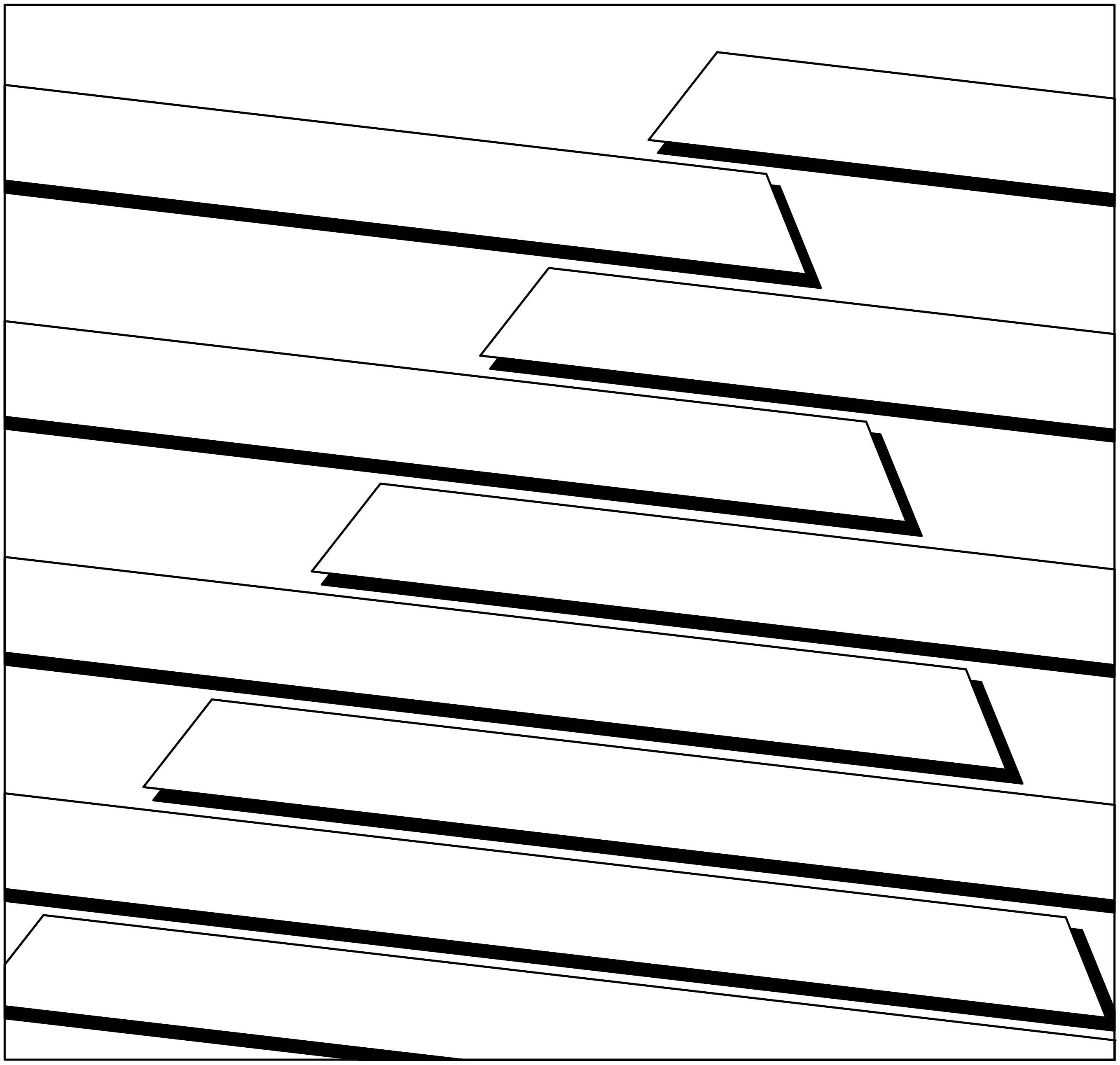
ALLEN-BRADLEY

OS-9 BASIC

User Manual



Copyright and Revision History

This manual reflects Version 2.4 of Microware BASIC. Version 2.4 of Microware BASIC is to be used with Version 2.4 or greater of the OS-9 operating system.

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Introduction

Microware BASIC is an enhanced structured Basic language programming system. It was created for the 68000 Microprocessor.

In addition to the standard BASIC language statements and functions, Microware BASIC includes many of the useful elements of the PASCAL programming language. This allows programs to be modular, well-structured, and use sophisticated data structures. It permits full access to almost all of the OS-9 operating system commands and functions so it can be used as a systems programming language.

Microware BASIC is unusual in that it is an **interactive compiler**. It has the fast execution speed typical of compiler languages and the ease of use and memory space efficiency typical of interpreter languages.

Microware BASIC includes a powerful text editor, a multi-pass compiler, a run-time interpreter, a high-level interactive debugger, and a system executive. Each of these components is carefully integrated so you see a friendly, highly interactive programming resource. It provides all the tools and helpful facilities needed for fast, accurate creation and testing of structured programs.

These features make Microware BASIC an ideal language for many applications: scientific, business, industrial control, and education.

Microware BASIC Features

Structured, recursive BASIC with Pascal-type enhancements:

- allows multiple, independent, named procedures
- procedures called by name with parameters
- multi-character, upper or lower case identifiers
- variables and line numbers local to procedures
- line numbers optional
- automatic linkage to ROM or RAM “library” procedures
- PACK command compacts program and provides security
- PRINT USING with FORTRAN-like format specifications

Extended Control Structures (with Unique Closure Elements):

- IF...THEN...[ELSE...] ENDIF
- FOR...TO...[STEP]...NEXT
- REPEAT...UNTIL...
- WHILE...DO...ENDWHILE
- LOOP...ENDLOOP
- EXITIF...THEN...ENDEXIT

High-speed, high-accuracy math:

- 14 decimal-digit 64 bit binary floating point
- Full set of transcendentals (SIN, ASN, ACS, LOG, etc.)

Extended data structures:

- Five Basic data types: BYTE, INTEGER, REAL, BOOLEAN, and STRING
- One, two, or three dimensional arrays
- User-defined complex structures and data types

Powerful interactive debugging and editing features:

- Integral, full-featured text editor
- Syntax error check upon line entry and procedure compile
- Trace mode reproduces original source statements
- Renumber command for line numbered procedures

The History of Microware BASIC

Microware Basic was conceived in 1978 as a high-performance programming language to demonstrate the capabilities of the 6809 microprocessor to efficiently run high-level languages. Microware BASIC was developed at the same time as the 6809 under the auspices of the architects of the 6809. It was originally titled **Basic09**. The project covered almost two years, and incorporated the results of research in such areas as interactive compilation, fast floating point arithmetic algorithms, storage management, high-level symbolic debugging, and structured language design. These innovations give Microware BASIC its speed, power, and unique flavor.

Microware BASIC was commissioned by Motorola, Inc., Austin, Texas, and developed by Microware Systems Corporation, Des Moines, Iowa. Principal designers of Microware BASIC were Larry Crane, Robert Doggett, Ken Kaplan, and Terry Ritter. The first release was in February, 1980.

Excellent feedback, thoughtful suggestions, and carefully documented bug reports from Microware BASIC users all over the world have been invaluable to the designers in their efforts to achieve the degree of sophistication and reliability Microware BASIC has today.

Concerning This Manual

This manual is divided into two parts: the BASIC Tutorial and the BASIC Reference Manual.

The tutorial section is written for beginning programmers having little experience with Pascal or other high level languages. Beginning programmers should work through the examples given to help familiarize themselves with Microware BASIC control structure.

Readers having adequate programming skills are urged to browse the tutorial for a feeling of the Microware BASIC environment. A complete index is provided for easy use of the reference section.

In this manual, Microware BASIC is referred to as BASIC, unless making reference to other BASIC languages.

SECTION 1 THE BASIC TUTORIAL

SECTION 2 BASIC REFERENCE GUIDE

Section 1

The BASIC Tutorial

This section of the manual describes:

- how new Microware BASIC users can become comfortable with programming BASIC
- how users get started programming BASIC
- complex data types and subroutines that you can use with Microware BASIC
- how to obtain program optimization when executing your procedures

Chapter 1

Overview

Introduction

This manual is designed for two purposes:

- to help new Microware BASIC users become comfortable with programming in BASIC
- to serve as a reference for new and existing users

In order to do this, this manual is divided into two sections. The first section is a user manual that explains how to create a program with BASIC and how to use BASIC's functions to make your programs better. The second section is a reference manual.

Before using Microware BASIC, you should be familiar with OS-9. You should be familiar with either the Using Personal OS-9 manual or the Using Professional OS-9 manual. These manuals provide an understanding of how OS-9 stores files as well as other useful information.

Getting Started

When you start your computer or log in to your account, the OS-9 prompt is displayed. This manual uses a dollar sign ($) to represent the OS-9 prompt.

To enter the BASIC environment, type **basic** at the $ prompt and press the **[Return]** key. OS9 responds by printing:

```
$ basic
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Microware Basic V2.4
Ready
B:
```

Important: If you are not running version 2.4 of BASIC, the version number will be different.

The `B:` prompt indicates that you are in BASIC's **system mode**. Microware BASIC has four modes:

Mode:	Description:
System Mode	Used for executing system commands.
Edit Mode	Used for creating and editing procedures.
Execution Mode	Used for running procedures.
Debug Mode	Used for testing procedures for errors

You must remember that BASIC *does* have different modes. You should be aware that some commands only operate in one mode. Therefore, if you execute a command that you feel should work and it does not, check that you are in the proper mode.

These modes are all discussed in more detail in the appropriate sections. A full description of each mode is located in the reference section of this manual.

When you create procedures in BASIC, they are created in BASIC's **workspace**. The workspace is the memory area where procedures are created or loaded, edited, and executed. The procedures in this area are not automatically saved when you exit BASIC. Therefore, you must save any files in your workspace before you exit BASIC.

Fundamental Commands

There are several commands that you should know before beginning to program in BASIC. These commands are as follows:

Command:	Description:
BYE	Exits BASIC.
DIR	Lists procedures currently in your workspace.
EDIT	Enters edit mode.
KILL	Deletes a procedure from your workspace.
LOAD	Loads files from the OS-9 file system to your workspace.
MEM	Displays or requests workspace memory.
PACK	Compresses a BASIC procedure into BASIC intermediate code.
SAVE	Saves your procedures in the OS-9 file system.

BYE: Exiting BASIC

When you have finished using BASIC and have saved all procedures that you want to save, you can exit BASIC by typing the command **BYE** at the system prompt:

```
B: BYE
```

You are returned to your OS-9 shell prompt.

DIR: Listing Procedure Names in Your Workspace

The DIR command displays the names and sizes of all procedures in your workspace. You can also use a carriage return while in system mode.

`DIR` displays a table of all procedure names with two numbers next to each name. The first column, proc size, is the size of the corresponding procedure. The data size column shows the amount of memory that the procedure requires for its variables. For example:

```
B:DIR

  Name      Proc–Size  Data–Size
   testprog       226         66
   prog2          162         82
   exloop         220         74
  *readit         224         66
4266 free
Ready
B:
```

The last line shows the amount of free bytes of workspace memory remaining. You may use this information to estimate how much memory your program needs to run. You must have at least as much free memory as the data size of the procedure(s) to be run. If a data size number is followed by a question mark, you need more memory.

EDIT: Entering Edit Mode

When you enter the EDIT or E command, you exit system mode and enter edit mode. To enter edit mode, type **EDIT** or **E** and the name of a procedure file to edit:

```
e myprocedure
```

If you do not enter a procedure file, BASIC assigns the name Program to your procedure. The EDIT command is discussed in more detail in the next chapter.

KILL: Deleting Procedures in Your Workspace

At any time, you may permanently erase one or all of your procedures in your workspace by using the KILL command. **`KILL`** followed by a procedure name erases the specified procedure. **`KILL*`** erases all procedures in the workspace. For example:

Command:	**Description:**
B: KILL prog1	Erases prog1 from workspace.
B: KILL*	Erases all procedures from workspace.

LOAD: Loading Procedures

To retrieve a procedure from your current data directory, you can use the LOAD command followed by the name of the file:

```
B: LOAD oldprog
```

This command loads the file oldprog into your workspace. If you have a procedure in your workspace with the same name as one in the file, BASIC uses the procedure loaded from the file.

MEM: Displaying or Requesting Workspace Memory

When you enter BASIC, OS-9 automatically allocates approximately 4K of workspace memory for BASIC. If you need more memory, you can use the MEM command to get additional memory, if the additional memory is available. To use the MEM command, type **`MEM`** and the amount of memory you want in bytes. For example:

```
MEM 20000
```

This command line requests 20K of memory. BASIC always rounds the amount you request up to the next highest multiple of 256 bytes. If MEM displays the following, the requested amount of memory is not available:

```
What?
```

You can also use OS-9's #<memory> option to specify more memory when you enter BASIC. For example, to call BASIC with 16K of memory, enter the following command:

```
$ basic #16k
```

PACK: Compressing Procedures

The PACK command compresses a BASIC procedure and places it in your current execution directory. Depending on the number of comments, line numbers, etc., packed procedures execute from 10% to 30% faster than unpacked procedures. BASIC loads the packed procedure when you try to run it after it has been packed. The following is an example of using PACK:

```
B: PACK exloop
```

Important: Before you PACK a procedure, always SAVE it first. You *cannot* load a packed file into your workspace. Packing a procedure removes it from your workspace.

SAVE: Saving Procedures

When you exit BASIC, all unsaved procedures are erased. The SAVE command allows you to save your programs.

You can use SAVE in a number of ways:

Command:	Description:
Type SAVE by itself.	BASIC creates a file with the name of the last edited or run procedure in your current data directory. If a file already has this name, BASIC returns the prompt: Rewrite?. If you respond y for yes, it replaces the file previously stored in that space with the new procedure. OS-9 does not allow two files with the same name in the same directory. By answering n for no, you cancel the SAVE command without changing the procedure in your workspace or the file in your directory.
Type SAVE > and a file name.	This saves the procedure in a file with the specified name.
Type SAVE* and a file name.	This saves all procedures in your workspace in the specified file.
Type SAVE, followed by one or more procedures, followed by a >, followed by a file name.	This saves the specified procedures in the specified file.

Important: If you exit from BASIC, your programs *will not* automatically be saved. You *must* save them using one of these methods or they will be lost.

Chapter 2

Getting Started

Naming Your Procedure

Programs in BASIC are called **procedures**. A procedure contains BASIC instructions as specified by the BASIC language.

Procedures are created in edit mode. To enter edit mode, type e and the name of the procedure you want to create:

```
B: e myprogram
```

Procedure names may contain from 1 to 28 upper or lower case letters, numbers, or special characters (as listed below). While the file name may begin with any of the following characters or digits, the file name must contain at least one number or letter. Within these limits, a name may contain any combination of the following:

Description:	Character:
upper case letters	A-Z
underscores	_
lower case letters	a-z
dollar signs	$
numbers	0-9
periods	.

If you do not specify a procedure name, BASIC assigns the name Program to the new procedure.

BASIC responds with the following:

```
B: e myprogram
PROCEDURE myprogram
*
E:
```

BASIC prints the word PROCEDURE and the name of the procedure. This is followed by an asterisk (*) signifying the current edit line in the procedure. The last line displays the edit mode prompt, `E:`.

In edit mode, the first character of each line is reserved for edit commands. If you forget to type an edit command, BASIC responds with the following prompt:

```
What?
```

The most important edit command is the **`[Space]`** character. Placing a **`[Space]`** in the first character position saves the line of the procedure that immediately follows as a BASIC statement.

Important: The edit commands are discussed later in this chapter. There is also a chapter in the reference section which deals with the edit commands.

Writing Your First Procedure

When writing your procedure, you will probably want to receive and print data. You can use the INPUT statement to receive data and the PRINT statement to print the data.

- INPUT accepts data during the execution of a procedure. The data is normally read from your terminal (the **standard input device**).
- PRINT outputs the text or the values given on the print line. The output is normally sent to the terminal (the **standard output device**).

Important: Both input and output can be redirected. This allows you to read data from a file or print a file to the printer. For more information on redirecting input and output, refer to either Using Personal OS–9 or Using Professional OS–9.

With these two commands, you can write a simple procedure, myprogram. This procedure asks you for your name and prints a message. The first line of the procedure asks you to enter your name:

```
E: PRINT “type your name”
```

You must enter a space before the PRINT statement. If you forget to do this, BASIC will not save your command. If entered correctly, when you execute myprogram, the characters between the quotes will be printed on the terminal screen.

Important: If you make a mistake while entering this procedure line, skip ahead to the section in this chapter on editing procedures.

Because the user will try to enter their name, the next statement reads their input:

```
E: INPUT name$
```

Once again, you must enter a space before the INPUT statement to save the line. When this procedure is executed, this command causes Basic to wait for a line of text to be received from the keyboard. BASIC accumulates text from the keyboard, character by character, until a **`[Return]`** ends the line. This text is saved in the memory reserved for the variable name$.

Important: Variables are discussed in more detail in a later section.

To finish this program, enter the final two lines:

```
E: PRINT “Hi, ”;name$;“. It’s been nice talking to you.”
*
E: END
```

The semicolon following the quote after “Hi,” tells BASIC that something else is to be printed on this line. BASIC inserts the text that the variable name$ represents. The next semicolon informs BASIC that there is more to print on the same line.

When a PRINT statement contains multiple values, it prints the values consecutively. You must separate each of these values by a comma or a semicolon. If the separator is a comma, BASIC moves to the next 16-column tab stop before printing the next value. If the separator is a semicolon, no space separates the fields.

Important: If you do not want to use the default tab stops, refer to the description of the TAB command located in the command summary.

The END statement is optional. It tells BASIC to stop executing the procedure and return to system mode. BASIC returns to system mode after executing the last line of code within the procedure.

To list your procedure, type **l***. This edit mode command lists the procedure:

```
E:l*
PROCEDURE myprogram
 0000      PRINT “type your name”
 0012      INPUT name$
 0017      PRINT “Hi, “; name$; ”. It’s been nice talking to you.”
 0035      END
*
E:
```

Important: The editor has added some information which you did not type. The numbers to the left of the program are **I-code addresses**. These are the actual memory locations where each line begins relative to the start of the procedure. These numbers may appear strange because they are in hexadecimal (base 16). The I-code addresses are important because when BASIC finds an error in a procedure, it conveys as much information as it has concerning the error. One such piece of information is the I-code address. Basic automatically supplies I-code addresses.

Now, run the procedure. To run a procedure, you must be in system mode. You can exit the editor and return to system mode by typing `q`:

```
E:q
READY
B:
```

Now type `run myprogram` or `run`. If you enter the RUN command without a procedure name, BASIC executes the last edited procedure.

```
B: RUN myprogram
type your name
? Ellen
Hi, Ellen. It’s been nice talking to you.
READY
B:
```

Important: The question mark (`?`) prompt tells you that the program is waiting for input.

Congratulations! You have just written and executed your first program with Microware BASIC.

The DIM Statement: Declaring Variables

Procedures use variables to hold values during the execution of the procedure. The value of a variable may change during execution. In the example myprogram, name$ was used as a variable to hold the value Ellen.

There are two ways of declaring a variable:

- the DIM statement
- inferred declaration

The DIM statement declares the variable name and the type of data that is assigned to it during the course of the procedure. The DIM statement must occur before you use the variable in the program. This prevents a variable from being defined with a default data type (inferred declaration). By standard convention, the DIM statement is used in the first few lines of a procedure.

The syntax for the DIM statement is as follows:

```
DIM <variable>[, <variable>] : <data type>
```

If you declare more than one variable as the same data type, separate the variables with commas. If you declare more than one data type in the same DIM statement, separate the <var>:<type> statements with semicolons. For example:

```
DIM x,y,z: INTEGER; a,b,c: REAL
```

In this example, the variables x, y, and z are defined as integer values, and a, b, and c are defined as real values.

If the DIM statement is not used and variables are present in a procedure, the variables are declared with default data types. All undeclared string variables must end in a dollar sign ($). These variables are assigned a maximum length of 32 characters.

In the case of name$ in the example myprogram, name$ was declared as a string variable with a length of 32 characters. If the character string assigned to name$ is longer than 32 characters, only the first 32 characters are accepted.

By default, all other variables used are declared as REAL numbers regardless of the intent of the procedure.

Initializing Variables

Generally, you must initialize variables. BASIC assigns a certain space in memory large enough to hold the declared type of data. Consequently, if the variables are not initialized, the variable may contain just about any value. This makes any operation depending on these variables to be very unreliable.

You can use either of two assignment statements to initialize variables.

The LET statement has the following syntax:

```
LET <variable> := <value or constant>
```

For example, if you have the following command in your procedure, x equals one:

```
LET x:=1
```

You could also enter the following:

```
LET x=1
```

You can also use an implied statement. Implied statements have the following syntax:

```
<variable> := <value or constant>
```

For example, if you have the following command in your procedure, y equals ten:

```
y := 10
```

You could also enter the following:

```
y = 10
```

Naming Variables: Reserved Words

Variable names may be of any length, but you will probably want to keep them short. This_is_a_legal_variable is legal, but tedious to type. Variable names must conform to the following rules:

- Names must begin with either an underscore or letter.
- Names cannot contain embedded blanks or dollar signs.
- Names can end in a dollar sign.
- Names can contain any alphanumeric or underscores.
- Names may not be any BASIC reserved word.

BASIC recognizes certain words as **reserved**. They cannot be used as variable names. These reserved words are all commands and key words used within BASIC statements:

Table 2.A
BASIC Reserved Words

ABS	ACS	ADDR	AND
ASC	ASN	ATN	BASE
BOOLEAN	BYE	BYTE	CHAIN
CHD	CHR$	CHX	CLOSE
COS	CREATE	DATA	DATE$
DEG	DELETE	DIM	DIGITS
DIR	DO	ELSE	END
ENDEXIT	ENDIF	ENDLOOP	ENDWHILE
EOF	ERR	ERROR	EXEC
EXITIF	EXP	FALSE	FILSIZ
FIX	FLOAT	FOR	GET
GOSUB	GOTO	IF	INKEY
INPUT	INT	INTEGER	KILL
LAND	LEFT$	LEN	LET
LNOT	LOG	LOG10	LOR
LOOP	LXOR	MID$	MOD
NEXT	NOT	ON	OPEN
OR	PARAM	PAUSE	PEEK
PI	POKE	POS	PRINT
PROCEDURE	PUT	RAD	READ
REAL	REM	REPEAT	RESTORE
RETURN	RIGHT$	RND	RUN
SEEK	SGN	SHELL	SIN
SIZE	SQ	SQR	SQRT
STEP	STOP	STR$	STRING
SUBSTR	TAB	TAN	THEN
TO	TRIM$	TROFF	TRON
TRUE	TYPE	UNTIL	UPDATE
USING	VAL	WHILE	WRITE
XOR			

Variable Data Types

BASIC recognizes five data types:

Type:	Description:
INTEGER	Whole numbers (no decimal) ranging from –2,147,483,648 to 2,147,483,647.
REAL	Floating point numbers (decimal point allowed) ranging from ±2.2 10 −308 to ±1.8 10 308.
BYTE	Whole numbers (no decimal) ranging from 0 to 255.
STRING	Letters, digits, and/or punctuation.
BOOLEAN	True or False.

Important: Numbers may be INTEGER, REAL, or BYTE values. While REAL numbers are the most versatile (that is, they have the greatest range and can represent decimals), math operations involving them are relatively slow. INTEGER and BYTE operations use less memory and are executed faster.

A STRING is a variable length sequence of characters. An "empty" STRING is a special case and contains no characters. A STRING may be declared to have a specified length by using the DIM statement. This is useful for saving memory space when 32 characters are not needed (the default STRING size is 32 characters).

To declare a STRING length, type dim, followed by <variable name>: STRING[len]. For example, to declare the variable word with a length of five characters, you would type:

```
DIM word: STRING[5]
```

The BOOLEAN variable is most often used in conditional statements to divert execution to certain parts of the procedure. If something is true, then do this; otherwise, continue.

Important: For more information about data types, refer to the chapter on data types and data structures.

Constants

Constants are frequently used in procedures to assign values to variables. BASIC has rules that allow you to specify constants that correspond to the five BASIC data types. There are three basic types of constants:

- numeric
- boolean
- string

Numeric Constants

Numeric constants can be either REAL or INTEGER data types. If a number constant includes a decimal point or uses the “E format” exponential form, BASIC stores the number in REAL format, regardless of whether the number could have been stored in INTEGER or BYTE format. If you want a REAL constant, use a decimal point (for example, 12.0). This is sometimes done if all other values in an expression are of type REAL so that BASIC does not have to do a time-consuming type conversion at run-time.

Numbers that do not have a decimal point but are too large to be represented as integers are also stored in REAL format. The following are examples of REAL constants.

Table 2.B
REAL Constraints

1.0	9.8433218	1.95E+12	10000000000
–.01	–999.000099	–99999.9E–33	5655.34532

Numbers that do not have a decimal point and are in the INTEGER range are treated as INTEGER numbers. BASIC also accepts integer constants in hexadecimal in the range 0 to $FFFFFFFF. Hex numbers must have a leading dollar sign. The following are examples of INTEGER constants:

Table 2.C
INTEGER Constraints

12	–3000	64000	$20	$FFFE	$0

BOOLEAN Constants

The two legal BOOLEAN constants are TRUE and FALSE:

```
DIM flag, state: BOOLEAN
flag := TRUE
state := FALSE
```

STRING Constants

STRING constants consist of a sequence of any characters enclosed by quotation marks. To represent a quotation mark within the string, use two consecutive quotation marks (“”). An empty string can also be represented by two consecutive quotation marks. The following are examples of STRING constants:

```
“This is a STRING constant”
“”   (a null string)
“This is the ““real”” thing”
```

Operators

An operator combines or compares values of operands: constants and variables. Operators (except negation) take two operands and perform some operation to produce a result. This result is generally the same type as the operands. The table on the following page lists the operators available and the types they accept and produce.

Operators have precedence which means they are evaluated in a specific order (for example, multiplication is performed before addition). You can use parentheses to override natural precedence. The compiler, however, may remove extraneous parentheses. The legal operators are listed below, in order from highest to lowest.

Table 2.D
Legal Operators

Highest Precedence	NOT	–(negate)
	^	**
	*	/
	+	–
	>	< <> = >= <=
	AND	
Lowest precedence	OR	XOR

Operators of equal precedence are shown on the same line, and are evaluated left to right in expressions. The only exception to this rule is exponentiation, which is evaluated right to left. Raising a negative number to a power is not legal in BASIC.

In the examples below, BASIC expressions on the left are evaluated as indicated on the right. You may enter either form, but the compiler always generates the simpler form on the left.

BASIC representation:	**Equivalent form**
a:= b+c**2/d	a:= b+((c**2)/d)
a:= b>c AND d>e OR c=e	a:= ((b>c) AND (d>e)) OR (c=e)
a:= (b+c+d)/e	a:= ((b+c)+d)/e
a:= b**c**d/e	a:= (b**(c**d))/e
a:= –(b)**2	a:= (–b)**2
a:=b=c	a:= (b=c) (returns BOOLEAN value)

Operator:	**Function:**	**Operand type:**	**Result type:**
–	Negation	NUMERIC	NUMERIC
^ or **	Exponentiation	NUMERIC (positive)	NUMERIC
*	Multiplication	NUMERIC	NUMERIC
/	Division	NUMERIC	NUMERIC
+	Addition	NUMERIC	NUMERIC
–	Subtraction	NUMERIC	NUMERIC
NOT	Logical Negation	BOOLEAN	BOOLEAN
AND	Logical AND	BOOLEAN	BOOLEAN
OR	Logical OR	BOOLEAN	BOOLEAN
XOR	Logical EXCLUSIVE OR	BOOLEAN	BOOLEAN
+	Concatenation	STRING	STRING
=	Equal to	ANY	BOOLEAN
<> or ><	Not equal to	ANY	BOOLEAN
<	Less than	NUMERIC, STRING 1	BOOLEAN
<= or =<	Less than or Equal	NUMERIC, STRING 2	BOOLEAN
>	Greater than	NUMERIC, STRING 3	BOOLEAN
>= or =>	Greater than or Equal	NUMERIC, STRING 4	BOOLEAN
When comparing strings, the ASCII collating sequence is used, so that 0 < 1 < ... < 9 < A < B< ... < Z < a < b< ... < z			

Important: NUMERIC refers to either BYTE, INTEGER, or REAL types.

Conditional Control: The IF..THEN Structure

The IF..THEN..ELSE structure is frequently used in programs. The syntax is as follows:

```
IF <boolean> THEN
   <statement>
ELSE
   <statement>
ENDIF
```

This executes certain statements only if specified conditions exist. The following example demonstrates the IF..THEN..ELSE structure:

```
PROCEDURE MESSAGE
  PRINT “Type your name.”
  INPUT name$
  PRINT “Would you like the message of the day, “;name$;”? (y/n)”
  INPUT answer$
  IF answer$ = “y” THEN
    PRINT “Space is the future”
  ELSE
    PRINT “Suit yourself.”
  ENDIF
  PRINT “Bye, “; name$; ”. It’s been nice talking to you.”
  END
```

This procedure prints one of two messages depending on your input. The condition could also depend on a computed value. Also, there could be many statements or procedures separating the THEN and ELSE segments of the conditional. This example just shows one of the ways you can use this structure.

You can also use the IF..THEN statement as a single statement:

```
IF <boolean> THEN <line#>
```

This sends the control of the procedure to the specified line number if the control condition is met. You should rarely use the IF..THEN statement in this way.

Important: Multiple ELSE statements are not considered errors by the compiler (that is, they do not generate error signals). However, they do produce irregular and non-reliable results.

Looping Statements

When you write your programs, you may find that you want to repeat a section of code several times. You can do this using a **looping** statement. Loops cause repeated or conditional execution of the statements located between the starting point and the ending point of the loop. Generally, loops have one entry at the top and only one exit at the bottom. In this sense, it becomes one statement, regardless of how many individual statements it contains.

You can nest loops. This allows the internal statements to be executed even more times. You should know at least what will happen on the first, second, next to the last, and last passes through the looping structure. It is usually during these passes when a procedure produces errors which can halt execution.

BASIC supports four ways of adding loops into your program:

Type of loop:	**Description:**
FOR..NEXT	Executes code an exact number of times.
WHILE..DO	Tests for a control variable before executing any code, and performs only as long as the control statement remains true.
REPEAT..UNTIL	Executes the code at least once regardless of the initial conditions, and repeats the code as long as a control statement remains valid.
LOOP..ENDLOOP	Tests one or more control variables anywhere within the loop (and perhaps more than once).

Each loop structure is discussed in greater detail. When you write your programs, you should use the most appropriate loop for what you want to accomplish; each loop structure has its own advantages.

As a general comment about loops, the initialization placement is very important. You can easily create an endless loop (a loop that does not end) by forgetting to initialize variables or by placing the initialization in the wrong place. This is especially true when changing from one type of loop structure to another. You should make sure that you know what happens at the beginning and end of each loop sequence. This helps reduce the chance of creating an endless loop.

The FOR..NEXT Loop

The FOR..NEXT loop executes a set of statements a specific number of times. A FOR..NEXT loop begins with the FOR statement. The FOR statement initializes the loop, and the NEXT statement ends the loop. The following is an example of a FOR..NEXT loop:

```
FOR x=1 TO 3
   PRINT “Hi There!”
NEXT x
```

This loop prints the string Hi There! three times. The first time BASIC encounters the FOR statement, x equals 1 (FOR x=1). BASIC executes the statement(s) within the loop, which in this example is a PRINT statement. When it reaches the NEXT statement, it increments x and goes back to the FOR statement. x now equals 2, so BASIC again executes the PRINT statement and goes to the NEXT statement. Once again, x is incremented. x now equals 3. BASIC executes the PRINT statement and goes to the NEXT statement. This time when the NEXT statement increments x, x is greater than three. Therefore, BASIC does not execute the PRINT statement. Instead, it jumps to the statement that follows NEXT.

Using STEP Within a FOR..NEXT Loop

By default, the NEXT statement increments the variable by one each time. If you want to increment the variable by a value other than one, you need to include a STEP declaration in the FOR statement. For example:

```
FOR x=1 to 10 STEP 2
   PRINT “Hi There!”
NEXT x
```

The string Hi There! is printed five times because each time BASIC comes to the NEXT statement, x is incremented by two. Therefore, after the first pass through the loop, x equals three instead of two.

The value to STEP may be a positive or negative number, and it may be either an integer or a real. If it is a real data type (for example, STEP .5) the control variable must also be a real data type. The following is an example of a real data type for the STEP value:

```
DIM x:REAL
FOR x=1 TO 5 STEP .5
   PRINT x
NEXT x
END
```

This example prints the value of x for each pass through the loop.

The WHILE..DO Loop

The WHILE..DO loop tests for a control variable before executing any code. It continues to loop as long as the control statement located in the WHILE statement remains true. If the control statement in the WHILE statement is false the first time it is encountered, the loop is not executed. The WHILE..DO loop has the following syntax:

```
WHILE <boolean> DO
   .
   .
ENDWHILE
```

<boolean> may be an expression (such as x<5) or merely a BOOLEAN variable (such as WHILE red DO).

The following is an example of a WHILE..DO loop:

```
x:=1
WHILE x<5 DO
   PRINT x
   x:=x+1
ENDWHILE
```

The first line is outside of the WHILE..DO loop, but it is important for this loop because it initializes the value of x. The next line begins the loop. It tells BASIC to test the value of x. If x is less than five, then the statements inside the loop are executed. If the value of x is five or greater, the statements inside the loop are not executed. Therefore, the output from this loop looks like this:

```
1.
2.
3.
4.
```

Important: You *must* change the value of the conditional within the loop. If you do not, the loop never exits. For example, the following is an endless loop because the internal commands do not affect the conditional statement:

```
a:= 5
WHILE a < 10 DO
   PRINT “This is an endless loop”
ENDWHILE
```

The REPEAT..UNTIL Loop

Another loop statement is REPEAT..UNTIL. It is similar to the WHILE..DO statement. The syntax is as follows:

```
REPEAT
   .
   .
UNTIL <boolean>
```

The major difference is that in a REPEAT..UNTIL statement, the conditional statement is tested at the bottom of the loop. This means that the statements within the loop are executed at least once, even if the conditional statement is false the first time.

The following is an example of a loop using REPEAT..UNTIL:

```
x := 1
REPEAT
   PRINT x
   x := x+1
UNTIL x>10
```

Notice again that x is initialized outside of the loop. If it were initialized inside of the loop, the loop would never end. The next statement, REPEAT, begins the loop. The statements within the loop are always executed during the first pass. The UNTIL statement tests the conditional value. If the statement is false, the loop executes again. If the statement is true, the loop is not executed again.

Because the variable is tested at the bottom of the loop, it usually has an opposite test from one you would find in a WHILE loop. You can easily introduce errors into your program when you change from a WHILE..DO loop to a REPEAT..UNTIL loop by forgetting to change the conditional statement.

The LOOP..ENDLOOP Loop

The final type of loop structure available in BASIC is the LOOP..ENDLOOP statement. It has no built-in control statement to test for exit, so it uses an internal structure, the EXITIF..THEN statement. The syntax for these two structures are as follows:

```
LOOP

   <statements>

   EXITIF <boolean> THEN
   <statements>
   ENDEXIT

   <statements>

ENDLOOP
```

The LOOP structure would execute endlessly without the EXITIF construct. You can use the EXITIF structure as many times as needed within a LOOP. In this way, you may exit a loop for different reasons. The following is an example of a LOOP..ENDLOOP:

```
x := 1
LOOP
   PRINT “x is a small number”
   x := x +1

EXITIF x>3 THEN
   PRINT “x is now greater than three”
ENDEXIT

ENDLOOP
```

The execution of this procedure is similar to the REPEAT..UNTIL. The loop is executed until x > 3. Then, the statement between the THEN and the ENDEXIT is executed (PRINT). The loop is then exited.

You can omit the statement to be executed in the EXITIF loop. For example, you could enter:

```
EXITIF x>3 THEN
ENDEXIT
```

This is known as a null statement because nothing occurs.

The EXITIF..THEN structure may be used in any of the looping structures to exit anywhere within the loop. This allows greater freedom in building your procedures.

Editing Your Procedures

Once you have written a procedure, you can change it by using the editor. There are a number of commands available in edit mode for this purpose. They are as follows:

Command:	**Description:**
<return>	Moves the edit pointer forward one line.
+[<number>]	Moves the edit pointer forward the specified number of lines (default is 0).
+*	Moves the edit pointer to the end of the procedure.
–[<number>]	Moves the edit pointer back the specified number of lines.
–*	Moves the edit pointer to the beginning of the procedure.
<space> <text>	Inserts a line directly before the current line.
<space> <line#> <text>	Inserts or replaces a numbered line.
<line#> <return>	Moves edit pointer to specified line.
c[*]<delim><string1> <delim><string2> <delim>	Replaces <string1> with <string2> in the current line. If used with an asterisk (*), the entire procedure is searched and replaced. <delim> is a delimiter character that is not within either string. For example: c.why.why not?. Legal syntax c?why?why not?? Illegal syntax: ? is in the string
d[*] [line#]	Deletes the specified lin. eIf no line is specified, the current line is delete. dIf a negative number is specified, the specified number of lines before the current line are delete. The forms d–* or d+* are also allowed. They delete all lines before or after the current line respectively. d* deletes the entire procedure.
l[*] [<number>]	Lists the specified number of lines from the current edit pointer. If the number is negative, the specified number of lines before the current line is displayed. l* lists the entire procedure.
q	Quits the editor, and returns to system mode.
r[*] [<number>], [<increment>]	Renumbers the numbered lines in a procedure. The r command begins at the current line and renumbers the first numbered line found with the specified number. After that, it increments the line number by the specified increment. If an asterisk (*) is used, the renumbering begins with the start of the procedure. This also renumbers any references to line numbers (GOTO or IF..THEN statements). The default values for renumbering are a starting value of 100 with an increment of 10.
s[*] <del> <string> <del>	Searches for the indicated string on the current line. If an asterisk (*) is used, the entire procedure is searched and the pointer is moved to the first matching string. Delimiters (<del>) follow the same rules as the c command.
<escape>	Quits the editor.

Using the Edit Mode Commands

To use the editor, you must be in edit mode. You can use these commands to create, display, and edit the procedure mtable. This section goes step by step. You should enter the commands on your own terminal.

First, enter the command e mtable from the system mode:

```
B:e mtable
```

When you have pressed return, the following is displayed:

```
PROCEDURE mtable
*
```

Now, enter the procedure. Notice that you can type the procedure all in lower case characters. When the procedure is displayed, you will see that all reserved words have been converted to upper case letters. Remember to add a space before each line.

```
E: dim a,b: integer
*
E: a:=1
*
E: print
*
E: while a<10 do
*
E:b:=1
What?
```

The last two lines show what happens when you forget to add the <space> command before a line. Just re-type the line and continue:

```
E: b:=1
*
E: while b<=10 do
*
E: print a; “ * “; b; “ = “; a*b; tab(mod(b,5)*13)
*
E: if pos>55 then print
*
E: ednif
 ednif
      ^
Error #000:027
*00AE ERR ednif
E:
```

The last six lines of this section show what happens if you make a mistake while typing in a command line. If this happens, enter an extra carriage return and re-type the command line. The line containing the error can be deleted later.

```
E:
*
E: endif
*
E: b:=b+1
*
E: endwhile
*
E: print
*
E: a:=a+1
*
E: endwhile
*
E: end
*
E:
```

Now that the procedure is entered, type **q** to exit edit mode:

```
E:q
Ready
```

To run the procedure, type run mtable:

```
B:run mtable
Error #000:051
Ready
```

In this example, the procedure will not execute until the line containing the error is deleted. Therefore, you should re-enter edit mode and use the l* command to list your program:

```
B:e mtable
PROCEDURE mtable
*0000      DIM a,b:INTEGER
E:l*
*0000      DIM a,b:INTEGER
 0012      a:=1
 0020      PRINT
 0024      WHILE a<10 DO
 003A        b:=1
 0048        WHILE b<=10 DO
 005E          PRINT a; “ * “; b; “ = “; a*b; TAB(MOD(b,5)*13)
 0098          IF POS>55 THEN PRINT
 00B0 ERR ednif
 00BA          ENDIF
 00BE          b:=b+1
 00D2        ENDWHILE
 00DC        PRINT
 00E0        a:=a+1
 00F4      ENDWHILE
 00FA      END
E:
```

Notice that the first line of the procedure is displayed with an asterisk (*) before the line. This points to the location of the edit pointer. Because the error is on line nine of the procedure, you must move the edit pointer to line nine. You can use the +<num> command to do this. If you redisplay the procedure (with the l* command) after executing this command, the asterisk (*) is now in front of the ninth line.

```
E:+9
*00B0 ERR ednif
```

The d command deletes the line:

```
E:d
*00B0      ENDIF
```

You can now exit edit mode (by typing **q**) and run the procedure:

```
E:q
Ready
B:run mtable
1 * 1 = 1     1 * 2 = 2     1 * 3 = 3     1 * 4 = 4     1 * 5 = 5
1 * 6 = 6     1 * 7 = 7     1 * 8 = 8     1 * 9 = 9     1 * 10 = 10

2 * 1 = 2     2 * 2 = 4     2 * 3 = 6     2 * 4 = 8     2 * 5 = 10
2 * 6 = 12    2 * 7 = 14    2 * 8 = 16    2 * 9 = 18    2 * 10 = 20

3 * 1 = 3     3 * 2 = 6     3 * 3 = 9     3 * 4 = 12    3 * 5 = 15
3 * 6 = 18    3 * 7 = 21    3 * 8 = 24    3 * 9 = 27    3 * 10 = 30

4 * 1 = 4     4 * 2 = 8     4 * 3 = 12    4 * 4 = 16    4 * 5 = 20
4 * 6 = 24    4 * 7 = 28    4 * 8 = 32    4 * 9 = 36    4 * 10 = 40

5 * 1 = 5     5 * 2 = 10    5 * 3 = 15    5 * 4 = 20    5 * 5 = 25
5 * 6 = 30    5 * 7 = 35    5 * 8 = 40    5 * 9 = 45    5 * 10 = 50

6 * 1 = 6     6 * 2 = 12    6 * 3 = 18    6 * 4 = 24    6 * 5 = 30
6 * 6 = 36    6 * 7 = 42    6 * 8 = 48    6 * 9 = 54    6 * 10 = 60

7 * 1 = 7     7 * 2 = 14    7 * 3 = 21    7 * 4 = 28    7 * 5 = 35
7 * 6 = 42    7 * 7 = 49    7 * 8 = 56    7 * 9 = 63    7 * 10 = 70

8 * 1 = 8     8 * 2 = 16    8 * 3 = 24    8 * 4 = 32    8 * 5 = 40
8 * 6 = 48    8 * 7 = 56    8 * 8 = 64    8 * 9 = 72    8 * 10 = 80

9 * 1 = 9     9 * 2 = 18    9 * 3 = 27    9 * 4 = 36    9 * 5 = 45
9 * 6 = 54    9 * 7 = 63    9 * 8 = 72    9 * 9 = 81    9 * 10 = 90

Ready
B:
```

The table looks pretty good now, but it needs a header. To add the header, re-enter edit mode and display the procedure:

```
B:e mtable
PROCEDURE mtable
*0000      DIM a,b:INTEGER
E:l*
*0000      DIM a,b:INTEGER
 0012      a:=1
 0020      PRINT
 0024      WHILE a<10 DO
 003A        b:=1
 0048        WHILE b<=10 DO
 005E          PRINT a; “ * “; b; “ = “; a*b; TAB(MOD(b,5)*13)
 0098          IF POS>55 THEN PRINT
 00B0          ENDIF
 00B4          b:=b+1
 00C8        ENDWHILE
 00CE        PRINT
 00D6        a:=a+1
 00EA      ENDWHILE
 00F0      END
E:
```

Now, move the edit pointer to the first PRINT statement, and insert a line to print a header:

```
E:+2
*0020      PRINT
E: print tab(13); “Multiplication Tables”
*0046      PRINT
E:
```

Important: Instead of using the +<num> command, you could enter a carriage return twice.

If you list your program again, the new line is now the third line of your procedure:

```
E:l*
 0000      DIM a,b:INTEGER
 0012      a:=1
 0020      PRINT TAB(13); “Multiplication Tables”
*0046      PRINT
 004A      WHILE a<10 DO
 0060        b:=1
.
.
.
 0116      END
```

Now when you run this procedure, your table will have a header.

You should experiment with the edit commands until you feel comfortable with them. This makes creating and editing your procedures much easier.

Line Numbers and the GOTO Statement

As mentioned before, the listing Basic displays is not in the exact format as the input. There is a space between the I-code address and the actual procedure. This is reserved for line numbers.

Although line numbers are required in many versions of BASIC, Microware BASIC does not require them. Line numbers must be positive whole numbers in the range of 1 to 32767. They do not need to be used for every line. They are generally used with a GOTO or GOSUB statement.

The GOTO statement transfers control unconditionally to the specified line. For example:

```
    PROCEDURE gotodemo
      PRINT “This is a GOTO example”
      GOTO 10
      PRINT “This line will never be printed”
10 PRINT “It works but it’s dangerous”
      END
```

As you can see, a GOTO statement could cause certain parts of a procedure’s code to be excluded from execution. There are generally better ways of obtaining the same results without ever using a GOTO statement.

The use of the GOSUB statement is discussed in detail in Chapter 3.

Important: If at all possible, do not use line numbers or the GOTO statement. Your procedures will be shorter, faster and easier to edit. There is less chance of error. If you must use a GOTO statement, use it sparingly and always document the code with a comment.

Putting It All Together

With the various control statements and editing commands presented in this chapter, you should be able to write some fairly advanced procedures.

For example, the following program was written using just what you have learned in this chapter:

```
PROCEDURE multable
      DIM less:BOOLEAN
      DIM answer$:STRING[1]
      DIM a,b,c:INTEGER
      PRINT “Type your name”
      INPUT name$
      PRINT “Hi, “; name$; “! “;
      PRINT “Would you like to print a multiplication table?”
      PRINT “Type y for yes. Type any other key for no.”
      INPUT answer$
      IF answer$=”y” THEN
        PRINT “What is the number you want to multiply?”
        PRINT “(please specify a number between 1 and 100)”
        INPUT a
        PRINT “What is the range of the multiplication table?”
        PRINT “(type 2 numbers between 1 and 50 separated by a space)”
        INPUT b,c
        WHILE b=c DO
          PRINT “Please specify two different numbers for the range.”
          INPUT b,c
        ENDWHILE
        PRINT “Thank you, “; name$
        count=1
        REPEAT
          PRINT b; “ * “; a; “ = “; b*a,
          IF POS>55 THEN PRINT
          ENDIF
          IF b>c THEN b:=b–1
            less=FALSE
          ELSE
            less=TRUE
            b:=b+1
          ENDIF
        UNTIL b=c+1 AND less OR b=c–1 AND NOT(less)
      ELSE PRINT “Your loss, “; name$
     ENDIF
      END
```

Chapter 3

Program Construction: Complex Data Types and Subroutines

Introduction

This chapter discusses the following complex data types and subroutines that you can use with Microware BASIC:

- arrays
- TYPE declarations
- external files
- subroutines
- command line parameters
- formatted output

Arrays

An array is an ordered sequence of data types. An array may be one, two, or three dimensional.

- A **vector** is a one-dimensional array.
- A **table** is a two-dimensional array.
- A **matrix** is a three-dimensional array.

The size of an array depends on the number of elements in each dimension and the size of each element. The array size is declared with a statement.

The syntax for declaring a vector array is as follows:

```
DIM <array name>(<rows>) : <DATA TYPE> [<num>]
```

For example, the following line declares the vector array names. Names has 80 string elements. Each element is 30 characters:

```
DIM Names(80) : STRING [30]
```

The syntax for declaring a table array is as follows:

```
DIM <array name>(<rows>,<cols>) : <DATA TYPE> [<num>]
```

The following line declares the table array, PHONEBOOK, with the two dimensions of 80 rows and 5 columns of STRING elements. Each element is 30 characters.

```
DIM Phonebook(80,5): STRING [30]
```

The syntax for declaring a matrix array is as follows:

```
DIM <array name>(<rows>,<cols>,<depth>) : <DATA TYPE> [<num>]
```

The following line declares the matrix array, Route, with three dimensions of 5 rows, 5 columns, and 5 depth INTEGER elements. Each element is 25 integers:

```
DIM Route(5,5,5) : INTEGER [25]
```

Like variables, you must initialize each array before you use it.

The following procedure initializes Phonebook to null values:

```
PROCEDURE init
  DIM Phonebook(80,5): STRING [30]
  DIM x,y : INTEGER
  FOR x := 1 TO 80
    FOR y := 1 TO 5
      Phonebook(x,y) = “”
    NEXT y
  NEXT x
  END
```

You should initialize numeric array elements to zero in the same manner.

Once an array is initialized, it can be loaded in various ways. The simplest way is to assign individual element’s values by an assignment statement which references the specified element:

```
Phonebook(1,1) := “Larry Crane”
Phonebook(1,2) := “unlisted”
```

Although this is simple, it is extremely time consuming. Instead, you can use a looping structure and the INPUT statement to load the array:

```
PROCEDURE Addphone
  DIM Phonebook(80,5):STRING[30]
  DIM x,y:INTEGER
  DIM done:BOOLEAN
  DATA “NAME”,“PHONE”,“ADDRESS”,“CITY, STATE”,“ZIP CODE”
  done:=FALSE
  x:=1
  WHILE NOT(done) AND x<=80 DO
    FOR y=1 TO 5
      READ prompt$
      PRINT “ENTER ”; prompt$
       INPUT Phonebook(x,y)
    NEXT y
    INPUT “If finished, type ”“done”“, otherwise <return>.”,flag$
    IF flag$=“done” THEN
      done:=TRUE
    ELSE
      x:=x+1
    ENDIF
  ENDWHILE
  END
```

In this procedure, the DATA and READ statements are used. The READ statement reads sequentially from the DATA statements output list. When the list is exhausted, it starts reading from the beginning of the list again. In this case, Addphone uses the READ statement to change prompts for each element of the array.

For more information on the DATA and READ statements, refer to the appropriate reference section.

Notice the INPUT statement following the FOR..NEXT structure:

```
INPUT “If finished, type ”“done”“, otherwise
<return>.”,flag$
```

This INPUT statement prints out the character string instead of the regular question mark (?) prompt. This eliminates an extra PRINT statement.

The TYPE Declaration

While the Addphone procedure is adequate for storing names and phone numbers, an array of varying data types and sizes is more efficient. In the Phonebook array, each element is thirty characters long, regardless of the use of the field. A phone number field rarely needs to be greater than twenty digits. A zip code can be held in nine.

By using the TYPE declaration, BASIC creates user-defined data types. A user-defined data type may consist of any of combination of the five basic data types, arrays, and other user-defined data types. For example:

```
TYPE rec=street:STRING[30];cityst:STRING[30];zip:STRING[9]
TYPE ENTRY=name:STRING[30]; phone:STRING[20]; address:rec
DIM Phonebook(80) : ENTRY
```

This example is functionally the same array as in Addphone. However, it is smaller and easier to access. By labeling each field with a descriptive name, there is no doubt as to what is stored there.

Each field within an element is referred to by the array name and the number of the element, followed by a period, followed by the field name (or names each separated by a period):

```
     Phonebook(32).address.zip := 50311
```

External Files

Once you have defined and accessed variable length records, you need to save them for future use. The current Addphone program only holds the memory of the phone number while it is running.

To save the input information, you must open an external file. You can then place information in this external file.

OS-9 supports two types of files:

- **Sequential files** hold records containing ASCII characters. There can be any number of characters within a record. There can be any number of records in a file (within the limits of your disk). Records are separated by a carriage return.
- **Random access files** contain records that store data in the same manner as BASIC; in binary. There are no carriage returns to indicate the end of a record. Records must be of a fixed size. There may be any number of records in the file (within the limits of your disk).

Sequential Files

Sequential files are generally used for text files because of the way data is accessed. To store data in a sequential file, BASIC supports two commands: READ and WRITE.

- The READ command reads characters from a file until it encounters a carriage return.
- The WRITE command sends each character in the record to the file and then sends a carriage return to indicate the end of record.

Sequential files must be read one record at a time, starting from where the file pointer is positioned. Because of the way data is stored in sequential files, the only way to position the file pointer is to read or write a record.

To access the third record of a sequential file, you must either read the first two records or rewrite them to place the file pointer at the beginning of the third record. If you were to rewrite the first record with a new record that is larger than the original, you will also write over the beginning of the second record. Obviously, this could cause many problems.

To effectively edit sequential files, you must use a text editor (word processor, etc.).

Random Access Files

To store data in a random access file, BASIC supports two commands:

- The PUT command puts a record in the specified place in your file.
- The GET command retrieves the record.

The PUT and the GET statements have the same syntax:

```
PUT <path no. var> <data struct>
GET <path no. var> <data struct>
```

You can access data elements in a random access file individually. The BASIC functions SEEK and SIZE can be used together to locate and place the file pointer at the beginning of any element. Through proper use of these functions, you can GET the record you want or PUT any record where you want it.

Creating Files

Before you can access a file, you must first create it. The syntax of the CREATE statement is as follows:

```
CREATE  #<int or byte var>, “<path>”: <access mode>
```

For example, the following command creates the file `datafile` in the `/h0/USR/ELLEN` directory:

```
CREATE #A “/h0/usr/ellen/datafile”: WRITE
```

This statement creates the specified file (`datafile`) and opens a path number to access it. The CREATE statement assigns a path number to a variable. The variable must be either an INTEGER or BYTE data type. The access mode may be any of the following:

Access mode:	Description:
WRITE	Only allows you to send (WRITE/PUT) data to the file.
UPDATE	Allows you to send and receive data (WRITE/PUT and READ/GET).
EXEC	Stores machine language code to be executed. It is rarely used except by advanced BASIC programmers.

When a file is created, it has a length of zero. It expands automatically as you send data to it.

Closing Files

When you open a path to a file, you must close it. Notice the line at the end:

```
CLOSE #file
```

The CLOSE statement closes the specified path number. Never close a path that you did not open, unless absolutely required.

A New Phonebook Example

The following procedure creates a random access file to hold Phonebook records. It assigns the prompted values to the individual Phonebook data fields one at a time. It places the entire data structure into the file at one time.

```
PROCEDURE Phonebook
  TYPE rec=street:STRING[30];cityst:STRING[30];zip:STRING[9]
  TYPE ENTRY=name:STRING[30]; phone:STRING[20]; address:rec
  DIM Phonebook : ENTRY
  DIM file : INTEGER
  CREATE #file, “phonebook”: UPDATE
  PRINT “Enter the information asked for by the prompt”
  PRINT “If information not available, hit <return>”
  REPEAT
    INPUT “name:           ”, Phonebook.name
    INPUT “phone number:   ”, Phonebook.phone
    INPUT “street address: ”, Phonebook.address.street
    INPUT “city, state:    ”, Phonebook.address.cityst
    INPUT “zip code:       ”, Phonebook.address.zip
    PUT #file, Phonebook
    PRINT “If finished, type ””done””.”
    INPUT “Otherwise hit the <return>  ”, done$
  UNTIL done$ = “done”
  CLOSE #file
  END
```

This works if the Phonebook file does not yet exist. However, trying to CREATE an already existing file causes an error (#218).

To access an already existing file, use the OPEN statement. The OPEN statement has the same syntax as the CREATE statement:

```
OPEN #<int or byte var>,“<path>”: access mode
```

There are five access modes that the OPEN statement uses:

Access mode:	Description:
READ	Reads data from a file.
WRITE	Writes data from a file.
UPDATE	Allows you to read and write to a file.
EXEC	Looks for and stores your file in your execution directory.
DIR	Opens a directory for read only.

You can OPEN a file in more than one mode, if the combination is valid. For example:

```
OPEN #file, “example”: READ + EXEC
```

Important: `DIR` and either WRITE or UPDATE causes an error. `READ +` WRITE is the same as UPDATE.

Using A Random Access File

To illustrate the access capabilities of random access files, examine this procedure:

```
 PROCEDURE Phonebook
    TYPE rec=street:STRING[30];cityst:STRING[30];zip:STRING[9]
    TYPE ENTRY=name:STRING[30]; phone:STRING[20]; address:rec
    DIM Phonebook : ENTRY
    DIM file,record : INTEGER
    DIM flag : BOOLEAN
    flag = TRUE
    ON ERROR GOTO 100
    CREATE #file, “phonebook”: UPDATE
    flag = FALSE
100 IF flag THEN OPEN #file, “phonebook”: UPDATE
    ENDIF
    ON ERROR
    REPEAT
      PRINT “Would you like to add or access entries?”
      PRINT “Or are you finished for now?”
      INPUT “Type ””add””, ””access”” or ””done””.”, answer$
      IF answer$ = “add” THEN
        SEEK #file, FILSIZ (#file)
        PRINT “If information not available, hit <return>”
        REPEAT
          INPUT “name:           ”, Phonebook.name
          INPUT “phone number:   ”, Phonebook.phone
          INPUT “street address: ”, Phonebook.address.street
          INPUT “city, state:    ”, Phonebook.address.cityst
          INPUT “zip code:       ”, Phonebook.address.zip
          PUT #file, Phonebook
          PRINT “If finished, type ””done””.”
          INPUT “Otherwise hit the <return>  ”, done$
        UNTIL done$ = “done”
      ELSE
        IF answer$ = “access” THEN
          REPEAT
            INPUT “What number record would you like?”, record
            SEEK #file, SIZE (Phonebook) * (record – 1)
            GET #file, Phonebook
            PRINT “name:           ”, Phonebook.name
            PRINT “phone number:   ”, Phonebook.phone
            PRINT “street address: ”, Phonebook.address.street
            PRINT “city, state:    ”, Phonebook.address.cityst
            PRINT “zip code:       ”, Phonebook.address.zip
            PRINT “If finished, type ””done””.”
            INPUT “Otherwise hit the <return>  ”, done$
          UNTIL done$ = “done”
        ENDIF
      ENDIF
    UNTIL answer$ = “done”
    CLOSE #file
```

Important: The BASIC statement ON ERROR GOTO gives control to the specified line if an error occurs. In this case, it bypasses the problem of recreating an existing file:

```
    flag = TRUE
    ON ERROR GOTO 100
    CREATE #file, “phonebook”: UPDATE
    flag = FALSE
100 IF flag THEN OPEN #file, “phonebook”: UPDATE
    ENDIF
```

Normally, when an error occurs, the procedure terminates, and BASIC changes to debug mode. A FALSE value is assigned to flag between the CREATE and IF..THEN OPEN structure. This assures that only one of the two access statements (OPEN or CREATE) is executed.

The ON ERROR without the GOTO effectively turns off the previous ON ERROR statement. This is important, because any other error that might occur would otherwise be routed to line 100.

Because you can use this procedure to both read and write to the phonebook file, you must access the file in UPDATE mode.

By prompting for one of three conditions (add, access, or done), you can channel control to any of these conditions. By placing this control structure within a REPEAT loop, you may add and access entries in the same session. By adding REPEAT loops within add and access sections of the code, you may add or access as many records as desired.

The SEEK statement allows access to the records. In the add loop, the file pointer is moved to the end of file with the following command:

```
SEEK #file, FILSIZ (#file)
```

The SEEK command positions the file pointer directly after the specified number of bytes. The FILSIZ function returns the size of the file specified by its path. Consequently, by using both together, the file pointer is positioned at the end of file.

In the access loop, the SEEK command positions the file pointer at the beginning of the user-specified record. For simplicity, this procedure uses numbers to specify records (first record, second record, etc.). The BASIC function, SIZE, returns the size of the specified data structure. By multiplying this size by one less than the desired record, the file pointer is correctly positioned:

```
SEEK #file, SIZE (Phonebook) * (record – 1)
```

Subroutines

The phonebook procedure is unnecessarily complex. When you repeatedly use a portion of a procedure, place it in a **subroutine**. Generally, subroutines clarify code or avoid repeating the same code throughout a procedure. In the previous program, you can place the add and access loops in subroutines to improve clarity.

The GOSUB statement accesses subroutines. The syntax for this structure is as follows:

```
GOSUB <line#>

<line#> (subroutine)
        RETURN
```

The GOSUB statement unconditionally passes control to the specified line. Basic continues to execute sequentially from that point until the RETURN statement is encountered. Control is then returned to the line immediately following the GOSUB statement.

Basic supports a related statement that provides better use of subroutines: ON..GOSUB. The syntax for this statement is as follows:

```
        ON <int expr> GOSUB {<line#>, <line#>}

<line#> (subroutine)
        RETURN
<line#> (subroutine)
        RETURN
```

ON..GOSUB evaluates the <int expr> and transfers control to the corresponding line number in the list following GOSUB. If the integer is greater than the number of line numbers in the list, no subroutine is executed. When used with a previous input statement, ON..GOSUB can run menu-type subroutines.

The following is the Phonebook procedure written with subroutines.

```
  PROCEDURE Phonebook
    TYPE rec=street:STRING[30];cityst:STRING[30];zip:STRING[9]
    TYPE ENTRY=name:STRING[30]; phone:STRING[20]; address:rec
    DIM Phonebook:ENTRY; flag:BOOLEAN; file,answer,record:INTEGER
    flag := TRUE
    ON ERROR GOTO 100
    CREATE #file, “phonebook”: UPDATE
    flag := FALSE

100 IF flag THEN OPEN #file, “phonebook”: UPDATE
    ENDIF
    ON ERROR
    REPEAT
      PRINT “TYPE: ””1”” for add new entries“
      PRINT ”       ””2”“ for access previous entries”
      PRINT “       ””3”” for exit procedure“
      INPUT  answer
      ON answer GOSUB 200,300
    UNTIL answer = 3
    CLOSE #file
    END

200 SEEK #file, FILSIZ (#file)
    REPEAT
      PRINT ”If information not available, hit <return>“
      INPUT ”name:            “,Phonebook.name
      INPUT ”phone number:    “,Phonebook.phone
      INPUT ”street address:  “,Phonebook.address.street
      INPUT ”city, state:     “,Phonebook.address.cityst
      INPUT ”zip code:        “,Phonebook.address.zip
      PUT #file, Phonebook
      PRINT ”If finished, type “”done“”.“
      INPUT ”Otherwise hit the <return>  “,done$
    UNTIL done$=”done“
    RETURN

300 REPEAT
      INPUT ”What number record would you like?“,record
      SEEK #file,SIZE(Phonebook)*(record –1)
      GET #file,Phonebook
      PRINT ”name:            “,Phonebook.name
      PRINT ”phone number:    “,Phonebook.phone
      PRINT ”street address:  “,Phonebook.address.street;
      PRINT ”city, state:     “,Phonebook.address.cityst
      PRINT ”zip code:        “,Phonebook.address.zip
      PRINT ”If finished, type “”done“”.“
      INPUT ”Otherwise hit the <return>  “,done$
    UNTIL done$=”done“
    RETURN
```

Calling Procedures

Procedures can often be used by other procedures. BASIC allows procedures to call each other, and a procedure can call itself. The RUN statement calls an external procedure. BASIC looks first in the workspace, then the data directory, and finally the execution directory. If it is found outside the workspace, BASIC loads and runs it. The RUN statement syntax is as follows:

```
RUN <proc name> [(<param>) {,<param>}]
```

The RUN statement can include parameters (a list of values) to pass to the called procedure. The called procedure must have a PARAM statement with variables of the same size and data type as the values passed. Parameters may be any type of data structure.

The syntax for the PARAM statement is as follows:

```
PARAM <declaration sequence>: <type>
```

If a parameter is a constant or an expression, it is passed **by value**. This means the called procedure can change it, but the changes are not returned to the calling procedure

If a parameter is a variable, array, or data structure, it is passed by **reference**. This means that any changes made to the value of the parameter are returned to the calling procedure. `BYTE` data types may only be passed by reference.

Commas (,) separate items in the declaration sequence. For example:

```
PARAM a,b: INTEGER
```

You can declare multiple data types on the same line by using semicolons (;). For example:

```
PARAM a,b: INTEGER; c,d: REAL; listing(10): BYTE
```

The following example passes an array of integers by reference. Example creates the array and passes it to prin. prin prints the array and passes it back to example. example passes it to reverse which reverses the order of the array. The reversed array is passed back to example. prin is run once more to validate the reversal process.

```
PROCEDURE example
  DIM a,intlist(10): INTEGER
  FOR a = 1 TO 10
    intlist(a) = a
  NEXT a
  RUN prin(1,10,intlist)
  RUN reverse(1,10,intlist)
  RUN prin(1,10,intlist)
  END
PROCEDURE prin
  PARAM a,b,prin(10): INTEGER
  DIM c: INTEGER
  FOR c = a TO b
    PRINT prin(c);“ ”;
  NEXT c
  PRINT
  END
PROCEDURE reverse
  PARAM a,b,intlist(10):INTEGER
  DIM c, temp(10): INTEGER
  FOR c = b TO a STEP –1
    temp(b+1–c) = intlist(c)
  NEXT c
  intlist = temp
  END
```

The output should look like this:

```
1 2 3 4 5 6 7 8 9 10
10 9 8 7 6 5 4 3 2 1
```

Command Line Parameters

Parameters may also be passed to the main procedure of a BASIC program. A PARAM statement must also appear in the main procedure.

One major difference between passing parameters between procedures and passing parameters to the main procedure is that parentheses are not required to enclose the parameters passed to the main procedure. For example, the following two statements pass parameters to a main procedure from the shell.

```
$ filter –z=myfiles –p=~ –l=11
$ basic makdoc –z=bman 12
```

A parameter passed to a procedure is determined to be either a string or numeric argument by the list of parameters given in the PARAM statement. The parameters may be expressions that result in the correct data type. For example, the following statement passes the numeric argument 15 and the string argument thisthat:

```
$ filter 11+4 "“this” + “that”"
```

Important: If a string parameter is in expression format (as above) or could be construed as a numeric parameter (12 or 1.5), the parameter must be within double quotes.

If you run a program from BASIC, you must use parentheses as if the procedure was being called from another procedure. For example:

```
run filter(“–z=myfiles”, “–p=~”, “–l=11”)
```

Optional Parameters

A parameter passing error only occurs if a parameter is accessed that has not been passed to a procedure. No error occurs, however, if too few or too many parameters are passed as long as the missing parameters are not accessed. The variables expecting parameters are not initialized if no matching parameters are passed. Consequently, you should create some sort of parameter handling subroutine for procedures receiving fewer parameters than expected.

By adding a command line parameter to the Phonebook procedure, you can create a help message for a first time user and an immediate access to records. The key to this type of strategy is finding whether a parameter has been passed, and if so, which one.

A second variable (str1) is declared to trap the parameter. It is initialized to the string oops. If the parameter is not passed, the ON ERROR routine passes control to the paramcheck routine. If a parameter is passed, str1 is set to pstr1 and the paramcheck routine is run.

In either case, paramcheck examines str1. By isolating the parameter checking, the program keeps its integrity and allows for easy maintenance. A question mark option (–?) is added to print a help message. The help message explains how to use the procedure.

```
  PROCEDURE Phonebook
    PARAM pstr1:string
    TYPE rec=street:STRING[30];cityst:STRING[30];zip:STRING[9]
    TYPE ENTRY=name:STRING[30]; phone:STRING[20]; address:rec
    DIM Phonebook:ENTRY; flag:BOOLEAN; file,answer:INTEGER
    DIM str1:string
    record = 0
    flag := TRUE
    str1="oops"
    ON ERROR GOTO 5
    str1=pstr1
  5 RUN paramcheck(str1,answer,record)
    ON ERROR
    ON ERROR GOTO 100
    CREATE #file, "phonebook": UPDATE
    flag := FALSE
100 IF flag THEN OPEN #file, "phonebook": UPDATE
    ENDIF
    ON ERROR
    REPEAT
      IF answer < 1 THEN
        PRINT "TYPE: ""1"" for add new entries"
        PRINT "      ""2"" for access previous entries"
        PRINT "      ""3"" for exit procedure"
        INPUT  answer
      ENDIF
      ON answer GOSUB 200,300
    UNTIL answer = 3
    CLOSE #file
    END
200 SEEK #file, FILSIZ (#file)
    REPEAT
      PRINT "If information not available, hit <return>"
      INPUT "name:            ",Phonebook.name
      INPUT "phone number:    ",Phonebook.phone
      INPUT "street address:  ",Phonebook.address.street
      INPUT "city, state:     ",Phonebook.address.cityst
      INPUT "zip code:        ",Phonebook.address.zip
      PUT #file,Phonebook
      PRINT "If finished, type ""done""."
      INPUT "Otherwise hit the <return>  ",done$
    UNTIL done$="done"
     answer = 0
    RETURN
```

```
300 REPEAT
        IF record = 0 THEN
          INPUT “What number record would you like?”,record
        ENDIF
        SEEK #file,SIZE(Phonebook)*(record –1)
        GET #file,Phonebook
        PRINT “name:            ”,Phonebook.name
        PRINT “phone number:    ”,Phonebook.phone
        PRINT “street address:  ”,Phonebook.address.street
        PRINT “city, state:     ”,Phonebook.address.cityst
        PRINT “zip code:        ”,Phonebook.address.zip
        PRINT “If finished, type ””done””.”
        INPUT “Otherwise hit the <return>  ”,done$
        record = 0
      UNTIL done$=“done”
      answer = 0
      RETURN
 PROCEDURE Paramcheck
   PARAM str1:STRING; answer,record:INTEGER
   IF str1 = “–?” THEN
     PRINT “Syntax:   phonebook [<opt>]”
     PRINT “Function: This is a little black book for phone numbers.”
     PRINT “<opt> = –?       prints this message.”
     PRINT “        –a       add mode allows you to add phone numbers.”
     PRINT “        –r=<rec> specifies the phone number desired.”
     PRINT “           <rec> = the record number of the phone/address.”
     STOP
   ELSE
     IF str1 = “–a” THEN
       answer = 1
     ELSE
       IF LEFT$(str1,3)=“–r=” THEN
         record = VAL(MID$(str1,4,(LEN(str1)–3)))
         answer = 2
       ELSE
         answer = 0
       ENDIF
     ENDIF
   ENDIF
 END
```

Formatted Output: The PRINT .. USING Statement

BASIC has a powerful output editing capability for generating reports and other applications where formatted output is required. The output editing uses the PRINT..USING statement:

```
PRINT [<path#>] USING <str expr> , <output list>
```

The string expression is evaluated and used as a format specification. This contains specific formatting directives for each item in the output list. The `<path#>` is optional and can redirect the output to the corresponding device.

Important: Blanks are not allowed in format strings!

The items in the output list can be constants, variables, or expressions of any basic type. As each output item is processed, it is matched with a specification in the format list. The type of each expression result must be compatible with the corresponding format specification. If there are fewer format specifications than items in the output list, the format specification list is repeated again from its beginning as many times as necessary.

A format string has one or more format specifications separated by commas. There are two kinds of specifications:

- those that control output editing of an item from the output list
- those that cause an output function by themselves (such as tabbing and spacing)

There are six basic output editing directives. Each has a corresponding one-letter identifier:

Identifier:	Description:
R	Real Format
E	Exponential Format
I	Integer Format
H	Hexadecimal Format
S	String Format
B	Boolean Format

The letter is followed by a positive constant number called the **field width**. This number indicates the exact number of columns in which to print the output. It must allow for the data *and* “overhead” character positions such as sign characters, decimal points, exponents, etc. The field width must be between 1 and 255.

Some formats have additional mandatory or optional parameters that control subfields or select editing options. Real and exponential formats use the **fraction field** to specify the number of digits to the right of the decimal point. The fraction field is separated from the field width by a decimal point. For example, a field width of 10 and a fraction field of 6 is represented by “10.6.”

All formats can use the justification option. This option specifies whether the output is to be centered, left, or right justified within the output field. Fields are commonly right-justified in reports because it arranges them into columns with decimal points aligned in the same position. The symbols used in the justification specifications are:

```
< (left),  > (right),  ^ (center).
```

In the previous prin procedure, the following print statement was used:

```
PRINT prin(c);“”;
```

The extra space was added to separate the integers being printed. A similar result can be obtained by using the PRINT..USING statement:

```
PRINT USING “I3>”,prin(c);
```

This formats each integer in a three space print field (I3). The integers are right justified (>). You should use some caution when formatting. While a leading sign is not printed (when positive), space for it must be allowed. I3> only prints two digit integers.

A full explanation of the PRINT..USING statement and each of the format types can be found in the reference section of this manual.

NOTES

Chapter 4

Program Optimization

General Execution Performance of BASIC

When you run your procedures, Microware's BASIC compiler makes multiple passes through the code. The compiler produces a compressed and optimized low-level I-code for execution. Compared to other BASIC languages, program storage is greatly decreased and execution speed is increased.

High-level language interpreters have a general reputation for slowness. This is partly because traditional BASIC interpreters compile from text as they run, and other BASIC interpreters must perform table-searching during execution.

Microware BASIC, however, is kept at a powerful level so that there is little performance difference between the execution of I-code and straight machine-language instructions. Instead, a single, fast, I-code interpretation often results in many MPU instruction cycles (such as execution of floating-point arithmetic operations). Also, BASIC Icode instructions that reference variable storage, statements, labels, etc., contain the actual memory addresses, so no table searching is ever required. In addition, BASIC fully exploits the power of the 68000's instruction set which was optimized for efficient execution of compiler-produced code.

BASIC I-code is interpreted. Therefore, a variety of entry time tests, run-time tests, and development aids are available to help in program development; aids not available on most compilers:

- The editor reports errors immediately when they are entered.
- The debugger allows debugging using the original program source statements and names.
- The I-code interpreter performs run-time error checking of things such as array bound errors, subroutine nesting, arithmetic errors, and other errors that are not detected (and usually crash) native-compiler-generated code.

Optimum Use of Numeric Data Types

BASIC includes several different numeric representations (REAL, INTEGER, and BYTE) and performs automatic type conversions between them. You can easily write expressions or loops that take at least ten times longer to execute than is necessary. Some BASIC numeric operators (+, –, *, /) and control structures (FOR..NEXT) include versions for both REAL and INTEGER values. The INTEGER versions are much faster and may have slightly different properties (for example, when you divide INTEGER values, the remainder is discarded). Converting data types takes time, so expressions whose operands and operators are of the same type are more efficient.

INTEGER operations are faster because they generally have corresponding 68000 machine-language instructions. Overall program speed increases and storage requirements decrease if INTEGERs are used whenever possible. INTEGER arithmetic operations use the same symbols as REAL, but BASIC automatically selects the INTEGER operations when working with an integer-value result. Only if all operands of an expression are of types BYTE or INTEGER will the result also be INTEGER.

Sometimes you can get similar or identical results in a number of different ways at various execution speeds. For example, if the variable value is an integer, value*2 is a fast integer operation. However, if the expression is value*2., the value 2. is represented as a REAL number, and the multiplication is a REAL multiplication which also requires that the variable value must be transformed into a REAL value, and finally the result of the expression must be transformed back to an INTEGER value if you assign it to a variable of that type. Therefore, a single decimal point slows down this operation by about ten times.

Looping Quickly

When Basic identifies a FOR..NEXT loop structure with an INTEGER loop counter variable, it uses a special integer version of the FOR..NEXT loop. This is much faster than the REAL-type version and is generally preferable. Other kinds of loops also run faster if INTEGER type variables are used for loop counters.

When writing program loops, remember that statements *inside* the loop may be executed many times for each single execution *outside* the loop. Thus, any value which can be computed before entering a loop increases program speed.

Optimum Use of Arrays and Data Structures

BASIC internally uses INTEGER numbers to index arrays and complex data structures. If the program uses subscripts that are REAL type variables or expressions, BASIC converts them to INTEGER before they can be used. This takes additional time, so use INTEGER expressions for subscripts whenever you can.

Important: The assignment statement (LET) can copy identically sized data structures. `LET` is much faster than copying arrays or structures element-by-element inside a loop.

The PACK Command

The PACK command produces a compressed version of a BASIC procedure. Depending on the number of comments, line numbers, etc., programs execute from 10% to 30% faster after being packed. Minimizing use of line numbers will even speed up procedures that are unpacked.

Eliminating Constant Expressions and Sub-Expressions

Consider the expression:

```
x := x+SQRT(100)/2
```

It is exactly the same as the expression:

```
x := x+5
```

The sub-expression SQRT(100)/2 consists of constants only, so its result does not vary regardless of the rest of the program. But every time the program is run, the computer must evaluate it. This time can be significant, especially if the statement is within a loop. You should calculate constant expressions or sub-expressions while writing the program.

Fast Input and Output Functions

Reading or writing data a line or record at a time is much faster than one character at a time. Also, the GET and PUT statements are much faster than READ and WRITE statements when dealing with disk files. This is because GET and PUT use the exact binary format used internally by BASIC. `READ`, `WRITE`, `PRINT`, and `INPUT` must perform binary-to-ASCII or ASCII-to-binary conversions.

Professional Programming Techniques

You can make a program faster by using efficient algorithms. You can use algorithms found in most standard BASIC and PASCAL books with little or no adaptation.

You should use a well-structured programming style that produces efficient, reliable, readable, and maintainable software. BASIC generates optimized code for the 68000 to execute. This code is currently the most powerful 16-bit processor in existence. A computer can only execute what it is told to execute. No language implementation can make up for an inefficient program. An inefficient program is evidence of a lack of understanding of the problem. The result is likely to be hard to understand and hard to update if program specifications change. The identification of efficient algorithms and their clear, structured expression is indicative of professionalism in software design.

Section 2

BASIC Reference Guide

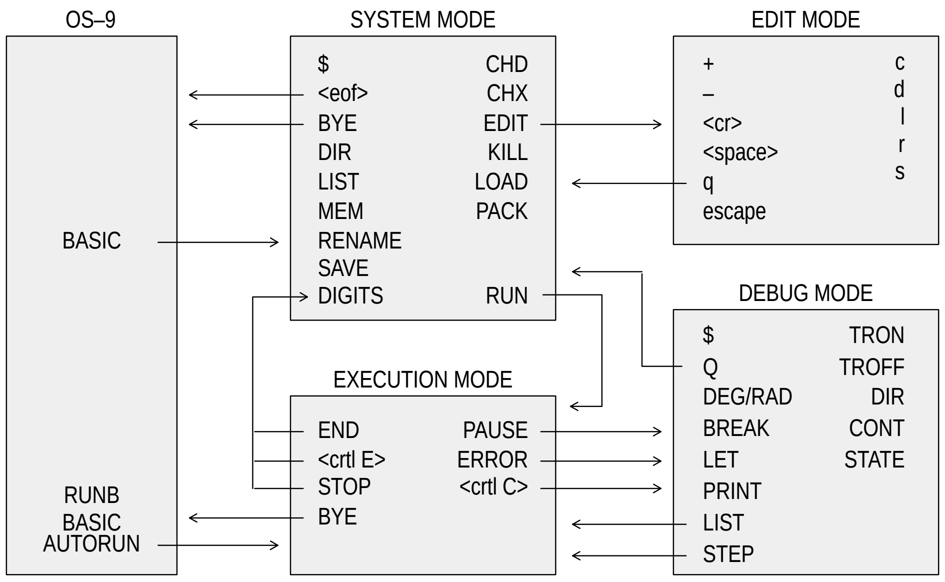
This section of the manual describes:

- BASIC's four command modes:

Mode:	Description:
SYSTEM	Used for executing system commands.
EDIT	Used for creating/editing procedures.
EXECUTION	Used for running procedures.
DEBUG	Used for testing procedures for errors.

Certain commands in each mode will change BASIC's mode. The following is a graphic representation of which commands accomplish this and what mode they are carried out in.

BASIC Mode Changes



Syntax Notation Used in System Command Descriptions
Individual descriptions of the available commands in each mode follow. In order to precisely describe their formats, the following syntax notation is used.

Notation:	Description:
[ ]	Items in brackets are optional.
{ }	Items in braces can be optionally repeated.
<procname>	A procedure name
<pathlist>	An OS-9 file name
<number>	A decimal or hex number

- how to use the edit mode (the editor) to create or modify BASIC procedures
- how to run a BASIC procedure
- symbolic debugging of programs
- data types and data structures
- expressions, operators and functions
- BASIC program statements and structure
- files and unified input/output

Chapter 5

System Mode

System Mode Commands

System mode includes commands to:

- save, load, and examine procedures
- interact with OS-9
- control the workspace environment

The following are the system commands:

$	BYE	CHD/CHX	DIGITS
DIR	E/EDIT	KILL	LIST
LOAD	MEM	PACK	RENAME
	RUN	SAVE	

The BASIC **command interpreter** processes system commands. The command interpreter always identifies itself with the B: prompt. You automatically enter the command interpreter when you start BASIC and when you exit any other mode. You can enter commands in either upper or lower-case letters.

Commands such as DIR, MEM, $, and BYE do not operate on specific procedures, but they may have optional or required parameters. Commands such as SAVE, LOAD, PACK, KILL, and LIST can operate on a specific procedure or on *all* procedures within the workspace.

If the command is used with a specific procedure name, the command is applied to only that procedure. This example displays the procedure named justin:

```
LIST justin
```

The asterisk is a special name that indicates all procedures in the workspace. Therefore, if you enter the following command, all procedures in the workspace are displayed:

```
LIST*
```

If you do not enter a name with the command, the **current working procedure** is used. The current working procedure is the procedure specified for the last command. The DIR command prints an asterisk before the current working procedure's name. This allows you to check which procedure is current.

If you have not yet given a name in any command, BASIC automatically uses the name Program. Some commands require a file name and (one or more) procedure names. They usually require that a greater-than sign (>) precede the file name so that it is not mistaken for a procedure name. If you omit the file name, the name of the (first) procedure is used.

Important: In this manual, the phrase **file name** means an OS-9 pathlist which describes either a file or device.

Here are some examples:

```
SAVE tom bill >myfile
SAVE* big_file
SAVE tic tac toe        (same as SAVE tic,tac,toe >tic)
```

The RUN and EDIT commands use only one procedure name, or the current working name if a name is omitted. These commands change BASIC’s mode by exiting the command mode and entering another mode.

Command:	Description:
RUN	Enters execution mode to run a procedure.
EDIT	Enters edit mode to create or change a procedure.

Important: You cannot directly enter debug mode from system mode.

$

Shell Command

Syntax

```
$ [<text>]
```

Function

This command calls the OS-9 shell command interpreter to process an OS9 command or to run another program. Running the shell command does not disturb BASIC or its workspace.

If the dollar sign ($) is followed by text, the shell is called to process the text as a single OS-9 command line. After the command is executed, BASIC is immediately re-entered.

If no text is specified, BASIC is suspended, and the OS-9 shell is called to process multiple command lines individually entered from the keyboard. BASIC regains control when an end-of-file character (usually escape) is entered. The contents of the BASIC workspace are not affected. This is a convenient way to temporarily leave BASIC to manipulate files or perform other housekeeping tasks.

This command is the gateway from BASIC to OS-9. It allows access to any OS-9 command or to other programs. It also permits creation of concurrent processes and other real-time functions.

Examples

Command:	Description:
B: $copy file1 file2	Calls the OS-9 copy command
B: $r68 sourcefile&	Calls the assembler as a background task
B: $basic fourier(20)&	Starts another concurrent BASIC program

BYE (or <eof> character)

Exit Basic

Syntax

```
BYE
```

Function

`BYE` exits BASIC and returns to OS-9 or the program that called BASIC. Any procedures in the workspace are lost if not previously saved. The end-of-file character (usually the escape key) does the same thing.

CHD/CHX

Change Directories

Syntax

```
CHD <pathlist>
CHX <pathlist>
```

Function

`CHD` changes the current OS-9 user data directory to the specified pathlist which must be a directory file. BASIC uses the data directory to LOAD or SAVE procedures.

`CHX` changes the current OS-9 user execution directory to the specified pathlist which must be a directory file. The execution directory is used to PACK or auto-load packed modules.

Example

```
CHD /d1/joe/games
```

DIGITS

Formats Numerical Output (Real Numbers)

Syntax

```
DIGITS [<number>]
```

Function

DIGITS controls the number of digits that are printed when REAL numbers are output.

DIGITS also controls the precision of transcendental calculation. The minimum precision is 1 digit to the right of the decimal point, and the maximum precision is 15. If the result is not within this range (1 to 15 precision), the result is brought into range without error. When no <number> is specified, DIGITS displays the current precision.

Example

```
PROCEDURE Digitsdemo
   DIM x: REAL
   DIGITS 2
   INPUT x
   PRINT x
   END
RUN Digitsdemo
? 44.9234692
44.
```

DIR

Display Directory of Workspace

Syntax

```
DIR [<pathlist>]
```

Function

DIR displays the name, size, and variable storage requirement of each procedure presently in the workspace. The current working procedure has an asterisk before its name. All packed procedures have a dash before their name (see PACK). The available free memory within the workspace is also given. If a pathlist is specified, output is directed to that file or device.

A question mark next to a data storage size means the workspace does not have enough free memory to run that procedure.

Important: Do not confuse this command with the OS-9 dir command. They have completely different functions.

EDIT/E

Enter Edit Mode

Syntax

```
EDIT [<procname>]
E [<procname>]
```

Function

`EDIT` (E) exits system mode and enters edit mode. If the specified procedure does not exist, a new one is created. See the next chapter for a complete description of how edit mode works.

Examples

```
E newprog
EDIT newprog
```

KILL/KILL*

Delete Procedure from Workspace

Syntax

```
KILL [<procname> {,<procname>}]
KILL*
```

Function

`KILL` deletes the procedure(s) specified by <procname>. `KILL*` clears the entire workspace. This process may take some time if there are many procedures in the workspace.

Examples

```
KILL formulas
KILL prog1, prog2, prog7
```

LIST/LIST*

Display Listing of Procedure

Syntax

```
LIST [<procname> {,<procname>}] [> <pathlist>]
LIST* [<pathlist>]
```

Function

`LIST` prints a formatted listing of one or more procedures. `LIST*` prints a formatted listing of all procedures in the workspace. The listing includes the relative I-code storage addresses in hexadecimal format in the first column. The second column is reserved for program line numbers (if line numbers are used).

If a pathlist is given, the listing is output to that file or device. This option is commonly used to print hard-copy listings of programs.

`LIST` prints on the OS-9 standard error path (#2) if no pathlist is given.

Important: If an asterisk (*) is used, the file name (<pathlist>) follows immediately *without* a greater-than sign (>) before it.

Examples

```
LIST* /p
LIST prog2,prog3 >/p
LIST prog5 >temp
```

LOAD

Load Procedure into Workspace

Syntax

```
LOAD <pathlist>
```

Function

`LOAD` loads all procedures from the specified file into the workspace. As procedures are loaded, their names are displayed. If any of the procedures being loaded have the same name as a procedure already in the workspace, the existing procedures are erased and replaced with the procedure being loaded.

If the workspace fills up before the last procedure in the file is loaded, an error (#32) is given. In this case, not all procedures may have been loaded, and the one being loaded when the workspace became full may not be completely loaded. You should KILL the last procedure, use the MEM command to get more memory or KILL unnecessary procedure(s) to free up space, and then LOAD the file again.

Example

```
LOAD quadratics
```

MEM

Display or Request Workspace Memory

Syntax

```
MEM [<number>]
```

Function

`MEM` used without a number displays the present total workspace size in (decimal) bytes. If a number is given, BASIC asks OS-9 to expand or contract the workspace to that size. A hex value can be used if preceded by a dollar sign. If MEM responds with What?, you either asked for more memory than is available, tried to give back too much memory (there has to be enough to store all procedures in the workspace), or gave an invalid number.

Example

```
MEM 18000
```

PACK/PACK*

Pack Procedure

Syntax

```
PACK [<procname> {,<procname>}] [> <pathlist>]
PACK* [<pathlist>]
```

Function

`PACK` causes an extra compiler pass on the specified procedure(s). This removes names, line numbers, non-executable statements, etc. The result is a smaller, faster procedure(s) that *cannot* be edited or debugged but can be executed by BASIC or by the BASIC run-time-only program called RunB.

If a pathlist is not specified, the name of the first procedure in the list is used as the file name. The packed file is stored in your execution directory.

The procedure is written to the file/device specified in OS-9 memory module format suitable for loading in ROM or RAM *outside* the workspace. BASIC automatically loads the packed procedure when you try to run it later. Here is an example sequence that demonstrates packing a procedure:

```
PACK sort    Packs procedure sort and creates a file
KILL sort    Kills procedure inside the workspace
RUN sort     Run (sort is loaded outside of the workspace)
KILL sort    Done; delete sort from outside memory
```

The last step does not have to be done immediately if you will be using the procedure again later, but you should kill it when you are done so its memory can be used for other purposes.

Important: The packed file cannot be loaded into the workspace later on. Always perform a regular SAVE before packing a procedure.

Example

```
PACK proc1,proc2 >packed.programs
```

RENAME

Rename a Procedure

Syntax

```
RENAME <procname>,<new procname>
```

Function

RENAME changes the name of a procedure. It can be used to allow two copies of the same procedure in the workspace under different names.

Example

```
RENAME thisproc thatproc
```

RUN

Execute a Procedure

Syntax

```
RUN [<procname> [ ( <expr> , {<expr>} ) ]]
```

Function

RUN executes the specified procedure. BASIC leaves system mode and enters execution mode.

You can use a parameter list to pass expected parameters to the procedure. This is generally used in the same way that a RUN statement inside a procedure calls another procedure. The only restriction is that all parameters must be constants or expressions without variables. See the PARAM statement description.

The procedure called can be normal or packed. If the procedure is not found inside BASIC's workspace, BASIC calls OS-9 to attempt to LINK to an external (outside the workspace) module. If this fails, BASIC attempts to LOAD the procedure from a file of the same name.

Examples

```
RUN getdata
RUN invert(“the string to be inverted”)
RUN power(12,354.06)
RUN power($32, sin(pi/2))
```

SAVE/SAVE*

Write Procedure to an Output File

Syntax

```
SAVE [<procname> { <procname>} [> <pathlist>]]
SAVE* [<pathlist>]
```

Function

SAVE writes the procedure(s) (or all procedures with SAVE*) to an output file or device in source format. SAVE is similar to the LIST command except the output is not formatted and I-code addresses are not included. If a pathlist is not specified, it defaults to the name of the first procedure listed.

If a file of the same name already exists, SAVE prompts with the following:

```
rewrite?
```

You may answer Y for yes which causes the existing file to be rewritten with the new procedure(s); or N to cancel the SAVE command.

Important: If an asterisk (*) is used, the file name (<pathlist>) follows immediately *without* a greater-than sign (>) before it.

Examples

```
SAVE proc2 proc3 proc4 >monday.work
SAVE* newprogram
SAVE
SAVE  >testprogram
```

Chapter 6

Edit Mode

Edit Mode Commands

You use the edit mode (**the editor**) to create or modify BASIC procedures. To enter edit mode from system mode, use the EDIT (or E) command. When you enter edit mode, the prompt `E:` is displayed. If you have used a text editor before, you will find the BASIC editor similar to many others except for these two differences:

- The editor is both string and line number oriented. Using line numbers is optional, and you can correct text without re-typing the entire line.
- The editor is interfaced to the BASIC compiler and decompiler. This lets BASIC perform continuous syntax error checking and allows programs to be stored in memory in a more compact, compiled form.

The editor includes the following commands. Each command is described in detail later in this chapter.

Command:	Description:
<cr>	Moves the edit pointer forward one line.
+[<number>]	Moves the edit pointer forward.
–[<number>]	Moves the edit pointer backward.
<space> <text>	Inserts an unnumbered line.
<space> <line#> <text>	Inserts or replaces a numbered line.
<line#> <cr>	Finds a numbered line.
c	Changes a string.
d	Deletes a line.
l	Lists line(s).
q	Quits editing.
r	Renumbers line.
s	Searches for string.
<esc>	Quits editing.

How the Editor Works

BASIC programs are always stored in memory in a compiled form called **I-code** (short for **Intermediate Code**). I-code is a complex binary coding system for programs that lies between your original source program and the computer's native machine language. I-code is relatively compact, can be executed rapidly, and most importantly, can be reconstructed almost back to the original source program. The editor is closely connected to the compiler and decompiler systems within BASIC that translate source code to I-Code and vice-versa.

When you enter or change a program line and press the return key, the compiler instantly translates this text to the internal I-code form. When BASIC displays program lines, it uses the decompiler to translate the I-code back to the original source format. These processes are completely automatic and do not require any special action on your part.

This technique has several advantages:

- It allows the text editor to report many (syntax) errors immediately so you can correct them instantly.
- The I-code representation of a program is more compact (by about 30%) than its original form. This allows you to have larger programs in any given amount of available memory.

When BASIC lists programs, they may appear slightly different than the way they were originally typed in, but they are always functionally identical to the original form. A different appearance can happen if the original program had extraneous spaces between keywords, unnecessary parentheses in expressions, etc. BASIC keywords are always automatically capitalized.

When you finish editing the procedure, use the q (for quit) command to exit edit mode and return to system mode. When you enter the q command, the compiler passes over the entire procedure again. At this time, syntax that extends over multiple lines is checked and errors reported. Examples of these errors are:

- GOTO or GOSUB to a non-existent line
- missing variable or array declarations
- improperly constructed loops

These errors are reported using an error code and the hexadecimal I-code address of the error. For example:

```
01FC ERR #000:043
```

This message means that error number 43 was detected in the line that included I-code address 01FC (hexadecimal). The LIST command gives the I-code addresses so you can locate lines with errors reported during the compiler's second pass.

Line-Number Oriented Editing

The editor can work on programs with or without line numbers. If you use line numbers, they must be positive whole numbers in the range of 1 to 32767.

If you have used another version of the BASIC language, this is the kind of editing you probably used. However, well-structured programs seldom really need line numbers. Do not use line numbers unless they are necessary. By not using line number, your programs will be shorter, faster, and easier to read.

The line-number oriented commands are:

Command:	Description:
<space> <line#> <text>	Inserts or replaces a numbered line.
<line#> <cr>	Finds a numbered line.
r	Renumbers a line.
r*	Renumbers all lines.

To enter or replace a numbered line, enter a `<space>`, followed by the line number and statement. You can enter numbered lines in any order, but they are stored in ascending sequence. To move the edit pointer to a numbered line, type the line number followed by a carriage return. The editor moves to that line (or the line with the next higher number if the specified number is not found) and displays it. You can delete the line with the d command.

The r renumber command uniformly resequences all numbered lines and lines that refer to numbered lines. The syntax for this command is as follows:

```
r [ <beg line #>  [,<incr> ] ] [CR]
r*[ <beg line #>  [,<incr> ] ] [CR]
```

The first format renumbers the program starting at the current line and moving forward to the end of the procedure. Lines are renumbered using <beg line#> as the initial line number. <incr> is added to the previous line number for the next line's number. The following example gives the first line number 200, the second 205, etc. If <beg line#> and/or <incr> are not specified, the values 100 and 10, respectively, are assumed.

```
r 200,5
```

The second form of the command renumbers all lines in the procedure.

String-Oriented Editing

Most editor commands are string-oriented, which means that you can enter or change whole or partial lines without using line numbers. String-oriented editing is generally fast and convenient.

Because line numbers are not used, the editor maintains an **edit pointer** to indicate which line is the present working location within the procedure. String-oriented commands work relative to this point.

The editor shows you the location of the edit pointer by displaying an asterisk (*) at the left side of the program line where the edit pointer is presently located.

Moving the Edit Pointer

Use the addition (+) and subtraction (–) commands to reposition the edit pointer:

Command:	**Description:**
– <number>	Moves backward <number> lines.
–*	Moves to the beginning of the procedure.
+	Moves forward one line.
+ <number>	Moves forward <number> lines.
+*	Moves to the end of procedure.

The <number> indicates how many lines to move. Backward means towards the first line of the procedure. If the number is omitted, one is used (this is true of most edit commands).

A line consisting of a carriage return only moves the pointer forward one line, which makes it easy to **step** through a program one line at a time. Therefore, the following commands all do the same thing:

```
[CR]
+ [CR]
+1 [CR]
```

Inserting Lines

The insert line function consists of a space followed by a BASIC statement line. The statement is inserted just ahead of the edit pointer position. The space itself is not inserted.

Deleting Lines

The d command deletes one or more lines:

```
d [<number>] [CR]
d*
```

The first form deletes the specified number of lines starting at the edit pointer's current position. If the number is negative, that many lines *before* the current line are deleted. If a line number is omitted, only the current line is deleted.

The second form deletes *all* lines in the procedure. The editor also accepts two variations of this command:

Command:	Description:
d+*	Deletes all lines to the end of the procedure.
d–*	Deletes all lines to the beginning of the procedure.

Important: Be careful when using the d* command. You may delete lines unintentionally.

Listing Lines

The l command displays one or more lines:

```
l [<number>] [CR]
l*
```

The first form displays the specified number of lines starting at the edit pointer's current position. If the number is negative, previous lines are listed.

The second form displays the entire procedure. Neither form changes the edit pointer's position. The line that is the current position of the edit pointer is displayed with a leading asterisk.

Search: Finding STRINGS

A **string** is a sequence of one or more characters. This can include letters, numbers, or punctuation, in any combination. Strings allow you to change or locate a portion of a statement without having to type the entire statement.

In the editor, strings must be surrounded by **delimiters**. Delimiters are two matching characters located at the beginning and the end of a string. The editor uses delimiters to locate the beginning and the end of strings. The characters used for delimiters are not considered part of the string. Therefore, the character you use for a delimiter must not appear within the string.

Do not confuse the strings used by the editor with BASIC's data type which is also called STRING –. Although they have the same name, they are quite different.

You can use the s command to locate the next occurrence or all occurrences of a string. The format for this command is as follows:

```
s <delim> <match str> [<delim>] [CR]
s*<delim> <match str> [<delim>] [CR]
```

The first format searches for the <match str> starting with the current line. If any line at or following the edit pointer includes a sequence of characters that match the search string, the edit pointer is moved to that line and the line is displayed. If the string cannot be located, the following message is displayed and the edit pointer remains at its original position:

```
CAN'T FIND: "<match str>"
```

The s* variation searches for all occurrences of the string in the procedure starting at the present edit pointer and displays all lines in which it is found. The edit pointer is moved to the last line where the string occurred.

Here are some examples:

Command:	Description:
E:s/counter/	Looks for the string: counter
E:s.1/2.	Looks for the string: 1/2
E:s?three blind mice?	Looks for the string: three blind mice

Change: STRING Substitution

The change string function can eliminate a tremendous amount of typing. It allows strings within lines to be located, removed, and replaced by another string. This command is commonly used for fixing error lines without having to retype the entire line or changing a variable name throughout a program. The format for the c command is as follows:

```
c <delim> <match str> <delim> <repl str> [<delim>] [CR]
c*<delim> <match str> <delim> <repl str> [<delim>] [CR]
```

In the first form, the editor looks for the first occurrence of the match string starting at the present edit pointer position. If found, the match string is removed from the line and the replacement string is inserted in its place.

The second form works the same way, except it changes *all* occurrences of the match string in the procedure starting at the edit pointer's current position.

The c* command stops when it finds or creates a line with an error.

Important: Sometimes you can inadvertently change a line you did not intend to change because the match string is imbedded in a longer string. For example, if you attempt to change no to yes and the word normal occurs before the no you are looking for, normal will change to yesrmal.

Examples

```
c/xval/yval/
c*,GOSUB 5300,GOSUB 5500
```

Chapter 7

Execution Mode

Running Programs

To run a BASIC procedure, enter:

```
RUN <procname>
```

If the procedure you want to run was the last procedure edited, listed, saved, etc., you can execute it without specifying a procedure name (the asterisk (*) shown in the DIR command identifies this procedure).

If the procedure expects parameters, you can enter them on the same command line. They must all be constant numbers or strings, as appropriate, and must be given in the correct order. For example:

```
RUN add(4,7)
```

This calls a program (such as the one that follows) and passes it the specified parameters.

```
PROCEDURE add
PARAMETER a,b a,b receive the values 4,7
PRINT a+b
END
```

The ability to pass parameters to a program allows you to specifically initialize program variables. Sometimes certain procedures are parts of a larger software system and are designed to be called from other procedures. You can use this feature to individually test such procedures by passing them test values as parameters.

When you execute the RUN statement, BASIC enters execution mode. The procedure runs until one of the following events occur:

- an END or STOP statement is executed
- you type **[Ctrl-E]**
- a run-time error occurs
- you type **[Ctrl-C]** (keyboard interrupt)

Important: In the first two cases, you return to system mode. In the last two cases, you enter debug mode.

Execution Mode: Technically Speaking

The RUN statement is simple and normally you do not need to know what is happening inside BASIC when you use it. The technical description of execution mode that follows is given for the benefit of advanced BASIC programmers.

Execution mode is BASIC's state when you run any procedure. It involves executing the Icode of one or more procedures inside or outside the workspace. Many procedures can be in use because they can call each other (or themselves) and nest exactly like subroutines.

You can enter execution mode in two ways:

- the RUN system command
- BASIC's auto-run feature

The auto-run feature allows BASIC to get the name of a file to load and run from the same command line used to call BASIC. The file can be either a SAVED file in the data directory or a PACKED file in the execution directory. The file may contain several procedures; the one executed is the one with the same name as the file. Parameters may be passed following the specified pathname. When using the auto-run feature, upon finishing execution, control returns to BASIC's command mode. For example, the following OS-9 command lines use this feature:

```
$ BASIC printreport “Past Due Accounts”
$ BASIC evaluate COS(7.8814)/12.075,–22.5,129.055
```

Chapter 8

Debug Mode

Overview of Debug Mode

Symbolic debugging is the testing and manipulation of programs using the actual names and program statements used in the program. This is accomplished by BASIC's powerful symbolic debugging commands:

- $
- BREAK
- CONT
- DEG/RAD
- DIR
- LET
- LIST
- PRINT
- Q
- STATE

This chapter discusses how the debug mode can let you watch your program run in slow motion. This allows you to observe each statement as it is executed. This chapter also includes how to use the debug mode as a calculator.

Debug mode is entered from execution mode in one of three ways:

- when an error occurs during execution of a procedure (that is not intercepted by an ON ERROR GOTO statement within the program)
- when a procedure executes a PAUSE statement
- when a keyboard interrupt (**`[Ctrl-C]`**) occurs

When any of the above happen, debug mode displays the suspended procedure name like this:

```
BREAK: PROCEDURE test5
D:
```

Important: Debug mode displays a `D:` prompt when it is waiting for a command. You can then use any debug mode command to examine or change variables, turn trace mode on/off, etc. Depending on which commands are used, execution of the program can be terminated, resumed, or executed one source line at a time.

$

Shell Command

Syntax

```
$ <text>
```

Function

$ calls OS-9's shell command interpreter to run a program or OS-9 command. This command executes the same as the system mode $ command.

BREAK

Set Breakpoint

Syntax

```
BREAK <proc name>
```

Function

`BREAK` sets a **breakpoint** at the specified procedure. This command is used when procedures call each other and provides a way to re-enter debug mode when returning to a specific procedure.

To illustrate how BREAK works, suppose three procedures are in your workspace: Proc1, Proc2, and Proc3. Assume that Proc1 calls Proc2, and Proc2 calls Proc3. While Proc3 is executing, you type **`[Ctrl-C]`** to enter debug mode. To use the BREAK command, type:

```
D: BREAK proc1
ok
D:
```

Important: `BREAK` responds with ok if the procedure was found on the current RUN stack. You can use the STATE command to verify that the three procedures are nested as expected.

You can resume execution of Proc3 by typing cont. After Proc3 terminates, control passes back to Proc2, which eventually returns to Proc1. As soon as this happens, the breakpoint you set is encountered, Proc1 is suspended, and debug mode is re-entered.

There are three characteristics of BREAK you should note:

- The breakpoint is removed as soon as it occurs.
- You can use one breakpoint for each active procedure.
- You cannot put a breakpoint on a procedure unless it has been called but not yet re-entered. Therefore, BREAK cannot be used on procedures that have not yet run.

CONT

Continue Execution

Syntax

```
CONT
```

Function

`CONT` continues program execution at the next statement. It may resume programs suspended by **`[Ctrl-C]`**, PAUSE statements, BREAK command breakpoints, or after non-fatal run-time errors.

DEG/RAD

Select Degree or Radian Units for Computation

Syntax

```
DEG
RAD
```

Function

The DEG and RAD commands set a state flag. The system uses this state flag to determine whether degrees or radians (respectively) should be used as the angle unit for trigonometric functions. These commands only affect the procedure currently being debugged or run.

DIR

Display Workspace Directory

Syntax

```
DIR [<path>]
```

Function

`DIR` displays the workspace procedure directory in the same way as the system mode DIR command.

LET

Assignment Statement

Syntax

```
LET <var> := <expr>
```

Function

The debug mode LET command is essentially the same as the BASIC LET program statement. It allows the value of a procedure variable to be set to a new value using the result of the evaluated expression. The variable names used in this command must be the same as in the original source program; otherwise, an error is generated. `LET` does not work on user-defined data structures.

LIST

List Current Procedure

Syntax

```
LIST
```

Function

`LIST` displays a formatted source listing of the suspended procedure with Icode addresses. An asterisk is printed to the left of the statement where the procedure is suspended. You can only list the current procedure.

PRINT

Print Present Value of Variables

Syntax

```
PRINT [#<expr>,] [USING <expr>,] <expr list>
```

Function

`PRINT` can be used to examine the present value of variables in the suspended program. All variable names must be the same as in the original program. You cannot use new variable names. User-defined data structures cannot be printed.

Q

Quit Debug Mode

Syntax

```
Q
```

Function

`Q` terminates execution of all procedures and exits debug mode by returning to system mode. Any open paths are closed at this point.

STATE

List Calling Order of Procedures

Syntax

```
STATE
```

Function

`STATE` lists the calling (nesting) order of all active procedures. The highest-level procedure is always shown at the bottom of the calling list, and the lowest-level procedure is always listed first.

Example

```
D:state
PROCEDURE DELTA
CALLED BY BETA
CALLED BY ALPHA
CALLED BY PROGRAM
```

STEP

Single (or Specified) Line Execution

Syntax

```
STEP [<number>]   or   [CR]
```

Function

`STEP` executes the suspended procedure one or more source statements at a time.

For example, step 5 executes the equivalent of the next five source statements. A debug command line which is just a carriage return is considered the same as step 1. `STEP` is most commonly used with the trace mode on. This allows you to see the original source lines as they are executed.

Important: Because compiled I-code contains actual statement memory addresses, the top or bottom statements of loop structures are usually executed just once. For example, in FOR...NEXT loops the FOR statement is executed once, so the statement that appears to be the top of the loop is actually the one following the FOR statement.

TRON/TROFF

Turn On/Off Trace Mode

Syntax

```
TRON
TROFF
```

Function

These commands turn the suspended procedure’s trace mode on and off. In trace mode, the compiled code of each equivalent statement line is reconstructed to source statements and displayed before the statement is executed. If the statement causes the evaluation of one or more expressions, an equal sign and the expression result(s) are displayed on the following line(s).

Trace mode is local to a procedure. If the suspended procedure calls another, no tracing occurs until control returns to the calling procedure (unless the called procedure has trace mode on).

Debugging Techniques

If your program does not do what you expect, it is sure to show one of two symptoms:

- premature termination due to an error
- incorrect results

The first case automatically sends you into debug mode. In the second case, you have to force the program into debug mode either by pressing **`[Ctrl-C]`** (assuming you have time to do so), or by using edit mode to put one or more PAUSE statements in the program. Once you are in debug mode, you can debug your program.

Usually, after an error stops the program you should use the PRINT command to look at the present values of crucial program variables. Bad values are usually quite apparent. Perhaps you forgot to initialize a variable or forgot to increment a loop counter.

If examining variables is not fruitful, you should place a PAUSE statement at the beginning of the suspected procedure or at a place within the code where you think things begin to go wrong. Then, rerun the program. When the program hits the PAUSE statement, it enters the debug mode.

Next, turn the trace mode on and watch your program run. Type:

```
D: TRON
```

Then, press the carriage return key once for every statement you want to trace. You will see the original source statement, and if expressions are evaluated by the statement, debug mode prints an equal sign and the result of the expression.

Notice that some statements such as FOR and PRINT may cause more than one expression to be evaluated.

Using this technique, you can watch your program run one step at a time until you see where it goes wrong.

If in the process of tracing, you encounter a loop that works, but executes 200 statements repetitively, you do not have to trace line by line. In this case, you may turn the trace off and use the STEP command to quickly run through the loop. Then, turn trace mode back on, and resume single-step debugging. The command sequence for this is:

```
D: TROFF
D: STEP 200
D: TRON
```

Important: Trace mode is **local** to one procedure only. If the procedure being tested returns to another procedure you need to use the BREAK command or put a PAUSE statement in the procedure to enter debug mode. If you call another procedure from the procedure being debugged, tracing stops when it is called until it returns. If you also want to trace the called procedure, it needs its own PAUSE statement.

Debug Mode as a Desk Calculator

The simple program listed below turns debug mode into a powerful calculator. Calculator declares 26 working variables, then goes into debug mode. This allows you to use interactive PRINT and LET statements.

```
PROCEDURE Calculator
DIM a,b,c,d,e,f,g,h,i,j,k,l,m
DIM n,o,p,q,r,s,t,u,v,w,x,y,z
PAUSE
END
```

Recall that while in debug mode, you cannot create new variables. Therefore, DIM pre-defines 26 working variables for you. You can use more or fewer variables. `PAUSE` causes you to enter debug mode. The following is a sample session:

```
B: run calculator
BREAK: PROCEDURE Calculator
D:let x:=12.5
D:print sin(pi/2)
1.
D:let y:=exp(4+0.5)
D:print x,y
12.5   90.0171313
D:Q
B:
```

Important: The debug mode PRINT command can use PRINT USING to produce formatted output (including hexadecimal).

Chapter 9

Data Types and Data Structures

Data Types

Computer programs process data. The computer's performance, and even sometimes whether or not a computer can handle a particular problem, depends on how the software stores data in memory and operates on it. BASIC offers many possibilities for organizing and manipulating data.

There are many types of data. You can have numerical data, textual data, etc., but you can seldom mix data types. Not only do they have different storage size requirements, but they are logically incompatible. For example, it would be meaningless to multiply letters and punctuation.

Even within the same general kind of data, there are different ways to represent data. You can represent numbers in three different ways. Each way has its own advantages and disadvantages. You should use the way that fits your needs for each procedure.

To help you select the most appropriate way to store data variables, BASIC provides five different basic data types. BASIC also lets you create new customized data types based on combinations of the five basic types.

Data Structures

A **data structure** refers to storage for more than one data item under a single name. Data structures can be composed of various data types. Data structures are often the most practical and convenient way to organize large amounts of similar data.

The simplest kind of data structure is the **array**, which is a table of values. The table has a single name, and the storage space for each individual value is numbered. Arrays are created by DIM statements.

For example, to create an array having five storage spaces called AGES, use the statement:

```
DIM AGES(5):INTEGER
```

(5) tells BASIC how many spaces to reserve. :INTEGER indicates the array's data type. To assign a value of 22 to the third storage space in the array, use the statement:

```
LET AGES(3):=22
```

The Five Basic Data Types

BASIC includes five basic data types:

Type:	Allowable values:	Memory requirement:
BYTE	Whole Numbers 0 to 255	One byte
INTEGER	Whole Numbers –2,147,483,648 to 2,147,483,647	Four bytes
REAL	Floating Point (+/–) 2.2*10^–308 to 1.8*10^308	Eight bytes
STRING	Letters, digits, punctuation	One byte/character
BOOLEAN	True or False	One byte

REAL numbers appear to be the most versatile data type. They have the greatest range and are floating-point. Arithmetic operations involving them, however, are relatively slow (by a factor directly related to the memory required) when compared to the INTEGER or BYTE types.

Therefore, using INTEGER values for loop counters, indexing arrays, etc. can significantly speed up your programs. While the BYTE type is not appreciably faster than INTEGER, it conserves memory space in some cases and serves as a building block for complex data types in other cases.

If you neglect to specify the type of a variable, BASIC automatically assumes the REAL data type.

Arrays of any of these data types can be created using one, two, or three dimensions.

The BYTE Data Type

BYTE variables hold integer values in the range 0 through 255 which are stored as a single byte. BYTE values are always converted to INTEGER values and/or REAL values for computation, thus they have no speed advantage over other numeric types. However, BYTE variables require only a quarter of the storage used by integers, and an eighth of that used by reals.

Attempting to store an integer value outside the BYTE range to a BYTE variable results in the storage of the least-significant 8-bits (the value modulo 256) without error.

The INTEGER Data Type

INTEGER variables consist of four bytes of storage. These bytes hold a numeric value in the range –2,147,483,648 through 2,147,483,647 as signed 32-bit data. Decimal points are not allowed. INTEGER constants may also be represented as hexadecimal values in the range $00000000 through $FFFFFFFF to facilitate address calculations. INTEGER values are printed without a decimal point. INTEGER arithmetic is faster and requires less storage than REAL values.

Arithmetic which results in values outside the INTEGER range does not cause run-time errors but instead "wraps around" modulo 4,294,967,296; (for example, 2,147,483,647 + 1 yields 2,147,483,648). Division of an integer by another integer yields an integer result, and any remainder is discarded. Values outside the INTEGER range are converted to REAL values. Consequently, they return an input error when passed to a procedure as integers. Additionally, certain functions (LAND, LNOT, LOR, LXOR) use integer values, but produce results on a non-numeric bit-by-bit basis.

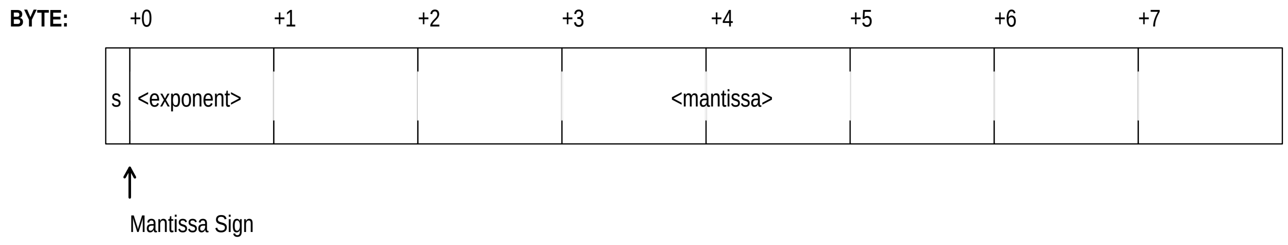
The REAL Data Type

The REAL data type is the default type for undeclared variables. However, a variable may be explicitly typed REAL (for example, twopi:REAL) to improve a program's internal documentation. REAL-type values are always printed with a decimal point, and only those constants which include a decimal point are actually stored as REAL values.

REAL numbers are stored in eight consecutive memory bytes. The representation is based on the double-precision format of IEEE Draft Standard 754. Bit 7 of the first byte is the sign of the mantissa. Bits 0-6 of the first byte and bits 4-7 of the second byte form the exponent. The exponent is biased by 1024. The remaining 52 bits comprise the mantissa.

The mantissa has an implied leading one bit.

Internal Representation of REAL Numbers



The exponent covers the range 2.2*10^-308 (2^-1022 through 1.8*10^308 (2^1024)) as powers of 2. Operations which result in values out of the representation range cause overflow or underflow errors (which may be handled automatically by the ON ERROR command).

The mantissa covers the range from 1.0 through 1.99999999999999 in steps of 2^-31. This means that REAL numbers can represent values on the number line about .0000000005 apart. Operations which cause results between the representable points are rounded to the nearest representable number.

Floating point arithmetic is inherently inexact, thus a sequence of operations can produce a cumulative error. Proper rounding (as implemented in BASIC) reduces this effect but cannot eliminate it. Programmers using comparisons on REAL quantities should use caution with strict comparisons (= or <>), because the exact desired value may not occur during program execution.

The STRING Data Type

A STRING is a variable length (0 or more) sequence of characters. A STRING of zero characters is called an empty STRING. A variable may be defined as a STRING either explicitly (DIM title:STRING) or implicitly by appending a dollar-sign character to the variable name (title$:= “My First Program.”).

The default maximum length allocated to each string is 32 characters, but each string may be dimensioned less (DIM A:STRING [4]) for memory savings or more (DIM long:STRING [2880]) to allow long strings.

Important: Strings are inherently variable-length entities, and dimensioning the storage for a string only defines the maximum-length string which can be stored there.

When a STRING value is assigned to a STRING variable, the bytes composing the string are copied into the variable storage byte-by-byte. The beginning of a string is always character number one, and this is *not* affected by the BASE0 or BASE1 statements. Operations which result in strings too long to fit in the dimensioned storage truncate the string on the right and no error is generated.

Normally the internal representation of the string is hidden. A string is stored in a fixed-size storage area and is represented by a sequence of bytes terminated by the value zero or by the maximum length allocated to the STRING variable. Any remaining *unused* storage after the zero byte allows the stored string to expand and contract during execution.

The example below shows the internal storage of a variable dimensioned as STRING[6] and assigned a value of SAM. Notice the byte at +3 contains the zero string terminator, and the two following bytes are not used.

BYTE:	+0	+1	+2	+3	+4	+5
	S	A	M	00		

If the value ROBERT is assigned to the variable, the zero byte terminator is not needed because the STRING fills the storage:

BYTE:	+0	+1	+2	+3	+4	+5
	R	O	B	E	R	T

The BOOLEAN Data Type

A BOOLEAN data type can have only two values: TRUE or FALSE. They are stored as single byte values, but they may not be used for numeric computation. A variable may be typed BOOLEAN (DIM done_flag:BOOLEAN). BOOLEAN values print out as the character strings: “TRUE” and “FALSE.”

BOOLEAN values result from comparing two compatible types. BOOLEAN values are appropriate for logical flags and expressions. For example, result:=a AND b AND c.

Do not confuse BOOLEAN operations AND, OR, XOR, and NOT with the logical functions LAND, LOR, LXOR, and LNOT. Logical functions use integer values to produce results on a bit-by-bit basis.

Attempting to store a non-BOOLEAN value in a BOOLEAN variable (or the reverse) causes a binding error or an error on the second compiler pass when leaving edit mode.

Automatic Type Conversion

Expressions that mix numeric data types (BYTE, INTEGER, or REAL) are automatically and temporarily converted to the largest type necessary to retain accuracy. In addition, certain BASIC functions also perform automatic type conversions as necessary. Therefore, numeric quantities of mixed types may be used in most cases.

Type-mismatch errors happen when an expression includes types that cannot legally be mixed. These errors are reported by the second compiler pass which automatically occurs when you leave edit mode. Type conversions can take time. Therefore, you should use expressions containing all values of a single type wherever possible.

Constants

Constants are frequently used in program statements and in expressions to assign values to variables. BASIC has rules that allow you to specify constants that correspond to the five basic data types.

Numeric Constants

Numeric constants can be either REAL or INTEGER. If a number constant includes a decimal point or uses the “E format” exponential form, BASIC stores the number in REAL format. This is true even if the value could be represented by an INTEGER or BYTE data type. For example, 8.0.

Therefore, if you want to use a REAL constant, include a decimal point. This is sometimes done if all other values in an expression are of type REAL so BASIC does not have to do a time-consuming type conversion at run-time.

Numbers that do not have a decimal point but are too large to be represented as integers are also stored in REAL format. The following are examples of REAL values:

16.0	–10.1234567	–.002
100000055	2.67E+12	–458.9E–33

Numbers that do not have a decimal point and are in the range of –2,147,483,648 to +2,147,483,647 are treated as INTEGER numbers. BASIC also accepts integer constants in hexadecimal in the range 0 to $FFFFFFFF. Hexadecimal numbers must have a leading dollar sign. The following are examples of INTEGER values

12	–2771	49908	$20
$FEED	$0A	0	

Boolean Constants

The two legal boolean constants are TRUE and FALSE:

```
DIM flag, state: BOOLEAN
flag := TRUE
state := FALSE
```

String Constants

String constants consist of a sequence of any characters enclosed in quotation marks. The binary value of each character byte can be 1 to 255. Quotation marks can be included in the string by using two quotation marks in a row to represent one quotation mark.

The null string (“”) is important because it represents a string having no characters. It is analogous to the numeric zero. The following are STRING examples:

```
“BASIC is a microcomputer language”
“AABBCCDD”
“”   (a null string)
“An ””older woman”“ is wiser”
```

Variables

Each BASIC variable is **local** to the procedure where it is defined. Local means that it is only known to the program statements within that procedure. You can use the same variable name in several procedures and the variables will be completely independent. If you want other procedures to be able to share a variable, you must use the RUN and PARAM statements to pass the variable when a procedure calls another procedure.

Storage for variables is allocated from the BASIC workspace when the procedure is called. You cannot force a variable to occupy a particular absolute address in memory. When the procedure is exited, variable storage is given back and the values stored in it are lost. Procedures can call themselves (this is referred to as **recursion**) which causes another separate storage space for variables to be allocated.

⚠ **ATTENTION:** BASIC does not automatically initialize variables. When a procedure is run, all variables, arrays, and structures will have random values. Your program must assign any initial value if needed.

Parameter Variables

Procedures may pass variables to other procedures. When this occurs, the variables passed to the called procedure are referred to as **parameters**. Parameters may be passed in two ways:

Name:	Description:
by reference	This allows values to be returned from the called procedure to calling procedure variables.
by value	This protects the values in the calling procedure so that the called procedure cannot change them.

Parameters are usually passed by reference. This is done by enclosing the names of the variables to be sent to the called procedure in parentheses as part of the RUN statement. The storage address of each parameter variable is evaluated and sent to the called procedure, which then associates those addresses with names in a local PARAM statement.

The called procedure uses this storage as if it had been created locally (although it may have a new name) and can change the values stored there. Parameters passed by reference allow called procedures to return values to their callers.

Parameters may be passed by value by writing the value to be passed as an expression which is evaluated at the time of the call. Useful expression-generators that do not alter values are +0 for numbers or +“” for strings. For example:

```
RUN inverse(x)              Passes x by reference.
RUN inverse(x+0)            Passes x by value.
RUN translate(word$)        Passes word$ by reference.
RUN translate(word$+“”)     Passes word$ by value.
```

When parameters are passed by value, a temporary variable is created when the expression is evaluated. The result is placed in temporary storage. The address of this temporary storage is sent to the called procedure. Therefore, the value actually given to the called procedure is a copy of the result, and the called procedure cannot change the variable(s) in the calling program.

Important: Expressions containing numeric constants are either INTEGER or REAL; there is no type BYTE constant. Thus, BYTE-type variables may be sent to a procedure as parameters, but expressions will be of types INTEGER or REAL. For example, a RUN statement may evaluate an INTEGER as a parameter and send it to the called procedure. If the called procedure is expecting a BYTE-type variable, it uses only the high-order byte of the (four-byte) INTEGER (which, if the value was intended to be in BYTE-range, is probably zero.).

Arrays

The DIM statement can create arrays of from one to three dimensions:

- A **vector** is a one-dimensional array.
- A **table** is a two-dimensional array.
- A **matrix** is a three-dimensional array.

The sizes of each dimension are defined when the array is typed (for example, DIM plot(24,80):BYTE) by including the number of elements in each dimension.

Therefore, a table dimensioned (24,80) has 24 rows (1-24) of 80 columns (1 - 80) when accessed in the default (BASE 1) mode. You may elect to access the elements of an array starting at zero (BASE 0), in which case there are still 24 rows (now 0-23) and 80 columns (now 0-79). Arrays may be composed of basic data types, complex data types, or other arrays.

Complex Data Types

The TYPE statement defines a new data type as a **vector** (a one-dimensional array) of any basic or previously-defined types. For example:

```
TYPE employee_rec = name:STRING; number(2):INTEGER; malesex:BOOLEAN
```

This structure differs from an array in that the various elements may be of mixed types, and the elements are accessed by a field name instead of an array index. For example:

```
DIM employee_file(250): employee_rec
employee_file(1).name := “Tex”
employee_file(20).number(2) := 115
```

The complex structure allows you to store and manipulate related values that are of many types, to create new types in addition to the five defined data types, or to create data structures of unusual shape or size. The position of the desired element in complex-type storage is known and defined at compile time and need not be calculated at run time. Therefore, complex structure accesses may be slightly faster than array accesses.

The elements of a complex structure may be copied to another similar structure using a single assignment operator (:=). An entire structure may be written to or read from mass storage as a single entity (for example, PUT #2, employee_file).

Arrays or complex structures may be elements of subsequent complex structures or arrays.

Chapter 10

Expressions, Operators, and Functions

Evaluation of Expressions

Many BASIC statements evaluate expressions. The result of an evaluation is always a value of some basic type: REAL, INTEGER, STRING, or BOOLEAN. The expression itself may consist of values and operators. For example, the expression 5+5 results in an integer with a value of ten.

A **value** can be a constant value, a variable name, or a function which returns the result as a value. An operator combines values (typically, those adjacent to the operator) and also returns a result.

When evaluating an expression, each value is copied to an **expression stack** where functions and operators take their input values and return results. If the expression is used in an assignment statement, the assignment is made only when the result of the entire expression has been. This allows the variable which is being modified to be one of the values in the expression. The same principles apply for numeric, string, and boolean operators. These principles make assignment statements such as X=X+1 legal in all cases, even though it would not make sense in a mathematical context.

Any expression evaluates to one of the five basic data types. This does not mean, however, that all the operators and operands in expressions have to be of an identical type. Often types are mixed in expressions because the **result** of some operator or function has a different type than its operands. An example is the “less than” operator:

```
24 < 100
```

The less-than operator (<) operator compares two numeric operands. The result of the comparison is of type BOOLEAN; in this case, the value TRUE.

BASIC allows you to mix the three numeric types because it performs automatic type conversion of operands. If different types are used in an expression, the result is the same type as the operand(s) having the largest representation. As a rule, any numeric type operand may be used in a expression that is expected to produce a result of type REAL. Expressions that must produce BYTE or INTEGER results must evaluate to a value that is small enough to fit the representation. BASIC has a complete set of functions that can perform compatible type conversion. Type-mismatch errors are reported by the second compiler pass when leaving edit mode.

Operators

Operators (excepting negation) perform some operation on two operands. This produces a result, which is generally the same type as the operands. The following table lists the operators available and the types they accept and produce.

Operator:	Function:	Operand type:	Result type:
–	Negation	NUMERIC	NUMERIC
^ or **	Exponentiation	NUMERIC (positive)	NUMERIC
*	Multiplication	NUMERIC	NUMERIC
/	Division	NUMERIC	NUMERIC
+	Addition	NUMERIC	NUMERIC
–	Subtraction	NUMERIC	NUMERIC
NOT	Logical Negation	BOOLEAN	BOOLEAN
AND	Logical AND	BOOLEAN	BOOLEAN
OR	Logical OR	BOOLEAN	BOOLEAN
XOR	Logical EXCLUSIVE OR	BOOLEAN	BOOLEAN
+	Concatenation	STRING	STRING
=	Equal to	ANY	BOOLEAN
<> or ><	Not equal to	ANY	BOOLEAN
<	Less than	NUMERIC, STRING 1	BOOLEAN
<= or =<	Less than or Equal	NUMERIC, STRING 2	BOOLEAN
>	Greater than	NUMERIC, STRING 3	BOOLEAN
>= or =>	Greater than or Equal	NUMERIC, STRING 4	BOOLEAN
When comparing strings, the ASCII collating sequence is used, so that 0 < 1 < ... < 9 < A < B< ... < Z < a < b< ... < z			

Important: NUMERIC refers to either BYTE, INTEGER, or REAL types.

Operator Precedence

Operators have **precedence**. This means they are evaluated in a specific order. Parentheses can override natural precedence. However, the compiler may remove extraneous parentheses. The legal operators are listed here, in precedence order from highest to lowest:

Precedence:	Operator:
Highest Precedence	NOT
	–(negate)
	^
	**
	*
	/
	+
	–
	>
	< <> = >= <=
	AND
Lowest Precedence	OR
	XOR

Operators of equal precedence are shown on the same line, and are evaluated left to right in expressions. The only exception to this rule is exponentiation, which is evaluated right to left. Raising a negative number to a power is not legal in BASIC.

In the following examples, BASIC expressions on the left are evaluated as indicated on the right. Either form may be entered, but the decompiler always generates the form on the left:

BASIC representation:	Equivalent form:
a:= b+c**2/d	a:= b+((c**2)/d)
a:= b>c AND d>e OR c=e	a:= ((b>c) AND (d>e)) OR (c=e)
a:= (b+c+d)/e	a:= ((b+c)+d)/e
a:= b**c**d/e	a:= (b**(c**d))/e
a:= –(b)**2	a:= (–b)**2
a:=b=c	a:= (b=c) (returns BOOLEAN value)

Functions

Functions accept one or more arguments enclosed in parentheses, perform some operation, and return a value. They may be used as operands in expressions. Functions expect that the arguments passed to them are expressions, constants, or variables of a certain type and return a result of a certain type. Giving a function an argument of an incompatible type results in an error.

In the descriptions of functions that follow, the following notation describes the type required for the parameter expressions:

Name:	Description:
<num>	Specifies any numeric-result expression.
<str>	Specifies any string-result expression.
<int>	Specifies any integer-result expression.

The functions below return REAL results. Accuracy of transcendental functions is 8+ decimal digits. Angles can be either degrees or radians (see DEG/RAD statement descriptions).

Important: Transcendental functions take a long time to return a value if passed an extremely large value (for example, SIN(100000000)).

Name:	Description:
SIN(<num>)	Trigonometric sine of <num>. Result: –1 <= SIN(<num>) <= 1
COS(<num>)	Trigonometric cosine of <num>. Result: –1 <= COS(<num>) <= 1
TAN(<num>)	Trigonometric tangent of <num>.
ASN(<num>)	Trigonometric arcsine of <num>. Result: –PI/2 <= ASN(<num>) <= PI/2
ACS(<num>)	Trigonometric arcosine of <num>. Result: 0 <= ACS(<num>) <= PI
ATN(<num>)	Trigonometric arctangent of <num>. Result: –PI/2 <= ATN(<num>) <= PI/2
LOG(<num>)	Natural logarithm (base e) of <num>, which must be positive.
LOG10(<num>)	Logarithm (base 10) of <num>, which must be positive.
SQR(<num>)	Square root of <num>, which must be positive.
SQRT(<num>)	Square root of <num>; same as SQR.
EXP(<num>**)**	e (2.71828183) raised to the power <num>, which must be a positive number.
FLOAT(<num>)	<num> converted to type REAL (from BYTE or INTEGER).
INT(<num>)	Truncates all digits to the right of the decimal point of a REAL <num>. Examples: INT(0.21) = 0. INT(–2.5) = –2.
PI	The constant 3.141592653589793.
RND(<num>)	If <num>=0, returns random x, 0 <= x < 1. If <num>>0, returns random x, 0 <= x < <num>. If <num><0, use ABS(<num>) as new random number seed.

The following functions return results of type INTEGER or BYTE:

Name:	**Description:**
FIX(<num>)	Rounds REAL <num> and converts to type INTEGER.
MOD(<num1>,<num2>)	Modulus (remainder) function. MOD returns the remainder of <num1> divided by <num2>. If <num1> is negative, the result is negative. Examples: MOD(9,5) = 4 ; MOD(–11,3) = –2
ADDR(<name>)	Absolute memory address of variable, array, or structure named <name>.
SIZE(<name>)	Storage size in bytes of variable, array, or structure named <name>.
ERR	Error code of most recent error, automatically resets to zero when referenced.
PEEK(<int>)	Value of byte at memory address <int>. **WARNING:** The specified memory address must be within the limits of accessible memory space. PEEK(–1) gives a bus error on most systems. This causes BASIC to abort.
POS	Current character position of PRINT buffer.
ASC(<str>)	Numeric value of first character of <str>.
LEN(<str>)	Length of string <str>.
SUBSTR(<str1>,<str2>)	Substring search: returns starting position of first occurrence of <str1> in <str2>, or 0 if not found.
INKEY(#<num>)	Returns the number of characters in data buffer.
FILSIZ(#<num>)	Returns size of a file.

The following functions can return any numeric type, depending on the type of the input parameter:

Name:	**Description:**
ABS(<num>)	Absolute value of <num>.
SGN(<num>)	Signum of <num>: –1 if <num> < 0; 0 if <num> = 0; or 1 if <num> > 0.
SQ(<num>)	Square <num>.
VAL(<str>)	Convert type STRING to type NUMERIC.

The following functions perform bit-by-bit logical operations on integer or byte data types and return integer results. Do not confuse them with the BOOLEAN-type operators.

Name:	**Description:**
LAND(<num>,<num>)	Logical AND
LOR(<num>,<num>)	Logical OR
LXOR(<num>,<num>)	Logical EXCLUSIVE OR
LNOT(<num>)	Logical NOT

These functions return a result of type STRING:

Name:	**Description:**
CHR$(<int>)	ASCII character equivalent of <int>. <int> must be within range of 0-127.
DATE$	Date and time, format: yy/mm/dd hh:mm:ss.
LEFT$(<str>,<int>)	Leftmost <int> characters of <str>.
RIGHT$(<str>,<int>)	Rightmost <int> characters of <str>.
MID$(<str>,<int1>,<int2>)	Middle <int2> characters of <str> starting at character position <int1>.
STR$(<num>)	Converts numeric type <num> to displayable characters of type STRING representing the number converted.
TRIM$(<str>)	<str> with trailing spaces removed.

The following functions return BOOLEAN values:

Name:	**Description:**
TRUE	Always returns TRUE.
FALSE	Always returns FALSE.
EOF(#<num>)	End-of-file test on disk file path <num>, returns TRUE if end-of-file condition exists.

Chapter 11

Program Statements and Structure

Program Structure

A BASIC program can be written as a single procedure, or it may be divided into a number of smaller procedures, each of which performs a specific function.

Single procedure programs may be useful when the program is relatively small. However, large complex programs are generally much easier to develop, test, and maintain when the program is divided into several procedures. To do this, you should create a main routine which calls other BASIC procedures to perform specific functions as subroutines. These BASIC procedures may in turn call other BASIC procedures in the same manner. These techniques reflect sound structured programming practice.

A procedure consists of any number of program statement lines. Each line can have an optional line number. More than one program statement can be placed on the same line if separated by backslash (\) characters. For example, the following statements are equivalent:

```
GOSUB 550 \ PRINT X,Y \ RETURN                 GOSUB 550
                                               PRINT X,Y
                                               RETURN
```

While these statements are functionally equivalent, the second is generally considered preferable. The first method runs no faster and tends to hide the structure of the program.

The number of characters on a line is dependent on the content of the line. In general, lines should be limited to 128 characters or less, to avoid the generation of errors when BASIC decompiles the I-code for listing purposes or at run time.

Loop nesting is limited to 39 levels. Nested procedure and subroutine calls are only limited by stack space.

Program readability is improved if all variables are declared with DIM statements at the beginning of the procedure, but this is not mandatory.

Line numbers are optional. They can be any integer number in the range of 1 to 32767. Only use line numbers where absolutely necessary (such as with GOSUB). They make programs harder to understand, use additional memory space, and increase compile time considerably. Line numbers are local to procedures. That is, the same line number can be used in different procedures without conflict.

You can terminate programs with END or STOP statements. These statements are optional.

Assignment Statements

Assignment statements are used for computing or initializing of variables. The two assignment statements available with BASIC are LET and POKE.

LET

Assignment State

Syntax

```
[LET] <var> := <expr>
[LET] <var> = <expr>
[LET] <struct> := <struct>
[LET] <struct> = <struct>
```

Function

`LET` evaluates an expression and stores the result in <var>. <var> may be a simple variable or data structure element. The result of the expression (<expr>) must be of the same or compatible type as <var>.

BASIC accepts either = or **:**= as an assignment operator. However, the second form (:=) is preferred because it distinguishes the assignment operation from a comparison (the test for equality). The **:**= operator is also used in PASCAL.

You can also use the assignment statement to copy the entire value of an array or complex data structure to another array or complex data structure. The data structures do not have to have the same type or shape. The only restriction is that the size of the destination structure be the same or larger than the source structure.

You can use this type of assignment to perform unusual type conversions. For example, a string variable of 80 characters can be copied to a one-dimensional array of 80 bytes.

Examples

```
A := 0.1

value := temp/sin(x)

DIM array1(100), array2(100)
array1 := array2

LET AUTHOR$ := FIRST_NAME$ + LAST_NAME$

DIM truth,lie:BOOLEAN
lie := 100 < 1
truth := NOT lie

count = total-adjustment
matrix(2).coefficient(n+2) := matrix(1).coefficient(n)
```

POKE

Store Data at Specific Memory Address

Syntax

```
POKE <integer expr> , <byte expr>
```

Function

`POKE` allows a program to store data at a specific memory address. The first expression is used as the absolute address to store the type BYTE result of the second expression. `POKE` can alter any memory address, so you must be careful when using it.

ATTENTION: Using POKE with an invalid address causes BASIC to abort.

Examples

```
POKE ADDR(buffer)+5,ASC("A")

POKE 1200,14

POKE $1C00,$FF

POKE pointer,PEEK(pointer+1)

(* same as alphabet$ := "ABCDEFGHIJKLMNOPQRSTUVWXYZ" *)
FOR i=0 to 25
  POKE ADDR(alphabet$)+i,$40+i
NEXT i
POKE ADDR(alphabet$)+26,$00
```

Control Statements

Control statements affect the sequential execution of program statements. They are used to construct loops or make decisions that alter program flow. BASIC provides a selection of loop statements that allow you to create any kind of loop using sound structured programming style. The control statements are IF..THEN..ELSE, FOR..NEXT, WHILE..DO, REPEAT..UNTIL, LOOP..ENDLOOP, GOTO, GOSUB..RETURN, ON GOTO..RETURN, ON GOSUB..RETURN, and ON ERROR GOTO.

IF..THEN..ELSE

Control Statement

Syntax

```
IF <bool expr> THEN <statements>
[ ELSE <statements> ]
ENDIF

IF <bool expr> THEN <line #>
```

Function

The IF structure evaluates an expression to a BOOLEAN value. If the result is TRUE, the statement(s) immediately following the THEN are executed. If an ELSE clause exists, statements between the ELSE and ENDIF are skipped. If the expression is evaluated to FALSE, control is transferred to the first statement following the ELSE (if present) or to the statement immediately following the ENDIF.

A special form of the IF statement transfers execution to the statement having a line number specified if the result of the expression is TRUE. The line number follows immediately after THEN. This is an implied GOTO statement. Use this with caution (as all GOTO statements should).

Examples

```
IF a < b THEN
  PRINT “a is less than b”
  PRINT “a:”;a;“ b:”;b
ENDIF

IF a < b THEN
  PRINT “a is less than b”
ELSE
  IF a=b THEN
    PRINT “a equals b”
  ELSE
    PRINT “a is greater than b”
  ENDIF
ENDIF

IF payment < balance THEN 400
```

FOR..NEXT

Control Statement

Syntax

```
FOR <var> = <expr> TO <expr> [ STEP <expr> ]
NEXT <var>
```

Function

`FOR..NEXT` creates a loop that usually executes a specified number of times while automatically increasing or decreasing a specified counter variable.

The first expression is evaluated and the result is stored in <var>. <var> must be a simple integer or real variable. The second expression is evaluated and stored in a temporary variable.

If you use STEP, its expression is evaluated and used as the loop increment. If the increment is negative, the loop counts down.

The **body** of the loop (the statements between the FOR and NEXT) is executed until the NEXT variable (a counter) is larger than the terminating expression value. For negative STEP values, the loop executes until the loop counter is less than the termination value. If the initial value of <var> is beyond the terminating value, the body of the loop is never executed.

You can jump out of FOR..NEXT loops.

ATTENTION: When using REAL control and STEP expressions, there is a possibility of not completing the number of loops logically indicated. For example, the following loop would seem to complete x number of loops. Due to the rounding nature of REAL numbers, it may only complete (x – 1) loops:

```
FOR a = 1/x TO 1 STEP 1/x
  .
  .
next a
```

To make sure that the loop is executed the correct number of times, use INTEGER values for all expressions.

Examples

```
FOR var = min–1 TO min+max STEP increment-adjustment
  PRINT var
NEXT var

FOR x = 1000 TO 1 STEP –1
  PRINT x
NEXT x
```

WHILE..DO

Control Statement

Syntax

```
WHILE <bool expr> DO
  <statements>
ENDWHILE
```

Function

This loop tests its control expression at the top of the loop. Statements within the loop are executed as long as <bool expr> is TRUE. The body of the loop is not executed if the boolean expression evaluates to FALSE when first executed.

Examples

```
WHILE a<b DO     is equivalent to     100 IF a>=b THEN 500
  PRINT a                                 PRINT a
  a := a+1                                a := a+1
ENDWHILE                                  GOTO 100
                                      500 REM

DIM yes:BOOLEAN
yes=TRUE
WHILE yes DO
  PRINT “yes!  ”;
  yes := POS<50
ENDWHILE

REM reverse the letters in word$
backward$ := “”
INPUT word$
WHILE LEN(word$) > 0 DO
  backward$ := backward$ + RIGHT$(word$,1)
  word$ := LEFT$(word$,LEN(word$)–1)
ENDWHILE
word$ := backward$
PRINT word$
```

REPEAT..UNTIL

Control Statement

Syntax

```
REPEAT
  <statements>
UNTIL <bool expr>
```

Function

This loop tests its control expression at the bottom of the loop. The statement(s) within the loop are executed until the result of <bool expr> is TRUE. The body of the loop is always executed at least one time.

Examples

```
x = 0            is the same as        x=0
REPEAT                             100 PRINT x
  PRINT x                              x=x+1
  x=x+1                                IF X <= 10 THEN 100
UNTIL x>10

(* compute factorial: n! *)
temp := 1.
INPUT “Factorial of what number? ”,n
REPEAT
  temp := temp * n
  n := n–1
UNTIL n <= 1.0
PRINT “The factorial is ”; temp
```

LOOP..ENDLOOP/ EXITIF..ENDEXIT

Control Statement

Syntax

```
LOOP
  <statements>
ENDLOOP

EXITIF <bool expr> THEN <statements>
ENDEXIT
```

Function

`LOOP..ENDLOOP` and `EXITIF..ENDEXIT` are inherently related. They can be used to construct loops with tests located anywhere in the body of the loop. The LOOP and ENDLOOP statements define the body of the loop. EXITIF clauses can be inserted anywhere inside the loop to leave the loop if the result of its test is true.

Important: If there is no exit clause, you will create an endless loop.

`EXITIF..ENDEXIT` allows control to be passed to the next statement outside the structure containing the EXITIF statement (this includes IF..THEN statements). `EXITIF` evaluates an expression to a boolean result. If the result is TRUE, the statements between the THEN and the ENDEXIT are executed, and control is transferred outside the binding structure. Otherwise, the statement following ENDEXIT is executed. This exit clause is often used to perform some specific function upon termination of the loop which depends on where the loop terminated.

`EXITIF` statements are almost always used when LOOP..ENDLOOP is used, but they can also be useful in any type of loop or conditional construct.

Examples

```
LOOP                 is equivalent to     100 count = count+1
count = count+1                               IF count <= 100 THEN
EXITIF count > 100 THEN                         PRINT count
  done = TRUE                                   GOTO 100
ENDEXIT                                       ELSE
  PRINT count                                   done = TRUE
ENDLOOP                                       ENDIF
                                              REM out of loop
```

```
INPUT x,y
LOOP
  PRINT
EXITIF x < 0 THEN
  PRINT “x became zero first”
ENDEXIT
  x := x–1
EXITIF y < 0 THEN PRINT “y became zero first”
ENDEXIT
  y := y–1
ENDLOOP
```

GOTO

Control Statement

Syntax

```
GOTO <line #>
```

Function

`GOTO` unconditionally transfers execution flow to the line having the specified number.

Important: The line number is a constant, not an expression or a variable.

Example

```
GOTO 1000
```

GOSUB..RETURN

Control Statement

Syntax

```
GOSUB <line #>
     .
        .
<line#> <statements>
        RETURN
```

Function

GOSUB transfers program execution to a subroutine starting at the specified line number. The subroutine is executed until a RETURN statement is encountered which causes execution to resume at the statement following the calling GOSUB. Subroutines may be nested to any depth.

Example

```
FOR n := 1 to 10
  x := SIN(n)
  GOSUB 100
NEXT n
FOR m := 1 TO 10
  x := COS(m)
  GOSUB 100
NEXT m
STOP

100 x := x/2
PRINT x
RETURN
```

ON GOTO/ON GOSUB

Control Statement

Syntax

```
ON <integer expr> GOTO <line #> {,<line #>}
ON <integer expr> GOSUB <line #> {,<line #>}
```

Function

These statements evaluate an integer expression and use the result to select a corresponding line number from an ordered list. Control is then unconditionally transferred to that line number in ON GOTO statements or as a subroutine in ON GOSUB statements.

These statements are similar to CASE statements in other languages.

Each <line #> in the ordered list is given a value (beginning with 1, 2, 3, ...). <integer expr> must evaluate to a positive INTEGER result having a value between 1 and N; N being the highest line number in the list. N is limited by input line length and the number of digits in each line number. The best case limit for N is 60.

Important: If the expression has a result that does not correspond with the ordered list, no GOSUB statement is selected and the next sequential statement is executed.

Example

```
(* spell out the digits 0 to 7 *)
DIM digit:INTEGER
A$=“one digit only, please”
INPUT “type in a digit”; digit
ON digit+1 GOSUB  10,11,12,13,14,15,16,17
PRINT A$
STOP

   (* names of digits *)
10 A$ := “ZERO”
   RETURN
11 A$ := “ONE”
   RETURN
12 A$ := “TWO”
   RETURN
13 A$ := “THREE”
   RETURN
14 A$ := “FOUR”
   RETURN
15 A$ := “FIVE”
   RETURN
16 A$ := “SIX”
   RETURN
17 A$ := “SEVEN”
   RETURN
```

ON ERROR GOTO

Control Statement

Syntax

```
ON ERROR [ GOTO <line #> ]
```

Function

This statement sets a trap that transfers control to the specified line number when a non-fatal run-time error occurs. If no ON ERROR GOTO has been executed in a procedure before an error occurs, the procedure stops and enters DEBUG mode. You can turn off the error trap by executing ON ERROR without a GOTO.

This statement is often used with the ERR function which returns the specific error code, and the ERROR statement which artificially generates errors.

Important: `ERR` automatically resets to zero any time it is called.

Example

```
(* List a file *)

DIM path,errnum: INTEGER; name: STRING[45]
DIM line: STRING[80]
ON ERROR GOTO 10
INPUT “File name? ”; name
OPEN #path,name:READ
LOOP
  READ #path, line
  PRINT line
ENDLOOP

10 errnum=ERR
IF errnum = 211 THEN
(* end-of-file *)
  PRINT “Listing complete.”
  CLOSE #path
  END
ELSE
(* other errors *)
  PRINT “Error number ”; errnum
  END
ENDIF
```

Execution Statements

Execution statements run procedures, stop execution of procedures, create shells, or affect the current execution of the procedure.

RUN

Run Procedure

Syntax

```
    RUN <proc name> [ ( <param> {,<param>} ) ]
```

Function

RUN calls a procedure by name. When that procedure ends, control passes to the statement after the RUN statement. It is most often used to call a procedure inside the workspace, but it can also be used to call a previously compiled procedure or a 68000 machine language procedure outside the workspace. The name can be optionally taken from a string variable.

Parameter Passing

RUN can include a list of parameters enclosed in parentheses to be passed to the called procedure. The called procedure must have PARAM statements of the same size and order to match the parameters passed to it by the calling procedure.

The parameters can be variables, constants, or the names of entire arrays or data structures. They can be of any type, *except* variables of type BYTE. However, BYTE arrays are allowed.

If a parameter is a constant or expression, it is passed by value. A parameter passed by value is evaluated and placed in a temporary storage location and the address of the temporary storage is passed to the called procedure. Parameters passed by value can be changed by the receiving procedure, but the changes are not reflected in the calling procedure.

If the parameter is the name of a variable, array, or data structure, it is passed by reference. When passed by reference, the address of that storage is sent to the called procedure, and the value in that storage may be changed by the receiving procedure. These changes are reflected in the calling procedure.

Calling External Procedures

If the procedure named by RUN cannot be found in the workspace, BASIC checks to see if it was loaded by OS-9 outside the workspace. If it is not found there, BASIC tries to find a disk file having the same name in the current execution directory, loads it, and runs it.

In either case, BASIC checks to see if the called procedure is a BASIC I-code module or a 68000 machine language module and executes it accordingly. If it is a 68000 machine language module, BASIC executes a JSR instruction to its entry point and the module is executed as 68000 native code. The machine language routine can return to the original calling procedure by executing an RTS instruction. The diagram on the next page shows what the stack frame passed to machine-language subroutines looks like.

Machine language modules return error status by setting the carry bit of the MPU condition codes register and by setting the low order word of register D1 to the appropriate error code. For an example of a machine language subroutine (SYSCALL), see Appendix A.

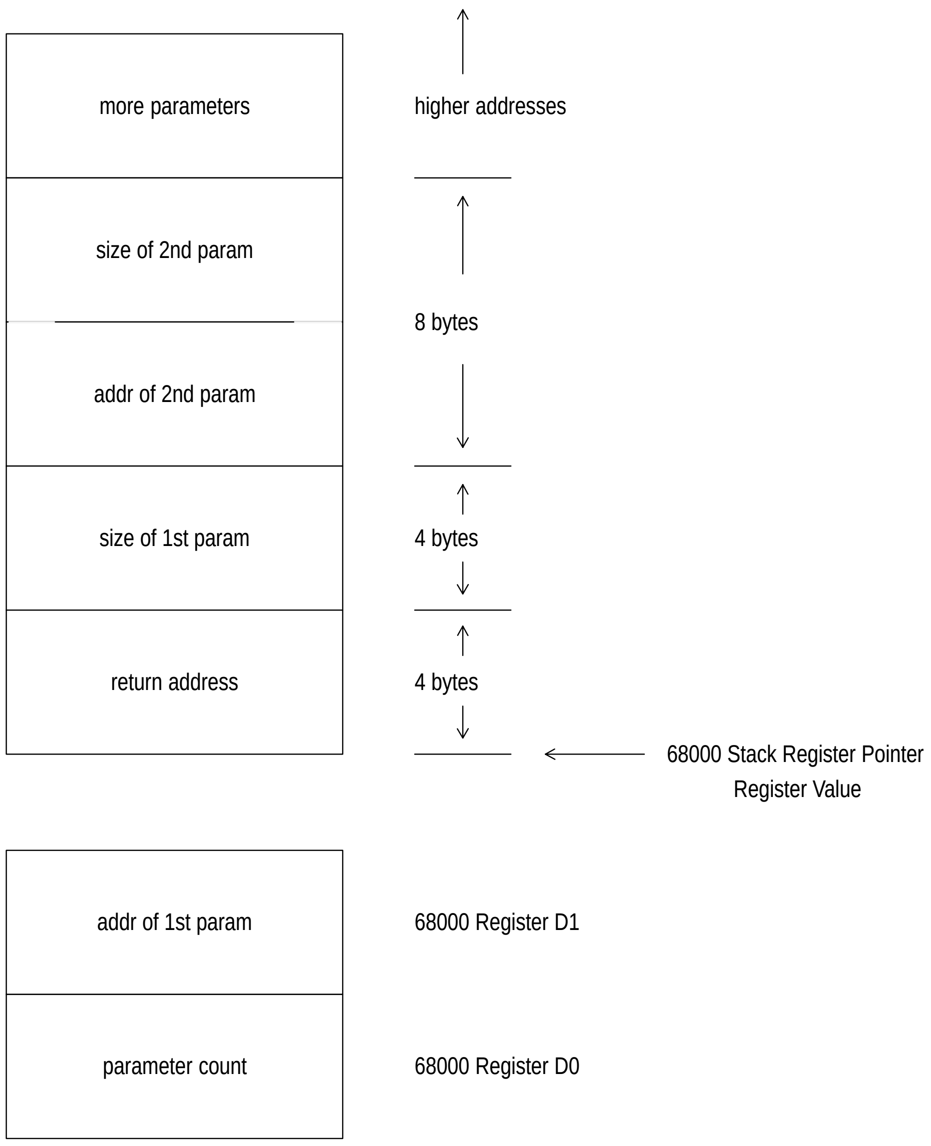
After an external procedure has been called but is no longer needed, the KILL statement should be used to get rid of it so its memory space can be used for other purposes.

Example

```
PROCEDURE trig_table
num1 := 0 \ num2 := 0
REPEAT
  RUN display(num1,SIN(num1))
  RUN display(num2,COS(num2))
  PRINT
UNTIL num1 > 1
END

PROCEDURE display
PARAM passed,funcval
PRINT passed;“:”;funcval,
passed := passed + 0.1
END
```

Figure 11.1
Stack Frame Passed to Machine Language Procedures



KILL

Stop Execution of Procedure

Syntax

```
KILL <proc name>
```

Function

`KILL` unlinks an external procedure, possibly returning system memory, and removes it from BASIC's procedure directory. If the procedure is inside the workspace, nothing happens and no error is generated. `KILL` can be used with auto-loading PACKed procedures as an alternative to CHAIN when program overlay is desired.

The procedure name may be optionally called from a string variable.

ATTENTION: It can be fatal to OS-9 to KILL an active procedure.

When KILL is used with RUN, both statements must use the same string variable which contains the name of the procedure. See the first example below:

Examples

```
LET procname$="average"
RUN procname$
KILL procname$

INPUT "Which test do you want to run? ",test$
RUN test$
KILL test$
```

CHAIN

Execute Shell Command Line

Syntax

```
     CHAIN <SHELL command line>
```

Function

`CHAIN` performs an OS-9 chain operation on the shell, passing the specified command line as a parameter. `CHAIN` causes BASIC to be exited, unlinked, and its memory returned to OS-9. The command line should evaluate to the name of an executable module (such as BASIC), passing parameters if appropriate.

`CHAIN` can begin execution of any module, not just BASIC. It executes the module indirectly through the shell. This allows CHAIN to use the shell's parameter processing. This leaves an extra active shell. Programs that repeatedly chain to each other eventually find all memory filled with waiting shells. To prevent this, use the shell's ex option.

Consult Using Personal OS-9 or Using Professional OS-9 for more details on the capabilities of the shell.

Important: If it is necessary to pass an open path to another program using the CHAIN command, use the shell's ex option.

Examples

```
CHAIN “ex BASIC menu”

CHAIN “BASIC #10k sort (“”datafile“”,“”tempfile“”)”

CHAIN “DIR /D0”

CHAIN “Dir; Echo * Copying Directory *; ex basic09 copydir”
```

SHELL

Create a Shell Process

Syntax

```
SHELL <SHELL command line>
```

Function

`SHELL` allows BASIC programs to run any OS-9 command or program. SHELL gives access to virtually any OS-9 function including multiprogramming, utility commands, terminal, and I/O control.

Consult Using Personal OS-9 or Using Professional OS-9 for a detailed discussion of OS-9 standard commands.

`SHELL` requests OS-9 to create a new process. This initially executes the shell, which is the OS-9 command interpreter. The shell can then call any program in the system. The command line is evaluated and passed to the shell to be executed as a command line. If no command line is specified, BASIC is temporarily suspended and the shell process displays prompts and accepts commands in its normal manner. When the shell process terminates, BASIC becomes active again and resumes execution at the statement following the SHELL statement.

Examples

```
SHELL “copy file1 file2”   Sequential execution

SHELL “copy file1 file2&”  Concurrent execution

SHELL “edt document”       Calling text editor

SHELL “asm source o=obj ! spl &”        Concurrent assembly

SHELL “”     Transfer control to SHELL
```

END

End Procedure Execution

Syntax

```
    END [<output list>]
```

Function

END stops execution of the procedure and returns to the calling procedure or to BASIC’s command mode if it was the highest level procedure. If an output list is specified, END prints the list to standard output (the same as a PRINT statement).

END is an executable statement. You can use it several times in the same procedure. END is optional; it is not required at the bottom of a procedure.

Examples

```
    END

    END “I have finished execution”
```

STOP

Stop Procedure Execution

Syntax

```
    STOP [<output list>]
```

Function

STOP immediately terminates execution of all procedures and returns to the command mode. If an output list is specified, it also executes like a PRINT statement.

BYE

End Procedure Execution and BASIC

Syntax

```
BYE
```

Function

BYE ends execution of the procedure and terminates BASIC. Any open files are closed, and any unsaved procedures or data in the workspace is lost. You can use BYE to create packed programs and/or programs to be called from OS-9 procedure files.

ATTENTION: BYE causes BASIC to abort. Only use it if the program has been saved before it is tested!

DIGITS

Set Precision

Syntax

```
DIGITS [<int expr>]
```

Function

DIGITS controls the precision of real numbers displayed by a PRINT statement. If no <int expr> is specified, DIGITS returns the current precision.

DIGITS also controls the precision of transcendental functions. If the result of the expression is not between 1 and 15, the result is brought into that range with no error.

Example

```
PROCEDURE DIGITDEMO
   DIM a,b : REAL
   DIGITS 2
   a := 9.2
   b := 0.11
   PRINT a,b,a*b

RUN DIGITDEMO
9.2            .11             1.
```

ERROR

Generate Error

Syntax

```
ERROR<integer expr>
```

Function

ERROR generates an error having the error code specified by the result of evaluation of the expression. ERROR is often used for testing error routines. Also see the ON ERROR description.

PAUSE

Suspend Execution

Syntax

```
PAUSE [<output list>]
```

Function

PAUSE suspends execution of the procedure and causes BASIC to enter debug mode. If an output list is specified, it also executes as a PRINT statement. When a PAUSE is encountered the following is displayed:

```
<output list> BREAK IN PROCEDURE <procedure name>
```

You can use the debug mode CONT command to resume procedure execution at the following statement.

Examples

```
PAUSE
PAUSE “now outside main loop”
```

CHD/CHX

Change Directories

Syntax

```
CHD <pathlist>
CHX <pathlist>
```

Function

`CHD` and `CHX` change the current default data or execution directories, respectively. The pathlist must refer to a file which has the DIR attribute. For more information on the OS-9 directory structure, consult Using Personal OS-9 or Using Professional OS-9.

DEG/RAD

Set Angle Units to Degrees or Radians

Syntax

```
DEG
RAD
```

Function

`DEG` and `RAD` set the procedure's state flag to assume angles stated in degrees or radians in SIN, COS, TAN, ACS, ASN, and ATN functions. This flag applies only to the currently active procedure. The default state is radians.

Example

```
DIM a : REAL

DEG
INPUT “enter degree of angle”, a
PRINT “The sin of ”; a; “degrees is ”; SIN (a)
END
```

BASE0/BASE1

Set Low Array Index

Syntax

```
BASE 0
BASE 1
```

Function

`BASE 0` and `BASE 1` indicate whether a particular procedure's lowest array or data structure index is zero or one. The default is one. These statements do not affect the string operations where the beginning character of a string is always index one.

TRON/TROFF

Turn Trace Mode On/Off

Syntax

```
TRON
TROFF
```

Function

`TRON` and `TROFF` turn the trace mode on or off. This is useful for debugging. When trace mode is turned on, each statement is decompiled and printed before execution. The result of each expression evaluation is printed as it occurs.

Comment Statements

REM/(*

Comment Statement

Syntax

```
REM <chars>
(* <chars> [ *) ]
```

Function

These statements are used to put comments in programs. The second form of the statement is for compatibility with PASCAL programs. Comments are retained in the I-code but are removed by the PACK compile command. The exclamation point (!) character can be typed in place of the keyword REM when editing programs. The compiler trims away extra spaces following REM to conserve memory space.

Examples

```
REM this is a comment

(* This is also a comment *)

(* This is another kind of comment
```

Declaration Statements

The DIM, PARAM, and TYPE statements are called declaration statements because they define and/or declare variables, arrays, and complex data structures. `DIM` and `PARAM` are almost identical, the difference being that DIM declares storage used exclusively within the procedure, and PARAM declares variables received from another calling procedure.

You do not need to use DIM for simple variables of type REAL, because this is the default format for undeclared variables. You also do not need to use DIM for 32-character STRING type variables (any name ending with a $ is automatically assigned this type). Even though you do not have to declare variables in these two cases, using DIM improves your program's internal documentation. The things you must declare are:

- any simple variables of type BYTE, INTEGER, or BOOLEAN
- any simple STRING variables shorter or longer than 32 characters
- arrays of any type
- complex data structures of any type

The TYPE statement does not really create variable storage. Instead, it describes a new data structure type that can be used in DIM or PARAM statements in addition to the five basic data types built-in to BASIC. Therefore, TYPE is only used in programs that use complex data structures.

DIM

Declare Variables, Arrays, Etc.

Syntax

```
     DIM <var> {, <var>} : <type> {;<var> {, <var>} : <type>}
```

Function

`DIM` declares simple variables, arrays, or complex data structures of the five basic types or any user-defined type. During compilation, BASIC assigns storage required for all variables declared in DIM statements.

Declaring Simple Variables

Simple variables are declared by using the variable name in a DIM statement without a subscript. If variables are not explicitly declared, they are automatically assumed to be REAL or, if the variable name ends with a $ character, STRING[32]. Therefore, you must explicitly declare all simple variables of other types. For example:

```
     DIM logical:BOOLEAN
```

You can declare several variables in sequence by separating each variable with a comma (,):

```
DIM a,b,c: STRING
```

In addition, you can declare several different types in a single DIM statement by using a semicolon (;) to separate different types:

```
DIM a,b,c:INTEGER; n,m:decimal; x,y,z:BOOLEAN
```

In this example a, b, and c are type INTEGER, n and m are type decimal (a user-defined type), and x, y, and z are type BOOLEAN.

String variables are declared the same way, except you can specify an optional maximum string length. If a length is not explicitly given, 32 characters are assumed:

```
DIM name:STRING[40]; address,city:STRING; zip:REAL
```

In this case, name is a string variable of 40 characters maximum, address and city are string variables of 32 characters each, and zip is a real variable.

Array Declarations

Arrays can have one, two, or three dimensions. The DIM statement format is the same as for simple variables except each name is followed by a subscript(s) to indicate its size. The maximum subscript size is 2,147,483,647, although memory may limit this. You can mix simple variable and array declarations in the same DIM statement:

```
DIM a(10),b(20,30),c:INTEGER; x(5,5,5):STRING[12]
```

In this example, a is an array of 10 integers, b is a 20 by 30 table of integers, c is a simple integer variable, and x is a matrix of 12-character strings.

Arrays can be any basic or user-defined type. By declaring arrays of user-defined types, structures of arbitrary complexity and shape can be generated.

The following is an example declaration that generates a doubly-linked list of character strings. Each element of the array consists of the string containing the data and two integer pointers.

```
TYPE link_pointers = fwd,back: INTEGER
TYPE element = info: STRING[64]; ptr: link_pointers
DIM list(100): element; index: INTEGER

(* make a circular list *)
BASE0
FOR index := 0 TO 99
  list(index).info := “secret message ” + STR$(index)
  list(index).ptr.fwd := index+1
  list(index).ptr.back := index–1
NEXT index
(* fix the ends *)
list(0).ptr.back := 99
list(99).ptr.fwd := 0

(* Print the list *)
index=0
REPEAT
  PRINT list(index).info
  index := list(index).ptr.fwd
UNTIL index=0
END
```

PARAM

Declare Variables, Arrays, Etc.

Syntax

```
PARAM <var> {, <var>} : <type> {;<var> {, <var>} : <type>}
```

Function

PARAM is almost identical to the DIM statement, but it does not create variable storage. Instead, it describes what parameters the called procedure expects to receive from the calling procedure.

You must insure that the total size of each parameter conforms to the amount of storage expected for each parameter in the called procedure as specified by the PARAM statement.

BASIC checks the size of each parameter, but it *does not check the type*. You should ensure that the parameters evaluated in the RUN statement and sent to the called procedure agree exactly with the PARAM statement specification with respect to the number of parameters, their order, size, shape, and type.

Because type-checking is not performed, if you understand how the system operates, you can make the parameter passing operation perform useful but normally illegal type conversions of identically-sized data structures. For example, passing a string of 80 characters to a procedure expecting a BYTE array having 80 elements assigns the numeric value of each character in the string to the corresponding element of the byte array.

TYPE

Define Data Types

Syntax

```
TYPE <typename> = <type decl>
```

Function

TYPE defines new data types. New data types are defined as a vector (a one-dimensional array) of previously defined types. This structure differs from an array in that the various elements may be of different types, and the elements are accessed by field name instead of an array index. The syntax of the <type decl> conforms to the syntax of the DIM and PARAM statements. For example:

```
TYPE cust_recd := name,address(3):STRING; balance
```

This example creates a new data type called cust_recd which has three named fields:

- a field called name which is a string
- a field called address which is a vector of three strings
- a field called balance which is a (default) REAL value

TYPE can include previously defined types so that you can create complex structures such as lists and trees. TYPE does not create any variable storage itself; the storage is created when the newly defined type is used in a DIM statement.

The following example creates an array having 250 elements of type cust_recd. cust_recd is defined above.

```
DIM customer_file(250):cust_recd
```

To access elements of the array in assignment statements, the field name and the index are used:

```
name$ = customer_file(35).name
customer_file(N+1).address(3) = “New York, NY”
customer_file(X).balance= 125.98
```

The complex structure allows you to create appropriate data types by providing more natural organization and association of data. Additionally, the position of the desired element is known and defined at compilation time and need not be calculated at run time, unlike arrays. Therefore, they can be accessed faster than arrays.

Type Structure Size

Occasionally, you need to know the exact size of a data structure. Each basic data type is stored in a certain format:

Type:	**Memory format:**
BYTE	One Byte
INTEGER	Four Bytes
REAL	Eight Bytes
STRING	One Byte / Character
BOOLEAN	One Byte

While it would seem easy to just add the components’ sizes together to find the size of the entire structure, it is not that simple. BASIC only starts INTEGERS, REALS, and complex data structures on an even word boundary. Additionally, complex data structures are of even word length. Therefore, BASIC pads certain structures with an empty byte.

For example, the size of the following structure’s individual components add up to nine bytes:

```
TYPE junk = a : BYTE; b,c : INTEGER
```

The actual size of this structure is ten bytes. BASIC inserts a byte between a and b.

The following examples show different data structures and their corresponding size:

Structure:	Size:
TYPE demo = a : BYTE; b : REAL; c : BYTE	12
TYPE junk = d(3) : STRING [3]; e : BOOLEAN	10
TYPE crap = f : BYTE; g : demo; h : BYTE; i : junk	26

If you are ever in doubt of the size of a data structure, you can use the function: SIZE (<name>). <name> is the name of the variable, array, or structure. The size is returned as the number of bytes of the structure.

Chapter 12

Files and Unified Input/Output

Files and Unified Input/Output

Hardware input/output (I/O) devices used by OS-9 also work like files. You can generally use any I/O facility regardless of whether you are working with disk files or I/O devices (such as printers). This single interface is standard for any device. Simple communication facilities allow any device to be used with any other device. This concept is known as **unified I/O**.

Important: Unified I/O can benefit routine programming. For example, file operations can be debugged by communicating with a terminal or printer instead of a storage device, and procedures which normally communicate with a terminal can be tested with data coming from and sent to a storage device.

BASIC normally works with two types of files:

- sequential files
- random-access files

A sequential file sends or receives textual data only in the order it is received. Once you have accessed a number of bytes, you cannot (generally) start over at the beginning of a sequential file. Many I/O devices such as printers are necessarily sequential.

A sequential file contains only valid ASCII characters. The READ and WRITE commands perform format conversion similar to that done automatically in INPUT and PRINT commands. A sequential file contains record-delimiter characters (carriage return) which separate the data created by different WRITE operations. Each WRITE command sends a complete sequential-file record, which is a variable number of characters terminated by a carriage return. Each READ reads all characters up to the next carriage return.

A random-access file sends and receives data in binary form (by the PUT or GET statements) exactly as it is internally represented in BASIC. This minimizes both the time involved in converting the data to and from ASCII representation and reducing the file space required to store the data.

You can PUT and GET individual bytes or a substructure of many bytes (in a complex structure). The GET structure statement recovers the number of bytes associated with that type of structure. You can move to a particular byte in a random-access file by using SEEK to find it and using PUT or GET sequentially from that point.

In general, SEEK #path,0 is equivalent to the REWIND used in some forms of BASIC. Because the random-access file contains no record-separators to indicate the size of particular elements of the file, use the SIZE function to determine the size of a single element, then use SEEK to move to the desired element within the file.

A new file is created on a storage device by executing CREATE. Once a file exists, the OPEN command sets up a channel to the desired device and returns that path number to the BASIC program. This channel number is then used in file-access operations (READ, WRITE, GET, PUT, SEEK, etc.). When you are finished with the file, you should close it to assure that the file system has updated all data back on to magnetic media.

I/O Paths

A **path** is a description of a channel through which data flows to or from a given program or device. When a path is created, OS-9 returns a unique number to identify the path in subsequent file operations. I/O statements use this **path number** to specify the file to use.

Important: In order for data to flow to or from a device, there must be an associated OS-9 device driver. For detailed information on device drivers, consult the OS-9 Technical Manual.

Three path numbers have special meanings because they are **standard I/O paths** representing BASIC's interactive input/output. These are automatically opened for you and should not be closed except in special circumstances. The standard I/O path numbers are:

Number:	Description:
0	Standard Input (Keyboard)
1	Standard Output (Terminal Display)
2	Standard Error/Status (Terminal Display)

The following table summarizes the I/O statements within BASIC and their general use. This reflects typical use; most statements can be used with any I/O device or file. Sometimes certain statements are used in unusual ways by advanced programmers to achieve certain special effects.

Statement:	Generally used with :	Data format (file type):
INPUT	Keyboard (interactive input)	Text (Sequential)
PRINT	Terminals, Printers	Text (Sequential)
OPEN	Disk Files and I/O Devices	Any
CREATE	Disk Files and I/O Devices	Any
CLOSE	Disk Files and I/O Devices	Any
DELETE	Disk Files	Any
SEEK	Disk Files	Binary (Random)
READ	Disk Files	Text (Sequential)
WRITE	Disk Files	Text (Sequential)
GET	Disk Files and I/O Devices	Binary (Random)
PUT	Disk Files and I/O Devices	Binary (Random)

INPUT

Accept Input

Syntax

```
INPUT [#<path num>,] [“<prompt>”,] <input list>
```

Function

`INPUT` accepts input during the execution of a program. Input is normally read from the standard input device (terminal) unless an optional path number is specified. When the INPUT statement is encountered, execution is suspended and a question mark prompt (`?`) prompt is displayed.

`INPUT` is both an input and output statement. If the optional prompt string is specified, it is displayed instead of the normal `?` prompt. Therefore, if a path other than the default standard input path is used, open the path in update mode. This makes INPUT dangerous if used on disk files. Unless you like prompts in your data, use READ.

The entered data is assigned in order to the variable names as they appear in the input list. The variables can be of any basic type, and the input data must be of the same or compatible type. The line is terminated by a carriage return. There must be at least as many input items given as variables in the input list. The length of the input line cannot exceed 256 characters.

If any error occurs (type mismatch, insufficient amount of data, etc.), you must re-enter the entire input line. The following message is displayed, followed by a new prompt:

```
**INPUT ERROR – RETYPE**
```

`INPUT` uses OS-9's line input function (READLN) which performs line editing such as backspace, delete, end-of-file, etc. To perform input without editing, use the GET statement.

To test if data is available from the keyboard without hanging the program, use the INKEY function. `INKEY` returns the number of characters in the data buffer.

Examples

```
INPUT number,name$,location

INPUT #14, “What is your selection”, choice

INPUT “What’s your name? ”,name$
```

To read a single character (without editing) from the terminal

```
DIM char:STRING[1]
GET #0,char
```

PRINT

Output to Path

Syntax

```
PRINT <output list>
PRINT #<path num>, <output list>
PRINT USING <str expr>, <output list>
PRINT #<path num>, USING <str expr>, <output list>
```

Function

`PRINT` outputs the values of the items in the output list to the standard output device (path #1, the terminal) unless you specify another path number.

The output list consists of one or more items separated by a comma or semicolon delimiter. Each item can be a constant, variable, or expression of any basic type. PRINT evaluates each item and converts the result to corresponding ASCII characters which are then displayed.

If the separator character following the item is a semicolon, the next item is displayed without any intermediate spacing. If a comma is used, spaces are output so the next item starts at the next tab zone. The tab zones are 16 characters in length, starting at the beginning of the line. If the line is terminated by a semicolon, the usual carriage return following the output line is inhibited.

TAB(<expr>) can be used as an item in the output list. This function causes the next item in the output list to start in the specified column (<expr>). If the output line is already past the desired tab position, TAB is ignored.

A related function, POS, can be used in a program to determine the output position at any given time. The output columns are numbered from one to a maximum of 255. The size of BASIC's output buffer varies according to stack size at the moment.

The PRINT USING form of this statement is described at the end of this chapter.

Examples

```
PRINT value,temp+(n/2.5),location$
PRINT #printer_path,“The result is ”; n
PRINT “what is ” + name$ + “’s age? ”;
PRINT “index: ”;i;TAB(25);“value:  ”;value

(* print an 8–character line of all dashes *)
REPEAT
  PRINT “–”;
UNTIL POS >= 80
PRINT
```

OPEN

Open Path

Syntax

```
OPEN #<path num>,“<pathlist>” {: <access mode>}
```

Function

`OPEN` issues a request to OS-9 to open an I/O path to an existing file or device.

The specified path number can be a variable. If so, it must be dimensioned as type INTEGER or BYTE. It receives the path number OS-9 assigned to the path. The path number references the specific file/device in subsequent input/output statements.

The pathlist must be within quotes. A string variable is allowed. It is evaluated and passed to OS-9 as the descriptive pathlist.

`OPEN` may also specify the path’s desired access mode which can be READ, WRITE, UPDATE, EXEC, or DIR. The access mode defines which direction I/O transfers occur. If no access mode is specified, UPDATE is assumed and both reading and writing are permitted. The DIR mode allows OS-9 directory-type files to be accessed, but should *not* be used with WRITE or UPDATE modes. The EXEC mode causes the current execution directory to be used instead of the current data directory. For more information on files access modes, refer to Using Personal OS-9 or Using Professional OS-9.

Examples

```
DIM printer_path:BYTE; name:STRING[24]
name=“/p”
OPEN #printer_path,name:WRITE
PRINT #printer_path,“Mary had a little lamb”
CLOSE #printer_path

DIM inpath:INTEGER
dev$=“/winchester/”
INPUT name$
OPEN #inpath,dev$+name$:READ

OPEN #path:userdir$:READ+DIR

OPEN #path,name$:WRITE+EXEC
```

CREATE

Create a New File

Syntax

```
CREATE #<path num>,“<pathlist>” {: <access mode>}
```

Function

`CREATE` creates a new file on a multifile mass storage device such as disk or tape. If the device is not of multifile type, CREATE works like an OPEN statement.

The path number may be a variable. The variable name receives the path number OS-9 assigned. The variable must be of BYTE or INTEGER type. The pathlist must be within quotes. A string variable is allowed and is evaluated and passed to OS-9 as the descriptive pathlist.

The access mode defines the direction of subsequent I/O transfers and should be either WRITE or UPDATE. UPDATE mode allows the file to be either read or written.

OS-9 has a single file type that can be accessed either sequentially or at random. Files are byte-addressed, so no explicit record length need be given (see GET and PUT statements). When a new file is created, it has an initial length of zero. Files are expanded automatically by PRINT, WRITE, or PUT statements that write beyond the current end of file.

Examples

```
CREATE #trans,“transactions”:UPDATE

CREATE #spool,“/user4/report”:WRITE

CREATE #outpath,name$:UPDATE+EXEC
```

CLOSE

Close Path

Syntax

```
CLOSE #<path num> {,#<path num>}
```

Function

`CLOSE` notifies OS-9 that one or more I/O paths are no longer needed. The paths are specified by their number(s). If the closed path used a non-sharable device (such as a printer), the device is released and can be assigned to another user. The path must have been previously established by means of OPEN or CREATE.

ATTENTION: Paths #0, #1, and #2 should never be closed unless you immediately open a new path to take over the standard path number.

Examples

```
CLOSE #master,#trans,#new_master

CLOSE #5,#6,#9

CLOSE  #1          \(* closes standard output path *)
OPEN #path,“/T1”   \(* Permanently redirects Std Output *)

CLOSE #0            \(* closes standard input path *)
OPEN #path,“/TERM”  \(* Permanently redirects Std Input *)
```

DELETE

Delete File

Syntax

```
     DELETE <pathlist>
```

`DELETE` deletes a mass storage file. The file’s name is removed from the directory and all its storage is deallocated. Any data in the file is lost. The pathlist must be within quotes. A string variable is allowed. It is evaluated and passed to OS-9 as the descriptive pathlist.

You must have write permission for the file to be deleted. See Using Personal OS-9 or Using Professional OS-9 for more information.

Examples

```
DELETE “/D0/old_junk”

name$=“file55”
DELETE name$
DELETE “/D2/”+name$      (deletes file named “/D2/file55”)
```

SEEK

Seek to Address

Syntax

```
SEEK #<path num>,<real expr>
```

Function

SEEK changes the file pointer address of a mass storage file, which is the address of the next data byte(s) that are to be read or written. Therefore, SEEK is essential for random access of data in files using GET and PUT.

The <path num> may be an expression that specifies the path number of the file. It must evaluate to a byte value. The <real expr> specifies the desired file pointer address. It must evaluate to an INTEGER or REAL value in the range 0 <= result <= 2,147,483,647. Any fractional part of the result is truncated. Of course, the actual maximum file size depends on the capacity of the device.

Although SEEK is normally used with random-access files, you can use it to rewind sequential files. For example:

```
SEEK #path,0
```

This is the same as a rewind or restore function. This is the only form of the SEEK statement that is generally useful for files accessed by READ and WRITE. These statements use variable-length records, so it is difficult to know the address of any particular record in the file.

Examples

```
SEEK #fileone,filptr*2

SEEK #outfile,208894

SEEK #inventory,(part_num – 1) * SIZE(inv_rcd)
```

READ

Read Data

Syntax

```
READ #<path num>,<input list>
```

Function

`READ` reads input data in ASCII character format from a file or device.

The #<path num> may be an expression which specifies a path number. The path number must have been previously opened by OPEN or CREATE in READ or UPDATE access mode (except the standard input path #0). Data is read starting at the path's current file pointer address which is updated as data is read.

`READ` calls OS-9 to read a variable length ASCII record. Individual data items within the record are converted to BASIC's internal binary format. These results are assigned in order to the variables specified in the input list. The input data must match the number and type of the variables in the input list.

The individual data items in the input record are separated by ASCII null characters. Numeric items can also be delimited by commas or space characters. The input record is terminated by a carriage return character.

Important: `READ` is also used to read lists of expressions in the program. See the DATA statement section for details.

Examples

```
READ #inpath,name$,address$,city$,state$,zip

PRINT #1,“height,weight? ”

READ #0,height,weight
```

WRITE

Write Data

Syntax

```
WRITE #<path num>,<output list>
```

Function

`WRITE` writes data in ASCII character format on a file/device. The first expression specifies the number of a path that was previously opened by OPEN or CREATE in WRITE or UPDATE mode.

The output list consists of one or more expressions separated by commas. Each expression can evaluate to any expression type. The result is then converted to an ASCII character string and written on the specified path beginning at the present file pointer which is updated as data is written.

If the output list has more than one item, ASCII null characters ($00) are written between each output string. The last item is followed by a carriage return character.

Important: This statement creates variable-length ASCII records.

Examples

```
WRITE #outpath,cat,dog,mouse

WRITE #xfile,LEFT$(A$,n),count/2
```

GET/PUT

Read and Write Data Records

Syntax

```
GET #<path num>,<struct name>
PUT #<path num>,<struct name>
```

Function

GET and PUT read and write fixed-size binary data records to files or devices, respectively. These are the primary I/O statements used for random access input and output.

The path number may be an expression which is evaluated and used as the number of the I/O path. The I/O path must have been previously opened by OPEN or CREATE. Paths used by PUT statements must have been opened in WRITE or UPDATE access modes, and paths used by GET statements must be in READ or UPDATE mode.

The statement uses exactly one name which can be the name of a variable, array, or complex data structure. Data is written from, or read into, the variable or structure named. The data is transferred in BASIC's internal binary format without conversion. This affords high throughput compared to READ and WRITE statements. Data is transferred beginning at the current position of the path's file pointer which is automatically updated.

OS-9's file system does not inherently impose record structures on random-access files. All files are considered continuous sequences of addressable binary bytes. A byte or group of bytes located anywhere in the file can be read or written in any order. Therefore, you can use the basic file access system to create any desired record structure.

Record I/O in BASIC is associated with data structures defined by DIM and TYPE. GET and PUT write entire data structures or parts of data structures. PUT, for example, can write a simple variable, an entire array, or a complex data structure in one operation.

To illustrate how this works, the following example is based on a simple inventory system that requires a random access file having 100 records. Each record must include the following information: the name of the item (a 25-byte character string), the item's list price and cost (both real numbers), and the quantity on hand (an integer).

First, use TYPE to define a new data type that describes such a record:

```
TYPE inv_item=name:STRING[25];list,cost:REAL;qty:INTEGER
```

This statement describes a new record type called inv_item but does not assign variable storage for it. Next, create two data structures: an array of 100 records of type inv_item called inv_array and a single working record called work_rec:

```
DIM inv_array(100):inv_item
DIM work_rec:inv_item
```

To calculate the total size of each record, you can manually count the number of bytes assigned for each type or use the built-in SIZE function. `SIZE` returns the number of bytes assigned to any variable, array, or complex data structure. The syntax is as follows:

```
SIZE(<name>)
```

For this example, SIZE(work_rec) returns the number 46, and SIZE(inv_array) returns 4600. `SIZE` is often used with SEEK to position a file pointer to a specific record's address.

The following procedure creates a file called inventory and initializes it with zeroes and nulls:

```
PROCEDURE makefile
TYPE inv_item =
name:STRING[25];list,cost:REAL;qty:INTEGER
DIM inv_array(100):inv_item
DIM work_rec:inv_item
DIM path:byte
CREATE #path,“inventory”
work_rec.name = “”
work_rec.list := 0.
work_rec.cost := 0.
work_rec.qty := 0
FOR n = 1 TO 100
  PUT #path,work_rec
NEXT n
```

Important: The assignment statements reference each named field of work_rec by name, but PUT references the record as a whole.

The following subroutine requests a record number, then requests data and writes it in the file at the specified record:

```
INPUT “Record number ?”,recnum
INPUT “Item name? ”,work_rec.name
INPUT “List price? ”,work_rec.list
INPUT “Cost price? ”,work_rec.cost
INPUT “Quantity? ”,work_rec.qty
SEEK #path, (recnum – 1) * SIZE(work_rec)
PUT #path,work_rec
```

This routine uses a loop to read the entire file into the array inv_array:

```
SEEK #path,0 \ (* “rewind” the file *)
FOR k = 1 TO 100
  GET #path,inv_array(k)
NEXT k
```

Because entire structures can be read, you can eliminate the FOR/NEXT loop with the following:

```
SEEK #path,0
GET #path,inv_array
```

This example is simple, but it illustrates the power of BASIC09’s complex data structures and the random access I/O statements. When fully exploited, this system has the following important characteristics:

- It is self-documenting. You can clearly see what a program does because structures have descriptively named sub-structures.
- It is extremely fast.
- Programs are simplified and require fewer statements to perform I/O functions than in other BASIC languages.
- It is versatile. By creating the appropriate data structures, you can read or write almost any kind of data in any file, including files created by other programs or languages.

These advantages are possible because a single GET or PUT statement can move any amount of data, organized any way you want.

DATA/READ/RESTORE

Internal Data Statements

Syntax

```
DATA <expr> , { <expr> }
READ <input list>
RESTORE [ <line number> ]
```

Function

These statements provide an efficient way to build constant tables within a program.

- `DATA` statements provide values.
- `READ` statements assign the values to variables.
- `RESTORE` statements set which data statement is read next.

The DATA statements have one or more expressions separated by commas. They can be located anywhere in a program. The expressions are evaluated each time the data statements are read and can evaluate to any type.

The following examples demonstrate DATA:

```
DATA 1.1,1.5,9999,“CAT”,“DOG”
DATA SIN(temp/25), COS(temp*PI)
DATA TRUE,FALSE,TRUE,TRUE,FALSE
```

The READ statement has a list of one or more variable names. When executed, it reads input by evaluating the current expression in the current data statement. The result must match the variable type. When all the expressions in a DATA statement have been evaluated, the next DATA statement is used. If there are no more DATA statements following, processing wraps around to the first data statement in the program.

The RESTORE statement used without a line number causes the first DATA statement in the program to be used next. If it is used with a line number, the data statement having that line number is used next.

Example

```
   DATA 1,2,3,4

    DATA 5,6,7,8
100 DATA 9,10,11,12
    FOR N := 1 TO X
      READ ARRAY(N)
    NEXT N
    RESTORE 100
    READ A,B,C,D
```

Formatted Output: The Print Using Statement

BASIC09 has a powerful output editing capability useful for generating reports and other applications where formatted output is required. The output editing uses the PRINT USING statement:

```
PRINT [<path#>,] USING <str expr> , <output list>
```

You can use the optional path number expression to specify the path number of any output file or device. If it is omitted, the output is written to the standard output path.

The string expression is evaluated and used as a format specification. This contains specific formatting directives for each item in the output list. *Blanks are not allowed in format strings.*

The items in the output list can be constants, variables, or expressions of any type. As each output item is processed, it is matched up with a specification in the format list. The type of each expression result must be compatible with the corresponding format specification. If there are fewer format specifications than items in the output list, the format specification list is repeated again from its beginning as many times as necessary.

A format string has one or more format specifications separated by commas (,). There are two kinds of specifications:

- Those that control output editing of an item from the output list.
- Those that cause an output function by themselves (such as tabbing and spacing).

There are six basic output editing directives. Each has a corresponding one-letter identifier:

Name:	Description:
R	Real Format
E	Exponential Format
I	Integer Format
H	Hexadecimal Format
S	String Format
B	Boolean Format

The identifier letter is followed by a constant number called the field width. This number indicates the exact number of print columns the output is to occupy and must allow for the data and overhead character positions such as sign characters, decimal points, exponents, etc.

Some formats have additional mandatory or optional parameters that control subfields or select editing options. One of these options is justification to specify whether the output is to center or line up the output field on the left or right side. Fields are commonly right-justified in reports because it arranges them into columns with decimal points aligned in the same position.

The abbreviations and symbols used in the syntax specifications are:

Symbol:	**Description:**	**Syntax:**
w	Total field width	1 <= w <= 255
f	Fraction field	1 <= w <= 9
j	OPTIONAL justification	< (left) > (right) ^ (center)

Real Format

Syntax

```
Rw.fj
```

Function

Real format can be used for numbers of types REAL, INTEGER, or BYTE. The total field width specification must include two overhead positions for the sign and decimal point. The f specifies how many fractional digits to the right of the decimal point to display. If the number has more significant digits than the field allows, the undisplayed places are used to round the displayed digits. For example:

```
PRINT USING “R8.2”, 12.349 Output:      12.35
```

The justification modes are:

Mode:	Description:
<	Left justify with leading sign and trailing spaces. (default if justification mode omitted)
>	Right justify with leading spaces and sign.
^	Right justify with leading spaces and trailing sign (financial format)

Example

```
PROCEDURE printdemo
PRINT USING “R8.2<”,5678.123
PRINT USING “R8.2>”,12.3
PRINT USING “R8.2<”,–555.9
PRINT USING “10.2^”,–6722.4599
PRINT USING “R5.1”,9999999
END

RUN printdemo
 5678.12
   12.30
–555.90
  6722.46–
*****
```

Exponential Format

Syntax

```
Ew.fj
```

Function

Exponential format prints numbers of types REAL, INTEGER, or BYTE in the scientific notation format using a mantissa and decimal exponent. The syntax and behavior of this format is similar to the REAL format except the w (field width) must allow for eight overhead positions for the mantissa sign, decimal point, and exponent characters.

The justification modes are:

Mode:	Description:
<	Left justify with leading sign and trailing spaces. (This is the default if justification mode is omitted.)
>	Right justify with leading spaces and sign.

Example

```
PROCEDURE expodemo
PRINT USING “E12.3”,1234.567;
PRINT USING “E13.5>”,–0.001234;
PRINT USING “E12.2”,1234567
END

RUN expodemo
 1.235E+003  –1.23400E–003 1.23E+006
```

Integer Format

Syntax

```
Iwj
```

Function

Integer format is used to display numbers of types INTEGER or BYTE and REAL numbers that are within range for automatic type conversion. The w (field width) must allow for one position overhead for the sign.

The justification modes are:

Mode:	Description:
<	Left justify with leading sign and trailing spaces. (default if justification mode omitted)
>	Right justify with leading spaces and sign.
^	Right justify with leading spaces and trailing sign (financial format)

Example

```
PROCEDURE intdemo
PRINT USING “I4<”,10
PRINT USING “I4>”,10
PRINT USING “I4^”,10
END

RUN intdemo
 10
  10
 010
```

Hexadecimal Format

Syntax

```
Hwj
```

Function

Hexadecimal format can be used to display the internal binary representation of any data type, using hexadecimal characters. The w (field width) specifies the total field size. If the hexadecimal representation to display is shorter than the field size, it is padded with spaces according to the justification mode. If a representation of a numeric is too long, it is truncated on the left side (see the second line in the procedure and its matching output below). Representations of STRINGS that are not allowed a large enough field are truncated from the right.

The number of bytes of memory used to represent data varies according to type. The following specifications are the minimum required field widths to display the entire hexadecimal representation for each data type:

Specification:	Description:
H2	Boolean, byte (one byte)Boolean, byte (one byte)Left justify with trailing spaces (default)
H8	Integer (four bytes)
H16	Real (eight bytes)
Hn*2	String of length n

The justification modes are:

Mode:	Description:
<	Left justify with trailing spaces (default)
>	Right justify, leading spaces
^	Center justify

Examples

```
PROCEDURE hexdemo
PRINT USING “H8”,100
PRINT USING “H4”,100
PRINT USING “H16”,1.5
PRINT USING “H8,H10,H20>”,“ABC”,1,1.5
END

RUN hexdemo
00000064
0064
01C0000000000000
414243  00000001      01C0000000000000
```

String Format

Syntax

```
Swj
```

Function

String format is used to display string data of any length. The w (field width) specifies the total field size. If the string to display is shorter than the field size, it is padded with spaces according to the justification mode. If it is too long, it is truncated on the right side.

The justification modes are:

Mode:	Description:
<	Left justify (default if mode omitted)
>	Right justify
^	Center justify

Examples

```
PROCEDURE stringdemo
PRINT USING “S9<”,“HELLO”
PRINT USING “S9>”,“HELLO”
PRINT USING “S9^”,“HELLO”
END

RUN stringdemo
HELLO
    HELLO
  HELLO
```

Boolean Format

Syntax

```
Bwj
```

Function

Boolean format displays boolean data. The result of the boolean expression is converted to the strings TRUE and FALSE. The w (field width) specifies the total field size. If the string to display is shorter than the field size, it is padded with spaces according to the justification mode. If it is too long, it is truncated on the right side.

The justification modes are:

Mode:	Description:
<	Left justify (default if mode omitted)
>	Right justify
^	Center justify

Example

```
PROCEDURE booldemo
PRINT “IS 10<4 ?”
PRINT USING “B9>”, 10<4
PRINT “IS 4<10 ?”
PRINT USING “B9”, 4<10
END

RUN booldemo
IS 10<4 ?
    FALSE
IS 4<10 ?
TRUE
```

Control Specifications

Function

Control specifications are useful for horizontal formatting of the output line. They are not matched with items in the output list and can be used freely. The control formats are:

Mode:	Description:
Tn	Tab to column n
Xn	Space n columns
'str'	Print constant string. The string must not include single or double quotes, backslash or carriage return characters.

ATTENTION: Control specifications at the end of the format specification list are *not* processed if all output items have been exhausted.

Example

```
PROCEDURE demo
PRINT USING “’addr’,X2,H4,X2,’data’,X2,H2”,1000,100
END

RUN demo
addr  03E8  data  64
```

Repeat Groups

Function

Many times, identical sequences of specifications are repeated in format specification lists. The repeated groups can be enclosed in parentheses and preceded by a repeat count. These repeat groups can be nested.

Examples

`“2(X2,R10.5)”` is the same as `“X2,R10.5,X2,R10.5”`

`“2(I2,2(X1,S4))”` is the same as `“I2,X1,S4,X1,S4,I2,X1,S4,X1,S4”`

Appendix A

Sample Programs

This appendix contains 24 example procedures that can be used immediately or studied and adapted for use within user procedures. The procedures are:

Name:	Function:	Page:
Fibonacci	Computes first eleven Fibonacci numbers	A-2
Fractions	Finds rational approximations for real values	A-2
Prinbi	Prints integer value in binary	A-3
Hanoi	Moves n discs in Tower of Hanoi game	A-3
Roman	Prints integer value as a Roman numeral	A-4
Eightqueens	Finds the arrangement that eight queens may be placed on a chess board without conflict	A-5
Electric	Prints pictorial representation of the electrical field around charged points	A-6
Structst	Example of intermixed array and record structures	A-8
Wordlook	Displays word at given address by use of subroutines: Prinbyte: prints byte as binary	A-9
Qsortl	Example quicksort with use of subroutine: Exchange: exchanges values of two variables	A-10
Sortest	Procedure to test Qsortl with use of subroutine: Prin: prints an array of 1000 integers	A-11
Upadd, Upsub Uprint, Upinput Uptoreal, Ultra	Demonstrates multiple-precision arithmetic using five integers to represent a forty decimal digit number, with eight fractional places	A-12
Patch	Examines and patches any byte of a disk file using the subroutine: PrintASCII.	A-14
MakeProc	Generates an OS-9 command file to apply a command	A-16
SysCall	Subroutine to use OS-9 system calls	A-19

```
PROCEDURE fibonacci
  REM computes the first eleven Fibonacci numbers
  DIM x,y,i,temp:INTEGER

  x:=0 \y:=0
  FOR i=0 TO 10
    temp:=y

    IF i<>0 THEN
    y:=y+x
    ELSE y:=1
    ENDIF

  x:=temp
    PRINT i,y
  NEXT i

PROCEDURE fractions
  REM by T.F. Ritter
  REM finds increasingly–close rational approximations
  REM to the desired real value
  DIM m:INTEGER

  desired:=PI
  last:=0

  FOR m=1 TO 30000
    n:=INT(.5+m*desired)
    trial:=n/m
    IF ABS(trial–desired)<ABS(last–desired) THEN
      PRINT n; "/"; m; " = "; trial,
      PRINT "difference = "; trial–desired;
      PRINT
    last:=trial
    ENDIF
  NEXT m
```

```
PROCEDURE prinbi
   REM by T.F. Ritter
   REM prints the integer parameter value in binary
   PARAM n:INTEGER
   DIM i:INTEGER

   FOR i=31 TO 0 STEP –1
     IF n<0 THEN
       PRINT “1”;
     ELSE PRINT ”0”;
     ENDIF
   n:=n+n
   NEXT i
   PRINT
  END

PROCEDURE hanoi
  REM by T.F. Ritter
  REM move n discs in Tower of Hanoi game
  REM See BYTE Magazine, Oct 1980, pg. 279

  PARAM n:INTEGER; from,to_,other:STRING[8]

  IF n=1 THEN
     PRINT “move #”; n; “ from ”; from; “ to ”; to_
  ELSE
     RUN hanoi(n–1,from,other,to_)
     PRINT “move #”; n; “ from ”; from; “ to ”; to_
     RUN hanoi(n–1,other,to_,from)
   ENDIF

  END
```

```
PROCEDURE roman
  REM prints integer parameter as Roman Numeral
  PARAM x:INTEGER
  DIM value,svalu,i:INTEGER
  DIM char,subs:STRING

  char:=“MDCLXVI”
  subs:=“CCXXII ”
  DATA 1000,100,500,100,100,10,50,10,10,1,5,1,1,0

  FOR i=1 TO 7
    READ value
    READ svalu

    WHILE x>=value DO
      PRINT MID$(char,i,1);
      x:=x–value
    ENDWHILE

    IF x>=value–svalu THEN
      PRINT MID$(subs,i,1); MID$(char,i,1);
      x:=x–value+svalu
    ENDIF

  NEXT i
  END
```

```
PROCEDURE eightqueens
  REM originally by N. Wirth; here re–coded from Pascal
  REM finds the arrangements by which eight queens
  REM can be placed on a chess board without conflict
  DIM n,k,x(8):INTEGER
  DIM col(8),up(15),down(15):BOOLEAN
  BASE 0

  (* initialize empty board *)
  n:=0
  FOR k:=0 TO 7 \col(k):=TRUE \NEXT k
  FOR k:=0 TO 14 \up(k):=TRUE \down(k):=TRUE \NEXT k
  RUN generate(n,x,col,up,down)
  END

PROCEDURE generate
  PARAM n,x(8):INTEGER
  PARAM col(8),up(15),down(15):BOOLEAN
  DIM h,k:INTEGER \h:=0
  BASE 0

  REPEAT
    IF col(h) AND up(n–h+7) AND down(n+h) THEN
      (* set queen on square [n,h] *)
      x(n):=h
      col(h):=FALSE \up(n–h+7):=FALSE \down(n+h) := FALSE
      n:=n+1
      IF n=8 THEN
        (* board full; print configuration *)
        FOR k=0 TO 7
          PRINT x(k); "   ";
        NEXT k
        PRINT
      ELSE RUN generate(n,x,col,up,down)
      ENDIF

      (* remove queen from square [n,h] *)
      n:=n–1
      col(h):=TRUE \up(n–h+7):=TRUE \down(n+h):=TRUE
    ENDIF
    h:=h+1
  UNTIL h=8
  END
```

```
PROCEDURE electric
     REM re–programmed from “ELECTRIC”
     REM by Dwyer and Critchfield
     REM Basic and the Personal Computer (Addison–Wesley, 1978)
     REM provides a pictorial representation of the
     REM resultant electrical field around charged points
     DIM a(10),b(10),c(10)
     DIM x,y,i,j:INTEGER
     xscale:=50./78.
     yscale:=50./32.

     INPUT “How many charges do you have? ”,n
     PRINT “The field of view is 0–50,0–50 (x,y)”
     FOR i=1 TO n
       PRINT “type in the x and y positions of charge ”;
       PRINT i;
       INPUT a(i),b(i)
     NEXT i
     PRINT “type in the size of each charge:”
     FOR i=1 TO n
       PRINT “charge ”; i;
       INPUT c(i)
     NEXT i

     REM visit each screen position
     FOR y=32 TO 0 STEP –1
       FOR x=0 TO 78
         REM compute field strength into v
         GOSUB 10
         z:=v*50.
         REM map z to valid ASCII in b$
         GOSUB 20
         REM print char (proportional to field)
         PRINT b$;
       NEXT x
       PRINT
     NEXT y
     END
```

(continued on next page)

electric continued

```
10   v=1.
     FOR i=1 TO n
       r:=SQRT(SQ(xscale*x–a(i))+SQ(yscale*y–b(i)))
       EXITIF r=.0 THEN
         v:=99999.
       ENDEXIT
       v:=v+c(i)/r
     NEXT i
     RETURN

20   IF z<32 THEN b$:=“ ”
     ELSE
       IF z>57 THEN z:=z+8
       ENDIF
       IF z>90 THEN b$:=“*”
       ELSE
         IF z>INT(z)+.5 THEN b$:=“ ”
         ELSE b$:=CHR$(z)
           ENDIF
         ENDIF
       ENDIF
     RETURN
```

```
PROCEDURE structst

  REM example of intermixed array and record structures
  REM note that structure d contains 200 real elements

  TYPE a=one(2):REAL
  TYPE b=two(10):a
  TYPE c=three(10):b
  DIM d,e:c

  FOR i=1 TO 10
    FOR j=1 TO 10
      FOR k=1 TO 2
        PRINT d.three(i).two(j).one(k)
        d.three(i).two(j).one(k):=0.
        PRINT e.three(i).two(j).one(k)
        PRINT
      NEXT k
    NEXT j
  NEXT i

  REM this is a complete structure assignment
  e:=d

  FOR i=1 TO 10
    FOR j=1 TO 10
      FOR k=1 TO 2
        PRINT e.three(i).two(j).one(k);
      NEXT k
      PRINT
    NEXT j
  NEXT i

  END
```

```
PROCEDURE wordlook
  REM Display a word at a user specified address
  REM By Andy Nicholson

  DIM address, datum: INTEGER
  INPUT “Enter word address:  ”;address

  datum := PEEK(address)
  RUN prinbyte(datum)
  datum := PEEK(address + 1)
  RUN prinbyte(datum)
  datum := PEEK(address + 2)
  RUN prinbyte(datum)
  datum := PEEK(address + 3)
  RUN prinbyte(datum)
  END

PROCEDURE prinbyte
  REM print a byte as binary
  PARAM n: INTEGER
  DIM i: INTEGER

  n:= n*16777216
  FOR i = 7 TO 0 STEP –1
  IF n < 0 THEN
    PRINT “1”
  ELSE
    PRINT ”0”
  ENDIF
  n:= n + 1
  NEXT i

  PRINT
  END
```

```
PROCEDURE qsort1
  REM quicksort, by T.F. Ritter
  PARAM bot,top,d(1000):INTEGER
  DIM n,m:INTEGER; btemp:BOOLEAN

  n:=bot
  m:=top

  LOOP  \REM each element gets the once over
    REPEAT  \REM this is a post–inc instruction
      btemp:=d(n)<d(top)
      n:=n+1
    UNTIL NOT (btemp)
    n:=n–1 \REM point at the tested element
    EXITIF n=m THEN
    ENDEXIT

    REPEAT  \REM this is a post–dec instruction
      m:=m–1
    UNTIL d(m)<=d(top) OR m=n
    EXITIF n=m THEN
    ENDEXIT

    RUN exchange(d(m),d(n))
    n:=n+1 \REM prepare for post–inc
    EXITIF n=m THEN
    ENDEXIT

  ENDLOOP

  IF n<>top THEN
    IF d(n)<>d(top) THEN
      RUN exchange(d(n),d(top))
    ENDIF
  ENDIF

  IF bot<n–1 THEN
    RUN qsort1(bot,n–1,d)
  ENDIF

  IF n+1<top THEN
    RUN qsort1(n+1,top,d)
  ENDIF

  END
```

(continued on next page)

qsort1 continued

```
PROCEDURE exchange
  PARAM a,b:INTEGER
  DIM temp:INTEGER

  temp:=a
  a:=b
  b:=temp

  END

PROCEDURE prin
  PARAM n,m,d(1000):INTEGER
  DIM i:INTEGER

  FOR i=n TO m
    PRINT d(i);
  NEXT i
  PRINT

  END

PROCEDURE sortest
  REM This procedure is used to test Quicksort
  REM It fills the array “d” with randomly generated
  REM numbers and sorts them.
  DIM i,d(1000):INTEGER

  FOR i=1 TO 1000
    d(i):=INT(RND(100))
  NEXT i

  RUN prin(1,1000,d)

  RUN qsort1(1,1000,d)

  RUN prin(1,1000,d)

  END
```

The following procedures demonstrate multiple-precision arithmetic, in this case using five integers to represent a 40 decimal digit number, with eight fractional places.

```
PROCEDURE upadd
  REM a+b=>c:five_integer_number (T.F. Ritter)
  PARAM a(5),b(5),c(5):INTEGER
  DIM i,carry:INTEGER

  carry:=0
  FOR i=5 TO 1 STEP –1
    c(i):=a(i)+b(i)+carry
    IF c(i)>=100000000 THEN
      c(i):=c(i)–100000000
      carry:=1
    ELSE carry:=0
    ENDIF
  NEXT i

PROCEDURE upsub
  PARAM a(5),b(5),c(5):INTEGER
  DIM i,borrow:INTEGER

  borrow:=0
  FOR i=5 TO 1 STEP –1
    c(i):=a(i)–b(i)–borrow
    IF c(i)<0 THEN
      c(i):=c(i)+100000000
      borrow:=1
    ELSE borrow:=0
    ENDIF
  NEXT i

PROCEDURE uprint
  PARAM a(5):INTEGER
  DIM i:INTEGER; s:STRING

  FOR i=1 TO 5
    IF i=5 THEN PRINT “.”;
    ENDIF
    s:=STR$(a(i))
    PRINT RIGHT$(“00000000”+s,8);
  NEXT i
```

```
PROCEDURE upinput
  PARAM a(5):INTEGER
  DIM n,i:INTEGER
  DIM b$:STRING[64]

  INPUT “input ultra–precision number: ”,b$
  b$:=TRIM$(b$)
  n:=SUBSTR(“.”,b$)

  IF n<>0 THEN
    a(5):=VAL(MID$(b$+“00000000”,n+1,8))
    b$:=LEFT$(b$,n–1)
  ELSE a(5):=0
  ENDIF

  b$:=“00000000000000000000000000000000”+b$
  n:=1+LEN(b$)
  FOR i=4 TO 1 STEP –1
    n:=n–8
    a(i):=VAL(MID$(b$,n,8))
  NEXT i

PROCEDURE uptoreal
  PARAM a(5):INTEGER; b:REAL
  DIM i:INTEGER

  b:=a(1)
  FOR i=2 TO 4
    b:=b*100000000
    b:=b+a(i)
  NEXT i
  b:=b+a(5)*.00000001

PROCEDURE ultra
  DIM one(5),two(5),out(5):INTEGER; r:REAL

  RUN upinput(one)
  RUN upinput(two)
  PRINT “add”
  RUN upadd(one,two,out)
  RUN uprint(out)
  PRINT
  RUN uptoreal(out,r)
  PRINT r
  PRINT “sub”
  RUN upsub(one,two,out)
  RUN uprint(out)
  PRINT
  RUN uptoreal(out,r)
  PRINT r
```

```
PROCEDURE Patch
  (* Program to examine and patch any byte of a disk file *)
  (* Written by L. Crane *)
  DIM buffer(256):BYTE
  DIM path,offset,modloc:INTEGER; loc:REAL
  DIM rewrite:STRING
  INPUT “pathlist? ”,rewrite
  OPEN #path,rewrite:UPDATE
  LOOP
    INPUT “sector number? ”,rewrite
  EXITIF rewrite=“” THEN ENDEXIT
    loc=VAL(rewrite)*256
    SEEK #path,loc
    GET #path,buffer
    RUN DumpBuffer(loc,buffer)
    LOOP
      INPUT “change (sector offset)? ”,rewrite
    EXITIF rewrite=“” THEN
      RUN DumpBuffer(loc,buffer)
    ENDEXIT
    EXITIF rewrite=“S” OR rewrite=“s” THEN ENDEXIT
      offset=VAL(rewrite)+1
      LOOP
      EXITIF offset>256 THEN ENDEXIT
        modloc=loc+offset–1
        PRINT USING “h4,’ – ’,h2”,modloc,buffer(offset);
        INPUT ”:“,rewrite

      EXITIF rewrite=”“ THEN ENDEXIT
        IF rewrite<>” “ THEN
          buffer(offset)=VAL(rewrite)
        ENDIF
        offset=offset+1
      ENDLOOP
    ENDLOOP
    INPUT ”rewrite sector? “,rewrite
    IF LEFT$(rewrite,1)=”Y“ OR LEFT$(rewrite,1)=”y“ THEN
      SEEK #path,loc
      PUT #path,buffer
    ENDIF
  ENDLOOP
  CLOSE #path
  BYE
```

(continued on next page)

patch continued

```
PROCEDURE DumpBuffer
  (* Called by PATCH *)
  TYPE buffer=char(4):INTEGER
  PARAM loc:REAL; line(16):buffer
  DIM i,j:INTEGER
  WHILE loc>65535. DO
    loc=loc–65536.
  ENDWHILE
  FOR j=1 TO 16
    PRINT USING “h4”,FIX(INT(loc))+(j–1)*16;
    PRINT ”:“;
    FOR i=1 TO 4
      PRINT USING ”X1,H8”,line(j).char(i);
    NEXT i
    RUN printascii(line(j))
    PRINT
  NEXT j

PROCEDURE PrintASCII
  TYPE buffer=char(16):BYTE
  PARAM line:buffer
  DIM ascii:STRING; nextchar:BYTE; i:INTEGER
  ascii=“”
  FOR i=1 TO 16
    nextchar=line.char(i)
    IF nextchar>127 THEN
      nextchar=nextchar–128
    ENDIF
    IF nextchar<32 OR nextchar>125 THEN
      ascii=ascii+“ ”
    ELSE
      ascii=ascii+CHR$(nextchar)
    ENDIF
  NEXT i
  PRINT “  ”; ascii;
```

```
    PROCEDURE MakeProc
      (* Generates an OS–9 command file to apply a command *)
      (* Such as copy, del, etc., to all files in a directory *)
      (* or directory system.  Author: L. Crane *)

      DIM DirPath,ProcPath,i,j,k:INTEGER
      DIM CopyAll,CopyFile:BOOLEAN
      DIM ProcName,FileName,ReInput,ReOutput,response:STRING
      DIM SrcDir,DestDir,DirLine:STRING[80]
      DIM Function,Options:STRING[60]
      DIM ProcLine:STRING[160]

      ProcName=“CopyDir”
      Function=“Copy”
      Options=“–b=32k”

      REPEAT
        PRINT “Proc name (”; ProcName; “)”;
        INPUT response
        IF response<>“” THEN
          ProcName=TRIM$(response)
        ENDIF

        ON ERROR GOTO 100
        SHELL “del ”+ProcName

100     ON ERROR
        INPUT “Source Directory? ”,SrcDir
        SrcDir=TRIM$(SrcDir)
        ON ERROR GOTO 200
        SHELL “del procmaker...dir”

200     ON ERROR
        SHELL “dir –u ”+SrcDir+“ >procmaker...dir”
        OPEN #DirPath,“procmaker...dir”:READ
        CREATE #ProcPath,ProcName:WRITE
        PRINT “Function (”; Function; “)”;
        INPUT response

        IF response<>“” THEN
          Function=TRIM$(response)
        ENDIF
```

(continued on next page)

makeproc continued

```
INPUT “Redirect Input? ”,response

IF response=“y” OR response=“Y” THEN
     ReInput=“<” \ ELSE  \ReInput=“”
ENDIF

INPUT “Redirect Output? ”,response

IF response=“y” OR response=“Y” THEN
  ReOutput=“>” \ ELSE  \ReOutput=“”
ENDIF

PRINT “Options (”; Options; “)”;
INPUT response

IF response<>“” THEN
  Options=TRIM$(response)
ENDIF

INPUT “Destination Directory? ”,DestDir
DestDir=TRIM$(DestDir)
WRITE #ProcPath,“t”
WRITE #ProcPath,“TMode .1 –pause”
READ #DirPath,DirLine
INPUT “Use all files? ”,response
CopyAll=response=“y” OR response=“Y”

WHILE NOT(EOF(#DirPath)) DO
  READ #DirPath,DirLine
  i=LEN(TRIM$(DirLine))

  IF i>0 THEN
    j=1

    REPEAT
      k=j

      WHILE j<=i AND MID$(DirLine,j,1)<>“ ” DO
        j=j+1
      ENDWHILE

      FileName=MID$(DirLine,k,j–k)
```

(continued on next page)

makeproc continued

```
        IF NOT(CopyAll) THEN
          PRINT “Use ”; FileName;
          INPUT response
          CopyFile=response=“y” OR response=“Y”
        ENDIF

        IF CopyAll OR CopyFile THEN
          ProcLine=Function+“ ”+ReInput+SrcDir+“/”+FileName

          IF DestDir<>“” THEN
            ProcLine=ProcLine+“ ”+ReOutput+DestDir+“/”+FileName
          ENDIF

          ProcLine=ProcLine+“ ”+Options
          WRITE #ProcPath,ProcLine
        ENDIF

        WHILE j<i AND MID$(DirLine,j,1)=“ ” DO
          j=j+1
        ENDWHILE

      UNTIL j>=i
    ENDIF
  ENDWHILE

  WRITE #ProcPath,“TMode .1 pause”
  WRITE #ProcPath,“Dir e ”+SrcDir

  IF DestDir<>“” THEN
    WRITE #ProcPath,“Dir e ”+DestDir
  ENDIF

  CLOSE #DirPath
  CLOSE #ProcPath
  SHELL “del procmaker...dir”
  PRINT
  INPUT “Another ? ”,response
UNTIL response<>“Y” AND response<>“y”

IF response<>“B” AND response<>“b” THEN
  BYE
ENDIF
```

```
*!--------------------------------------------------------------!
*!   SysCall  –  a subroutine for Basic09/68000
*!
*!   Called by:  RUN SysCall(Code,Regs)
*!
*!    Code  –  An integer contained the OS9 function code
*!    Regs  –  Register pack, must be at least 48 bytes for
*!                registers D0 thru A4
*!
         use      <oskdefs.d>

*!   Definition of Parameters on Stack
         org      0
Return   do.l     1              Return Address
Length1  do.l     1              Length of first parameter
Param2   do.l     1              Address of second parameter
Length2  do.l     1              Length of second parameter

         psect
SysCall,(Sbrtn<<8)!Objct,(ReEnt<<8)!1,0,0,SysCall

SysCall  cmpi.l   #2,d0          check parameter count
         bne.s    ParamErr       branch if error
         cmpi.l   #4,Length1(a7) is first parameter integer?
         bne.s    ParamErr       branch if not
         cmpi.l   #52,Length2(a7) 48 bytes of registers?
         blo.s    ParamErr       branch if not
*!   Now put the model on the stack
         move.w   #Modllen/2,d2  number of words for dbra
         lea      Model+Modllen(pc),a0 get address of model
         bra.s    SysC02         branch into loop
SysC01   move.w   –(a0),–(a7)    move a word
SysC02   dbra     d2,SysC01      continue if not done
         move.l   d1,a0          point to function code
         move.w   2(a0),2(a7)    set function code
*!   Get the registers
         movea.l  Param2+Modllen(a7),a5 get address of parameter
         movem.l  (a5)+,d0–d7/a0–a4 get register
         jsr      (a7)           call function
         movem.l  d0–d7/a0–a4,–(a5)
         lea.l    Modllen(a7),a7 clear stack
         rts

ParamErr move.w   #E$Param,d1    get error code
         ori      #Carry,ccr     set carry
         rts

Model    os9      F$Fork         model system call to put on stack
         rts
Modllen  equ      *–Model
         ends
```

Appendix B

Quick Reference

System Mode Commands

$	BYE	CHD	CHX
DIGITS	DIR	E	EDIT
KILL	LIST	LOAD	MEM
PACK	RENAME	RUN	SAVE

Edit Mode Commands

+	–	<cr>	c
d	l	r	s
+*	–*	<line #>	c*
d*	l*	r*	s*
<space>	q		

Debug Mode Commands

$	BREAK	CONT	DEG
DIR	LET	LIST	PRINT
Q	RAD	STATE	STEP
TROFF	TRON		

Basic Reserved Words

ABS	ACS	ADDR	AND
ASC	ASN	ATN	BASE
BOOLEAN	BYE	BYTE	CHAIN
CHD	CHR$	CHX	CLOSE
COS	CREATE	DATA	DATE$
DEG	DELETE	DIM	DIGITS
DIR	DO	ELSE	END
ENDEXIT	ENDIF	ENDLOOP	ENDWHILE
EOF	ERR	ERROR	EXEC
EXITIF	EXP	FALSE	FIX
FLOAT	FOR	GET	GOSUB
GOTO	IF	INPUT	INT
INTEGER	KILL	LAND	LEFT$
LEN	LET	LNOT	LOG
LOG10	LOOP	LOR	LXOR
MID$	MOD	NEXT	NOT
ON	OPEN	OR	PARAM
PAUSE	PEEK	PI	POKE
POS	PRINT	PROCEDURE	PUT
RAD	READ	REAL	REM
REPEAT	RESTORE	RETURN	RIGHT$
RND	RUN	SEEK	SGN
SHELL	SIN	SIZE	SQ
SQR	SQRT	STEP	STOP
STR$	STRING	SUBSTR	TAB
TAN	THEN	TO	TRIM$
TROFF	TRON	TRUE	TYPE
UNTIL	UPDATE	USING	VAL
WHILE	WRITE	XOR	

Basic Statements

BASE 0	BASE 1	BYE	CHAIN
CHD	CHX	CLOSE	CREATE
DATA	DEG	DELETE	DIM
ELSE	END	ENDEXIT	ENDIF
ENDLOOP	ENDWHILE	ERROR	EXITIF/THE
N	FOR/TO/	STEP	GET
GOSUB	GOTO	IF/THEN	INPUT
KILL	LET	LOOP	NEXT
ON ERROR	GOTO	ON/GOSUB	ON/GOTO
OPEN	PARAM	PAUSE	POKE
PRINT	PUT	RAD	READ
REM	REPEAT	RESTORE	RETURN
RUN	SEEK	SHELL	STOP
TROFF	TRON	TYPE	UNTIL
WHILE/DO	WRITE		

Transcendental Functions

ACS (x)	ASN (x)	ATN (x)	COS (x)
EXP (x)	LOG (x)	LOG10 (x)	PI
SIN (x)	TAN (x)		

Numeric Functions

ABS (x)	FIX (x)	FLOAT (m)	INT (x)
LAND (m,n)	LNOT (m,n)	LOR (m,n)	LXOR (m,n)
MOD (m,n)	RND (x)	SGN (x)	SQ (x)
SQR (x)	SQRT (x)		

String Functions

ASC (char$)	CHR$ (m)	DATE$	LEFT$
(str$,m)			
LEN (str$)	MID$ (str$,m,n)	RIGHT$ (str$,m)	STR$ (x)
SUBSTR(st1$,st2$)	TRIM$ (str$)	VAL(str$)	

Miscellaneous Functions

ADDR (var)	EOF (#path)	ERR	FALSE
FILSIZ(#<path>)	INKEY(#<path>)	PEEK (addr)	POS
SIZE (var)	TAB (m)	TRUE	

Operator Precedence

highest	NOT	–(neg)
	^	**
	*	/
	+	–
	> < <> = >= <=	
	AND	
lowest	OR	XOR

Notes

Basic Error Codes

10 – Unrecognized Symbol
11 – Excessive Verbage (too many keywords or symbols)
12 – Illegal Statement Construction
13 – I-code Overflow (need more workspace memory)
14 – Illegal Channel Reference (bad path number given)
15 – Illegal Mode (Read/Write/Update/Dir only)
16 – Illegal Number
17 – Illegal Prefix
18 – Illegal Operand
19 – Illegal Operator

20 – Illegal Record Field Name
21 – Illegal Dimension
22 – Illegal Literal
23 – Illegal Relational
24 – Illegal Type Suffix
25 – Too-Large Dimension
26 – Too-Large Line Number
27 – Missing Assignment Statement
28 – Missing Path Number
29 – Missing Comma

30 – Missing Dimension
31 – Missing DO Statement
32 – Memory Full (need more workspace memory)
33 – Missing GOTO
34 – Missing Left Parenthesis
35 – Missing Line Reference
36 – Missing Operand
37 – Missing Right Parenthesis
38 – Missing THEN statement
39 – Missing TO

40 – Missing Variable Reference
41 – No Ending Quote
42 – Too Many Subscripts
43 – Unknown Procedure
44 – Multiply-Defined Procedure
45 – Divide by Zero
46 – Operand Type Mismatch
47 – String Stack Overflow
48 – Unimplemented Routine
49 – Undefined Variable

50 – Floating Overflow
51 – Line with Compiler Error
52 – Value out of Range for Destination
53 – Subroutine Stack Overflow
54 – Subroutine Stack Underflow
55 – Subscript out of Range
56 – Parameter Error
57 – System Stack Overflow
58 – I/O Type Mismatch
59 – I/O Numeric Input Format Bad

60 – I/O Conversion: Number out of Range
61 – Illegal Input Format
62 – I/O Format Repeat Error
63 – I/O Format Syntax Error
64 – Illegal Path Number
65 – Wrong Number of Subscripts
66 – Non-Record-Type Operand
67 – Illegal Argument
68 – Illegal Control Structure
69 – Unmatched Control Structure

70 – Illegal FOR Variable
71 – Illegal Expression Type
72 – Illegal Declarative Statement
73 – Array Size Overflow
74 – Undefined Line Number
75 – Multiply-Defined Line Number
76 – Multiply-Defined Variable
77 – Illegal Input Variable
78 – Seek Out of Range
79 – Missing Data Statement
80 – Print Buffer Overflow

Error codes above 80 are those used by OS-9 or other external programs. Consult Using Personal OS-9 or Using Professional OS-9 for a list of error codes and explanations.

Notes

RUNB

Runb is the BASIC run-time package. It is similar to BASIC with the following exceptions: Runb is about half the size of BASIC and no file editing or debugging can be done. The main purpose of Runb is to save space and to execute packed modules. It should be noted that Runb only executes packed modules. Another feature of Runb is that **`[Ctrl-C]`** and **`[Ctrl-E]`** can be trapped by ON ERROR GOTO where BASIC cannot.

When the name of a packed module is typed at the OS-9 prompt, the shell determines that the module is packed BASIC I-code. The shell then loads and forks Runb, and Runb links to and executes the named program. To run packed modules in this way, Runb must be in the commands directory.

Important: Packed modules can be executed without Runb if they are still within the workspace, but BASIC will have to be used and more space will be required.

Notes

Index

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