

Macintosh BASIC

A semicompiled language with tools designed to simplify the writing of code

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Since so many things about Apple's new Macintosh computer are different from other computers, it should come as no surprise that Donn Denman's Macintosh BASIC is also different. Briefly stated, Macintosh BASIC is a semicompiled, multitasking, structured language system (without line numbers), complete with a full-screen text editor and a highly sophisticated debugger, that takes advantage of many of the Macintosh's unique features. This article describes what is unique about the language.

Macintosh BASIC is semicompiled. When you type in a new program line, the line is immediately passed to a part of the system called the B-

code generator. This generator compiles the program line and updates the program data structures. The system checks the syntax of the line as the line is compiled and provides immediate feedback as to the line's general lexical correctness. Later, when the program is executed, the compiler makes another quick pass through the program (about 2 seconds for a 50K-byte program) to check the integrity of its control structures. Assuming there are no final compilation errors, program execution continues. The compact B-code is then interpreted, making for a very fast BASIC.

Macintosh BASIC is quite large (48K bytes), and it can grow. It is

segmented; about 32K bytes live in memory at any time, leaving about 50K bytes for program and variable table space. (Actually, because of the CALL command, programs can be virtually any length.) If a program needs a part of BASIC that isn't in RAM (random-access read/write memory), such as formatted output, the editor, the debugger, or some other large code segment, it loads in from the disk.

Macintosh BASIC lets you execute any number of programs simultaneously and develop one or more additional programs at the same time (see figure 1). Each time a line of code is interpreted, the system checks for other events that might need attention and handles them accordingly. Each program is granted a fixed amount of execution time in 1/60-second increments or any interval set by the programmer. When a program's time slice is up, the system moves to the next program for interpretation.

No line numbers are required in Macintosh BASIC. You get around the program by branching to sections of code identified by *labels*. You can use numbers, but labels tend to be a lot more meaningful and make tracing program flow much easier.

Environment

In most BASICs, the entire display area is ordinarily occupied by the program listing or by the output. In Macintosh BASIC, the display area, called the *desktop*, is typically oc-

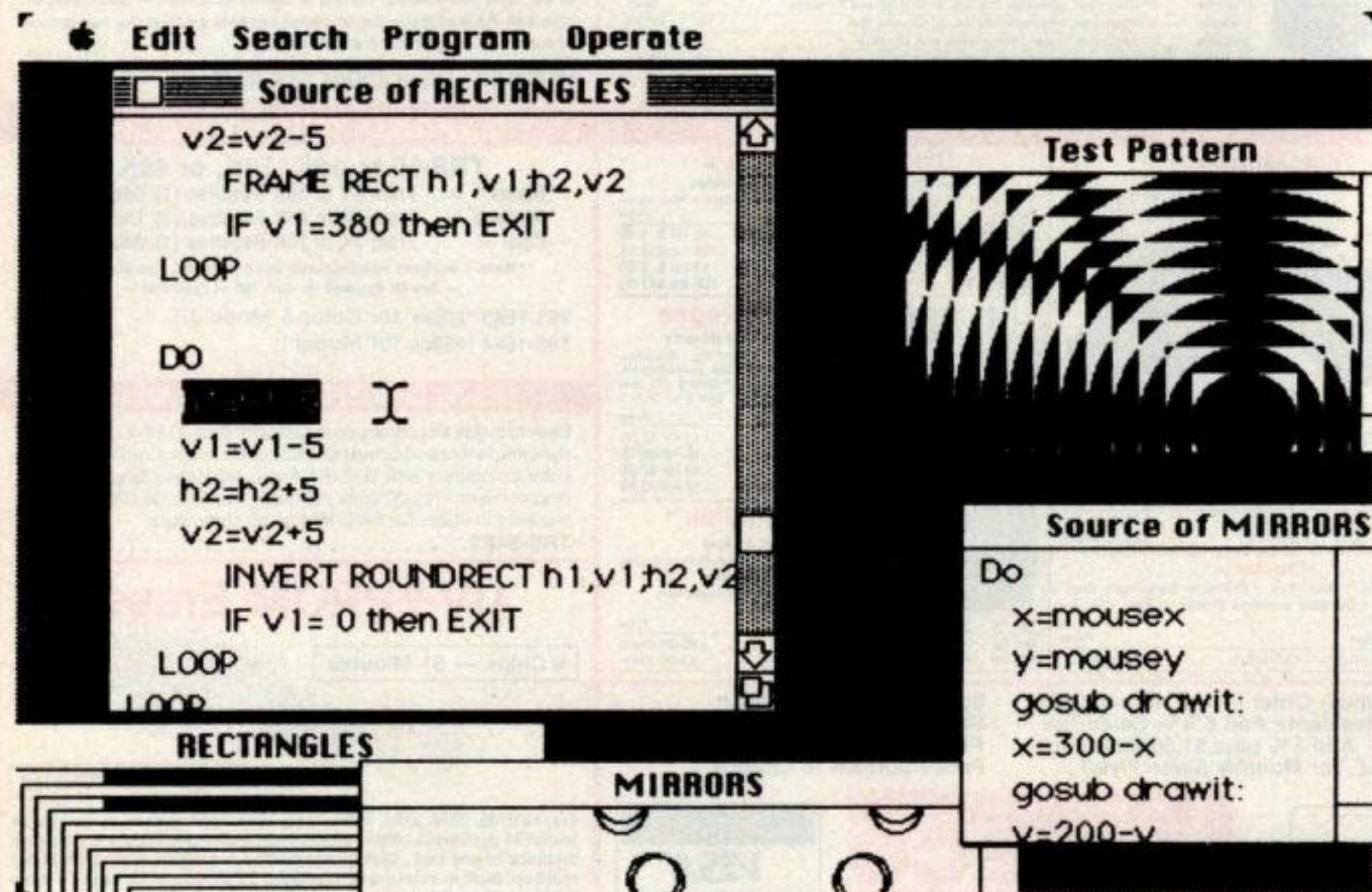


Figure 1: Multitasking in Macintosh BASIC.

cupied by a variety of graphics and text material. Most material appears in *windows*, sections of the desktop that can grow, shrink, or move at the discretion of the programmer. Figure 2a shows the BASIC desktop with three copies of the same program in windows of different sizes. Listing 1 shows what the whole program looks like; you can't see all of it because all of it won't fit in the viewing area of the Listing window. Figure 2b shows what running the program produces. Note that none of these windows shows an entire program; there are more lines in the program than will fit in any of the visible areas. To see the rest of the program listing, you press the mouse button with the pointer on the down arrow in the *scroll bar* (located at the right of the window), revealing the rest of the code.

When a Macintosh BASIC program is executed, the Listing window is overlaid by an Output window that displays any text or graphics produced by the executing program. Both the Listing window and the Output window can be (and often are) displayed at the same time, making program development and debugging easier than in traditional environments.

Macintosh BASIC's tools and command words (verbs that affect programs as a whole, like RUN, LOAD, and SAVE) appear in menus whose titles are listed in the *menu bar* running across the top of the desktop. To

choose a menu item, use the mouse to move the pointer to the menu you want, press and hold the mouse button, and drag the pointer down to the specific tool or command you want.

The Macintosh BASIC interactive programming environment makes writing code a lot easier than do most other BASICs because of the huge variety of tools. The tools include those available to every Macintosh application (specifically, the *desk accessories*, the screen-oriented editor, and the Clipboard) and a set of special development and debugging aids designed for the language, including flexible search and replace capabilities, several printing options, and a very sophisticated debugger.

Desk Accessories

Among the desk accessories, accessible from the desktop menu, programmers will find the Calculator, the Note Pad, and the Clock most useful (see figure 3). The Calculator is a simple four-function calculator useful for doing quick operations; you can use the system editor to transfer calculation results into your program code. The Note Pad lets you write memos to yourself about special sections of code that need attention, or anything else you need to remember but don't want to scribble on a piece of paper that will quickly get lost. The Clock is extremely useful, either to time program execu-

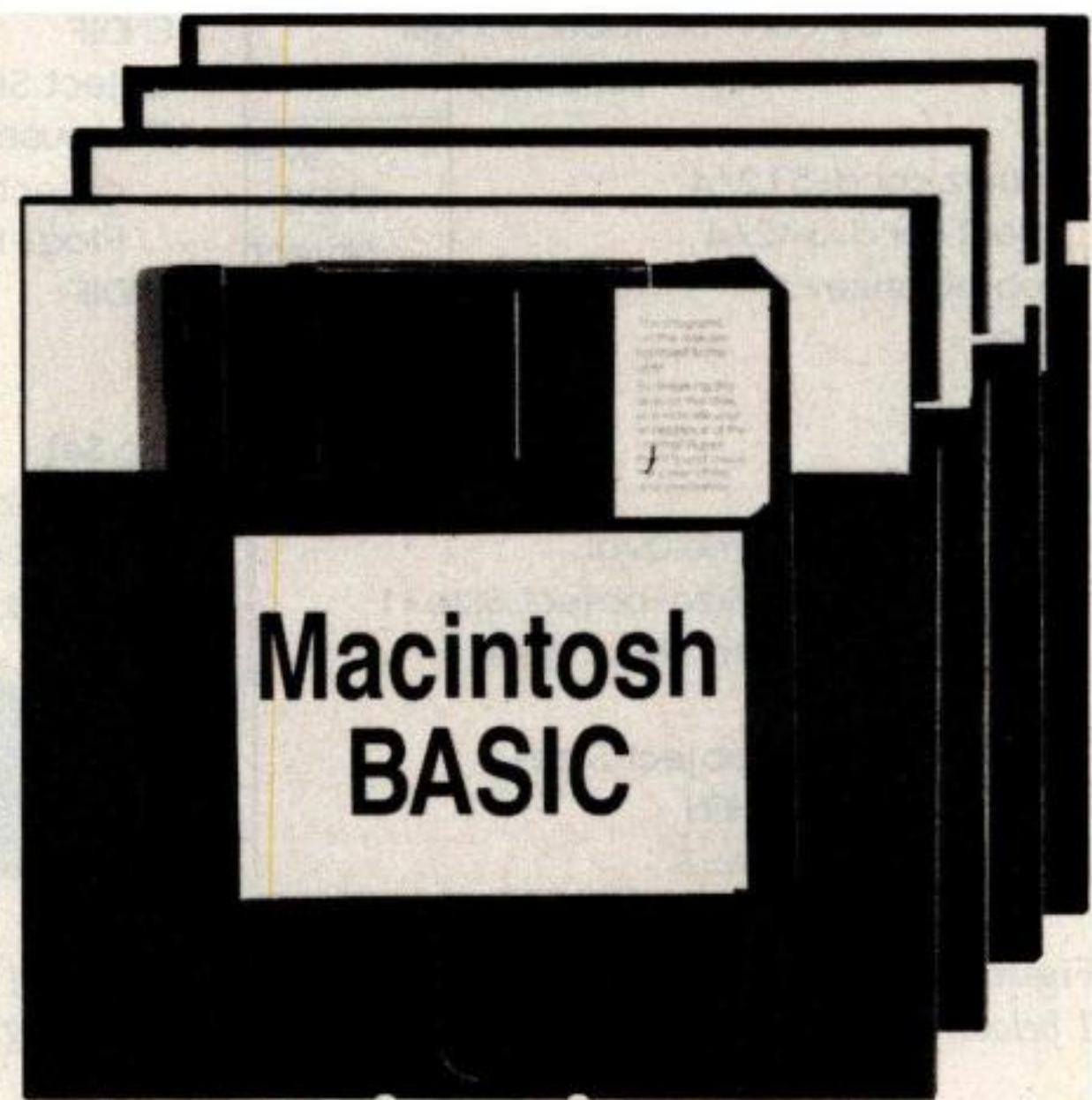
tion or to remind a hacker when to eat lunch. You can have all these tools (and any others, for that matter) operating while you develop and run programs.

Using the mouse and the screen-oriented editor, you can cut, copy, paste, or entirely remove all or part of a program. In combination with the Clipboard, the system-wide text and graphics buffer, you can quickly and easily move whole blocks of code from one section of a program to another section of the same program or to a different program (see figure 4). Additionally, you can move material into (or out of) the BASIC programming environment from any other Macintosh application including a spreadsheet, a word processor, or the Mac Paint graphics application.

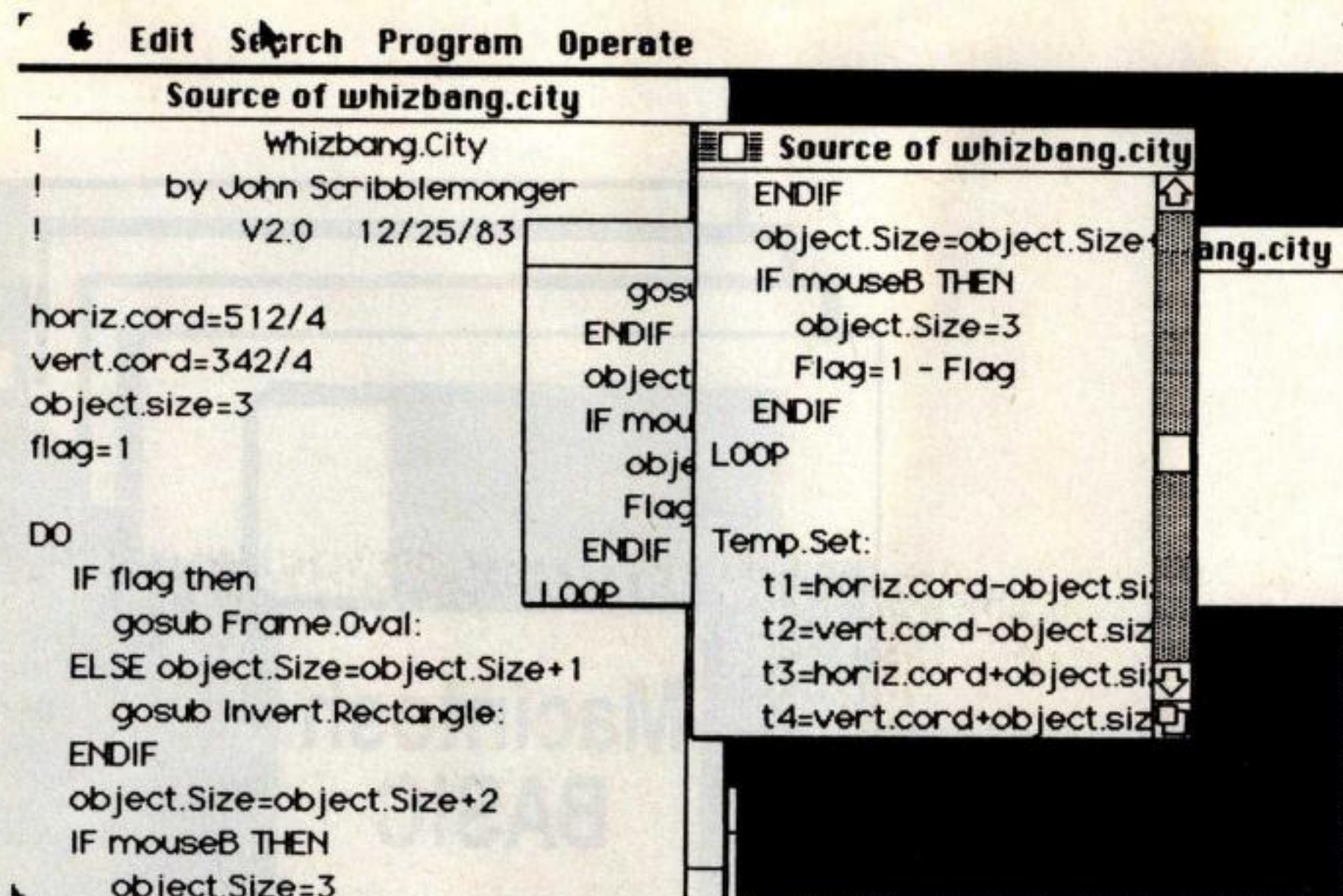
Also on the Menu

The other menus provide access to tools specific to Macintosh BASIC. Among the tools seldom seen in other systems are Search and Replace, in the Search menu; Debug, in the Program menu; and Directory, in the Operate menu.

The search tools help you to locate and/or change any group of characters, either once or repeatedly, matching or ignoring the case of the alpha-



(2a)



(2b)

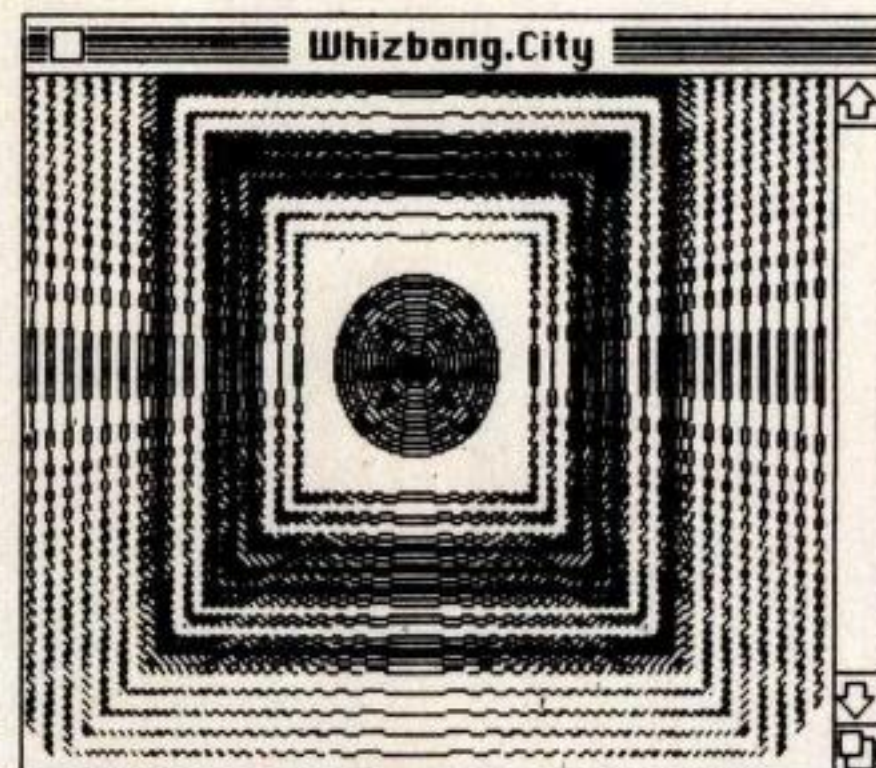


Figure 2: Three "views" of the same program in windows of different sizes (2a). None of these windows shows an entire listing (see listing 1 below). Figure 2b shows the Output window for the program Whizbang.city (listing 1).

betic characters. These search tools can be extremely useful for changing a nondescriptive variable to one that makes more sense—say, changing all occurrences of the variable E7 to EMPLOYEE.7—or to replace improper spellings in variable names, labels, or prompting phrases.

Listing 1: The Whizbang.city program.

```

Whizbang.City
by John Scribblemonger
V2.0 12/25/83

horiz.cord=512/4
vert.cord=342/4
object.size=3
flag=1

DO
  IF flag then
    gosub Frame.Oval:
  ELSE object.Size=object.Size+1
    gosub Invert.Rectangle:
  ENDIF
  object.Size=object.Size+2
  IF mouseB THEN
    object.Size=3
    Flag=1 - Flag
  ENDIF
LOOP

Temp.Set:
  t1=horiz.cord-object.size
  t2=vert.cord-object.size
  t3=horiz.cord+object.size
  t4=vert.cord+object.size
Return

Frame.Oval:
  Gosub Temp.Set:
  Frame Oval t1,t2; t3,t4
Return

Invert.Rectangle:
  Gosub Temp.Set:
  Invert Rect t1,t2; t3,t4
Return

```

The Program menu (see figure 5) lists the command verbs, or menu selections, programmers tend to use most during code development, including certain commands not available or meaningful in other BASIC systems. Most notable here are the two Save commands, the Update command, and the Debug command.

Selecting Save Source sends an ASCII (American National Standard Code for Information Interchange) text copy of the program to the disk, just as it appears in the Listing window. Save Object stores only the program's B-code—that is, the code in its compiled form. You can retrieve, edit, and execute a program saved as text, but a program saved as code can be

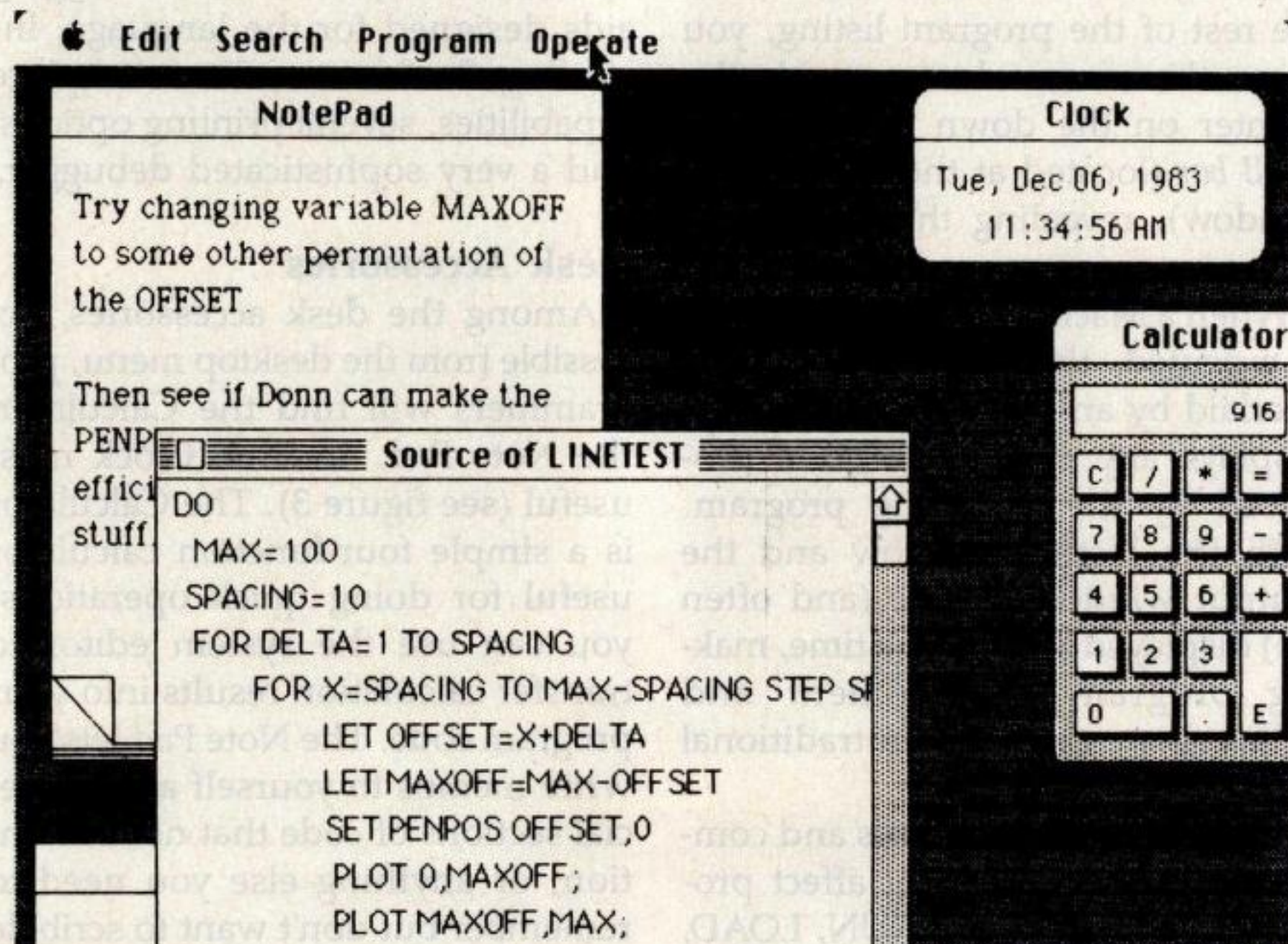


Figure 3: Macintosh desk accessories run concurrently with program development. The Note Pad (in the background) has eight pages and holds 256 bytes per page.

executed only. Code files are safe from tampering; once they go to disk, they cannot be viewed or changed. Thus, profit-minded programmers can protect their code from the prying eyes of unscrupulous code pilferers. Update lets you modify running programs. You can change a program line in the Listing window, select Update from the Program menu, and watch the immediate effects of the change in the Output window.

Choosing Debug turns on the debugging environment. When this command is in effect, the normal Listing window is replaced by the one in figure 6. The finger symbol moves up and down the listing, pointing to the line of code currently being executed. Simultaneously, the system displays a dynamic variable and breakpoint table showing the current values of all non-array variables; all of these values can be changed while the code being debugged is executing (updating is automatic).

You can set and clear breakpoints for any or all variables. The program can break whenever a particular variable is referenced or changed or is equal to, less than, or greater than some value or other variable. When the program hits a breakpoint, execution halts and it waits for the programmer to determine what happens next. By using the mouse to press a button displayed on the desktop beneath the Listing window, you can make execution resume at full speed until the next breakpoint, full speed through the next control block (a DO/LOOP, FOR/NEXT, SELECT CASE, subroutine, etc.), or go immediately into a single-step mode. In single-step mode, only one line of code is executed; the programmer tells BASIC to execute each subsequent line of code by pressing the space bar.

Additionally, there's an alphabetical list of all the labels in the program. This feature makes it easy for you to see why you got that "undefined label" error when your program is trying to branch to CALL.YOUR.MOTHER: instead of to CALL.YOUR.MOM:.

Function	Description
BTN	tells which interactive button has been pushed
DIAL	tells which interactive dial has been activated
FORMAT\$	Macintosh BASIC equivalent of PRINT USING
KBD	gives the ASCII code of the most recent key pressed
MENU	tells when an interactive menu is chosen
MOUSEB	yields the state of the mouse button
MOUSEX	returns the horizontal position of the mouse pointer
MOUSEY	returns the vertical position of the mouse pointer
TYP	tells the data type of the next item in the input stream (numeric, string, or picture)

Table 1: Macintosh BASIC numeric data types.

Storage Form	Symbol	Accuracy	Range
Double-precision real	none	15	1E+-1022
Single-precision real		7	1E+-126
Extended-precision real	\	18+	1E+-4000
Short integer	%	4+	+ - 32767
Long integer	#	18+	+ - 9E18
Boolean	~	1	0 or 1

Table 2: Some Macintosh BASIC functions not available in most other BASICs. "Interactive" refers to graphics objects (menus, buttons, dials) that appear on the screen and can be manipulated with the mouse.

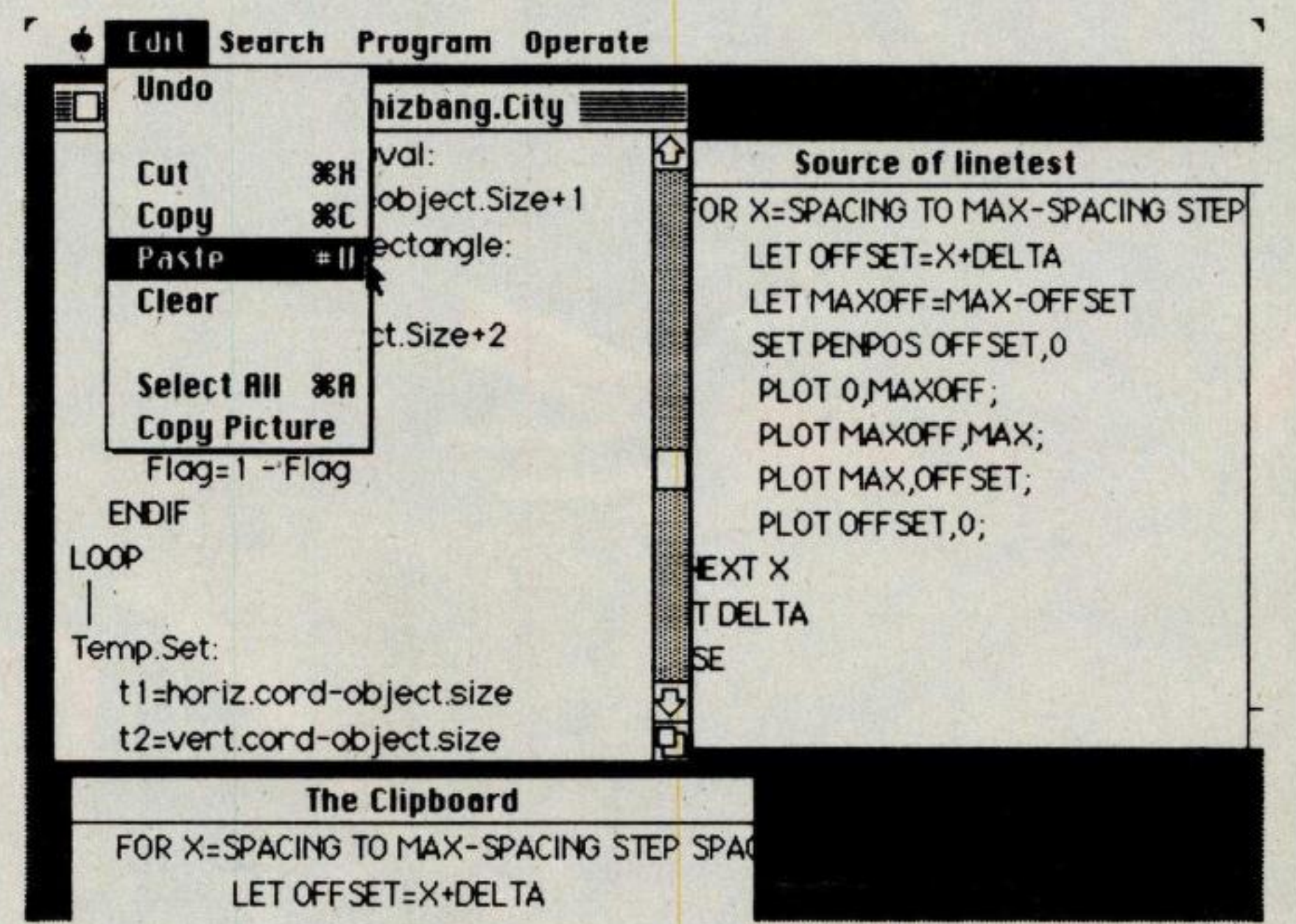


Figure 4: Material in the Clipboard, just copied from the Linetest program on the right, is about to be pasted into a second program. The source lines in Linetest remain undisturbed.

The Operate menu holds commands you might typically use to test programs. RUN is the usual BASIC command to execute a program (something in this language has to be usual). In Macintosh BASIC, Halt and Continue are useful for checking the program's Output window and variable table from time to time. The Directory selection produces a menu of all BASIC programs on the disk; drag the pointer to one of the program names and BASIC loads the program for you. The Quit command is your way out of BASIC, returning you to the main Macintosh system (called the Finder).

With Macintosh BASIC, you can obtain four kinds of hard-copy printouts: everything on the screen, everything in the Listing window including material you can't see, all text and graphics in the Output window, and material sent to the printer by the running program itself. The listings in this article were all printed directly from the Macintosh.

The Language

Variable names in Macintosh BASIC can be of any length, and all characters in the name are significant. The first character must be alphabetic; the rest can be nearly anything you can type from the keyboard, which includes the entire ASCII code set plus nonroman and other special characters. The only exceptions are arithmetic symbols and other delimiters (comma, semicolon, colon, and space).

Macintosh BASIC supports array

variables for all eight data types and subtypes discussed later. Arrays can have any number of dimensions, and each dimension can have 32,767 elements. All arrays must be dimensioned before use. When you DIM an array, you can specify ranges for element numbers. Thus, you can say DIM YEAR%(1900 TO 1986) to specify an 87-element integer (the % denotes integer) array whose first number is 1900 and whose last number is 1986. You can also stipulate ranges for separate dimensions, as in DIM NAME\$(10 TO 75, 165 TO 300).

There are three main data types in the language: strings, pictures, and numerics. Strings are pretty standard; they are enclosed in quotes, either single or double, and their variable names end in the usual BASIC symbol, \$.

You create a picture data type by either creating a shape or a whole picture in a graphics application (like Mac Paint) and transferring it to BASIC through the Clipboard or by drawing a shape in BASIC using various graphics commands. You can then assign the shape to a picture variable; the variable name ends in the symbol @.

The numeric data type is further divided into six subtypes: Booleans, two types of integers, and three types of reals. Table 1 shows the storage form, symbol, range, and digits of accuracy for each subtype.

In addition to the five standard arithmetic operators (+, -, *, /, ^), Macintosh BASIC includes DIV for integer division and MOD for

modulo, defined as the arithmetic remainder of integer division. The relational operators (<, =, >, <>, ><) and logical operators (AND, OR, and NOT) are standard; the string concatenation symbol is &.

Macintosh BASIC has the usual range of arithmetic, trigonometric, and string functions, including DEF FN (user-defined functions) for both numbers and strings. Table 2 describes many of the functions that don't appear in most other BASICs or are unique to Macintosh BASIC in some major way. The term "interactive," appearing in several of the descriptions, refers to graphics objects (entire menus, buttons, dials) you can make appear on the screen and can manipulate with the mouse.

Control Structures

Most flow of control statements in Macintosh BASIC take the form of control structures. The language has a GOTO statement, but you never have to use it. In fact, the only place the GOTO statement appears in the language manual as part of a code example is in the section describing GOTO itself.

Besides the familiar FOR/NEXT structure and the DO/EXIT/LOOP structure, in which all statements between the keywords DO and LOOP are repeated infinitely (EXIT lets you escape the loop), this BASIC includes some variations on new structures proposed in the 1982 ANSI (American National Standards Institute) BASIC proposal. A multiline IF/THEN/ELSE/ENDIF lets you execute

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PRS: Solutions	CALL	List Handler	59
d Base II	384	Wordstar	249
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Tax Preparer	169	Screenwriter II	CALL
OZ by F & G	CALL	Magic Window	97
Infostar	259	Magic Call	99
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Home Acct. Plus	112	Zaxxon	27
Peachtree	CALL	Choplifter	26
Property Management	329	Frogger	24
Digital Research	SALE!	Wizardry	39
DESO	NEW!	Jumpman	29
Select	299		

Listing 2: A multiple-line IF control block.

```

Source of IF...THEN/ELSE/ENDIF
IF DAY.TEMP > HOT THEN
    CLOTHES$ = SWIM.STUFF$
    GOSUB BEACH:
ELSE CLOTHES$ = WALK.STUFF$
    GOSUB CITY:
ENDIF

```

as many statements as you want if a condition is either true or false (see listing 2). An extremely flexible SELECT CASE/ENDCASE construct takes the place of the restrictive ON...GOSUB statement. It enables the program to transfer execution to sets of statements based on the value of some expression. There can be multiple statements for each case or range of cases (see listing 3). The language has several interrupt control structures, all of which are based on a structure bounded by the keywords WHEN and ENDWHEN; these interrupts let you determine which code is executed if any one of a number of events occurs anytime during program execution. You can plan interrupts to occur whenever a key is pressed, when the mouse is moved or its button pushed, when an error occurs, or at other times (see listing 4).

Subroutines are handled in the usual way (except that the language uses GOSUB labels); additionally there's a CALL statement that enables entire programs to act as subroutines. CALL lets you pass parameters back and forth with the summoned program; when the called program ends, control returns to the statement following CALL in the source program.

Graphics

Macintosh BASIC provides commands for both static and animated graphics on a bit-mapped 512-by-342-point screen. You can plot points with the PLOT command (controlling the size of the pixels with PENSIZ) or create shapes with the keywords RECT (for rectangle), ROUNDRECT (a rectangle with rounded corners), or OVAL. Shapes can be outlined

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Listing 3: A *SELECT CASE* construct using strings (3a) and a *SELECT CASE* construct using numerics (3b).

(3a)

Source of SELECT CASE/ENDCASE (STRINGS)

```
SELECT CASE PARTY$
  CASE "REPUBLICAN"
    CALL REPUBLICAN.PRIMARY.BALLOT
  CASE "COMMUNIST"
    CALL MILITIA
  CASE "DEMOCRAT", "TORY", INDEPENDENT$
    GOSUB FURTHER.CHOICE:
    CALL GENERAL.PARTY.BALLOT
  CASE LEFT$(PARTY$, 3) = "SEP"
    CALL SEPARITIST.PRIMARY.BALLOT
  CASE ELSE
    CALL GENERAL.PRIMARY.BALLOT
ENDSELECT
```

(3b)

Source of SELECT CASE/ENDCASE (NUMBERS & RANGES)

```
SELECT CASE AGE
  CASE 2, 4, 5
    GOSUB PRESCHOOL:
  CASE 6 TO 12
    GOSUB GRAMMAR.SCHOOL:
  CASE 15, 18 TO 35, VAL (OLD$)
    CALL CHECK.DEMOGRAPHICS
  CASE >70
    GOSUB MIGHT.BE.RETIRED:
ENDSELECT
```

(FRAME), filled in (PAINT) with a preestablished shade or pattern (SET PATTERN), complemented from the last appearance (INVERT), or erased altogether (ERASE). The various shapes can then be combined into a single picture and stored in a picture variable (RECORD PICTURE) and recalled (DRAW PICTURE). For animated sequences, you can ROTATE, SCALE, and ANIMATE a picture, moving it across the display. All graphics appear within the Output window, so your Listing and Debugging windows can coexist with a running graphics program.

Disk File Structures

Disk file structures have many options. I will cover only the major highlights; many of the available statements and options are not examined here.

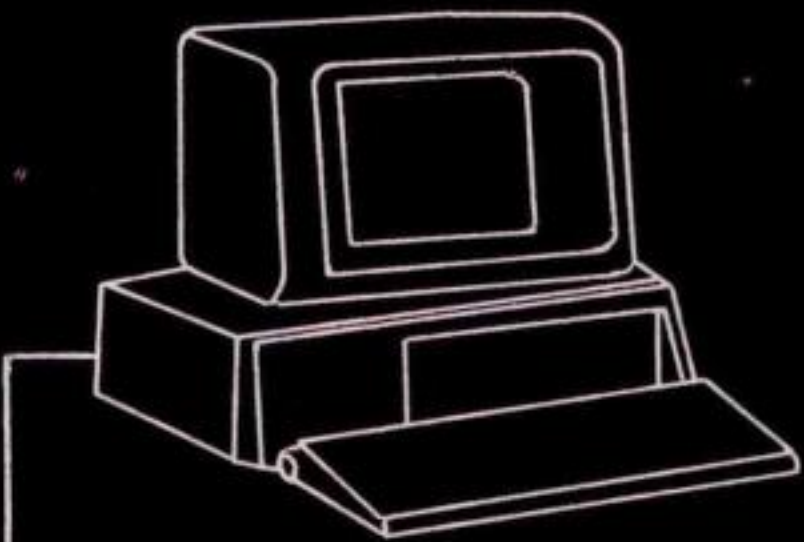
There are three types of file organization: sequential (serial access for text data), stream (serial access for binary data), and relative (random access, usually for text data). Length of a record in a relative file must be set in advance, but it can be any length

Listing 4: The interrupt construct for errors and keypress.

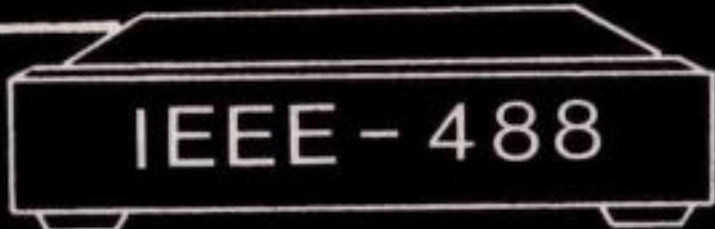
Source of WHEN / ENDWHEN

```
WHEN ERR
  CALL ERROR.CHECK
  GOSUB SECOND.CHANCE:
ENDWHEN

WHEN KBD
  PRINT "WHICH MENU DO YOU NEED?"
  GOSUB MENU.CHOICE:
  CALL MENU$
ENDWHEN
```



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you choose; there is no limit (beyond memory) to the number of records in a file.

The keyword RECTYPE determines how data is stored: display files are standard ASCII and can be shown in a window or be printed; internal files are binary and are for storage only. You can designate any file, no matter what type, to be an input file (a file which can only be read), an output file (to which data is sent but not retrieved), or OUTIN (accessible for both input and output). You can later change a file's access designation.

You create a file, and later make it accessible for use, with the OPEN statement. OPEN sets the channel number (1 through 99) that links the file to the system and the name of the file associated with the channel:

OPEN #3: NAME "Macmumble"

The preceding statement opens a file named Macmumble and assigns it to channel #3. Since no further parameters are given, the file uses the default parameters, which makes it a sequential display file enabling OUTIN access. The following statement opens a relative file with a record length of 250 characters for the storage of ASCII text data.

OPEN #54: NAME "Foobar", ACCESS OUTPUT, ORGANIZATION RELATIVE, RECSIZE 250

The OPEN statement is intelligent: after you've opened a file, you don't have to restate the organization, record size, or RECTYPE each time you use it. Assuming you've issued the CLOSE statement for the file "Foobar" described above, you can later access it again by just saying OPEN #54: NAME "Foobar". Up to 10 channels can be open at the same time.

All devices (like the serial port, the printer, windows on the desktop) can be accessed in the same manner as files. Device names are specified in the same way as any filename except that the first character in the name is a period.

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- ☐ UNIX⁶ SYS V O/S with C, PASCAL, FORTRAN 77, BASIC, RM COBOL⁷, ADA⁸, INFORMIX⁵, Relational DBMS
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Listing 5: Five programs used for benchmark tests (5a). Listing 5b is the Sieve benchtest program using Print Quick from the Program menu.

(5a)

```
Source of gosubs
print time$; ' at start'
for x=1 to 5000
  gosub foo:
next x
print time$; ' when done'
end

foo: return
```

```
Source of loops
! Loops
Print "Start at ";time$
FOR I=1 TO 5000
NEXT I
PRINT "Done at ";time$
```

```
Source of divs
print time$; ' at start'
for x=1 to 5000
  y=x div 3
next x
print time$; ' when done'
```

```
Source of divides
print time$; ' at start'
for x=1 to 5000
  y=x/3
next x
print time$; ' when done'
```

```
Source of mid$
print time$; ' at start'
b$='Apple Computer Inc'
for x=1 to 5000
  a$=mid$(b$,6,7)
next x
print time$; ' when done'
print a$
end
```

(5b)

```
! Sieve
s%=8190
dim flags%(s%+1)
print "start ";time$
count%=0
for i%=0 to s%
  flags%(i%)=1
next i%
for i%=0 to s%
  if flags%(i%)=0 then goto 250
  prime%=i%+i%+3
  k%=i%+prime%
200  if k%>s% then goto 240
  flags%(k%)=0
  k%=k%+prime%
  goto 200
240 count%=count%+1
250 next i%
print 'done ';time$
print count% ; ' primes'
```

Test	Time (seconds)
Empty GOSUBs	3.0
Empty FOR/NEXT loop	1.5
Midstring search	9.0
Real divide (by 3)	18.0
Integer divide (by 3)	3.0
Eratosthenes Sieve (1899 primes)	31.5

Table 3: Benchmark results.

OPEN #1: NAME ".PRINTER"
OPEN #35: NAME ".SERIAL",
ACCESS INPUT
OPEN #17: NAME ".WINDOW:
FOOBAR"

The first of the three lines above assigns channel 1 to the printer. Because printers by their nature are write-only devices, you don't need to specify the file as access output. The second line provides the serial port channel #35; its access mode is specified because serial ports are two-way. The third line addresses the Output window created by the program FOOBAR. This enables some other file either to add to the Output window or to read the window's contents.

To send and retrieve data, use the keywords PRINT and INPUT for ASCII text (display files) and WRITE and READ for binary data (internal files). Potential overwriting or "out of data" problems are handled with the

key phrases IF THERE and IF MISSING.

```
PRINT #7, RECORD 53, IF THERE
  THEN GOSUB DONT.WRITE.
OVER:: A$
```

The preceding statement sends a field of text data (A\$) to record 53 of the relative file on channel #7. If that record already exists, then program control branches to the subroutine called DONT.WRITE.OVER:. The first colon after the subroutine name is required by label syntax, the second by file syntax.

The following example retrieves two fields of binary data from an internal file hooked to channel 67 and stores them in real variable NUMBER and string variable NAME\$; if there's no data there, control branches to a program named PROTECTIT.

```
READ #67, IF MISSING THEN
  CALL PROTECTIT: NUMBER,
  NAME$
```

The Macintosh provides some fairly sophisticated sound stuff, and BASIC takes advantage of it. You can control the volume, pitch, timbre, and amplitude of each of four individual tones. You can also play any note over a four-octave range. (You can play over a greater range, but really low notes sound too soft and really high ones sound too shrill for my ears.)

Set-options are system parameters that you can control. You can ASK or SET the current value of any set-option. There are set-options for nearly all parts of the language, but the most important ones have to do with graphics, windows, and text. Graphics options include the height and width of the penstroke and the pattern the penstroke produces. Window options control how much of a program's output is displayed on the desktop in pixels, how large the entire graphics area is, and what logical boundaries to associate with physical ones. Text set-options include the current position of the insertion point (the mouse's footprint), margins within which text is to appear, and the number of characters between tab stops.

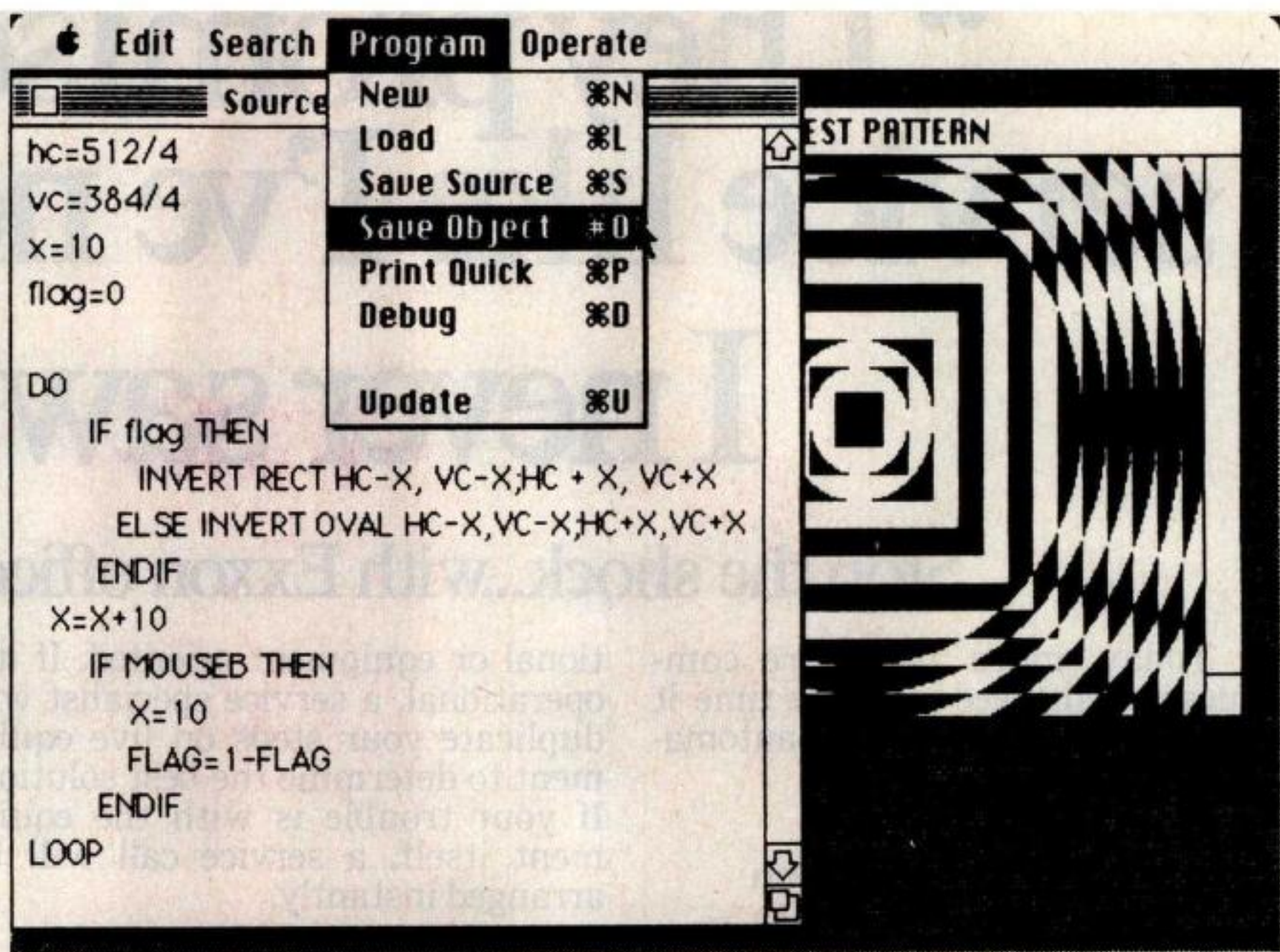


Figure 5: A program menu with Save Object selected by the mouse. This command is used to save a binary version of a program.

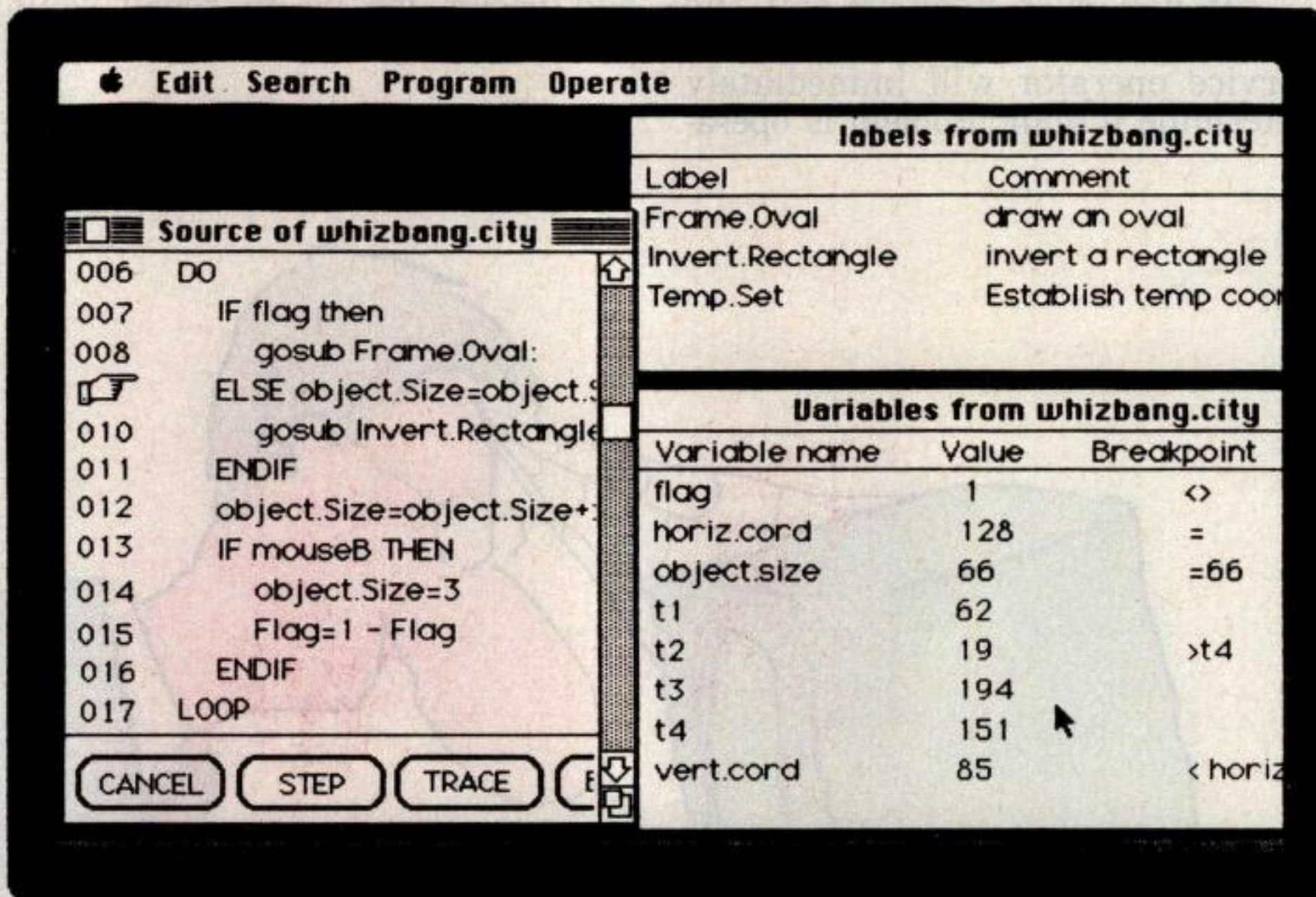


Figure 6: The Macintosh BASIC Dynamic Debugger. The windows have been "shrunk" so that the major parts of all three would show. The Debugger adds line numbers for easy reference.

Table 3 shows the results of some standard benchmark tests I ran on my Macintosh; the programs are shown in listing 5. I used the Macintosh's internal clock to do the timing; the smallest increment it reports is in full seconds. I ran each test five times; all but the Sieve were run for 5000 iterations. The results of two similar trials were sometimes different because the timing started in midsecond. ■

Macintosh BASIC will be available in the summer of 1984 at a price of \$99. The language will be known officially as Macintosh BASIC. This would seem to preclude its use on other Apple computers. Microsoft BASIC also is available for the Macintosh; the price is \$150.

Scot Kamins is senior writer for Technology Translated Inc. (1047 Sutter St., San Francisco, CA 94109), a technical writing firm.