot density. A print sample's rating in these three areas seems to account for 80 percent of its subjective score, provided it is a normal sample without gross errors.

Smearing (ink where it is not supposed to be) and voids (no ink where it is supposed to be) correspond to our measurements of edge roughness and sharpness.

Shape attributes correspond to our measurements of the blank-area factor, position grid, and shape deviation.

Dot density relates to the tuning of the virtual and the actual grid, the blank-area factor, and the gray-level variance.

Once we have agreed on a correlation between our objective measurements and subjective judgments, we still are not done. Finding the reason for the flaws in a print sample—a design limitation of the printer, a faulty adjustment, poor quality or incorrectly matched ribbon, or unsuitable paper—is outside the scope of our tests but is important nonetheless.

We are continuing to work on the problem of measuring print quality, and we welcome comments and suggestions from users and from others involved in printer design. ■

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Engineering Close-Ups

Printers encompass technologies from a wider variety of engineering disciplines than any other component of a computer system. Most design improvements go far beyond electronics and electromechanics into areas such as ballistics, chemistry, thermal mechanics, optics, fluid mechanics, and metallurgy.

At the same time, the engineering goals behind these improvements are easy to appreciate, since the ultimate product, printing, is one with which we are all familiar.

Considering these two points about printer technology—its variety and concrete end-product—we thought it would be interesting to present close-up views of specific printer developments, written by engineers with firsthand knowledge of the problems involved.

The five close-ups that follow don't cover all the various printing technologies, but they do illustrate the engineering process that underlies any technological improvement: analysis, design, modeling, prototyping, and refining to a finished design.

As you'll see, printer technology is a mature but by no means static area of engineering.

—George A. Stewart
Technical Editor

Taming the Hot Heads

As printers get faster, print heads get hotter. Computer-aided design plays a major role in solving the problem.

Keith B. Davenport

A warning label ("Hot") appears on almost every current-model dot-matrix impact (DMI) print head. The need for that warning is a direct result of the increased speeds in today's printers. New print-head designs are capable of 200 to 300 characters per second. Just as important, character throughput has increased due to improved printer firmware and increased paper slew rates. The negative side of increased throughput is that the print head has a higher duty cycle; it has less time to cool off.

Keith B. Davenport is advanced techniques manager at Newbury Data Recording Ltd., Hawthorne Rd., Staines, Middlesex, England.

Other than the safety issue, what's wrong with a hot print head? Operating at high temperatures reduces the useful lifespan of most materials or requires that more expensive, high-temperature materials be used. High temperatures reduce the ferromagnetic qualities of most materials, which are the heart of any electromechanical device. The more energy wasted, the larger the power supply must be. Finally, a hot print head often reduces throughput because the printer must slow the printing rate at various times during printing to let the head cool off.

Most DMI print heads are very inefficient, with typically 94 percent to 99 percent of the input energy wasted. Figure 1 illustrates the various kinds of losses in the DMI design.

Engineers at Newbury Data Recording have been making DMI print heads since the early 1970s. Their first print head was a seven-pin device using coaxial solenoids to drive the print wires (see figure 2). Though it was in step with the state of the art at that time, the design had several disadvantages: The nonlaminated structure allowed for high magnetic "eddy current" losses; the completely encased coil restricted heat dissipation; the large remanent air gap in the rear bearing re-

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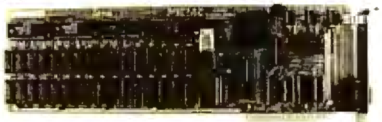


duced the magnetic efficiency; and the large armature mass, required to carry the magnetic flux and drive the print pin, made the device mechanically inefficient, with poor response. As a result of these factors, the print head was limited to low-frequency operation and was quite inefficient (1.5 percent).

With this analysis in mind, engineers at Newbury Data Recording resolved the problems to provide designs for 9-, 12-, and 18-wire print heads that ran cool. This meant increasing the devices' efficiency.

The plan of action involved considerable mathematical work, CAD, and optimization using prototype models. Here's a summary of the process by which they maximized the efficiency of a DMI print-head design:

1. Generate the actuator (pin-drive) mechanism.
2. Describe the actuator mathematically.
3. Compile a computer program to optimize the efficiency.
4. Predict the overall performance using a finite-element analysis program.
5. Compare computer predictions with the actual model.
6. Realize a manufacturable design using CAD.
7. Use open construction to allow forced-convection cooling to occur during carriage motion.
8. Maximize the heat-conducting surfaces.
9. Use laminated structure to minimize the eddy currents.

Because of the decision to laminate, New-

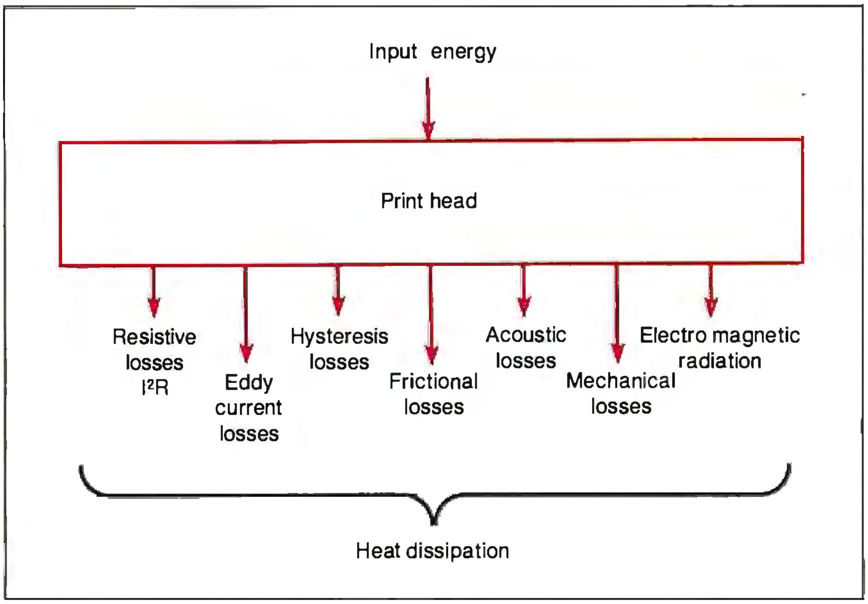


Figure 1: *Types of losses associated with a DMI print head.*

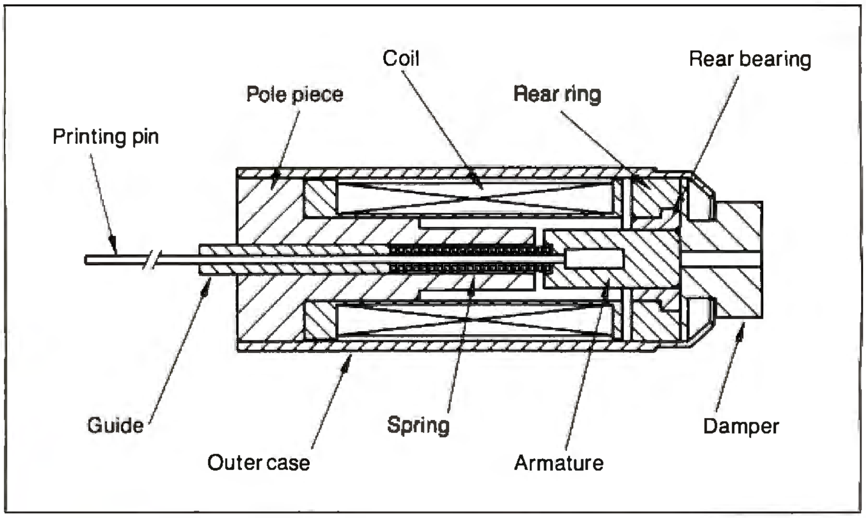


Figure 2: *Coaxial solenoid used as an actuator in an early seven-pin design.*

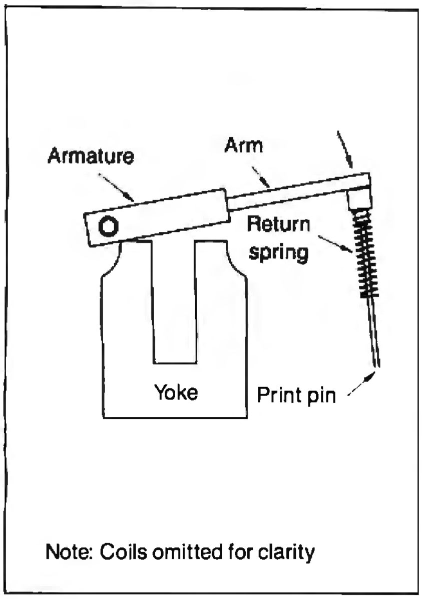
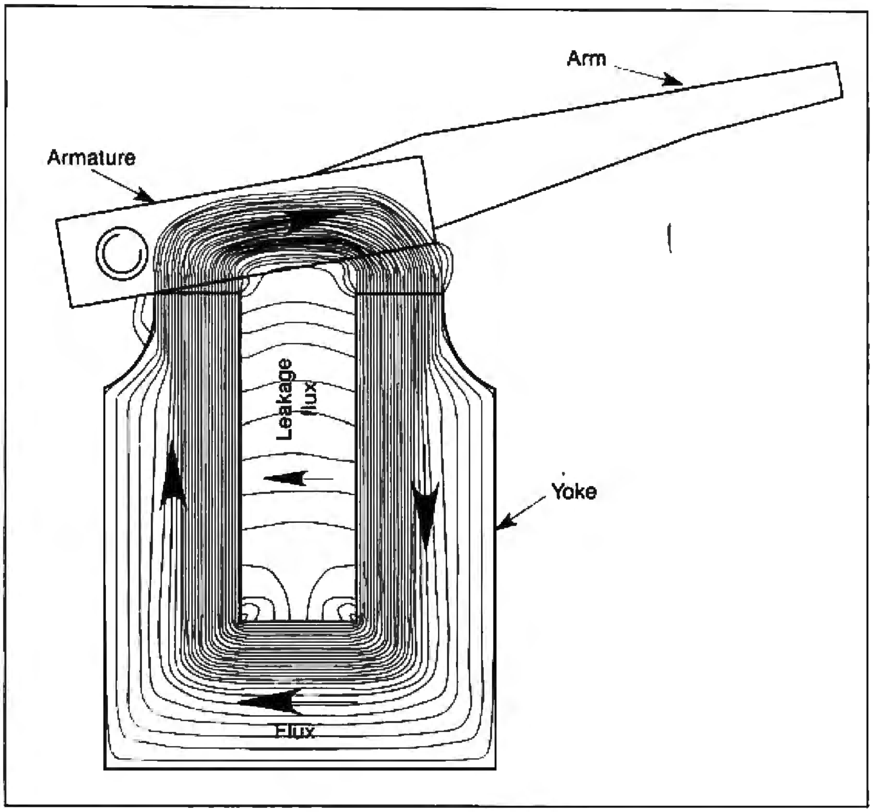


Figure 3: *This U-shaped yoke and pivoted-armature model formed the basis of the computer-aided modeling process.*

Figure 4: *Flux distribution across the yoke and armature.* ▶



bury engineers rejected the previous coaxial design. A laminated cylinder is expensive to manufacture and is less efficient. Instead, they chose a simple U-shaped yoke with a pivoted armature (see figure 3) and used this design as the basis for a mathematical model describing the dynamics of the actuator to the point of air-gap closure (when the armature is pulled down by magnetic force onto the yoke).

The engineers made one major assumption about the magnetics of the model: The flux in the armature equalled the flux in the air gaps. Reluctance (magnetic resistance) was calculated as four components: yoke, air gaps, leakage, and armature.

Mathematical Model

The model describes every aspect of the print head: electrical, magnetic, and mechanical, as well as their interrelationships, and with respect to time.

When the coil receives an electrical pulse, the current generates a flux field concentrated in the yoke and passing across the air gaps (see figure 4). The flux field increases with time, accelerating the armature/arm/print wire assembly until the air gap closes, launching the print wire into free flight to place a dot upon the paper. The print wire returns by rebound, colliding with and imparting momentum to the arm; a visco-elastic damper absorbs most of the energy over the course of several bounces.

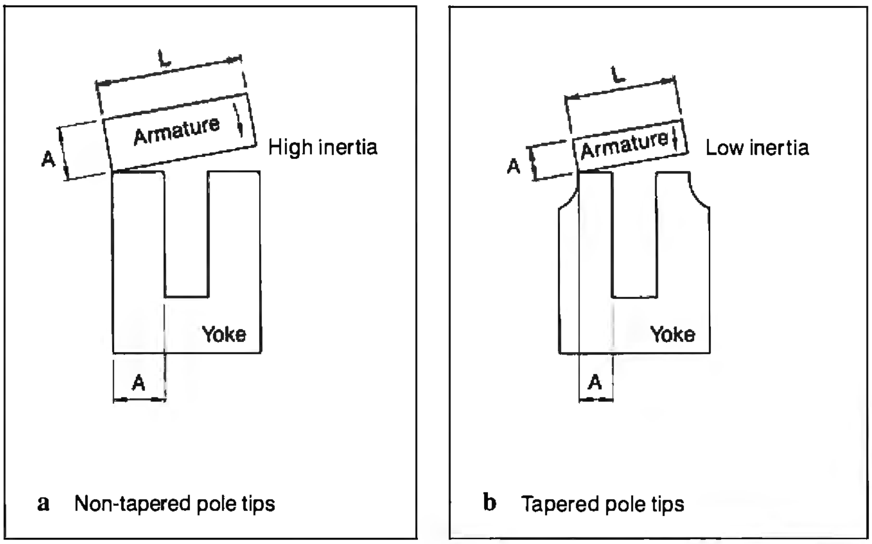


Figure 5: *Nontapered yoke tips (a) and tapered tips (b). Tapering the yoke tips reduces the length and hence the inertia of the armature.*

In modeling the electrical input energy, the engineers chose a capacitor-discharge circuit that provides an LCR (inductance-capacitance-resistance) network. They concentrated on the capacitor-discharge drive because it provides a constant energy input. However, two other designs can also be used by simple changes to the mathematical model: voltage drive and current limit. Providing an infinite value of capacitance would force the model to behave as a voltage drive, and placing a current-limit trap in the algorithm would let it simulate a current-limit circuit.

To maximize the coil surface area and minimize leakage flux, they placed a coil on each limb of the yoke. Tapering the yoke tips let them (at the expense of magnetic saturation) significantly reduce the length and hence inertia of the armature, a function of $(\text{length})^3$ (see figure 5).

Within the armature/arm assembly, they calculated a theoretical mechanical

continued

efficiency of 65 percent, but much depends on the arm shape and the practical limitations of manufacture.

Computer Modeling and Design

Having settled on a model, the engineers developed a computer program called Sheba (which stands for simulated high-speed electromagnetic ballistic actuator) to optimize the efficiency, based on the following inputs:

- time to shut the air gap
- capacitor voltage
- print energy at launch ($\frac{1}{2}mv^2$)
- starting values for all dimensions
- capacitor value
- frictional allowances
- material characteristics

At various stages within the program's operation, ferromagnetic data is extrapolated using linear interpolation. The program attempts to optimize efficiency by varying five dimensions of the model: armature thickness, yoke thickness, yoke throat width and depth, and yoke limb width. These are the key parameters affecting the electromagnetic actuator.

The program outputs all dimensions and voltages, electrical current profile, number of turns in the coil, initial air-gap distance, time to launch, other electrical and mechanical characteristics, and, of course, the overall efficiency.

The mathematical model and Sheba describe the actuator only to the point of air-gap closure. Since this is only 30 percent of the total cycle, the engineers needed another means of completing the study. They used a general-purpose finite-element program, ANSYS, to analyze the time/displacement histories of the structure under various loading conditions. This let them graphically describe the important components of the system and follow their behavior under various flux-field situations.

To measure actual performance of prototype models for the print-head actuator, they used a noncontacting displacement follower, deriving time/displacement and first and second derivative curves for single-shot or continuous operation of any of the moving parts. They then correlated the measured and predicted results and made the necessary modifications to the computer model. For example, the visco-elastic damper has nonlinear characteristics that are particularly difficult to model.

To ensure a manufacturable design, they made extensive use of CAD. All detail, assembly drawings, and the bill of materials were produced from a solids model (see photo 1).

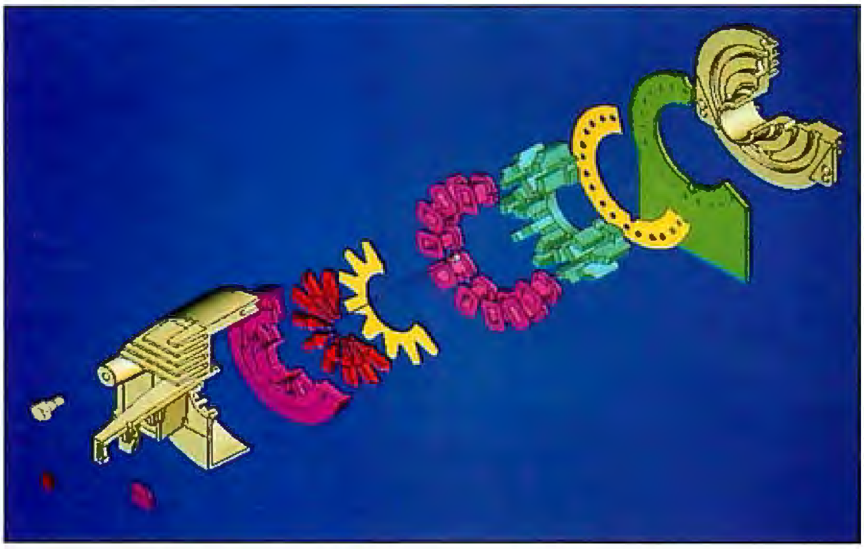


Photo 1: *The culmination of the CAD process was an accurate solids model.*

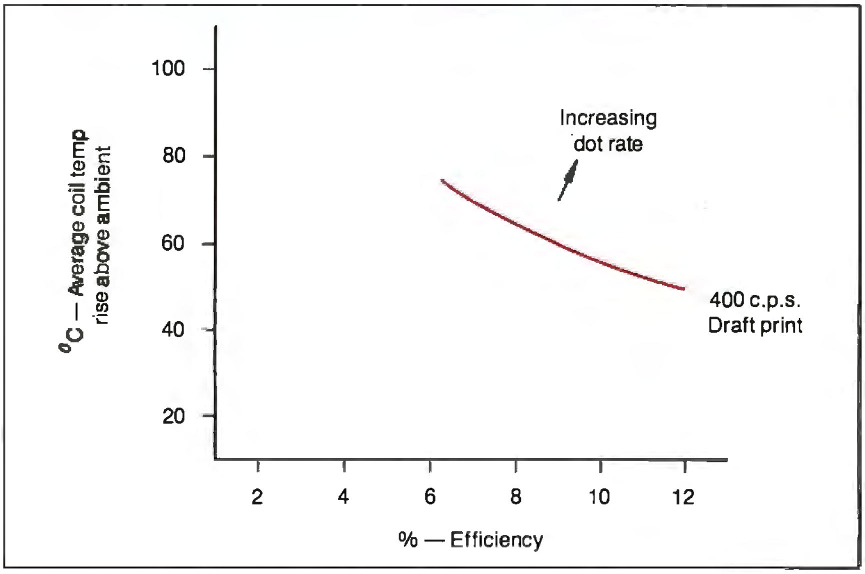


Figure 6: *The curve shows the relationship between efficiency and head temperature for a 400-cps (draft mode) printer.*

The overall design is suited for a variety of product ranges, resulting in further benefits from using a computer model in the design. It was a straightforward process to produce components for a variety of print-head models by duplicating components in the computer model. The use of CAD also made possible the generation of complex three-dimensional and sectional views in any orientation—invaluable for checking manufacturability.

The resulting print head, incorporated into a capacitor-discharge drive circuit, requires only 4.7 millijoules per cycle per actuator (12 percent efficient); incorporated into a voltage drive circuit, the head requires 8 mJ/cycle/actuator (7.4 percent efficient). Contrast these numbers with typical industry figures of 11 mJ/cycle/actuator (6.3 percent efficient).

The Future

Still greater demands will continue to be made on DMI print heads, and therefore it becomes increasingly important to provide devices with higher efficiencies (see figure 6). The flapper or armature print head is limited in its performance by the high inertia of the moving parts. Stored-energy heads may become increasingly important because they offer potentially higher firing frequencies with better efficiency. [Editor's note: *The stored-energy design is described in "Matrix-Line Printing" on page 215.*]

The design approach summarized in this article—with suitable changes to the mathematical algorithms—will be equally beneficial to future print heads, keeping efficiency high and temperatures low. ■

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Matrix-Line Printing

In this alternative to serial character printing, an 8-inch-wide bank of print hammers moves just ⅓ inch to print an entire line

Mark Hohneker

Matrix-line technology has been used in commercial, heavy-duty printers for over 12 years but has only recently been adapted for personal computing applications. I am going to explain some of the more unusual features of matrix-line printing as implemented in printers from Printronix.

The typical dot-matrix printer uses a print head with 9 to 24 closely spaced pins. The print head generates print characters in serial fashion, moving horizontally back and forth across the full width of a page, printing a vertical bar of nine or more dots at each dot column position. In this design, printing speed is largely a function of the number of characters printed.

In matrix-line technology, 24 print hammers are arrayed horizontally on an 8-inch shuttle (wide-carriage designs use more print hammers and a wider shuttle). The hammers fire simultaneously, printing an entire horizontal line of dots with a single ⅓-inch sweep of the shuttle assembly. Figure 1 is a simplified drawing showing the design's major components.

During the course of this sweeping movement, each hammer prints a horizontal dot pattern for characters that belong in the ⅓-inch zone covered by that hammer. At a setting of 10 characters per inch in an 8-by-9 matrix, each zone contains 30 dots, or 3 characters.

At the completion of the horizontal sweep, the printer advances the paper by one dot row. The shuttle then reverses direction and prints the next row.

Although the matrix-line printer uses a hammer bank in place of a serially moving print head, it does maintain a logical

continued

Mark Hohneker is a technical writer for Printronix Inc. (17500 Cartwright Rd., P.O. Box 19559, Irvine, CA 92713).

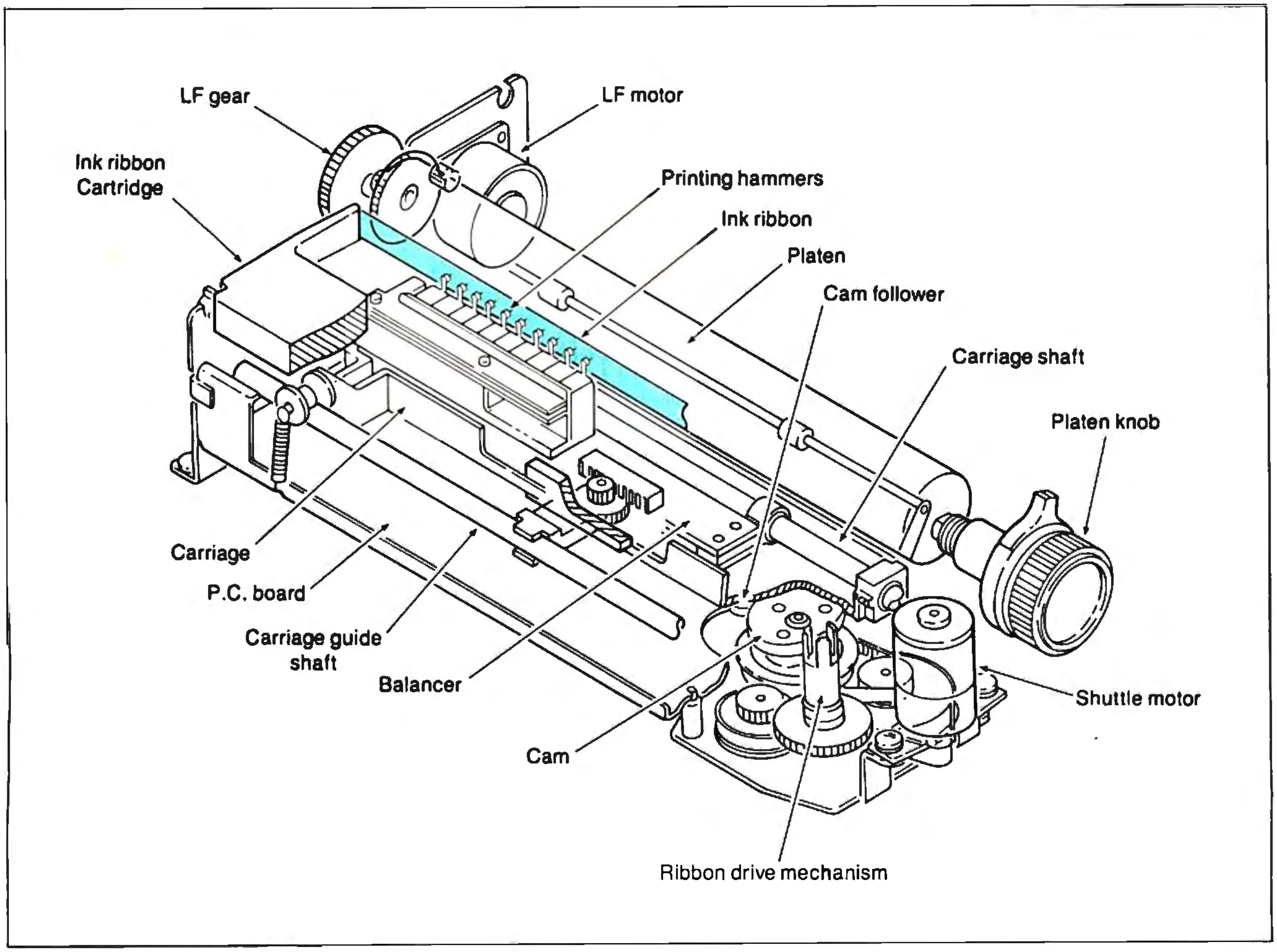

Figure 1: *A simplified cutaway drawing of the matrix-line printer design, showing only 10 print hammers.*

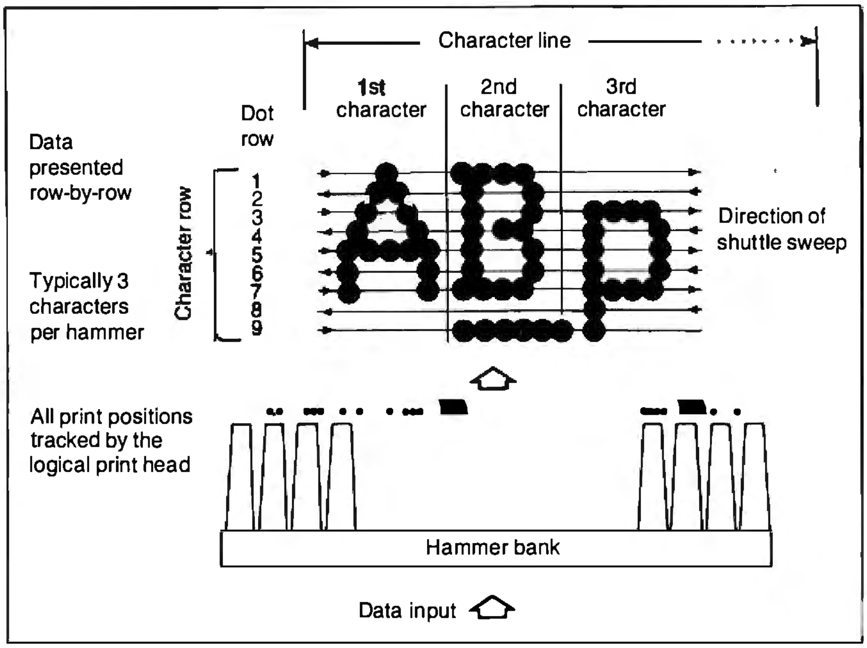

Figure 2: *On-board printer firmware rasterizes a full line of text into a buffer called the logical print head, which is then mapped into the hammer bank. The figure shows the number of dots printed by a single print hammer to produce three characters in nine sweeps of the shuttle.*

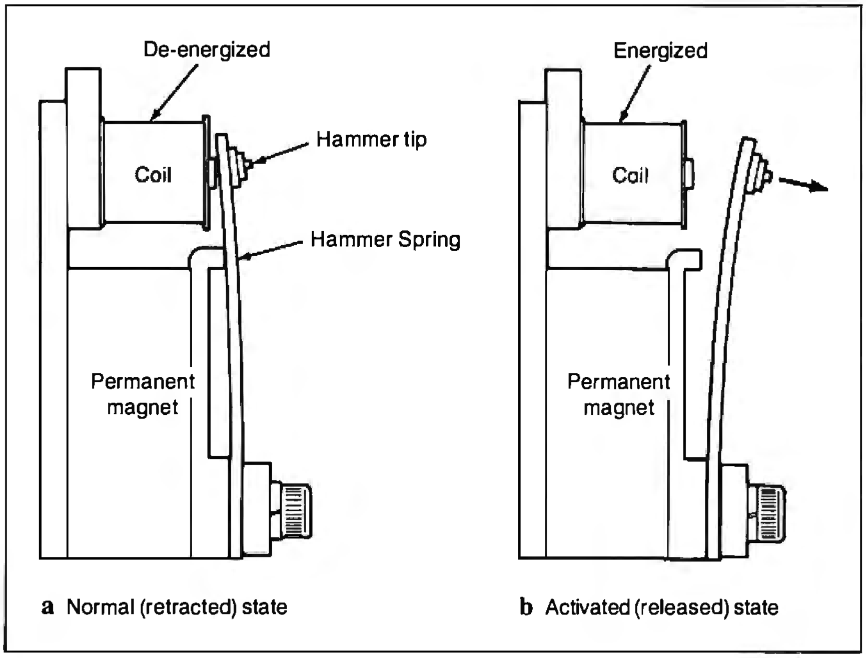

Figure 3: *The hammer bank consists of 24 stored-energy print hammers.* **a)** *While the coil is de-energized, the permanent magnet holds the hammer in tension.*
b) *When the coil is energized, its magnetic force field cancels that of the permanent magnet, letting the hammer spring forward, striking the ribbon onto the paper on the platen.*

print head in on-board memory to map the rasterized data from the character generator into the appropriate print zones, as figure 2 illustrates in simplified form.

The key to matrix-line printing is the hammer bank, patented by Printronix. It is a group of individually controlled, stored-energy print hammers mounted on a shuttle assembly.

The stored-energy print hammer consists of three basic parts: the print hammer, a stiff leaf spring with an 8-mil carbide steel tip; a permanent magnet to hold the individual hammer retracted in tension (stored energy); and an electromagnetic coil.

When energized by a signal from the hammer-driver circuit, the electromagnetic coil neutralizes the effect of the permanent magnet and lets the hammer spring forward and strike the ribbon against the paper, printing a dot. The coil is immediately de-energized, letting the permanent magnet recapture the rebounding hammer.

Figure 3 shows the stored-energy print hammer in the de-energized and activated states.

The maximum frequency for firing a stored-energy hammer depends on the mechanical characteristics of the hammer spring. Its natural frequency is similar to that of a pendulum swinging from one extreme position through a midpoint to another extreme position and back:

$$f = 1/(2\pi\sqrt{k/M_e}),$$

where k is the spring constant and M_e is the effective mass of the hammer tip. However, actual hammer flight is restricted to about half the natural cycle because the travel is cut short when the hammer strikes the paper. Consequently, hammer-firing frequency is almost twice the natural frequency. In the Printronix design, each hammer fires up to 1493 times per second.

Advantages of the Hammer-Bank Design

Since the shuttle motion of the printer is the same regardless of the contents of each dot row, the number of rows in a character matrix solely determines printing speed. It is independent of the number of characters to be printed on a given line of text.

Since the 24 individual print hammers serve the same function as the 9 print wires in a serial moving-head design, the duty cycle per pin is far less, and the life cycle increases correspondingly. Since horizontal motion is confined to a span of ⅓ inch, position tolerances are easier to maintain, assuming the mechanical spacing of the hammers is correct to start with.

In terms of graphics, matrix-line printers have no vertical bias; the same set of hammers produces each row of dots. In contrast, nine-wire printers tend to produce visible bands or patterns that are nine dots wide.

The matrix-line printer design proves that, in dot-matrix printing, there is indeed more than one way to put the dots on paper. ■

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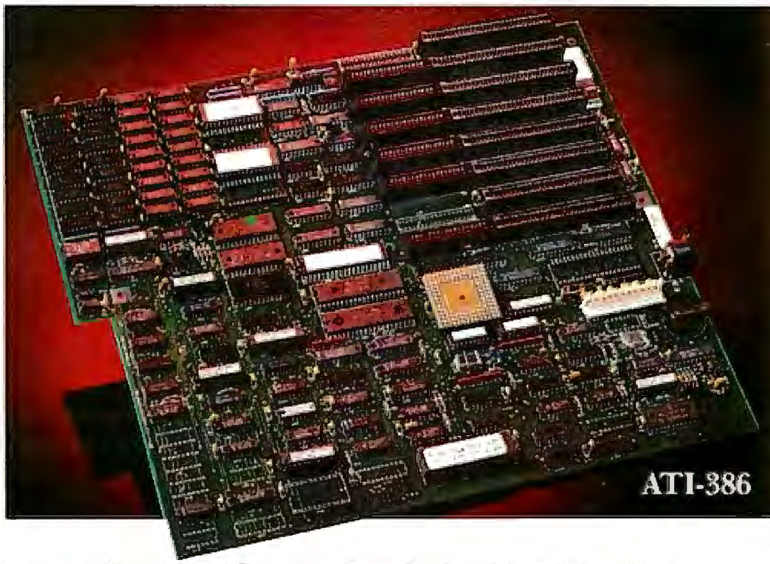

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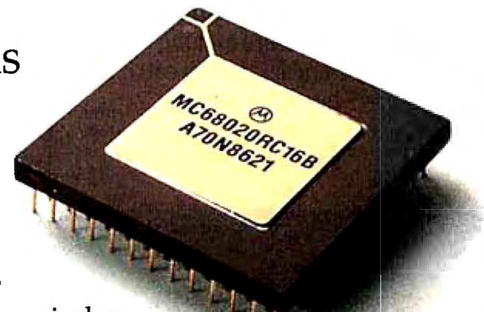

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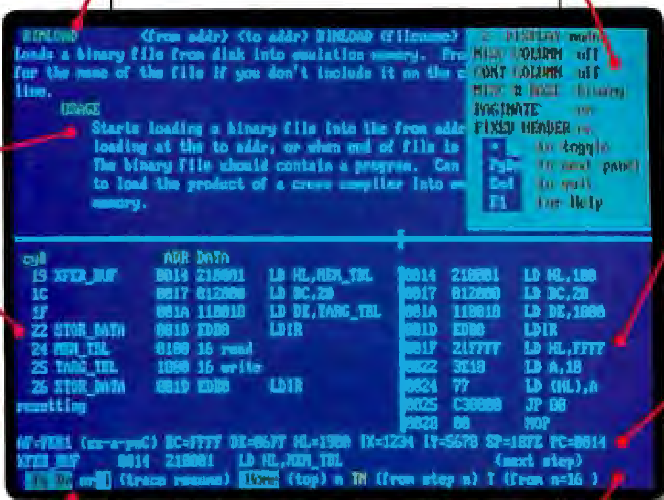

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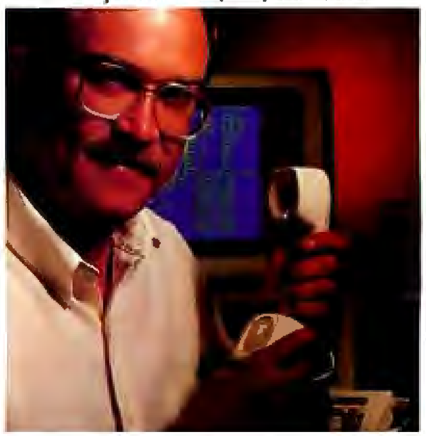

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Color Thermal-Transfer Printing

Getting good results requires solutions to a variety of engineering challenges

Julio Guardado

The thermal-transfer process is simple in principle, but its implementation for high-quality printing like that shown in photo 1 is quite complex. I'll describe some of the engineering challenges and show how CalComp solved them in designing a series of color printers.

In the thermal-transfer process, a donor ribbon coated with a solid ink is heated to the ink's melting point. The ink is then transferred to the receiving paper or film, to which it adheres after cooling. Figure 1 illustrates the process.

By repeating the process three times using combinations of inks of the three primary subtractive colors (yellow, magenta, and cyan), you can produce colors across the full spectrum.

Lining Up the Dots

Registration of the three passes is the first challenge. For instance, to produce a blue dot, the printer must place a dot of magenta ink directly on top of a yellow dot. The molten layers of ink mix to form a light filter that turns white light into blue. However, if the second dot is misregistered, it ruins the effect. The ColorMaster design places up to 200 dots per linear inch, each dot with a 0.005-inch diameter. That doesn't leave much room for error in the placement of dots that are supposed to be overlaid.

Any multipass device is subject to errors caused by tolerance buildups in the mechanism. A small variance in paper positioning, added to a small variance in printhead positioning and a small amount of vibration, may result in a variance that exceeds the design tolerance. The thermal nature of the design introduces an additional source of variance: the expanding and contracting caused by changes in the moisture content of the medium.

To minimize registration error, ColorMaster uses a unidirectional media-feed mechanism. The paper or transparency film is fed from an automatic sheet feeder and clipped to a rubberized drum (with a circumference of 12 inches).

The media-handling drum makes three rotations, exposing the paper to three panels of yellow, magenta, and cyan ribbon. Each pass takes about 20 seconds, yielding a page rate of one per minute.

The ColorMaster's unidirectional media transport avoids the backlash that can occur when a drive changes direction. The drum's rubberized surface also helps by overcoming the media's tendency to slip or change shape better than would a sprocket feed or friction feed; the holding force is spread out over the entire paper surface rather than being concentrated along the edges of the paper.

The net result of this media-handling system is an overall registration of about half a dot, which is well below the threshold at which fringing and other undesirable visual effects appear.

Thermal Print Heads

As with any raster printing device, including impact printers, the designer has a choice between using a scanning head, which moves across the width of the page printing dots as it goes along, and a stationary head, which prints an entire line of dots simultaneously.

Stationary heads—because there are more of them and they print simultaneously—offer greater throughput than scanning heads. The design also reduces the problem of registration to one dimension,

continued

Photo 1: *Sample output from the ColorMaster thermal-transfer printer.*

Julio Guardado is director of the small-format raster business unit at CalComp, a Lockheed Company (P.O. Box 3250, Anaheim, CA 92803).

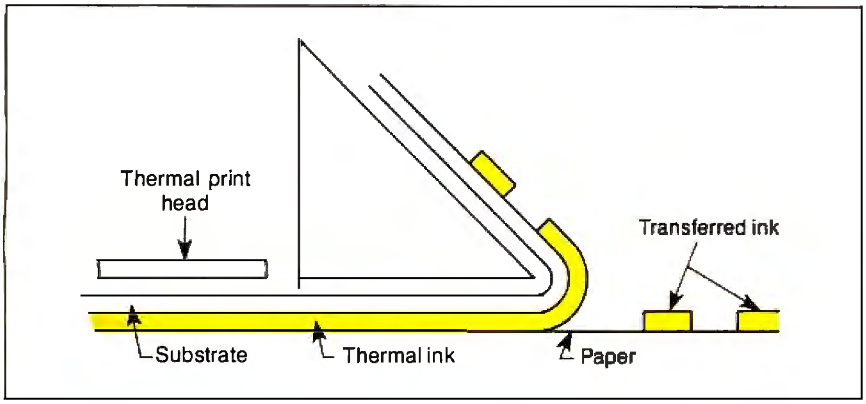

Figure 1: *A simplified diagram of the thermal-transfer process.*

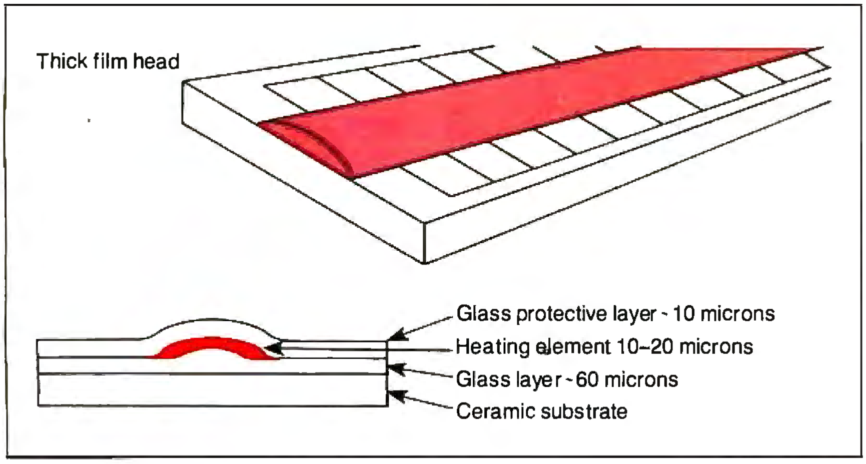

Figure 2: *Thick-film heads offer durability and greater leeway in manufacturing tolerances.*

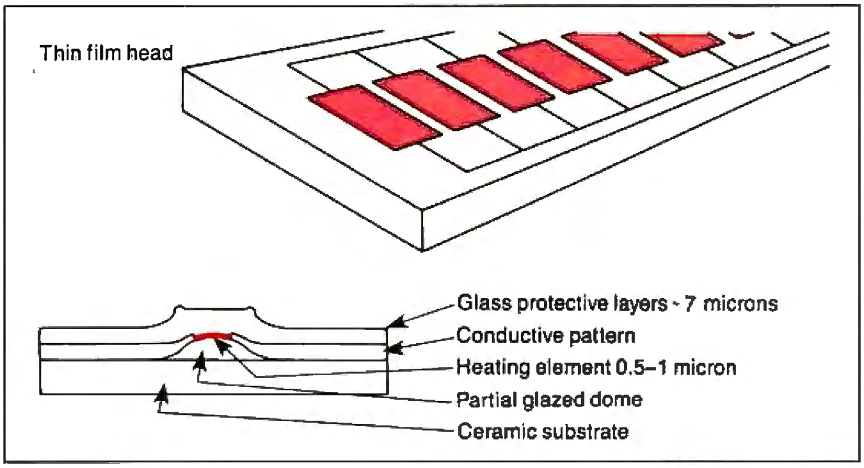

Figure 3: *Thin-film heads offer the potential for higher resolution and are more energy-efficient.*

since there is movement along one axis.

Thermal heads are either thick-film or thin-film. Thick-film heads (see figure 2) are manufactured by silk-screening a 0.015-millimeter-thick resistive material across an array of conductor leads. When power is applied to one of the leads, the head heats up across the path of current flow, the shortest path between the two conductors. This creates a "virtual" print element—virtual because there is no distinct element. All the electronics to drive the head are built right onto the thermal head.

Thin-film heads (see figure 3) are manufactured much in the same way as ICs. A resistive material 0.5- to 1-micron thick is deposited between each pair of conductors, forming a discrete heating element. A protective glass layer 7 to 10 microns thick is applied to both print-head types.

Heat transfer from the heads to the ink is 20 percent efficient. The head heats to about 350° C within a span of about 1 millisecond, raising the ink temperature to its melting point of 70° C. To minimize power requirements, current is applied in multiple strobes.

By definition, thick-film heads are more durable than thin-film. They also allow higher tolerances in their mechanical design since they project farther from the background surface. Thin-film heads, on the other hand, can be manufactured less expensively, use about 20 percent to 30 percent less energy, and can provide higher dot densities.

The ColorMaster design uses a thick-film stationary head to maximize throughput and reliability while providing 200-dpi resolution. In terms of manufacturing, the key challenge has been to achieve element-to-element uniformity, since this largely determines the lateral evenness of color on the final printed page. Head uniformity is a function of the resistance distribution of the thick-film material. At the beginning of the ColorMaster's development, element-to-element variation was as high as 25 percent over all the elements. Heads now used in the ColorMaster production units have a variation of 5 percent over 95 percent of the elements.

Thermal Ribbon and Media

Thermal ribbon is a substrate coated with a heat-sensitive solid ink made primarily of waxes, oils, and dyes. Varying the ratio of these ingredients changes the viscosity, melting point, and, ultimately, image quality. The substrate itself introduces another variable, determining the efficiency of heat transfer from the heads to the ink.

Thermal-transfer printers usually output on paper or transparency film (for use with overhead projectors). The properties of these two media are quite different, and getting good results on both using the same ink and the same print head is another difficult challenge.

The Future of Thermal Transfer

Manufacturers of color thermal printers are currently working on several challenges: to lower the cost of the units through improvements to the manufacturing process, to provide even higher resolution through improvements to thin-film technology, and to allow printing on lower-cost, rougher papers. ■

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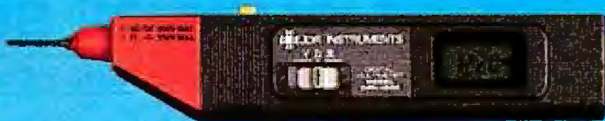

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Designing a High-Speed Page Printer Controller

Fast forms processing is an ideal application for page printers. The controller is often the bottleneck.

Phil Ellison

Common sense tells us that an electromechanical print engine should be slower than an all-electronic controller, but the reverse is usually true. Most of the time, in a desktop page printer, the engine outperforms the controller. The engines are capable of printing at a rate of six or more pages per minute, while the controllers often feed the printer data at less than one page per minute. Unless the printer is producing the same page multiple times, the speed of the print engine is meaningless.

In electronic forms processing, the form exists as an electronic image until it is printed with the data filled in. The forms are designed, stored, managed, updated, and completed in computer memory and translated to paper only when needed in a paper format.

The controller bottleneck is a serious problem in forms processing, where the printer must turn out many different form sets every day. The requirements for forms printing are stringent. The controller must be able to handle complex combinations of fonts (sometimes as many as 36 per form plus 36 for the variable data to fill in the blanks), graphics, logos, and digitized signatures. The overall forms-processing system usually needs to be a turnkey system because its typical operators are not computer specialists.

Design Solutions

Most first-generation personal page printers have the controller built into the printer. In fact, the dedicated computers in those controllers are commonly more powerful than the microcomputers attached to them (for instance, a 68000-based printer attached to an 8088-based computer).

Placing the printer controller in the computer lets the computer's microprocessor handle memory-intensive page makeup and processing operations. The controller writes the byte stream to the print engine. This approach eliminates duplicating parts of the computer system, such as chassis, memory, and power supply. It also eliminates the need to have font memory (RAM, ROM, or disk) in the printer and provides for a convenient user interface (the keyboard and display screen as opposed to a printer control panel and set of LEDs).

Phil Ellison is engineering manager at Electronic Form Systems. He can be contacted at EFS, 2395 Midway Rd., Carrollton, TX 75006.

The controller we at EFS designed, the Formwriter Adapter Card (see photo 1), is a single board with a Motorola 68008 microprocessor, several custom logic arrays, and 256K bytes of 120-nanosecond RAM. It runs under a multitasking operating system written specifically for this application; the system can handle an unlimited number of separate tasks.

The operating system, written in assembly language, allocates resources by time slices and interrupts. Time slices control most of its activities, but important events, such as the horizontal sync pulses, generate interrupts. By design, the controller is fast but limited. It detects error conditions at the printer, for instance, but passes them on to the host processor for action.

Forms are created and stored in FGL (forms-generation language), a document description language optimized for forms. FGL resolution is 2400 dots per inch horizontally and vertically. This permits easy scaling to the resolution of the output device being driven.

A moderately complex form, compiled in FGL, like the IRS Form 1040 page 1, requires about 8K bytes to store. Variable information for forms is stored and managed separately and merged for display and printing. This eliminates the need to store the form multiple times.

The Computer/Printer Interface

The connection between the computer and page printer is often another bottleneck. Conventional serial connections are limited to 19.2K bits per second. Parallel connections at 56K bps are better, but still not fast enough to keep pace with the print engine's capacity. Because a full page of graphics represents, on the average, about 1.05 megabytes of information, sending a full page over a parallel interface requires about 150 seconds.

The Formwriter Adapter Card connects directly to the video port of the laser engine over a shielded twisted-pair cable. The data-transmission rate ranges from 1.5 to 8 megabits per second, depending on the capacity of the print engine.

Almost all print engines receive data through a video interface. This means that one controller card can drive a variety of print engines, such as models from Xerox, Ricoh, and Canon. However, video interfaces differ among the various printers; there is no standard.

All the interfaces support the basic functions of control, status reporting, and image synchronization. Control commands allow the controller to start and stop the printer, select paper trays, control display indicators, and so forth. In some cases, commands are sent over a serial line using a command/response protocol. In other cases, commands are implemented using TTL signals.

Status functions allow the controller to monitor the condition of the printer and detect various errors, such as paper jams, out of paper, engine errors, and so forth. In some systems, the controller uses hardware signals to sample and evaluate the printer status in real time. More commonly, status information is passed over a serial communications line using a query/status exchange. Sometimes the control and status protocols are combined or intermixed in such a way that the controller might issue a print command and receive back a status response such as `out of paper`.

Image synchronization applies separately to the horizontal and vertical dimensions. The controller needs to know when the printer's photoreceptor is positioned at the top of the page and when to

continued

begin sending raster data for each scan line down the page.

A print command typically initiates the vertical synchronization sequence. When it has a page ready to print, the controller issues a print command and the printer responds with a vertical sync signal that begins the print cycle. The controller then looks for horizontal sync signals from the printer and sends one scan line of raster image for each horizontal sync, progressing down the page.

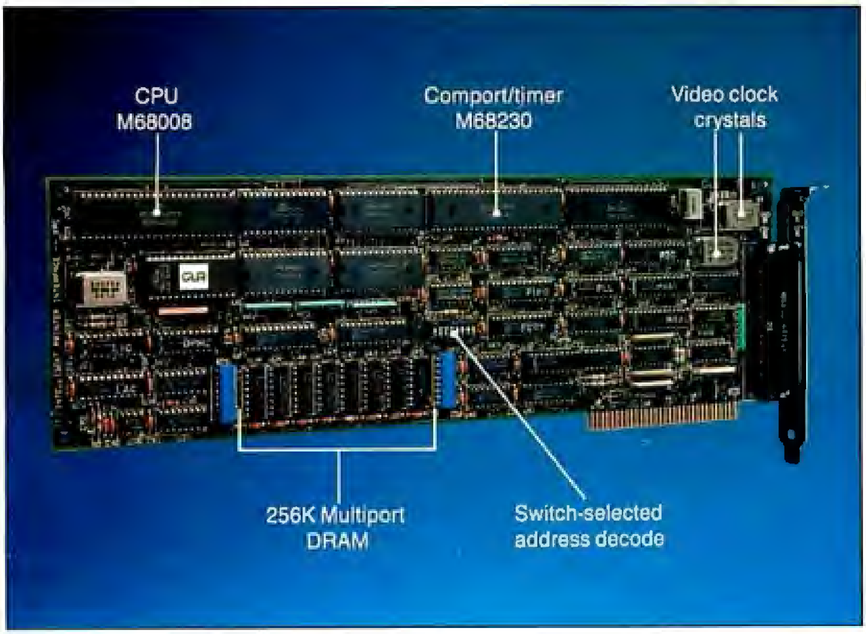


Photo 1: *The Formwriter Adapter Card can control a variety of printer engines from Xerox, Ricoh, and Canon.*

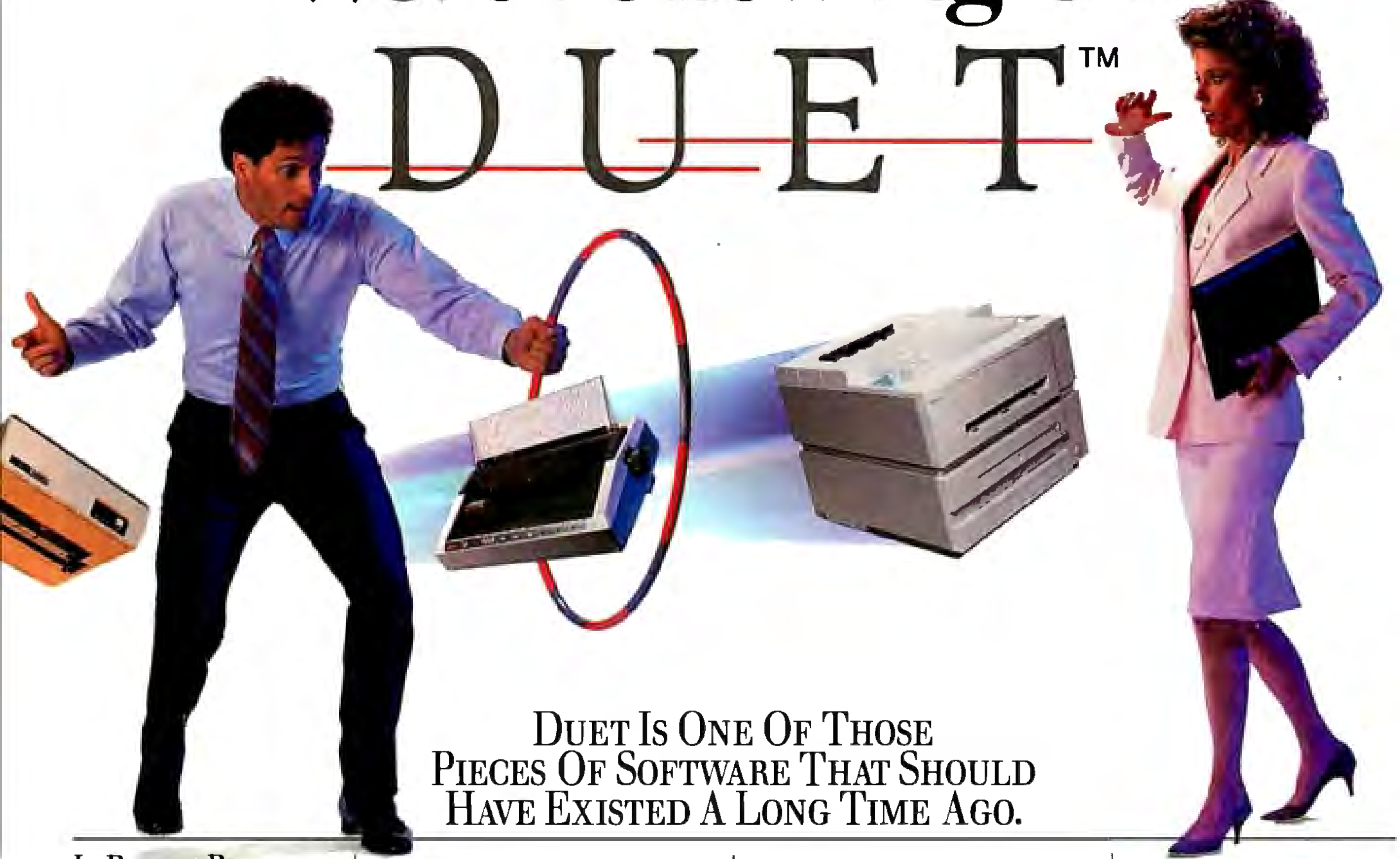
Again, the specifics of sending the raster image vary with each printer. Normally the image is sent at video rates of 1.5 MHz or higher and is synchronized with a video clock signal that is provided by the printer. The printer samples the video data signal at each strobe of the video clock and writes a dot when the signal is TRUE.

Implications for Other Printer Applications

The EFS Formwriter Adapter Card proves that the controller does not have to bottleneck the printing system. However, it is not intended as a general-purpose printer controller, rather it is optimized for forms processing.

Page printers have raised the expectations of many personal computer users with regard to traditional word processing and data reporting. Don't be surprised if the next generation of general-purpose page printers incorporates many of the design concepts that we found to be so effective in driving page printers at top-rated speed. ■

Introducing Printer Control Worth Showing Off



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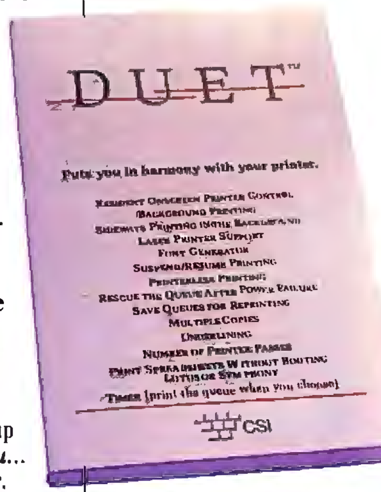

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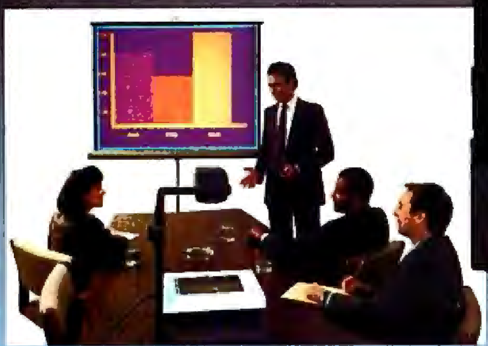

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Strip-Buffer vs. Full-Page Bit-Map Imaging

As printer resolution increases, the cost of a full-page bit map goes up quadratically. Strip-buffer technology is a memory-thrifty alternative.

Bert Douglas

One of the jobs of a printer controller is to convert a page of two-dimensional objects (text characters and other shapes) into a sequence of dot rows that can be transmitted to the engine for printing. That job is getting harder as the number of dots increases.

With traditional full-page bit-map designs, the controller generates a bit-map image of the entire page to be printed; one bit in memory corresponds to one dot location on the printed page. The image is not sent to the print engine until the entire page is ready.

This method allows for virtually unlimited complexity on the page, but it also requires a lot of memory. At a resolution of 300 dots per inch, an 8½- by 11-inch image requires a megabyte of RAM; doubling the resolution to 600 dpi ups the memory requirement to 4 megabytes.

Time is another cost of the full-page bit-map approach. The two-cycle mode of writing the image and then copying it to the print engine frequently results in waiting periods between pages, making it difficult for the system to meet the rated speed of the printer.

Strip-buffer imaging is an alternative technology that minimizes memory requirements while sacrificing some of the capacity for complexity. Another purpose of the design is to ensure that the controller drives the print engine to its throughput capacity, regardless of the contents of the pages.

Strip buffering is similar to the virtual-memory technique used in large computers to provide a logical address space larger than the available physical memory. The logical address space is the print drum, and the physical address space is the strip buffer (see figure 1).

The strip buffer is a narrow, horizontal bit matrix (typically 256 by 2550 bits). At any given time, the content of the strip buffer is a partial-page bit image.

The bit image can consist of any arrangement of predefined text characters and graphics, with certain limitations. Each individual text character and graphic object must be able to fit entirely within the strip buffer. (However, some graphic elements, such as lines and boxes, can be larger than the size of the strip buffer.) The constraints in no way hinder the use of the system for general forms printing and word processing, but they might make it unsuitable for extremely complex graphic arts work.

Imaging a Page of Text

In the strip-buffer controller design, printing and imaging take place simultaneously. While one line of dots is being output to the print engine, another line is being written into the strip buffer. The top row of bits from the strip buffer is output to the print engine, the remaining lines of the buffer scroll up one row, and a new line of dots fills the bottom row of the strip buffer.

Printer software in the host computer sends a page of text in the form of a display list (i.e., a sequence of instructions for printing). The display list is a concise, high-level description of the page to be printed. A typical page-display list is only about 1 percent as large as a full-page bit-map description.

Inside the controller, a display-list interpreter (DLI) goes to work on the display list, generating rasterized data for the strip buffer.

To illustrate the operation of the DLI, I'll follow its handling of a hypothetical stream of commands from a simple display list. For the sake of simplicity, I'll reduce the dimensions of the output: Page size is 20 by 50 dots rather than the typical 3300- by 2550-dot page. The strip buffer is 10 dots deep rather than the usual 256 dots. The character matrix is 5

continued

Bert Douglas is a senior design engineer with Office Automation Systems Inc. He can be contacted at OASYS, 8352 Clairemont Mesa Blvd., San Diego, CA 92111.

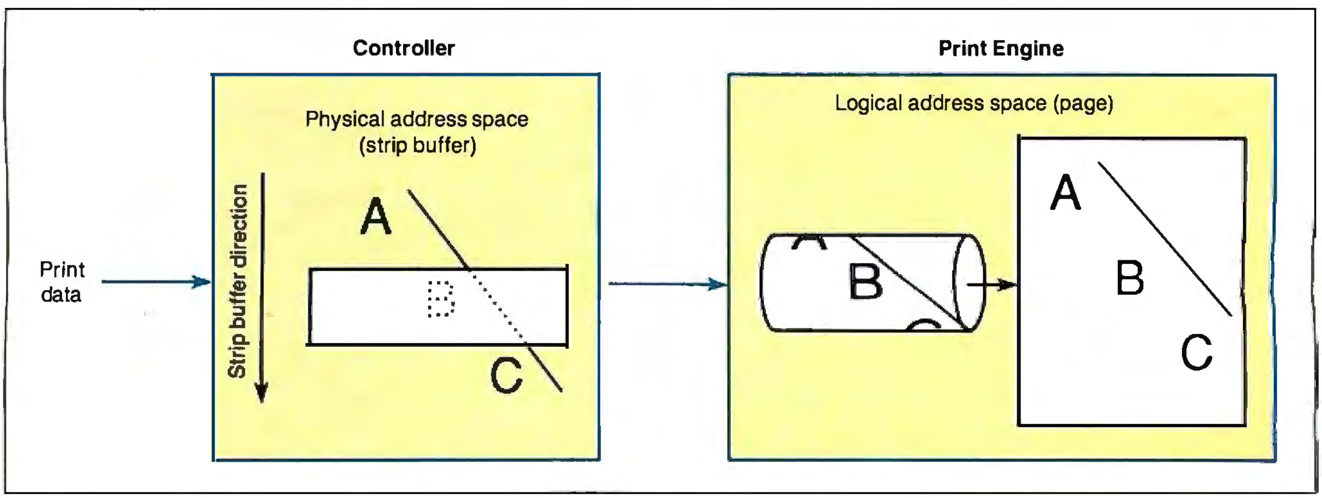

Figure 1: *At any given time, the strip buffer contains only a partial-page bit image. In a process similar to virtual-memory techniques, the physical address space of the strip buffer scrolls across the much larger logical space of the printed page.*

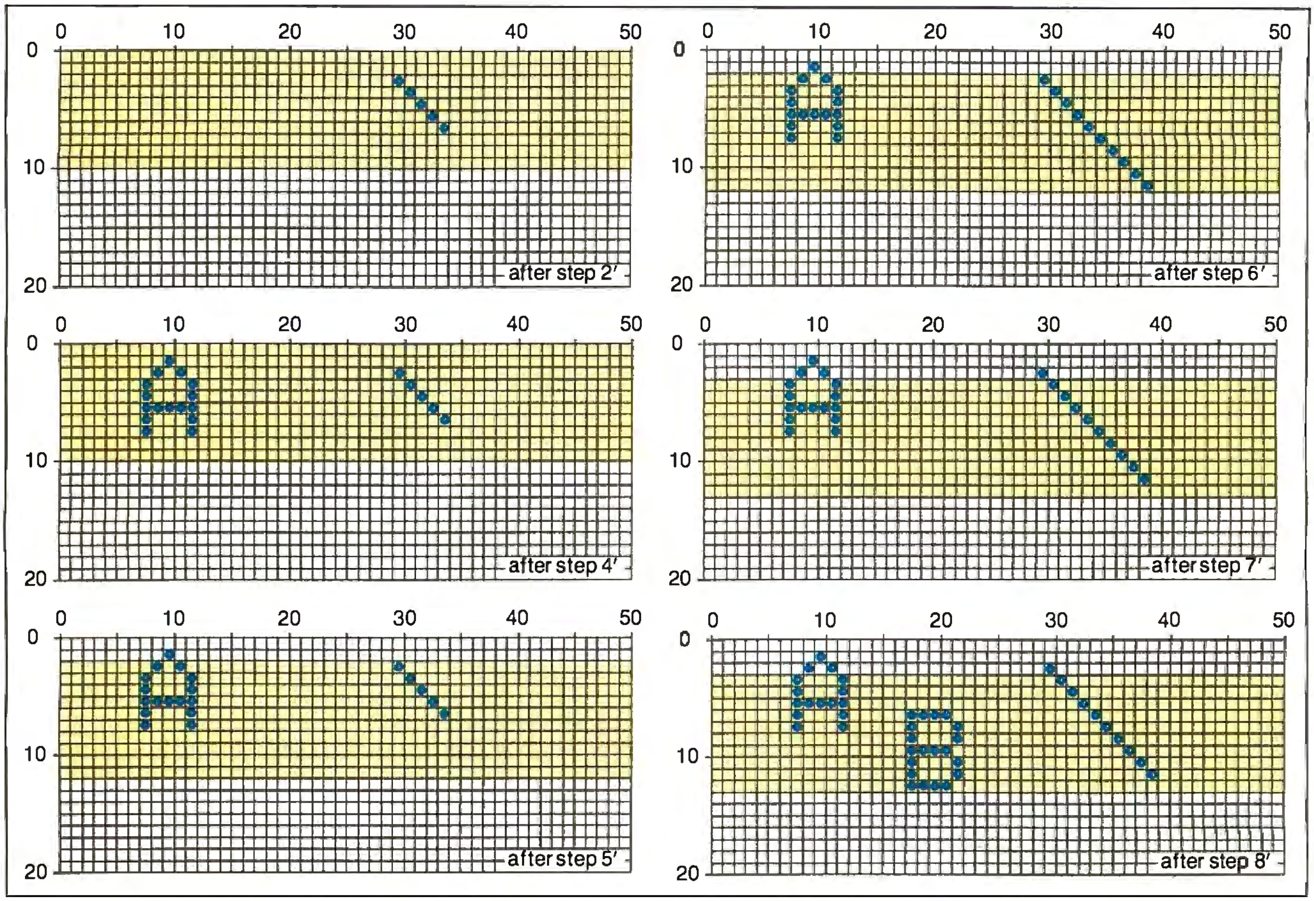

Figure 2: *Step-by-step imaging of a simplified page using the strip-buffer technique. Not all steps are shown.*

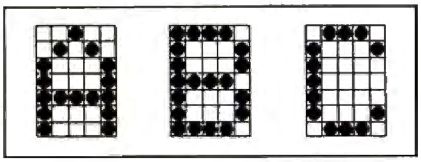

Figure 3: *Character matrices.*

by 7 dots rather than the typical 32 by 40. The line space is set for 5.5 dots.

The host computer sends the following commands:

(1) Print the letter *A*.
(2) Do a linefeed.
(3) Print a *B*.
(4) Do a linefeed.
(5) Print a *C*.
(6) Draw a line from (2,30) to (19,47).
(7) Print the page.

The DLI scans through the list to find all the graphic elements that exceed the buffer size (such as the line specified in (6) above). These are broken down into smaller units that will fit into the strip buffer. The characters and line segments are sorted according to their position on the page, using the lowest dot position of each object as the sort key.

The DLI generates a new display list, inserting dot-row wait commands before every object located at a dot row greater than that of the preceding object:

(1′) Wait for dot row 6 to be in the strip buffer.
(2′) Draw a line from (2,30) to (6,34).
(3′) Wait for dot row 7 to be in the strip buffer.
(4′) Draw an *A* at (1,8).
(5′) Wait for dot row 11 to be in the strip buffer.
(6′) Draw a line from (7,35) to (11,39).
(7′) Wait for dot row 12 to be in the strip buffer.
(8′) Draw a *B* at (6,18).

Subsequent steps are omitted.

I've omitted specifications of the type font to be used for text characters; in a real system, that information would be included in the display list. The controller looks up the bit image for each character. Logos and other graphic objects are handled the same way. Graphic elements such as lines and boxes are generated algorithmically by the DLI.

Figure 2 traces the contents of the strip buffer at selected points during the execution of these 15 commands. The strip-buffer rows are highlighted with shading. Note that the character reference point is the upper left corner of its matrix, as shown in figure 3.

Recall that I assumed a line spacing of 5.5 dots. The first linefeed moves the cursor down 5 dots, and the second one moves it down 6 dots. The DLI handles fractional line spacing by rounding to the nearest dot, while retaining the ideal fractional dot position for subsequent line-space calculations.

As dot rows in the strip buffer are printed, the DLI examines the next object in its list and determines when the strip buffer has advanced far enough down the logical page to encompass the next object inside the limits of the strip buffer. The whole process operates in step with the print engine.

As shown in the figure, the physical bit image never exceeds the size of the strip buffer, even though the logical bit image (written to the print engine) spans a full page. In this way, the use of a strip buffer ensures a low memory requirement.

While the full-page bit-map design is required for truly unlimited page complexity, the strip-buffer design can handle most applications. Furthermore, the strip-buffer design can be modified to accommodate more demanding graphics. As printer resolution increases, the strip-buffer approach may be an essential element in keeping printer costs down. ■

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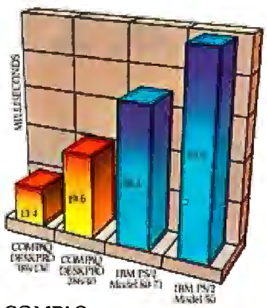

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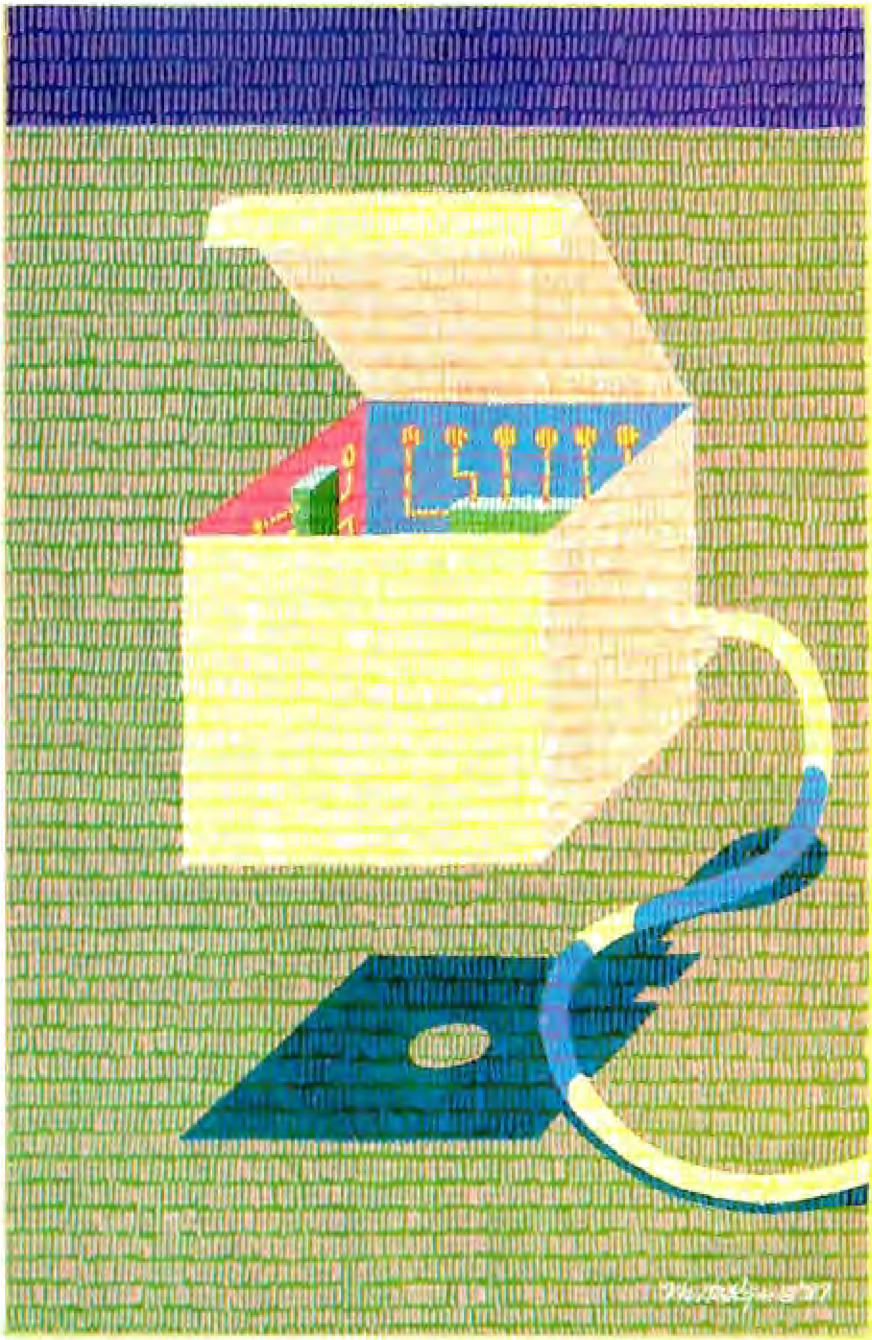

REVIEWER'S NOTEBOOK

On page 110 in this issue, you'll see comparative benchmarks for a variety of 80386 and 68020 systems. Take a look at the results achieved by Definicon Systems' DSI-780 coprocessor board. This board and its compiler, which we installed in an 8-megahertz IBM PC AT, turned in a performance better than that of any of the other 68000 and 68020 systems and compilers we tested, including the Arete. In half of the tests—the Fibonacci, Savage, and Sieve—the DSI board outperformed the Compaq Deskpro 386 and the IBM PS/2 Model 80.

The price you pay for this performance is $3295, which gets you the DSI-780 with 16-MHz 68020 and 68881 microprocessors and 4 megabytes of RAM. Look for a full review of this board in the October issue. Definicon also sells other models, including the DSI-780+, which runs at 20 MHz and can hold up to 16 megabytes of RAM. With 1 megabyte, the DSI-780+ costs $2295; with 4 megabytes, $3595. You can contact Definicon Systems at 1100 Business Center Circle, Newbury Park, CA 91320, (805) 499-0652.

This month, beta versions of Microsoft's new Quick C and C 5.0 compilers arrived in our offices. BIX senior editor David Betz, who reported on Borland's Turbo C last month, offers his early impressions of both Microsoft compilers below.

—Cathryn Baskin
Senior Technical Editor, Reviews

Like Borland's Turbo C, Microsoft's Quick C ($99) is a fast integrated C development environment for IBM PCs, ATs, and true compatibles. Quick C provides a compiler, linker, editor, make facility, and source-level debugger, all within a single integrated environment.

For programmers who aren't comfortable with an integrated environment, Quick C also provides a command-line interface, as well as a stand-alone make facility, linker, and object-module librarian. Quick C supports four different memory models (small, medium, compact, and large) and mixing of models through the command-line interface. The integrated environment always uses the medium memory model.

The copy of Quick C I looked at was a beta release that I couldn't benchmark for either compile speed or execution speed. I was able to compile and run the same code that I used to benchmark the Turbo C compiler last month, but because the integrated environment supports only the medium memory model, I was unable to compare the results directly with those from Turbo C.

Running a program within the Quick C integrated environment causes an executable file to be created in the current directory. Unlike with Turbo C, this file can't be used outside the Quick C environment. The separate option that allows stand-alone programs to be built can be somewhat confusing because you can't run the stand-alone programs from inside the environment, and the programs generated to run in the environment can't be run as stand-alone programs.

The main advantages of Quick C over Turbo C are its source-level debugger and compatibility with Microsoft C. Both products provide an easy-to-use user interface and a command-line interface for experienced programmers. Both are fast compilers that provide quick turnaround time for the edit/compile/link/execute cycle.

Microsoft will sell Quick C both alone and as part of the new C version 5.0 compiler ($450). To compare version 5.0 with 4.0, I used the beta version of 5.0 that I received to run some of BYTE's standard benchmark programs (see table 1) on a Compaq Portable 286 with an 8-MHz 80286. To get an idea of how using the large memory model slows down program execution, I ran the Dhrystone with both the large and small memory models. I ran the remaining benchmarks with only the small memory model, and I ran each test with and without optimization. For the optimized versions, I used the compiler's `-Ox` switch to get the highest level of optimization. For the unoptimized versions, I used the `-Od` switch to disable all optimizations.

Using optimization caused some rather strange problems with some of the benchmarks. For instance, the Float benchmark consists of a series of floating-point operations whose values aren't used for anything. With optimization enabled, Microsoft C 5.0 recognized that the results weren't going to be used and eliminated all the computations. This kind of "dead code" elimination is good for a real application but invalidates benchmarks like this implementation of the Float test.

Quick C runs on the IBM PC and compatibles with 384K bytes of memory, MS-DOS 2.0 or higher, and one doubled-sided floppy disk drive. Microsoft C 5.0 will run on the IBM PC and compatibles with 384K bytes of RAM, MS-DOS 2.0 or higher, and a hard disk drive. For more information, contact Microsoft Corp., 16011 Northeast 36th Way, P.O. Box 97017, Redmond, WA 98073-9717, (800) 426-9400 or (206) 882-8088.

(Note: In July, I mentioned that Turbo C had a bug that prevented large-model programs from linking correctly. Borland has provided a fix for the problem that will be made available to any current owner of Turbo C on request.)

—David Betz
Senior Editor, BIX

Table 1: *Benchmark results for Microsoft C 4.0 and the beta version of 5.0.* `-Ox` *tests were run with the highest level of optimization;* `-Od` *tests were run with no optimization. Numbers in parentheses indicate how many iterations were performed. All times are in seconds.*

	5.0 (-Ox)	5.0 (-Od)	4.0 (-Ox)	4.0 (-Od)
Sieve (10)	1.63	3.30	2.78	4.14
Sort (10)	3.79	5.33	4.25	5.35
Fib (10)	11.73	22.96	12.85	23.14
Float	0.00	75.63	45.75	76.16
Savage (2500)	53.08	56.44	59.48	59.48
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The Kaypro 386

Ray Duncan

A solid contender in the high-performance PC AT–compatible arena

The Kaypro 386 is an entrant in the newly emerging class of high-performance IBM PC AT compatibles. These machines have the general architecture of a PC AT but are based on an Intel 80386 32-bit microprocessor. In addition to a normal PC AT-compatible expansion bus, they also have a nonstandard 32-bit memory bus for increased performance.

The Kaypro 386's exterior appearance is similar to that of a PC AT, with the keylock, 1.2-megabyte floppy disk drive, disk- and power-indicator lights, connectors, and power switch all in their familiar locations. The computer is currently available in two models. The Model A ($4495) comes with 512K bytes of RAM and no hard disk drive. The Model E comes with 2.5 megabytes of RAM and either a 40- or a 130-megabyte hard disk drive. The two configurations sell for $5795 and $8095, respectively. At the time of this writing, Kaypro announced that an additional model, the Model N, was expected to begin shipping this summer. It is intended for use as a network server, and it comes with 2.5 megabytes of RAM and either a 240- or a 330-megabyte hard disk drive. Prices for the two configurations are $14,450 and $19,450, respectively.

Standard equipment on the Model A and Model E includes a real-time clock, a parallel port, a serial port, a combination floppy disk and hard disk controller board that can handle up to two floppy disk drives and two hard disk drives, and a 102-key keyboard that is similar to the IBM 101-key enhanced keyboard, with 12 function keys across the top, a separate numeric keypad, and arrow and paging keys. The case has room for up to five half-height storage devices. The power supply is switch-selectable between 110 and 220 volts and is rated at 215 watts.

All three models of the Kaypro 386 use the same motherboard, the Intel iSBC 386 AT, which has a 16-MHz 80386 microprocessor and 512K bytes of 120-nanosecond RAM. [Editor's note: *The motherboard is similar in design to the ALR Access 386's motherboard, another Intel-derived design. For more information, see "The ALR Access 386 and the Compaq Deskpro 386" by Stanley J. Wszola and Curtis Franklin Jr. in the February BYTE.*] You can slow down the Kaypro 386's microprocessor to the equivalent of 6 MHz under software control (by inserting wait states) or by entering a special key sequence for use with timing-dependent programs. For expansion, the machine has two 8-bit IBM PC-compatible slots and four 16-bit PC AT-compatible slots, as well as two 32-bit slots that can accept either 8-bit boards or special 2-megabyte 16-bit memory-expansion boards built by Intel and available from Kaypro for $665; 8-megabyte boards may be available in the future. One of the Kaypro 386's 16-bit slots is occupied by the disk-controller card.

The expansion bus runs at 6 MHz for compatibility with older boards, except for the two 32-bit slots, which you can configure with jumpers on the motherboard to make them run at 16 MHz when 32-bit memory cards are present. A 68-pin grid-array (PGA) socket is present on the motherboard for installation of a 16-MHz 80387 numeric coprocessor (not yet available from Kaypro) or an Intel Math Coprocessor Module piggyback board ($495), which adapts a 10-MHz 80287 40-pin DIP chip with some support circuitry to the 80387 PGA socket.

Two video display adapters are available as options for the Kaypro 386. One is the Kaypro Multi-Video Board, which can emulate the IBM Monochrome Adapter, the IBM Color Graphics Adapter, or the Hercules Monochrome Graphics Card. The other is the Kaypro Enhanced Graphics Adapter, which is based on the Chips and Technologies four-chip EGA set. Two optional monitors are available for the Kaypro 386: a 12-inch monochrome monitor and a 14-inch enhanced graphics monitor.

continued

Ray Duncan is a software developer for Laboratory Microsystems Inc. (3007 Washington Blvd., Suite 230, Marina del Rey, CA 90292) and author of Advanced MS-DOS: The Microsoft Guide for Assembly Language and C Programmers *(Microsoft Press, 1986).*

Kaypro 386

Company
Kaypro Corp.
533 Stevens Ave.
Solana Beach, CA 92075
(619) 481-3900

Size
21¼ by 16½ by 6½ inches; 42 pounds

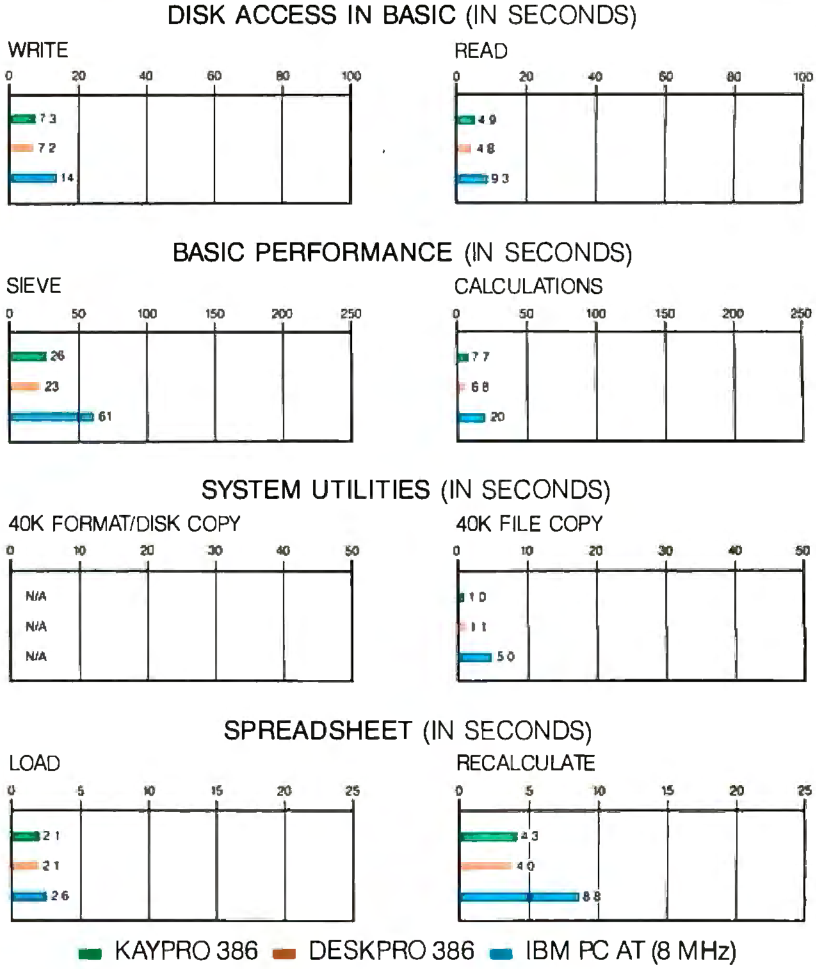
Components
Processor: 32-bit Intel 80386 running at 16 MHz, switchable to 6 MHz; socket for Intel 80387 numeric coprocessor
Memory: 512K bytes on system board; optional 2-megabyte Intel MEM020 plug-in expansion board, expandable to 16 megabytes
Mass storage: One 1.2-megabyte high-density floppy disk drive (all models) and one 40- or 130-megabyte hard disk drive (Model E) or one 240- or 330-megabyte hard disk drive (Model N)
Keyboard: 102 keys; 12 function keys
I/O interfaces: Eight slots: two 8-bit IBM PC compatible; four 16-bit PC AT compatible; two 32-bit slots for special Intel MEM020 memory boards; one serial port with DB-9 connector; one parallel port with DB-25 connector

Software
Microsoft MS-DOS 3.21; GWBASIC 3.20; Quarterdeck Office Systems' QEMM-386 1.0; Storage Dimensions' SpeedStor hard disk utility package

Options
2-megabyte 16-bit memory-expansion board: $665
2-megabyte 32-bit memory-expansion board: $1145
Kaypro Multi-Video Board: $210
Kaypro Enhanced Graphics Adapter: $295
12-inch monochrome monitor: $145
14-inch enhanced graphics monitor: $595
360K-byte floppy disk drive: $145
40-megabyte hard disk drive: $1398
80-megabyte hard disk drive: $1750
133-megabyte hard disk drive: $3595
Kaypro 386 Technical Manual: $125

Documentation
160-page *Kaypro 386 User's Guide*; 500-page *MS-DOS 3.2 User's Guide and Reference Manual*; 310-page *GWBASIC 3.1 Interpreter Manual*; 64-page SpeedStor operations booklet; 8-page QEMM-386 brochure

Price
Model A (does not include a hard disk drive): $4495
Model E (with 40-megabyte hard disk drive): $5795
Model E (with 130-megabyte hard disk drive): $8095



The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a hard disk. The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to perform 10,000 multiplication and 10,000 division operations using single-precision numbers. The 40K Format/Disk Copy benchmark was not performed because the computers had only one floppy disk drive. The 40K File Copy graph shows how long it takes to copy a 40K-byte file from one location on the hard disk to another. The Spreadsheet benchmarks show how long it takes to load and recalculate a 100-row by 25-column spreadsheet in which each cell equals 1.001 times the cell to its left. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) All benchmark tests were run without any extended memory management, hard disk-driver, or disk-caching programs. Tests on the Kaypro 386 were done with MS-DOS 3.21 and GWBASIC 3.20; tests on the Compaq Deskpro 386 were done using Compaq DOS 3.1 and Compaq BASIC 3.11; and tests on the IBM PC AT were done with PC-DOS 3.2 and BASICA 3.2. All spreadsheet benchmarks were done using Multiplan 1.06.

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Other options include additional 1.2-megabyte and 360K-byte floppy disk drives; 40-, 80-, and 133-megabyte hard disk drives; and internal and external 60-megabyte tape-backup units.

My review unit was a Model E with 2.5 megabytes of RAM, a Kaypro Enhanced Graphics Adapter and monitor, a 1.2-megabyte floppy disk drive, and a Priam ID40 42-megabyte hard disk drive with a rotary voice-coil head positioner and a claimed 30-millisecond average access time. The CORE International Coretest Disk Performance Test program recorded a data-transfer rate of 164K bytes per second, an average seek time of 24.8 ms, and a track-to-track seek time of 4.4 ms for the Kaypro 386's hard disk system. The disk-controller card uses Western Digital chips.

Essential Software

The Kaypro 386 comes with Microsoft MS-DOS 3.21 and GWBASIC 3.20. In addition, the computer comes with a setup program for system configuration that is easy to use; Quarterdeck Office Systems' Expanded Memory Manager (QEMM-386) 1.0, which allows you to configure extended memory above 1 megabyte according to the Lotus/Intel/Microsoft Expanded Memory Specification (EMS); and Storage Dimensions' SpeedStor 4.02a hard disk utility package. SpeedStor includes the HARDPREP and PARTED programs, which are used to format and partition the hard disk, and HARDRIVE.SYS, an installable device driver that configures the partitions of a larger-than-32-megabyte hard disk drive for use as multiple logical volumes.

The Printed Word

The *Kaypro 386 User's Guide* describes the standard features and options of the computer's various models, unpacking and setting up the system, and configuration of the system for various options. It also covers the keyboard and use of the editing keys, some introductory material on MS-DOS commands and management of files, and instructions for using some of the Kaypro utility programs. Appendixes include an MS-DOS bibliography, a table of the extended character set, and charts of the system board jumpers and the pin-outs of the various connectors.

Also included with the Kaypro 386 are an *MS-DOS 3.2 User's Guide and Reference Manual* and a *GWBASIC 3.1 Interpreter Manual.* In addition, the Kaypro 386 comes with an 8-page glossy brochure about Quarterdeck's QEMM-386 1.0, which contains installation and operating instructions and a license and disclaimer of liability. The SpeedStor disk comes with a 64-page instruction booklet from Storage Dimensions.

My review unit also came with an 84-page preliminary copy of the *Kaypro 386 Technical Manual.* This book contains some general descriptive material and a block diagram and jumper settings for the system board, pin-outs for the various connectors and power supply, a list of the interrupt numbers assigned to the BIOS functions and hardware controllers, and a fairly detailed summary of the disk controller's registers and commands. The preliminary manual has no schematics or BIOS listings.

Compatibility

To evaluate the Kaypro 386's hardware compatibility with the IBM PC and PC AT, I loaded the machine with various combinations of expansion boards, including Hercules and Vega EGA video adapters, an Intel Above Board/AT with 2 megabytes of RAM, a 3COM Etherlink network card, a Microsoft Mouse (bus version), a Hayes-compatible 1200-bit-per-second internal modem, and a Hitachi CDR-1502S CD-ROM drive and adapter. The Kaypro 386 worked flawlessly with all these boards.

To assess the machine's software compatibility, I tried running a broad variety of popular application packages, utilities, and programming tools on it. The software I tested included Morgan Computing's Trace86 debugger 2.00, Microsoft's SYMDEB 4.00 and CodeView 1.11 debuggers, Chris Dunford's ProCED command-line editor 1.02L, Datastorm's ProComm 2.4.2 (a telecommunications program), Revolution Software's Cruise Control 2.15 (a keyboard enhancer), Microsoft Word 3.1, MicroPro's WordStar 3.30, Microsoft Windows 1.03, Fifth Generation Systems' Fastback 5.13, Laboratory Microsystems' UR/Forth 1.01, Microrim's R:BASE System V 1.1, Quarterdeck's DESQview 1.3, and Lotus 1-2-3 2.0.

The only program that did not work as expected at 16 MHz was Lotus 1-2-3, which did not recognize its key disk. When I slowed the processor to 6 MHz by pressing Control-Alt-1, the copy-protection scheme functioned properly and the program loaded. I then resumed 16-MHz operation with the Control-Alt-2 key sequence.

Reliability and Performance

I used the Kaypro 386 for one month on a daily basis in my office along with a Compaq Deskpro 386 on a local area network for normal programming and word-processing tasks. During this time, the machine proved completely reliable, and I encountered no problems.

The results of the BYTE benchmark tests show that the hard disk access times for the Kaypro 386 and the Compaq Deskpro 386 are basically equivalent. The floppy disk access times varied, with the results slightly favoring the Kaypro 386. This discrepancy may be because the Deskpro 386 automatically slows down to 8 MHz when accessing a floppy drive to provide automatic compatibility with most copy-protection schemes.

The BASIC Sieve and Calculations benchmarks and the Spreadsheet Recalculate test demonstrate a consistent 7 percent to 10 percent advantage in execution speed for the Deskpro 386. Since the microprocessor in both machines runs at 16 MHz, the speed difference seems to be due to the Deskpro 386's static memory chips and the more sophisticated 32-bit memory bus's access to those chips, in contrast to the Kaypro 386's dynamic RAM board.

I ran all the benchmark tests with no programs running in the background and with the extended memory management program, QEMM.SYS, and the program for use with the 40-megabyte hard disk drive, HARDRIVE.SYS, disabled. Thus, the benchmark results in the graph on page 240 reflect the performance of the raw hardware.

I tested these two 80386 machines further by writing two highly optimized assembly language implementations of the Sieve of Eratosthenes algorithm popularized by Jim Gilbreath. [Editor's note: *For more information, see "Eratosthenes Revisited: Once More through the Sieve" by Jim and Gary Gilbreath in the January 1983 BYTE. The listings are available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4.*]

The first implementation, SIEVE86, uses only 8086 instructions and can run on the Intel 8086/8088 or 80286/80386 microprocessors in real mode (i.e., the 8086 emulation mode used by these processors when running MS-DOS). I assembled and linked SIEVE86 into an .EXE file with the Microsoft Macro Assembler (MASM) and the Microsoft Object Linker, respectively. The second implementation, SIEVE386, uses the 80386's 32-bit registers and operations throughout. I assembled, linked, and debugged the program with Phar Lap's 386|ASM, 386|LINK, and MINIBUG 80386 programming tools. I then ran it for timing purposes under the control of the Phar Lap 386|DOS-Extender, which provides a 32-bit protected-mode runtime environment for programs. The 386|DOS-Extender tool loads a 32-bit application into extended memory (above

continued

the 1-megabyte boundary) for execution, leaving lower memory undisturbed and switching back to real mode as needed to perform MS-DOS function calls.

The Kaypro 386 ran the SIEVE86 and SIEVE386 programs in 48 and 56 seconds, respectively, while the Compaq Deskpro 386 ran each of the programs in 41 seconds. This confirms the Kaypro 386's significantly slower throughput in the BASIC benchmarks and demonstrates that the Kaypro's extended memory is slower than its conventional memory. This finding contradicts the statement in the *Kaypro 386 Technical Manual*, which says that the access times to memory on cards in the 32-bit expansion slots are the same as the access times to the 512K bytes of RAM on the motherboard. When I called the company, Kaypro admitted that the access times for the 32-bit memory board are slower. [Editor's note: *The reason for the slowness of the memory board is that the memory is organized into two banks of 1 megabyte each, with one bank containing the even addresses and the other containing the odd addresses. Accessing successive odd and even addresses will usually cause one wait state per access.*]

Picking Some Nits

The Kaypro 386 has some flaws, particularly when compared to the Compaq Deskpro 386. For example, the various option jumpers on the motherboard are spread from one end to the other instead of being centralized in one location as they are in the Deskpro 386. Similarly, the socket for the 80387 in the Kaypro 386 is buried under the edges of the hard disk drive and power supply in such a manner that it would be nearly impossible to add a numeric coprocessor chip or module without disassembling the computer.

The portions of the documentation that originate with Kaypro (i.e., the *Kaypro 386 User's Guide* and *Kaypro 386 Technical Manual*) are barely adequate. The user's guide is poorly organized, inconsistent, and often omits important information or provides information that is inaccurate or misleading. For instance, the key sequence to increase the volume of the key clicks is not documented; I discovered it to be Control-Alt-+ by trial and error. The procedure for making the hard disk bootable is located in Chapter 2 under "Hardware Installation," while the section in Chapter 3 entitled "Loading MS-DOS onto the Hard Disk" describes only how to copy MS-DOS files from the distribution floppies to drive C. The entire "Getting Started" section is oriented toward floppy disk-based systems, even though the typical 80386 system is hard disk-based. The page entitled "Redirecting Screens" discusses redirection of the standard output device; redirection of the standard input device is not mentioned at all.

Final Thoughts

The Kaypro 386 is a reliable personal computer that delivers two to three times the performance of the IBM PC AT. Its compatibility with standard 8086- and 80286-based PCs and software is excellent. Its performance is similar to that of the Compaq Deskpro 386. The deficiencies in its documentation and other minor inconveniences, such as the position of the jumpers on the motherboard and the layout of the keyboard, will be no great obstacles to experienced users.

If you need to run software applications at the fastest possible speed, or if you are prototyping 80386 software, the Kaypro 386 is perfectly suitable. As a slightly more economical alternative to the Compaq Deskpro 386, whether for software development or for crunching data, the Kaypro 386 appears to be a good buy. ■

 Inquiry 267

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Mail-Order Performance

Frederick D. Davis

Two high-speed PC AT compatibles with a catalog of options

The Proteus-286GT from Proteus Technology Corp. ($2395) and the GV-286 from PC Designs ($2920) offer a multitude of optional hard disks, monitors, display adapters, and keyboards. Although each improves on the performance of the IBM PC AT, each has a different way of doing so. As evidence of a growing trend, both of these 12-MHz dual-speed PC AT compatibles are available only by mail order from their respective companies.

Proteus Technology's Proteus-286GT (left) and PC Designs' GV-286 (right).

Common Denominators

Because the Proteus-286GT and the GV-286 both have the same chassis, the computers look a lot alike, except for the front panels. The units I reviewed were both equipped with 30-megabyte Seagate ST4038 hard disk drives, each with a 40-millisecond average access time; 1 megabyte of 100-nanosecond RAM on the main board, 640K bytes below the 1-megabyte address and 384K bytes above; an EGA adapter based on the Chips and Technologies chip set; an NEC MultiSync monitor; and a 1.2-megabyte floppy disk drive. Both machines also had Western Digital disk controllers and were supplied with MS-DOS 3.2 and GWBASIC 3.2.

The chassis used for both machines is a sturdy 21¼- by 16½- by 6¼-inch steel case containing a 200-watt UL-approved 110/220-volt power supply. At the rear of the chassis are cutouts for three DB-25 connectors and two DB-9 connectors. These cutouts enable you to install up to five ports without taking up extra rear slot ends for connectors. The chassis incorporates five half-height drive slots with individual power and ground connectors and two floppy disk drive data connectors. The full-height hard disk drive occupies two of the five slots, and the 1.2-megabyte floppy disk drive takes up another slot.

The chassis also has a rear switched-power outlet for a monitor. This outlet is convenient, but it requires a plug with a special rectangular cross-section ground prong. The standard three-prong plug won't fit, and neither machine comes with an adapter.

Both computers have cylindrical vending machine-style locks for enabling and disabling their keyboards and retaining their covers. The motherboards of both systems have six 16-bit PC AT-compatible slots and two 8-bit PC-compatible slots. Neither motherboard has any visible rework on the top side. Unfortunately, neither system filters its cooling air, and a heavy buildup of dust on high-performance chips can contribute to failure due to overheating.

Each machine I reviewed came with its own custom BIOS and two modes of operation: a high-speed microprocessor mode with a low-speed bus and a low-speed mode for both the bus and microprocessor. You can change speeds by internal switches or from the keyboard in MS-DOS by using special key combinations.

The Proteus-286GT

The Proteus-286GT has a 12.5-MHz Intel 80286 microprocessor that runs with one wait state. As an alternative, you can jumper-select either a 6-MHz or an 8-MHz clock rate with zero wait states. Under MS-DOS, you can select the microprocessor speed (but not the wait state) from the keyboard.

You select the wait-state condition via a jumper on the motherboard; however, the bus speed for both modes is 6 MHz to avoid problems with PC AT-compatible accessory boards. The computer has no fast slot for full-speed add-on memory boards; therefore, you must use the 6-MHz PC AT bus speed when you are using memory that is not on the motherboard. In addition, the Proteus-286GT has no indicator on the front panel to tell you when you are in high-speed mode.

The Proteus-286GT I reviewed had a 10-MHz 80287-10 math coprocessor installed and running at 10 MHz (a $375 option). To accomplish this speed, the

continued

Frederick D. Davis (P.O. Box 427, Riverton, UT 84065) is a self-employed consultant and programmer/analyst.

80287 is mounted on a piggyback board with its own crystal. This setup outperforms a directly mounted 80287, which would have to run at the 6-MHz bus speed.

The system motherboard is socketed for up to 4 megabytes of RAM using 1-megabit chips. The motherboard memory runs at 12.5 MHz with one wait state and is a major improvement over add-on memory boards that must run on the 6-MHz bus.

The Proteus-286GT has a potential heat problem that is not evident on the GV-286—the 80286 microprocessor chip does not have a heat-sink cover. The piggyback 80287 board raises the height of the math coprocessor chip, which is oriented parallel to the bus slots. When an accessory board is mounted above it, the bottom of this board comes in direct contact with the entire length of the top of the chip, which further reduces the chip's ability to dissipate heat. In spite of this situation, however, I did not experience any heat problems with my review unit.

The Proteus-286GT comes with three serial ports and two parallel ports mounted on the motherboard. The three serial ports all have DB-25 male connectors mounted in the chassis cutouts. The two parallel-port connectors (female DB-25 style) are mounted separately on two slot-end covers, effectively blocking those two slots from being used for boards. Although five of the six 16-bit slots and one of the two 8-bit slots are available, only four of the 16-bit slots can easily be used due to the port mountings. Furthermore, the lithium battery for the CMOS configuration RAM blocks one of the DB-9 chassis cutouts. A few changes in layout would have made better use of the system's resources.

The standard configuration of the Proteus-286GT includes two Teac floppy disk drives (one a 1.2-megabyte drive and the other a 360K-byte 5¼-inch drive). You can get a 3½-inch 720K-byte floppy disk drive instead of the 5¼-inch drive if you prefer. The only remaining half-height disk location has available power but no front-panel access opening, which rules out the possibility of adding a tape drive.

The Proteus-286GT uses Video-7's EGA-compatible Vega Deluxe graphics board, which is based on the Chips and Technologies EGA chip set. The characters on both machines are clear and sharp, and I experienced no problems working all day with either system combination.

The GV-286

The PC Designs GV-286 has an Advanced Micro Devices 80286 micropro-

Proteus-286GT

Company
Proteus Technology Corp.
377 Route 17, Airport 17 Center
Hasbrouck Heights, NJ 07604
(201) 288-8629

Size
21¼ by 16½ by 6¼ inches; 55 pounds

Components
Processor: 80286 running at 12.5 MHz with one wait state or at 6 or 8 MHz with zero wait states (jumper-selectable)
Memory: 1 megabyte, expandable to 4 megabytes on the motherboard and 16 megabytes in the system
Mass storage: One half-height 1.2-megabyte floppy disk drive; one half-height 360K-byte floppy disk drive; one 30-megabyte hard disk drive
Display: Review unit was supplied with an NEC MultiSync monitor and a Video-7 Vega deluxe graphics card
Keyboard: Review unit was supplied with an 84-key PC AT-type keyboard
I/O interfaces: Eight slots: two 8-bit IBM PC-compatible and six 16-bit PC AT-compatible; three serial ports and two parallel ports on motherboard

Software
Hardware and software utility programs; EMS 3.2 memory simulator

Options
Hard disk drives (from 20 megabytes to 190 megabytes): $279 to $3295
Floppy disk drives: $109 to $149
Tape-backup units: $455 to $795
Graphics cards: $109 to $385
Display monitors: $109 to $625
Internal modems: $109 to $219
Mice: $98 to $159
10-MHz 80287-10 math coprocessor: $375
MS-DOS 3.2/GWBASIC 3.2: $85

Documentation
MS-DOS User's Reference, 376 pages; *MS-DOS User's Guide*, 92 pages; *MS-DOS Programmer's Reference*, 406 pages; *GWBASIC User's Guide and Reference*, 423 pages; *Introduction to the Proteus Environment*, 30 pages; *Proteus-286GT User's Guide and Technical Manual*, 59 pages; Vega EGA board manual, 42 pages

Price
$2395

GV-286

Company
PC Designs Inc.
2500 North Hemlock Circle
Broken Arrow, OK 74012
(918) 251-5550

Size
21¼ by 16½ by 6¼ inches; 55 pounds

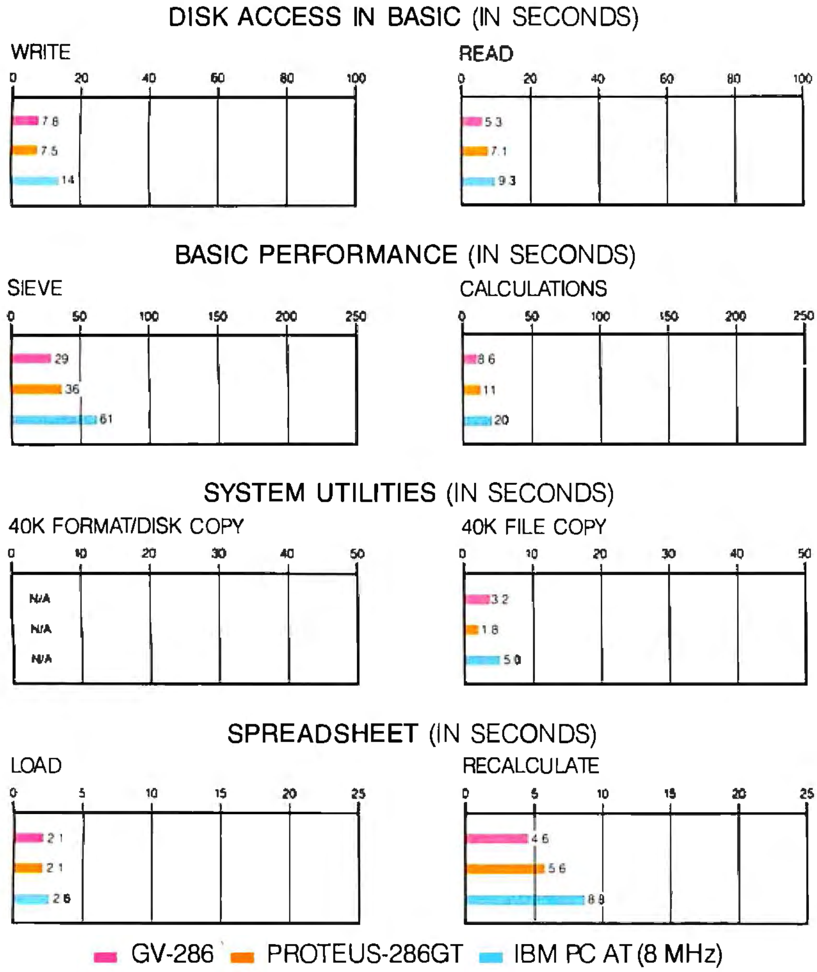
Components
Processor: 80286, selectable between 12 MHz and 6 MHz with one wait state to main memory and zero wait states to cache memory
Memory: 1 megabyte of main memory, expandable to 16 megabytes; 32K bytes of 45-ns static RAM cache
Mass storage: Either one half-height 1.2-megabyte floppy disk drive or one 360K-byte floppy disk drive and one 30-megabyte hard disk drive
Display: Optional; review unit was supplied with an NEC MultiSync monitor and Everex EGA card
Keyboard: Optional; review unit was supplied with Maxi-Switch 101 and Key Tronic KB101 keyboards
I/O interfaces: Eight slots: two 8-bit IBM PC-compatible and six 16-bit PC AT-compatible; two serial ports and one parallel port on I/O board

Software
Quarterdeck DESQview; PC-Write

Options
Hard disk drives (from 24 megabytes to 130 megabytes): $480 to $989
60-megabyte ¼-inch internal cartridge: $757
Graphics cards: $100 to $350
Display monitors: $179 to $569
Keyboards: up to $20
MS-DOS 3.2/GWBASIC 3.2: $99

Documentation
MS-DOS User's Guide and Reference, 340 pages; *GWBASIC User's Guide and Reference*, 407 pages; *GV-286 User's Guide and Operations Manual*, 144 pages; Quarterdeck DESQview manual, 125 pages

Price
$2920



The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a hard disk. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The 40K Format/Disk Copy benchmark was not performed because the computers had only one floppy disk drive. The 40K File Copy graph shows how long it takes to copy a 40K-byte file from the hard disk to the floppy disk using the system utilities. The Spreadsheet graphs show how long it takes to load and recalculate a 100-row by 25-column spreadsheet in which each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft Multiplan 1.10.

cessor running at 12 MHz with one wait state. I have been unable to determine the equivalence of this chip to the Intel 80286 with regard to protected-mode operations on suitable operating systems. A major design difference between the Proteus-286GT and the GV-286 is the GV-286's 32K bytes of 45-ns static RAM cache. The microprocessor runs from this cache with no wait states when you enable the cache from the keyboard by pushing the Control, Alt, and left Shift keys simultaneously and then pressing the plus (+) key. You disable the cache by pressing the same key combination and then pressing the minus (−) key.

Using the cache memory produces a significant increase in performance under many circumstances. The amount of this performance improvement depends on the size of the program running in the cache and the size and organization of the program data.

The GV-286's motherboard has five empty 16-bit slots and is socketed for an 80287 math coprocessor chip. The 80286 microprocessor, unlike the Proteus-286GT's, has a heat-sink cover. The motherboard uses the Chips and Technologies PC AT chip set. PC Designs claims that, despite the 12-MHz clock speed, the company has not exceeded the specifications for any of the chips.

PC Designs chose to design its internal bus around the 8-MHz PC AT single-cycle specification (i.e., the bus actually runs at 6 MHz for multiple cycles but is compatible with 8-MHz boards). The GV-286 also has a switch on the motherboard that sets the internal bus speed to 12 MHz, which is nonswitchable. This is an added extra for system optimization; all your peripheral and memory boards must be compatible with this speed before you can use this feature. However, all the timing loops in the custom BIOS have been rewritten to be completely independent of the 12-MHz microprocessor clock.

The GV-286 comes with 1 megabyte of 100-ns RAM on the motherboard. The motherboard also contains a CMOS battery-backed clock/calendar that is powered by inexpensive and easily available AA cells.

The floppy disk drive supplied with the GV-286 is a 1.2-megabyte Toshiba drive, and two half-height floppy disk drive slots are on the front panel of the machine. Also on the front panel is a high-speed indicator light (next to the hard disk access light) and a reset button (located next to the vending machine-style lock).

The GV-286 comes with a 30-megabyte Seagate ST4038 hard disk drive, an

continued

The GV-286 is the clear winner in ease of reconfiguring the CMOS RAM.

EGA-compatible graphics board, and a serial/parallel port board, as well as the necessary documentation, all supplied by Everex. Also included with the machine is a detailed printout of the hard disk checkout data.

One of the GV-286's two serial ports terminates in a DB-25 connector mounted in a chassis cutout, and the other terminates in a DB-9 connector on the same slot cover with a single DB-25 parallel port connector. Everex's documentation about these ports is far more complete than the information that you would normally receive about them. You can configure the serial ports on this board as either data terminal equipment (DTE) or data communications equipment (DCE) by changing a jumper. A 9-pin-to-25-pin adapter cable is also included with the Everex serial/parallel port board.

Configuring CMOS RAM

Of the two machines, the GV-286 is the clear winner in ease of reconfiguring the CMOS RAM. Each time you power up the GV-286, you are given the chance to reconfigure it. The dialog box closely follows that of the IBM PC AT diagnostics, in which the default answers are your previous configuration data. The system automatically detects and configures the memory.

The Proteus-286GT comes with a program that clears parts of the CMOS memory, so you must reconfigure the CMOS RAM each time you boot up the machine. To add or delete memory data, you must disconnect the CMOS battery for about 30 minutes. The next time you boot up the computer, the memory is automatically resized and stored in CMOS RAM, and you must reconfigure everything in the CMOS memory area; there is no way to edit the information once it is in the CMOS memory.

Keyboards

I used two optional keyboards with the GV-286: a Maxi-Switch 101 and a Key Tronic KB101. Both of these enhanced keyboards have 12 function keys located in a row above the number keys and a numeric keypad to the right of the main keyboard. A separate small keypad, which contains the cursor-control keys and the function keys that are normally active when the Num Lock is off, is located between the main keyboard and the numeric keypad. The Escape key is next to the number 1 key, 1½ inches above its traditional left-hand position. Both keyboards interchange the normal positions of the Caps Lock and Control keys. The Num Lock, Scroll Lock, and Caps Lock keys on both of these keyboards all have LED indicators.

The Maxi-Switch 101 contains a switch that lets you swap the Control and Caps Lock keys. An alternate set of key caps is supplied with the keyboard, since the two keys are different sizes. This keyboard has maximum resistance in the first millimeter of key travel and then practically no resistance. The Key Tronic KB101 has a soft, linear resistance for the entire keystroke.

The Proteus-286GT I reviewed came with an 86-key IBM PC AT-style keyboard with 10 function keys and an even resistance over the full keystroke that is more crisp than that of the Key Tronic KB101 keyboard.

Operating Systems and Software Compatibility

Both of my review units were shipped with MS-DOS 3.2, GWBASIC 3.2, EGA board utilities, and hard disk utilities. The MS-DOS/GWBASIC combination is a separately priced option for both machines. The Proteus-286GT comes with several specific utilities that let you reset the date and time (although you can't do this when booting the computer), an EMS 3.2 memory simulator, and a program that moves a file from one directory to another. The GV-286 software package includes a utility for the Everex serial/parallel port board, a copy of PC-Write on the Everex I/O utilities disk, and a copy of Quarterdeck's DESQview multitasking program.

I tested the high-speed mode of both machines by running the DOS 3.xx versions of the following programs: Graph-in-the-Box 1.3, dBASE III, Story Teller, WordStar Professional 3.31, SuperCalc 3 2.1, Multiplan 1.06, and Boardroom Graphics 3.0. In addition, I tested Connect on the Proteus-286GT. All these programs worked fine.

I also tried three additional operating systems on each machine: Concurrent PC DOS 4.1 and Concurrent PC DOS XM 5.0, Microport Unix System V/286 1.3, and Digital Research's FlexOS 286 1.31, a new multiuser/multitasking, real-time, protected-mode operating system. Concurrent PC DOS 4.1 and Concurrent PC DOS XM worked fine on both machines most of the time. However, the GV-286 crashed twice while running Concurrent PC DOS 4.1 with Access Manager 1.1 as a background task, a task running on one virtual console doing intensive disk I/O (through both Access Manager 1.1 and Concurrent PC DOS 4.1), and VEdit 1.3 running on a second virtual console while VEdit was apparently attempting disk I/O.

I say "apparently" because I may have caused the failure by entering disk I/O commands. Both failures occurred while I was using the Maxi-Switch 101 keyboard. I used three different keyboards (the Maxi-Switch 101, the Key Tronic KB101, and the Proteus-286GT's PC AT-style keyboard) on the GV-286 at various times. The two crashes occurred over a 30-hour period of mixed usage with Concurrent PC DOS 4.1 and various programs, but despite four more hours of purposely attempting to crash the system under the same circumstances, I was unable to do it.

I brought up Microport Unix System V/286 on both machines without any problems, but I couldn't extensively test the multitasking capabilities of this operating system due to a lack of suitable software. I installed 2.5 megabytes of additional memory on the Proteus-286GT and started up Digital Research's FlexOS, but it would not run. The Proteus-286GT was able to read the boot track and load the operating system, but when it attempted to read in COMMAND.286 (the equivalent of COMMAND.COM), the system displayed an error message saying that COMMAND. couldn't be found.

The most significant incompatibility I encountered was with a 2.5-megabyte 70-millisecond RAM chip Cheetah memory board. When the GV-286's and Proteus-286GT's microprocessors were running at 12 and 12.5 MHz, respectively, neither machine could recognize and size the board correctly, even though both companies say that the buses run at 6 MHz. The Proteus-286GT couldn't find the board at all, while the GV-286 either couldn't find it or sized it incorrectly and detected errors in it. When I set both review machines up with the microprocessor and the bus at 6 MHz, however, they ran the Cheetah board flawlessly. This might be a timing problem caused by the difference between the microprocessor and bus speeds. I had no way to determine this, however.

Benchmarks

The GV-286 is from 15 percent to 23 percent faster than the Proteus-286GT on all microprocessor and memory benchmarks; how much faster depends on the particular benchmark and the design of the two computers. The Disk Access in BASIC test results were mixed, since they don't depend on just microprocessor and memory speed.

The program and the data used for the Calculations benchmark will fit in cache memory concurrently and will therefore run with no wait states. The Sieve benchmark's data is a large array, so data has to be swapped in and out of cache memory along with the program and appropriate parts of GWBASIC. The GV-286 ran slower than a true zero-wait-state machine, but still faster than a machine without cache memory. The bottom line is that the Proteus-286GT is almost twice as fast as the 8-MHz IBM PC AT, while the GV-286 is a little more than twice as fast as the 8-MHz PC AT. The complete benchmark results are shown in the graph on page 247.

Documentation

Both machines come with a user's manual, an MS-DOS 3.2 user's guide, and a GWBASIC user's guide. In addition, the Proteus-286GT comes with the *MS-DOS Programmer's Reference*. The Proteus

continued

Technology's version of the above manuals consists of four small softbound volumes in a single slipcase. The PC Designs' version comes in two miniature vinyl three-ring binders. The Proteus-286GT also comes with an additional *Introduction to the Proteus Environment*, which is tailored to the novice user and describes computer basics (e.g., floppy disks and graphics boards).

Both machine's user's guides include sections for the novice, with information on handling computer boards and removing and replacing the case and disk drives. Beyond that, the Proteus-286GT user's manual has a weak technical section that is confined mostly to diagrams and annotations of items like connector pins and slot and socket locations. The manual gives little explanation of what is going on, and the diagram descriptions are weak. [Editor's note: *Proteus Technology says that it is now preparing a new user's manual.*]

The GV-286 user's manual is more complete and clearer on technical matters, such as definitions of the system interrupts and I/O address mapping, than the Proteus-286GT manual. The material is also easier to find and understand in the GV-286 manual. In short, the GV-286 manual is adequate, but the Proteus-286GT's manual is not.

Warranty and Service

PC Designs provides a one-year repair or replacement warranty and one year of toll-free technical telephone support with the GV-286. The company also has a 30-day money-back (except for shipping charges) compatibility guarantee. All service is handled by PC Designs at its Broken Arrow, Oklahoma location.

Proteus Technology has a 30-day money-back satisfaction guarantee and a 15-month labor and parts warranty for the Proteus-286GT. During this period, service is provided by a third-party service supplier. Proteus provides the first 60 days of service at the customer's site for no additional charge. Proteus also has a technical-support number during business hours and operates a 24-hour on-line bulletin-board service for registered owners.

Assessing the Trade-Offs

Both of these machines offer substantial gains in microprocessor performance over the PC AT and many of its clones, and both exhibit good PC AT software compatibility. However, they both suffer some hardware compatibility problems when the microprocessor is running in fast mode with the bus at a PC AT–compatible speed.

PC Designs pays better attention to details, such as board layout, heat dissipation, CMOS reconfiguration, port placement, and documentation, with the GV-286 than Proteus Technology does with the Proteus-286GT. Proteus,on the other hand, offers better service if you can't afford downtime. The Proteus-286GT can also hold a full 4 megabytes of RAM on the motherboard, which may eliminate the need for an add-on board. [Editor's note: *Due to variations in price and availability of options, contact the companies for the latest configurations of these systems.*]

In either case, you should weigh the cost and performance advantages of a higher-speed hard disk drive for either of these systems. The Seagate ST4038 just isn't fast enough for the performance potential that these computers offer. Both machines are strong contenders for multitasking, and a faster hard disk drive can only improve this situation.

If you want a high level of performance in a moderately priced computer and you are willing to carefully check out the add-on boards, either of these machines is a good buy. ■

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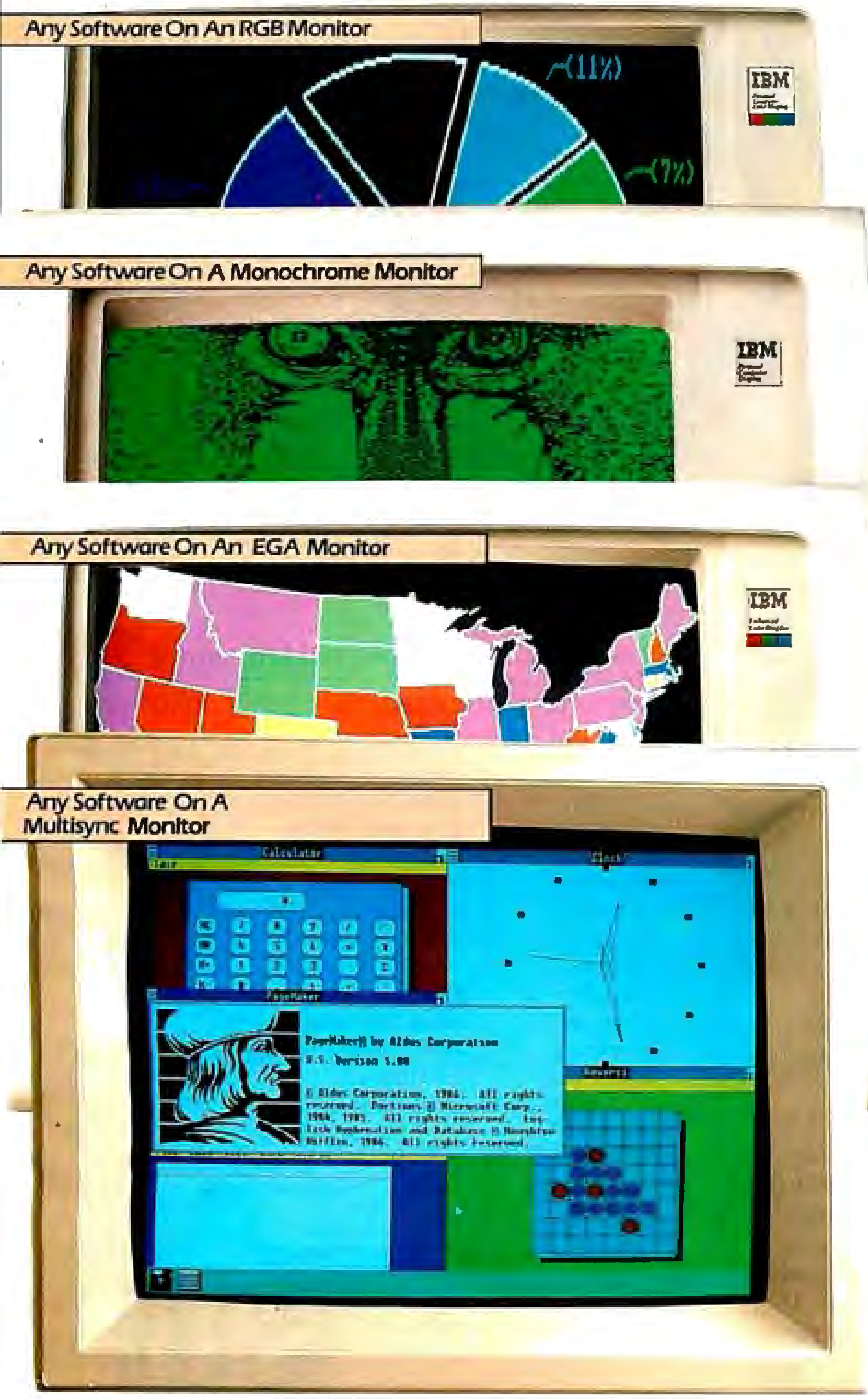

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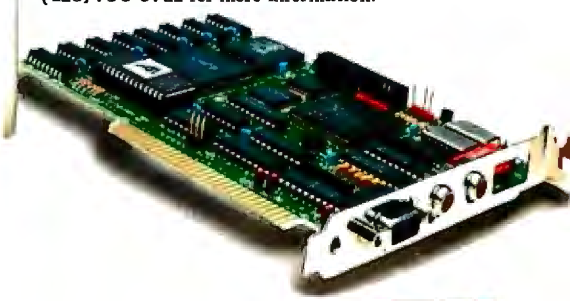

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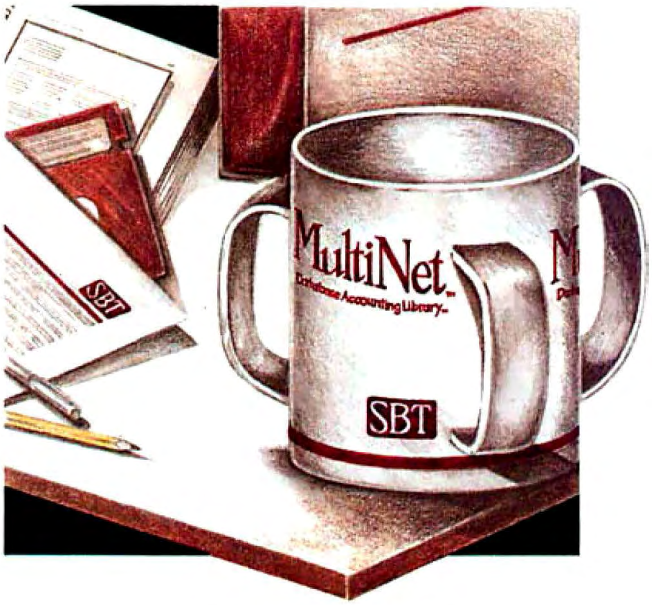

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The NEC MultiSpeed

David Satz

Portability, speed, user-friendliness, a low price, but with some flaws

The NEC MultiSpeed tries to hold true to the adage that good things come in small packages. The MultiSpeed is a portable, battery-operated MS-DOS computer with 640K bytes of RAM and a supertwist LCD screen. It runs at both 4.77 and 9.54 MHz and comes with ROM-resident utility software and on-line help files. In addition to having two internal 720K-byte 3½-inch floppy disk drives, the MultiSpeed is capable of maintaining files in an internal, nonvolatile RAM disk. Its suggested retail price of $2195 includes MS-DOS 3.20, the ROM-resident utilities, a set of four spiral-bound manuals, and an AC adapter. [Editor's note: *NEC has introduced the MultiSpeed EL ($2495). It has the same features as the original MultiSpeed plus an electroluminescent backlit LCD screen and a larger power supply.*]

The Inner Sanctum

The MultiSpeed is built around NEC's V30 microprocessor, a CMOS chip that is compatible with Intel's 8086 but with a different internal architecture, giving faster performance even at the nominal 4.77-MHz clock rate. Normally, though, the computer boots up and runs at 9.54 MHz. You can select the slower speed by invoking a ROM-resident setup routine or by setting a rear-panel configuration switch. NEC claims that the MultiSpeed's microprocessor runs with zero wait states at either speed, except when the LCD screen is being updated. There are two empty ROM sockets in the underside of the computer, but no socket for a numeric coprocessor.

This 11-pound computer is not the most petite of laptop designs, but you can carry it comfortably by the slide-out aluminum handle. Its extra few cubic inches provide keyboard features that will be reassuringly familiar to desktop computer users: a separate numeric/cursor-control keypad on the right-hand side (set above the main keyboard) and 10 function keys arranged in two columns along the left. The 85 full-size, full-stroke keys are cleanly designed with a moderately stiff spring action and very little play or wiggle; they touch bottom with a smart tap. The nonslip-textured key tops are comfortably contoured, with the *F* and *J* keys scooped out more deeply than the others. The layout of the main keyboard closely resembles that of the original IBM PC's keyboard, except for the addition of special Pop Up and Help keys. LED indicators are built into the Caps Lock and Num Lock keys.

The MultiSpeed is ready to run as soon as you check the four rear-panel configuration switches, install the main battery, connect its polarized three-pin cable connector, and switch the backup battery into operation. After turning on the main power switch and angling the screen into position, you can abort the power-on self-test RAM-check routine by pressing the space bar. A slider control to the right of the LCD screen adjusts the screen's contrast.

The reflective (nonbacklit) supertwist LCD screen has a 1.6-to-1 aspect ratio and good overall legibility. The screen can display 80 characters by 25 lines and either 320 by 200 or 640 by 200 pixels. Programs that require an IBM Color Graphics Adapter (CGA) can be indirectly displayed with differential shading of the LCD. The main character font is attractively designed with a single-dot line thickness in an 8 by 8 matrix. The pixels look like thin upright purple rectangles set against a vaguely greenish metallic background. The contrast is distinctly greater than that of other LCD screen types. The screen is mounted in the lid of the unit, and you can remove it to facilitate the use of a CRT monitor if desired. No audible alarm or shut-off switch is provided to prevent the lid from closing when the battery power is still on.

The NEC MultiSpeed features a battery-backed RAM disk; its contents survive rebooting DOS, even after a crash due to main battery failure. You can set the RAM disk for any size up to 126K bytes. Usually, 2K bytes of battery-backed RAM is reserved for system setup parameters, so that even with no RAM

continued

David Satz (118 State St., Apt. C, Brooklyn Heights, NY 11201) is a classical musician and recording engineer.

disk allocated, the maximum memory space available for DOS and applications software is actually 638K bytes. (The KILL64R.COM program, which is available on the system disk or from NEC, will free up the remaining 2K bytes of RAM.)

Mass-storage facilities consist of two 3½-inch floppy disk drives that use the same 720K-byte double-sided, double-density format as that of the IBM, Toshiba, Zenith, Data General, Kaypro, Datavue, and Bondwell laptops. The disk drive openings, located along the right-hand side of the computer, are protected by spring-loaded door flaps. When you insert a disk, its window shutter is slid aside immediately to save a few moments during initial access. A front-panel LED shows when the drives are operating, although the drives are loud enough to remove any doubt.

You can set up the floppy disk controller (FDC) to draw its operating current either continuously or only during a disk operation. The *User's Guide* warns of a slight slowdown of initial disk access when this FDC Power Save mode is on, but I found it had no observable effect on disk performance either in the benchmark tests or during ordinary use.

The back panel has DB-25 connectors for the parallel and RS-232C serial ports and a DB-9 for the RGB color monitor. Also on the back panel are a tiny blue hardware reset button, a coaxial socket for an AC adapter or an optional automobile 12-volt adapter cord, four DIP configuration switches, and a backup power switch that controls an internal nickel-cadmium battery, which preserves the setup parameters and the RAM disk contents when the main battery is discharged or being exchanged. The MultiSpeed also has a 15-pin socket, labeled EXT FDC, that you can connect via an optional cable to the FDC port of an IBM PC or PC XT to allow the disks in the MultiSpeed's internal drives to be directly accessed by the other computer. This is partial compensation for the lack of any means of connecting external disk drives or expansion units. No access to the system bus is available from outside the computer.

The MultiSpeed's nickel-cadmium battery can run the computer for up to 4 to 6 hours following an 8-hour charge. The battery life varies with floppy disk usage. When the battery voltage begins to trail off, a red LED above the main keyboard blinks during disk operations and then glows steadily. After a few minutes, a beep is sounded, and this warning appears on the screen: `Power failure has occurred. Save all data files immediately. Press any key to resume session.` Saving data to a floppy disk requires a lot of power, which often brings this message up repeatedly (e.g., between individual disk operations when you try to comply with its demands). On my first cycle, I was granted 45 minutes of continued use after the audible warning, but the next time around it was only 15 minutes before it crashed. You can use the nonvolatile RAM disk for saving files on short notice, but you must enable it beforehand because you can't set one up without rebooting; there wouldn't normally be enough juice left anyway.

The MultiSpeed's main battery is easily accessible from the top of the computer through an access cover. Owners might want to carry a spare; replacement batteries cost $99. You can operate the computer while the battery is recharging, but the *User's Guide* warns that external power should not be connected while the computer is switched on. Therefore, to continue operating, you would have to save your data, power down, change to external power or a spare battery, and reboot. The battery-charging current automatically decreases after about seven hours of recharging. However, if a battery that still has some power left is connected to the computer's external power, it can become rather warm, whether the computer is running or not. According to NEC, too much overcharging can decrease the life of the battery.

Hits and Misses

The MultiSpeed can be fitted with an optional 300/1200-bps auto-dial/auto-answer internal modem, which operates to U.S. standards only. It responds to the Hayes-type AT command set and should be compatible with most communications software or with the built-in TELCOM program.

For instructions on overall operation, the *User's Guide* is helpful and clearly written. A brief (76-page) *Introduction to MS-DOS* explains the most rudimentary DOS commands for beginners. The two other volumes included with the MultiSpeed describe the operation of the ROM-resident programs. Nowhere is there any mention of the more advanced DOS utilities—not even an overview of their functions or a summary of their command syntax.

The overall construction of the computer is good, except for the faulty design of the screen-lid hinge mechanism. For it to work, you must set the lid into position in exactly a certain way. You must lift up the lid, set the angle, and press a button on the right side; it must never be readjusted backward unless you first release the hinge lock by pulling the lid forward, or you can damage the hinge. NEC has elected to exclude any such damage from its warranty coverage.

The MultiSpeed has a one-year parts and labor warranty period, with an optional extended-service contract. According to NEC, MultiSpeed owners who need repairs can call a toll-free number, identify themselves, and give a credit card number, whereupon NEC will ship out a replacement computer and a return authorization. Owners then send the defective units to NEC.

Compatibility

The MultiSpeed's major obstacle to software compatibility is its inability to interface with external disk drives and use copy-protected software on 5¼-inch floppy disks. The availability of software on 3½-inch floppy disks has improved with the introduction of the IBM Personal System/2 computers. However, limiting a computer exclusively to 3½-inch disks is somewhat premature. The only hardware solution, slaving the MultiSpeed to an IBM PC or PC XT, does not overcome the copy-protection problem, and some users do not have access to suitable desktop computers at their convenience.

The machine's special features bring about another potential source of trouble. The interrupts that trigger the ROM-resident programs and on-line help (interrupts 80, 81, and 82), although officially reserved for BASIC, are occasionally used by applications programs. Such programs can run on the MultiSpeed only if the ROM-resident programs are disabled, which the SETUP program allows you to do by reclaiming their workspace in RAM. However, SETUP cannot disable itself. For drastic instances, you can disconnect the special keys entirely from their interrupts with the KILLPOP.COM program, available on disk with the system, from NEC dealers, or by downloading it from the NEC bulletin board. [Editor's note: *You can obtain this program by calling 1-800-NEC-SOFT for information or 1-800-NEC-RBBS to access the NEC bulletin board.*]

NEC claims that software that produces a conflict is rare. Despite my earnest attempts to make trouble, all my MS-DOS software ran well on the MultiSpeed, including Flight Simulator 2.13, Turbo Pascal 3.01A, SideKick 1.56A, MEX-PC 1.65A, Microsoft Word 3.1, and QuickBASIC 2.01 (once they were transferred to 3½-inch disks).

Resident Programs

The MultiSpeed's ROM-resident programs include SETUP, for the selection of system parameters, including RAM disk size, microprocessor clock speed, CGA emulation parameters, and the FDC Power Save mode; OUTLINER, for out-

NEC MultiSpeed

Company
NEC Home Electronics (U.S.A.) Inc.
Computer Products Division
1255 Michael Dr.
Wood Dale, IL 60191-1094
(312) 860-9500

Size
13½ by 12 by 3 inches; screen size: 9 by 4¾ inches; weight: 11 pounds

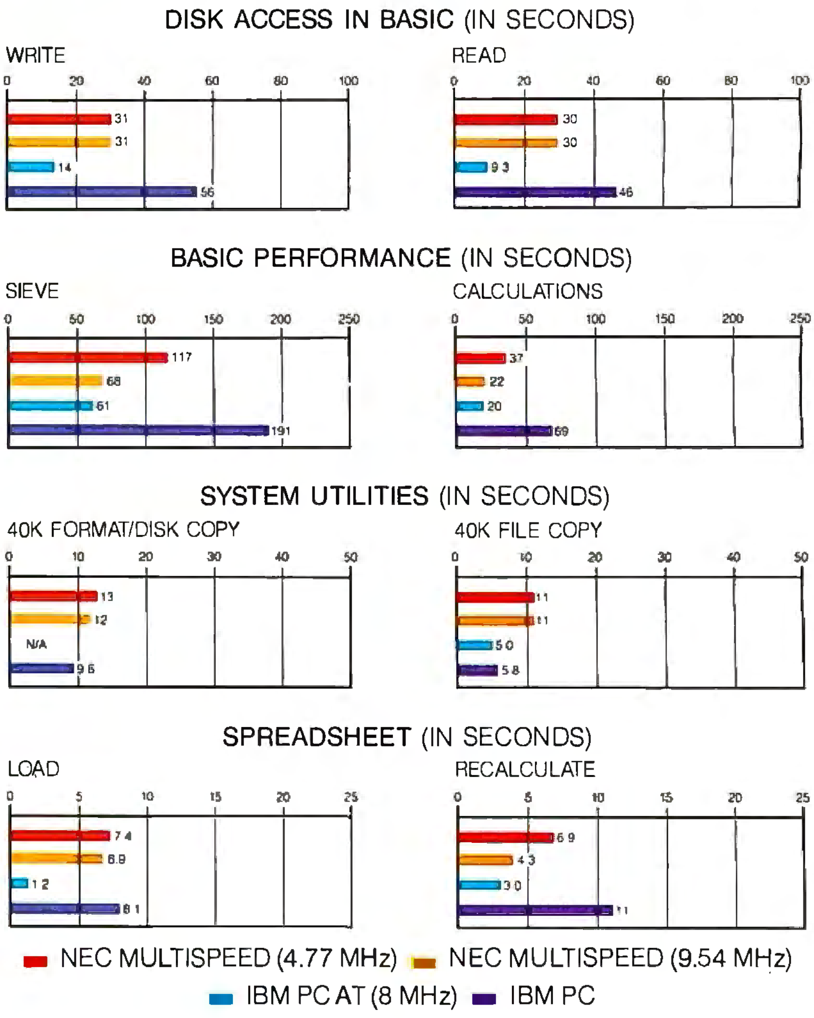
Components
Processor: Intel 8086-compatible NEC V30, switchable between 4.77 and 9.54 MHz
Memory: 640K bytes of 150-ns CMOS and dynamic RAM (up to 126K bytes can be allocated to the nonvolatile RAM disk); 512K bytes of ROM; internal sockets for additional ROM
Mass storage: Two 720K-byte double-sided, double-density 3½-inch floppy disk drives
Display: 80-column by 25-row supertwist LCD; emulates IBM CGA to give 320 by 200 or 640 by 200 monochrome graphics
Keyboard: 85 keys; 10 function keys; separate numeric/cursor-control keypad
I/O interfaces: RS-232C serial port, male DB-25 connector; Centronics parallel printer port, female DB-25 connector; external floppy disk controller interface port, female DB-15 connector; IBM PC-compatible RGB video port; coaxial socket for DC operation and battery-charging current

Software
MS-DOS 3.20; Phoenix ROM BIOS; TELCOM, NOTEPAD, FILER, OUTLINER, DIALER, and SETUP programs; on-line help files

Options
300/1200-bps internal modem: $399
External Transfer Kit (includes cable and software for slaving the MultiSpeed's internal disk drives to an IBM PC or PC XT FDC port): $99
12-volt automobile power adapter cord: $20
Carrying case: $99

Documentation
User's Guide, 186 pages;
Introduction to MS-DOS, 76 pages;
TELCOM/DIALER User's Manual, 136 pages; OUTLINER/FILER/NOTEPAD User's Manual, 284 pages

Price
$2195



The graphs for Disk Access in BASIC show how long it takes to write and then read a 64K-byte sequential text file to a blank floppy disk. (For the program listings, see BYTE's *Inside the IBM PCs*, Fall 1985, page 195.) The Sieve graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations graph shows how long it takes to do 10,000 multiplication and 10,000 division operations using single-precision numbers. The System Utilities graphs show how long it takes to format and copy a 40K-byte file using the system utilities. The 40K Format/Disk Copy test was not performed on the PC AT because the computer had only one floppy disk drive. The Spreadsheet graphs show how long it takes to load and recalculate a 25- by 25-cell spreadsheet in which each cell equals 1.001 times the cell to its left. The spreadsheet used was Microsoft Multiplan. Tests on the NEC MultiSpeed were done using MS-DOS 3.2, GWBASIC 3.2, and Multiplan 1.06. Because the MultiSpeed's software package does not include any programming language, all BASIC tests were run with a generic version of GWBASIC.

line processing; NOTEPAD, for basic word processing; FILER, for message filing; DIALER, for operation of the internal modem's dialing facility; and TELCOM, for telecommunications. You call an overall menu onto the screen by pressing the Pop Up key for about 1 second, or you can invoke a particular routine by pressing the Pop Up key plus the first letter of the program's name. You can also call ROM-resident programs by name from the DOS command line, and they can interrupt most applications and each other freely. NEC has designed a

continued

certain measure of data protection into the MultiSpeed: If you shut off the power switch or press Control-Alt-Delete while there are ROM-resident programs suspended with data unsaved, a warning message appears and gives you a chance to save the data. All unsaved data is lost when you reboot with the hardware reset switch. Also, changing the RAM disk parameters forces a cold start and the loss of all the RAM disk's previous contents; the exit menu from the SETUP program warns of this eventuality.

The ROM-resident software attempts to be self-documenting by means of menus and a context-sensitive on-line help facility. In a manner that is strikingly similar to Microsoft Multiplan and Word, the prompt/menu lines are always on-screen during program execution. Backing these up are more detailed messages that appear in large on-screen windows whenever you press the Help key. The messages are available whenever ROM-resident programs are run, even to remote users when TELCOM is operating the auto-answer modem. The message texts could stand to be proofread (e.g., `Newline: Toggles whether or not a linefeed with follow each carriage return.`). But they are thorough; if they don't tell you how to do something, you probably can't do it.

Impressions

The MultiSpeed was pleasant to operate as soon as I learned where to reach for the cursor-control keys. I also found the Shift and Enter keys too small and narrow for my taste. The LED indicator on the Num Lock key toggles when the key is pressed, regardless of the actual status-bit setting; when I ran SideKick, its calculator, which manipulates the status bit directly, was able to throw the indicator into the reverse of its proper function.

The supertwist LCD screen is easy to read under strong overhead lighting; I observed no ripple under 60-hertz fluorescent lighting. However, the single-dot thickness of the normal font characters makes reverse video very difficult to read. The slowness of the screen display, a characteristic of supertwist LCDs, is also bothersome at times. Still-standing screen messages waft gently into place; I found scrolling text difficult to read. I could not scan bulletin-board messages using an external 2400-bps modem, nor could I read screen listings using the DOS `TYPE` and `DIR` commands. Rapid typing is also a bit disorienting—I suffered "cursor anxiety" when deleting text with repeated backspaces. I did, however, like the screen's effect on animated displays and game programs. For example, it imparts an eerie, slithering motion to the cells in Conway's Game of Life, and the screen objects in Flight Simulator seemed to rhythmically undulate.

The ROM-resident software contains numerous bugs, some of which could cause significant loss of data. In TELCOM, for example, if you begin capturing text within the Terminal mode and then suspend it, you must rename the file from the Command mode, or the file is never closed. If it is not renamed, you'll have a zero-length file in the disk directory, and you'll lose most of your data; no warning is given unless you happen to page through the various Terminal mode help screens. When operating without the XON/XOFF protocol, the pause needed for writing captured text to a floppy disk or to view the previous screen causes a loss of any incoming data.

NOTEPAD gets confused by ASCII control codes, which it interpreted as end-of-line and end-of-file characters the first time I tried to use it with preexisting text. When I gave the program a chance to originate a text file more to its own liking, I typed for a while and, long before the end of the available buffer space, it suddenly decided not to allow characters to be inserted. It signaled `INTERNAL ERROR` (which the on-line help explained as `Severe internal error was detected`) and asked whether I wanted to recover this file. I typed a *Y* and was greeted with the message: `Document in memory cannot be recovered. Press any key to resume.` The text file itself, which I had saved to disk a moment before the error message appeared, showed no irregularities, and I could edit it under SideKick. This error message came up each time I reloaded the file and attempted to insert a character. (When I contacted NEC about the problem, the company responded by saying that NOTEPAD was designed for general-purpose word processing with ASCII text files, and that files created with other word-processing programs that contain control codes embedded in text may not be compatible with it.)

Other details of NOTEPAD and TELCOM are poorly thought out. NOTEPAD starts in the Edit mode with an empty screen while displaying the Command mode menu, looking like it needs a command letter; the command letter goes, of course, into the text window, and you must delete it before hitting Escape to get to the actual Command mode. In Command mode, however, there is no prompt for getting back to the Edit mode; you have to ask for help to find out that you have to press Escape once again.

Benchmark Performance

The benchmark results for the NEC MultiSpeed show a level of microprocessor performance that puts it in the speed category of a slow PC AT-class machine; this is quite commendable for a computer with a list price of just over $2000. By comparison, the similarly priced Zenith Z-181 takes over 205 seconds to run the Sieve test, while the MultiSpeed runs it in just under 140 seconds. The Core International Disk Performance Program gives average access times for the MultiSpeed in the neighborhood of 200 milliseconds, just slightly better than those obtained with the Toshiba T1100 Plus and the IBM PC Convertible. I obtained the MultiSpeed's benchmark times for the Disk Access in BASIC tests with the FDC Power Save mode off. This had no measurable effect on the benchmarks, since, in these tests, the disk drives run continuously. The complete benchmark results appear on page 255.

Final Impressions

The MultiSpeed is relatively inexpensive, highly portable, has a fast microprocessor, and is user-friendly. The keyboard is of good quality; for some users, the existence of a separate numeric keypad will justify the awkward position of the cursor-control keys. The nonvolatile RAM disk facility is a natural feature for a battery-operated computer.

The supertwist screen is nicer to look at than to use. Its qualitative advantage over the best conventional LCD screens should not be overstated; it is still critically dependent on ambient lighting (especially in reverse video), and, while its contrast ratio is higher than that of many other units, it is still a contrast between two dark colors. Furthermore, the supertwist pixels are a little slow, which can be irritating.

The lack of an external 5¼-inch floppy disk drive (or any hardware expansion at all) is a severe limitation. I'm sure most users would rather have the FDC socket rewired for this purpose. However, serial-port transfer programs, such as Brooklyn Bridge and LapLink, are available for file transfer via the RS-232C port.

The MultiSpeed's ROM-resident programs offer more than minimal functionality, but they also contain more than minimal bugs. The computer's software compatibility is infringed upon by these features, and some users may choose to disable them.

Despite its weak points, the MultiSpeed is a fast and easy-to-use computer. If you disregard the bugs in the ROM-resident software, the extra features and fast microprocessor could make this computer a favorite with first-time users, as well as experienced users who need portability and speed. ■

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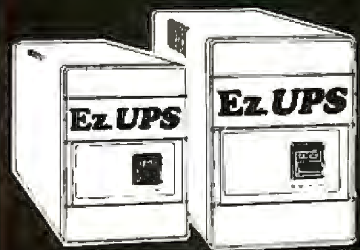

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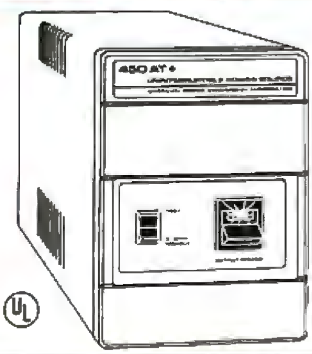

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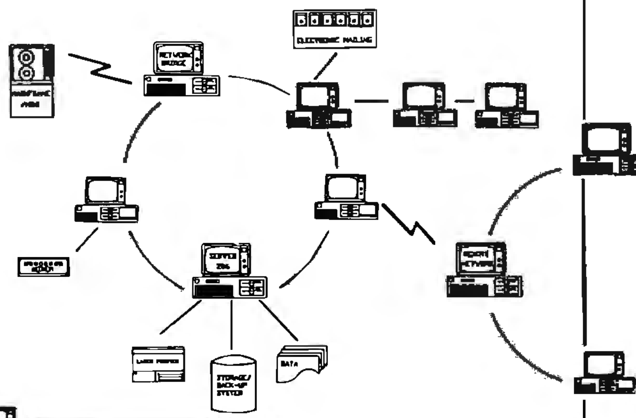

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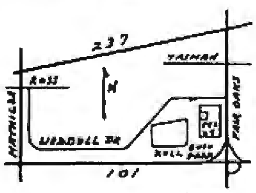

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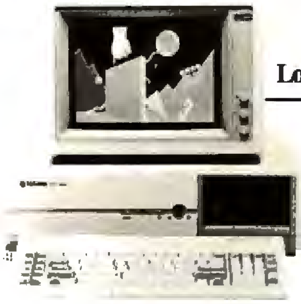

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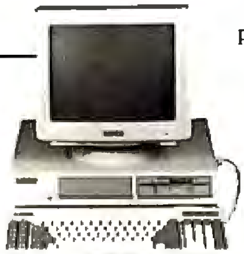

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The Micro Clipper Graphics Subsystem

Charles Weston

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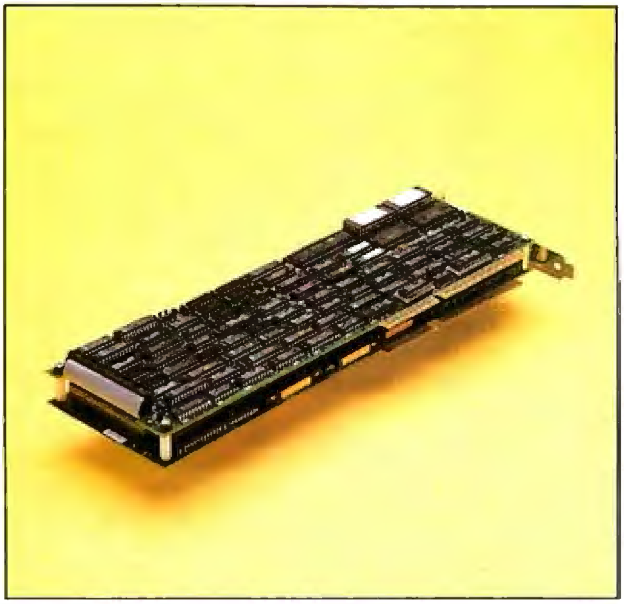

Graphics performance has been the traditional stumbling block to truly productive IBM PC-based CAD systems. Specifically, the problems with running popular packages, such as AutoCAD, are low screen resolution and poor graphics throughput. However, at least one solution is now available.

Micro Clipper Graphics from Pixelworks ($3295) is a two-board graphics subsystem for the IBM PC AT, RT, and compatibles that typically improves AutoCAD graphics performance by 5 to 10 times. The subsystem provides enhancement functions, such as continuous real-time pan and zoom and a split-window display. It also operates with other popular CAD packages, including EasyCAD, Personal Designer, and VersaCAD.

The subsystem features a 66-MHz internal clock, pipelined architecture, and direct memory access (DMA) to a locally generated graphics-display list. It supports a "multisync" mode of 720 by 560 pixels with 4-bit planes, a 1020- by 816-pixel 4-bit-plane mode (these modes both provide 16 colors from a palette of 4096), and emulation of IBM CGA and EGA. The subsystem uses a 9-conductor NEC MultiSync-type (9-pin D to 9-pin D) cable. An optional jumper is available for CGA or EGA pass-through, allowing you to route your CGA or EGA adapter's signal through Micro Clipper Graphics to avoid switching monitor cables whenever you want to use your standard display adapter. Unfortunately, although you can use Micro Clipper Graphics as a CGA or EGA adapter, you have to manually toggle a switch on the board.

The Micro Clipper Graphics subsystem requires a host computer with two adjacent 16-bit slots (like those on an IBM PC AT or RT PC), 22.5 watts of 5-volt power, and a 60-hertz noninterlaced 3-wire RGB monitor, such as the NEC MultiSync. All CAD programs recommend, and some require, a math coprocessor. RAM requirements vary, depending on the CAD package. Generally, you'll need enough RAM to satisfy not only the CAD software's basic needs, but also about double the amount of RAM you would normally need for the display list. This means that if you're processing 250K-byte AutoCAD drawings, at least another half megabyte of RAM is required. AutoCAD specifies a minimum of 512K bytes of RAM, but as the program "pages" a drawing from disk into RAM, the more memory you have, the more efficiently your system will run.

Pixelworks also offers a big brother to Micro Clipper Graphics, called Clipper Graphics ($4500), that is designed primarily for three-dimensional use. It has a 119-MHz clock, resolution of 1024 by 1280 pixels, and 256 simultaneous colors from a 4096-color palette. A 16.7-million color palette is available as an option. Its special three-dimensional functions include rotation, translation, perspective, and shading.

I evaluated Micro Clipper Graphics on a TeleVideo Tele-CAT-286[8] equipped with an 8-MHz 80286 processor, 2 megabytes of RAM, an 80287 math coprocessor chip, a 30-megabyte hard disk drive, and an NEC MultiSync monitor.

Inside the Graphics Engine

The most interesting component of the Micro Clipper Graphics subsystem is the graphics engine. Its primary function is to manipulate "transformed vectors," which are the definitions of lines based on a coordinate system. The graphics engine accomplishes all scaling, rotation, zooming, and panning by matrix multiplication of these vectors.

A bus interface processor on the subsystem communicates with the host computer's bus. This processor is responsible for DMA, using a 16-bit DMA channel in Cascade mode to access nonsequential addresses. To increase the overall processing speed, Micro Clipper Graphics becomes the bus master, sourcing the addresses necessary to get the display-list data. (CAD drawing data is stored in hierarchical tree structures throughout the memory space.)

A display-list processor interprets the

continued

Charles Weston is a BYTE technical editor. He can be contacted at BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

Micro Clipper Graphics

Type
Graphics subsystem

Company
Pixelworks Inc.
225A Lowell Rd.
Hudson, NH 03051
(603) 880-1322

Size
Two 13½- by 4¾-inch boards; weight: 2 pounds

Features
Ten enhanced CAD functions, including Autopan and Zoom; CGA- and EGA-emulation modes; split screen; writable control store for user-defined graphics primitives; line, polyline, rubber-band, and drag support; 16 simultaneous colors from a palette of 4096; support for AutoCAD, VersaCAD, and other popular CAD packages; third-party software support for the GKS standard and Tektronix and DEC terminal emulation; comes with Pixelworks' drivers and diagnostics on two 5¼-inch floppy disks.

Hardware Required
IBM PC AT, RT, and compatibles with at least 512K bytes of RAM, a hard disk drive, and an NEC MultiSync-type RGB monitor capable of 720- by 560- or 1020- by 816-pixel resolution; math coprocessor and extra memory recommended

Software Required
MS-DOS or PC-DOS 3.0 or higher or GEM plus CAD application software package

Documentation
29-page user's manual

Price
$3295

data coming from the DMA channel. The data can be of two types: branches (conditional or unconditional), which are based on some status change dictated by the drawing operation, or graphics commands (e.g., points, lines, and arcs), which are control points within a "modeling space." A modeling space can best be described as a virtual drawing. The modeling space on Micro Clipper Graphics theoretically can comprise 32,000 by 32,000 addressable points.

The control points interpreted by the display-list processor are then fed through the graphics engine's transform-and-clip processors, where they are translated from virtual-drawing coordinates to "screen-space" coordinates. The screen space on Micro Clipper Graphics is 1020 by 816 pixels, but the actual display window for the NEC MultiSync comprises only 720 by 560 pixels.

The 720- by 560-pixel display-window area is actually a translated subset of the virtual drawing. The drawing is represented as a vector list, which describes the 32,000 by 32,000 points. To translate the vector list to the screen image, Micro Clipper Graphics multiplies the coordinates by a scale plus an added offset and then clips the image to the screen boundaries.

Without Micro Clipper Graphics, a CAD system running with a CGA, EGA, or other standard graphics interface forces the microprocessor to do all the vector computation. Micro Clipper Graphics, however, has a floating-point package implemented in microcode on the subsystem for doing the vector calculations. This arrangement frees the host processor from graphics-calculation tasks.

Micro Clipper Graphics's draw processor contains microcode to produce 16 different line styles and patterns commonly used in CAD drawings, such as dashed and broken lines. Circles, ellipses, and arcs are also defined by the microcode. The graphics engine needs only the center point and a radius to create arcs and circles. The draw processor has a 32K-byte writable control-store area that you can load with user-defined graphics primitives, such as custom text fonts.

The draw processor also contains the logic required to create windows. Plane-masking and Boolean operations on pixels also take place within the draw processor. Raster-operations logic is responsible for bit-block transfers (BIT/BLTs) to the pixel memory, and, ultimately, to the screen. The pixel memory contains the video RAMs that store the screen-space image, which is rasterized in the last stage of the viewing pipeline by the high-speed D/A converter (a Brooktree BT451 RAMDAC chip).

All text generated by the graphics engine is "stroke text"; that is, text made up of vectors arranged in head-to-tail fashion that compose the individual letters. This type of text has the advantage of being easier to scale and rotate than pixel-oriented fonts. To rescale the text, the graphics engine merely rescales the matrix of the endpoints that define the characters. Similarly, the graphics engine can rotate text—a time-consuming process with pixel-oriented text.

Panning Around

Before using Micro Clipper Graphics, you must configure the switches and jumpers on the subsystem board set. I altered my system configuration to allow routing of the CGA/EGA board signals through the Micro Clipper Graphics subsystem to my MultiSync monitor.

The two high-end graphics resolutions are switch-selectable, and the DMA channel is jumper-selectable. Normally, the graphics subsystem uses DMA channel 6, but you can select channel 7 and change the corresponding interrupt vector by switch-selection to avoid conflicts with other boards in your system. Setting the switches and connecting the factory-supplied feed-through cable was no problem. I also ran the factory-supplied `TESTME` diagnostic, which indicated that the boards were functioning properly. I encountered difficulty in configuring AutoCAD and the software, however.

First, you must delete the `ACAD.MNX` and `ACAD.MNU` files from the AutoCAD directory and rename the Pixelworks ADI (AutoCAD device interface) driver file, which corresponds to your memory model, as `DSCLIPER.EXE` and then add it to the directory. I used a simple 640K-byte nonextended memory model for this.

The next file that you need to copy into the AutoCAD directory is Pixelworks' `DSCLIP.MNU`. You must rename this file `ACAD.MNU` to replace the original AutoCAD menu file with it. AutoCAD compiles this file into a smaller executable file, called `ACAD.MNX`, which contains the icons that appear at the lower right corner of the screen. Then you enter the AutoCAD configuration and the type of digitizer used; I used a Logitech C7 Mouse. The version of AutoCAD that I used, version 2.6, contains the option for the Pixelworks ADI driver file in the configuration menu, and, once I selected it, AutoCAD came up in 720- by 560-pixel resolution with the six extra menu items that appear on the right edge of the AutoCAD display.

In short, installing Micro Clipper Graphics for use with AutoCAD is not for the fainthearted. The Pixelworks disks supplied with the subsystem contain the necessary software, but the user's manual is not explicit about the actual installation. According to Pixelworks, software-installation support is the responsibility of the application vendor. Nonetheless, Pixelworks has a hotline to call for troubleshooting information, and I made good use of it.

New Level of Functions

Micro Clipper Graphics adds a level of functions that are completely resident in the subsystem's hardware, and the CAD application software has no knowledge of

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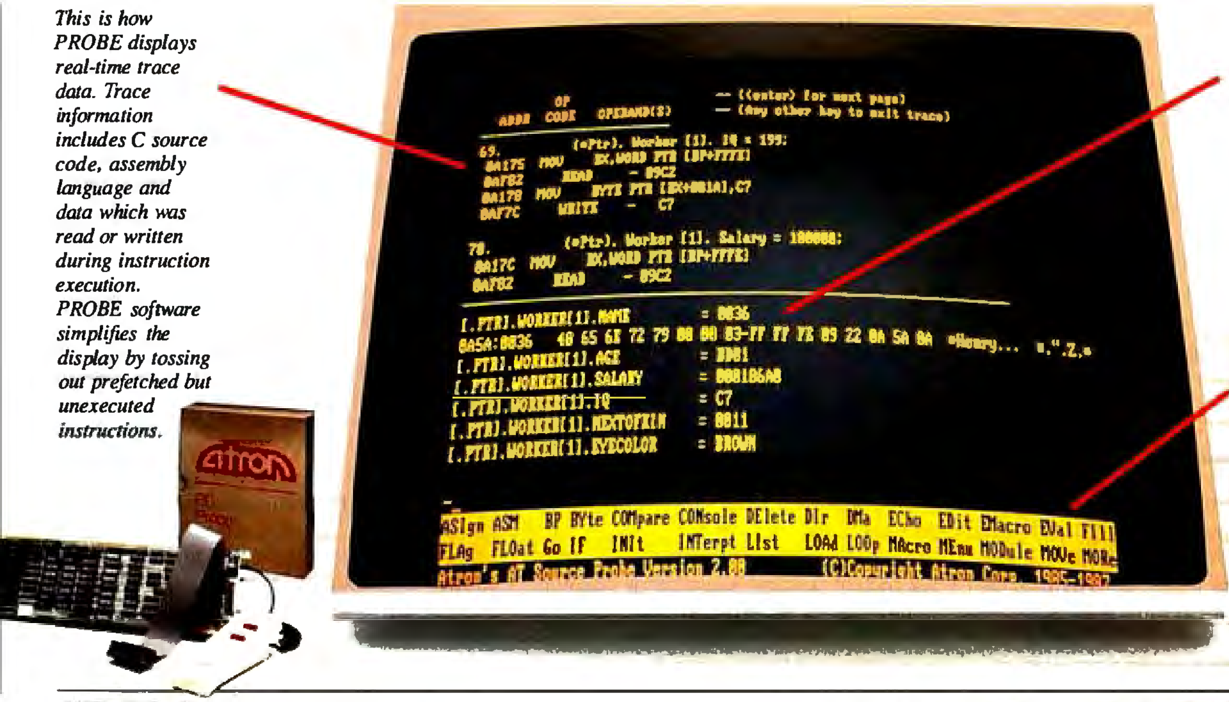

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Table 1: *Benchmark results; all times are in seconds. Anomalies in timings for some tests, such as the ×25 zoom, are due to the ability of high-resolution graphics boards to capture more detailed information in Zoom mode. Thus, more time is required to draw these images than would be expected.*

AutoCAD nozzle drawing	QuadEGA+ (CGA) (320 by 200 pixels)	QuadEGA+ (EGA) (640 by 350 pixels)	Micro Clipper Graphics (720 by 560 pixels)	Clipper Graphics (1280 by 1024 pixels)
Redraw	1.25	1.58	0.267	0.320
×5 zoom	0.77	1.22	0.245	0.295
×25 zoom	0.51	0.64	0.228	0.273
PCB layout				
Redraw	13.95	16.59	1.92	2.15
×5 zoom	4.09	6.24	1.84	2.03
×25 zoom	2.60	3.03	2.04	2.22
CADSource Shootout drawing				
Redraw	9.65	15.08	1.15	1.33
×5 zoom	5.88	8.27	0.86	1.05
×25 zoom	5.25	6.84	0.53	0.64

whether any of the functions has been invoked, or even that they exist. Zooming in AutoCAD with Micro Clipper Graphics occurs entirely inside the graphics engine of the subsystem.

A small window in the upper left corner of the screen displays a scaled version of the complete drawing being edited with its own cross-hair cursor. The cursor position in the small window corresponds to the position of the working cursor. In Zoom mode, a lightened transparent block within the small window shows you where you are working in relation to the complete drawing. The level of detail in ×25 zoom makes it difficult to see where you are without this indicator.

To change the zoom level, you use AutoCAD's Control-L command. Micro Clipper Graphics traps the command and controls the zoom from the graphics engine. Control-L steps continually among three zoom factors. The first time the function is invoked, the graphics subsystem will execute a ×5 zoom; the next time, a ×25 zoom; and the third time, a ×1 zoom (a return to the original drawing scale). A zoom is not a pixel replication, but a total recalculation and scaling of the individual lines' endpoints described by the clipping rectangle.

The six "local" commands (so named because they execute on the subsystem) are AUTOPAN, ZMALL, SPLIT, SIZE, CLEANUP, and REDRAW. The most useful of these added features is AUTOPAN. In Zoom mode, you simply use the mouse to move the cross hair and the transparent window around the scaled drawing in the small window, and the rest of the screen displays a panorama of the drawing at the zoomed magnification practically as fast as you can move the mouse.

The ZMALL function redraws the original picture without zooming or panning. SPLIT toggles the small window that displays the scaled drawing. The SIZE function prints out the current number of display-list pages in use at the bottom of the screen. The CLEANUP command erases all unnecessary dots, such as those for control points for circle and arc centers. The REDRAW function redraws an image. Although AutoCAD already has a REDRAW command, the function added by Micro Clipper Graphics is performed quickly by the subsystem.

Other functions offered by Micro Clipper Graphics include ZMWIND, LPAN, and LDRAG. The ZMWIND function, which you invoke from the command line, defines the zoom area, and it simplifies the DEFWIND implementation in AutoCAD. The first selection of ZMWIND, done with the mouse or the cursor, sets the start corner of the area, or block, to be zoomed, and the second selection sets the opposite corner. The area is then enlarged to fill the entire view window of AutoCAD.

LPAN pans the screen to the current cursor position shown in the small window. LDRAG drags the current zoom window to a new point on the screen. LDRAG works whether the small window is in use or not, so you can zoom around a drawing even if you don't know the precise cursor position in relation to the complete drawing.

Graphics Performance

Graphics system performance is not easy to assess; comprehensive benchmarks for graphics systems are still being evaluated and debated. The performance of Micro Clipper Graphics can best be measured by using some actual AutoCAD drawings. For the benchmark drawings, I selected the well-known AutoCAD nozzle drawing, a printed circuit board layout from The Great SoftWestern Company, and the CADSource Shootout (a drawing specifically designed to exercise CAD functions).

The tasks I timed were a redraw, a ×5 zoom, and a ×25 zoom. I created a script-command file and used AutoCAD's timing function to calculate the elapsed times for doing the assigned benchmark tasks. The script-command file started the AutoCAD timer, executed 100 iterations of each test function using the AutoCAD nozzle drawing, and then stopped the timer. I conducted the same tests using the CADSource Shootout and the printed circuit board layout, but I executed only two iterations because of the time required. I then divided the total elapsed time by the number of iterations to determine the time required for one iteration. The benchmark results of the AutoCAD system running on my TeleVideo TeleCAT-286[8] with a Quadram QuadEGA+ board in both CGA and EGA modes, with Micro Clipper Graphics, and with Clipper Graphics, are shown in table 1.

Time Caveats

The benchmark times for the CGA and EGA modes of the QuadEGA+ board are close to those of the Micro Clipper Graphics subsystem for some of the zoom tests, but these results can be misleading. Due to the lower resolution of the CGA and EGA graphics modes, there is not much detail in the zoomed image, and therefore the images are drawn relatively fast. However, the lack of detail in a 320- by 200-pixel ×25 zoomed image renders the drawing useless for all practical purposes—there are just not enough pixels to accurately represent the information. The slower-than-expected zoom times for Micro Clipper Graphics and Clipper Graphics is caused by the subsystems' higher resolution, which provides more detail than the CGA and EGA modes; the greater the number of pixels, the more processing required.

Overall, the benchmark tests show that the Redraw speed of Micro Clipper Graphics is several times faster than that of AutoCAD running with a math coprocessor. In addition, while its price at first seems prohibitive, the Redraw speed, enhanced resolution, and the ease with which you can zoom and pan around drawings makes Micro Clipper Graphics a useful graphics enhancement tool. ■

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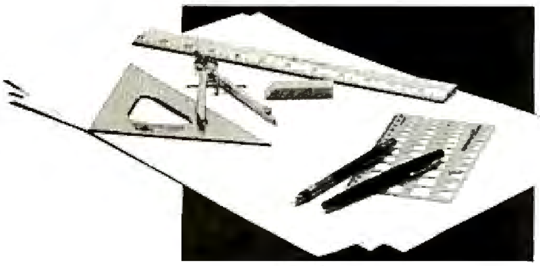

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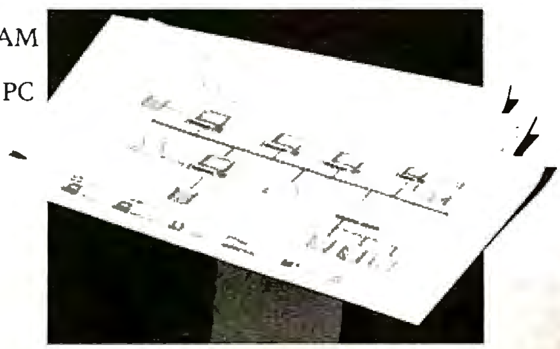

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TABX

PC-MOS/386

Richard Grehan

A DOS-compatible multitasking, multiuser operating system for 80386-based hardware

PC-DOS just isn't cut out as an 80386 operating system, and new OSs are trickling out in an effort to fill the gap. One of the early arrivals is The Software Link's PC-MOS/386. Its design is ambitious: PC/MOS-386 attempts to retain compatibility with PC-DOS while adding a host of multitasking and multiuser capabilities, plus the ability to run protected-mode 80386 applications when they become available.

These goals, though, fall short in the execution. I tested PC/MOS-386 release 1.01 on two Compaq Deskpro 386s: one with an 80287 coprocessor, 2 megabytes of RAM, and a 20-megabyte hard disk drive, and the other with an 80387 coprocessor, 4 megabytes of RAM, and a 40-megabyte hard disk drive. In addition to a five-user version ($595), PC-MOS/386 comes in two other forms: a single-user version ($195) and a 25-user version ($995).

A Promising Start

Installing PC-MOS/386 is as painless as it gets. I simply inserted the master disk in the floppy disk drive, booted the system, ran `HDSETUP` (analogous to PC-DOS's `FDISK`) to create a PC-MOS partition on the hard disk, ran `FORMAT` to format the hard disk, executed `.MSYS C:` to write boot information on it, and copied three files to it to get a bootable PC-MOS drive. The manual guided me step-by-step through all this, and I encountered no problems in getting the system operational.

Since PC-MOS lets you create a logical drive of up to 256 megabytes, I was able to use the entire 40-megabyte drive on one machine. PC-MOS has no trouble reading standard PC-DOS 360K- and 320K-byte floppies, so transferring files onto the hard disk was simply a matter of using the `COPY` command.

All the commands in PC-DOS for creating, deleting, copying, and renaming files and directories are available in PC-MOS/386, and most of them use the same syntax. I found some differences that led to momentary confusion; for example, the PC-DOS `CHKDSK` command is called `VERIFY` in PC-MOS/386, and PC-DOS's `VERIFY` command is called `WVER`.

PC-MOS/386 uses a `CONFIG.SYS` file to define the operating system's environment at boot-up time. Several of the `CONFIG.SYS` directives are similar to those in PC-DOS. For instance, `BUFFERS=nnn` tells PC-MOS to set aside *nnn* (which can range from 1 to 999) 530-byte records in memory for disk buffers. `DEVICE=<filename>` directs PC-MOS to load `<filename>` as a device driver.

Other directives, listed below, have no PC-DOS counterparts.

- `FREEMEM=`*m,n* informs PC-MOS of free memory your system might have between 640K bytes and 1 megabyte; *m* and *n* specify the low and high boundaries, respectively.
- `SLICE=nnn` sets the time-slice size in units of 1/18 second. The default is `SLICE=1`, in which case the processor will service a task for 1/18 second before swapping in the next task.
- `SMPSIZE=`*nnn*`K` allots *nnn*K bytes to the system memory pool, which PC-MOS uses to track open files and created tasks. The default is 20K bytes, but as you anticipate running more tasks, you must increase the size.
- `USERFILE=<path> $$USER.SYS` tells PC-MOS/386 where to find the `$$USER.SYS` file, which holds security information.

You can specify a number of other driver files in `CONFIG.SYS`. For instance, `DEVICE=$CACHE.SYS` *nnn*`K` installs a disk-caching system. If you include `DEVICE=$EMS.SYS` *nnn*`K`, then at boot time PC-MOS installs driver code that emulates Lotus-Intel-Microsoft expanded memory *nnnK* bytes long. Finally, `DEVICE=$PIPE.SYS <devname>`, *n* installs a pipe with buffer size *n* that partitions can use to communicate with one another. Your tasks can access the pipe like any other device with the name `<devname>`.

And You'll Also Receive . . .

ED is PC-MOS/386's source-file editor, which, fortunately, does not adhere to the format of PC-DOS's Edlin. You can operate ED in one of two modes: a command mode, where you work a line at a time from a prompt line (similar to Edlin), and a visual mode, where ED becomes an easy-to-use screen-oriented editor. I found myself switching to the visual mode constantly, since I could figure out how to make changes with only rare forays to the manual.

`DEBUG` is the PC-MOS/386 equivalent to the PC-DOS version of `DEBUG`, with some handy enhancements. Not only does PC-MOS's `DEBUG` have all the commands of the PC-DOS version, but you can also set up to 10 breakpoints, access the registers of a math coprocessor, and use a remote terminal for your debugging session. Another clever addition is `DEBUG`'s assemble/unassemble command (`AU`). Using `AU` when you can enter a machine-code source statement at a selected address, `DEBUG` will automatically echo your input and display the address and the hexadecimal bytes that the source code translates to.

At the time of this writing, only the user's manual for the operating system was available. Instructions for installation and for setting up various device drivers are clear. Whenever I had trouble with the system, I had no difficulty locating topics in the manual. Sometimes,

continued

Richard Grehan is a technical editor for BYTE. He can be reached at BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

PC-MOS/386 Modular Operating System version 1.01

Type
Multitasking, multiuser operating system

Company
The Software Link
3577 Parkway Lane
Atlanta, GA 30092
(404) 448-5465

Format
Two 5¼-inch floppy disks

Computer
80386-based computers with 1 megabyte of RAM and a hard disk drive

Language
Assembly language

Documentation
349-page 8½- by 9-inch ring-bound user's guide

Price
Single-user version: $195; five-user version: $595; 25-user version: $995

though, essential information is missing, as I'll describe later.

I would have liked to have a technical reference manual to experiment with the programming interface. Unfortunately, people at The Software Link said that one wouldn't be available until the early part of August. (One engineer described the programming interface as looking exactly like PC-DOS 3.x with NETBIOS. PC-MOS uses a NETBIOS emulation for task-to-task communications.)

Moving into Multitasking

PC-MOS/386 lets you execute more than one program at once by dividing extended memory (i.e., memory above 1 megabyte) into multiple partitions in which DOS applications execute. The maximum size of any partition is 640K bytes, and the size and number of partitions that you can have depends, of course, on the amount of RAM on your computer. When PC-MOS/386 first boots up, it sets up partition 0 in the memory region below 640K as attached to the main console.

To create a new partition, you use the `ADDTASK` command. This command lets you specify the partition's size, its task ID, its security class, and a start-up batch file name that's analogous to `AUTOEXEC.BAT` in PC-DOS. By specifying these parameters, you create a second task that is associated with the main console. To access a given partition, you simply press the Alt key and then type that partition's number on the numeric keypad.

To set up a multiuser configuration, you use the `ADDTASK` command as before, except you specify parameters that indicate the serial port the partition is associated with, the data rate of the port, and the device driver that PC-MOS/386 should use to talk to the remote terminal you're using. (You have your pick of PC-type, ADDS Viewpoint, TeleVideo 910, DEC VT-52, or Teletype terminals, among others.)

Once you've got multiple tasks running, you can call a number of task-maintenance commands. Many of these are grouped under the `MOS` utility command. They include:

•`MAP`, which displays a map of all the partitions currently defined, the address at which the partition starts in memory, the size of the partition, the serial port that it's associated with (if any), and more.

•`DIS`, which lets you disable any code in the current partition that polls the keyboard looking for input (since this could eat up processor time). If PC-MOS senses that a task is awaiting keyboard input, the task is suspended until an actual keyboard request is issued. As I'll discuss later, this may not work for some programs that must have direct access to the keyboard.

•`USEIRQ` *n*, for reserving control of interrupt vector *n* (where *n* can range from 2 to 7). This handles the situation where two or more tasks attempt to gain control of the same interrupt vector, say, for managing an I/O port. Once a task is completed, it can free whatever interrupts it has control of by using the `MOS FREEIRQ` *n* command.

Additional commands for managing partition parameters are available in the `MOSADM` utility command. These include commands for setting the time slice for the task in a partition, assigning a priority to a partition, and turning the system's disk-caching on or off.

Since PC-MOS/386 is a multiuser OS, there's an optional security system that you can install. Basically, it gives you 26 security classes and the ability to assign a class to each directory and file. A user's privileges for a particular directory or file depend on an access-level code associated with that class. This code ranges from 0 to 3 and is read from a user log file (`$$USER.SYS`) and attached to a user when logging onto the system. A 0 access level means the user has no access to a directory or file, a 1 grants execute-only privileges, a 2 grants read and execute privileges, and a 3 means unrestricted access.

What Works and What Doesn't

I tried a number of popular IBM PC programs with PC-MOS, and the following is a brief description of what I encountered.

•XyWrite III (version 3.05): I loaded a document and did some simple editing. All went well until I tried to quit and received the `File open, QUIT anyway?` prompt, at which point the machine locked up completely. This is probably a case of an application that sidesteps the operating system and "talks" directly to the keyboard. The PC-MOS user's manual warns of problems with packages like this.

•Norton Commander (version 1.00): When I tried to execute this program, PC-MOS reported that a general software error had occurred and that it was attempting to terminate the application. It succeeded.

•WordStar (version 3.30): This worked fine. I loaded a file, did minor editing, and saved.

•SideKick (version 1.50): When I installed SideKick and attempted to activate it, the machine simply beeped at me four times.

•QuickBASIC (version 2.0): I used the BASIC version of BYTE's Sieve benchmark to test QuickBASIC and had no problem with the compiler.

•Turbo Pascal (version 3.01A): I used a number of the demo programs supplied with Turbo Pascal, and they all worked (including the spreadsheet demo). I also successfully compiled and ran the programs using the version of Turbo Pascal that includes 8087 support. Turbo Pascal's `SOUND.PAS` demo turned up an interesting effect, however. If I started the program (which causes the computer to sound like a ringing phone) in one partition and switched to another partition, sometimes the sound followed me across partitions. An engineer at The Software Link said that this was due to a program that fools with the system timer, which is a sensitive area to PC-MOS/386 since it uses the timer to generate task-switching interrupts.

•Turbo C (version 1.0): Using Turbo C's interactive environment editor, I recoded the timing routines for the BYTE C benchmarks to use Turbo C's `gettime()` function, recompiled, and executed the programs. I did not run any benchmarks that performed floating-point operations, due to problems with the math coprocessor that I'll discuss later.

•AutoCAD (version 2.6): AutoCAD worked until I attempted to load a drawing, at which time the screen flickered strangely and I was returned immediately to the system prompt.

•Lotus 1-2-3 (version 2.01): This worked fine in partition 0, but when I created a second task in a 500K-byte partition and switched to the second partition, 1-2-3 simply killed the machine when I executed it. The company said that the version of PC-MOS/386 I was using lets you create a partition that is too big, and that a rule of thumb for maximum partition size was 640K bytes minus whatever size I had set the system-memory pool to. So I reduced the partition size to 400K bytes, and, sure enough, I could run 1-2-3 in both partitions simultaneously.

•Microsoft C (version 4.0): Microsoft C worked fine. However, it was while using this package that I first discovered that PC-MOS/386 and the 80387 didn't get along.

•MetaWare's High C (version 1.3): I really hoped I could execute this package, since it's currently the only C compiler that can generate 80386 code. However, you can run programs created by High C only under Phar Lap's RUN386, and RUN386 will not execute in PC-MOS/386. This is due to the fact that RUN386 attempts to create a protected-mode environment, and since PC-MOS/386 runs programs in virtual 8086 partitions, it won't let RUN386 take control of the 80386. A programmer at The Software Link informed me that the company was working on a fix to allow High C to execute under PC-MOS/386 but did not indicate when the fix would be available.

•GWBASIC (version 2.02): This version of GWBASIC worked like a champ. I used it to run the BASIC benchmarks. It was while running GWBASIC from a remote terminal that I encountered additional problems, however, which I'll discuss below.

Complaints

At the top of my list of gripes is the lack of a list of software that The Software Link has tested on PC-MOS/386. It would be helpful to know what programs you shouldn't even bother trying with this operating system.

I also ran into problems determining the proper setting for environment parameters as defined in the `CONFIG.SYS` file. Specifically, the manual gives little guidance for choosing a proper time-slice value, and no help at all in picking a proper system-memory-pool size. Your best method for zeroing in on a proper time-slice is experience, and you'll surely want to experiment with different values as the task load changes. However, the only way I could determine a system-memory-pool size that worked was by booting the system, trying to add a second task, getting a `Not enough memory` message, editing the `CONFIG.SYS` file, rebooting the system, and repeating the process all over again.

I spent most of an afternoon trying to get an external terminal to work with PC-MOS. First I connected a Wyse terminal via a serial cable, but when I initialized a task associated with the serial port, PC-MOS would do nothing but transmit spaces to the monitor. Oddly enough, flow control worked—I could hit Control-S on the Wyse to halt the incoming characters and then use Control-Q, and they'd resume; but I could get no prompt, nor any way to send a command to PC-MOS from the terminal.

Next, I connected an IBM PC and started up the VTERM terminal-emulation program. I finally got things to work and started GWBASIC from the remote terminal. Scrolling was horribly slow, however, since the screen completely rewrote itself for every new line that rolled in at the bottom. I'm certain that the scrolling was being done by VTERM, so I shouldn't fault PC-MOS for the lack of speed. But during rewriting of the remote terminal's screen, the task running on the main console simply came to a standstill. I could type characters at the console, and the type-ahead buffer would remember them; when scrolling on the terminal was completed, they would burst out onto the screen as the main console task sprang back to life. I contacted The Software Link about this problem and was told that they had not seen it happen before.

Benchmarks

To get a sense of how the operating system performed, I ran the standard BASIC and C benchmarks. The results of the BASIC benchmarks are in table 1. I tried the benchmarks with the time slice set to both 1 and 2 and with a second task (with a partition size of 600K bytes) sitting at the PC-MOS prompt on a remote terminal (i.e., quiescent). The alteration in timeslice size had little or no effect on the execution time. If you compare these results with those obtained running a Compaq Deskpro 386 under Compaq DOS 3.1 (see page 240), you'll see that PC-MOS has little effect on CPU-intensive operations when there's only one active task. Adding a second task added only minor overhead.

PC-MOS/386 runs the Calculation, Sieve, and Read tests as fast as, or only slightly slower than, MS-DOS on a Deskpro 386. However, PC-MOS's Write benchmark is nearly twice as slow. I think this is due to additional code that PC-MOS must run to coordinate multiple tasks accessing the same disk (code that executes even when you're only running one task).

To test the effects of running multiple tasks, I used the `TIME$` function in GWBASIC. I set up three 500K-byte partitions (in addition to partition 0), executed GWBASIC in each one, and loaded and executed the BASIC benchmark programs with the additional statement

```
50 IF TIME$<>"13:00:00" GOTO 50
```

tacked on the front of each parameter. In this way, the system executed four copies of each benchmark simultaneously.

The average result for each benchmark

continued

Table 1: *(a) Byte's BASIC benchmarks run in partition 0 with no other partitions activated.*
(b) The same benchmarks, this time run in partition 0 with another task added (in partition 1) and sitting at the PC-MOS/386 system prompt. All times are in seconds.

a. 1 task in partition 0

	Slice = 1	Slice = 2
Write	10.4	10.4
Read	4.8	4.8
Calculation	7.0	7.0
Sieve	23.4	23.4

b. 2 tasks (1 active, 1 waiting at system prompt)

	Slice = 1	Slice = 2
Write	10.6	10.5
Read	4.9	4.9
Calculation	7.4	7.1
Sieve	24.5	24.0

Table 2: *The BYTE C benchmarks run under PC-MOS/386 using Microsoft's C compiler version 4.0.*

	No coprocessor	80287
Fibonnaci	8.5	8.5
Float	22.7	4.4
Savage	41.7	2.8
Sieve	1.1	1.1
Sort	2.2	2.2
Fileio	128.0	128.0
(with cache)	114.0	113.0
Dhrystone	3125.0	3125.0

(Note: All times are in seconds, except the Dhrystone, which is in Dhrystones per second.)

was as follows: Write, 42.5 seconds; Read, 17.5 seconds; Calculation, 28.5 seconds; and Sieve, 97.5 seconds. Except for the Read benchmark, these times are approximately four times greater than the times for the benchmarks run in partition 0 with three additional quiescent partitions. The Read benchmark is only about three times greater. This makes sense: Since all tasks were reading from the same file, the system was most likely performing only one physical read per sector, so three of the four partitions could read the data from memory buffers.

Finally, I executed the standard BYTE C benchmarks. The times you see in table 2 were generated by programs processed by Microsoft C version 4.0. I tested the programs with and without the 80287 math coprocessor, and here's where I ran into another problem. One of our Deskpro 386s has an 80387 installed, and each time I tried executing a C program that made use of the math coprocessor, the machine froze. All these programs worked on the same machine under PC-DOS and executed fine on our other Deskpro 386, which has an 80287. A programmer at The Software Link informed me that the company was aware of this problem and was working on a fix.

A Nice Idea

My most vivid memory of working with PC-MOS/386 is how many times I had to power the machine off and back on again after something I'd done had locked it up. Case in point: The manual clearly documents that the maximum partition size you can create using ADDTASK is "determined by the amount of free memory that is remaining on your computer and cannot be larger than approximately 640K," but I can't remember how many times I executed ADDTASK 600K (and even ADDTASK 500K) on a 4-megabyte machine only to have it lock up—and with only two partitions. The Software Link says it's working on a fix to keep the machine from freezing in such a situation.

Engineers at The Software Link also said they were aware of most of the other problems I had encountered, that they were working on fixes, and that users of PC-MOS/386 would receive free updates for them all. (I was told that the first update was due out in July.)

All in all, although PC-MOS/386 has a great deal of potential, I cannot at this point recommend it. I wonder whether its multiuser capabilities make any sense in an application beyond, say, a means for a background task to control infrequent access to the system via a modem. And if you're interested only in multitasking, other packages on the market (Quarterdeck's DESQview, for example) provide this capability.

Admittedly, PC-MOS/386 offers an environment for executing protected-mode 80386 programs, and this might prove useful if you're developing 80386 code. But I was unable to use the only high-level 80386 development package that I had—High C—because of PC-MOS's incompatibility with RUN386. Even if The Software Link can get High C to work on this operating system, PC-MOS/386 carries with it the old PC-DOS restriction of a 640K-byte maximum partition size, so there's no way to experiment with larger address spaces.

The idea of a multitasking 80386 operating system with PC-DOS compatibility combined with advanced task communications is exciting. But PC-MOS's designers still have some work to do. ■

Actor 1.0

Leonard Moskowitz

Object-oriented programming languages (OOPL), of which the best-known is Smalltalk, ease program development and maintenance. Often, however, these languages are also slow, memory-hungry, and have a steep learning curve. Actor is an OOPL designed to be a fast, memory-efficient, easy-to-learn alternative to Smalltalk.

Actor version 1.0 ($495) runs under the Microsoft Windows operating environment version 1.03 on IBM PCs and compatibles with MS-DOS 2.0 or higher. It requires a hard disk drive, a graphics display adapter, a mouse, and 640K bytes of memory. I ran Actor on a 6-MHz IBM PC AT with 640K bytes of memory, an EGA graphics adapter, a 30-megabyte hard disk drive, and a Mouse Systems optical mouse running under PC-DOS 3.2 and Microsoft Windows 1.03.

Actor achieves its speed through use of a token-threaded interpreter, optional early binding, and an incremental dynamic-memory garbage collector, as opposed to Smalltalk's byte-code interpreter, late binding, and various implementation-dependent garbage-collection schemes. Like Smalltalk, Actor is an interpreted language and provides a rich programming environment.

Actor differs from other object-oriented languages in that its syntax is similar to Pascal and C. Actor allows optional termination with semicolons to make Pascal programmers feel more at home. Assignment is via the := form, which, again, is much like Pascal. Blocks are enclosed in curly brackets, as in C, and the then can be left out of conditional forms. Although these points don't make object-oriented programming concepts any easier to absorb, they do ease the transition.

As with any new release of software, there are a few problems with Actor. A README file on the disk describes most of them and mentions that they will be fixed in the next version. An additional shortcoming is that in the 640K-byte limit of PC-DOS, Actor leaves little room for application code. Future releases of Actor will increase the amount of memory available to a programmer.

[Editor's note: *In the August 1986 issue of BYTE, dedicated to the theme of object-oriented languages, Charles B. Duff, the author of the Actor language, discusses the philosophy behind its design. Other articles in that issue explain what an object-oriented language is and its advantages and disadvantages over more conventional programming languages, like C or Pascal.*]

A Complete Environment

Actor provides a complete programming environment, familiar to the users of Smalltalk and Flavors, including browsers, inspectors, a workspace, and a file editor. Browsers are specialized edit windows designed to view and change Actor-class source code and immediately implement the changes. When you edit in a browser, text is automatically formatted. Inspectors, another kind of window editor, allow you to view an object, send it messages, or modify it. You can use inspectors to trace an object's inheritance of methods and instance variables. The Actor workspace is the developer's primary interaction window. In the workspace, you can write and interpret Actor source code (as you can in the browser and inspector windows), edit, select to browse or inspect, and check on certain system parameters.

Actor provides a solid base of programming code. It comes with more than 90 predefined object classes and hundreds of methods, including various types of windows, collections (arrays, structures, bags, strings, symbols, sets, dictionaries, and graphic objects), associations (for making ordered pairs), characters, and numbers (16-bit signed integers, longs, and reals). One class, `Behavior`, lets you treat classes as objects and is used to implement inheritance. You can use the browser to explore the class-hierarchy source code for 92 of the classes and their methods. The source for primitive methods is not provided. Primitive methods perform basic operations required by Actor objects, and, in the interest of speed, are written in assembly language.

Two classes, `Library` and `Proc`, let you call library procedures from Microsoft languages such as C, FORTRAN, Pascal, and assembly language. You use the `Library` class to set the filename of the library, and then you add entries for each procedure in the library that you want to use. The `Library` class creates an instance (or object) of class `Proc` for each entry, which you can call by sending a `pcall` message to the `Proc` object that defines the procedure.

Not all the classes come already loaded into Actor; in some cases, you load them into the environment when you need them. For example, to use the file editor that comes with Actor, you must load in the `FileWindow` class. If you want the editor to be present each time you enter Actor, you can save a copy (or snapshot) of the environment that you've built up during a session for later use.

When using an editor within Microsoft Windows, such as Microsoft Write, I had to take Actor out of the system because Windows spent most of its time accessing the disk, compensating for the memory shortage. I used WordStar and PC-Write outside of Microsoft Windows, and both worked just fine.

Actor is tightly integrated with Microsoft Windows' mouse-and-menu operating environment, which gives it a familiar feel to those who have used Windows. Windows is slow and ungainly on PCs and XTs, but on an AT, response was timely as long as I was running only Actor and not too close to the memory limit.

Actor provides a full set of interface functions to Windows. You can define windows, menus, dialog boxes, accelerator keys, and icons and pass information between Actor and Windows. Each window becomes an Actor object, and you communicate with it and command it much as you do with any Actor object.

Speed Optimizations

Actor gives you the option of defining the type of a program's variable at compile (early binding) rather than at run time (late binding). By using this option, you can substantially improve a program's run-time efficiency. As an example, running the Sieve of Eratosthenes with late binding took 6.6 seconds; with early binding, it took 5.4 seconds.

Early binding should be used only after the application is completely debugged and the algorithms are optimized. You can use the class `PROF.ACT` to profile your application to find which functions the application is spending the most time in. Once you have isolated the heavily used functions, you can specify early binding by explicitly assigning the class of the receiving object so that the compiler can search this class for the object pointer of the method.

[Editor's note: *The source code for both versions of the Sieve test are available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4.*]

In most languages that provide garbage collection, long pauses occur intermittently while the computer reclaims discarded memory. In Actor, however, garbage collection is interleaved with program execution; thus, Actor never stops for a noticeable interval. Actor's object memory is divided into static and dynamic areas. (You can adjust the size of each with parameters in the Microsoft Windows initialization file.) The garbage collector polices the dynamic memory; this memory contains volatile objects, such as strings and integers.

Static memory, which contains objects such as classes, methods, and symbols, rarely changes during run time. But it may fill up during the edit/modify/compile cycle of code development. Then you can explicitly evaluate the `cleanup( )` object to invoke the static-memory garbage collector. The manual cautions that you should save the image of the system first; if Actor runs out of dynamic memory during the static-memory cleanup, you lose all the work done since the last snapshot. I found this out the hard way.

Using Actor

Actor comes on seven 5¼-inch floppy disks. Three hold the Actor files and an installation program, and the other four hold a run-time version of Microsoft Windows. Since I already had a complete version of Windows on my PC AT, I only had to run Actor's installation program. The program transfers the files from the floppy disks to the appropriate directories on your hard disk and adds Actor's static- and dynamic-memory-allocation variables to Windows's initialization file. The process takes under 5 minutes.

Actor 1.0

Type
Object-oriented programming language

Company Name
The Whitewater Group Inc.
Technology Innovation Center
906 University Place
Evanston, Illinois 60201
(312) 491-2370

Format
Seven 5¼-inch floppy disks; not copy-protected

Computer
IBM PC, XT, AT, or compatible with a hard disk drive, at least 640K bytes of RAM, a graphics display adapter, and a mouse

Software Required
MS-DOS 2.0 or higher

Documentation
500-page user's guide with tutorial

Price
$495 with Microsoft Windows run-time support package; academic price: $99

The Whitewater Group recommends that memory-resident programs not be used with Actor or Windows and mentions that you may have to delete device drivers and RAM disks to make enough space for Actor. The memory problems were apparent the first time I tried to run Actor: I met with a `Not enough memory to run Actor` message.

After I deleted all the graphics drivers from my `AUTOEXEC.BAT` and `CONFIG.SYS` files, Actor loaded up. I immediately checked to see how much memory was free by using the Microsoft Windows system menu `about` item (the run-time version supplied with Actor doesn't have this item); only 6K bytes was left. The Actor user's guide says that when less than 10K bytes is available, Actor is running critically short of memory and could crash, so I went back to my `CONFIG.SYS` and `AUTOEXEC.BAT` files and deleted the mouse drivers (superfluous under Microsoft Windows). I then had 40K bytes free.

Finally, I deleted my RAM disk driver and 3½-inch floppy disk driver, rendering my extended-memory RAM and the 3½-inch floppy drive useless. This freed up another 12K bytes, making a total of only 52K bytes available. (If I'd been running an IBM EGA board instead of

continued

my Vega video card, roughly another 8K bytes could have been reclaimed, for a total of 60K bytes).

Actor takes up over 350K bytes of memory. Adding Windows's RAM requirement (about 230K bytes in my system) leaves very little for the user. Multitasking under Windows with Actor installed is just about impossible. Even using Windows's spooler causes Windows to access the disk continuously, slowing the work pace to a crawl.

Quirks

Windows considerably eases the task of programming user interfaces, but it has its quirks. It is possible to move a window so that its control areas—size box, caption bar, and system menu—are inaccessible to the mouse. Then you have to remember the keyboard equivalents to the mouse commands to get the window back on the screen. Also, Windows's naming conventions conflict with those of Actor. Method names are lowercase in Actor unless the name is the concatenation of two English words, in which case the first letter of the second word is capitalized. Windows comes with predefined uppercase messages. In addition, Windows limits you to a maximum of five active display contexts at one time.

Actor's user interface is inconsistent. In the workspace window, if you want to execute a section of code, you can position the mouse at the end of the line and press Return. However, if you do this in an editor window (the file editor or the browser), the code is not executed; instead, a new line is inserted. To execute code in the editor or browser, you must select the text with the mouse and click on the `Doit!` menu item. There is a hazard to this: Highlighting (inverse video) is used for both editing and execution. If you highlight a section of code to run it via the `Doit!` command and then accidentally type some input, the highlighted code is deleted and cannot be retrieved.

There are other inconsistencies: In the workspace, you press Control-Return to insert a new line. In other windows, that does nothing. In some windows, the Control-A accelerator key highlights the entire text; in others, it doesn't. The `Select All` edit menu item doesn't work at all. Neither does the `Undo` menu item, which the documentation says will be implemented in a future release.

Cautions

As I mentioned earlier, Actor has a few serious bugs. Once I iconized (i.e., inactivated) a sample window that I'd built during a tutorial exercise. When I reactivated it and tried to close it via the system menu `Close` item, I received an error message, and the machine locked up so tight I had to reboot, losing the environment I'd built up during the tutorial.

Another time, I ran the file editor provided with Actor. I selected Actor's parent directory and then its parent, my root directory. When I tried to edit a file, an error window popped up with the message: `Dynamic memory is full.` When I clicked on its confirmation, Actor exited to Windows and its icon was deleted, and again the environment was lost. This was due to the memory limitations.

On occasion, an error window would pop up claiming that Actor's stack overflowed. If I closed Actor's windows and attempted to reload, Windows would indicate an infinite wait. I could not correct this error, and the only alternative was to reboot. At other times, Actor would lock up for no apparent reason.

There are a few less serious bugs, too, including odd highlighting of areas in the Actor workspace window (the Whitewater Group now has a patch that fixes this), incompatibilities between long and integer objects, and the printing of returned results in inappropriate areas of the workspace. Error messages are printed to the Actor Display window, which is overwritable and not refreshed, so if you have a window overlaying the error message, you will never see it. If you move the window, the text is not restored. This, again, is due to the memory limitations. Other error messages, which are printed in the pop-up window, are truncated and often uninformative. When a file loads, and also when a program runs that prints out to the Actor Display window, other windows' caption lines get replicated over and over again up to the top of the display window. Once the program is loaded or finishes running, the garbage goes away.

Documentation

The Actor user's guide comes in a 500-page three-ring binder. It includes a review of all major classes; sections on memory management, calling external library procedures, accessing MS-DOS and Windows functions, and building applications; a class reference; a language description; a list of error messages; and a complete subcategorized index.

The documentation opens with a quick section on hardware requirements and installation, and then goes through a pleasant and thorough 74-page tutorial. The tutorial includes a short discussion of the Microsoft Windows user interface. Next is a clear description of what object-oriented programming is all about, including descriptions of classes, objects, methods, messages, instances, instance variables, and inheritance. This discussion is highlighted by a short demonstration program implementing a LOGO-like turtle. The tutorial covers the use of inspectors, browsers, some of the primary programming constructs and classes, and it closes with a demonstration of Actor's facility with windows.

On the whole, the documentation is very effective. In some areas, though, it doesn't match the way the programs operate. The file-read method requires an integer argument, but the manual specifies a long-number argument in several places. Methods that the documentation says should return `<A Turtle>` return their message parameters instead (e.g., the message `r(90)` returns 90 instead of `<A Turtle>`).

Also, since Actor is case-sensitive, a user expects the documentation to be reasonably consistent about case. But when you type the message `home(Sam)`, it returns `<a Turtle>`, which is not quite the same as the documentation's `<A Turtle>`. Later the manual shows that when you add an element to `SortedCollection` objects, they return the whole object. In fact, they don't; they return the element.

All in all, however, even with the minor hiccups, the documentation and demonstrations are well written and pleasant to use, and they serve their purpose.

Support

The Whitewater Group provides three levels of support. The first (Level 0) is free access to an Actor bulletin-board service for all registered users, three calls to The Whitewater Group Technical Support Hotline, a promised prompt response to mailed inquiries, and no penalty or charge for bug fixes or reports.

The next two levels of support are $100 and $250 options. Level One ($100) support provides for up to 20 free calls per year to the Hotline, up to a 20 percent discount on future products, free access to a special section on the bulletin-board service, which has maintenance releases and small system enhancements, and interface for one user representative per unit purchased, up to a maximum of three. The Level Two support plan ($250) provides unlimited phone support from the Technical Support Hotline, access to a developer's workshop on the bulletin-board service, and up to five user representatives. Serious software developers should consider this option. Special support plans are available for academic sites.

Other Considerations

As a development language for the Microsoft Windows operating environment, Actor has the potential to be a powerhouse, but this potential won't be realized in the cramped quarters of today's 8088/8086/80286–based MS-DOS machines. Actor will come into its own when OS/2 becomes available or when versions of Actor are developed for fast, large-memory-space machines, like the Apple Macintosh II, Commodore Amiga, Atari ST, or 80386-based machines. While it runs acceptably fast on the 80286-based PC AT, it fairly begs for expanded memory. The Whitewater Group says it plans to port Actor to multiple machine architectures and operating systems and to implement a standard graphics layer. The next release of Windows will provide for expanded memory.

Although Actor 1.0 is expensive, it is also easy to learn and pleasant to use, and it provides strong development and run-time features. Actor's philosophy of appealing to C and Pascal programmers just might lure proceduralists to object-oriented programming. Subsequent releases will probably clean up the minor documentation errors and the software bugs; until then, however, let the user beware. ■

[Editor's note: *Actor version 1.1 is now available and, according to the company, is 60K bytes smaller than version 1.0. The static garbage collector now uses the hard disk as a temporary storage device instead of the dynamic memory region, and the window class hierarchy has been revised.*]

Leonard Moskowitz (0-75 Morlot Ave., Fair Lawn, NJ 07410) heads a Research and Development group that applies artificial intelligence technology to the problems of maintenance and diagnostics at Allied Corporation's Bendix Test Systems Division.

ALS Prolog

Alex Lane

The ALS Prolog compiler from Applied Logic Systems is a Prolog language compiler for MS-DOS computers. It is available in two versions, the Professional version 1.0 ($499) and the Personal version 1.0 ($199), and requires an IBM PC or compatible with a minimum of 256K bytes of memory and one floppy disk drive. I reviewed both packages on an IBM PC XT with 640K bytes of memory and a 20-megabyte hard disk drive.

Compiling on the Fly

The heart of the ALS Prolog software is ALSPRO.EXE, which reads source files and compiles them on the fly into abstract machine instructions. The package provides object-code files of such instructions for the built-in predicates, a debugger, and a definite-clause-grammar (DCG) expander. The Professional version also provides source code for these predicates.

The Personal version of ALS Prolog comes with a number of examples, including the eight queens problem, the missionaries and cannibals problem, and a symbolic differentiator. The Professional version has a larger number of examples, including a couple of expert programs.

Other software in the ALS package includes VI.EXE, a full-screen text editor from Manx Software Systems that is similar to the Unix vi editor, and ALSKEY.EXE, a memory-resident keyboard-enhancement program.

How ALS Prolog Works

If you've worked with traditional compilers, you might expect ALS Prolog to generate separate object modules that, when linked, form stand-alone programs independent of the ALS software. However, this is not the case.

The ALS Prolog compiler is an incremental interactive compiler, which means that when you consult Prolog source files, ALS Prolog reads in the consulted files statement-by-statement and compiles them into an intermediate code (as opposed to native 8086 machine language). When compilation is complete, the predicates of the consulted file are represented as a series of instructions for an abstract Prolog machine; these instructions are executed when you run the program. The result is a Prolog implementation that feels like an interpreter yet appears to run much faster than an interpreter, due in part to efficient garbage collection.

A major disadvantage of using intermediate code is that if you plan to sell Prolog applications written with the ALS compiler version 1.0, each of your customers must have a copy of the compiler; the intermediate code won't run without it. Furthermore, there is no way to hide predicates, so the source code for your application is available to anyone with a rudimentary knowledge of Prolog.

ALS automatically saves the abstract object code generated by the compiler in a file with an .OBP extension (unlike the .OBJ extension for object files in other languages) for future loading. If you make no changes to the source file, ALS saves compilation time by directly loading the object file the next time you consult the source file.

A make-like facility that is transparent to the user decides whether to load existing .OBP instruction files or to read in and compile new source code. Its decision is based on the DOS date-time stamp on the file, so if you are one of those who never enter the correct date and time on

continued

ALS Prolog 1.0

Type
Programming language

Company
Applied Logic Systems Inc.
Box 90, University Station
Syracuse, NY 13210
(315) 471-3900

Format
One (Personal version) or two (Professional version) 5¼-inch floppy disks

Computer
IBM PC, XT, AT, or compatible with at least 256K bytes of memory (512K bytes recommended for Personal version) and one floppy disk drive (hard disk drive recommended for Professional version)

Software Required
PC-DOS/MS-DOS 2.0 or higher

Compatible Software
Aztec C86 C compiler, version 3.2

Documentation
ALS Prolog Technical Reference Manual; Prolog Programming for Artificial Intelligence by Ivan Bratko (Reading, MA: Addison-Wesley, 1986)

Price
$499 (Professional version)
$199 (Personal version)

your PC as you boot and reboot your system, beware. It is entirely possible for the ALS program to ignore your most recent changes to a Prolog source file and load old object code that has a "fresher" date.

ALS Syntax

By and large, ALS Prolog implements the standard Prolog syntax found in C-Prolog and Edinburgh Prolog, as published in *Programming in Prolog* by W. F. Clocksin and C. S. Mellish (New York: Springer-Verlag, 1982). ALS's one major extension (besides the use of uninterned atoms, discussed below) is the implementation of modules to support good software-engineering practice. The use of modules lets you isolate some procedures from others by judiciously placing them in separate modules with appropriate use declarations and export declarations.

After working with the software, I concluded that, aside from a few added features, such as an interface to the Aztec C compiler, the Professional version of ALS Prolog is basically the same program as the Personal version. One major difference, however, is that the Professional version supports both interned and uninterned atoms, while the Personal version supports only interned atoms. Thus, in the Professional version, atoms that seldom appear in the program text can be stored on the Prolog heap in memory instead of in the symbol table, thereby conserving valuable space in the table.

Another difference is that the Professional version has predicates that invoke the ROM BIOS services as well as the BIOS keyboard services. This gives programmers an opportunity to write procedures to manipulate the user's screen.

The biggest extra in the Professional package, however, is the ability to utilize the `$icode/4` predicate to access the code generator for the abstract machine instructions. This lets programmers experiment with compilation on the abstract machine or compile "roll-your-own" clauses. The ALS Prolog manual contains several examples of the use of the `$icode/4` predicate, and several more appear in the accompanying source files.

Documentation: Thin but Adequate

The basic ALS package consists of a three-ring IBM-style binder containing printed documentation, one disk of software for the Personal version or two disks for the Professional version, and a card entitling you to a free copy of Ivan Bratko's *Prolog Programming for Artificial Intelligence* (Reading, MA: Addison-Wesley, 1986). [Editor's note: *See Alex Lane's review of Ivan Bratko's book in the August issue of BYTE.*]

The core section of the ALS documentation is about 60 pages long, and most of those pages are devoted to a terse description of the language syntax and the built-in predicates. Another dozen or so pages discuss the example programs that come with the package. If you consider that ALS intends Ivan Bratko's book to serve as a language tutorial, the documentation is adequate.

The Professional version's documentation contains additional pages that discuss the use of the `$icode/4` predicate, the interface to the Aztec C compiler, and the extra example programs. Both versions include approximately 60 pages of documentation on the VI.EXE editor.

Page 101 of the Professional version manual catalogs a raft of arcane limitations for the package—compiled code is limited to 48K bytes, functors are limited to 15 arguments, the symbol table is limited to 907 entries, and so on. Other limitations were not included in the manual. For example, I learned early on to be leery of floating-point operations in ALS Prolog, such as

```
C is 1.0,
D is C/3.14159,
E is D/28,
F is E*3.14159,
G is F*28,
C =:= G.
```

This would very likely fail, because the actual value of G is something like 1.0000000000000001, rather than 1.0. However, the debugger would display

```
1 =:= 1 ?
```

and then calmly announce the failure of the test. This is a problem, because `1 =:= 1` *must* be true.

I liked the compact debugger implemented in ALS Prolog. It has the standard `trace/1` and `spy/1` predicates and a `leash/1` predicate, which controls the debugger's prompts at the call, redo, fail, and exit ports.

Editor Interface

The ALS package comes set up with the VI.EXE editor, although you can change the default editor using the `change_editor/1` predicate. Thereafter, typing

```
edit <filename>
```

suspends operation of the ALS package and lets you use the default editor to edit whatever file you've indicated. If you don't supply a filename, the editor will call up the last file that you edited.

Upon leaving the editor, ALS Prolog "reconsults" the file you are working on;

that is, any predicates in that file overwrite existing predicates in memory. If the system finds any syntax errors while reconsulting the file, it flags them and displays the line number of the error on the screen. As with most compilers, this line number is only approximate. It reflects the line where the error was detected, which is not necessarily where it actually occurred.

Benchmarking ALS Prolog

I performed a series of benchmarks similar to those previously carried out on Borland's Turbo Prolog (see page 295 in the September 1986 BYTE). I did not measure the time required for compilation of code in memory, since this time never exceeded 10 seconds and usually was too short to be noticeable. For the sake of comparison, I also ran the tests on version 1.1 of Turbo Prolog. The results are shown in table 1.

The Math Functions test measures how fast Prolog can calculate the square root, natural logarithm, exponential, arctangent, and sine of a fixed argument 1000 times. The Floating Point test repeats a series of four basic operations 5000 times, while the Sieve extracts the prime numbers between 1 and 100.

The Disk Read and Disk Write tests are Prolog implementations of the standard BYTE benchmarks and measure the time required to perform the respective tasks 512 times on 128-byte atoms.

In my opinion, these benchmarks are of limited value because the power of Prolog lies not in how fast it can calculate a transcendental function or in how quickly it can isolate primes, but in how rapidly it can manipulate symbols and make inferences. The conclusion to draw from these particular benchmarks is: If

continued

Table 1: *Results of the benchmark tests run on the ALS Prolog Compiler and Arity Prolog. Tests were conducted on an IBM PC XT with 640K bytes of memory and a 20-megabyte hard disk drive. All times are in seconds.*

Test	ALS Prolog 1.0	Turbo Prolog 1.1
List Reversal	13.79	11.27
Floating Point	201.91	30.83
Sieve	6.7	2.89
Math Functions		
Sqrt	30.81	5.19
Logs	31.25	13.58
Exp	29.0	24.24
Atan	30.21	15.46
Sin	35.05	16.18
Factorial	34.6	21.86
Tower of Hanoi		
5 rings	4.18	2.69
7 rings	19.06	10.87
10 rings	153.13	87.71
Disk Write	29.05	29.73
Disk Read	29.39	15.85

you want a language that's suitable for numerical analysis, Prolog isn't it.

Other tests, however, do provide some evidence of the package's performance. These include the Factorial test, which uses simple recursion to measure how fast 10! can be calculated 1000 times; the List Reversal test, which measures the time required to reverse a list of 50 integers 30 times; and, to a lesser extent, the Tower of Hanoi program, which performs recursion and screen output.

I also performed the Peak System Performance and Nondeterministic Behavior benchmarks from the Logic Programming Group and the Computer Architecture Group of the European Industry Research Center in Munich. The Boresea performance benchmark consists of a sequence of 200 predicates having no arguments and no choice points. The results show the effect of pure calls, and the KLIPS (thousands of logical inferences per second) figure gives a rough idea of peak system performance. ALS Prolog ran 1000 iterations of the Boresea test in 5.66 seconds and performed 35.33 KLIPS. The Choice Point benchmark tests calls that invoke the creation of a branch point to which execution may possibly backtrack. The compiler ran 100 iterations of this test in 0.37 seconds and performed 5.40 KLIPS.

[Editor's note: *The benchmark programs are included in the file ALS-PRO.TXT, which is available on disk, in print, and on BIX. See the insert card following page 256 for details. Listings are also available on BYTEnet. See page 4. You will need an IBM PC and ALS Prolog or another compatible version of Prolog to run the tests.*]

ALS Prolog Version 1.1

Although the upcoming release of ALS Prolog version 1.1 was not part of the formal review, I did discuss it with Applied Logic Systems. Version 1.1 addresses some of the shortcomings of the current package, and the company said that all owners of version 1.0 will receive a free upgrade to 1.1.

As mentioned earlier, in version 1.0 the size of the compiled code is limited to approximately 48K bytes. According to the company, version 1.1 implements a virtual-memory scheme that will let you write much larger programs. Version 1.1 will also let you create stand-alone `.EXE` files and allow predicates to be hidden. In addition, an interface to the Microsoft C compiler will be provided.

Finally, the company told me that additional predicates will implement DOS function calls and destructive assignments (along the lines of LISP's `RPLACA` and `RPLACD`) to permit creation of Pascal-like data structures.

Nice Product, Some Shortcomings

ALS Prolog is a comfortable, competent package to work with. ALS's conformance to the Edinburgh syntax means that you don't have to master a "new, improved" variation of the language. Compilation is pretty much transparent to the user; if I hadn't been told that ALS Prolog was a compiler, I'd have assumed from the interactive response that it was an interpreter. Two features I particularly liked were the editor interface and the compact debugger.

In general, I liked the ALS Prolog compiler, but I think version 1.0 has too many shortcomings—such as the inability to develop salable applications and the limited clause space of 48K bytes for compiled code—to be worth the price. ■

Alex Lane (Reynolds, Smith and Hills, P.O. Box 4850, Jacksonville, FL 32201) is a senior software engineer and moderator of the Prolog conference on BIX.

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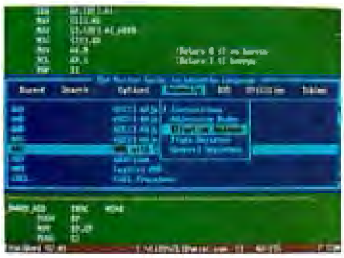

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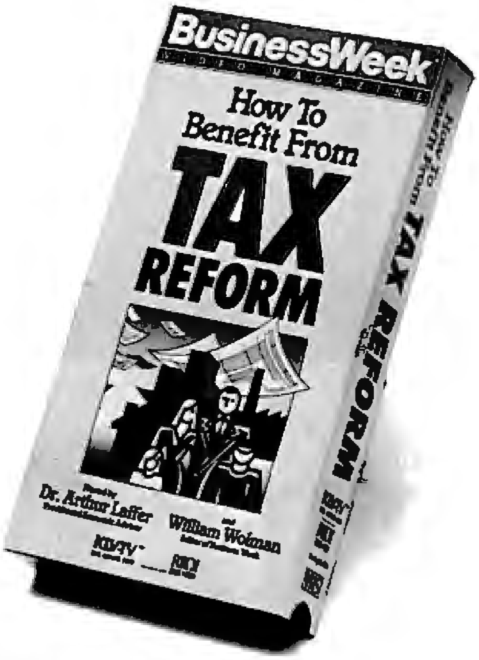

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Benchmarking dBASE III Plus Compilers

Malcolm C. Rubel

Three packages that have extended features as well as a speed advantage

Quicksilver 1.1 from Wordtech Systems and Clipper (Autumn 1986 version) from Nantucket, two true compilers, and FoxBASE + 2.00 from Fox Software, a pseudocompiler, are all unique implementations of the dBASE III language. Each is a subset of the dBASE III Plus language as defined by Ashton-Tate, and each program has some commands, functions, and capabilities that are not contained in the other packages.

These three compilers are also supersets of dBASE III Plus, because each contains features that are not available in dBASE III. These programs take dBASE III instructions and compile them into more compact code that takes up less memory space and executes faster. Comparing these compilers to dBASE III is therefore a more complex task than simply measuring speed differences. Each program has its own strengths and weaknesses when compared to dBASE III Plus and to each other.

Each of these products supports networking. The network support is included with Clipper and Quicksilver; with FoxBASE +, it costs an additional $200. Neither Nantucket nor Fox Software will say what local area networks their compilers will run on; they will only say that their compatibility relies on the LAN's proper adherence to using DOS function calls. Wordtech says that Quicksilver will run on the Novell, IBM, and Software 2000 LANs.

All three products support record- and file-locking, exclusive file use, and printer commands. Quicksilver also has an Automatic mode that lets applications run on a LAN without the user's having to go in and do all the programming manually.

Clipper and Quicksilver, the two true compilers, have the ability to integrate unique functions into applications compiled with their libraries. You can write the functions in dBASE, C, or assembly language and then link them to the application when the load module is assembled. You can even include these routines in the working .PRG files or develop them as separate object modules. This capability gives both programs a decided edge over dBASE III Plus and FoxBASE +, in that you can develop or purchase custom extensions to the language for a specific purpose and include them as an integral part of the application.

To do this with dBASE III, you must fudge some of these features as a part of a procedure file or purchase one of the add-on packages that will enable you to gain access to the functions. Tom Rettig's Library (which is available in Clipper and dBASE III editions) and the dBASE Tools for C package enable you to perform this type of function, but both require you to use more programs and more memory. If you intend to distribute your final application, this also adds more files and more cost for the end user.

One negative aspect of both Clipper and Quicksilver is that neither permits access to the dBASE III Plus full-screen functions, including `APPEND`, `BROWSE`, `CHANGE`, and `EDIT`. This means that you must spend time programming replacements for these functions if you need them. This is not as great a loss as it would seem, however, as commercial-quality applications should not be using these functions anyway because they permit unrestricted access to the database without any edit checks.

Clipper

Nantucket's Clipper, the first of the native-code dBASE compilers, was released over two years ago and has undergone four major revisions. The current release, which is simply called the Autumn 1986 version, includes network support, some new commands, and a better memory-management capability that includes support for expanded memory. Nantucket says that Clipper-compiled programs can use up to 1 megabyte of RAM for indexing, although I did not test this. In certain situations with large indexes, this should substantially improve the product's indexing speed.

Of the three compilers, Clipper is probably the least compatible with dBASE III Plus. Several commands, including box commands, `READKEY`, and `Return to Master`, are either not supported by Clipper or are supported in a different manner than that of dBASE III Plus. Clipper also has many commands and functions that are not available in dBASE III Plus. These include special help capabilities, memory variables, the ability to open multiple parent-child relationships at once, special menu-creation commands, the `SAVE SCREEN` command, arrays, `FOR...NEXT` loops, and the `VALID` function, to name a few.

The differences between Clipper and dBASE III can make Clipper more versatile than dBASE III, but they also make programming more difficult, as most people would use dBASE III for program development and then compile their applications with Clipper. Nantucket supports a `CLIPPER` public variable that enables developers to include Clipper-specific code in their development files that does not run when the file is executed on an interpreter such as dBASE III Plus. Unfortunately, as soon as you start including some of the more powerful Clipper commands, you must start writing

continued

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	Clipper (Autumn 1986 version)	Quicksilver 1.1	FoxBASE + 2.00
Type	dBASE compiler	dBASE compiler	dBASE pseudocompiler
Company	Nantucket Inc. 12555 Jefferson Blvd. Los Angeles, CA 90066 (213) 390-7923	Wordtech Systems Inc. P.O. Box 1747 Orinda, CA 94563 (415) 254-0900	Fox Software Inc. 27493 Holiday Lane Perrysburg, OH 43551 (419) 874-0162
Format	Three 5¼-inch floppy disks	Eight 5¼-inch floppy disks	Two 5¼-inch floppy disks
Computer	IBM PC or compatible with at least 256K bytes of RAM to compile programs, two floppy disk drives (hard disk drive recommended), and DOS 2.0 or higher	IBM PC and most other MS-DOS computers with at least 256K bytes of RAM, two floppy disk drives (hard disk drive recommended), and DOS 3.1 or higher	IBM PC or compatible with at least 360K bytes of RAM, two floppy disk drives (hard disk drive recommended), and DOS 2.0 or higher
Language	C	C	C
Documentation	User's manual, 200 pages	User's manual, 452 pages	User's manual, 350 pages
Price	$695	$599	Single-user version: $395 Multiuser version: $595 Single-user run-time: (10/unlimited) $300 / $500 Multiuser run-time: (10/unlimited) $500 / $700

code solely for Clipper, because the code differences between Clipper and dBASE III quickly become a burden.

Clipper also supports many of dBASE III's functions in a slightly different manner than dBASE III does, so you must learn a slightly different language if you want to compile your applications with Clipper. For example, the Clipper VALID function as a part of the PICTURE template language provides a way for you to program direct access to HELP, lookup tables, or to other programs during the middle of a READ; dBASE III does not support this feature. To use the feature, you must learn how to program this function for Clipper, as well as how to write code that will execute under dBASE III during program development.

While there is a tremendous amount of information in the Clipper user's manual, it is sometimes not easy to find what you need (even with the index), and then you must read the information carefully. Nantucket should do some work to make the manual a more usable document. The manual is split into two different sections: the basic manual and the Autumn 1986 update. For a compiler that costs close to $700, it is not too much to expect a better-quality manual.

Clipper comes with a custom version of Phoenix Computer Products' Plink86, so you can compile applications that are too large to fit into RAM as overlay programs. Unless you need to use the overlay capabilities of Plink86, however, the DOS LINK program supplied with MS-DOS works just as well and is quicker. I used DOS LINK as a linker for Clipper for all the benchmark tests.

Unless specifically told otherwise, Clipper compiles the named program and all called programs into a single object file. You can then link that object file or files with the Clipper library to create an executable load module. Clipper lets you compile separate specified object modules using a special compiler file with a .CLP extension. Clipper will then compile only those files you specify. This feature can be used for reducing compile times during debugging and for creating overlays.

By press time, Nantucket had not yet released its Spring 1987 version of Clipper. I called the company, however, and received a description of the latest version's new features and enhancements. Nantucket says it has improved Clipper's indexing speed due to recoding and compatibility. Clipper indexes can be either Clipper- or dBASE-compatible. The compiler's sorting speed has also been improved due to recoding.

The Spring 1987 version of Clipper also has a number of new commands. The SET SOFTSEEK ON/OFF command allows "relative" seeking (i.e., if a record is not found, the pointer is set at the next logical record). The SET CURSOR command turns the cursor on or off, SET MESSAGE TO <expN> [CENTER] centers a message on the specified line, and the MEMOLINE and MLCOUNT functions can format a memo for printing. In addition to these functions, the latest version of Clipper has a number of file-handling functions that are compatible with DOS 3.3. The program now provides for more than 150 open files and can handle strings up to 64K bytes long.

Quicksilver 1.1

Wordtech Systems advertises Quicksilver 1.1 as the first dBASE III Plus compiler. The compiler supports the dBASE III Plus language more closely than Clipper does, but if you use the full capabilities of Quicksilver, it is not compatible with dBASE III either. Although version 1.1 of Quicksilver is more compatible with dBASE III Plus than the original version was, it also implements some commands that take it further away from dBASE III Plus.

Quicksilver 1.1 supports FOR...NEXT loops and has an excellent help function that is part of the @ GET command. A set of AUTOMEM functions provides a mechanism for creating, loading, and clearing memory variables with the same names as field variables, as well as replacing data-table fields with the contents of these memory variables.

Several of Quicksilver's functions bring it much closer to the extended capabilities of Clipper. The SET ORDER TO function enables you to have more than one index active at a time, FROW( ) and FCOL( ) position the cursor in an alternate file, CENTER( ) centers text, and PRINTER( ) tests whether the printer is on-line. The PROPER( ) function capitalizes the first letter of a character string, SELECT( ) returns the current work area, SKIP(alias) moves the pointer in open tables without requiring you to first select them, and SLEEP( ) pauses the program for a specified length of time.

The cost of all these improvements is increased code size and longer sort times. The minimum native-code .EXE file has grown from 126K bytes for Clipper 1.0 to 167K bytes for version 1.1, an increase of 41K bytes, or 32.5 percent. In addition, sorting times have nearly doubled. However, since sorting is seldom necessary on large applications and because alternatives are available, longer sort times are not a serious drawback.

The main difference between dBASE III Plus and Quicksilver is Quicksilver's use of windows. Quicksilver has a complete set of window commands that allow the developer to define and display up to 99 different windows on the screen at any one time. This opens up virtually limitless possibilities for help screens, menus, and the like. One of the nice things about this window capability is that it is fully supported by Wordtech System's dBASE interpreter, dBXL, which sells for $169. These two programs in tandem make an interesting and cost-effective development pair.

Quicksilver 1.1's revised user's manual is well thought out and well put together. The discussion of overlay strategies is excellent and informative. I found that as I went through the manual, I learned things that were unrelated to what I was looking for, but helpful nonetheless.

Quicksilver takes a different approach to compiling than Clipper does. Instead of compiling a single object module, which is then linked into an .EXE file, Quicksilver compiles two different types of programs.

The first type is what Wordtech calls a compiled d-code program. The "linker" (not to be confused with a native-code linker) creates three files: an .EXE file, an .OVL file, and a .DBC file. These three files execute as a stand-alone application, requiring a minimum of 256K bytes of memory. You can compile or recompile the Quicksilver intermediate-stage program much faster than you can when using Clipper. This compiled program does not execute as fast as the finished native-code (or "optimized" in Wordtech's terminology) .EXE file, nor does it support more than 256 memory variables, but it supports UDFs and serves as an excellent vehicle for program development and debugging.

Quicksilver does not come with a linker. Wordtech Systems suggests that you use the DOS LINK program, which is fine, unless you must create overlays. Quicksilver supports Plink86, but you must buy it separately from Phoenix Computer Products for $495.

FoxBASE + 2.00

FoxBASE + 2.00 from Fox Software is not a true compiler, but rather an interpreter of tokenized code. The latest version has automatic memory management and allocates all available memory, including up to 64K bytes of expanded memory. This is a boon to developers whose code must run on different types of machines. FoxBASE + adjusts itself to the machine's available memory when it is loaded and optimizes its performance for that environment. If the environment changes (due to activating a spooler, for example), you no longer have to change the CONFIG.FX file.

Version 2.00 of FoxBASE + requires only 360K bytes of memory (versus the 375K bytes needed for version 1.21), and

continued

the product now runs faster than version 1.21 in all areas that I tested by an average of 23 percent. The program is memory-sensitive; I ran out of room running large indexes with under 480K bytes of free memory. This should not have happened, but at least Fox Software is up-front about this and will tell you that the program likes a lot of memory.

FoxBASE + has several capabilities, commands, and functions that look and act very much like Clipper's. The compiler also has some excellent dBASE III language extensions of its own. It supports UDFs and has a VALID function for data verification. UDFs can now be added as part of the VALID argument. The program handles arrays (with each element a separate MEMVAR that counts as part of the maximum number of variables), multiple children open to one parent file, and the ability to create bounce-bar menus, pop-up boxes, and save-and-restore screens.

FoxBASE + automatically converts dBASE III code to FoxBASE + code when you DO a program. You have the option of compiling code beforehand, which speeds up program loading but not execution. You can also assemble up to 180 programs into a single procedure file with the FOXBIND utility before compilation. This way, you end up with a single .FOX file that you can execute using FoxBASE + or the optional FoxBASE runtime module.

FoxBASE +'s indexing is faster than dBASE III's, and its indexes are smaller. They are not dBASE-compatible, however. The index files in version 2.00 are a bit larger than those in version 1.21, but they are still smaller than those in dBASE III, Clipper, or Quicksilver.

Table 1: *Execution benchmark results (from a 31K-byte test) for Clipper, Quicksilver, and FoxBASE +. Times for the dBASE III compiler are provided for comparison. The first set of results given for Quicksilver, .DBC, is for the d-code overlay program; the second set, Native, is for the speed-optimized native code. All times are in seconds.*

Test	dBASE III	Clipper	Quicksilver (.DBC)	Quicksilver (Native)	FoxBASE +
SCREEN1	58	34	47	28	8
SCREEN2	97	125	62	33	13
SCREEN3	196	50	85	46	19
APPEND	36	207	137	142	14
CALC1	188	29	100	55	19
CALC2	59	5	17	9	4
CALC3	144	8	33	16	8
CALC4	32	51	22	17	6
CALC5	1000	135	237	132	70
LOCATE1	39	36	63	54	14
LOCATE2	26	25	52	41	13
REPLACE	74	347	148	120	31
SORT1	85	372	756	714	47
SORT2	46	348	601	605	23
SORT3	108	859	1303	1300	61
SORT4	84	382	701	660	41
INDEX1	121	136	164	161	43
INDEX2	77	88	92	91	20
INDEX3	173	293	195	196	43
INDEX4	52	60	101	97	39
INDEX5	111	172	207	212	53
JOIN	521	626	1642	1087	224
SEEK1	53	33	47	42	10
SEEK2	62	66	50	44	12
SEEK3	59	67	54	48	12
SEEK4	43	50	24	19	9
LINK	48	36	48	46	3

Table 2: *Compiler benchmark results (from a 31K-byte test) for the three packages. The first set of results given for Quicksilver, .DBC, is for the d-code overlay program; the second set, Native, is for the speed-optimized native code. Times are in seconds; code sizes are in K bytes.*

Test	Clipper	Quicksilver (.DBC)	Quicksilver (Native)	FoxBASE +
Compile	121	65	97	00
Link	47	32	192	00
Total time	168	97	289	17
Code size	156	244	208	28

Execution Benchmarks

One of the main reasons to compile dBASE III code is to make the code execute faster. Surprisingly, when subjected to a series of benchmark tests, both of the true compilers showed significant weaknesses when compared to dBASE III Plus in their ability to move speedily through a data table. Both compilers were fast on calculations, but they were slow when doing anything with an unindexed file. Both of the true compilers were also slow in the indexing benchmarks, averaging about 75 percent of the speed of dBASE III Plus.

Because Quicksilver 1.1 gives you the option of two different types of executable code, I've supplied two separate times for this compiler for each benchmark test. The first time given, .DBC, is for the d-code overlay program; the second time, Native, is for the speed-optimized native code.

I ran all the benchmark tests on a 6-MHz IBM PC AT with 574K bytes of free RAM and a Priam 60-megabyte hard disk drive with a 30-millisecond access time. I optimized the hard disk drive using the Mace Utilities program before each test run to make sure disk-access time was not a factor in the results. The complete execution benchmark results are shown in table 1.

Compiler Benchmarks

While the speed at which the final application executes is of primary importance in most situations, the speed at which the compilers can compile code is also of great interest to the developer. Each of the three compilers converts code at different speeds. During the development process, a slower compilation speed can add up to hours of extra work.

The program sizes shown for the compiler benchmark test are for the finished programs. For both Clipper and Quicksilver, these programs will execute without any support from another program. The FoxBASE + program must be executed under either FoxBASE + or the

FoxBASE run-time module.

The compiler test I ran uses a 31K-byte benchmark program to generate the results shown in table 2. The FoxBASE + code size shown in the table is only for comparison to the standard dBASE code size.

Indexing

In addition to the indexing speed shown in the benchmark results in table 1, each of the three compilers creates indexes that are slightly different from those of dBASE III Plus. Only the Quicksilver indexes are compatible with dBASE and carry the same .NDX extension. Clipper's indexes have an .NTX extension and must be created explicitly. FoxBASE + indexes carry an .IDX extension and are created automatically in place of dBASE indexes if the application is brought over from dBASE III Plus.

Both Clipper's and Quicksilver's indexes are bigger than those created by dBASE. The indexing of these programs is slower, and their seeking is no faster than that of dBASE III Plus. FoxBASE + uses B + Tree indexing and creates smaller, faster indexes.

Strengths and Weaknesses

On the surface, it would seem that FoxBASE + is the clear winner in the compiler benchmarks. Version 2.00 has eliminated most of the limitations of version 1.21, and its impressive speed usually overcomes the few areas in which it is weaker than the true compilers. Of course, Clipper and Quicksilver can do certain things better than FoxBASE + can: They enable you to link in C and assembly language procedures; Clipper has better array capabilities; Quicksilver offers windows; no run-time program is needed with either compiler; and their memory requirements are not as stringent as FoxBASE + 's in most circumstances. However, in most cases, FoxBASE + will still outperform the true compilers simply through sheer speed.

If you eliminate FoxBASE + and are left with a decision between Quicksilver and Clipper, neither product has a clear edge in speed, and, while Clipper's code is much more compact than Quicksilver's, it does not contain the full support for windows that Quicksilver has. The compiled code size of a medium-size application (104K bytes of program code) is 277K bytes, or 36 percent larger than Clipper's load module. The compiled code size of a large application (268K bytes of program code) is 438K bytes, or 56 percent larger than Clipper's load module. Quicksilver's single file will not even fit on a floppy disk for distribution. These differences may become critical when an application is prepared for distribution.

On the other hand, applications compiled in Quicksilver's d-code overlay program, which is slower than the optimized code, consist of three files, none of which is too large to fit on a floppy disk, and they still execute reasonably fast. Even using the large library, large applications will run in as little as 256K bytes of free memory. Quicksilver's indexing and sorting speeds improve dramatically as the available memory increases.

Clipper's indexes are larger than Quicksilver's and are not compatible with dBASE III + indexes. Quicksilver holds a slight edge in indexing speed, and its indexes are compatible with dBASE .NDX files.

Quicksilver is definitely an easier product to work with when developing programs, and its symbolic debugger appears to be better than that supplied with Clipper.

Which program is better? It's hard to give a simple answer. Quicksilver is probably a better choice for the first-time compiler user because it is closer to dBASE and is supported by several development tools. Its manual, an important tool for the first-time user, is much better than Clipper's. Quicksilver is not, however, so much better than Clipper that current Clipper users should switch. I would certainly not recommend switching if code size is an important factor in your applications. Once you discover some of its powerful extensions, Clipper is still a fine program. Nantucket will, however, have to do something to improve the compiler for the Spring 1987 release. ■

DESQview 2.00

John McCormick

If you're looking for multitasking capability for the new IBM Personal System/2 computers, Quarterdeck Office Systems' DESQview 2.00 ($129) can provide it now. (The standard edition of IBM's multitasking operating system OS/2 will not be generally available until the first quarter of 1988.) DESQview is a windowing program for MS-DOS that lets you load multiple DOS programs and run them concurrently. DESQview also lets you run more programs than will fit in memory by swapping programs to disk, to a RAM disk, or to expanded memory, which Quarterdeck refers to as virtual memory.

Besides providing windows, concurrent processing, virtual memory, and expanded memory support, DESQview provides batch-file support, data transfer between windows, scaling of bit-mapped graphics screens, mouse support, on-line help, an auto-dialer, DOS services, and macros. DESQview can also run Microsoft Windows-, GEM-, and TopView-specific programs in Video Graphics Array (VGA)- or Enhanced Graphics Adapter (EGA)-mode windows. For 80386 machines, it supports virtual screens, allowing you to run text and Color Graphics Adapter (CGA) graphics programs in the background. On IBM PS/2 machines that have 1 megabyte of memory (the Model 50 and above), DESQview is able to move 60K bytes of its overhead into memory above the 640K-byte DOS limit region, reducing the amount of memory below 640K bytes that DESQview takes up from 145K bytes to 85K bytes. Version 2.00 allows you to keep up to 60 windows open at the same time (versus the nine windows with previous versions). Version 2.00 will take up a bit more lower memory than version 1.30 does, unless your computer has extended or expanded memory.

DESQview runs on the IBM PC, XT, AT, and compatibles; the Compaq Deskpro 386; and the IBM PS/2 computers under PC-DOS or MS-DOS 2.0 or higher. It requires 512K bytes of memory (640K bytes is recommended), and it runs with boards that support the Lotus/Intel/Microsoft Expanded Memory Specification (EMS), such as the Intel Above Board. It also runs with enhanced expanded memory boards, such as the AST RAMpage!, the AST SixPak-Premium, the AST Advantage Premium, and the Quadram QuadEMS+. DESQview also supports monochrome, CGA, EGA, VGA, or Hercules display-adapter boards. You can operate the program with or without a mouse; mice that are supported include the PC Mouse, Microsoft Mouse, Logitech C7 Mouse, Visi On Mouse, Maynard Mouse, AT&T Mouse, and any mouse that is compatible with the Microsoft Mouse driver.

continued

DESQview 2.00

Type
Concurrent, multitasking, windowing environment

Company
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica, CA 90405
(213) 392-9701

Format
One 5¼-inch floppy disk

Computer
IBM PC, XT, AT, or compatible, IBM PS/2 computer, or Compaq Deskpro 386 with 512K bytes of memory (640K bytes recommended), two floppy disk drives or one floppy disk drive and one hard disk drive, and a monochrome, CGA, EGA, VGA, or Hercules display adapter; mouse recommended

Software Required
PC-DOS or MS-DOS 2.0 or higher

Language
Assembly language

Options
Quarterdeck Expanded Memory Manager 386: $59.95

Documentation
210-page user's guide; 14-page version 2.00 upgrade booklet

Price
$129.95

I installed and ran DESQview on two different machines. One was a 10-megahertz PS/2 Model 60 with 1 megabyte of RAM, one 1.44K-byte 3½-inch floppy disk drive, a 40-megabyte hard disk drive, parallel and serial ports, and a mouse. The other computer I used was a 4.77-MHz Tandy 1200 with a 10-megabyte hard disk drive, 640K bytes of memory, and an AST SixPakPremium Enhanced Expanded Memory Specification (EEMS) board with 2 megabytes of memory.

A big advantage for some users is that version 2.00 of DESQview enables you to run DOS programs, such as Format and Copy, in the background. The documentation for version 2.00 is nearly twice as long as that of older versions, and it also contains more colorful graphics, more troubleshooting information, and a new guide to error messages. A section entitled "Programmer's Reference" explains how to interface programs with DESQview. Version 2.00 has 12 options that aid in custom-installing programs, and its help screens are context-sensitive.

Installation

During the normal installation procedure for hard disk operation, DESQview searches for programs it recognizes, such as Lotus 1-2-3 or Multiplan, and, at your option, it can automatically install its custom DESQview Program Information File (DVP) setup for these programs. This file contains information about the program it describes, such as the DOS command that starts it up, how much memory it needs, and the drive and directory that it is stored on. DESQview can also use IBM TopView Program Information Files (PIFs).

Installing a program that has a PIF file merely requires that you name the program and tell DESQview what directory it is located in. The rest of the setup information is included in that file. You can easily modify window characteristics (such as size, colors, and so forth) either permanently during setup or temporarily while in a window.

You can custom-install programs that don't come with a PIF file by specifying a set of parameters, such as how much memory the program will require, whether it uses graphics, whether it can be swapped to disk, whether it requires a key disk, and what key letters you want to use when calling it up.

Auto-dial settings and modem characteristics, as well as long-distance access codes, are also set during initial setup, as is the proportion of time spent in foreground and background processing and which, if any, mouse you will be using. If you have an earlier version of DESQview installed in your system, the custom installation features are retained when you upgrade to version 2.00.

Running Programs

WordStar, WordPerfect, and Lotus 1-2-3 run fine under DESQview and will even run in small windows because they have automatic custom installation available in DESQview's setup. Copy-protected programs requiring start-up disks are easier to operate using DESQview, because once they are started, you can switch to a program in another window and back again without having to shut down the copy-protected program and insert the key disk to start it up again.

Because DESQview enables you to window most nonresident programs, and because DESQview provides its own macro key facility, your need for many memory-resident programs is greatly reduced. DESQview supports version 1.5 of SideKick, which should be started in its own window but will operate in all windows. Print spoolers and RAM disks should be loaded before DESQview.

While DESQview will operate in a system with only 512K bytes of memory, if you want to do multitasking you will quickly run out of memory when loading programs in different windows on a 512K-byte system. For instance, a copy of KnowledgeMan/2 will practically fill 640K bytes, and, if you want to run Lotus 1-2-3, DESQview will have to swap KnowledgeMan/2 to disk; if your system has only floppy disk drives, you will have a long wait, and even swapping to a hard disk takes about 15 seconds.

Using DESQview with EMS memory gives your programs more room, but, because you can't run programs completely in EMS memory, there is a limit to how much it can help. EMS memory provides a 64K-byte window onto a memory space above the 1-megabyte limit of DOS. Programs such as Lotus 1-2-3 Release 2.0, which are designed to use EMS memory for data storage, make use of the EMS memory regardless of the amount of memory assigned in the program setup (as long as enough regular memory is allocated to load the program). For programs that are not designed to specifically take advantage of EMS memory, you can use this memory as a RAM disk.

DESQview operates best when EEMS memory is available because, unlike EMS memory, you can run a larger part of programs from it. When using EEMS boards, you will want to remove or disable as much of your system memory as possible, setting the EEMS board to replace up to 640K bytes. DESQview uses EEMS memory as "shadow" memory (i.e., DOS doesn't know it exists) below the 640K-byte DOS limit. By having only 128K bytes of motherboard memory and the remainder derived from the EEMS board, DESQview can allocate 636K bytes to the first window you open and more than 600K bytes to each additional window until you run out of memory.

Only users who have large amounts of EEMS memory available in their systems will be able to take full advantage of DESQview 2.00's capabilities. Without EEMS memory, you have to spend a lot of time waiting for programs to be swapped on and off a disk or RAM disk when the regular memory is not sufficient to accommodate all the resident software. If you have about 5 megabytes of EEMS memory available, this completely eliminates the need for disk swapping, even if nine windows are open, since each window has nearly 640K bytes available to it, and any MS-DOS program will run in that amount of memory.

Background Processing

In addition to loading multiple programs simultaneously, DESQview will allow programs to continue to run in the background. The more time devoted to these background programs (such as a spreadsheet recalculation, for instance), the slower the foreground screen becomes. For tasks such as word processing, data entry, or other relatively slow operations, you can allocate a lot of time to the background, and the machine will not appear to run slowly. Allocating little time to the background will enhance the performance of the foreground program.

When running DESQview on the IBM PS/2 Model 60 with a fast (33-millisecond access time) hard disk drive, I found that it was practical to run several programs, even in a machine that did not have EEMS memory. Disk swapping was so much faster that it took an average of only 1.95 seconds to swap large programs. Even with 1 megabyte of standard memory, however, it was difficult to open more than 11 windows before running out of common memory.

Even if you are limited to only 640K bytes of regular memory, some programs that require only 60K bytes to run in a window, such as WordStar 3.31, let you load multiple copies with ease and switch between projects or files with two keystrokes and no wait for disk swapping.

For 80386 machines, the Quarterdeck Expanded Memory Manager 386 ($59.95) is available as an option. It allows you to take advantage of the 80386 extended memory. DESQview also supports the virtual 80386 architecture on the Deskpro 386. The installation procedure is slightly different, but otherwise DESQview works as it does with other computers, using up to 5.5 megabytes of memory to run programs in windows as big as 624K bytes each. Version 2.00 supports virtual screens on 80386-based computers and takes advantage of the EGA screen's larger text capacity.

One ideal use of a multitasking system would be to run a communications program in the background for uploading or downloading while you work on something else in the foreground. When installing a communications program, you must be sure that it is never swapped to disk while operating. One communications program that I have found to work well in the background is HyperACCESS from Hilgraeve Inc.

What's It Good For?

I found DESQview to be particularly handy for use with copy-protected programs that require a key disk. I found it practical to always keep a copy of Lotus 1-2-3 running in one window because it is so easy to access when I don't have to deal with copy protection every time I want to reload it during a workday.

DESQview is suitable for users who need multitasking and can afford to slightly increase processing time for each program, or for users who need to switch between a number of programs quickly and often. If you run programs concurrently, however, they will all slow down (considerably, if your computer is running at 4.77 MHz). If you stick to programs that have PIF setup information or programs for which DESQview has a special setup, then DESQview will operate with no problems, and installation will be very simple. ■

John McCormick (RD #1, Box 99, Mahaffey, PA 15757) is a computer consultant and freelance writer.

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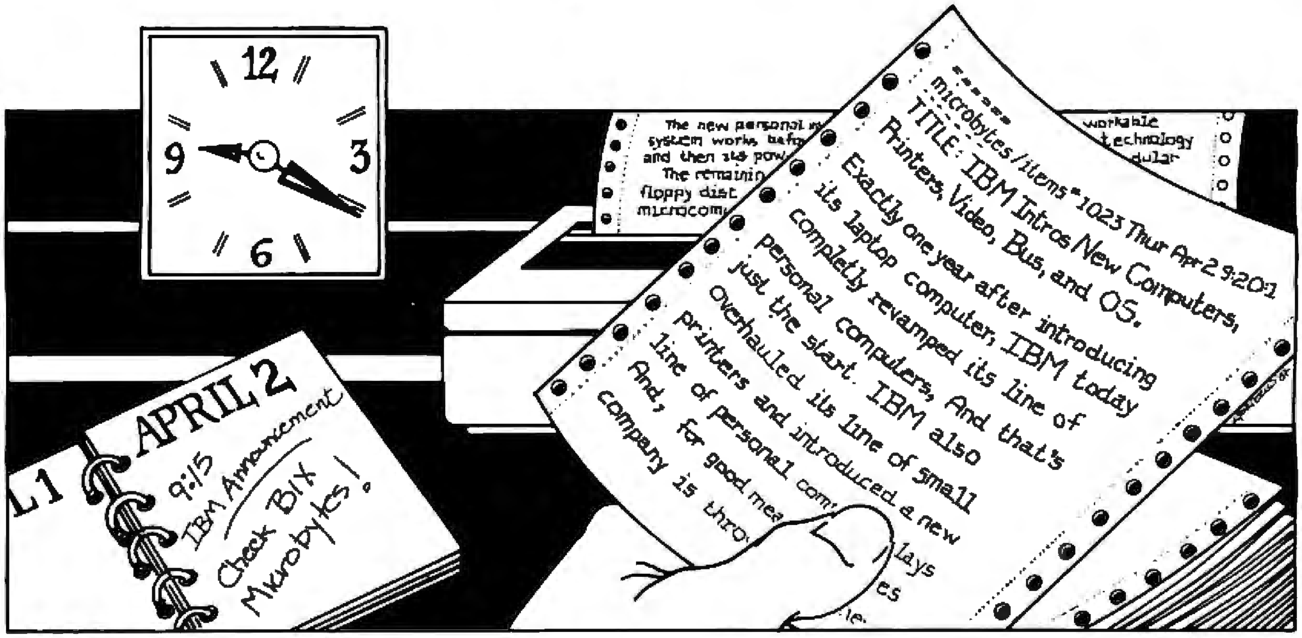

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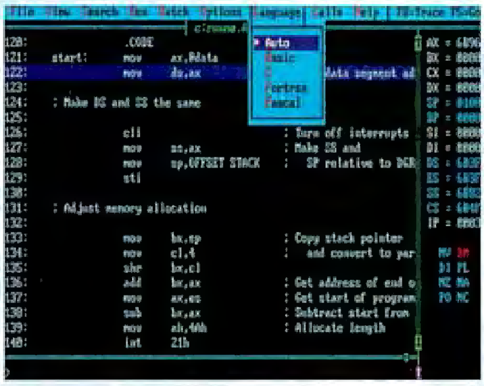
MICROSOFT LANGUAGES NEWSLETTER VOL. 2, NO. 9

News about the Microsoft Language Family

Microsoft® Macro Assembler Version 5.0

Microsoft Macro Assembler Version 5.0 has a host of exciting new features that make assembly language programming easier and more powerful than ever! Microsoft Macro Assembler Version 5.0 now includes the Microsoft CodeView® window-oriented debugger and can assemble instructions written for the Intel® 80386 CPU. Comprehensive documentation and example programs help you write assembly code subroutines that can be called from other Microsoft languages such as C, BASIC, FORTRAN, and Pascal. Microsoft Macro Assembler Version 5.0 also assembles your programs 25 - 40% faster than Version 4.0.



Microsoft Macro Assembler's CodeView at Work.

Now it's easy to write assembly language subroutines for high-level language programs

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Microsoft Macro Assembler now includes the CodeView source-level debugger

CodeView, Microsoft's famous debugger for its C and FORTRAN languages, now comes to the world of assembly language programming. Source-level debugging allows you to view your program just as you wrote it, including the comments and spacing that are especially important in helping you follow your program's execution. You can access variables by name, even if they aren't declared public, and see constants as names instead of as anonymous numbers.

Write programs for the 80386

Microsoft Macro Assembler Version 5.0 can assemble the new instructions available with the powerful 80386 CPU and the 80387 math coprocessor, as well as 80286 instructions that have been enhanced to work with 32-bit registers. You can also use the new 32-bit wide registers to write faster programs than ever by using such operations as 32-bit add and subtract and 32-bit multiply and divide without using multiple registers. For more powerful data access Microsoft Macro Assembler Version 5.0 allows you to choose any 32-bit register for indirect memory access, to use "scaling" for easy array access, and to move 32 bits of data directly from memory into a register and back.

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In the Chips

Jerry Pournelle

Fast Kat gets even faster with a math coprocessor, DESQview, and VOPT.

It was almost a quiet month. Of course, we did have to go to Atlanta for Spring COMDEX. Then there were publicity arrangements for *Janissaries III: Storms of Victory* and the new Niven/Pournelle/Barnes book *Legacy of Heorot*, and Niven and I have been hard at work on *The Moat Around Murcheson's Eye*, and we got a new puppy and had to persuade the cat not to leave home; but all in all, nearly quiet.

Fast Kat

It's official: the main machine at Chaos Manor is now Fast Kat. For the record, Fast Kat is a Kaypro 386 with built-in EGA color. Mine has accessories: the Intecolor Megatrend 19-inch EGA monitor, a DataDesk Turbo-101 keyboard, Xerox PC TypeRight in-line spelling checker box, and Amdek CD-ROM reader. They work together fine, and the system is *fast*. While I was changing over from Zelda the Zenith Z-248 to Fast Kat, I did some rearranging. My desk is now completely surrounded by computers. One of these days I'm going to design some computer furniture; nothing I've seen makes really efficient use of the limited space near a desk.

Otherwise, I don't have a lot to report about Fast Kat that I didn't say last month. Once in a while I think I've found PC-compatible software Fast Kat won't run, but every time that has turned out to be my fault.

We did make one improvement since last month; we managed to install a math chip. It wasn't easy.

Math Chips

Last month's column featured a new round of tests with my matrix benchmark program. Examining the results gave me a surprise: no matter what the basic speed of the machine, for math-intensive programs like matrix operations, the really dominant factor is the presence of a math chip. There are differences between the 8087, 80287, and 80387, but they are nothing compared to the difference between having a math chip and not having one.

Fast Kat didn't come with a math chip, but once I started playing with benchmarks, it became obvious he'd need one.

Intel makes a small adapter board about 3 inches square to adapt the 80287 math chip so that it can work with an 80386 CPU. The Intel people were kind enough to send me several of them for the various machines we have here. First to get one was the CompuAdd Standard 286-II with the Cheetah Adapter/386 board.

On opening the machine I found a minor problem: Cheetah makes its own adapter to accept an 80287. The solution was to pry the 287 from the Intel adapter. I'd heard the 287 doesn't have to run at the same speed as the 386 chip, and this seemed a good time to test it. We dropped the 6-megahertz 287 into the adapter in the Cheetah. It worked fine. For the past couple of weeks, Dave Moore has been using this as the development machine for fixing up FTL Modula-2, so the system has been getting a heavy workout; no problems.

After that, it was Fast Kat's turn. Since Intel makes the Kaypro 386's motherboard as well as the 287 chips and adapters I had, this should have been a snap, but it wasn't. Because of the geometry of the hard disk and power supply installations on the Kaypro 386, you physically cannot install the standard Intel 287 adapter.

A quick call to the Kaypro technical-support people established that Kaypro has a special version of the adapter board, and that they'd send me one. In a couple of days there appeared a box that was prominently marked Intel Singapore Limited. The label said it was a "Single Board Computer," but actually it contained an adapter board with circuitry identical to the standard 287 adapter, but laid out differently; basically, all the components were rotated 90 degrees.

Now it'll be easy, I thought. The little chip assembly goes next to the power supply and under the hard disk cage; it looked like a tight fit, but I thought that would only be a matter of moving things.

Hah. It was no trouble to remove the front clips holding the hard disk and slide the disk forward; but then I found that the hard disk's cage doesn't come out. The bottom support of that cage is a piece of steel bent at a right angle; it's bent down far enough that it was impossible to slide the chip board under the disk cage. It was clear that if I could ever get the adapter board inserted into its socket I'd have plenty of room; but while the pins on the square gate-array socket are considerably more rugged than those on a standard chip, I didn't want to force things.

Eventually I took the vise grips to the cage-support bar; by bending that angle bracket so that it's about 60 degrees instead of 90 degrees, I haven't weakened it much (as all Kaypro stuff is, it's strong enough to resist 7.5 on the Richter scale); and that made just enough room to slide the assembly under the cage. I'd previously lubricated the pins with Stabilant (what I used to call Tweek), and it dropped right in.

After that, things went fast. Reassembly was no trouble, and everything works fine. A few days later, while talking to the Kaypro technicians about setup software, I mentioned the problem I'd had getting the math chip in.

"Gee," one said. "We didn't think you

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future.

could do that. We always take out the motherboard."

Sigh.

DESQview Yet Again

Yesterday morning, I got a beta-test developer's copy of Softguard's VM/386 virtual operating system for the 386. I haven't had a chance to do anything with it; at least it exists.

For the moment, though, the best way to get much of the power of the 386 is with Quarterdeck's DESQview. For those who've missed the past few months' discussions, DESQview is a program that allows multitasking. In a 286 AT system, DESQview does this by swapping programs in and out of extended memory or, if need be, to disk or RAM disk files. It can do that on a 386, too, but, in fact, Quarterdeck's QEMM 386 Memory Manager program coupled with the 386's speed makes all that pretty well invisible.

DESQview isn't perfect. Far from it. It has DESQview Utilities consisting of a calculator, calendar, dialer, and notepad, and while they're all right, they're not as easy or convenient (at least for me) to use as SideKick is. For example, I like to use SideKick to grab stuff from the BIX screen, edit and modify it, and then squirt it back to BIX through the modem. With SideKick, the importation is almost trivially easy. The export is tougher: first you do `Control-K E`, then tell it what key to trigger the squirt, then mark the beginning and end of the block to be squirted. I have a SuperKey macro that makes all that a great deal simpler.

For a while my SideKick upload procedure didn't work, and I thought it was something to do with the 386; but it turned out I'd copied my AUTOEXEC.BAT file wrong and invoked SideKick before SuperKey. SideKick has to be last, and if it isn't, not only can you mess up SideKick's ability to export stuff with the `Control-K E` command, but you can muck up other programs as well.

As an example, I've set up Brief, my favorite programming editor, in its own directory and put a path to that directory in the AUTOEXEC.BAT file. This works fine, unless you put SuperKey after SideKick. When you do that, if you call Brief from anything but its own subdirectory, the machine locks up. The first time that happened I thought it was Brief's fault, but it wasn't.

The moral of the story is that if you use memory-resident programs and get odd results from anything else, you'll probably want to check the memory residents before spending a lot of time in diagnostics.

Provided that SideKick is installed last, though, it really is convenient.

Alas, SideKick won't work with DESQview. If you invoke SideKick in its own window, DESQview won't let it have a communications port; if you invoke it in a batch file in the same DESQview window as, say, Crosstalk, your communications are going to be slow and jerky. I don't know why, but the effect is very real—and even if you were willing to put up with that, the SideKick export won't work anyway!

All of which means that if you use DESQview, you have to put up with the DESQview Mark, Cut, and Paste routine, which is awkward. The DESQview notepad editor uses mostly the same commands as WordStar, and they can be changed if you like, so it's not hard to use. But unless you invoke the DESQview notepad before you start any other job, the colors are so grimly horrible you can't believe them. In theory, it's easy to change colors in a DESQview window. In practice, it's one more thing to try to learn, and the colors for the notepad would *still* depend on when you opened

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its window. Unlike the SideKick editor, there's no way to set colors for the notepad itself.

Then, too, if I invoke the notepad first (and thus get the screen colors The Norton Utilities set for me on boot-up), odd things can happen. At least once I brought Fast Kat up in DESQview, opened the notepad as one window, opened Crosstalk as another, and connected to BIX. I used the Mark, Cut, and Paste routines to do some editing. All worked fine. Then I closed the Crosstalk window and went to bed, leaving the DESQview notepad as the sole surviving job.

The next morning the machine was locked up. I had to reset to get started.

That could, of course, be the result of a mini power failure or some kind of hardware glitch. I'd be more inclined to think so if similar things hadn't happened under DESQview, and not when DESQview was turned off. Of course, most of my problems have been due to insufficient spelunking of the DESQview manual; but some, I think, were just plain bugs.

For all that, I tend to use DESQview more and more. For one thing, Quarterdeck is quite responsive to bug reports; the DESQview you'll be able to buy when you read this will not be the same one I'm running. Also, DESQview has some really neat features, including a very nice keyboard swap and macro program similar to SuperKey. It's possible to build a customized file of keyboard macros that will be "automagically" invoked whenever you bring in the program they're associated with.

For example, when I bring in WordPerfect under DESQview, I also bring in a macro that redefines the backspace to "left-arrow delete left-arrow right-arrow." The "left-arrow delete" business is necessary because DESQview won't let you define a key recursively; and the "left-arrow right-arrow" monkey motion makes WordPerfect reformat the paragraph. I expect that would be a silly thing to do on a slower machine, but on the Kaypro 386, the operation is instantaneous.

The macros are neat, but mostly, DESQview is still the only way to do real multitasking; and that's quite often worth the problems DESQview can cause.

Swaps

I use DESQview a lot, but not always; often, it's just more convenient to have my usual bunch of memory-resident programs. Of course, I want them installed automatically; I also tend to want a different configuration of memory residents

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depending on which job I want to do. That used to take me more time than I like.

The solution to that seems obvious enough now, but I confess it took me a while to think of it. What I've done is make a series of batch files that copy specialized versions of AUTOEXEC.BAT and CONFIG.SYS. As an example, I have a file called MAKEREG.BAT that says

```
Echo off
Echo Setting up to make ''REGULAR''
Echo This installs Ready!, Super-
   Key, and SideKick
Echo on
Copy autoexec.reg autoexec.bat
Copy config.reg config.sys
Echo off
Echo NOW RESET SYSTEM
```

Similar batch files are MAKEDV.BAT, which sets things up to install DESQview; MAKEFRAM.BAT, which sets up to install Framework; and so on. Fast Kat resets very quickly, so it's no inconvenience. All of this is so obvious, I wonder why it took me so long to think of it.

Q&A

I've had Q&A version 2.0 for the 80386 for most of the month, and I like it a lot. There are more powerful database programs, and there are certainly better text editors; but I think there isn't a much better combination database and word processor, and each of them separately is a great deal better than good enough. The main attraction, though, is that there's nothing easier to use right out of the box.

Q&A isn't perfect. The original version ate memory like mad, and so does this version. This is because of an artificial intelligence routine called the Intelligent Assistant. There aren't any small and compact AI programs. If you run Q&A without the Intelligent Assistant, it's not much larger than other database programs. Q&A for the 386 is partly written in 386 native code, but it doesn't take much advantage of extended memory. Symantec says they'll change that.

Another problem with the new Q&A is the manual. Unlike the original, this one isn't loose-leaf. It's spiral-bound in two parts. That probably wouldn't be a problem for some people, but it is for me. The two volumes are very different in size. Volume II is quite thin. I'm always losing it—and it contains the index, so then it's nearly impossible to find anything in Volume I. This is a dumb way to organize material. I've ended up digging out the old loose-leaf manuals for version 1.2. They're not seriously out of date.

On the good side, Q&A for the 386 is

blazingly fast. Moreover, it not only runs fine under DESQview, the DESQview script (key-swap and macro) capability lets you improve Q&A quite a lot. Q&A has a pretty powerful macro capability of its own, but it's not always as convenient to use as DESQview's.

For example, the Q&A people went to considerable trouble to make the backspace work differently when in type-over and insert mode. I'm not used to that; I want the backspace to be the Rubout key that both deletes the letter to the left of the cursor and sucks up the empty space formerly occupied. It was no great trick to use the DESQview macro capability to set things so the backspace does that all the time. Since Q&A's word processor automatically reformats paragraphs with every insert/delete, no monkey motions were needed.

The Q&A word processor is plenty good enough for just about everything I'm likely to do, but if that were all there was to the program, I'd never use it; TNT Software's MyWord and Bob Wallace's shareware PC-Write both pack more features and cost quite a lot less; and some of Q&A's editing features are not particularly easy to use.

As an example, to get a word count, you must go into search mode, then search on the wild card for "any word" (which happens, in Q&A, to be '..'). That uses a lot of keystrokes, and for what? Also, to get line counts, you have to do arithmetic; there's nothing corresponding to WRITE's command that tells you words, lines, and paragraphs before cursor, after cursor, and for entire document in one (almost instantaneously executed) command.

So: the word processor is easy to learn and better than adequate, but not spectacular. The big deal with Q&A is that it's an easy-to-use database.

It certainly is easy to learn. When Mrs. Pournelle decided to try organizing some of the flood of software that pours into Chaos Manor, she had to choose a database program to do it with. Heaven knows we have enough of them around here. She'd never before worked with a computer database, and I didn't have time to tell her anything. She was on her own.

She looked through the manuals of about a dozen and chose Q&A as the simplest to set up. First thing I knew about it was when I came downstairs and found one of the editorial assistants happily logging in software data.

A couple of weeks later, I got involved with Sundog, a computer game written originally for the Apple II by my friend and colleague Bruce Webster. Sundog has been ported to the Atari ST, and it's

The word processor with Q&A is easy to learn and better than adequate, but not spectacular. The big deal is that Q&A is an easy-to-use database.

my kind of game, which is to say there's a little arcade skill involved, but it's mostly strategy. Part of that strategy is commodity trading; and in Sundog that can be complex.

In fact, the game information was so complex I found myself wanting a database program to organize it; and since I needed a way to test Q&A for myself, this seemed a good way to do it.

A Database for Sundog

I had the same experience Mrs. Pournelle did, namely, that it took almost no time to get things set up. Q&A organizes records as "forms," and designing a form is literally no trick at all. Of course, I wasn't sure what information I wanted, or how to organize it, but that didn't turn out to be difficult, either.

Sundog is a complex game. There are about a dozen solar systems, each with one to four planets. Each planet has from one to seven cities. Each city has an exchange building located randomly inside its boundaries. The exchanges offer a variety of commodities, but not all commodities are offered at all exchanges.

Each commodity comes in grades A (best) through G (worst). Prices for commodities in various grades vary from planet to planet, and from city to city on each planet. You can get information about prices in a particular city only by visiting that city's exchange and either offering to sell something you've brought or waiting to see what's offered for sale.

One object of the game—or at least a necessary action—is to make money through buying commodities in one place, transporting them to another, and selling them. Of course, if you buy inappropriate items for the place you're going, you can lose money, especially since fuel isn't cheap.

To make things even more complicated, the game lets you engage in black-market trading of ship and computer parts. These don't come in grades (al-

continued

Q&A is, after all, a file management program, and what I have here is a relational-database problem.

though you could consider them all to be of grade A) and aren't bought and sold in exchanges; to buy, you generally go to a parts store on a high-tech planet, and to sell, you generally go to a bar.

Finally, there is information about the cities themselves; information unrelated to any commodity. Things like, does the city have parts stores? What do they look like? Where is the exchange? (You can spend half an hour of real time looking for it if you haven't made notes.) What's the price of beer and hamburgers? (This gives a good indication of the general price levels for the city as a whole.)

This makes for a complicated database. When I started, I set it up so that a record consisted of the name of the star system; planet; city; commodity; grade; price; and I left fields for comments.

I certainly don't have information about all commodities or all grades for each city. On the other hand, if I find that in one city the price for grade D biochips is higher than the price for grade B in another city, I don't need to know more to get a handle on the profit to be made in that commodity.

Q&A is admirable for organizing information like that. Once I had my database established, I had it print out reports: one set was organized alphabetically by commodities, so that any time I needed to buy a given commodity, I could look up all the places that commodity might be available and the price I'd be likely to pay; and another report was organized by cities, so that I could look up for any given city what commodities I'd been offered and what they sold for.

Q&A could handle other information, but organizing it wasn't quite so simple. In fairness, what I have isn't a simple problem. For example, how to preserve general information not associated with commodities? Do I note the location of the exchange in a field on a typical form with commodity information, and thus have that blank field on most entries; or do I put it on a special form with the commodity information blank; or do I make a special file that contains only that information?

No database easily handles this kind of problem. What I really need is a pair of linked relational databases, as well as some ingenuity in modeling my data problems. Q&A certainly does this as well as most, and because it's comparatively easy to add new data fields, or even get the Intelligent Assistant to make new databases from your old one, I was able to work around the difficulty. Q&A is, after all, a file management program, and what I have here is a relational-database problem. More on this in the next few months.

Meanwhile, my main problem was that blanks are sorted to the beginning of a report, and sometimes my reports had unaesthetic blank-line entries at the top when printed out.

Another example: suppose I know that in the city of Drahew I can buy grade C droids for 10,000 and grade E for 9000. A good guess would be that grade D sells for 9500; it would sure be nice if I could make the computer go through the database and fill in blanks everywhere through interpolation and averaging. Of

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course, I don't know any other program that can do that.

Finally, what I'm really looking for is the largest spreads. I don't really care what commodities I trade in; what I want is the largest profit for the shortest trip. Can I make the computer find me the best possible deals?

Intelligent Reports

As I mentioned earlier, Q&A has an AI routine—written originally in LISP, as a matter of fact—called the Intelligent Assistant. This makes report generation and database manipulation much easier. For instance, I can, with patience, tell the Assistant to go through and make new forms based on information derived from the old ones and present the information in interesting ways.

Intelligent Assistant can be taught all manner of things. It knows the difference between verbs and adjectives. You can teach it a new vocabulary, and since it has automatically learned a lot about the database the first time it's invoked, it's easy to give it synonyms. I can do a lot with the Assistant, and it's easier to use every time I try.

On the other hand, I haven't been able to get the Assistant to give me much help finding the most profitable deals. It's easier to print out the data organized in different ways and search through myself.

Q&A uses a menu system. The menus are one of the main reasons why Q&A is so easy to learn and use, and I wouldn't change them for the world, especially since there's context-sensitive on-line help at all stages, from database creation to report design. Sometimes, though, the menus get in the way when I'd like to jump from one place to another. Macros do only part of the job. Oh, well, you can't have everything.

I suppose it's a bit silly to complain on the one hand that Q&A is a memory hog, and on the other to wish for new features. Of course, it wouldn't be impossible to get Q&A smarter and effectively smaller by using the 386's capabilities.

Q&A is both easy to learn and easy to use. There are lots of features and utilities to help import data from other databases, including PFS:File, dBASE II and III, and Lotus 1-2-3, so the data can be reorganized. With Q&A, it's particularly simple to add new categories of information you didn't think of, and the Intelligent Assistant helps a lot. Q&A is fast. For most jobs, it's more than good enough. The next step up is something like Guru from Micro Data Base Systems, and that's complex, not easy for beginners to learn or use, and quite expensive. The bottom line is that Q&A is what I find myself using at Chaos Manor for everything from games to organizing the files.

Fixing WordStar

There are a lot of new text editors out, but it's amazing how many people still use WordStar. Clearly, there's a dance in the old girl yet.

Serious WordStar users may want to get WordStar Professional 4.0, which fixes a number of complaints people had about version 3.3 and adds new features—but there are some disadvantages to that. When MicroPro married WordStar and NewWord to produce 4.0, they made some changes in the file, menu, and command structures. Most of the changes were trivial, but some weren't, so there can be some incompatibilities between old and new WordStar files.

For those who really like the look and feel of the old WordStar, there may be a better route. Over the years, user's groups have built a body of folklore on ways to customize WordStar by patching the code. Patching means using DDT, Debug, or a similar utility to modify a copy of the command file; it's simple enough to do, provided you know what has to be done.

You can find tips on how to modify WordStar on both free and commercial bulletin boards, in user's group publications, or in conversations at computer club meetings. But if you want to go at it systematically, the simplest way is to get hold of the following two items.

The first is Stuart Bonney's *The Wordstar Customizing Guide* (Wordware Publishing, P.O. Box 1747, Plano, TX 75074, (214) 423-0090). This used to be called *Wordstar As You Like It*, and it features a pretty complete presentation of how to use Debug to customize WordStar. It has an excellent discussion of WordStar's hidden proportional spacing capability and goes into principles of printer installation. There's a supplementary section for CP/M users. If you use WordStar at all, this book is worth the price.

If you're really serious about patching WordStar, you need StarFixer by Stephen Manes and Paul Somerson (Bantam Books, but you can get your copy directly from the authors at Hard/Soft Press, P.O. Box 1277-B, Riverdale, NY 10471, (800) 222-9409). This package bills itself as "The Ultimate WordStar Enhancement." I suspect MicroPro would say that WordStar 4.0 has a better claim to that

continued

Eureka is powerful enough to get most engineering and financial jobs done.

title, but it's not really misleading.

StarFixer comes with a disk of programs that will "automagically" do a lot of customization without having to load Debug. There's a Rescue program that will retrieve text if you exit WordStar without saving and a Filter program that will convert WordStar files into ASCII. Finally, there's a discussion of how to use Debug to do even more advanced modifications of WordStar.

Bonney's book has somewhat clearer discussions of what you're doing and why, while StarFixer is generally more complete, and its programs are easier to use. Both are just about indispensable for anyone doing professional work with WordStar. Recommended.

Eureka!

It used to be that if you got a small computer, you'd sooner or later be surrounded by scornful philistines demanding to know "What can you *do* with it that a calculator can't do?" It wasn't always easy to answer that question unless you were a programmer.

There have always been "math programs" for small computers, but they haven't been easy to learn. There's muMath, based on MIT's MACSYMA symbolic algebra program: extremely powerful, but complicated to get going and easy to forget if you didn't use it a lot. There was TK!Solver, not so powerful, but nearly as tough to learn. The ultimate, I suppose, was the language APL, which made child's play out of all kinds of hairy mathematical problems but was something between a hobby and a career to learn.

Now there's Borland's Eureka:The Solver. It's not as powerful as APL or muMath, but it will get most engineering and financial jobs done. It's very easy to use. The manual is clearly written, and there are plenty of examples. You can get Eureka up and running in about five minutes.

My first Eureka task was elementary planet design. As Poul Anderson put it in the old *SFWA Handbook*, "Far too many stories merely give us a planet exactly like Earth except for having neither geography nor history. Other stories, trying for the exotic, serve up an unbelievable mishmash." The remedy to that is to use imagination but fit what you imagine into the equations that govern the real universe.

For example, the size of a sun pretty well determines both its color and brightness. The illuminance a planet will receive is determined by the solar luminosity and the distance to its star

$$i = L/R^2$$

(where i is illuminance received relative to what Earth gets from Sol, L is the star's luminosity relative to Sol, and R is distance to the star relative to Earth's distance from Sol). The planet's year is determined by that distance and also the star's mass ($MP^2 = R^3$, where M is stellar mass relative to mass of our sun, P is the period in years, and R is the distance relative to Earth's distance from the sun). The apparent size of the star as seen from the planet depends on distance and stellar diameter. And so forth.

To design a planet, you pick the numbers you want and stuff them into the equations, then solve for everything else. This isn't hard, but it used to be tedious. Eureka has changed all that.

When you invoke Eureka, you come up in the Borland editor that's used for nearly all their programs. You then write your equations using pretty standard notation (e.g., M*P^2 = R^3 and i = L/R^2), then set the values you want fixed (e.g., by writing i = 0.97, L = 0.93, and so forth), then turn Eureka loose. It will give self-consistent values for every variable in your equations. If some of those values turn out not to your liking, you can change them. If you fix too many of the variables so that the system of equations is no longer self-consistent, Eureka will tell you that. The whole process is nearly instantaneous and completely painless.

Of course, you can use Eureka for a lot more than planet design. The manual gives examples of solving financial problems, like mortgage payments, ballistic problems, polynomials, charged particles in a gravitational field, and a whole bunch of other stuff.

Eureka can make graphs and generate reports. It doesn't require a math chip, but it will automatically use one if your computer has a math chip installed.

I've often said that if I could do arithmetic, I might well have become an astrophysicist. I understood high school and college physics, but I got lousy grades because, although I set up the equations right, I never got the right answers. If I'd had a PC and Eureka, I would have.

Borland's blurb says that "if you're a scientist, engineer, financial analyst, student, teacher, or any other professional

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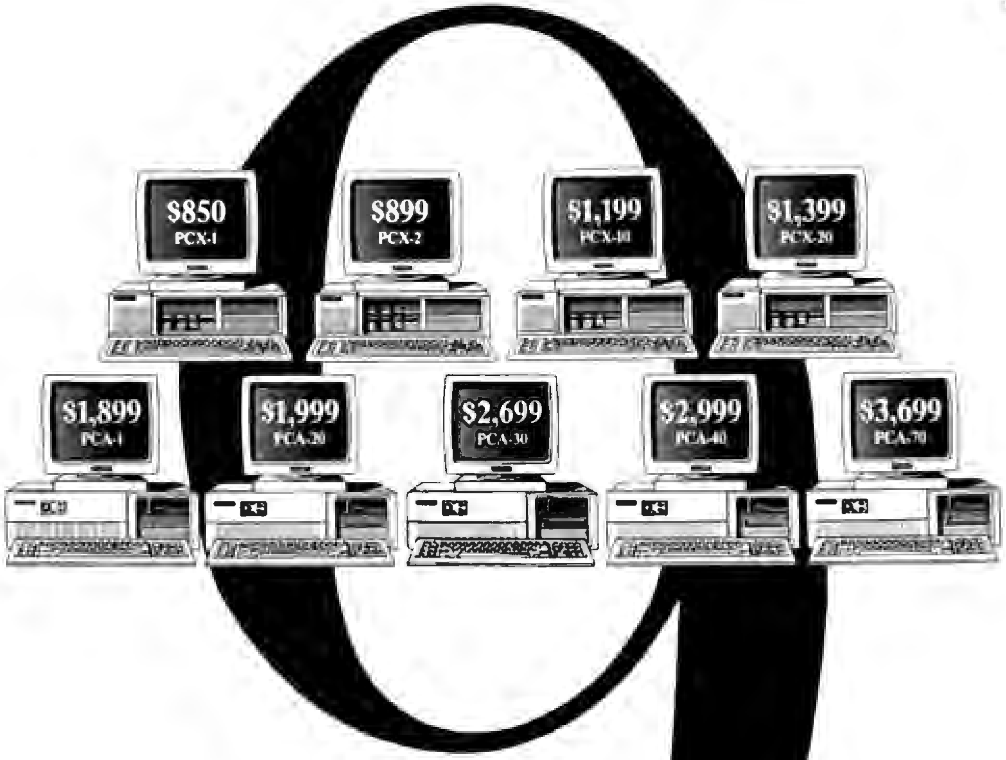

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working with equations, Eureka:The Solver can do your algebra, trigonometry, and calculus problems in a snap." That's pretty well true. I'd add that eventually everyone has to deal with equations and numbers, and when it happens, Eureka will make it a lot easier. I'll go further: programs like this may go a long way toward correcting some of the deficiencies of our school system. A computer can't teach math, but with a PC and this program, you can learn to use math on your own.

Get Eureka. You won't regret it. Highly recommended.

Care and Feeding of Fixed Disks

Hard disks are wonderful, but after a while, reading and writing to them takes longer and longer. What happens is that when you start with an empty disk there's plenty of space available, and your files are written in one long string. As the disk gets full and you erase files, things get patchier and patchier until, finally, the space that's left is all chopped up, so that the disk controller has to keep looking for space, finding it, writing to it, and recording where it wrote it. This makes for a lot of head movement and takes time.

The remedy for that is to repack your disk every now and then. Several disk management programs are available, but the one I use is Golden Bow's VOPT. This comes with VMAP, which paints a map of which disk sectors are in use and which are empty, and VOPT, which moves the files around so that everything that can be saved is saved in contiguous blocks. VOPT keeps track of how many files it has moved and how long it took; on the Zenith Z-248 and the Kaypro 386, that will typically be some 25 files moved in around 30 seconds.

It makes a real difference. As a test, I let my disk get cluttered and disorganized, then wrote an enormous text file to it, retrieved it, erased it, used VOPT to repack, and did all that again. Retrieving the file took about 16 percent less time after VOPT. Now I routinely use VOPT every couple of days.

VOPT comes with a jazzed-up version of the DOS utility CHKDSK, but for some reason the Golden Bow CHKDSK has never worked on either the Z-248 or the Kaypro 386. It hardly matters: VMAP and VOPT are what's important.

The other program you need is SpeedStor, which I mentioned last month. SpeedStor is a hard disk drive integration and diagnostic program that lets you install virtually any size hard disk in your system. I finally got around to partitioning Fast Kat's 40-megabyte hard disk, of which DOS could find only 32 megabytes. Thanks to SpeedStor, it now has two 20-megabyte logical drives. (VOPT, incidentally, can operate on both of them with no difficulty.)

SpeedStor is especially useful if you're installing your first hard disk in a PC or XT. The manual is detailed, and since the program works automatically in batch mode for most hard disk installations, SpeedStor makes the installation fairly simple.

Winding Down

I'm out of time and space, and I haven't even got started on the pile I set out to write about.

I do want to mention Definicon's 68020 and graphics boards for the PC. Their boards drop into a PC and turn it into the fastest thing this side of a VAX; maybe faster. There's not a lot of software, but there are compilers. My matrix benchmark runs (in C) so fast you can't really measure it. Anyone doing serious software development ought to know about Definicon.

Then there's a flier from the good guys at The Software Toolworks reminding me that Chessmaster 2000 makes a great Christmas gift. I think they have a weird idea of BYTE deadlines, but, in fact, that's the best chess program I know of. There's a pile of stuff I collected at Spring COMDEX, including pc-ditto, which lets you run just about any PC program there is on your Atari ST. There's Borland's new C compiler and a big package of new stuff from Microsoft. It will all have to wait.

The game of the month (other than Sundog for the Atari ST) is Faery Tale Adventure for the Amiga. This has fabulous graphics and a pretty good story line. It's hard to get started—I kept getting killed in the first three minutes, so I never saw much of the scenery—but my son Phillip has definitely mastered the system and is able to romp about bashing bad guys.

The book of the month is Arthur Ferrill's *The Fall of the Roman Empire—The Military Explanation* (Thames and Hudson, 1986). Good reading and plenty of lessons for our time.

With any luck, by next month I'll have written some new text-handling benchmark programs. ■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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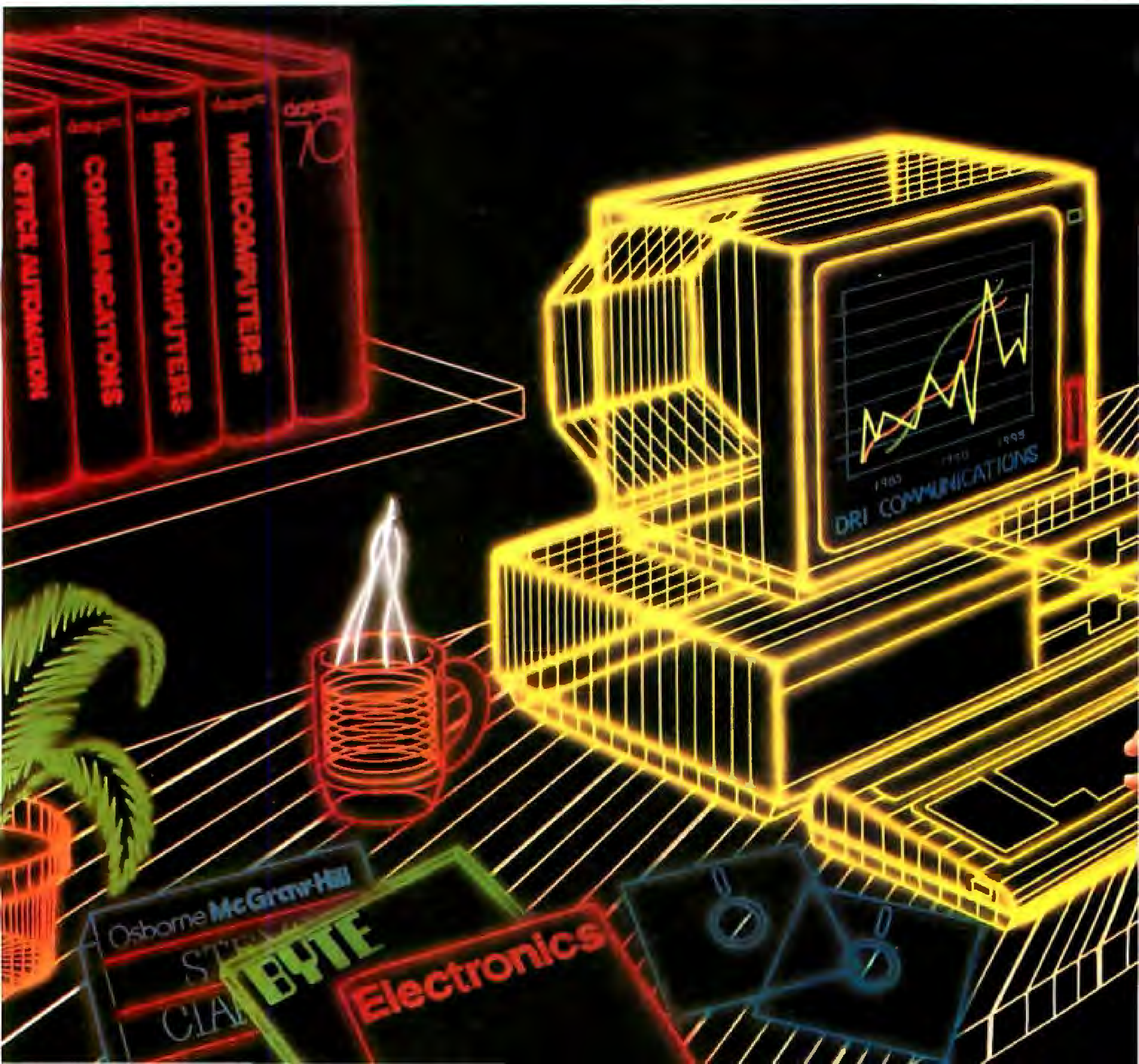

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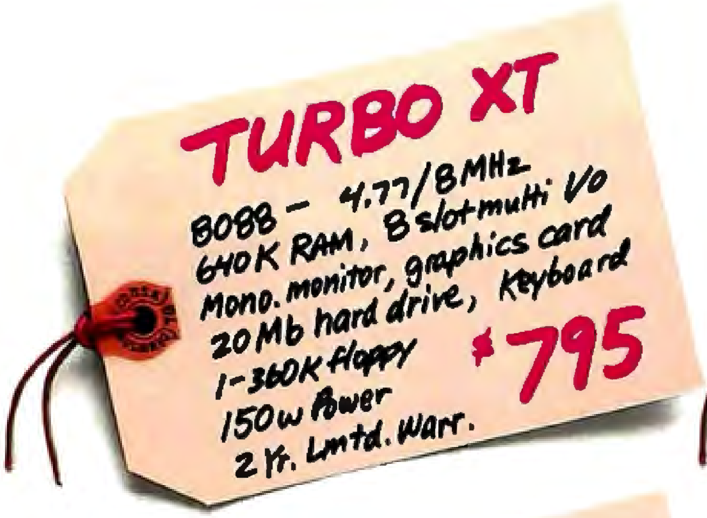

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Potpourri

Ezra Shapiro

MemoryMate, Mirror II, Tracker, Oyster, Guide, and The Comic Strip Factory

I've bitten the bullet. The Macintosh Plus and the QMS laser printer live on, but my faithful Compaq is sitting in a corner gathering dust. I'm now running my MS-DOS programs on a Tandon AT clone, a PCA-40 to be exact, equipped with an EGA card and a Quimax monitor. The Tandon is not the slickest, fastest AT out there—it runs only at 6 or 8 megahertz—but I needed a stock machine for evaluating software in a clean environment. The "40" in the name indicates that this baby comes with a 40-megabyte, 40-millisecond hard disk drive.

So far, it has run like a dream, right out of the box. Nary a problem. The monitor is a little fuzzy, and it broadcasts annoying interference to the Mac two feet away, but that isn't Tandon's fault. I'm pleased with the machine.

I'm pointing this out for two reasons. First, I'll be able to look at software that requires AT speed and EGA graphics (such as desktop-publishing products). Look for some AT/EGA packages to hit this column in the next few months. Second, my estimates of software speed will now be based on 80286 performance levels rather than the old 8088. Bear that in mind when you're reading about MS-DOS programs here; if I say a program is merely a little slow, you'll know it's absolutely impossible on an 8088 machine.

Name Change

Last October, I wrote about a neat shareware MS-DOS text database product called Instant Recall. It's a great little data-retrieval system: simple, fast, and uncluttered. You can store up to 2 megabytes of free-form text records, each of which can be up to 60 lines by 80 characters. There are no field names as such; you can search on any word or phrase that appears anywhere in the database. Because the program can operate either as a stand-alone application or as a pop-up with cut-and-paste capabilities, I've been using it to store all sorts of fragments, including notes about appointments, stray electronic-mail messages, and reference materials for this column.

I've been waiting for an update for some time, but nothing has happened. I suspect Michael Fremont, the program's creator, has been caught in the trap that catches many shareware authors: He's been too busy running a small business to spend much time improving the code.

The good news is that relief is in sight. By the time you read this, the product will have become a commercial offering from Broderbund, and Fremont will no longer have to worry about marketing and distribution. The program will be known as MemoryMate (a horrible name, but there's at least one other package on the market called Instant Recall, so a name change was inevitable), and it will sell for $69.95.

The first release of MemoryMate will not be a major revision of the package. I've been told to expect a slightly different look to the program's menu and a method of shutting off the Control-key command triggers to avoid contention with keyboard macro programs, but not much else.

I'm hoping Fremont will finally have the freedom to work on enhancements; I'll report changes when they happen. In the meantime, though, I still recommend the basic product; it's a winner.

No Longer a Clone

When Mirror, an MS-DOS telecommunications package, entered the world, it did so as a copy of Crosstalk XVI. Sure, there were some enhancements, but Mirror was intended to appeal to those seeking a low-cost alternative to Crosstalk. It looked like Crosstalk, it acted like Crosstalk, and it read Crosstalk scripts.

As you would expect, there was a lawsuit. Mirror lost. Now we have Mirror II (SoftKlone, $69.95), sporting a user interface that doesn't look anything like Crosstalk XVI. No more infringement. However, Mirror II still reads Crosstalk script files, and the new interface causes hardly a moment's pause to anyone familiar with Crosstalk.

This is my favorite stand-alone communications program. It supports more protocols and emulates more terminals than I'll ever need. A "learn" mode automatically creates Crosstalk log-on scripts (a nifty technique—Mirror stuffs the last 10 characters received from the remote computer into a variable so it can tie your actions to the actual prompts). If you initiate a file transfer, you can lean on both Shift keys and send Mirror into the background and continue working in the foreground; I've noticed no performance degradation when I do this.

There's a built-in editor for creating scripts, mail messages, and so on. Command lines can be edited without retyping. You can monitor call progress if your modem supports the procedure. Mirror II can keep a time-stamped transaction log. And your old Crosstalk files can be run without modification.

I used Mirror for a year. I've been using Mirror II for a month. I have been, and still am, extremely happy with this package.

A Better Card File

Tracker (Adaptive, $99) is the kind of software package that can best be termed a "no-brainer." Designed for businesspeople with little patience for intricate computer procedures, it's an MS-DOS

continued

Ezra Shapiro is a consulting editor for BYTE. Contact him at P. O. Box 146069, San Francisco, CA 94114. Because of the volume of mail he receives, Ezra, regretfully, cannot respond to each inquiry.

client/contact database from Australia that runs either as a memory-resident utility or as a stand-alone program. Nothing spectacular, but it's simple and handy for anyone who has to make a lot of phone calls.

The program presents you with a data-entry screen containing 15 predefined fields for name, address, telephone number, and so on. Though you can change the field names, you can't alter the length of the fields or the appearance of the screen. Perhaps the most useful items here are the three date fields, for first contact, last contact, and next contact; one touch of a function key retrieves the records for all the calls you have to make today.

Tracker has two secondary windows for each record. The first lets you attach a list of up to 20 keywords; the second is a utilitarian editor for adding text notes. Notes are stored by date; you can have as many as you like, provided you enter no more than—ahem—64,000 lines per note per day. Records can be dredged up and reports printed, sorted on any field or the keywords. The program will dump out text files delimited for mail merge into half a dozen of the most popular word processors. Tracker will also auto-dial your phone and print mailing labels.

Objections? In resident mode, Tracker is a glutton, gobbling more than 200K bytes of RAM, a total that puts it at the extreme fringe of acceptability. If you use large applications, Tracker is just too fat to use as a pop-up. My only other complaint is that the display is downright unattractive. I really don't need a half-inch logo to remind me of the program's name on every data screen.

The documentation is readable and thorough. Collectors of curiosities will appreciate the full-color photograph of an Australian aborigine on the disk itself.

Tracker is obviously limited, but it's functional. If you need exactly what it offers, I recommend it. If you need anything more flexible, try MemoryMate or the contact tracking systems that come as sample files with so many database managers these days.

Now here's a question: Do you call software from Australia "Down Underware," or is that something you buy from L. L. Bean to keep you warm in the winter?

Another Courseware Package

I suppose it's fate that just because I decided to write about Macintosh courseware-authoring systems last month, another product in that category arrived precisely a week after my deadline. Sigh. Oyster (Poseidon, $79.95) is a straightforward development system for instructional materials.

While Oyster isn't as flexible as its more ambitious competitors, it is easy to learn and use. It produces self-contained files that can be run as independent applications, and it's roughly a quarter the price of either Course Builder or Guide. Oyster lacks administrative functions, so it's useless for testing, but it's quite effective for training and drilling.

The basic building block is the multiple-choice question. You create the question and responses with the built-in editor, then drag radio buttons (called "hot dots" by Oyster) into position on the screen. A student using the completed course clicks on a dot to indicate the answer. Oyster allows importation of graphics through the Clipboard and Scrapbook functions; dots can be placed on top of images, so you can develop picture questions.

Any response can be linked to another screen full of information or another question, so you can organize files in any order you like—branching, linear, or even circular. The program keeps track

continued

of the structure with an outline, much like a table of contents, that appears in a window in the lower portion of the editing display.

The documentation is superb. It's well-written and logical, and it contains one of the best discussions on how to develop successful computerized training programs that I've ever seen.

Oyster is a solid package, fairly priced, and good at what it's supposed to do.

A Direct Port

The MS-DOS version of Guide (OWL International, $199.95) is a mirror image of Guide on the Macintosh, running under Microsoft Windows. I've already written extensively about Guide in my April and August columns, so I won't go into much detail here. It's a hypertext system; sliding the cursor over a section of text or a graphics image will pop open a new layer of information. You can organize material in surprising ways because you're freed from the linear constriction of either flat text or outline format. I like the concept, and Guide is an excellent implementation of it.

Once again, though, I'm dismayed at the clunkiness of the Windows interface as opposed to that of the Mac. First, you'd better have a PC AT to run the program at acceptable speed. Second, the text characters are rather ugly, even with an EGA setup. Third, Guide changes the shape of the cursor to indicate hidden layers within a document. This works fine on the Mac, but the special cursors in Windows seem huge and misshapen; moving through a Guide document is rather like dialing a telephone with a baseball bat.

Guide itself runs fine, but I was disappointed at the lack of color, which seemed a natural addition to an MS-DOS version. The sample files included are quite helpful, and the documentation is excellent.

Beggars Can't Be Choosers Department: For reasons I can't fathom, Guide on the PC costs $65 more than the same product on the Macintosh. What can I say? Go buy a Mac?

Funnies Program

Now that Mindscape's ComicWorks has grown up into GraphicWorks, a powerful artistic tool, I could argue that the world once again has room for a Macintosh program designed exclusively for the creation of comic books. However, after playing with The Comic Strip Factory (Foundation, $89.95), I'm not so sure.

What we have here is a comic strip assembly program. To call it a graphics package would be a mistake; though there are a few features you might find in painting and drawing software, The Comic Strip Factory (TCSF) has little capacity for the creation of original graphics.

You start with a blank page, on which you lay out borders for comic strip boxes. Next, you paste in backgrounds. Then you add characters, or rather you build them from a storage file of MacPaint body parts. You move a torso into position, then you graft on the appropriate head and limbs. Finally, you add speech balloons. What this is, really, is an object-oriented toolkit for constructing comics from graphic elements. If you will, The Comic Strip Factory is a PageMaker for the funny papers.

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The program is clear, simple to run, and its operations are all handled smoothly. You've got a pixel editor (similar to FatBits) for refining images and a separate utility called PartMaker for collecting objects from MacPaint files to be used in TCSF. I found no real bugs or anomalies when I built a few strips of my own.

The only problem I encountered was in printing, and that had more to do with the nature of laser printers than with TCSF. The Comic Strip Factory is really best at ImageWriter printing. When I forgot to disable smoothing, the poor QMS laser printer took forever to calculate the transition from 72 to 300 dots per inch. Printing was positively painful.

TCSF comes with a collection of six characters (actually a collection of their body parts) that you can combine into a comic strip. You get a moth-eaten wizard, a fantasy lizard with big teeth, a computer nerd with thick glasses (destined to offend anyone who's ever spent time with a computer), an elfin dancer with breasts and tiger stripes, and two cutesy insects. The insects are named, so help me, Broadway Bug and Sweet Patootie. It's easy enough to tell them apart—the male has a top hat; the female has eyelashes and a brassiere. Drawn by Trici Venola, they're proof that the Macintosh can be used to produce glib, trite comic art.

The four backgrounds provided with TCSF, by Kurt Wahlner, are much more neutral, and hence better. I admit that this is a judgment call, but if you've got any imagination, creativity, or self-pride, you won't want to use this stuff.

If you want to be original, you're going to have to use MacPaint to create your artwork, then chop it up with PartMaker so it can be digested by TCSF. In order to create a comic strip, you're going to be using three programs. Both SuperPaint and GraphicWorks are supersets of MacPaint, and not much tougher to learn. And those programs give you object orientation and rotation, as does TCSF, but you also get a full palette of graphics tools, editing at laser-printer resolution, and a host of other features lacking in TCSF. With a teeny bit more effort, you can create comics entirely within either program.

The Comic Strip Factory is fun to use, and it's well-documented. Its creators seem to be neat people. I wish I could justify the purchase of it for those reasons alone, but I can't. This is a limited graphics environment for the assembly of comic strips, priced roughly equivalent to superior graphics programs that can do everything that TCSF does and more. The Comic Strip Factory is just too little too late. ■

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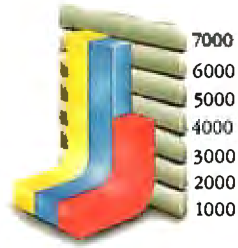

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"sleep": You put a request to the system for a keypunch and then gracefully get out of the way of the CPU so other tasks can have more time. If you busy-wait, you hog the CPU and prevent some other tasks from running.

Another rule to follow is to go through the operating system for almost any procedure. Once programs start viewing the operating system as the resource manager, they are freed from the task of determining the exact configuration of the particular machine they are running on. Sure, there is an overhead for multitasking and for having to consult the operating system for resources. But the overall gain in productivity is a more important factor.

Programs written for the earlier 8-bit micros, and even for the IBM PCs, are for the most part assembly language hacks that attempt to get the most out of every byte and every microsecond. Thus, they tend to pay little attention to the operating system. In the 8-bit 1-MHz world, this sort of programming is acceptable. In the 16- or 32-bit 8-MHz world, it is not.

Unfortunately, the Atari ST has the body of a 16-bit computer but the mind of an 8-bit computer. As a result, the primitive and inflexible software practices for the Atari ST remain in the dark ages—even if it is easier to port to the ST than to the Amiga.

Ali Ozer
Stanford, CA

I suppose you're right. The fact is, though, that while I see very elegant stuff for the Amiga, I see five times as much software developed for the Atari ST.

Every now and then, too, I get a finished program that, when put in the Amiga, gives me a guru meditation. I've given up copying that long-number error message.

But it's a gorgeous machine, and I have no doubt you're right about its versatility.—Jerry

Dear Jerry,

Concerning the letter from Warren Block in the March Chaos Manor Mail and your subsequent response, I am inclined to think that both of you are, in fact, correct and that there should be no argument.

Version 1.1 of the Amiga's operating system is prone to the "quest for the guru," and there is also a lot of irresponsible software out there in Amigaland. The reason for the slop in the available software may be partly due to the following problems: The Addison-Wesley manuals are fraught with ambiguities, errors, and missing explanations; there is very little support for assembly language programming in comparison with the voluminous C support; and only low-level programming can keep a fairly firm grip on the reins of the operating system (yes, I know C is a systems language, but try writing interrupt code with it, or perhaps time-critical disk code).

Version 1.2 is more stable. Available software is rarely able to run correctly on both versions, however, and I find myself cataloging my software according to this phenomenon. Also, RAM expansions don't seem to be supported very well (if at all).

I think the Amiga is an excellent piece of hardware. But when it comes to software—both systems and applications—it fails the test. A multitasking system is fine for use within an application, but on a system of this size with so few physical devices (not to mention the fact that any application can usurp the system), I really don't see the point.

Most likely it will take a few more years before the Amiga is truly understood. When this happens, we may well see the appearance of some very phenomenal software. Until then we will just have to settle for being both amazed and disgruntled at the same time.

Michael N. McFarland
Littlerock, CA

Close to my own sentiments. Thanks. —Jerry

Disk Could Be a Problem

Dear Jerry,

In the March Chaos Manor Mail, you stated in reply to Paul Horvick that "most of that stuff is on such cheap media that I won't even put them in my machine for fear it will mar the disk heads." How can we identify disks that are likely to damage disk heads? Do some disks contain abrasive materials that cause this problem? As cheap disks are flooding the market now, I would appreciate some comments on how to select disks.

Harry H. Hull
Sun City Center, FL

In the old CP/M days, there were certainly disk brands I wouldn't put in my drives. I more than once found marks on the disk heads that mucked up both read and write operations. In those days I pretty well knew the cheap brands.

Now, I don't; but I do know the good brands, like Dysan, Scotch, and Maxell.

I'm probably too paranoid, but if a disk looks at all questionable—marks on the media, lack of high polish, etc.—I'll run it once, but only to copy what's on it.—Jerry ■

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The Best of BIX is a small sample of the type of one-on-one interaction that users of the BYTE Information Exchange enjoy regularly. If you'd like to take part, see the advertisement on page 285.

APPLE

The Apple section this month consists entirely of a long message from conference comoderator Morgan Davis about the results of his investigation into the virtually undocumented IIGS serial ports.

THE IIGS SERIAL PORT PROCESSOR: AN INVESTIGATION

apple/source #50, from mdavis (Morgan Davis, conference comoderator), Tue May 12 16:23:35 1987.

I've come to the conclusion that if one requires information about how to access certain features of the Apple IIGS, the one is left to one's investigative devices. This has been traditional for as long as I can remember, anyway.

With the emergence of the IIGS we were supposed to see a plethora of technical information being made available to anyone who could pay for it. Addison-Wesley is publishing the huge technical volumes on the IIGS's Toolbox, as well as a "suite" of other IIGS technical manuals. And anyone can walk down to the bookstore and pick up a copy.

One area where nobody seems to know what is going on is with the IIGS's serial port. Those of you who have had BIX accounts for at least eight months have seen many pleas for information about the ports, but so far, none of our knights in shining phosphor from Apple have been able to provide much assistance.

CAP ON, MAGNIFYING GLASS IN HAND
Being generally curious, finding out what the deal is with the ports has become more of an adventure for me than a real need. To start my investigation, I obtained a large "Components Data Book" for Zilog chips. As we all know, the two Apple IIGS ports are governed by a single Zilog 8530 serial communications controller (SCC) chip. From this, I've learned that the SCC in the IIGS is a very powerful and exciting chip to work with.

Without getting into the heavy technical descriptions of the features of this chip, let's just say that it does a lot of fancy stuff that the old 6551, used by the IIc and the Super Serial Card, never could have accomplished.

The 8530 has two channels, one for the printer port and the other for the modem port. They are labeled "Channel A" and "Channel B." In the peripheral I/O area of the IIGS ($E0C0xx) are four locations that allow a program to directly access the 8530. They are:

```
C038 - Channel B control and status register
C039 - Channel A control and status register
C03A - Channel B data register
C03B - Channel A data register
```

For programmers, this arrangement makes it easy to access the register for the channel you require by using an indexed instruction. What's slick about this dual-channel system is that the same location can be used to obtain status information (by reading), or to control certain SCC modes (by writing). For passing data in and out of the SCC, you either read the data register to grab a character, or you write to the data register to send one out. Overall, a simple scheme.

Here's where it gets messy.

REGISTERS FOR DAYS
Unknown to most is that the 8530 has many internal 8-bit registers that correspond to a variety of functions and statuses. In all, the chip has nine read registers and 16 write registers!

Of the nine read registers, only four of them can actually be used for reading status information: RR0, RR1, RR10, and RR15. Read Register #8 (RR8) is the same as the associated channel's data register ($C08A or $C08B).

All the 16 write registers (WR0 through WR15) can be accessed, and, like RR8, Write Register #8 is the data register, used for sending a character out of the port.

Some of you might wonder how one would access up to 16 independent registers on the 8530 when we're given just one location per channel in which to access the chip. This is done by selecting the register you want to work with. To select a register, you store the register's number (0 to 16) in the lower three bits of the appropriate channel's control register (either $C038 or $C039). The next time you access one of those two locations, you'll be accessing the 8530 register you specified by the initial write.

So, in order to read a certain register, it would require one write to select it, and then the read. Conversely, to write to a specific register, you must write once to select it, and then write again to make your change. As an example, the following will read RR12 from the monitor:

```
*c038:0c      ;Select register 12, Channel B
*c038
[RETURN]      ;Read RR12's value
```

One important note needs to be made. If you select, for example, Register #2 and then read $C038 (Channel B status) twice in a row, you'll get two different values. This is because the 8530 will reset the selected register back to Register #0 (RR0 or WR0) after you've either read or written to your selection. You'd read RR2 the first time, and then read RR0 the second time.

(By the way, register selection is made by writing to WR0. If you're not sure if WR0 is selected when you first want to access the 8530, you should read the status register first so that the 8530 will reset the register selection to #0 for you. This isn't written down anywhere, but I think it would be a safe thing to do).

HIGH LEVEL, HIGH ADVENTURE
For those of you who don't enjoy having to get down on your hands and knees to access the bare hardware, relax in knowing that you can talk to the 8530 through the serial port firmware on the Apple IIGS. You'll have to make extended calls to the firmware using GetSCC and SetSCC to reach the many registers of the 8530, but at least it keeps your clothes clean.

continued

As an example, the following routine, which can be typed into the monitor, will read RR12 (the low byte of the data-rate time constant).

```
]call-151          ;Enter the monitor
*!                 ;Enter mini-assembler
!300: lda #80      ;A, X, and Y to point to parameters
! ldx #03          ;(the address is $00/0380)
! ldy #00
! jsr c214         ;Pascal 1.1 extended-call entry point
! rts
! [RETURN]         ;Exit mini-assembler
*380:04            ;Parameter count is 4
*381:08            ;Extended code is 8 = GetSCC
*382:00 00         ;Result space
*384:0c            ;0c = RR12
*385:00            ;Value from RR12 is returned here
*300G              ;Call our routine at 300
*385 [RETURN]      ;View contents of RR12
```

This shows how to make an extended call to the Pascal 1.1 firmware for slot 2 (usually the modem port). It's hardcoded to $C214, but you should look at the byte at $C212 to find the low-byte offset into $C200 for the extended-call entry point.

WRANGLING WREGISTERS
By now, you're probably wondering what each of the read and write registers do, and which bits control what. Sorry, I'm not going to type in the settings for 200 bits. If you're really interested in this stuff, I strongly recommend that you order a data sheet from Zilog or pick up a components manual. Why the spec sheet for the 8530 was not included with all the other data sheets in the Apple IIGS Hardware Reference is beyond me. Then again, there are many things Apple does that are beyond the grasp of rational comprehension. :-)

If interest is high, perhaps I can type in descriptions of what I consider to be the few most useful registers. Until then, good luck with your own investigations, and I'll be sure to post any other pertinent information on this subject when I uncover more.

--Morgan ("Real Programmers Don't Need Manuals") Davis

MACINTOSH

Nobody's perfect, as shown by a BIXen's look at the typos inside a Macintosh SE. That discussion eases into a hot debate on the SE's cooling fan. There's a discussion on the apparent fragility of the SE, and a how-to on hooking up MultiSync/Multiscan monitors to the Macintosh II. And how compatible is the Mac II NuBus anyway?

THE GREAT MAC SE TYPO-AND-FAN SAGA

macintosh/mac.se #220, from bmug (Raines Cohen), Fri May 22 08:32:41 1987.

For the curious, while disassembling a Mac SE, I noticed the following:

>> The analog card is labeled "MATINTOSH," with a T!

>> The video card is marked "ALADDIN VIDEO CARD," and a wire label reads "ORAMGE."

>> There is a spot for a resistor just below the fan. Perhaps to slow and quiet it down?

macintosh/mac.se #221, from lloeb (Larry Loeb, conference moderator), Fri May 22 10:06:49 1987. A comment to message 220.

The Billy Steinberg solution for the fan:

"100 ohms at 1/2 watt."

macintosh/mac.se #225, from nz_mhamel (Michael Hamel), Sun May 24 00:44:23 1987. A comment to message 221.

Speaking of the fan, surely some thoughtful hardware person (coughing violently and pointing to self) could, if they had an SE (more coughing), make the fan thermostatically controlled. I mean, it must be designed to cool a fully loaded SE with hard disk, external drive, and something in the slot at ambient temperatures of 35c or so. So most of the time it's running much too fast. A temperature sensor coupled to a proportioning control should ensure it only comes on when it has to and at whatever speed it has to to keep things cool. Probably it would just start to make enough noise to be annoying after you had worked at the SE long enough to be really irritated by it, eh?

macintosh/mac.se #226, from wbeck (Warren Beck), Sun May 24 01:51:11 1987. A comment to message 225.

On the fan, also, has anyone else noticed that when the hard disk in the SE is reading in a long file, such as an application, that the speed of the fan changes. I mean to say, the pitch of the whine goes lower transiently and then returns to its normal continuous-wave whine. Does this mean that the power supply is being taxed such that the voltage on the fan drops a little when the hard disk is turning? Sounds like the power supply is a little too close to the specifications for the hardware being powered. Which means that the fan is really needed to keep the SE from becoming a baked apple (which the Mac Plus I use at work has done twice), since a larger power supply was not used, apparently owing to heat constraints.

macintosh/mac.se #228, from lloeb, Sun May 24 08:33:48 1987. A comment to message 226.

I've had two review machines in here and BOTH fans never changed pitch under any load or disk operation.

The Sony power supply is 100 watts up from 60 watts on the "Classic" Mac.

I think there is AMPLE margin designed in this time; and would disagree with your thoughts on this.

macintosh/mac.se #230, from rsimonsen (Redmond Simonsen), Mon May 25 01:29:29 1987. A comment to message 228.

Could be a harmonic that is changing the sound of the fan rather than a slowdown due to stressing the power supply.

macintosh/mac.se #233, from bohannan (Bruce Bohannan), Fri May 29 23:56:54 1987. A comment to message 226.

I have the same problem (attribute?) with my SE fan. . . about once an hour, the pitch rises and then falls back to normal. It sounds like some sort of harmonic distortion to me.

macintosh/mac.se #229, from bvanantwerp (Bill Vanantwerp), Sun May 24 15:13:10 1987. A comment to message 225.

Trouble is that a true pid-type controller costs more than it's worth, I would think. My solution on a Plus was to install a

continued

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fan with a switch that I turned on only when I wasn't within earshot. Works like a dream. Inside my Plus rarely gets to be more than 30c.

FRAGILE SE: HANDLE WITH CARE

macintosh/mac.se #235, from tom__thompson (Tom Thompson, BYTE), Mon Jun 8 08:47:03 1987.

Well, we just got our SE back from COMDEX, and it turns out that they don't take to being hauled about too well. Case in point:

A key on the keyboard was broken off. I managed to reattach it by *very* carefully using epoxy cement. One foul-up and the key could have been glued permanently into the "on" position, but with a lot of care and a little luck I managed it. This reaffirms my previous opinion about the new keyboard - a tad too frail for my liking, especially when compared to the classic Mac keyboard. (We've shipped some of these Macs to various shows, and I've yet to hear of a keyboard problem.)

The video display didn't work. This provoked a number of four-letter runic incantations, after which I switched the SE off. Turning it back on, I could see that the internal hard disk seemed to run through a typical boot sequence. So I stuck in a formatted floppy, which the SE appeared to read properly. Now the test: I hit Command-E on the keyboard and phwang, out pops the floppy. Now that we know the CPU is OK, it's time to open the case and take a look at the analog board. I did this and discovered the connector to the rear of the video tube had popped off. It seems there's this thick grounding cable or some such with very little slack that can yank the connector off the tube when the SE gets jarred. Apple needs to put some slack in that wire: I've heard of this happening to another SE user.

At any rate, fixing that problem was simply a matter of plugging the connector back on. The hard disk seems OK, and I'm using the SE now to file this comment. But be advised: I don't think the SE is nearly as shippable as the classic Macs. Be careful!

macintosh/mac.se #238, from wbeck, Wed Jun 10 01:08:39 1987. A comment to message 235.

How did you ship the SE? Did you use a special shipping container, or just the standard box the SE comes in?

Another question: Have you heard any stories of the hard drive being damaged by carrying the SE from home to work, etc.? I do this two or three times a week with my SE, and I am a little scared that the disk will crash eventually. So far, I haven't had any problems at all in the month that I've had my SE (and I am hoping that my luck will remain on track. . .).

macintosh/mac.se #239, from tom__thompson, Wed Jun 10 09:28:08 1987. A comment to message 238.

I also had the experience of shipping the SE as regular baggage in its canvas bag. The baggage guys mashed it so bad the main power cords were loosened. The internal hard disk didn't lose a byte. I dunno how without parking. Apple says it's because it's a low-mass head.

macintosh/mac.se #241, from reviews6 (Joel West), Thu Jun 11 21:18:10 1987. A comment to message 239.

A techie at a company that makes internal hard disks showed me the internal 20 and commented on the lack of shock mounting. The Apple is much less than the norm for a transportable (e.g., as on a Compaq), but since he's a software type, he wasn't sure if it really mattered.

HOOKING A MULTISYNC/SCAN TO THE MAC II

macintosh/mac.ii #196, from reviews6, Fri May 15 18:49:15 1987.

A local dealer kindly provided me with the manual for the NEC MultiSync. It provides a detailed pin assignment and advice for use with non-IBM drivers. The information seems pretty clear on hooking one up to a Mac II, although, according to Apple's shipment desk, if a developer hasn't received one yet, the next batch is a month away.

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CABLE

NEC DE9	Description	Apple video card ("DB"-15)
1	Red	2 Red
2	Green	5 Green
3	Blue	9 Blue
4	Composite Sync	3 CSync
5	V. Sync	N/C or 1 Ground
6,7,8,9	Ground	1 Ground

macintosh/mac.ii #212, from reviews6, Thu May 21 22:01:55 1987.

The Sony Multiscan, like the NEC MultiSync, is a monitor designed for compatibility with several IBM standards. It handles PGA and VGA.

It also works very nicely with the Mac II. I'm told that it looks identical to the Apple monitor except for the case. (Apple has acknowledged using a Sony tube; other differences are unclear.)

I also heard that only the late-model NECs can handle the Mac's scan rate.

A LOOK AT NUBUS COMPATIBILITY

macintosh/mac.ii #205, from murdock (Albert Sousa), Mon May 18 22:06:27 1987.

Will TI NuBus cards work on the Mac II? I'm referring to the LISP processor card on the Explorer and the memory, CPU, and peripheral cards from the Business Pro. Also, a magazine made reference to a new Mac in alpha. It said this new Mac was as big a jump over the Mac II as the II was over the Plus. Any comments?

macintosh/mac.ii #210, from nwallach (Naor Wallach), Thu May 21 19:48:48 1987. A comment to message 205.

Looking at the pictures from AST for its 286 card, I believe that Apple has developed its own form factor for its cards. I do not believe that it has followed the NuBus spec in its mechanical design. Therefore, no NuBus card compatibility. Electrically, Apple used NuBus though.

macintosh/mac.ii #216, from tom_thompson, Tue May 26 14:12:26 1987. A comment to message 210.

I think it's the other way around: Apple has followed the form-factor (mechanical) specs from the NuBus doc, but it's only partially compatible electrically. If the card requires the -5.2V that the Apple NuBus doesn't supply. Except for this one change, the Mac II follows the NuBus electrical specs closely and should work.

macintosh/mac.ii #233, from nwallach, Sun May 31 21:03:48 1987. A comment to message 216.

The spec I have mentions a form factor that is identical to VMEbus. I'll check my spec if someone will post the mechanical dimensions for their Apple NuBus cards.

macintosh/mac.ii #240, from tom_thompson, Mon Jun 1 09:06:56 1987. A comment to message 233.

Just a guess, but what version of the NuBus spec do you have? I had spec. 1.6, which only *mentioned* the VME form factor. Things didn't look too pleasant electrically, either. However, when I received my copy of the NuBus spec, I found out it's now in draft version 2.0. Apple is pretty well in order with the electrical definitions (except for the -5.2V), and a "PC" form-factor card was introduced. The dimensions for the PC form factor are:

101.6mm (4.0") in height
327.03mm (12.875") in length max.

Length shall vary on left side of card; minimum length is 177.8 mm (7.0").

Connector is a Eurocard type C connector; specifically, 603-2-IEC-C096-M.

This is probably the form factor Apple is using for the boards (certainly not the VME form factor!).

macintosh/mac.ii #243, from nz_mhamel, Tue Jun 2 04:17:46 1987. A comment to message 240.

I thought Apple was a bit more deviant than that from the NuBus spec: Hasn't A31, which was a ground, become an interrupt line, IRQ*? And Apple doesn't support block transfers (or is that optional now?)?

macintosh/mac.ii #244, from jmonti, Tue Jun 2 04:37:39 1987. A comment to message 243.

Yes, upgrading the video card is just a matter of putting in the chips. I saw it done and it took about 2 minutes, maybe 3. And the chips weren't even from Apple. I believe $41 is a reasonable price if bought in quantity through a user's group co-op or something.

macintosh/mac.ii #247, from tom_thompson, Tue Jun 2 09:04:53 1987. A comment to message 243.

No, A31 is an address/data line, it can't be a ground. The interrupt request is now RQST*, which can be bused or non-bused (Apple chose the latter route, so that each card could have its own dedicated interrupt). No, the Mac II doesn't support block transfers, and they are optional in version 2.0 of the spec.

macintosh/mac.ii #249, from nwallach, Tue Jun 2 19:29:58 1987. A comment to message 240.

Hmmmmmmmmmm!

My spec. is document #TI-2242825-0001, published by Texas Instruments. You know, the people who developed NuBus.

Of course, there is nothing to say that they are perfect. Thanks anyway.

macintosh/mac.ii #250, from sjones (Scott Jones), Tue Jun 2 19:36:06 1987. A comment to message 249.

You're wrong! TI didn't develop the NuBus. Some of my

continued

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Personal Computer Music System

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Inquiry 334

professors at MIT developed it a number of years ago. TI just licensed the NuBus from them! I was surprised to hear that Apple had chosen it for the Mac II. I still have some course notes describing the bus-arbitration protocol that the professors had designed [from a class called 6.032].

macintosh/mac.ii #251, from tom_thompson, Tue Jun 2 21:27:15 1987. A comment to message 250.

What's the date on that thing? I've got the IEEE P1196 specification, draft 2.0, dated December 15, 1986. It's also an unapproved draft, but since it's still in the proposal stage (hence the "P" with the spec number), no big deal. No idea when it'll be finalized, but this document's the latest I've seen.

macintosh/mac.ii #252, from paul.hoffman (Paul Hoffman), Wed Jun 3 00:15:09 1987. A comment to message 250.

Ah, 6.032. Course name: Computers for Masochists. Brings back memories.

macintosh/mac.ii #253, from microprose (MicroProse Software), Thu Jun 4 22:36:58 1987. A comment to message 252.

Lord, 6.032! Haven't thought about that in years! Guess I took it before NuBus was created (Fall '80). . .

macintosh/mac.ii #254, from sjones, Thu Jun 4 23:53:31 1987. A comment to message 253.

Hmmm, all these MIT types coming out of the woodwork!

I do wish that Apple had kept in some of the features of the NuBus. Like the fast block transfers.

IBM PC

Can you use a single-sided 3½-inch floppy disk in one of the new 1.4-megabyte PS/2 drives? It seems so at first glance. But wait, there's more. If that isn't enough to pique your interest, you can read all about the stuttering ROM BIOS or the nonfunctioning alternate Alt. In the realm of the more contemporary PS/2 systems, there's a discussion of the pros and cons of the Micro Channel bus and bus ID numbers. This month's IBM PC section finishes up a thread on how EXEC does temporary exits to DOS.

THE DANGERS OF SINGLE-SIDED DISKS

ibm.ps/model.50 #214, from swnev (Scott Neville), Mon Jun 8 23:59:02 1987.

I had an old single-sided 3 1/2-inch disk laying around, and, just for kicks, I decided to see if it would format properly. I used the FORMAT command without any parameters, and lo and behold! It formatted fine and showed a full 1.4 megs of available space!

I confirmed this with CHKDSK. I couldn't believe it, so I copied over a meg of data onto the disk (actually programs and ASCII files). I used the /v (verify) option with the copy and got no errors. Every program I run off the disk works without a hitch. The ASCII files are complete and unadulterated!

Is there a mega$$$ conspiracy afoot? Am I being overcharged for high-density disks, when any old 3 1/2-inch disk will work? Is there a difference in reliability between these disks? Anyone have any suggestions?

ibm.ps/model.50 #215, from barryn (Barry Nance), Tue Jun 9 00:01:04 1987. A comment to message 214.

Good question. Even with a discount, the 3 1/2-inch disks we bought at work cost about $60 per box. And that's too much.

ibm.ps/model.50 #216, from swnev, Tue Jun 9 00:09:23 1987. A comment to message 215.

I have some Sony single-sided disks. I'll try them next. The store I bought my Model 60 from wanted $100 for the hard disks! I finally found them for $65. Seems way overpriced. I chalked it up to new technology, but now I begin to wonder!!

ibm.ps/model.50 #217, from barryn, Tue Jun 9 00:11:48 1987. A comment to message 216.

Well, just watch out for the single-sided disks. . ."single-sided" means that the disks failed the certification tests on one surface but not the other. There could be a very slight flaw on the bad side. . .or there could be a large one.

ibm.ps/model.50 #220, from grr (George Robbins, Commodore Business Machines), Tue Jun 9 04:56:58 1987. A comment to message 217.

This is an open issue that has been explored elsewhere at great length. It boils down to personal preference. Some people are happy to save a buck at some increased risk; others are willing to pay more for some assurance of better data reliability.

The details of certification, finishing, testing, and whatnot vary between manufacturers and over time. There isn't a single answer.

ibm.ps/model.50 #227, from matt.trask (Matt Trask), Tue Jun 9 11:32:59 1987. A comment to message 217.

Single-sided means a statistically meaningful sample from the production run failed on one surface and not the other - not necessarily every disk. DOS should be able to handle any bad sectors that are found during format of a single-sided disk for double-sided use.

STUTTERING ROM BIOS

ibm.ps/model.50 #230, from barryn, Tue Jun 9 21:03:42 1987.

I dumped the ROM BIOS of my Model 60 out to disk earlier today, just so I could do some spelunking. Here's a picture of the front end of the file:

```
-d 100

9900XX66881158
((CC))CCOOPPYYRRIIGGHHTT
IIBBMM CCOORRPPOORRAATTIIOONN
11998811,, 11998877
AALLLL RRIIGGHHTTSS
RREESSEERRVVEEDD
```

ibm.ps/model.50 #231, from greenber (Ross Greenberg), Tue Jun 9 21:33:57 1987. A comment to message 230.

WWhhaatt''ss wwrroonngg wwiitthh tthhaatt??

Barry, what do you get if you output that as a direct image to the screen, using the alternate bytes as attribute bytes? Must look pretty funny.

continued

ibm.ps/model.50 #232, from barryn, Tue Jun 9 21:37:27 1987. A comment to message 231.

I can try it when I get to work tomorrow. I wonder if it'll blow up the machine (hope, hope).

ibm.ps/model.50 #233, from mced (Edward McNierney, Number Nine Computer Corp.), Tue Jun 9 22:52:42 1987. A comment to message 232.

Gee, these software guys don't know much about hardware, do they?

Actually, I've wondered about that BIOS stuttering for years (you can find it in every PC from the very first one) until I started working for a hardware company. You see, ROMs are usually organized as "by 8," meaning that they can be accessed 8 bits at a time. Since 16-bit accesses are much faster if you don't have to read the same ROM twice, IBM (and most everyone else) arranges ROMs as two 8-bit ROMs with their addresses interleaved. In other words, all the even-numbered bytes are in one ROM and all the odd-numbered bytes are in the other. Most software for burning ROMs comes with a "byte-split" utility, which takes your object code and splits it into two files, one for each ROM.

So, all IBM is doing is making sure that the complete text of the copyright message in stored in each ROM!

ibm.ps/model.50 #234, from barryn, Tue Jun 9 22:59:42 1987. A comment to message 233.

Well, that *does* make sense. Thanks, Ed.

ibm.ps/model.50 #237, from barryn, Wed Jun 10 02:56:19 1987. A comment to message 232.

Does anyone have a clone that has a "stuttering" BIOS footprint like that? Mine doesn't; its front end is a perfectly readable copyright message (maybe this means that the low-byte ROM chip is not copyrighted unless it's treated as a set along with the high-byte chip, and vice versa?).

ibm.ps/model.50 #239, from matt.trask, Wed Jun 10 11:44:14 1987. A comment to message 237.

I suppose they could protect their rights by only copyrighting every other byte. Any 16-bit machine (8086, 80286, . . .) should exhibit this same stutter.

THE NONFUNCTIONING ALTERNATE ALT

ibm.ps/model.50 #259, from swnev, Sun Jun 14 12:30:36 1987.

The second Alt key (to the right of the space bar) isn't recognized by any of my programs. The second Control key (also to the right of the space bar) functions normally. Do I need to trade in my keyboard? Or did IBM just do something different with the second Alt key? Also, does anyone know how to make use of the F11 and F12 function keys? I don't have the Tech Ref yet; do they use special return codes?

ibm.ps/model.50 #265, from kkonnerth (Karl Konnerth), Mon Jun 15 01:40:15 1987. A comment to message 259.

We haven't had many problems with the Alt keys on our 50s and 60s. Occasionally, a program will reject one of the Alt keys, but it happens so infrequently that I can't remember which program was affected! Have you run the diagnostics yet? Nota bene: You can access the advanced diagnostics by pressing Control-A at the main menu for the Reference Disk.

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BTW, not many programs used F11 and F12 when that keyboard was offered with the XT and AT, and not many use it now. I seem to recall that they require a separate BIOS call to read.

A LOOK AT THE MICRO CHANNEL BUS

ibm.ps/the.bus #50, from greenber, Tue Jun 9 09:03:50 1987.

Well, now that the smoke has cleared a bit (and now that I finally have my Tech Ref so I understand the answers!):

Q: What makes the Micro Channel superior to the old XT bus? To the old AT bus? To other buses put out by other companies?

Q: These IDs that IBM promises to give to everybody: Is that the only way to get them, or can manufacturers make a deal and split a given number in some way between themselves?

Q: What peripherals might be uniquely suited to the PS/2 and why? In fact, why isn't the motherboard, and the CPU on it, considered a peripheral?

Q: When the Model 80 comes out, will the real power of the 386 shine through on the Micro Channel? Or will the Micro Channel start to shine when powered by the 386?

Well, now that I can follow what the heck people are gonna say, I'll try to translate a bit as required.

ibm.ps/the.bus #51, from matt.trask, Tue Jun 9 11:38:28 1987. A comment to message 50.

yes yes yes no yes size 9 yes maybe yes

Well, anyway, the reason the CPU is not a peripheral is because guest masters on the bus cannot control the watchdog timer - control will always return to it. Of course, if the CPU disables the timer, all bets are off.

ibm.ps/the.bus #52, from greenber, Tue Jun 9 11:46:42 1987. A comment to message 51.

Now, since I'm just starting to wade through the tech spec, perhaps you can help me out:

What the heck *is* the watchdog timer, and should I care that it exists?

ibm.ps/the.bus #53, from matt.trask, Tue Jun 9 12:02:31 1987. A comment to message 52.

It is a programmable timer that normally would be reset by the BIOS on each timer tick. It can be set for 0 to 255 ticks. If the preset number of ticks occurs without a reset to this timer, it yanks down on the NMI line. This NMI is _not_ maskable by the normal NMI mask register, and because the timer's ports are below 100h, they are not visible over the bus to other bus masters. This allows the planar CPU to always regain control of the bus from rude bus riders.

ibm.ps/the.bus #54, from greenber, Tue Jun 9 15:42:32 1987. A comment to message 53.

Sounds like there are a lot of nifty things you could do with a decent NMI interrupt-service routine, eh?

What kind of stuff is loaded in there now??

ibm.ps/the.bus #56, from matt.trask, Tue Jun 9 17:27:12 1987. A comment to message 54.

The normal NMI services, such as parity check (yechh!) and NDP error, are implemented through the NMI vector in the normal

continued

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Announcing DT01/DR01
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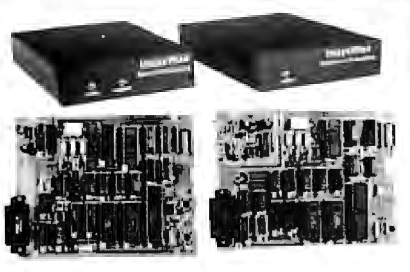

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IMAGEWISE SYSTEM SPECIFICATIONS

- NOT bus dependent – can function standalone
- True framegrabber – uses a high speed flash A/D converter and 64K bytes of static RAM to capture an image in 1/60th second.
- Accepts any B/W or color NTSC video signal.
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  - Selectable Resolutions
    - High: 256x244x6
    - Med: 128x122x6
    - Low: 64x61x6
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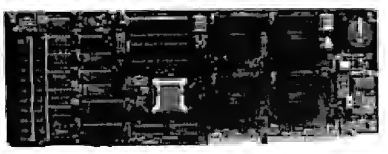

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The OEM-286 is available in both 8 and 10 Mhz versions and comes with the Award BIOS

OEM-286 FEATURES

- 100% AT compatible
- 80286 Microprocessor, 8 or 10Mhz
- 80287 Co-Processor optional
- 64 Kbytes of ROM, can accommodate 128 Kbytes
- 512 Kbytes of RAM
- Keyboard Controller
- Expansion card size factor
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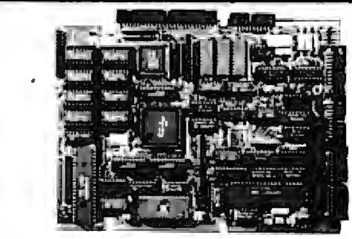
SB180FX — $409.00
Single Board Computer



SB180FX TECHNICAL SPECIFICATIONS

PROCESSOR
- Hitachi HD64180, an 8-bit CPU in a 68 pin PLCC package
- Superset of Z-80 instruction set, including hardware multiply
- Integrated Memory Management Unit with 512K bytes address space
- Dynamic RAM refresh
- Wait state generator
- Clocked serial I/O port
- 2 channel Direct Memory Access Controller
- 2 channel Asynchronous Serial Communication Interface
- 2 channel 16-bit Programmable Reload Timer
- 12 interrupts
- Dual bus interface to 68xx and 80xx support chips
- 6.144MHz, 9.216MHz, and 12.288 MHz system operation

MEMORY
- 512K bytes dynamic RAM on board
- Memory externally expandable to 4 Mbyte RAM
- Either an 8K 2764, 16K 27128, or 32K 27256 EPROM usable
- Full function 8K ROM resident monitor

INPUT/OUTPUT
- Console RS-232 serial port with auto baud rate select to 38,400 baud
- Peripheral RS-232 serial port, full handshaking, 150-38,400 baud
- Line printer parallel I/O port
- 24 bits bi-directional parallel I/O
- 19-bit address decoding, I/O port decoding, and dual bus interface brought out to expansion bus connector
- Can be directly attached to GT180 640x480 color graphics adapter
- Fully implemented SCSI hard disk and communications bus interface

FLOPPY/HARD DISK INTERFACE
- Uses Standard Microsystems 9266 disk controller
- Compatible with NEC 765A controller
- On-chip digital data separator
- Can control 3½", 5¼", and 8" floppy disk drives—up to 4 in any combination
- Handles both FM encoded (single density) and MFM encoded (double density) data
- NCR 53C80 SCSI bus controller for hard disk or network communication

SOFTWARE COMPATIBILITY
- CP/M, ZRDOS, ZCPR3 Compatible

SB180FX-1	SB180FX - 6.144 MHz computer board populated w/ 256K bytes RAM, 8K byte ROM monitor, without SCSI chip. Add $50.00 for 9 MHz.	[illegible]
SB180FX-1-30	SB180FX-1 computer board as described above with Z-System software including ZRDOS, ZCPR3, editor, utilities, ZAS assembler, and ZDM debugger, BIOS and ROM monitor sources, and BIOS for SCSI hard disk. Supplied on five 5¼" SB180 format DSDD disks.	[illegible]

SB180——$299.00
Single Board Computer

SB180-1	SB180 - 6.144 MHz single board computer w/256K bytes RAM and ROM monitor. Add $50.00 for 9 MHz	$299.00
SB180-1-20	Same as above w/ZCPR3, ZRDOS, BIOS and ROM sources	$399.00
COMM180-S	SCSI Hard Disk Interface	$150.00
SB180-1	OEM 100 QUANTITY PRICE	$195.00

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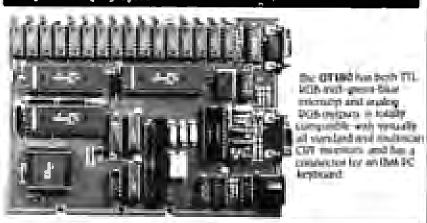

The GT180 offers these features:
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- Automatic translation of logical X-Y coordinates to physical frame buffer addresses
- Fast drawing speed of 2 million pixels per second
- Provides fully programmable horizontal split screens and window screen
- Fully supported by **GT180** Graphix Toolbox written in Modula-2

GT180-1	Graphic Display Expansion Board (TTL RGB only)	$395.00
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SB180
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SB180-U	Uniform Disk Format Conversion Software	$ 69.95
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SB180-MOD2	Turbo Modula 2	$ 69.00
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- 11 Graphic characters
- 25th line reverse video status display
- 21 escape functions
- 14 control functions
- Directly drives composite video or separated sync monitor
- All functions are firmware controlled. Source code available

EDITING FEATURES: typeover, clear to screen to space or null, erase to end of page, erase to end of line, absolute cursor addressing.

VIDEO ATTRIBUTES: reverse video, half intensity, double height, double width, underlined, blinking and blank characters.

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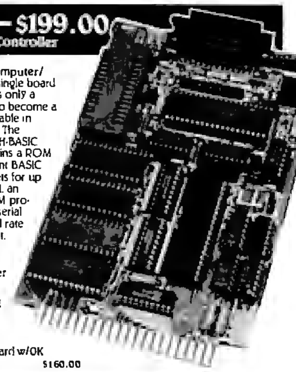

The MICROMINT **BCC52 Computer/Controller** is a stand-alone single board microcomputer which needs only a power supply and terminal to become a complete system programmable in BASIC or machine language. The **BCC52** uses the Intel 8052AH-BASIC microprocessor which contains a ROM resident 8K byte floating point BASIC interpreter. It contains sockets for up to 48K bytes of RAM/EPROM, an "intelligent" 2764/128 EPROM programmer, 3 parallel ports, a serial terminal port with auto baud rate selection, a serial printer port.

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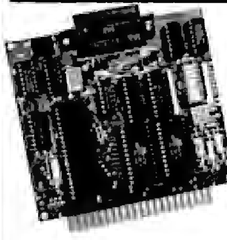

Features:
- Uses Z8 single chip microcomputer
- On board tiny basic interpreter
- 2 on board parallel ports & serial port
- 6 interrupts (4 external)
- Just connect a CRT and write control programs in Basic
- 6K Bytes of RAM or EPROM memory on board
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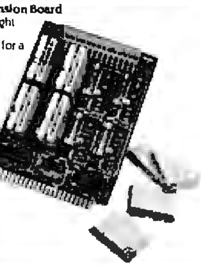

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fashion - they are still maskable via the NMI mask register. The new bus time-out mechanism and watchdog timers also cause NMI but can't be masked by this method. (Pause while I shuffle through a TRM - oh well, I saw it somewhere.) There is some method other than the PC NMI mask to shut off the watchdog timer. I thought it was via the BIOS, but now I can't find it. AHA! There it is: For PS systems (except the 30, of course), Int 15h with AH=C3h AL=00h disables the watchdog, and AL=01h enables it with BX=count. This would be subject to protection with a real OS so temporary masters would not be able to seize the bus forever.

---

ibm.ps/the.bus #55, from grr, Tue Jun 9 16:48:33 1987. A comment to message 52.

When your machine craps out, this gives it a more effective kick in the butt than the keyboard reset. Of course, if the software is the problem as opposed to a hardware glitch, you might get to reboot anyway, but at least you don't have to toggle the red switch. I don't know how well this works; the guy at the seminar said the machines were shipped with this feature disabled.

---

ibm.ps/the.bus #57, from matt.trask, Tue Jun 9 17:30:09 1987. A comment to message 55.

> When your machine craps out . . .

The bus time-out feature is supposed to save you in this situation. Presuming a real OS that knows about it, this is used to regain control from failed adapter cards that can then be shut off via the POS mechanism. This is also useful with intelligent devices that become bus masters and then crash while running on-board firmware/software.

---

ibm.ps/the.bus #58, from greenber, Tue Jun 9 19:23:42 1987. A comment to message 57.

Hmmmm. So I could set up an NMI intercept, which polls each card to see which one caused a crap-out, and disable it as required. . . .very interesting. . . .

---

ibm.ps/the.bus #59, from matt.trask, Wed Jun 10 11:49:07 1987. A comment to message 58.

> I could set up an NMI intercept . . .

That is probably the domain of an OS, not some TSR. It is also possible in software to "probe" a board via its slot address and get back a response (assuming the board is working, of course).

---

ibm.ps/the.bus #60, from greenber, Wed Jun 10 12:22:12 1987. A comment to message 59.

Well, that aspect (probing a board by its slot address) sounds like the real reason for all that board-numbering stuff.

---

ibm.ps/the.bus #61, from tmarshall (Trevor Marshall, Definicon Systems), Wed Jun 10 23:08:03 1987. A comment to message 60.

I got a call from the IBM address-allocation department today. They wanted ME to suggest a number, which, if it were free, they would allocate it. The catch was that unless I had a manual (which I don't think has been released yet) I couldn't look up the numbers. I told the guy to go recruit some other add-on developers.

---

ibm.ps/the.bus #62, from dmick (Dan Mick), Thu Jun 11 10:46:29 1987. A comment to message 61.

I guess I would, too. Geez, he wouldn't even give you any suggestions?

---

ibm.ps/the.bus #65, from tmarshall, Thu Jun 11 23:58:03 1987. A comment to message 62.

Nope. I asked him and he got very upset. You know, the usual "I only work here answering the phone" bit.

---

ibm.ps/the.bus #63, from matt.trask, Thu Jun 11 11:45:22 1987. A comment to message 61.

IBM reserves 0-32767 for internal use; you can choose from 32768-65535.

---

ibm.ps/the.bus #64, from jfleming (Jon Fleming), Thu Jun 11 20:57:21 1987. A comment to message 63.

But what about collisions?

---

ibm.ps/the.bus #70, from matt.trask, Sat Jun 13 08:55:28 1987. A comment to message 64.

In theory, if two boards have the same ID, they'd better be functionally identical. Matter of fact, the IBM guy said that we were welcome to use IDs from their boards if we develop clones. The gotcha is that software is allowed to make assumptions about boards based on the ID number.

---

ibm.ps/the.bus #78, from jfleming, Sun Jun 14 16:41:15 1987. A comment to message 70.

But let's say that three years from now I design a superfast MITS Altair emulation board or something that *nobody else in the world* is going to be functionally identical to; how do I pick a number that *nobody* else has ever grabbed? Is IBM going to maintain a register?

---

ibm.ps/the.bus #80, from grr, Sun Jun 14 19:23:10 1987. A comment to message 78.

At the tech seminar at COMDEX, the IBM guys sounded like they *would* register numbers and warn of any collisions. I'm not sure why they don't want to assign numbers; perhaps some political stance.

---

ibm.ps/the.bus #81, from matt.trask, Mon Jun 15 10:26:11 1987. A comment to message 78.

That's the theory. Actually, at the seminar, the guy said that they would maintain the number list "for awhile," the implication being that they would like someone else to volunteer their services. Sounds like a great opportunity for one of those companies that publishes lists of products - it'd give them a monopoly on knowing everything out there.

If there is a collision between two boards on IDs, the system can't recover; it uses the ID to "sleep" boards with conflicting port and memory needs. I guess they'd both just go to sleep.

---

ibm.ps/the.bus #66, from tmarshall, Thu Jun 11 23:58:43 1987. A comment to message 63.

Thanks, Matt. I wonder if he will still call me back?

---

ibm.ps/the.bus #82, from villi (Vilhjalmur Thorsteinsson), Tue Jun 16 00:12:39 1987. A comment to message 66.

It seems to me you're in a prime position to pick a good ID. . . say 40,000. And IBM has indeed officially said that it will keep the ID number register.

continued

THE CASE OF EXEC AND THE TEMPORARY DOS EXIT

ibm.pc/software #2739, from nickbaran (Nick Baran, BYTE), Tue May 19 12:58:43 1987.

A lot of programs these days provide a function for temporarily exiting to DOS. My understanding is that when you exit to DOS, a new copy of COMMAND.COM is loaded into memory. When you exit DOS *back* to your program, you type "Exit" at the DOS prompt. So, here's the question. What is the specific function in DOS for performing this operation, and, is there a "programmer's" term for it?

ibm.pc/software #2740, from rduncan (Ray Duncan), Tue May 19 13:13:08 1987. A comment to message 2739.

There isn't a specific operation in DOS to provide a new command processor; it's just a special case of the EXEC function (Int 21h Fn 4Bh). Your program must look in the environment for the COMSPEC string to find the disk location of COMMAND.COM, and then feed that to EXEC (after making sure enough unowned memory is available in the system so that COMMAND.COM can run).

ibm.pc/software #2748, from condorwizard (Jim Morgan), Wed May 20 02:48:33 1987. A comment to message 2740.

While we are talking about the EXEC function, I notice that any changes to the environment are not maintained after you exit each copy of COMMAND. How can you maintain a new variable across command-processor loads? I'd like to let my software know that something happened out there and set some new parameter to pass back to the lower- (or higher-) level processor. When I try it, it goes away with EXIT. Even when I put a dummy value in or change the dummy value to a real value, EXIT does not work.

ibm.pc/software #2749, from dmick, Wed May 20 03:09:33 1987. A comment to message 2748.

You can't. EXECing a program passes a copy of the environment, as Ray noted; EXITing the COMMAND.COM or terminating the child program loses the environment. There are ways to hunt for the "root" environment. . .take a look at tech.support/synopsis, somewhere in the first couple of messages, for one way. You can also look at the "snoop" code Ray Smith just uploaded recently (or will soon) or the MAPMEM.PAS module of the tsrsrc21.arc file for a clue as to how to locate COMMAND.COM and its environment (the first copy). This has to be the most common question on BIX, though, and it's all due to the half-usefulness of the environment under DOS.

Since I know it's a Unix feature, is there a way, oh Unix gods, to set the root environment from a child in that system?

ibm.pc/software #2750, from mjguz (Mark Guzdial), Wed May 20 09:00:37 1987. A comment to message 2749.

>set the root environment from a child in that system?

I took the Bell Labs shell programming course some time ago, and at least at that time, it was impossible. At least in the Bourne shell, all scoping is downward - you can change anything you want at a lower level, but everything bounces back to its original shape as you come back up.

continued

ibm.pc/software #2751, from rimorrisjr (Richard Morris), Wed May 20 13:10:28 1987. A comment to message 2750.

> Setting environment in Unix

Far as I know, that's right. Environment is singular. I suppose that a Supreme Kernel Hacker 3rd Class could track back through the PPIDs of a process to find the root process.

ibm.pc/software #2752, from dmick, Wed May 20 15:56:57 1987. A comment to message 2751.

Well, at least it wasn't MS's boo-boo then. Seems like a universally accessible environment would be of more use.

ibm.pc/software #2753, from patwood (Patrick Wood), Wed May 20 17:53:39 1987. A comment to message 2752.

Unix, being a multiuser system, allows the environment to be changed for a user at log-in time via the .profile. This fixes only that user's environment for all his or her processes.

ibm.pc/software #2754, from dmick, Wed May 20 19:16:02 1987. A comment to message 2753.

Better than nothing, surely, but still it would be nice to have programmatic control of a system-reserved and system-used parameter area like the environment. A wonderful way to pass parameters that don't warrant file overhead.

ibm.pc/software #2741, from jlonie (Joseph Lonie), Tue May 19 16:21:03 1987. A comment to message 2739.

>Exiting to DOS. . .

This operation is often referred to as "shelling" to DOS. When you use Int 21h Fn 4Bh to load and run a second (or third, or fourth. . .) copy of COMMAND.COM, DOS in effect isolates you from the task you shelled from, giving you a *copy* of the environment area to play with. That is, the descendant COMMAND.COM task inherits the environment from the parent task; any changes the descendant task performs to the environment (e.g., via the SET command) affect only the descendant's copy, not the parent's copy. Rduncan's point on making sure there is enough free memory is very important if you're writing software that will provide a shell operation. Many older compiler/linkers (and some new ones!) put a word in the .EXE file header that instructs DOS that this task uses all available memory. DOS will believe this, whether it is true or not, and you will have to free up some memory via int 21h Fn 4Ah or you will trash the system-memory arena, as the Tech Ref puts it.

ibm.pc/software #2744, from dmick, Tue May 19 18:23:35 1987. A comment to message 2741.

Actually, you can't do an EXEC if you don't have the memory, I believe. Also, the .COM files use all available memory by default. You can do a direct shrink with .EXE files or use the MAXALLOC field (see the /CPARMAXALLOC option for the linker for more info).

ibm.pc/software #2758, from geary (Michael Geary), Thu May 21 05:14:36 1987. A comment to message 2739.

If you would like some sample code for the EXEC function, take a look at tech.support/long.messages #9 and #10. It's a MASM program that demonstrates using the EXEC function, both to run COMMAND.COM and to run other programs.

These names do get confusing - assembler types tend to call the function EXEC, but if you write some C code, don't try to use the execxx() functions in the C library to do that - they do something else entirely! The C functions for this operation are called spawnxx(), where xx is different for the various flavors of the function. ■

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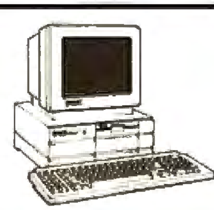

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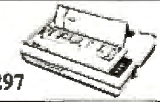

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TMS2532A	4096 x 8	(450ns) 21V	6.49
TMS2564	8192 x 8	(450ns) 25V	8.95
2708	1024 x 8	(450ns)	4.95
TMS2716	2048 x 8	(450ns) 3 Voltage	9.95
2716	2048 x 8	(450ns) 25V	3.75
2716-1	2048 x 8	(350ns) 25V	4.95
27C16	2048 x 8	(450ns) 25V (CMOS)	6.49
2732	4096 x 8	(450ns) 25V	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
27C32	4096 x 8	(450ns) 25V (CMOS)	6.49
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	4.25
2764-45	8192 x 8	(450ns) 21V	3.49
27C64-15	8192 x 8	(150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8	(200ns) 21V	5.95
27128-25	16,384 x 8	(250ns) 21V	5.25
27128A-25	16,384 x 8	(250ns) 12.5V	4.95
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-20	32,768 x 8	(200ns) 12.5V	6.95
27256-25	32,768 x 8	(250ns) 12.5V	5.95
27C256-25	32,768 x 8	(250ns) 12.5V (CMOS)	8.95
27512-20	65,536 x 8	(200ns) 12.5V	19.95
27512-25	65,536 x 8	(250ns) 12.5V	16.95
68764	8192 x 8	(450ns) 25V	15.95

EEPROMS

Part No.			Price
2816A	2 48 x 8	(350ns) 5V Read/Write	5.95
2817A	2048 x 8	(350ns) 5V Read/Write	8.95
2865A	8192 x 8	(250ns) 5V Read/Write	14.95
52B13 (21V)	2048 x 8	(350ns) 5V Read Only	1.69

COMMODORE CHIPS

Part No.	Price
WD1770	14.95
SI-3052P	5.95
6502	2.25
6504A	1.95
6507	3.49
6510	9.95
6520	1.75
6522	2.95
6525	4.95
6526	14.95
6529	2.95
6532	6.49
6545-1	2.49
6551	3.29
6560	10.95
6567	14.95
6569	10.95
6572	10.95
6581 (12V)	14.95
6582 (9V)	14.95
8360	10.95
8501	10.95
8502	5.95
8563	15.95
8564	12.95
8566	15.95
8701	9.95
8721	14.95
8722	7.95
*251104-04	10.95
318018-03	15.95
318019-03	15.95
318020-04	15.95
325302-01	15.95
*325572-01	24.95
*82S100PLA**	13.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	15.95

*No specs. available
**Note: 82S100PLA = U17 (C-64)

SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interlaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321N. $11.95

INTERSIL Also Available!

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	.99
74HC04	.29	74HC240	.79
74HC08	.29	74HC244	.79
74HC10	.29	74HC245	.89
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC595	1.19
74HC85	.79	74HC688	.79
74HC86	.39	74HC943	8.95
74HC123	.89	74HC4040	.89
74HC125	.49	74HC4049	.59
74HC132	.49	74HC4050	.59
74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74HCT — CMOS TTL

Part No.	Price	Part No.	Price
74HCT00	.29	74HCT139	.59
74HCT02	.29	74HCT157	.69
74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
74HCT138	.59	74HCT374	1.19

74C—CMOS

Part No.	Price	Part No.	Price
74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.49
74C08	.35	74C240	1.29
74C10	.35	74C244	1.29
74C14	.49	74C373	1.49
74C32	.35	74C374	1.49
74C74	.59	74C912	7.95
74C85	1.39	74C915	1.39
74C86	.35	74C920	9.95
74C89	5.19	74C921	9.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

Part No.	Price	Part No.	Price
DS0026CN	1.95	LM1458N	.39
TL074CN	.89	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-ICN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.85
LM311N	.45	MC1648P	4.95
LM317T	.79	LM1871N	2.95
LM318N	.99	LM1872N	2.95
LM319N	.99	LM1896N-1	1.59
LM323K	3.95	ULN2003A	.99
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	DS26LS29CN	4.49
LM348N	.69	DS26LS31CN	1.19
LM350T	2.95	DS26LS32CN	1.19
LF351N	.39	DS26LS33CN	1.95
LF353N	.49	LM2901N	.49
LF355N	.79	LM2907N	2.49
LF356N	.79	LM2917N (8 pin)	1.55
LF357N	1.09	MC3419CL	9.95
LM358N	.49	MC3446N	2.95
LM360N	2.19	MC3450P	2.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	4.95
LM386N-3	.99	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
LF497ACN	2.69	LM3909N	.99
NE540H (C540H)	2.95	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XR-L555	.75	NE5532	.89
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.69	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350	1.49	7905K (LM320K-5)	1.35
MC1372P	2.49	7905T (LM320T-5)	.59
MC1377P	3.19	75472	.99
MC1398P	8.95	75477	1.29
LM1414N	1.29	MC145106P	3.49
		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8 pin LP	.11	8 pin WW	.59
14 pin LP	.12	14 pin WW	.65
16 pin LP	.13	16 pin WW	.69
24 pin LP	.25	24 pin WW	1.19
28 pin LP	.27	28 pin WW	1.39
40 pin LP	.29	40 pin WW	1.89

Soldertail Standard (Gold & Tin) & Header Plug Sockets Also Available

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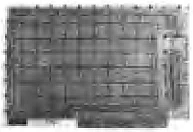
Jameco General Purpose NEW! Prototype PC Boards



- Wire Wrap
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection

JE417 (Pictured)

JE411 (8½", No Pads, Gen. Purp.) $12.95
JE415 (6½", No Pads, PC/XT) $14.95
JE417 (6½", Plated w/Pads, PC/XT) $19.95

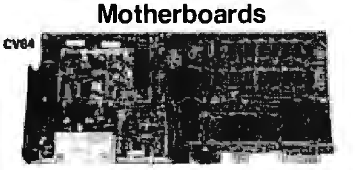
Extender Boards Designed for Troubleshooting and Testing

JE419 (Pictured)

JE419 (5¼" Extender, 22/44 Connector) . . $19.95
JE421 (4¾" Extender, 31/62 Connector) . . $19.95

Commodore VIC-20 and C-64 Motherboards

CV64



May have to troubleshoot or just use for spare parts.
CV20 Includes: (1) 6560, (2) 6522, (1) 6502, (2) 6116P-4, and much more!
CV64 Includes: (1) 6567, (1) 6581, (1) 6510, (1) 82-S100PLA, (1) 901227-03, (2) 6526, and much more!

CV20 (VIC-20 Motherboard) $14.95
08903-3 (SAMS VIC-20 Schematics) . . . $19.95
CV64 (C-64 Motherboard) $49.95
08906-8 (SAMS C-64 Schematics) $19.95

Additional Commodore Accessories

*CM-1 (300B Modem VIC-20, C-64) . $19.95
*JE232CM (RS232 Inter. VIC-20, C-64) . . $39.95
CPS-10 (C-64 Power Supply) $39.95
CPS-128 (C-128 Power Supply) $59.95
*Also compatible with C-128 in 64 mode only.

ZUCKERBOARD TANDY 1000 Expansion Memory Half Card

Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TAN-EM512K Includes 512K RAM $119.95
TAN-C Plug-In Clock option chip (only) $39.95

SALE! 20Meg Hard Disk SALE!

T20MB 20MB Hard Disk Drive Board for Tandy 1000 . . ~~$579.95~~ $494.95
SX20MB 20MB Hard Disk Drive Board for Tandy 1000SX ~~$589.95~~ $499.95

TANDY 1000 Multifunction Board with Clock Calendar

Expand the memory on your Tandy 1000 (128K Version) to as much as 640K. Complete with an RS232 port, clock/calendar, RAM Disk, Printer Spooler and on-board DMA controller chip.

MTAN-512K Includes 512K RAM . . $199.95

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Jameco's IBM™ AT Compatible Kit! Mini-286 6/8/10/12 MHz Kit!

JE1059 $569.95 EGA Monitor & Card (not included)

Part No.	Description	Price
JE1015	XT/AT Style Keyboard	$ 59.95
41256-120	512K RAM (18 Chips)	$ 71.10
JE1012	Baby AT Flip-Top Case	$ 79.95
JE1032	200W Power Supply	$ 99.95
JE1022	5¼" High Density Disk Drive	$119.95
JE1045	Hard Disk/Floppy Controller	$199.95
JE1003	Baby AT Motherboard (Zero-K RAM-Incl. Award BIOS ROM)	$449.95

NEW! Regular List $1,080.80
SAVE $105.85!

JE1008 IBM™ AT Compatible Kit $974.95
JE1059 EGA Monitor & Card SAVE $30.00 . . $569.95

Jameco's IBM PC/XT Compatible Kit

SAVE $90.35

Part No.	Description	Price
4164-150	128K RAM (18 Chips)	$20.70
IBM-FCC	Floppy Controller Card	$34.95
IBM-Case	Flip-Top Case	$34.95
JE1015	XT/AT Style Keyboard	$59.95
JE1030	150 Watt Power Supply	$69.95
JE1050	Mono/Graph. Crd. w/P.Port	$69.95
JE1020	5¼" DSDD Disk Drive	$99.95
IBM-MON	12" Mono. Green Monitor	$99.95
IBM-MB	XT Motherboard (Zero-K RAM-Incl. DTK/ERSO BIOS ROM)	$99.95

FREE! QUICKSOFT PC WRITE WORD PROCESSING SOFTWARE INCLUDED!

Regular List $590.30

JE1004 (IBM™ PC/XT Compatible Kit) $499.95

Jameco's 4.77/8MHz Turbo IBM Compatible Kit

Same as JE1004 except comes with 640K RAM, TURBO 4.77/8MHz motherboard, JE1071 multi I/O with controller and graphics, and AMBER monitor.

SAVE $146.50 Regular List $746.45

JE1005 (IBM™ PC/XT Turbo Compatible Kit) . $599.95

IBM Compatible Motherboards

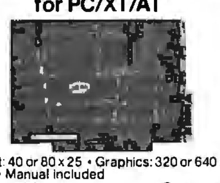
- 4.77/8MHz operation (Turbo only)
- 8087 Math Co-processor capability
- BIOS ROM included

SALE!

TURBO 4.77/8MHz . . . ~~$129.95~~ $119.95
IBM-MB 4.77MHz . . . . ~~$109.95~~ $ 99.95

Additional Add-Ons Available!

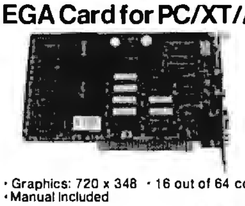
Color Graphics Card for PC/XT/AT



• Text: 40 or 80 x 25 • Graphics: 320 or 640 x 200 • Manual included

JE1052 . . . . $59.95

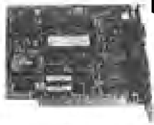
EGA Card for PC/XT/AT



• Graphics: 720 x 348 • 16 out of 64 colors • Manual included

JE1055 . . . . $199.95

I/O Cards for PC/XT/AT



- Printer Port
- RS232 Port
- Game Port
- Manual included

JE1060 (Pictured)

JE1060 I/O for XT $69.95
JE1065 I/O for AT $69.95

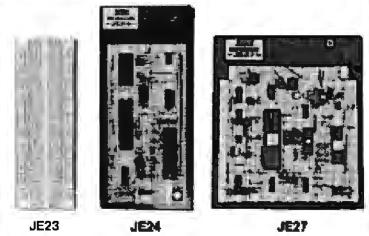
Multi I/O w/Controller & Graphics for PC/XT

• Printer port • RS232 port • Floppy controller • Graphics • Manual included

JE1071 . . . . $159.95

Jameco Solderless Breadboard Sockets

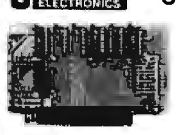
NEW



JE23 JE24 JE27

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
JE20	6½ x 3⁄8	100	0	$ 2.49
JE21	3¼ x 2⅛	400	0	$ 4.95
JE22	6½ x 1⅜	630	0	$ 6.49
JE23	6½ x 2⅛	830	0	$ 7.49
JE24	6½ x 3⅛	1,360	2	$13.95
JE25	6½ x 4¼	1,660	3	$24.95
JE26	6⅞ x 5¾	2,390	4	$29.95
JE27	7¼ x 7½	3,220	4	$39.95

Jameco Extended 80-Column Card for Apple *IIe*



• 80 Col./64K RAM • Doubles amount of data your Apple *IIe* can display as well as its memory capacity • Ideal for word processing • Complete with instructions

JE864 $59.95

ADD-12 (Disk Drive II, II+, *IIe*) $99.95

Additional Apple Compatible Products Available

NEW! Seagate 20, 30 & 40MB Half Height Hard Disk Drives

ST225K (Pictured)

ST225 20MB Drive only (PC/XT/AT) $274.95
ST225K 20MB w/Controller (PC/XT) $339.95
ST238K 30MB w/Cont. (PC/XT/AT) . . $399.95
ST251XT 40MB w/Cont. Card (PC/XT) . $599.95
ST251AT 40MB w/Cont. Card (AT) . . . $659.95

Jameco PC/XT & AT Compatible Disk Drives

JE1022 (Pictured)

JE1020 (360K Drive, PC/XT/AT) . . . $ 99.95
JE1022 (1.2MB, AT Compatible) . . . $119.95

DATA BOOKS

30003 National Linear Data Book (82) $14.95
30005 Logic Data Book - Vol. II (84) $14.95
30009 Intersil Data Book (86) . . . . $ 9.95
30032 National Linear Supplement (84) . . . . . S 6.95
210830 Intel Memory Handbook (87) $17.95
230843 Intel Microsystem Hndbk. Set (87) $24.95

MUFFIN/SPRITE-STYLE FANS

MUF60 . . . . $9.95
Torin Industries (4.68" sq., 60 cfm)
SU2A1 . . . . $8.95
EG&G Rotron (3.125" square, 20 cfm)

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Inquiry 36

Inquiry 67

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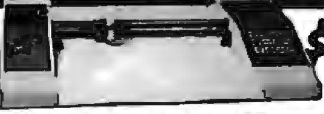

$129 PLOTTER

The Sweet "P" 100 was private labeled for the Epson corporation under the Comrex Brand. This plotter makes short work of translating financial and numeric data into a graphic presentation. Many ready to run programs such as Auto/CAD and Lotus 1-2-3 already support this plotter.

The Sweet "P" 100 features programmable paper sizes up to 8½ by 120 inches, 6 inch per second plot speed and 0.004" step size. Easy to implement Centronics interface allows the Sweet "P" 100 immediate use with the printer port of most personal computers.

This is your opportunity to purchase a plotter which was originally priced at $795 for only $129.

Also available is a support package which includes demonstration software, interface cable, a multicolor pen assortment and a variety of paper and transparency material.

PLOTTERS

Sweet "P" 100 (Comrex) 8½ by 120"	[illegible]	[illegible]	959
Houston Instruments DMP29, 11 by 17	[illegible]	[illegible]	7699
Houston Instruments DMP40, 11 by 17, 8 size	[illegible]	[illegible]	659
Houston Instruments DMP41/42C/D24 by 36	[illegible]	[illegible]	419
Houston Inst. DMP51/52MP C/D, 14 pen	[illegible]	[illegible]	99
Houston Instruments DMP56, E size 34 by 44	[illegible]	[illegible]	139
Houston Instr. PC695, 11 by 17 multi-pen	[illegible]	[illegible]	129

Free Interface Kit

~~$2495~~ $759 80 Character Daisy Wheel Printer

These Fujitsu Daisy Max 830 were manufactured for Motorola's Computer Division. The purchase order was canceled and Fujitsu was forced to liquidate these 80 character per second daisy wheel printers at "fire sale" prices.

Features: bullet proof construction, serial RS-232 interface, Diablo 630 wheels and commands, programmable line spacing in increments of 1/96" and column spacing of 1/120". The printer is also capable of underscoring, bold overprint, shadow print, centers and justifies along with vector plotting.

Factory suggested price of the Daisy Max 830 was $2495. California Digital is offering this liquidated special at only $759 and including FREE a serial card kit with cable. Also available: tractor and sheet feeders.

COLOR GRAPHICS TERMINAL

~~$3995~~ $659

The Lear Siegler 7107 color graphics terminal is both DEC (VT-100 / VT-51) and Tektronix (4010/4014) compatible.
The terminal offers a palette of 4,096 colors with a resolution of 640 by 480 pixels on a 13 inch non-glare black screen.
Horizontal pan and image zoom, to 16 times original size, are standard features of this color graphics terminal.
The 7107 is the ideal terminal for CAD/CAM applications.

PRINTERS

IBM Thermal printer, 80col., serial	[illegible]	Panasonic P1592 15" 180 cps.	[illegible]
Fujitsu D830 80cps., daisy wheel serial	759	StarGemini NX10, 120cps 10" NLQ.	239
Silver Reed EXP-800 136col., 40cps.	729	Star Gemini NX15, 120cps 15" NLQ.	359
Juki 6300 daisy wheel 40 cps.	[illegible]	Toshiba 321, 24 wirehead 216 cps; NLQ.	519
NEC8850 Spinwriter daisy wheel 55 cps.	1159	Toshiba 341, 24 wirehead 216 cps. 15".	629
NEC P6/660P 10" 216 cps. NLQ.	469	Printronics P300 dot matrix, 300 LPM	3995
NEC P7/760P 15" 216cps NLQ.	659	Printronics P600 dot matrix, 600 LPM	5795
EpsonFX86E NLQ 10" 240 char/sec.	399	Dataproducts B600/3 band ptr, 600 LPM	6985
EpsonFX286E NLQ 15" 240char/sec	539	LASER PRINTERS	
Epson EX1000 300cps. NLQ/54 cps.	599	Apple Laser Writer Plus; Postscript	4295
Citzen MSP-10 160cps. 10"	299	QMS PS/800 2 meg. Postscript, 8 pgs.	4295
CitzenMSP-15 160cps. 15"	449	Hewlett Packard Series II, laser printer	1795
Okidata 182 80column, par'l.	239	TexasInstr. OmniLaser 2108 P/S, 8pgs	4295
Okidata 192+ 136column, par'l.	345	TexasInst. OmniLaser 2115 P/S. 15pgs	5595
Okidata292 136column, parellel.	449	Quadram Quad/Laser, 5 Megabytes	2995
Panasonic P1080i 10" 120 cps	229	ASTTurbolaser, 8pages/minute.	3195
Panasonic P1091i 10" 160 cps	229		

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Omni-Reader... the first optical character reader designed and priced for the small computer

$159

COPY:
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APPLICATIONS:
·Mailing Lists ·Editing ·Data Base Management ·Transfering information between incompatible systems

Uses a standard RS-232 serial port hookup to interface ealsity with your computer.

20/20 Bernoulli Box

~~$3495~~ $1595

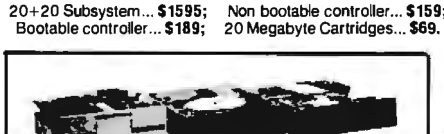
California Digital has purchased these 20/20 Bernoulli systems from Iomega. The units needed some minor alignment and had to be sent back to Iomega. These have to sold as as reconditioned... but for all practical purpose they are new and come with a **one year Iomega factory warranty.**

The 20/20 Bernoulli Box features removable cartridges, and delivers reliability, expandability, transportability, security and speed in one versatile subsystem. It lets you transfer megabytes of information safely and swiftly for primary or backup storage. Or combine several software programs onto a single cartridge for easy switching from one to another.

Reliable... the Box has incredible resistance to shock and vibration completely eliminating the possility of head crash.

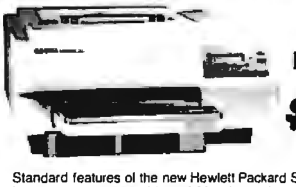
security essential? Don't lock up your system... just lock up the cartridges.

20+20 Subsystem... **$1595;** Non bootable controller... **$159;**
Bootable controller... **$189;** 20 Megabyte Cartridges... **$69.**



HEWLETT PACKARD LASER JET II

$1795



Standard features of the new Hewlett Packard Series II Laser printer: 512 K byte memory expandable to 4 Megabytes, both serial and parallel ports. List price $2495 California Digital price $1795. Memory upgrade, type fonts and toner cartridges available.

Other Laser Printers available:
**Texas Instruments ● Okidata ● Apple ● Ricoh
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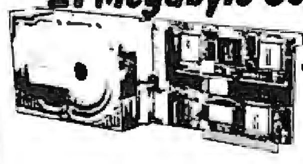
Quadram ● Centronics ● CIE C.Itoh ● DataProducts**

21 Megabyte Gold Card

$459



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$35

We have them again... The Remex 480 was a sell out two years ago but we located an additional 10,000 units and are offering these 2/3 height IBM/PC compatible 360K/Byte drives at only $35 each at quantity two.

115

The Panasonic 475 is jumper selectable between 96 TPI format and 1.2 Megabyte as used in the IBM/AT computer.
Suggested price of the 475 is $189 but California Digital located a computer manufacturer that had to liquidate stock making available 1000 of these choice drives. Quantity two $115 each.

	One	Two	Ten
REMEX 480 ⅔ height for PC	39	35	call
TANDON 65L/2 360K, ½ ht.	79	75	72
MITSUBISHI 4853 96 TPI.	99	95	92
MITSUBISHI new 501 half ht.	119	109	105
MITSUBISHI 504A AT comp.	149	139	135
TEAC FD55BV half height	109	99	89
TEAC FD55FV 96 TPI, half ht.	119	109	105
TEAC FD55GF for IBM AT	149	139	135
PANASONIC 455 Half Height	109	99	89
PANASONIC 475 1.2 Meg./96	119	115	109
Switching power supply			49
Dual enclosure for 5¼" drives			59

SONY $139

The Sony 53W is a 3½ inch double sided double density disk drive. The drive can be connected to your existing floppy controller but will require MS/DOS 3.2 to properly operate in the PC and compatibles. The 53W is similar to the drive being used in the PC portable.

$495 DEC/TS03 Tape Drive

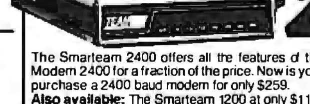
Manufactured by Kennedy Magnetics for Digital Equipment
Kennedy Model 9700 features BPI, 12.5 IPS, ninetrack with seven inch reels. Original price over $3000.
Other tape drives available: Pertec ● Wangco ● Perkin Elmer.

U.S. Robotics 2400

$189

The US Robotics Micro 2400 modem is one hundred percent Hayes compatible, auto dial, auto answer, auto everthing, loud-speaker included. A super value at only $189

Smarteam 2400



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The Smarteam 2400 offers all the features of the Hayes Smart Modem 2400 for a fraction of the price. Now is your opportunity to purchase a 2400 baud modem for only $259.
Also available: The Smarteam 1200 at only $119

MODEMS

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Signalman Mark VI, 300 baud internal PC.	35

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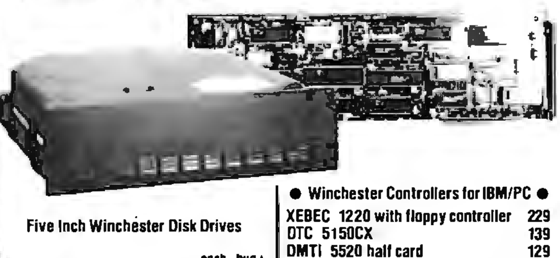
30 MEGABYTE WINCHESTER HARD DISK KIT



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SEAGATE 4051 51 M. 35mS.	695	659
SEAGATE 4096 96 M. 35mS.	959	829
FUJITSU 2242 55 M. 35mS.	1399	1329
FUJITSU 2243 86 M. 35mS.	1895	1819
RODIME RO-202E 27 Meg.	495	479
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RODIME RO-204E 53 Meg.	995	959
CONTROL DATA 94155-86 M.	1829	1779
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Or you can get our FREE expanded information package.

The choice is yours.

I'd like to see you in the office and computer supply business because it would be good for both of us.

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☐ Yes! Enclosed is my check or money order for $ 24.95. Please send me a copy of "Making Money In Office And Computer Supplies". I understand that I may return it within 10 days for a full refund for any reason whatsoever.

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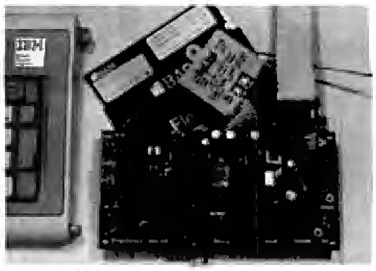

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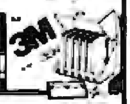

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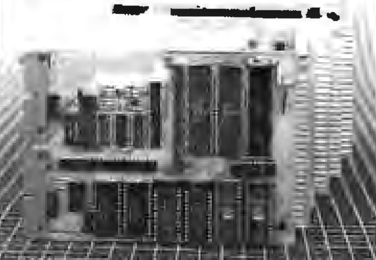

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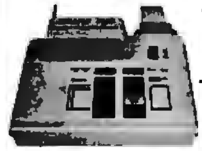

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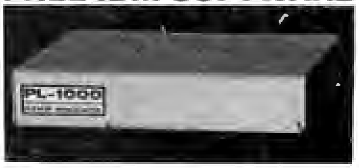

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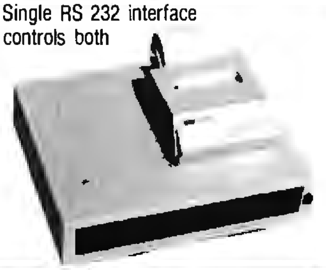

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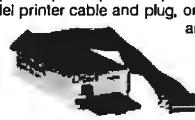

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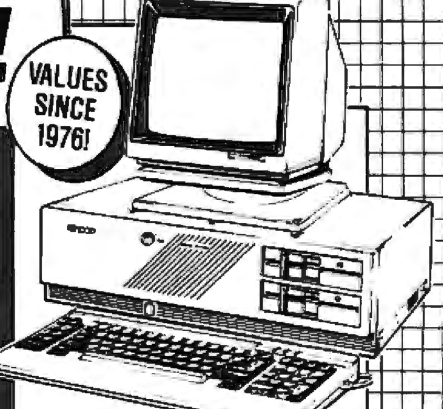

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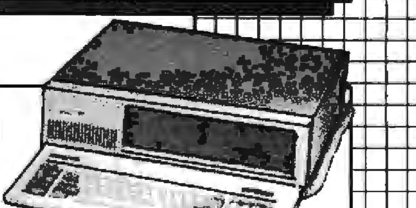

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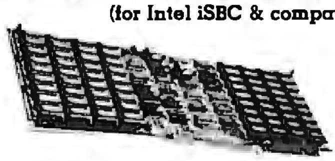

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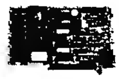
 Monographics adapter with printer port	 IBM® EGA, CGA, MDA compatible	 132 Column • Alphanumeric IBM® EGA, CGA, MDA compl. Super hi-res. 640×480 640×350, 720×348
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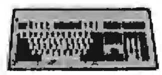
MAXI SWITCH  Enhanced 101 Key $75.00 XT/AT 84 Key $85	KX-P1080I 120cps, NLQ ....$195 KX-1091I 160cps/32cps NLQ ....$345 KX-1092 180cps/33cps NLQ ....$295 KX-1592 180cps/38cps NLQ ....$409 KX-1595 240cps/51cps NLQ ....$530 KX-P3131 17cps Daisywheel ....$245 KX-P3151 22cps LQ Parallel Printer...$382	DIRECT REPLACEMENT IBM XT, AT  200W AT Power Supply $139 150 W XT Power Supply $ 89

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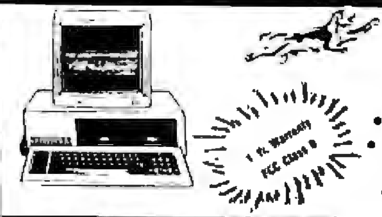

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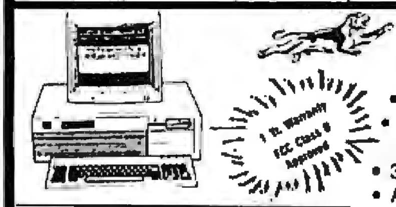

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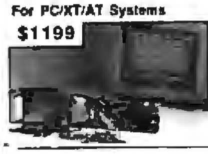

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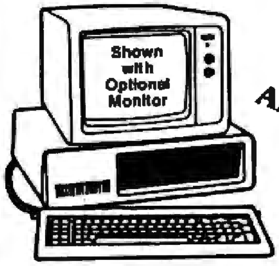

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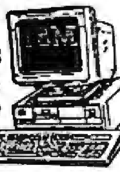

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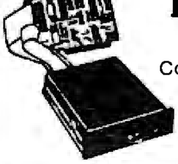

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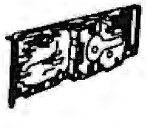

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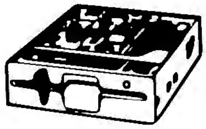

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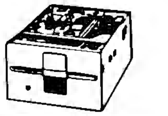

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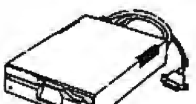

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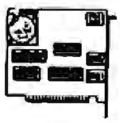

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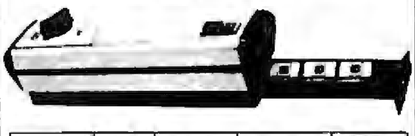

Model	Timer	Capacity Chip	Intensity (uW/Cm²)	Unit Price
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10.738635	1.95
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74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
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74LS153	.39	74LS684	3.20
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74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
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74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
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74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
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74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
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74HCT158	.99	74HCT4017	2.19
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74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
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4020	.59	4526	.79
4021	.69	4527	1.95
4024	.49	4528	.79
4025	.25	4529	2.95
4027	.39	4532	1.95
4028	.65	4538	.95
4035	.69	4541	1.29
4040	.69	4553	5.79
4041	.75	4585	.75
4042	.59	4702	12.95
4043	.85	74C00	.29
4044	.69	74C14	.59
4045	1.98	74C74	.59
4046	.69	74C83	1.95
4047	.69	74C85	1.49
4049	.29	74C95	.99
4050	.29	74C150	5.75
4051	.69	74C151	2.25
4052	.69	74C161	.99
4053	.69	74C163	.99
4056	2.19	74C164	1.39
4060	.69	74C192	1.49
4066	.29	74C193	1.49
4069	.19	74C221	2.49
4076	.59	74C240	1.89
4077	.29	74C244	1.89
4081	.22	74C374	1.99
4085	.79	74C905	10.95
4086	.89	74C911	8.95
4093	.49	74C917	12.95
4094	2.49	74C922	4.49
14411	9.95	74C923	4.95
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7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
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TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
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LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3130E	.99
LM339	.59	CA3146	1.29
LM340	see 7800	CA3160	1.19
LM350T	4.60	MC3373	1.29
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.69
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

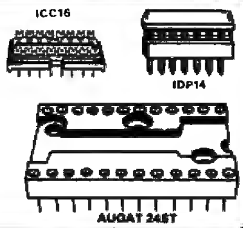
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

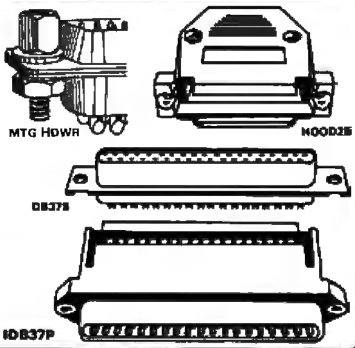
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP02	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	2.25
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	—	1.95	2.65	—
	FEMALE	DBxxSR	1.25	1.55	—	2.00	2.79	—
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	—	3.89	5.60	—
	FEMALE	DBxxSWW	2.76	4.27	—	6.84	9.95	—
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	—	3.98	5.70	—
	FEMALE	IDBxxS	2.92	3.20	—	4.33	6.76	—
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	—	—
	GREY	HOODxx	.65	.65	—	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	9.95

DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
BCD OUTPUT	10 POSITION 6 PIN DIP	1.95

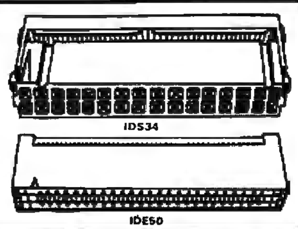
DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.38	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

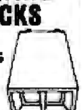
HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER, ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS



5/$1.00

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- ★ QUALITY MERCHANDISE, COMPETITIVE PRICES
- ★ MOST ORDERS SHIPPED WITHIN 24 HOURS
- ★ FRIENDLY, KNOWLEDGEABLE STAFF
- ★ MONEY BACK GUARANTEE (ASK FOR DETAILS)
- ★ TOLL FREE TECHNICAL SUPPORT
- ★ EXCELLENT CUSTOMER SERVICE

CALL FOR VOLUME QUOTES

MODEM 1200 BAUD 79^{95} — FOR IBM WITH SOFTWARE — MODEM 2400 BAUD 179^{95}

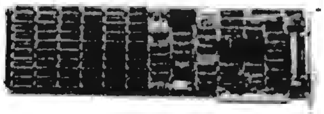
MULTIFUNCTION CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-MF $79.95

ALL THE FEATURES OF AST'S SIX PACK PLUS AT HALF THE PRICE!

- 0-348K DYNAMIC RAM USING 4164s
- INCLUDES SERIAL PORT, PARALLEL PRINTER PORT, GAME CONTROLLER PORT AND CLOCK/CALENDAR
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR



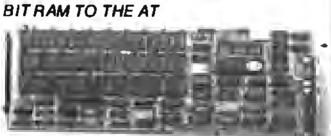
MCT-ATMF $139.95

ADDS UP TO 3 MB OF 1 BIT RAM TO THE AT

- USER EXPANDABLE TO 1.5 MB OF ON-BOARD MEMORY (NO MEMORY INSTALLED)
- FLEXIBLE ADDRESS CONFIGURATION
- INCLUDES SERIAL PORT AND PARALLEL PORT
- OPTIONAL PIGGYBACK BOARD PERMITS EXPANSION TO 3 MB

ATMF-SERIAL 2nd SERIAL PORT $24.95

MCT-ATMF-MC $29.95 - PIGGYBACK BOARD (ZERO K INSTALLED)

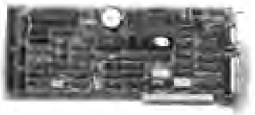


MCT-MIO $79.95

A PERFECT COMPANION FOR OUR MOTHERBOARD

- 2 DRIVE FLOPPY DISK CONTROLLER
- INCLUDES SERIAL PORT, PARALLEL PORT, GAME PORT AND CLOCK/CALENDAR WITH BATTERY BACK-UP
- SOFTWARE FOR A RAMDISK, PRINT SPOOLER AND CLOCK/CALENDAR

MIO-SERIAL 2nd SERIAL PORT $15.95



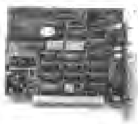
MCT-IO $59.95

USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OT LPT2 (x378 OR x278)
- CLOCK/CALENDAR WITH A BATTERY BACK-UP

IO-SERIAL 2nd SERIAL PORT $15.95

SHORT SLOT



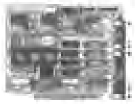
MCT-ATIO $59.95

USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED

- SERIAL PORT ADDRESSABLE AS COM1, COM2, COM3 OR COM4
- PARALLEL PRINTER PORT ADDRESSABLE AS LPTA OR LPTB (x378 OR x278)
- GAME PORT
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION IN AN AT

ATIO-SERIAL 2nd SERIAL PORT $24.95

SHORT SLOT



RAM CARDS

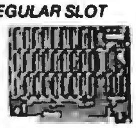
FROM MODULAR CIRCUIT TECHNOLOGY

MCT-RAM $59.95

A CONTIGUOUS MEMORY SOLUTION FOR YOUR SHORT OR REGULAR SLOT

- SHORT SLOT, LOW POWER PC COMPATIBLE DESIGN
- CAN OFFER UP TO 576K OF ADDITIONAL MEMORY
- USER SELECTABLE CONFIGURATION AMOUNTS OF 192, 384, 512, 256 & 576K, USING COMBINATIONS OF 64 & 256K RAM

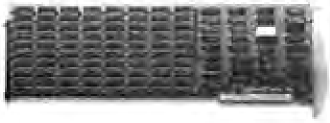
SHORT SLOT



MCT-EMS $129.95

2MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR THE XT

- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- USES 64K OR 256K DYNAMIC RAM (NO MEMORY INSTALLED)
- USE AS EXPANDED OR CONVENTIONAL MEMORY, RAMDISK OR SPOOLER
- SOFTWARE INCLUDES EMS DEVICE DRIVERS, PRINT SPOOLER AND RAMDISK

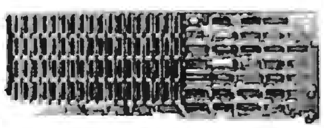


MCT-ATEMS $139.95

CAN BE USED FOR CONVENTIONAL, EXPANDED OR EXTENDED MEMORY

- A FINE EXAMPLE OF FLEXIBILITY: OFFERS EXTENDED (AT MEMORY) OR EXPANDED (LIM/EMS) MEMORY AS WELL AS THE ABILITY TO FILL OUT CONVENTIONAL (640K) MEMORY
- 2 MEGABYTE CAPACITY IN A SINGLE SLOT
- RAMDISK, PRINT SPOOLER AND LIM/EMS SOFTWARE INCLUDED
- SPECIAL MEMORY MAP ANALYSIS INCLUDED

MCT-ATEMS-MC $34.95 PIGGYBACK BOARD (ZERO K INSTALLED)



Seagate

HALF HEIGHT HARD DISK DRIVES

40 MB — *Model ST-251 5¼" half height FAST 40ms access time* — **$469**

60 MB — *Model ST-277 5¼" half height FAST 40ms access time (RLL)* — **$649**

HALF HEIGHT HARD DISK SYSTEMS

20 MB — **$299**

30 MB — **$329**

Systems include half height hard disk drive, hard disk drive controller, cables and instructions. All drives are pre-tested and warranted for one year.

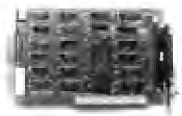
DISK CONTROLLER CARDS

FROM MODULAR CIRCUIT TECHNOLOGY

MCT-FDC $29.95

QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT

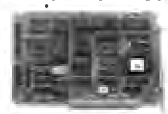
- INTERFACES UP TO 4 FDDs TO AN IBM PC OR COMPATIBLE
- INCLUDES CABLING FOR 2 INTERNAL DRIVES
- USES STANDARD DB37 CONNECTOR FOR EXTERNAL DRIVES
- SUPPORTS BOTH DS/DD AND DS/QD WHEN USED W/ DOS 3.2 OR JFORMAT



MCT-HDC $79.95

HARD DISK CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL

- IBM XT COMPATIBLE CONTROLLER SUPPORTS 16 DRIVE SIZES INCLUDING 5, 10, 20, 30 & 40MB
- OPTIONS INCLUDE THE ABILITY TO DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES
- INCLUDES CABLING FOR 1 INTERNAL DRIVE



MCT-RLL $119.95

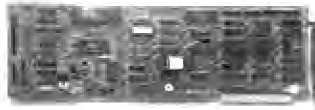
GET UP TO 50% MORE STORAGE SPACE ON YOUR HARD DISK

- INCREASES THE CAPACITY OF PLATED MEDIA DRIVES BY 50%
- RLL 2,7 ENCODING FOR MORE RELIABLE STORAGE
- TRANSFER RATE IS ALSO 50% FASTER; 750K/sec vs 500K/sec
- USE WITH ST-238 DRIVE TO ACHIEVE 30+ MB IN A HALF HEIGHT SLOT

MCT-FH $139.95

STARVED FOR SLOTS? SATISFY IT WITH THIS TIMELY DESIGN

- INTERFACES UP TO 2 FDDs & 2 HDDs
- CABLING FOR 2 FDDs & 1 HDD
- FLOPPY INTERFACE SUPPORTS BOTH DS/DD & DS/QD WHEN USED WITH DOS 3.2 OR JFORMAT
- ALL POPULAR HDD SIZES ARE SUPPORTED, INCLUDING 5, 10, 20, 30 & 40MB
- CAN DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES



MCT-ATFH $149.95

FLOPPY AND HARD DISK CONTROL IN A TRUE AT DESIGN

- AT COMPATIBLE, CONTROL UP TO 2 360K/720K OR 1.2MB FDDs AS WELL AS 2 HDDs USING THE AT STANDARD CONTROL TABLES
- SUPPORTS AT STYLE FRONT PANEL LED TO INDICATE HD ACTIVITY
- 16 BIT BUSS PROVIDES RAPID DATA TRANSFERS
- FULLY SUPPORTED BY AT BIOS

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BOMB

YOU CHOOSE THE BEST ARTICLE EACH MONTH

BYTE's ongoing monitor box (BOMB) lets you rate each article you've read in BYTE as excellent, good, fair, or poor. Each month, you can mail in the BOMB card found in the back of the issue. We tally your votes, total the points, tell you who won, and award the two top-rated nonstaff authors $100 and $50, respectively. An additional $50 award for quality goes to the nonstaff author with the best average score (total points divided by the number of voters). If you prefer, you can use BIX as your method of voting. We welcome your participation.

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BOMB RESULTS

The winning entries for June indicate that our readers have a great deal of interest in new IBM products. First place goes to the BYTE editorial staff for "First Impressions: The IBM PS/2 Computers." In second place is "Microsoft's New DOS" (aka OS/2) by Eva White and Richard Grehan of BYTE's editorial staff. "Puttering with Yin and Yang," the activity that took place at Chaos Manor, gave third place to Jerry Pournelle. It wasn't only new IBM products that garnered attention. What's New from the BYTE staff took the fourth-place award. Ciarcia's Circuit Cellar for June wound up in the fifth position. In it, Steve showed how to "Build a Gray-Scale Video Digitizer, Part 2: Digitizer/Transmitter." The BYTE staff shows up again in sixth place, this time for Microbytes. In seventh place overall, and winner of $100 as the highest nonstaff vote gatherer, is William G. Hood for his Programming Insight, "Polynomial Curve Fitter." In eighth place, and winner of $50, is Paul D. Bourke for his Programming Project, "A Contouring Subroutine." Mr. Hood wins the $50 bonus award for quality. Congratulations to all.

COMING UP IN BYTE

Features:
A survey of application packages that run under OS/2; Jef Raskin's new Cat "information appliance"; Acorn debuts the world's first commercial RISC machine, and Dick Pountain looks at it.

Circuit Cellar:
The concluding section on building an IBM PC AT clone.

Programming Insight:
An algorithm for deriving Xmodem cyclic redundancy checks.

Theme:
Heuristic algorithms includes articles on zero-knowledge proofs, back propagation and general learning rules, compiler optimization heuristics, a search strategy for common sense, PRESS—the Prolog equation solver system, and an introduction to neural networks.

Reviews:
The Macintosh II, the GRiDLite Portable, and the new Wang Portable are system reviews. Definicon's DSI-780 and a survey of four laser printers cover peripherals. Language reviews include three libraries of windowing menu design and data-form entry routines, as well as a comparison of two low-cost, low-functionality C-language packages. Application software reviews include an examination of Guide and a comparison of MathCAD, Eureka: The Solver, and Point Five equation-solving programs. We'll also have a review of a package said to be based on forward- and backward-chaining techniques, Personal Consultant Plus.

EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue.
Each reference is to the first page of the article or section in which the company name appears.

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* Correspond directly with company

Alphabetical Index to Advertisers

READER SERVICE

Advertising Supplements included with this issue:
Priority One Electronics (US Subscribers)
Computer Mail Order/CMO (Selected US Subscribers only.)

** Correspond directly with company.*

TIPS

SUBSCRIBERS ONLY!*

Use BYTE's Telephone Inquiry Processing System

Using TIPS can bring product information as much as 10 days earlier.

SEND FOR YOUR SUBSCRIBER I.D. CARD

1) If you are a new subscriber or have lost your I.D. card, circle #1 on the Reader Service Card; **attach mailer label**. We will immediately send your personal TIPS subscriber card.

GET PREPARED

2) Write your Subscriber Number, as printed on your Subscriber I.D. Card, in boxes in Step 5 below. (Do not add 0's to fill in blank boxes)

3) Write numbers for information desired in boxes in Step 7b below. (Do not add 0's to fill in blank boxes.)

CALL TIPS

4) Now, on a Touch-Tone telephone dial: (413) 442-2668 and wait for voice commands.

ENTER YOUR SUBSCRIBER AND ISSUE NUMBERS

5) When TIPS says: "Enter Subscriber Number"
(Enter by pushing the numbers and symbols [# or * enclosed in the boxes] on telephone pad ignoring blank boxes)
Enter ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ [#] [#]

6) When TIPS says "Enter magazine code & issue code"
Enter [1] [#] [9] [7] [#] [#]

ENTER YOUR INQUIRIES

7a) When TIPS says "Enter (next) Inquiry Number"
Enter one inquiry selection from below (ignore blank boxes)

b) Repeat 7a as needed (maximum 17 inquiry numbers)

1. ☐ ☐ ☐ [#] [#]   6. ☐ ☐ ☐ [#] [#]   10. ☐ ☐ ☐ [#] [#]   14. ☐ ☐ ☐ [#] [#]
2. ☐ ☐ ☐ [#] [#]   7. ☐ ☐ ☐ [#] [#]   11. ☐ ☐ ☐ [#] [#]   15. ☐ ☐ ☐ [#] [#]
3. ☐ ☐ ☐ [#] [#]   8. ☐ ☐ ☐ [#] [#]   12. ☐ ☐ ☐ [#] [#]   16. ☐ ☐ ☐ [#] [#]
4. ☐ ☐ ☐ [#] [#]   9. ☐ ☐ ☐ [#] [#]   13. ☐ ☐ ☐ [#] [#]   17. ☐ ☐ ☐ [#] [#]
5. ☐ ☐ ☐ [#] [#]

END SESSION

8) End session by entering [*] [*] [9] [1] [#] [#]

9) Hang up after hearing final message
If you are a subscriber and need assistance, call (603) 924-9281.

Available 24 Hours, 7 Days a Week

If you are not a subscriber fill out the subscription card found in this issue or, call BYTE Circulation 800-423-8912.
***Domestic and Canadian Subscribers Only!**

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Index to Advertisers by Product Category

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BYTE READER SERVICE CARD

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4	26	48	70	92	114	136	158	180	202	224	246	268	290	312	334	356	378	400	422	444	466	488	510	532	554	576	598	620	642	664	686	708	730	752	774	796
5	27	49	71	93	115	137	159	181	203	225	247	269	291	313	335	357	379	401	423	445	467	489	511	533	555	577	599	621	643	665	687	709	731	753	775	797
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21	43	65	87	109	131	153	175	197	219	241	263	285	307	329	351	373	395	417	439	461	483	505	527	549	571	593	615	637	659	681	703	725	747	769	791	813
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Fair	3	7	11	15	19	23	27	31	35	39	43	47	51	55	59	63	67	71	75	79	83	87	91	95	99
Poor	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96	100

Article No.*	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
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Fair	103	107	111	115	119	123	127	131	135	139	143	147	151	155	159	163	167	171	175	179	183	187	191	195	199
Poor	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200

* To determine this month's Article No., see BOMB as listed in Table of Contents under Departments.

Name ______________________

Title ______________________

Company ______________________

Address ______________________

City ______________________

State __________ Zip __________

Telephone ______________________

A. What is your principal occupation? (Please check one only.)

1. ☐ Business Owner
2. ☐ Manager/Administrator
3. ☐ Professional (law, medicine, architecture, etc.)
4. ☐ Computer Programmer/Analyst
5. ☐ DP/MIS
6. ☐ Engineer
7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify) __________

B. How many people does your company employ?

1. ☐ 1–49
2. ☐ 50–999
3. ☐ 1,000 or more

C. Information requested for:

1. ☐ Business use
2. ☐ Personal use
3. ☐ Both

D. Do you plan to purchase items inquired about within:

1. ☐ Next 3 months?
2. ☐ Next 6 months?
3. ☐ Next 12 months?

E. Please check the statement that best describes your involvement in your company's purchasing decisions. (Check all that apply.)

1. ☐ I determine the need
2. ☐ I evaluate products/systems
3. ☐ I select/recommend the vendor
4. ☐ I approve/authorize the purchase

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Excellent	101	105	109	113	117	121	125	129	133	137	141	145	149	153	157	161	165	169	173	177	181	185	189	193	197
Good	102	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	194	198
Fair	103	107	111	115	119	123	127	131	135	139	143	147	151	155	159	163	167	171	175	179	183	187	191	195	199
Poor	104	108	112	116	120	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200

* To determine this month's Article No., see BOMB as listed in Table of Contents under Departments.

Name ______________________

Title ______________________

Company ______________________

Address ______________________

City ______________________

State __________ Zip __________

Telephone ______________________

A. What is your principal occupation? (Please check one only.)

1. ☐ Business Owner
2. ☐ Manager/Administrator
3. ☐ Professional (law, medicine, architecture, etc.)
4. ☐ Computer Programmer/Analyst
5. ☐ DP/MIS
6. ☐ Engineer
7. ☐ Scientist
8. ☐ Educator/Student
9. ☐ Other (please specify) __________

B. How many people does your company employ?

1. ☐ 1–49
2. ☐ 50–999
3. ☐ 1,000 or more

C. Information requested for:

1. ☐ Business use
2. ☐ Personal use
3. ☐ Both

D. Do you plan to purchase items inquired about within:

1. ☐ Next 3 months?
2. ☐ Next 6 months?
3. ☐ Next 12 months?

E. Please check the statement that best describes your involvement in your company's purchasing decisions. (Check all that apply.)

1. ☐ I determine the need
2. ☐ I evaluate products/systems
3. ☐ I select/recommend the vendor
4. ☐ I approve/authorize the purchase

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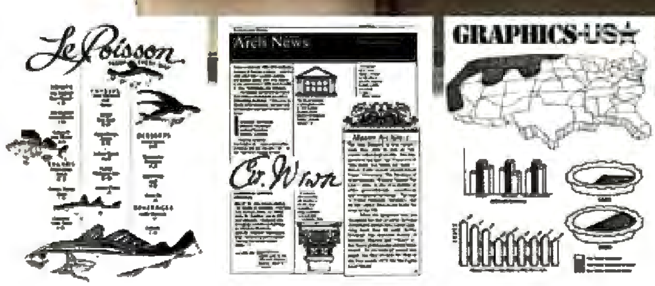
DON'T WASTE TIME WITH DESKTOP PUBLISHING.



You won't have to with our new Silentwriter™ LC890 page printer.

It's the desktop publishing printer with more than twice as much memory as an Apple® Laserwriter,™ for example. Which means it puts information together faster—and saves valuable minutes every time you create a new page of graphics or text. And the more complex the page, the more time saved.

The Silentwriter LC890 is also one of the least expensive printers that uses Adobe PostScript® page description language. Which lets you combine text, line art, and even digitized photographs on the same page.

Of course, you may not need all this pizazz for your printed pages. Then you should look into our Silentwriter LC860 Plus or our Silentwriter LC850, which are ideal for text and less complex graphics applications.

Our Silentwriter series will also keep you from wasting time with breakdowns and service. Because every Silentwriter printer has a life of about 600,000 pages—more than twice as much as ordinary lasers.

So if you want to make the most our of desktop publishing, don't waste a minute. Call 1-800-343-4418 (in MA 617-264-8635). Or write: NEC Information Systems, Dept. 1610, 1414 Massachusetts Ave., Boxborough, MA 01719.

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C&C Computers and Communications

NEC

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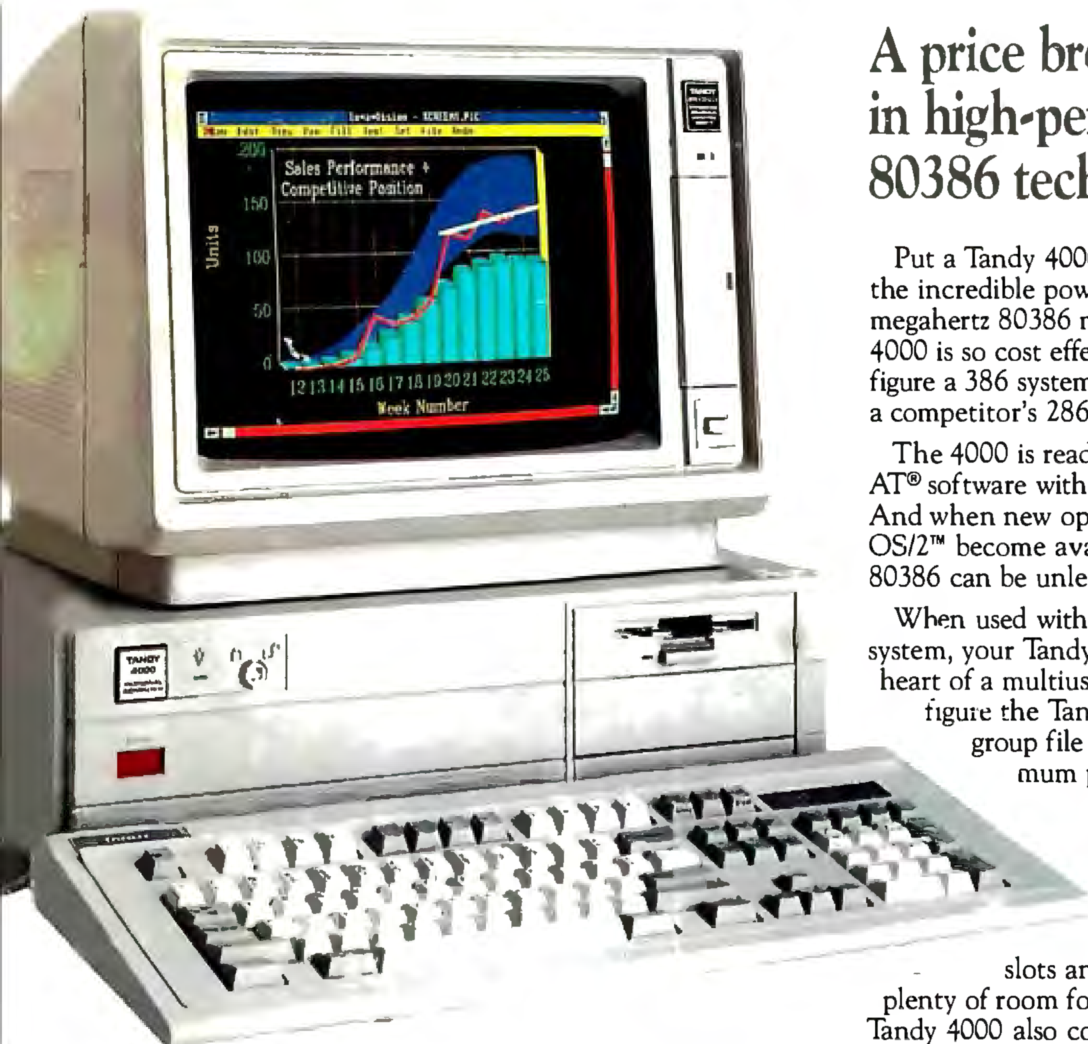

A price breakthrough in high-performance 80386 technology.

Put a Tandy 4000 on your desk and unleash the incredible power of the 32-bit, 16-megahertz 80386 microprocessor. Our Tandy 4000 is so cost effective you can actually configure a 386 system for less than you'd pay for a competitor's 286 model.

The 4000 is ready to run current PC and AT® software with incredible new speed. And when new operating systems such as OS/2™ become available, the full potential of 80386 can be unleashed.

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Price applies at Radio Shack Computer Centers and participating stores and dealers. Monitor, video display and operating systems sold separately. XENIX/Reg. TM and OS/2/TM Microsoft Corp. 3Com/Reg. TM 3Com Corp. AT/Reg. TM and XT/TM IBM.

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