VAX PL/I Reference Manual

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This manual defines the VAX PL/I programming language, including the keywords and the semantic and syntax rules of PL/I statements, attributes, built-in functions, and other language elements.

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Preface

Acknowledgment

The VAX PL/I programming language is an implementation of the PL/I General-Purpose Subset, ANSI X3.74-1981.

How to Use This Manual

This manual provides VAX PL/I language reference information. The first part of the manual consists of chapters on VAX PL/I language concepts. The second part is an encyclopedia of VAX PL/I; it is arranged by topical entry in alphabetic order. (You can use the running feet on the bottoms of the pages to find an entry, as with a dictionary, without resorting to the Table of Contents, when you are familiar with the entries.) You can find the entry for each specific language element by looking up the keyword (in all-capital letters) for that element (for example, VALUE Built-In Function, SELECT Statement, REFER Option, and ENTRY Attribute). In addition, there are entries for general topics. The general topics fall into the following approximate categories:

- Arithmetic, relational, and logical operations (for example, Addition, Exponentiation, and Precedence)
- I/O and other tasks (for example, Terminal Input and Output, List Processing, and String Handling)
- Data and data types (for example, Bit-String Data, Conversion of Data, and Entry Data)
- Language elements (for example, Argument, Controlled Variable, Keyword, Logical Operator, and Subroutine)
- Miscellaneous topics (for example, File Organization, Program Structure, and User-Generated Diagnostic Messages)

Each entry has cross-references to any related entries.

Who Can Use This Manual

This manual is intended for use by all programmers who are designing or implementing applications using VAX PL/I. They should already understand the concepts of programming in PL/I and be familiar with the keywords and topics that will be searched for information. This manual is not, therefore, suitable for use as a strictly tutorial document.

■ Where to Find More Information

The companion document to this manual is the *VAX PL/I User Manual.* The first part of the user manual contains an overview of the PL/I language and its implementation for the VAX computer, and is recommended for all programmers who are not familiar with PL/I or who need information on the extensions made to PL/I for the VAX computer. The *VAX PL/I User Manual* gives information on program development with the VMS command language, the extensive I/O capabilities provided in VAX PL/I, and programming techniques available to PL/I programs executing under the exclusive control of the VMS operating system.

■ Conventions Used in This Document

RET	A symbol with a 1- to 3-character abbreviation indicates that you press a key on the terminal, for example, RET or ESC .
CTRL/x	The symbol CTRL/x indicates that you press the key "x" while holding down the key labeled CTRL, for example, CTRL/C.
Enter string> Abcd RET	In computer dialogues, the user's response to a prompt is printed in red ink.
DECLARE X FIXED; . . . X = 5 ;	Vertical ellipses indicate that not all of the text of a program or program output is illustrated. Only relevant material is shown in the example.
option, . . .	Horizontal ellipses indicate that additional parameters, options, or values can optionally be entered. When a comma precedes an ellipsis, it indicates that successive items must be separated by commas.
quotation mark apostrophe	The term quotation mark is used only to refer to the double quotation mark character (″). The term apostrophe is used to refer to the single quotation mark character (′).
[OPTIONS (option, . . .)]	Except in VMS file specifications, square brackets indicate that a syntactic element is optional and you need not specify it.

[LIST] [EDIT]	Brackets surrounding two or more stacked items indicate conflicting options, one of which *can* optionally be chosen.
{ EXTERNAL } { INTERNAL }	Braces surrounding two or more stacked items indicate conflicting options, one of which *must* be chosen.
FILE (file-reference)	An uppercase word or phrase indicates a keyword that must be entered as shown; a lowercase word or phrase indicates an item for which a variable value must be supplied. This convention applies to format (syntax) lines, not to code examples.
Δ	A delta symbol is used in some contexts to indicate a single ASCII space character.

■ Technical Assumptions

All descriptions of the effects of executing statements and evaluating expressions assume that the initial procedure activation of the program is through an entry point with OPTIONS(MAIN).

It is further assumed that any non-PL/I procedures called by the program follow all conventions of the PL/I run-time environment. Except as explicitly noted, descriptions of I/O statements do not cover the effects of VAX-specific options. For details on mixed-language programming and VAX-specific options, **see** the *VAX PL/I User Manual*.

■ Technical Changes

Technical changes made since VAX PL/I Version 2.0 are summarized below. Specific information on each new feature is found in the individual entries in this manual.

- New attributes:
  - CONDITION defines an identifier as a condition name.
  - DESCRIPTOR (VAX PL/I specific) requests that an argument be passed to an external non-PL/I procedure by descriptor.
  - DIMENSION indicates that a variable is an array and defines the number and extent of its dimensions.
  - LIST (VAX PL/I specific) specifies that a parameter can accept a list of actual parameters, of arbitrary length.
  - MEMBER specifies that an item is a member of a structure.

- NONVARYING specifies that the length of a string is nonvarying.
- OPTIONAL (VAX PL/I specific) specifies in the declaration of a formal parameter that the actual parameter need not be specified in a call.
- PARAMETER indicates that a variable will be assigned a value when it is used as an argument to a procedure.
- PRECISION specifies the number of digits in an arithmetic variable and, with fixed-point data, the number of fractional digits.
- REFERENCE (VAX PL/I specific) requests that an argument be passed to an external non-PL/I procedure by reference.
- STRUCTURE specifies that a variable is a structure variable.
- TRUNCATE (VAX PL/I specific) specifies, in the declaration of a formal parameter, that the actual parameter list can be truncated at the point where this argument should occur.
- UNALIGNED specifies nonalignment for a bit-string variable in storage.

• New built-in functions:
  - ACTUALCOUNT returns the number of parameters a procedure was called with.
  - DATETIME returns the system date and time in the form CCYYMMDDHHMMSSXX.
  - DECODE converts a character string to an integer in a specified radix.
  - EMPTY returns an empty area value for use in initializing areas.
  - ENCODE converts an integer to a character string that represents the integer's value in a specified radix.
  - EVERY returns the result of a logical AND operation on the bits in a bit string ('1'B if all bits are '1'B).
  - MAXLENGTH returns the maximum possible length of a varying character string.
  - ONCHAR returns the character that caused a CONVERSION condition to be raised. (ONCHAR is also a pseudovariable.)
  - ONSOURCE returns the file containing the ONCHAR character that caused a CONVERSION condition to be raised. (ONSOURCE, like ONCHAR, is also a pseudovariable.)
  - PRESENT returns '1'B if the parameter in question was specified in a call.

  - PROD returns the arithmetic product of all the elements in an array.
  - REFERENCE forces its argument to be passed by reference to a non-PL/I procedure.
  - REVERSE reverses the characters or bits in a string.
  - SOME returns the result of a logical OR operation on the bits in a bit string ('1'B if one or more of the bits are '1'B).
  - SUBTRACT returns the value of $x - y$, with the specified precision and scale factor.
  - SUM returns the arithmetic sum of all the elements in an array.
  - VALUE forces a parameter to be passed by value.
- Enhanced built-in functions:
  - DESCRIPTOR now overrides a parameter declaration.
  - INDEX, SEARCH, and VERIFY have a new optional parameter specifying the starting position in a string.
  - HBOUND, LBOUND, and DIMENSION can now be specified with only the array parameter; and if they are so specified, the dimension parameter defaults to 1.
- New built-in subroutines:
  - FREE unlocks all the locked records in a file.
  - RELEASE unlocks a specified record in a file.
- New conditions:
  - AREA responds to an error detected during an operation on an area.
  - CONDITION responds to programmer-defined conditions.
  - CONVERSION responds to a data conversion error from CHARACTER to an arithmetic data type or bit string.
  - STORAGE responds to an error raised by LIB$GET_VM (most commonly occurring when virtual memory is exhausted).
  - STRINGRANGE responds to a substring reference beyond the length of the string.
  - SUBSCRIPTRANGE responds to array references with out-of-bound subscripts.

- New operators:
  - AND THEN (&:) performs a Boolean truth operation similar to AND (&) except that the second operand is evaluated if and only if the first operand, which is always evaluated first, is true ('1'B); also unlike AND, the AND THEN operator does not do a bit-by-bit operation when the two operands are bit strings.
  - EXCLUSIVE OR (dyadic or infix ^) performs a bit-by-bit EXCLUSIVE OR operation on two bit strings, or a Boolean EXCLUSIVE OR truth operation on expressions in an IF statement.
  - OR ELSE (|:) performs a Boolean truth operation similar to OR (|) except that the second operand is evaluated if and only if the first operand, which is always evaluated first, is false ('0'B); also unlike OR, the OR ELSE operator does not do a bit-by-bit operation when the two operands are bit strings.
- Enhanced statement:

  SELECT now has a second form that extends its usefulness: the SELECT (expression) form.
- Miscellaneous:
  - A comma list is now allowed on the left-hand side of an assignment statement, with the ALLOCATE and FREE statements, with the OPEN and CLOSE statements, and with the ON and REVERT statements.
  - The ANY CHARACTER(*) attribute (VAX PL/I specific) indicates that a parameter can take either a character descriptor or a character varying descriptor.
  - The /G_FLOAT qualifier is no longer required for using H-floating numbers.
  - The %GOTO preprocessor statement now allows movement either forward or backward in a program's text.
  - The ALLOCATE and FREE statments have a new IN option that takes a reference to an area, and language-supported storage allocation in areas is available.
  - The ENTRY and PROCEDURE statements have a new NONRECURSIVE option to indicate (for program documentation purposes) that the procedure will not invoke itself.
  - The ON statement has two new options, SNAP and SYSTEM, which invoke the debugger and invoke system handling of a condition, respectively.
  - The UNION attribute is now propagated across LIKE declarations.

- There is now debugger support for %REPLACE constants.
- %REPLACE constants can now be used in preprocessor expressions.
- The maximum line size after preprocessor text expansion has been increased from 255 to 32500 characters.
- Optimization has been improved.
- The LIKE attribute can reference a structure containing LIKE.
- An array can have an asterisk (*) as an intialization iteration factor; for example, DECLARE A(n) ((*)10) initializes all elements of the array A with the value 10.
- The %INCLUDE statement syntax has been extended to allow a library name in addition to the module name.
- Descending keys are now allowed in indexed files.
- The MATCH_NEXT keyword is now a synonym for MATCH_GREATER, and MATCH_NEXT_EQUAL is a synonym for MATCH_GREATER_EQUAL.

The following technical changes are documented in the *VAX PL/I User Manual*.

- Record-locking options
- USER_OPEN ENVIRONMENT option
- Miscellaneous ENVIRONMENT options (REVISION_DATE, BACKUP_DATE, and OWNER_ID)
- Additional fields returned by the DISPLAY built-in subroutine
- Support for the VAX Source Code Analyzer (SCA)
- Additional definitions for the VMS Run-Time Library and utility routines in the system interface library PLI$STARLET (not explicitly described in the VAX PL/I documentation)

Chapter 1

Program Structure and Content

This chapter introduces the following elements of a PL/I program:

- The blocks that make up a program and their effect during program execution
- The statements that make up a block and the general format and elements of a PL/I statement
- The PL/I data types
- The text of a PL/I program

Subsequent chapters discuss these topics in more detail. Complete reference information on these topics is given in alphabetic entries in the encyclopedia section of this manual.

1.1 Blocks

PL/I is a block-structured language: statements are grouped into blocks. When control passes to a block, a block activation is created. A block activation consists of the allocation of storage for some of the variables declared within that block and information that connects that block to the previous block.

There are two types of blocks: procedure blocks (usually called *procedures*) and begin blocks. A procedure executes only as the result of a specific request from another procedure or, in the case of the main procedure, as the result of a RUN command. A begin block is always contained within a procedure, and executes when control flows into it.

1.1.1 Begin Blocks

A begin block is a sequence of statements headed by a BEGIN statement and terminated by an END statement. In general, you can use a begin block wherever a single PL/I statement would be valid. In some contexts, such as an ON-unit, a begin block is the only way to perform several statements instead of one. A primary use of begin blocks is to localize variables. Because execution of a begin block causes a block activation, automatic variables declared within the begin block are local to it, and their storage disappears when the block completes execution.

Another way to allow your program to perform several statements in place of one is to use a DO-group (**see** Chapter 7 and the alphabetic entry "DO-Group"). You should choose it when possible because it does not incur the overhead associated with block activation. Use a begin block when there are declarations present or you require multiple statements in an ON-unit.

1.1.2 Procedures

A procedure is a sequence of statements (perhaps including begin blocks and other procedures) headed by a PROCEDURE statement and terminated by an END statement. Unlike a begin block, which executes when control reaches it, a procedure executes only when it is specifically invoked. Invocation occurs in two ways:

- The DCL command RUN invokes the main procedure of a PL/I program. This is either the procedure that has OPTIONS (MAIN) on its PROCEDURE statement or the first procedure encountered by the linker.
- Statements within a procedure can invoke other procedures. The CALL statement invokes a procedure as a subroutine. A function reference invokes a function, which is a procedure that returns a value for use in the evaluation of an expression.

A PL/I program must have at least one procedure, the main procedure. Any procedure, including the main procedure, can contain others; these are called internal procedures. A procedure that is not contained within any other is called an external procedure. The main procedure is therefore always an external procedure.

Except for the main procedure, no procedure executes unless it is invoked by a CALL statement or a function reference.

1.2 Statements

A statement is the basic element of a PL/I procedure. Statements are used to do the following:

- Define and identify the structure of the program and the data that it acts upon (possibly including text from other files (**see** "%INCLUDE Statement")
- Request specific actions to be performed on data
- Control the flow of execution in a program

The general format of a PL/I statement consists of an optional statement label, the body of the statement, and a required terminator, the semicolon (;).

In the encyclopedic section of this manual, each PL/I statement is described in the alphabetic entry under the statement's name (such as "DECLARE Statement"). For an alphabetic summary of all the VAX PL/I statements, **see** Table S–2, under the entry "Statement."

1.2.1 Statement Labels

A statement label is optional. Its purpose is to identify a statement so that the statement can be referred to elsewhere in the program, for example, as the target of a GOTO statement. A label precedes its statement; it consists of any valid identifier (**see** Section 1.2.3) terminated by a colon. For example:

```
TARGET: A=A+B;
READ_LOOP: READ FILE (TEXT) INTO (TEMP);
```

No statement can have more than one label.

1.2.2 Keywords

A keyword is a name that has a special meaning to PL/I when used in a specific context. In context, keywords identify statements, attributes, options, and other program elements. PL/I keywords are not reserved words, so it is possible to use them in a program in other than their keyword context.

PL/I has numerous keywords. A complete table of the VAX PL/I keywords is in Appendix A, including brief identifications of their uses and valid abbreviations for the keywords that can be abbreviated.

You can find many of the alphabetic entries in this manual under their keywords (for example, "DECLARE Statement" and "AUTOMATIC Attribute").

1.2.3 Punctuation

PL/I recognizes punctuation marks in statements. The punctuation marks serve the following two functions:

- They specify arithmetic or other operations to be performed on expressions.
- They delimit and separate identifiers, keywords, and constants.

For example:

```
A = B + C;
```

In this statement, the equal sign (=), the addition operator (+), and the semicolon (;) delimit the identifiers A, B, and C, as well as define the operation to be performed. (Chapter 5 describes the effect of the various operators in expressions.)

Whenever you use a punctuation mark in a PL/I statement, you can precede or follow the character with any number of spaces (except in the case of an operator consisting of two characters, like > = or **, which must be entered without a space between the two characters). For example, the following two statements are equivalent:

```
DECLARE ( A, B ) FIXED DECIMAL ( 7, 0 ) ;
DECLARE(A,B)FIXED DECIMAL(7,0);
```

In the second statement, all nonessential spaces are omitted; the parentheses and commas are sufficient to distinguish elements in the statement. The only space required in this statement is the space that separates the two keywords FIXED and DECIMAL.

For a table of all the punctuation marks recognized by VAX PL/I, **see** Table P–3, under the entry "Punctuation."

In addition to punctuation marks and spaces, PL/I accepts tabs and line-end characters between identifiers, constants, and keywords.

The line-end character is a valid punctuation mark between items in a PL/I statement except when it is embedded in a string constant, where it is ignored. For example:

```
A = 'THIS IS A VERY LONG STRING THAT MUST BE CONTI
NUED ON MORE THAN ONE LINE IN THE SOURCE FILE' ;
```

This assignment statement gives the variable A the value of the specified character-string constant, ignoring the line-end character. Note, however, that any tabs or spaces preceding "NUED" in the example above would be included in the string.

1.2.4 Identifiers

An identifier is a user-supplied name for a procedure, a statement label, or a variable that represents a data item. The rules for forming identifiers are as follows:

- An identifier can have from 1 to 31 characters.
- An identifier can consist of any of the following characters:
  - The alphabetic letters A through Z and a through z. PL/I converts all lowercase letters to uppercase when it compiles a source program. Thus, the identifiers abc, ABC, Abc, and so on, all refer to the same object.
  - The numeric digits 0 through 9.
  - The underscore character (_).
  - The dollar sign character ($).
- An identifier cannot contain any blanks.
- An identifier must begin with an alphabetic letter, a dollar sign ($), or an underscore (_). It cannot begin with a numeral.

Some examples of valid identifiers are as follows:

```
STATE
total
FICA_PAID_YEAR_TO_DATE
ROUND1
SS$_UNWIND
```

1.3 Data and Variables

The statements in a PL/I program process data, generally in the form of variables that take on different values as the result of program execution. In VAX PL/I, you usually must declare variables in a DECLARE statement before you can use them in other statements. Declaring a variable associates an identifier with a set of attributes and with a region of storage. Thus, when you declare a variable you must usually specify one or more data type attributes to be associated with it. (The concept of attribute is more basic to PL/I than the concept of data type.) Furthermore, you can specify how the variable is to be allocated by supplying a storage class attribute in the declaration.

A few examples of PL/I attributes are BIT, CHARACTER, BINARY, DECIMAL, FILE, FLOAT, PRINT, UPDATE, and VALUE. For a complete alphabetic list of the VAX PL/I attributes with their uses, **see** Table A–1 under the entry "Attribute."

An identifier can refer to a single variable (called a scalar variable) or to a collection of related variables. Such a collection is called an aggregate. There are two kinds of aggregate: the array, in which all members have the same data type and are referenced by relative position; and the structure, in which the members can have different data types and are referenced in a hierarchical fashion.

The following chapters provide information on these topics:

- Chapter 2 describes the data types that you can specify for variables.
- Chapter 3 describes aggregates.
- Chapter 4 describes the DECLARE statement and the scope of a declaration.

1.4 Program Text

The text of a PL/I program consists of PL/I statements and comments. This section discusses the format of program text and gives rules for comments.

1.4.1 Program Format

The source text of a PL/I program is freeform. As long as you terminate every statement with a semicolon (;), individual statements can begin in any column, be on additional lines, or be written with more than one statement to a line.

Individual keywords or identifiers of a statement, however, must be confined to one line. Only a character-string constant (which must be enclosed in apostrophes) can be on more than one line.

PL/I programs are easier to read and to comprehend if you follow a standard pattern in formatting. For example:

- Write source statements with no more than one statement per line.
- Use indention to show the nesting level of blocks and DO-groups.

1.4.2 Comments

A comment is an informational tool for documenting a PL/I program. To insert a comment in a program, enclose it within the character pairs /* and */. For example:

```
/* This is a comment.... */
```

Wherever the starting characters (/*) appear in a program, the compiler ignores all text until it encounters the ending characters (*/). Thus, a comment can span several lines.

The rules for entering comments are as follows:

- A comment can appear anywhere that a space can appear:
  - Between any identifiers, keywords, or constants
  - Preceding or following punctuation marks that normally serve as delimiters, for example, spaces, tabs, or commas

- A comment can contain any character except the pair */; comments cannot be nested.

Following are some examples of comments:

```
A = B + C ;              /* Add B and C */

/* *********  START OF SECOND PHASE ********* */

DECLARE/*COUNTER*/A FIXED BINARY (7);

/* This module performs the following steps:
   1. Initializes all arrays and data structures.
   2. Establishes default condition handlers.
*/
```

Although complete comments cannot be nested, you can "comment out" a statement such as the following:

```
DECLARE EOF BIT(1); /* end-of-file */
```

To do this, precede the DECLARE with another /* pair, as follows:

```
/* DECLARE EOF BIT(1); /* end-of-file */
```

The compiler will then ignore all text, including the DECLARE statement and the second /*, until it reaches the */.

Chapter 2

Data Types

This chapter includes the following topics:

- A brief summary of the data types
- Arithmetic data types, which are used to represent numeric values
- Character-string data, which consists of sequences of ASCII characters
- Bit-string data, which consists of sequences of binary digits (bits)

2.1 Summary of Data Types

VAX PL/I supports the following computational data types:

- The arithmetic data types define values that can be used in arithmetic computation. They are as follows:
  - Fixed-point (binary and decimal integers and fractions)
  - Floating-point (binary and decimal)
  - Pictured (fixed-point data stored in character form)
- Character-string data consists of a sequence of ASCII characters.
- Bit-string data consists of sequences of binary digits.

The data types listed below represent noncomputational program values that are used within a PL/I program for control. They are described in subsequent chapters and defined completely in alphabetic entries in the encyclopedic section of this manual.

- Entry constants and variables are used to invoke procedures through specified entry points.

- Label variables and constants provide you with a flexible means of control within a program.
- File variables and constants provide access to files.
- Pointers represent the location in memory of data, and are used to access based variables in areas and data in system-allocated buffers.
- Areas are regions of storage in which based variables can be allocated and freed. Offsets represent the location of a based variable in an area.

2.2 Arithmetic Data Types

Arithmetic data types are used for variables on which arithmetic calculations are to be performed. The arithmetic data types supported by VAX PL/I are as follows:

- Fixed-point—for binary and decimal data with a fixed number of fractional digits
- Floating-point—for calculations on very large or very small numbers, with the decimal point (number of fractional digits) allowed to "float"
- Pictured—for fixed-point decimal data that is stored internally in character form, with special formatting characters

When you declare an arithmetic variable, you do not always have to define all its characteristics, or attributes; the PL/I compiler makes assumptions about attributes that are not explicitly defined. For example:

```
DECLARE NUMBER FIXED;
```

The FIXED attribute implies the attributes BINARY(31,0). Thus, the variable NUMBER has the attributes FIXED BINARY(31,0).

For a table giving the implied attributes for computational data, **see** Table D–1 under the entry "Data and Data Types."

2.2.1 Fixed-Point Binary Data

The attributes FIXED and BINARY are used to declare integer variables and fractional variables in which the number of fractional digits is fixed (that is, non-floating-point numbers). The BINARY attribute is implied by FIXED.

For example, a fixed-point binary variable could be declared as follows:

```
DECLARE X FIXED BINARY(31,0);
```

The variable X is given the attributes FIXED, BINARY, and (31,0) in this declaration. The precision is 31. The scale factor is 0, so the number is an integer.

There is no representation in VAX PL/I for a fixed-point binary constant. Instead, integer constants are represented as fixed decimal. However, fixed decimal integer constants (and variables) are converted to fixed binary when combined with fixed binary variables in expressions. For example:

```
I = I+3;
```

In this example, if I is a fixed binary variable, the integer 3 is represented as fixed decimal, but PL/I converts it to fixed binary when evaluating the expression.

Fixed binary variables have a maximum precision of 31, and therefore fixed binary integers can have values only in the range –2,147,483,648 through 2,147,483,647. An attempt to calculate a binary integer outside this range, in a context that requires an integer value, signals the FIXEDOVERFLOW condition.

2.2.2 Fixed-Point Decimal Data

Fixed-point decimal data is used in calculations where exact decimal values must be maintained, for example, in financial applications. Fixed-point decimal data with a scale factor of zero can also be used whenever integer data is required.

The following sections describe fixed-point constants and variables and their use in expressions.

2.2.2.1 Fixed-Point Decimal Constants

A fixed-point decimal constant can have between 1 and 31 of the decimal digits 0 through 9 with an optional decimal point or sign, or both. If there is no decimal point, PL/I assumes it to be immediately to the right of the rightmost digit. Some examples of fixed-point decimal constants are as follows:

```
12
4.56
12345.54
-2
.0004
01.
```

The precision of a fixed-point decimal value is the total number of digits in the value. The scale factor is the number of digits to the right of the decimal point, if any. The scale factor cannot be greater than the precision.

2.2.2.2 Fixed-Point Decimal Variables

The attributes FIXED and DECIMAL are used to declare fixed-point decimal variables. The FIXED attribute is implied by DECIMAL.

If you do not specify the precision and the scale factor, the default values are 10 and 0, respectively.

Following are two examples of fixed-point decimal declarations:

```
DECLARE PERCENTAGE FIXED DECIMAL (5,2);
DECLARE TONNAGE FIXED DECIMAL (9);
```

2.2.2.3 Using Fixed-Point Data in Expressions

You cannot use fixed-point decimal data with a nonzero scale factor in calculations with binary integer variables. If you must combine the two types of data, use the DECIMAL built-in function (described in the entry "DECIMAL Built-In Function") to convert the binary value to a scaled decimal value before attempting an arithmetic operation. For example:

```
DECLARE I FIXED BINARY,
   SUM FIXED DECIMAL (10,2);

SUM = SUM + DECIMAL (I);
```

2.2.3 Floating-Point Data

The floating-point data types provide a way to express very large and very small numbers, for example, in scientific calculations. All floating-point calculations are performed on values in one of the VAX binary floating-point formats. In general, the precision of the result is determined by the maximum precision of any operands in the operation. The numerical result of an operation is rounded to the result precision; therefore, the results of most operations are approximate.

The following sections describe floating-point constants and variables and their use in expressions.

2.2.3.1 Floating-Point Constants

A floating-point constant can have one or more of the decimal digits 0 through 9 (with an optional decimal point), followed by the letter E and from one to five decimal digits representing a power of 10. The floating-point value and the integer exponent can both be signed. The first portion of the value, to the left of the letter E, is called the mantissa. The value to the right of the letter E is called the exponent.

Some examples of floating-point constants are as follows:

```
2E10
-3E8
32E-8
.45632E16
```

The decimal precision of each of these values is the number of digits in the mantissa.

If you write a constant without the E and the exponent, it is considered to be fixed-point decimal. However, you can use such constants anywhere in expressions involving floating-point data.

2.2.3.2 Floating-Point Variables

The keyword FLOAT identifies a floating-point variable in a declaration.

A floating-point value can be either binary or decimal. Because the internal representation of floating-point variables is binary, it is recommended that you use FLOAT BINARY (which is the default) to declare variables, unless you need the properties of FLOAT DECIMAL. (Note that the difference between FLOAT BINARY and FLOAT DECIMAL appears only when a conversion to another type, such as character for doing I/O, is necessary.) In any event, you should declare all floating-point variables using the same base.

You can optionally specify the precision for a floating-point variable in the declaration. For example:

```
DECLARE X FLOAT BINARY(53);
```

2.2.3.3 Using Floating-Point Data in Expressions

You can use both integer and scaled decimal constants in floating-point expressions. An arithmetic constant is always converted to the appropriate internal representation for use in a floating-point operation. The target type for the conversion depends on the context. For example:

```
DECLARE X FLOAT BINARY (53);
X = X + 1.3;
```

Here, the constant 1.3 is converted to floating point when the expression is evaluated.

2.2.3.4 Floating-Point Data Formats

VAX PL/I supports four types of floating-point values: F, D, G, and H. The approximate ranges of the VAX floating-point formats are as follows:

Format	Range
F	$0.29 * 10^{-38}$ to $1.7 * 10^{38}$
D	Same as F but with more precise mantissa
G	$0.56 * 10^{-308}$ to $0.9 * 10^{308}$
H	$0.84 * 10^{-4932}$ to $0.59 * 10^{4932}$

For a table summarizing the range of precision for each floating-point type, **see** Table F–3, under the entry "Floating-Point Data." For a table

showing how the PL/I compiler selects a floating-point type, **see** Table F–4, under the same entry.

2.2.4 Pictured Data

Use pictured data when you want to manipulate a quantity arithmetically and accept or display its value using a special format. Pictured variables are especially useful in applications that require values to be shown with special symbols, such as commas, dollar signs, or debit indicators (DB).

This section discusses the following topics:

- Pictured variables—variables declared with the PICTURE data attribute
- Assigning values to pictured data—the process by which a value is assigned to a pictured variable or written out with the P format item
- Extracting values from pictured data—the process by which a pictured value is assigned to other variables or acquired with the P format item
- Picture characters—the special characters that make up a specification in the PICTURE attribute and in the P format item

Although the formatting possible with pictured data is useful in many applications, pictured data is much less efficient than fixed-point decimal data in computations. Therefore, do not use pictured data unless you need the formatting.

2.2.4.1 Pictured Variables

A pictured variable has the attributes of a fixed-point decimal variable, but values assigned to it are stored internally as character strings. Such a character string contains digits representing the variable's numeric value as well as such special symbols as the dollar sign. When the value of a pictured variable is written out by, for example, the PUT LIST statement, the internally stored character string is placed in the output stream. The value that appears on a line printer or terminal thus contains a fixed-point decimal number that has been "edited" with the requested special symbols.

A picture specification (or picture) describes both the numeric attributes of a pictured variable and its output format. A simple picture might look like this in a DECLARE statement:

```
DECLARE CREDIT PICTURE '$99999V.99DB';
```

This statement declares the variable CREDIT as a pictured variable. The characters within the apostrophes describe its format: Each 9 stands for any decimal digit; the dollar sign ($) indicates a leading dollar sign; the V specifies the location of the decimal point; and the DB specifies how a debit (a negative value) will be shown.

The two assignments

```
CREDIT = 12443.00;
```

and

```
CREDIT = -12443.00;
```

would look like this on output:

```
$12443.00              /* a positive value (credit) */
$12443.00DB            /* a negative value (debit) */
```

2.2.4.2 Assigning Values to Pictured Variables

Assignment of a computational value to a pictured variable is performed in the following two steps:

1. The value is converted to fixed decimal, with precision and scale as specified by the picture.
2. The resulting fixed decimal value is edited into the pictured variable.

If PL/I cannot perform one of these steps in a meaningful fashion, an error occurs. The following examples show two programming errors that are common in assignments to pictured variables.

```
CREDIT = '$12443.00';
```

This example signals the ERROR condition, because the character string contains a dollar sign and is therefore not convertible to fixed-point decimal. The value assigned to CREDIT should be either '12443.00' or simply 12443.00, both of which result in the same value assigned to CREDIT.

If a negative value is assigned to a pictured variable, the picture must include one of the sign picture characters (such as DB). For example:

```
CREDIT = -12443.00;
```

If the picture of CREDIT did not contain the DB characters, this assignment would signal the FIXEDOVERFLOW condition, because the sign would be lost.

In some circumstances (for example, with the READ statement), it is possible to assign a value to a pictured variable that is not valid with respect to the variable's picture specification. In such cases, the VALID built-in function (**see** the entry "VALID Built-In Function") can be used to validate the contents of the variable.

2.2.4.3 Extracting Values from Pictured Data

When you use a pictured value in an arithmetic context (such as assignment to an arithmetic variable), the picture is used to extract the fixed-point decimal number from the character string that internally represents the pictured value. Extraction also occurs when you input a pictured value with the GET EDIT statement and the P format item. If the contents of the pictured variable or input item do not conform to the picture, an error occurs.

For example:

```
DECLARE CREDIT PICTURE '$99999V.99DB';
```

In the picture for CREDIT, the 9 character specifies the position of a decimal digit; because the picture contains seven of these, the fixed-point decimal precision of CREDIT is 7. The V character separates the integral and fractional digits; because there are two 9 characters to the right of the V, the scale factor of CREDIT is 2. The V character is unique among picture characters in that it specifies only a numeric property; it does not cause a decimal point (or any other character) to appear in the internal representation of CREDIT. Therefore, a period picture character (.) is included after the V to ensure that the output value has a decimal point in the correct place.

The period and dollar sign are always inserted in the internal representation and the output value regardless of CREDIT's numeric value.

The picture character DB appears only when the value of CREDIT is less than zero; otherwise, two spaces appear in the indicated positions. The DB character also indicates that a value of CREDIT is numerically negative, so that if CREDIT is later assigned to an arithmetic variable, the variable will be given a negative value.

2.2.4.4 Picture Characters

An individual picture character, and its position in the picture, indicate the interpretation of an associated position in the pictured value.

Any picture character that can appear more than once in a picture can be preceded by an iteration factor, which must be a positive integer constant enclosed in parentheses. For example:

```
'(4)9'
```

This picture is the same as the following one:

```
'9999'
```

The following paragraphs describe the picture characters.

Decimal Place Character (V)

The V character shows the position of the "assumed" decimal point, or, in other words, the scale factor for the fixed-point decimal value. It does not cause a decimal point to appear. (Use the period insertion character for this purpose.) The following rules apply to the V character:

- Only one V character can appear in a picture.
- If a picture does not contain the V character, the V is assumed to be at the right end of the picture.
- If a fixed-point value assigned to a pictured variable has fewer integral digits than are indicated by the picture characters to the left of the V, then the integral value of the pictured variable is extended on the left with zeros. If the assigned value has too many integral digits, the value of the pictured variable is undefined and the FIXEDOVERFLOW condition is signaled.
- If a fixed-point value assigned to a pictured variable has fewer fractional digits than are indicated in the picture, then the fractional value of the pictured variable is extended on the right with zeros. If the assigned value has too many fractional digits, then the excess fractional digits are truncated on the right; no condition is signaled. Thus, if the V character is the last character in the picture or is omitted, assigned fixed-point values are truncated to integers.

The following example illustrates the effect of the V character:

```
DECLARE PRICE PICTURE '$$9V.99',
    BAD_PRICE PICTURE '$$9.99';
        PRICE = .98;       /* Output as $0.98  */
        BAD_PRICE = .98;   /* Output as $0.00  */
        PRICE = 98;        /* Output as $98.00 */
        BAD_PRICE = 98;    /* Output as $0.98  */
```

In this example, note that the variable PRICE, which contains the V character, represents the value properly. The variable BAD_PRICE, which contains only the period insertion character, has an assumed V character at the end of the picture, which causes the variable to misrepresent the value.

Digit Characters (9, Z, *, Y)

The characters 9, Z, and Y, and the asterisk character (*) mark the positions occupied by decimal digits. The number of these characters present in a picture specifies the number of digits, or precision, of the fixed-point decimal value of the pictured variable.

- The position occupied by 9 always contains a decimal digit, whether or not the digit is significant in the numeric interpretation of the pictured value. Thus, leading zeros at positions occupied by a 9 are output.
- The position occupied by Z contains a decimal digit only if the digit is significant in the integral portion of the numeric interpretation; if the digit is a leading zero, it is replaced by a space.
  - The Z character must not appear in the same picture with the asterisk character (*). It must not appear to the right of the characters 9, T, I, or R nor to the right of a drifting string.
  - If the Z character appears to the right of the V character, then all digits to the right of the V must be indicated by Z characters. Fractional zeros are then suppressed only if all fractional digits are zero and all of the integral digits are suppressed; in that case, the internal representation contains only spaces in the digit positions.
- The position occupied by the asterisk character (*) functions identically with the Z character, except that leading zeros are replaced by asterisks instead of spaces.
- The position occupied by the Y character contains a decimal digit only if the digit is not zero. All zeros in the indicated positions, whether significant or not, are replaced by spaces.

Encoded-Sign Characters (T, I, R)

The characters T, I, and R are encoded-sign characters that can be used wherever 9 is valid. Each represents a digit that has the sign of the pictured value encoded in the same position. Only one encoded-sign character can be used in a picture.

An encoded-sign character cannot be used in a picture that contains one of the following characters: S, +, –, CR, or DB (described below).

The meanings of the characters are as follows:

- The T character indicates that the position contains an encoded minus sign if the numeric value is less than zero and an encoded plus sign if the numeric value is greater than or equal to zero.
- The I character indicates an encoded plus sign if the numeric value is greater than or equal to zero. Otherwise, the position contains an ordinary digit.
- The R character indicates an encoded minus sign if the numeric value is less than zero. Otherwise, the position contains an ordinary digit.

For a table showing the ASCII representation of encoded-sign digits, **see** Table P–1, under the entry "Picture."

Drifting Characters ($, +, –, S)

The S character and the dollar sign ($), plus sign (+), and minus sign (–) characters are drifting characters. The drifting characters can be used to indicate digits, and they also indicate a symbol to be inserted when, for example, a pictured value is written out by PUT LIST.

- The dollar sign ($) causes a dollar sign to be inserted.
- The plus sign (+) causes a plus sign to be inserted if the numeric value is greater than or equal to zero.
- The minus sign (–) causes a minus sign to be inserted if the numeric value is less than zero.
- The S character causes a plus sign to be inserted if the numeric value is greater than or equal to zero, and a minus sign if the value is less than zero.

If one of these characters is used alone in the picture, it marks the position at which a special symbol or space is always inserted, and it has no effect on the value's numeric interpretation. In this case, the character must appear either before or after all characters that specify digit positions.

However, if a series of n of these characters appears, then the rightmost $n-1$ of the characters in the series also specify digit positions. If the digit is a leading zero, the leading zero is suppressed, and the leftmost character "drifts" to the right; the character appears either in the position of the last drifting character in the series or immediately to the left of the first significant digit, whichever comes first.

Used this way, the $n-1$ drifting characters also define part of the numeric precision of the pictured variable, because they describe at least some of the positions occupied by decimal digits. For an example of this behavior by a drifting character (the dollar sign), **see** the V decimal place character above.

The following additional rules apply to drifting characters:

- A drifting string is a series of more than one of the same drifting character. Only one drifting string can appear in the picture; any other drifting characters can be used only singly and therefore designate insertion characters, not digits.
- The Z and asterisk (*) cannot appear to the right of a drifting string.
- A digit position cannot be specified (for instance, with a 9) to the left of a drifting string.
- A drifting string can contain the V character and one of the insertion characters (defined below).
  - If the drifting string contains an insertion character, it is inserted in the internal representation only if a significant digit appears to its left. In the position of the insertion character, a space appears if the leftmost significant digit is more than one position to the right; the drifting symbol appears if the next position to the right contains the leftmost significant digit.
  - If the drifting string contains a V character, all digit positions to the right of the V (the fractional digits) must also be part of the drifting string. In this case, insignificant fractional digits are suppressed only when all integral and fractional digits are zeros: they are replaced by spaces in the internal representation. If any digit is not zero, all fractional digits appear as actual digits.
  - Any insertion characters immediately to the right of a drifting string are considered part of it.

Insertion Characters

The insertion characters indicate that characters are inserted between digits in the pictured value. The insertion characters are the comma (,), period (.), slash (/), and the space (B). The B character indicates that a space is always inserted at the indicated position.

The drifting characters also function as insertion characters when used singly (that is, not as part of a drifting string).

Note that the period (.) does not imply a V decimal place character. See the example in the description of the decimal place character, above.

The following rules describe insertion by the comma, period, and slash insertion characters.

- If zero suppression occurs, the insertion character is inserted only in these cases:
  - If a significant digit appears immediately to its left
  - If the V character appears immediately to its left, and the fractional part of the numeric value contains significant digits
- To guarantee that the decimal point is in the same position in both the numeric and character interpretations, the V and period characters must be adjacent. Note, however, that if the period precedes the V, then it is suppressed if there are no significant integral digits, even though all the fractional digits are significant. This property can make fractions appear to be integers when the internal (character) value is displayed. Consequently, the period should immediately follow the V character; it will then be in the correct location and will appear whenever any fractional digit is significant. The following example illustrates correct and incorrect placement of the period:

```
DECLARE NUM PICTURE 'ZZZV.ZZ',
    BAD_NUM PICTURE 'ZZZ.VZZ';
NUM=0.02;       /* Output as .02 */
BAD_NUM=0.02;   /* Output as 02  */
```

- Other insertion characters, such as the comma, can be used to separate the integral and fractional portions of a number. However, the comma should not be used with GET LIST input, because in that context it separates different data items in the input stream.

Credit (CR) and Debit (DB) Characters

These picture characters are always specified as the character pairs CR and DB. If either pair is included, it appears if the numeric value is less than zero. In each case, the associated positions contain two spaces if the numeric value is greater than or equal to zero.

The characters are inserted with the same case as used in the picture. If the lowercase form cr is used in the picture, lowercase letters are inserted in the pictured value; if the combination Cr is used, then Cr is inserted.

The credit and debit characters cannot be combined in one picture, nor can they be used in the same picture as any other character that specifies the sign of the value (S, plus sign (+), and minus sign (-) characters). In addition, they must appear to the right of all picture characters specifying digits.

2.2.5 Precision and Scale of Arithmetic Data Types

The PRECISION attribute applies to binary and decimal data; the precision of a fixed-point data item is the total number of decimal or binary digits used to represent a value. The precision of a floating-point data item is the number of decimal or binary digits in the mantissa of the floating-point representation. You can specify the precision in a declaration. You can also specify the scale, which is the number of digits to the right of the binary or decimal point, but only when the variable is fixed-point. There is no scale factor for floating-point variables.

For example:

```
DECLARE x FIXED DECIMAL(10,3);
```

This indicates that the value of x has 10 decimal digits, and that 3 of those are fractional.

The ranges of values you can specify for the precision for each arithmetic data type, and the defaults applied if you do not specify a precision, are summarized as follows:

Data Type Attributes	Precision	Scale Factor	Default Precision
BINARY FIXED	1 <= p <= 31	<= p	31
BINARY FLOAT	1 <= p <= 113		24
DECIMAL FIXED	1 <= p <= 31	<= p	10
DECIMAL FLOAT	1 <= p <= 34		7

If no scale factor is specified for fixed-point data, the default is zero.

Positive scale factors for fixed binary numbers function the same as scale factors for fixed decimal numbers. A negative scale factor indicates the number of fractional bits that are shifted from the left to the right. For a fixed-point binary number, the scale factor has the effect of multiplying or dividing the number by a factor of 2.

Even though arithmetic operands can be of different arithmetic types, all operations must actually be performed on objects of the same type. Consequently, the compiler may convert operands to a derived type. Therefore, when you declare a fixed binary number with a scale factor and assign it a decimal value, the results may not be what you expect. The reason is that the binary scale factor left-shifts the specified number of bits to the right of the decimal point. During conversion to a decimal representation, the difference between the resulting binary number and its decimal representation is not the equivalent of dividing or multiplying the decimal number by 10. Instead, the binary number is divided or multiplied by 2 and then converted to its decimal representation.

In addition, excess fractional digits may be truncated, and no condition is signaled. Any resulting loss of precision may be difficult to detect because truncated fractional digits do not signal a condition.

2.3 Character-String Data

A character string is a sequence of zero or more characters. The value of a character-string variable can consist of any ASCII characters, to a maximum length of 32767 characters. (The ASCII characters are the first 128 characters of the DEC Multinational Character Set, given in Appendix B.)

This section discusses character-string constants and character-string variables.

2.3.1 Character-String Constants

A character-string constant can consist of any characters in the DEC Multinational Character Set (**see** Appendix B). When you use character-string constants in a program, you must enclose the strings in apostrophes, as shown in the following examples:

```
'Total is:'
'Enter your name and age'
'Error -- value is out of range'
```

To specify a string containing a literal apostrophe, use two apostrophes within the string. For example:

```
'Life isn''t fair'
```

When a character string that has embedded apostrophes is specified as shown above, the final result contains only a single apostrophe.

Note that the quotation mark (") is not a legal delimiter for PL/I character constants.

2.3.2 Character-String Variables

The CHARACTER keyword identifies a character-string variable in a declaration. The addition of the VARYING keyword indicates a varying-length character-string variable. An optional number in parentheses specifies the length of the variable, that is, the number of bytes needed to contain its value. The maximum is 32767. The length attribute specifies either the length of all values of the variable (fixed-length strings) or the maximum length of a value of the variable (varying-length strings). If the length is not specified, PL/I uses the default length of one character, or byte. The rules for specifying the length are as follows:

- For a static variable declaration, the length must be an integer constant.
- In the declaration of a parameter or in a parameter or returns descriptor, the length can be specified as an integer constant or as an asterisk (*). The resulting string is fixed length unless VARYING is also specified.

- For an automatic, based, or defined variable, the length can be specified as an integer constant or as an expression. In the case of automatic or defined variables, the expression must not contain any variables or functions that are declared in the same block, except for parameters.

If specified, n must immediately follow the keyword CHARACTER and must be enclosed in parentheses.

2.3.2.1 Fixed-Length Character-String Variables

For a particular allocation of a fixed-length character-string variable, all its values have the same length. When a program assigns a value to a fixed-length character-string variable, however, the value is not always exactly the same as the length defined for the variable. Depending on the size of the value, PL/I does the following:

- If the value is smaller than the length of the character string, PL/I pads the value with spaces on the right. For example:

```
DECLARE STRING CHARACTER (10);
STRING = 'ABCDEF';
```

  The final value of the variable STRING is 'ABCDEF   ', that is, the characters ABCDEF followed by four space characters.

- If the value is larger than the length of the variable, PL/I truncates the value on the right. For example:

```
DECLARE STRING CHARACTER (4);
STRING = 'ABCDEF';
```

  Here, the final value of STRING is 'ABCD', that is, the first four characters of the value 'ABCDEF'.

2.3.2.2 Varying-Length Character-String Variables

In a varying character-string variable, the length is not fixed. The length specified in the declaration of the variable defines the maximum length of any value that can be assigned to the variable. Each time a value is assigned, the current length changes. For example:

```
DECLARE NAME CHARACTER (20) VARYING;
NAME = 'COOPER';
NAME = 'RANDOM FACTOR';
```

The declaration of the variable NAME indicates that the maximum length of any character-string value it can have is 20. The current length becomes 6 when NAME is assigned the value 'COOPER'; the length becomes 13 when NAME is assigned the value 'RANDOM FACTOR'; and so on.

When a varying character string is assigned a value with a length greater than the maximum defined, the value is truncated on the right.

The initial length of an automatic varying-length character-string variable is undefined unless the variable is initialized.

You can use the LENGTH built-in function to determine the current length of any string, and the MAXLENGTH built-in function to determine the maximum length (**see** the entries "LENGTH Built-In Function" and "MAXLENGTH Built-In Function").

2.4 Bit-String Data

A bit string consists of a sequence of binary digits, or bits. It can be used as a Boolean value, which has one of two states: true (if any bit is 1) or false (if all bits are 0).

Like a fixed-length character string, a bit string has a fixed length defined in the declaration or specified by the number of bits in a bit-string constant. The maximum length of any bit string is 32767 bits. Bit-string variables cannot be declared with the VARYING attribute.

Sophisticated applications that depend on the internal representation of bit strings and other types of data may not be directly transportable from other PL/I implementations to VAX PL/I. In VAX, bit strings are stored in memory with the leftmost bit (as represented by PUT LIST) in the lowest memory location and bits following the leftmost in successively higher memory locations. This representation of a bit string by PUT LIST is reversed with respect to a conventional picture of memory locations, in which higher locations appear on the left, not on the right. For example:

```
DECLARE ABIT BIT (10);
ABIT = '1011'B;
```

A memory diagram of the storage resulting from this assignment would look like this:

```
    ... 0 0 0 0 0 0 1 1 0 1 ...
    HIGH MEMORY      LOW MEMORY
<-  LOCATIONS        LOCATIONS ->
```

This is of no concern until you try to interpret non-bit-string data as a bit string. For example, a fixed binary value is stored with the sign bit in the highest memory location, the most significant bit in the next highest location, and so on to the least significant bit in the lowest memory location. Thus, a FIXED BINARY (7) variable with a value of 2 would appear in memory as follows:

```
    ... 0 0 0 0 0 0 1 0 ...
    HIGH MEMORY   LOW MEMORY
<-  LOCATIONS     LOCATIONS ->
```

Should you treat this storage as a bit string (for example, by using it as the argument of the UNSPEC built-in function in a PUT LIST statement), the result would be as follows:

```
'01000000'B
```

If you are accustomed to using PL/I on computers other than VAX, this result may not be what you expect.

The rest of this section discusses bit-string constants and variables, alignment of bit-string data, and the use of bit strings to represent integers.

2.4.1 Bit-String Constants

To specify a bit-string constant, enclose the string in apostrophes and follow the closing apostrophe with the letter B. For example:

```
'0101'B
'10101010'B
'1'B
```

The length of a bit-string constant is always the number of binary digits specified; the B does not count in the length of the string. You can specify a bit-string constant with a maximum of 1000 characters between the apostrophes.

You can also specify a bit-string constant using the following syntax:

character-string'Bn

n
Is the number of bits in the range 1 through 4 to be represented by each character in the string.

This format allows you to specify bit-string constants with bases other than 2. For example:

```
'EF8'B4
'117'B3
'223'B2
```

These constants specify the hexadecimal value EF8, the octal value 117, and the base 4 value 223. All such constants are stored internally as bit strings, not as integer representations of the value.

The valid characters for each type of bit-string constant are listed below:

- For B or B1, only the characters 0 and 1 are valid.
- For B2, only the characters 0, 1, 2, and 3 are valid.
- For B3, only the characters 0, 1, 2, 3, 4, 5, 6, and 7 are valid.
- For B4, the characters 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F are valid. (The letters A through F can be either upper- or lowercase.)

Using the B format items, you can also acquire or output (with the GET EDIT and PUT EDIT statements) bit-string data in binary, base 4, octal, or hexadecimal format. **See** "B Format Item."

2.4.2 Bit-String Variables

Use the BIT attribute to declare a bit-string variable. You can optionally specify the length of the variable in parentheses. The length can be from 0 to 32767; the default length is one bit. The rules for specifying the length are as follows:

- If BIT is specified for a static variable declaration or in a returns descriptor, the length must be an integer constant.
- If BIT is specified in the declaration of a parameter or in a parameter descriptor, the length can be specified as an integer constant or as an asterisk (*).

- If BIT is specified for an automatic, based, or defined variable, the length can be specified as an integer constant or as an expression. In the case of automatic or defined variables, the expression must not contain any variables or functions that are declared in the same block, except for parameters.

If specified, the length must immediately follow the keyword BIT.

A program can assign to a bit-string variable a value larger or smaller than the variable's defined length. In such cases, PL/I does the following:

- If the assigned string is shorter than the defined length, PL/I pads the bit-string value with zeros in the direction of least significance. The less significant bits are on the right, as the string is represented by PUT LIST.
- If the assigned string is longer, PL/I truncates the least significant bits from the bit-string value.

You can convert bit-string variables to other data types; however, there are some precautions you must observe if you do so. Section 2.4.4 describes how to convert bit-string variables.

2.4.3 Alignment of Bit-String Data

PL/I distinguishes between aligned and unaligned bit-string variables. (Bit-string constants are always unaligned.) A bit-string variable is aligned only if it is declared with the ALIGNED attribute, as shown in the following example:

```
DECLARE FLAGS BIT (8) ALIGNED;
```

PL/I allocates storage for an aligned bit-string variable on a byte boundary and reserves an integral number of bytes to contain the variable. Unaligned bit-string variables always occupy only as many bits as are needed to contain them. They need not be on byte boundaries. You can optionally specify the UNALIGNED attribute in a declaration; UNALIGNED is the default for bit strings.

In general, operations involving unaligned bit-string variables are less efficient than those involving aligned bit-string variables. Unaligned bit-string variables are also invalid as the targets of the FROM and INTO options of record I/O statements, and as the argument of the ADDR built-in function. Moreover, most non-PL/I programs that accept bit-string arguments require the strings to be aligned.

It is recommended, therefore, that you declare bit-string variables with the ALIGNED attribute in most cases. Use unaligned bit-string variables when bit strings must be packed as tightly as possible, for example, in arrays and in structures.

See the entries "Bit-String Data" and "ALIGNED Attribute."

2.4.4 Bit Strings and Integers

PL/I defines conversions between bit-string data and other data types, and the VAX PL/I compiler carries out these conversions. However, the conversions defined by PL/I are not always straightforward or intuitive; the padding and truncation that take place during assignment of bit strings of different lengths result in implicit multiplication or division of the bit string's integer value. For example:

```
DECLARE BITSTR BIT (10);
        BITSTR = 1;
        PUT LIST (BITSTR);
```

The output is as follows:

```
'0001000000'B
```

Although the result may seem incorrect, it conforms to PL/I's rules for conversion to bit strings. In this case, the fixed-decimal constant 1 is converted to a FIXED BINARY(4) value, which is in turn converted to an intermediate bit string of length 4:

```
'0001'B
```

Next, this intermediate bit string is assigned to the variable BITSTR. Because BITSTR is of length 10, the intermediate bit string is padded on the right with zeros, producing the result as output by PUT LIST. If you now attempt to interpret the value of BITSTR as an integer (for example, by using BITSTR as the argument of the BINARY built-in function), the result would be 64, not 1.

Note also that extra execution time is required to reverse the order of bits when the integer's value is computed. Using arithmetic variables to represent integers is more efficient.

Because of the unexpected results and longer execution time, you should avoid using bit strings to represent integers or other data types.

2.4.5 Replication Factor for String Constants

A replication factor is an unsigned integer constant that specifies the number of times a simple string constant is replicated. A replication factor permits repetition of character strings and bit strings in any context where a simple string constant is permissible, including format items and assignment, string, and arithmetic operations. The format of a replication factor is as follows:

(r)'string'

r
An unsigned integer that represents the number of times that the string is to be replicated.

string
A simple string constant to be replicated. The string is enclosed in apostrophes.

For example:

```
(4)'season   '
```

This example replicates the string four times. The resulting character constant looks like this:

```
season   season   season   season
```

Another example of replication is as follows:

```
DECLARE (A) BIT (800);
     A = (400) '2'B2;
     PUT SKIP LIST ((A));
END;
```

In this example, A will be replicated to its maximum specified length of 800 characters.

The resulting character constant looks like this:

```
'10101010101010101010101010101010
     .
     .
     .
10101010101010101010101010'B
```

A replication factor can be used in combination with the iteration factor in INITIAL. For example, the following two statements are equivalent:

```
INITIAL ((10)('ABCABC'))

INITIAL ((10)((2)'ABC'))
```

The first statement uses an iteration factor exclusively; the second statement combines an iteration factor of 10 with a replication factor of 2. Note that an extra set of parentheses is required to separate the iteration factor from the replication factor and the character string.

Chapter 3

Aggregates

Aggregates are groupings of variables. There are two types of aggregate:

- An array is an aggregate in which all items, called elements, have the same data type. An individual element of an array is referred to by an integer subscript that designates the element's position, or order, in the array. Elements can be scalar data items or structures.
- A structure is an aggregate in which individual items, called members, can have different data types. Individual members are referred to by qualified references that give the names of the structure itself and of the individual member.

Aggregates can also be formed from arrays whose elements are structures, or from structures whose individual members are arrays.

3.1 Arrays

Arrays provide an orderly way to manipulate related variables of the same data type. An array variable is defined in terms of the number of elements that the array contains and the organization of those elements. These attributes of an array are called its dimensions.

3.1.1 Array Declarations

The declaration of an array specifies its dimensions, the bounds of each dimension, and the attributes of the elements.

One bound pair is specified for each dimension of the array, to define the number of elements in that dimension. The extent of an array is the product of the numbers of elements in its dimensions. If omitted, the lower bound is 1 by default.

You can use an asterisk (*) as the bound pair when you declare arrays as parameters of a procedure; the asterisk indicates that the parameter can accept array arguments with any number of elements. (If one dimension is specified with an asterisk, all must be specified with asterisks.)

For example:

```
DECLARE SALARIES (100) FIXED DECIMAL (7,2);
```

This statement declares a 100-element array with the identifier SALARIES. Each element is a fixed-point decimal number with a total of seven digits, two of which are fractional. The following statement declares a two-dimensional array of 64 integers:

```
DECLARE GAME_BOARD (8,8) FIXED BINARY (7);
```

The following statement declares a one-dimensional array of 12 character strings:

```
DECLARE PM_HOURS(13:24) CHARACTER(2);
```

The elements of the array are numbered 13 through 24 instead of 1 through 12.

You can replace the identifier in a statement with a list of declarations, thereby declaring several arrays with the same attributes. For example:

```
DECLARE (SALARIES,PAYMENTS)(100) FIXED DECIMAL(7,2);
```

This statement declares SALARIES and another array, PAYMENTS, with the same dimensions and other attributes.

The following rules apply to specifying the dimensions of an array and the bounds of a dimension:

- An array can have up to eight dimensions.

- The values you can specify for bounds are restricted as follows:
  - If the array has the STATIC attribute, you must specify all bounds as restricted integer expressions. (**See** the entry "Restricted Expression" for a definition.)
  - If the array has the AUTOMATIC, BASED, CONTROLLED, or DEFINED attribute, you can specify the bounds as optionally signed integer constants or as expressions that yield integer values at run time. If the array has AUTOMATIC or DEFINED, the expressions must not contain any variables or functions that are declared in the same block, except for parameters.
  - If an array is a parameter, you can specify the bounds with optionally signed integer constants or asterisks (*). If you specify any bound as an asterisk, you must specify all bounds with asterisks. An array parameter declared this way inherits the dimensions of the corresponding argument.
- The value of the lower bound you specify must be less than the value of the upper bound.

3.1.2 References to Individual Elements

You refer to an individual element in the array with subscripts. Because an array's attributes are common to all of its elements, a subscripted reference has the same properties as a reference to a scalar variable with those attributes.

You must enclose subscripts in parentheses in a reference to an array element. For example, in a one-dimensional array named ARRAY declared with the bounds (1:10), the elements are numbered 1 through 10 and are referred to as ARRAY(1), ARRAY(2), ARRAY(3), and so on. The lower and upper bounds that you declare for a dimension determine the range of subscripts you can specify for that dimension.

For multidimensional arrays, the subscript values represent an element's position with respect to each dimension in the array. In subscripted references for multidimensional arrays, the number of subscripts must match the number of dimensions of the array and must be separated by commas.

You can specify the subscript of an array element using any variables or expressions having integer values, that is, values that can be expressed as fixed binary or fixed decimal with a zero scale factor. For example:

```
DECLARE DAYS_IN_MONTH(12) FIXED BINARY;

DECLARE (COUNT, TOTAL) FIXED BINARY;
TOTAL = 0;
DO COUNT = 1 TO 12;
      TOTAL = TOTAL + DAYS_IN_MONTH(COUNT);
      END;
```

Here, the variable COUNT is used as a control variable in a DO loop. As the value of COUNT is incremented from 1 to 12, the value of the corresponding element of the array DAYS_IN_MONTH is added to the value of the variable TOTAL.

3.1.3 Initializing Arrays

Specify the INITIAL attribute for an array to initialize its values in the declaration. For example:

```
DECLARE MONTHS (12) CHARACTER (9) VARYING
   INITIAL ('January', 'February', 'March', 'April',
      'May', 'June', 'July', 'August',
      'September', 'October', 'November', 'December');
```

Each element of the array MONTHS is assigned a value according to the order of the character-string constants in the initial list: MONTH(1) is assigned the value 'January'; MONTH(2) is assigned the value 'February'; and so on.

If the array being initialized is multidimensional, the initial values are assigned in row-major order (**see** Section 3.1.5).

To assign identical initial values to some or all elements of an array, you can use an iteration factor with the INITIAL attribute. For example:

```
DECLARE TEST_AVGS (30,4) FIXED DECIMAL (5,2)
    STATIC INITIAL ((120) 50);
```

This statement declares the array TEST_AVGS with 120 elements, each of which is given an initial value of 50.

You can use the asterisk (*) iteration factor to initialize all the elements of an array to the same value.

Although VAX PL/I supports the initialization of automatic arrays with the INITIAL attribute, it is not always the most efficient way (in terms of program compilation and execution) to initialize array elements, for the following reasons:

- When you initialize elements in an array that has the AUTOMATIC, BASED, or CONTROLLED attribute, the compiler does not check that all elements are initialized until run time. Thus, you do not receive any compile-time checking of initialization, even if you used constants to specify the array bounds and iteration factors.
- Your programs will run more efficiently if you initialize automatic arrays with assignment statements rather than the INITIAL attribute.

However, if the array is not modified by your program, you can increase program efficiency by declaring the array with the STATIC and READONLY attributes and using the INITIAL attribute to initialize its elements. In this case, the compiler checks that you have initialized all the elements and that they are valid.

See "INITIAL Attribute" for more information.

3.1.4 Assigning Values to Array Variables

You can specify an array variable as the target of an assignment statement in the following cases:

```
array-variable = expression;
```

This is valid where the expression yields a scalar value. Every element of the array is assigned the resulting value. The array variable must be a connected array whose elements are scalar.

Note that the arithmetic operators, such as the plus sign (+) and the minus sign (-), cannot have arrays as operands. An assignment of the following form is invalid:

```
ARRAYC = ARRAYA + ARRAYB;
```

```
array-variable-1 = array-variable-2;
```

This is valid where the specified array variables have identical data type attributes and dimensions. Each element in array-variable-1 is assigned the value of the corresponding element in array-variable-2. In this type of assignment, both arrays must be connected. The actual storage they occupy must not overlap, unless the arrays are identical.

All other specifications of an array variable as the target of an assignment statement are invalid.

When you specify an array variable name in the input-target list of a GET LIST or GET EDIT statement, elements of the array are assigned values from the data items in the input stream. For example:

```
DECLARE VERBS (6) CHARACTER (15) VARYING;
GET LIST (VERBS);
```

When this GET LIST statement executes, it accepts data from the default input stream. Each input field delimited by blanks, tabs, or commas is considered a separate string. The values of these strings are assigned to elements of the array VERBS in the order VERBS(1), VERBS(2), . . . VERBS(6). If a multidimensional array appears in an input-target list, input data items are assigned to the array elements in row-major order (**see** Section 3.1.5).

An array can also appear, with similar effects, in the output-source list of a PUT statement.

3.1.5 Order of Assignment and Output for Multidimensional Arrays

When a multidimensional array is initialized, or when it is assigned values without references to specific elements, PL/I assigns the values in row-major order. In row-major order, the rightmost subscript varies the most rapidly. For example, an array can be declared as follows:

```
DECLARE TESTS (2,2,3);
```

If TESTS is specified in a GET statement or in a declaration with the INITIAL attribute, values are assigned to the elements in the following order:

TESTS (1,1,1)
TESTS (1,1,2)
TESTS (1,1,3)
TESTS (1,2,1)
TESTS (1,2,2)
TESTS (1,2,3)
TESTS (2,1,1)
TESTS (2,1,2)
TESTS (2,1,3)
TESTS (2,2,1)
TESTS (2,2,2)
TESTS (2,2,3)

When an array is output with a PUT statement, PL/I uses the same order to output the array elements. For example:

```
PUT LIST (TESTS);
```

This PUT statement outputs the contents of TESTS in the order shown above.

3.2 Structures

A structure is a data aggregate consisting of one or more members. The members can be scalar data items, arrays of scalar data items, structures, or arrays of structures, and different members can have different data types. Structures are useful when you want to group related data items having different data types.

A structure declaration defines a structure variable by means of level numbers. For example:

```
DECLARE 1 TRANSACTION,
          2 PART_NUMBER,
            3 FACTORY CHARACTER (3),
            3 ITEM CHARACTER (5),
          2 IN_STOCK BIT (1);
```

The level number 1 indicates that TRANSACTION is a structure variable. TRANSACTION is the name of the entire, or "major," structure. The relationship of the higher numbers (2 and 3) indicates that the associated identifiers are the names of members of the structure TRANSACTION or its "minor" structure, PART_NUMBER. The following example can help to clarify the terminology:

```
DCL 1 S,
      2 X,
        3 Y FIXED;
```

S

Is a "major structure", not a "member".

X

Is a "minor structure" and a "major member" because it comes under S and also contains Y.

Y

Is a "minor member" and not a "structure".

3.2.1 Structure Declarations

The declaration of a structure defines its organization and the names of members at each level in the structure. The major structure name is declared as structure level 1; minor members must be declared with level numbers greater than 1. For example:

```
DECLARE 1 PAYROLL,
          2 NAME,
            3 LAST CHARACTER(80) VARYING,
            3 FIRST CHARACTER(80) VARYING,
          2 SALARY FIXED DECIMAL(7,2);
```

This statement declares a structure named PAYROLL. You can access the last name with a qualified reference:

```
PAYROLL.NAME.LAST = 'ROOSEVELT';
```

Alternatively, because the last and first names have the same attributes, you can declare the same structure as follows:

```
DECLARE 1 PAYROLL,
          2 NAME,
            3 (LAST,FIRST) CHARACTER(80) VARYING,
          2 SALARY FIXED DECIMAL(7,2);
```

The following additional rules apply to the specification of level numbers:

- Level numbers must be specified with decimal integer constants.
- A level number must be separated from its associated variable name by at least one space or tab character.
- Level numbers after level 1 can have any integer value, as long as each level number is equal to or greater than the level number of the preceding level. (There can be only one level 1.)
- Each identifier in the structure must be separated from the declaration of the previous identifier by a comma.
- Substructures at the same logical level of nesting do not have to have the same level number.
- The deepest possible logical level is 15.
- The largest possible level number constant is 32767.

Within a structure, only members at the lowest level of each substructure can be declared with data type attributes. Additional rules for specifying attributes for the various components of a structure are as follows:

- Only the following attributes are valid for the major structure:

AUTOMATIC	GLOBALREF
BASED	INTERNAL
CONTROLLED	READONLY
DEFINED	STATIC
EXTERNAL	STRUCTURE
GLOBALDEF	UNION

- The major structure, a minor structure, or any member of the structure can be dimensioned: that is, there can be arrays of structures and structures whose members are arrays.
- Member names cannot have any of the attributes a major structure can have, except for INTERNAL.
- If a structure has the STATIC attribute, the extents of all members (lengths for character- and bit-string variables, dimensions for array variables, and area extents) must be specified with optionally signed decimal integer constants.

You can initialize a structure by giving the INITIAL attribute to its members. Not all members need to be initialized. For example:

```
DECLARE 1 COUNTS,
          2 FIRST FIXED BIN(15) INITIAL(0),
          2 SECOND FIXED BIN(15),
          2 THIRD (5) FIXED BIN(15) INITIAL (5(1));
```

The first and third members of the structure COUNTS are initialized.

You cannot specify the INITIAL attribute, however, for a major or a minor structure.

3.2.2 Member Attributes

VAX PL/I supports three "member attributes," so named because they apply specifically to the declaration of structure members rather than to the structure as a whole. The member attributes are as follows:

- The LIKE attribute
- The REFER option
- The UNION attribute

Each is discussed in detail in the following sections.

3.2.2.1 Using the LIKE Attribute

The LIKE attribute copies the member declarations in a major or minor structure declaration into another structure variable. It copies the logical structuring and member declarations from the major or minor structure to the target variable, but does not copy any storage class attributes or dimensioning (except for dimensioning that is applied to members).

An identifier names the variable to which the declarations in the reference are copied. The reference is the name of a major or minor structure known to the current block. The identifier must be preceded by a level number. Any attributes that can be used with a structure variable at that level can be used with the identifier; for example, a major structure can specify a storage class and dimensions, and a minor structure can specify dimensions.

The following example illustrates the LIKE attribute:

```
DECLARE 1 RES_DATA BASED (RPTR),
          2 DATE CHARACTER(8),
          2 HOTEL_CODE CHARACTER(3),
          2 PARTY_NAME,
            3 LAST CHARACTER(20),
            3 FIRST CHARACTER(10)
          2 STAY FIXED BIN(7),
        1 NEW_RESER LIKE RES_DATA,
            .
            .
            .
    GET LIST (NEW_RESER.DATE,NEW_RESER.HOTEL_CODE);
       .
       .
       .
    RES_DATA = NEW_RESER;
```

In this example, the declaration of NEW_RESER uses the LIKE attribute to create a set of member declarations that duplicate those in RES_DATA. The declaration of NEW_RESER is equivalent to the following:

```
DECLARE 1 NEW_RESER,
          2 DATE CHARACTER(8),
          2 HOTEL_CODE CHARACTER(3),
          2 PARTY_NAME,
            3 LAST CHARACTER(20),
            3 FIRST CHARACTER(10),
          2 STAY FIXED BINARY(7);
```

After the members of NEW_RESER are assigned data and that data is validated, the entire contents of NEW_RESER are assigned to RES_DATA. This assignment is possible because the two structures are identical, which results from the use of the LIKE attribute.

3.2.2.2 Using the REFER Option

Use the REFER option to create self-defining based structures. In a based structure, the value of one member is used to determine the size of the storage space allocated for another member of the same structure. The REFER option can be used in a DECLARE statement to specify array bounds, the length of a string, or the size of an area. For details, **see** "REFER Option."

An example of a structure declaration containing the REFER option is as follows:

```
DECLARE 1 STRUCTURE S BASED(P),
          2 I FIXED BINARY(31),
          2 A CHARACTER(20 REFER(I));
```

For the compiler to allocate storage for a based structure, the structure must have a known size. In the example, the initial length for A is taken from the refer element, 20. However, the REFER option permits the size of the structure to change at run time as the value of the refer object (I) changes. After allocation, the length of A is determined by I.

You can have multiple REFER options within a structure.

The following example and diagrams illustrate storage mapping with the REFER option.

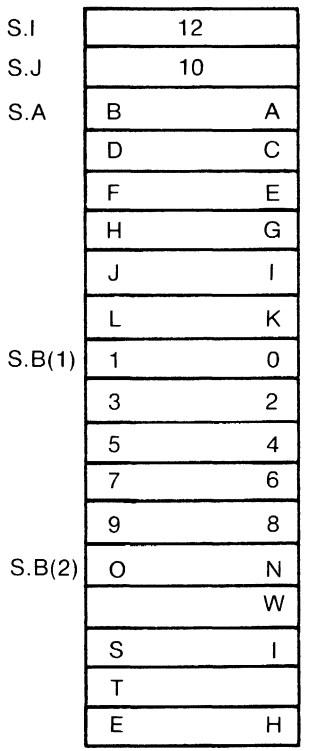
```
DECLARE 1 S BASED (POINTER),
          2 I FIXED BINARY(15),
          2 J FIXED BINARY(15),
          2 A CHARACTER ((X*2+2) REFER(I)),
          2 B(2) CHARACTER (Y REFER(J));

ALLOCATE S;
X = 5;
Y = 10;

S.A = 'ABCDEFGHIJKL';
S.B(1) = '0123456789';
S.B(2) = 'NOW IS THE';
    .
    .
    .
END;
```

When this structure is allocated, the refer elements (X*2+2) and Y are evaluated and used to determine the length of the associated string. The evaluated refer element value (X*2+2) is assigned to the refer object I and Y is assigned to J. Thereafter, the sizes of strings A and B are determined by the value of the refer objects I and J.

Storage for the above structure would look like this:



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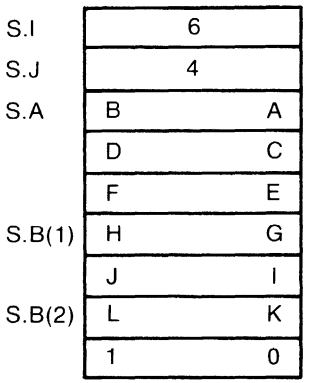
If the refer object I were assigned the value 6 and the refer object J were assigned the value 4, the resulting storage would be remapped as this:



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Note that VAX PL/I does not restrict the use of the REFER option within structure declarations: therefore, exercise caution in its use. If you change a value that causes the size of one or more structure members to decrease, then some storage at the end of the allocated storage will become inaccessible for future reference.

If the scalar variable (the refer object) does not satisfy the following criteria, the results are undefined:

- It must not be assigned a value that is less than zero or greater than the refer element value used for structure allocation.
- It must have the value used for allocation, if the structure is freed.

The following rules apply to structures containing the REFER option:

- A structure containing the REFER option cannot be the target of a LIKE reference.
- When a based structure is allocated, the order in which the refer elements are selected for evaluation is undefined.
- When a based structure is allocated, the order in which the refer objects are selected for initialization is undefined.

3.2.2.3 Using the UNION Attribute

A union is a variation of a structure in which all immediate members occupy the same storage. The UNION attribute (which must be associated with a level number in a structure declaration) declares a union. All immediate members of the union—that is, all members having a level number one higher—occupy the same storage. A reference to one member of a union refers to storage occupied by all members of the union. Therefore, a union provides a convenient way to look at a large entity (such as a character string or a bit mask) as a series of smaller entities (such as component character strings or individual flag bits).

A variable declared with the UNION attribute must be a major or minor structure. All members of a union must have a constant size. For format and details, **see** "UNION Attribute."

The UNION attribute is not part of the PL/I General-Purpose Subset; it is provided in VAX PL/I to give users convenient access to data as it is internally represented. Potential applications of unions might depend on the internal representation of data, and would therefore not be transportable to other implementations of PL/I.

The following example illustrates unions:

```
DECLARE 1 CUSTOMER_INFO,
            .
            .
            .
          2 PHONE_DATA UNION,
            3 PHONE_NUMBER CHARACTER (13),
            3 COMPONENTS,
              4 LEFT_PAREN CHARACTER (1),
              4 AREA_CODE CHARACTER (3),
              4 RIGHT_PAREN CHARACTER (1),
              4 EXCHANGE CHARACTER (3),
              4 HYPHEN CHARACTER (1),
              4 SPECIFIC_NUMBER CHARACTER (4),
          2 ADDRESS_DATA,
              .
              .
              .
```

The UNION attribute associated with the declaration of PHONE_DATA signifies that PHONE_DATA's immediate members (PHONE_NUMBER and COMPONENTS) occupy the same storage. Any modification of PHONE_NUMBER also modifies one or more members of COMPONENTS; conversely, modification of a member of COMPONENTS also modifies PHONE_NUMBER. Note, however, that the UNION attribute does not apply to the members of COMPONENTS because

they are not immediate members of PHONE_DATA. The members of COMPONENTS occupy separate storage in the normal fashion for structure members.

Unions provide capabilities similar to those provided by defined variables. However, the rules governing defined variables are more restrictive than those governing unions. The following example demonstrates a use of a union that would not be possible with a defined variable:

```
DECLARE 1 X UNION,
          2 FLOAT_NUM FLOAT BINARY (24),
          2 BREAKDOWN,
            3 FRAC_1 BIT (7),
            3 EXPONENT BIT (8),
            3 SIGN BIT (1),
            3 FRAC_2 BIT (16);
```

The union X has two immediate members, FLOAT_NUM (a floating-point variable) and BREAKDOWN. The members of BREAKDOWN are bit-string variables that overlay the storage occupied by FLOAT_NUM and provide access to the individual components of its internal representation. Assignment to FLOAT_NUM modifies the members of BREAKDOWN, and vice versa. For example:

```
EXPONENT = '0'B;
SIGN = '1'B;

FLOAT_NUM = FLOAT_NUM + 1;
```

The first two assignment statements set the exponent and sign fields of FLOAT_NUM to the reserved operand combination; the expression FLOAT_NUM + 1 causes a reserved operand exception to occur.

Note that, unlike the character-string example that precedes it, this example depends on the VAX internal representation of data.

3.2.3 Structure-Qualified References

To refer to a structure in a program, you use the major structure name, minor structure names, and individual member names. Member names need not be unique even within the same structure. To refer to the name of a member or minor structure, you must ensure only that the reference uniquely identifies it. You can qualify the variable name by preceding it with the name or names of higher-level (lower-numbered) variables in the structure; names in this format, called a qualified reference, must be separated by periods (.).

The following sample structure definition illustrates the rules for identifying names of variables within structures:

```
DECLARE 1 STATE,
          2 NAME CHARACTER (20),
          2 POPULATION FIXED (10),
          2 CAPITAL,
            3 NAME CHARACTER (30),
            3 POPULATION FIXED (10,0),
          2 SYMBOLS,
            3 FLOWER CHARACTER (20),
            3 BIRD CHARACTER (20);
```

The rules for selecting and specifying variable names for structures are as follows:

- The name of the major structure is subject to the rules for the scope of variables in a program.
- The name of any minor structure or member in a structure can be qualified by the names of higher-level members in the structure. The variable names must be specified from left to right in order of increasing level numbers, separated by periods. The members of the previous sample, completely qualified, are as follows:

  STATE.NAME
  STATE.POPULATION
  STATE.CAPITAL.POPULATION
  STATE.CAPITAL.NAME
  STATE.SYMBOLS.FLOWER
  STATE.SYMBOLS.BIRD

- Names of minor structures or members within structures do not have to be qualified if they are unique within the scope of the name. The following names in the sample structure can be referred to without qualification (so long as there are no other variables with these names):

  CAPITAL
  SYMBOLS
  FLOWER
  BIRD

- Intermediate qualification names can be omitted if the reference remains unambiguous. The following references to members in the sample structure are valid:

  STATE.FLOWER
  STATE.BIRD

If a name is ambiguous, the compiler cannot resolve the reference and issues a message. In the example, the names POPULATION and NAME are ambiguous.

You can specify the name of a major or minor structure in an assignment statement only if the source expression and the target variable are identical in size and structure, and all corresponding members have the same data types.

3.2.4 Arrays of Structures

An array of structures is an array whose elements are structures. Each structure has identical logical levels, minor structure names, and member names and attributes.

For example, a structure STATE can be declared an array:

```
DECLARE 1 STATE (50),
          2 NAME CHARACTER (20) VARYING,
          2 POPULATION FIXED (31),
          2 CAPITAL,
            3 NAME CHARACTER (30) VARYING,
            3 POPULATION FIXED (31),
          2 SYMBOLS,
            3 FLOWER CHARACTER (20),
            3 BIRD CHARACTER (20);
```

A member of a structure that is an array inherits the dimensions of the structure. For example, the member CAPITAL.NAME of the structure STATE inherits the dimension 50. You must use a subscript whenever you refer to the variable CAPITAL.NAME, as in the following example:

```
PUT LIST (CAPITAL.NAME(I)) ;
```

A subscript for a member of a structure that is an array element can appear following any name within a qualified reference. For example, all of these references are equivalent:

```
STATE(10).CAPITAL.NAME
STATE.CAPITAL(10).NAME
STATE.CAPITAL.NAME(10)
```

3.2.4.1 Arrays of Structures That Contain Arrays

A structure that is defined with a dimension can have members that are arrays. For example:

```
DECLARE 1 STATE (50),
          2 AVERAGE_TEMPS(12) FIXED DECIMAL (5,2),
              .
              .
              .
```

In this example, the elements of the array STATE are structures. At the second level of the hierarchy of each structure, AVERAGE_TEMPS is an array of 12 elements. Because AVERAGE_TEMPS inherits the dimension of STATE, any of AVERAGE_TEMPS's elements must be referred to by two subscripts:

1. The first subscript references an element in STATE.
2. The second subscript references an element in AVERAGE_TEMPS.

These subscripts can appear following any name in the qualified reference. For example:

```
STATE(3).AVERAGE_TEMPS(4)
STATE.AVERAGE_TEMPS(3,4)
```

These references are equivalent.

Note the following rules for specifying subscripts for members of structures containing arrays:

- The number of subscripts specified for any member must include any dimensions inherited from a major or minor structure declaration, as well as those specified for the member itself.
- The subscripts that refer to a member of a structure in an array do not have to follow immediately the name to which they apply. However, the order of subscripts must be preserved.
- The total number of dimensions, including the inherited dimensions, must not exceed eight.

3.2.4.2 Connected and Unconnected Arrays

A connected array is one whose elements occupy consecutive locations in storage. For example:

```
DECLARE NEWSPAPERS (10) CHARACTER (30);
```

In storage, the 10 elements of the array NEWSPAPERS occupy 10 consecutive 30-byte units. Thus, NEWSPAPERS is a connected array.

A connected array is valid as the target of an assignment statement, as long as the source expression is a similarly dimensioned array or a single scalar value.

In an unconnected array, the elements do not occupy consecutive storage locations. An unconnected array is not valid in an assignment statement or as the source or target of a record I/O statement. A structure with the dimension attribute always results in unconnected arrays. When a structure is dimensioned, each member of the structure inherits the dimensions of the structure and becomes, in effect, an array. For example:

```
DECLARE 1 STATE (50),
          2 NAME CHARACTER (20) VARYING,
          2 POPULATION FIXED (31);
```

The members NAME and POPULATION of the major structure STATE inherit the dimension 50 from the major structure. When PL/I allocates storage for a structure or a dimensioned structure, each member is allocated consecutive storage locations; thus the elements of the arrays NAME and POPULATION are not connected.

See Figure A–3 for an illustration of the storage of connected and unconnected arrays.

Chapter 4

Declarations

Before you can use a variable in a PL/I program, you must declare it with the DECLARE statement. When you declare a variable, you give it one of the fundamental data types by specifying its attributes; you can assign it to a storage class; and you can make it an array or structure variable.

Simple declarations define a single variable name. Multiple declarations define two or more variable names. Factored declarations define two or more variable names with the same attributes. For the formats of the various kinds of declarations, **see** "DECLARE Statement."

This chapter discusses declarations outside of procedures, initializing the values of variables in declarations, and the scope of declarations.

4.1 Declarations Outside of Procedures

In PL/I, a variable can be declared outside of any procedure. Any variable so declared will be visible within all procedures contained by the module; that is, the scope of the variable will be all procedures in the module. The format for declarations outside of procedures is the same as for other declarations except that variables can have any storage class except AUTOMATIC. If a storage class is not specified, STATIC is supplied.

The following example illustrates the use of this type of declaration.

```
    DECLARE A STATIC FIXED BINARY(31);
      .
      .
      .
FIRST: PROCEDURE;
    DECLARE B FIXED BINARY(31);
      .
      .
      .
END FIRST;

SECOND: PROCEDURE;
    DECLARE C FIXED BINARY(31);
       .
       .
       .
END SECOND;
```

In this example, variable A is visible in both the FIRST and SECOND procedures, but variables B and C are visible only in their containing procedures.

You can use the INITIAL attribute to provide an initial value for a declared variable. The value can be a string or arithmetic constant, or a scalar reference or expression, and can be specified with an iteration factor or a replication factor, or both.

Following are some examples:

```
DECLARE RATE FIXED DECIMAL (2,2) STATIC INITIAL (.04);
DECLARE EOF BIT STATIC INITIAL ('1'B);
DECLARE BELL_CHAR BINARY STATIC INITIAL ('07'B4);
DECLARE OUTPUT_MESSAGE CHARACTER(20) STATIC
           INITIAL ('GOOD MORNING');
DECLARE (A INITIAL ('A'), B INITIAL ('B'),
      C INITIAL ('C')) STATIC CHARACTER;
DECLARE QUEUE_END POINTER STATIC INITIAL(NULL());
DECLARE 1 LIST BASED,
        2 VALUE FIXED BINARY,
        2 NEXT POINTER INIT(NULL());
DECLARE TABLE (30,3) BINARY STATIC INITIAL ( (90) 10 );
```

The last example uses an iteration factor to initialize all elements of the array TABLE with the value 10.

For more information, **see** "INITIAL Attribute."

4.2 Scope of Declarations

The scope of a declaration is the region of the program in which the declared name is known. A declaration of a name is known in the following regions:

- The block in which it is declared
- Any blocks contained within the declaring block, so long as the name is not redeclared in the contained block
- Any procedures contained in the program, if the name is declared outside of all procedures

Two or more declarations of the same name are not allowed in a single block (unless one or more of the declarations are of structure members). Two declarations of the same name in different blocks denote distinct objects unless both specify the EXTERNAL attribute. All EXTERNAL declarations of a particular name denote the same variable or constant, and all must agree as to its properties. Note that EXTERNAL is supplied by default for declarations of ENTRY and FILE constants. It must be specified explicitly for variables.

See Figure S–1 for an illustration of the scope of internal names.

Declarations can appear outside of procedures and, if contained within the same block, have meaning throughout all procedures contained in the block. However, if there are multiple blocks, declarations outside of procedures must have the EXTERNAL attribute if they are to be recognized by all blocks and procedures in the program.

For example:

File A.PLI

```
   DECLARE X FIXED EXTERNAL STATIC;
A: PROCEDURE OPTIONS(MAIN);
   DECLARE B ENTRY;
      .
      .
      .
   END A;
```

File B.PLI

```
B: PROCEDURE;
     .
     .
     .
   END B;
```

In this example, the variable X has meaning in both procedures. Because the two procedures are in two different files, X must be declared with the EXTERNAL attribute. If X is declared with the INTERNAL attribute, X is recognized only in the first procedure.

Chapter 5

Expressions and Assignments

An expression is a representation of a value or of the computation of a value, and an assignment gives the value contained in an expression to a variable. Together, expressions and assignments form the mechanism for performing computation.

This chapter describes the following topics:

- The assignment statement
- Operators and operands, the elements of an expression
- The manner in which expression evaluation takes place
- Conversion of the data types of operands during expression evaluation and assignment

5.1 Assignment Statement

The assignment statement gives a value to a specified variable. The assignment operator in PL/I is the equal sign (=). The target of the assignment is on the left of the equal sign; the target receives the value of the expression on the right. For the format and detailed information, **see** "Assignment Statement" in the encyclopedic section of the manual.

Following are examples of assignment statements:

```
A = 1;
A = B + A;
SUM = A + 3;
STRING = 'word';
```

5.2 Operators and Operands

An operator is a symbol that requests a unique operation. Operands are the expressions on which operations are performed.

5.2.1 Operators

A prefix operator precedes a single operand. The prefix operators are the unary plus (+), the unary minus (−), and the logical NOT (^).

- The plus sign can prefix an arithmetic value or variable. However, it does not change the sign of the operand.
- A minus sign reverses the sign of an arithmetic operand.
- The logical NOT (^) prefix operator performs a logical NOT operation on a bit-string operand; the bit value is complemented.

Following are some examples of expressions containing prefix operators:

```
A = +55;
B = -88;
BITC = ^BITB;
```

An infix operator appears between two operands, and indicates the operation to be performed on them. PL/I has infix operators for arithmetic, logical, and relational (comparison) operations, and for string concatenations. Following are some examples of expressions containing infix operators:

```
RESULT = A / B;
IF NAME = FIRST_NAME || LAST_NAME THEN GOTO NAMEOK;
```

An expression can contain both prefix and infix operators. For example:

```
A = -55 * +88;
```

You can apply prefix and infix operators to expressions by using parentheses for grouping.

For a table giving the categories of operators and the operator symbols, **see** Table O–3, under the entry "Operator."

5.2.2 Operands

Because all operators must yield scalar values, operands cannot be arrays or structures. The data type that you can use for an operand in a specific operation depends on the operator:

- Arithmetic operators must have arithmetic operands; if the operands are of different arithmetic types, they are converted before the operation to a single type, called the derived data type. Section 5.4.1 describes this process.
- Logical operators must have bit-string operands.
- Relational operators must have two operands of the same type. (Note, however, that comparisons are allowed between offsets and pointers.)
- The operators greater than (>), less than (<), not greater than (^>), not less than (^ <), greater than or equal to (> =), and less than or equal to (<=) are valid only with computational operands.
- The concatenation operator must have two bit-string operands or two character-string operands.

5.3 Expression Evaluation

In a PL/I program, you can use expressions in the following ways:

- To indicate constant values or scalar variables. For example:

```
A = 55;
NAME = 'HECTOR';
B = A;
```

- To perform algebraic or logical calculations on variables or constants. For example:

```
B = A + 10;
C = A + B * 40;
B = ^A;
COMMON = A & B;
```

- To compare the values of two or more expressions and obtain a Boolean result. For example:

```
IF A < B THEN C = 10;
IF NAME = SAVED_NAME THEN GOTO REPEAT;
```

- To concatenate character- or bit-string values. For example:

```
NAME = FIRST_NAME||LAST_NAME;
```

All expressions except simple constants and references consist of an operator and one or more operands. Each operator requires operands of specific types (either arithmetic, character-string, or bit-string) and produces a result of a specific type. The operands can be constants, variable references, function references, or other expressions, as long as they are objects of the type required by the operator.

Built-in functions can also be considered operators in this sense, and their arguments, operands.

All VAX PL/I expressions and functions have scalar results.

Expressions are evaluated according to the precedence of operators. For a table giving the precedence of PL/I operators, **see** Table O–4, under the entry "Operator."

5.4 Conversion of Operands and Expressions

Data conversion in PL/I takes place in many contexts, not all of them obvious ones. Program results that seem improper may in fact be caused by data conversion at some point in the program's execution. This section discusses the following topics:

- How arithmetic operands of different types are converted to a single derived type during expression evaluation.
- How you can control conversions precisely by using conversion built-in functions designed for that purpose.
- Contexts in which VAX PL/I automatically converts data from one type to another—for example, in input and output by the GET and PUT statements.

5.4.1 Derived Data Types for Arithmetic Operations

Even though arithmetic operands can be of different arithmetic types, all operations will be performed on objects of the same type. Any set of operands of different arithmetic types has an associated derived type, as follows:

- If any operand has the attribute BINARY, the derived base is BINARY. Otherwise, the derived base is DECIMAL.
- If any operand has the attribute FLOAT, the derived scale is FLOAT. Otherwise, the derived scale is FIXED.

All arithmetic operations except exponentiation are performed in the derived type of the two operands. Exponential operations are performed in a data type that is based on the derived type of the operands. All operations, including exponentiation, have results of the same type as that in which they are performed.

The result of an arithmetic operation can be assigned to a target variable of any computational type. The result is converted to the target type, following the rules in Section 5.4.3. Such conversion may, however, result in a warning message from the compiler.

5.4.2 Built-In Conversion Functions

The built-in conversion functions can take arguments that are either arithmetic or string expressions. They are often used to convert an operand to the type required in a certain context—for instance, to convert a bit string to an arithmetic value for use as an arithmetic operand.

For the purpose of these functions, and in a few other contexts, derived arithmetic attributes are also defined for bit- and character-string expressions:

- The derived type of a bit string is fixed-point binary; its converted precision is 31, with a scale factor of 0.
- The derived type of a character string is fixed-point decimal; its converted precision is 31, with a scale factor of 0.

PL/I uses these derived attributes to determine the precision of values returned by the conversion functions if no precision is specified in the functions' argument lists. Note that the value of a string argument must also be convertible to the result type; for instance, '1.333' is convertible to arithmetic, but 'XYZ' is not.

Table 5–1 indicates which built-in functions you should use for each conversion between an arithmetic and a nonarithmetic type. In addition, you can use the BINARY, DECIMAL, FIXED, and FLOAT built-in conversion functions to control conversions between two arithmetic types.

Table 5–1: Built-In Functions for Conversions Between Arithmetic and Nonarithmetic Types

Conversion	Function
Arithmetic to bit	BIT
Arithmetic to character	CHARACTER
Bit to arithmetic	BINARY
Bit to character	CHARACTER
Character to bit	BIT
Character to decimal	DECIMAL
Character to float	FLOAT
Character to binary	BINARY
Character to binary	DECODE
Decimal to character	ENCODE

For more information, **see** the individual entries on the built-in functions in the encyclopedic section of this manual.

5.4.3 Implicit Conversion During Assignment

During assignment, VAX PL/I automatically converts the derived data type of an expression to the data type of a target, if necessary. In assignments, conversions are defined between the noncomputational types POINTER and OFFSET, and between any two computational types. The rules for assignments apply to the following:

- Assignment statements.
- Arguments passed to a procedure.
- Values specified in a RETURN statement.
- An argument converted by the built-in function FIXED, FLOAT, BINARY, DECIMAL, BIT, or CHARACTER.
- Conversions to and from character strings performed by the PUT and GET statements, respectively.

However, a conversion during assignment results in an error if PL/I cannot perform it in a meaningful way. For example, you can assign the string '123.4' to a fixed decimal variable; you cannot, however, assign the string 'ABCD' to the same variable. Similarly, an assignment of an arithmetic type to a fixed variable results in the FIXEDOVERFLOW condition if integral digits are lost.

Although VAX PL/I performs conversions in assignment statements, such conversions may represent programming errors and are in violation of the PL/I G subset standard. Therefore, the compiler issues a warning message that an implicit conversion is taking place. These messages do not terminate the compilation and may not indicate errors; they simply alert you to the fact that your program converts one data type to another in a way that may cause a problem when the program is run. You can prevent such warning messages in two ways:

- Use the built-in conversion functions to convert data types explicitly. This method is recommended. Section 5.4.2 summarizes the functions.
- Use the /NOWARNINGS qualifier to the PLI command to suppress diagnostic warning messages. (The compiler will continue to print messages of greater severity.) However, you run the risk of missing important diagnostic information.

For example:

```
DECLARE (A,B) FIXED DECIMAL (5,2);
    A = '123.45';              /* Warning message */
    B = FIXED('123.45',5,2);   /* No warning      */
```

Both assignment statements assign the same value to their targets; however, the first statement causes a warning message from the compiler, while the second statement does not.

Chapter 6

Procedures

A procedure is the basic executable program unit in PL/I. It consists of a sequence of statements, headed by a PROCEDURE statement and terminated by an END statement, that define an executable set of program instructions.

This chapter discusses the following topics:

- The general concepts of procedures and the statements for defining and invoking procedures and obtaining return values from them
- External procedures (procedures that are not contained within another block)

6.1 Using Procedures

Two types of procedures can be invoked by another procedure during its execution:

- Subroutines, which must be invoked with a CALL statement. Subroutines return values to the invoking procedure only by means of their parameter lists; they must not include an expression in their RETURN statements and must not include a RETURNS option on their PROCEDURE or ENTRY statements.
- Functions, which must be invoked by a function reference. A function reference can appear anywhere a scalar value can appear in a PL/I statement. A function returns to the invoking procedure a single value that becomes the value of the function reference in the invoking procedure. Functions can also return values through their parameter lists. Functions must include a RETURNS option to describe the

attributes of the returned value and must specify an expression in their RETURN statements.

Each type of procedure can be passed data from the invoking procedure by means of an argument list.

6.1.1 Statements for Procedures

The PROCEDURE statement defines the beginning of a procedure block and specifies the parameters, if any, of the procedure. If the procedure is invoked as a function, the PROCEDURE statement also specifies the data type attributes of the value that the function returns to its point of invocation. The PROCEDURE statement can denote the beginning of either an internal or an external subroutine or function.

For example:

```
PAYROLL: PROCEDURE OPTIONS(MAIN);
```

This PROCEDURE statement specifies that the entry name PAYROLL is the name of a program's main procedure.

The ENTRY statement defines an alternative entry point to a procedure.

An ENTRY statement is not allowed in a begin block, ON-unit, SELECT-group, or DO group except for a simple DO.

Additional rules governing the declaration of multiple entry points are as follows:

- A particular parameter need not be specified in all of a procedure's entry points (including the point defined by the PROCEDURE statement). However, a reference to the parameter is valid only if the procedure was invoked through one of the entries specifying the parameter.
- In a procedure with multiple entry points, a RETURN statement must be compatible with the entry point by which the procedure was invoked. If the entry point does not have a RETURNS option, the RETURN statement must not specify a return value (and, in addition, the entry point must be invoked as a subroutine—that is, with the CALL statement). If the entry point does have a RETURNS option, the RETURN statement must specify a value that is valid for conversion to the data type specified in the RETURNS option.

- An ENTRY statement is not executable. If control reaches it sequentially, control passes on to the next statement.

The following example shows a procedure with two alternate entry points:

```
QUEUES: PROCEDURE(ELEMENT,QUEUE_HEAD);
    .
    .
    .
ADD_ELEMENT: ENTRY(ELEMENT);
    .
    .
    .
REMOVE_ELEMENT: ENTRY(ELEMENT);
```

This procedure can be entered by CALL statements that reference QUEUES, ADD_ELEMENT, or REMOVE_ELEMENT. If it is invoked at QUEUES, it must be passed two parameters. At either of the entries ADD_ELEMENT or REMOVE_ELEMENT, it must be passed only one parameter. When it is entered at either alternate entry point, the entire block beginning at QUEUES is activated, but execution begins with the first executable statement following the entry point.

You should avoid unnecessary use of ENTRY statements, because their effect is detrimental to the overall optimization of the program.

The CALL statement invokes a subroutine. It transfers control to an entry point of a procedure and optionally passes arguments to the procedure.

Unless OPTIONS(VARIABLE) is specified in the declaration of an external entry name, the number of arguments must match the number of parameters in the parameter list of the invoked entry name. OPTIONS(VARIABLE) is valid only for use with non-PL/I procedures. Arguments must be enclosed in parentheses, and multiple arguments separated by commas.

The following example illustrates a main procedure, CALLER, and a call to an internal subroutine, PUT_OUTPUT. PUT_OUTPUT has two parameters, INSTRING and OUTFILE, that correspond to the arguments LINE and DEVICE specified in the CALL statement.

```
CALLER: PROCEDURE OPTIONS(MAIN);
    .
    .
    .
        CALL PUT_OUTPUT(LINE,DEVICE);
    .
    .
    .
PUT_OUTPUT: PROCEDURE(INSTRING,OUTFILE);
    .
    .
    .
END PUT_OUTPUT;
END CALLER;
```

You can terminate subroutines and functions with the following statements:

- A RETURN statement—A RETURN statement provides a normal termination for a subroutine or function. For a function, a RETURN statement must specify a return value.
- A STOP statement—A STOP statement normally ends the entire program execution. It does not pass a return value. (The STOP statement signals the FINISH condition, thereby allowing a FINISH ON-unit to execute before the program terminates.)
- An END statement—If an END statement closes the procedure block of a subroutine before a RETURN or STOP statement is executed, it has the same effect as RETURN. A function cannot be terminated without a RETURN statement.
- A nonlocal GOTO statement—A GOTO statement that transfers control to a label outside the current block terminates a subroutine or a function. The label specified on the GOTO statement must be known within the block that contains the GOTO statement, and the block containing the specified label must be active when the GOTO statement is executed.

6.1.1.1 Specifying Entry Points

The entry points of a procedure are the points at which it can be invoked. The PROCEDURE statement specifies one entry point. You can specify additional entry points with ENTRY statements within the procedure block. ENTRY statements are allowed anywhere except within a begin block, an ON-unit, or a DO group (except a simple, noniterative DO group).

The labels used on PROCEDURE and ENTRY statements declare those names as entry constants. The scope of the declarations is internal if the PROCEDURE and ENTRY statements appear in internal procedures, and external if they appear in external procedures.

You declare an entry name in the block containing the procedure to which the entry point belongs. For example:

```
P: PROCEDURE;

Q: PROCEDURE;
   DECLARE E FIXED BINARY;
   E: ENTRY;
END Q;
```

The entry names E and Q are declared in procedure P. Within procedure Q, E is declared as a fixed-point binary variable. This does not conflict with the declaration of E as an entry in procedure P.

You can invoke an entry point by using the appropriate entry constant as the reference in a CALL statement or function reference. Invoking an entry point enters a procedure at the specified point and activates the procedure block that contains the entry point.

6.1.1.2 Passing Arguments to Subroutines and Functions

You specify arguments for a subroutine or function by enclosing the arguments in parentheses after the procedure or entry point name. Arguments correspond to parameters specified on the PROCEDURE or ENTRY statement of the invoked procedure. For example, you can write a procedure call as follows:

```
CALL COMPUTER (A,B,C);
```

The variables A, B, and C are arguments to be passed to the procedure COMPUTER, which might have a parameter list like this:

```
COMPUTER: PROCEDURE (X, Y, Z);
DECLARE (X,Y,Z) FLOAT;
```

The parameters X, Y, and Z, specified in the PROCEDURE statement for the subroutine COMPUTER, are the parameters of the subroutine. PL/I establishes the equivalence of the arguments A, B, and C with the parameters X, Y, and Z.

6.1.2 Functions and Function References

A function is a procedure that returns a scalar value and that receives control when its name is referenced in an expression. There are two types of functions:

- PL/I built-in functions
- User-written functions

The built-in functions, which are available in all programs and generally need not be declared, are described in individual entries under their names, and are summarized in Table B–1, under the entry "Built-In Function".

A user-written function must have the following elements:

- The RETURNS option on the PROCEDURE statement
- A value on the RETURN statement; the value must be of a data type that is valid for conversion to the one specified on the RETURNS option

For example:

```
ADDER: PROCEDURE (X,Y) RETURNS (FLOAT);
DECLARE (X,Y) FLOAT;
        RETURN (X+Y);
        END;
```

The function ADDER has two parameters, X and Y. They are floating-point binary variables declared within the function. When the function is invoked by a function reference, it must be passed two arguments to correspond to these parameters. It returns a floating-point binary value representing the sum of the arguments. The function ADDER can be referenced as follows:

```
TOTAL = ADDER(5,6);
```

The arguments in the reference to ADDER are converted to FLOAT.

If a function has no parameters, you must specify a null argument list; otherwise, the compiler treats the reference as a reference to an entry constant. Specify a null argument list as follows:

```
GETDATE = TIME_STAMP();
```

This assignment statement contains a reference to the function TIME_STAMP, which has no parameters.

This rule applies to PL/I built-in functions as well; however, if you declare a PL/I built-in function explicitly with the BUILTIN attribute, you need not specify the empty argument list. For example:

```
DECLARE P POINTER,
        NULL BUILTIN;
    .
    .
    .
P = NULL;
```

This example assigns a null pointer value to P. Without the declaration of NULL as a built-in function, the assignment statement would have been as follows:

```
P = NULL();
```

6.1.3 RETURNS Attribute and Option

The RETURNS option must be specified on the PROCEDURE or ENTRY statement if the corresponding entry point is invoked as a function. The RETURNS attribute is specified with the ENTRY attribute, to give the data type of a value returned by an external function.

The data types you can specify for a returns descriptor are restricted to scalar elements of either computational or noncomputational types. Areas are not allowed.

The extent of a character-string value can be specified as an asterisk (*), to indicate that the string can have any length. Otherwise, you must specify extents using unsigned decimal integer constants.

The RETURNS option and RETURNS attribute must not be used for procedures that are invoked by the CALL statement.

The attributes specified in a returns descriptor of a RETURNS attribute must correspond to those specified in the RETURNS option of the PROCEDURE statement or ENTRY statements in the corresponding procedure. For example:

```
CALLER: PROCEDURE OPTIONS (MAIN);
     DECLARE COMPUTER ENTRY (FIXED BINARY)
         RETURNS (FIXED BINARY); /* RETURNS attribute */
     DECLARE TOTAL FIXED BINARY;
         .
         .
         .
     TOTAL = COMPUTER (A+B);
```

The first DECLARE statement declares an entry constant named COMPUTER, which will be used in a function reference to invoke an external procedure. The function reference must supply a fixed-point binary argument. The invoked function returns a fixed-point binary value, which then becomes the value of the function reference.

The function COMPUTER contains the following lines:

```
COMPUTER:PROCEDURE (X)
RETURNS (FIXED BINARY); /* RETURNS option */
DECLARE (X, VALUE) FIXED BINARY;
    .
    .
    .
RETURN (VALUE);
```

In the PROCEDURE statement, COMPUTER is declared as an external entry constant, and the RETURNS option specifies that the procedure returns a fixed-point binary value to the point of invocation. The RETURN statement specifies that the value of the variable VALUE is returned by COMPUTER. If the data type of the returned value does not match the one specified in the RETURNS option, PL/I converts the value to the correct data type.

6.1.4 Parameters and Arguments

A parameter is a variable that occurs in the parameter list of a PROCEDURE or ENTRY statement. When the entry point is invoked, each parameter in the list is associated with an argument variable. Within the procedure invocation, any reference to the parameter is equivalent to a reference to the associated argument variable.

If the invoked entry point is external to the invoking procedure, the attributes of the parameters must be described in parameter descriptors, which are part of the declaration of the external entry point.

Each entry point in a procedure must have a parameter list if that entry point is to be invoked with an argument list. Multiple entry points in a procedure do not need to have identical parameters, but a reference to a parameter is valid only if the procedure was invoked through an entry point that specified that parameter.

An argument is an expression or variable reference denoting a value to be passed to the invoked procedure. A procedure must be invoked with the same number of arguments as it has parameters; the maximum number is 253. The argument variable associated with a parameter, or "actual argument," can be a variable written in the argument list or a dummy argument. The compiler creates a dummy argument when the specified argument is a constant or expression existing only for the duration of the procedure invocation. Therefore, references in the invoked procedure to the parameter associated with a dummy argument do not modify any storage in the invoking procedure.

An argument list consists of zero or more arguments specified in the invocation of a procedure, built-in function, or built-in subroutine. In the case of built-in functions, arguments are expressions that supply values to the built-in function, and the argument types must be those required by it. In the case of user-defined procedures, arguments correspond to parameters defined on the PROCEDURE or ENTRY statement of the invoked procedure.

6.1.4.1 Rules for Specifying Parameters

The general rules listed below for specifying parameters are followed by specific rules that pertain only to certain data types.

- You must declare a parameter explicitly in a DECLARE statement (to give it a data type) within the invoked procedure. This declaration must not be part of a structure.
- You cannot declare a parameter with any of these attributes:

AUTOMATIC	EXTERNAL	READONLY
BASED	GLOBALDEF	STATIC
CONTROLLED	GLOBALREF	
DEFINED	INITIAL	

- A maximum of 253 parameters can be specified for an entry point.
- The parameters of an external entry must be explicitly specified by parameter descriptors in the declaration of the entry constant. The parameters of a procedure that is invoked through an entry variable must be specified by parameter descriptors in the ENTRY attribute of the variable's declaration. You cannot declare an internal entry (and its parameters) in the containing procedure.
- Each parameter must have a corresponding argument at the time of the procedure's invocation. PL/I matches the data type of the parameter with the data type of the corresponding argument and creates a dummy argument if they do not match.

Array Parameters

If the name of an array variable is passed as an argument, the corresponding parameter descriptor or parameter declaration must specify the same number of dimensions as the argument variable. You can declare the bounds of a dimension for an array parameter using asterisks (*) or optionally signed integer constants. If the bounds are specified with integer constants, they must match exactly the bounds of the corresponding argument. An asterisk indicates that the bounds of a dimension are not known. (If one dimension contains an asterisk, all the dimensions must contain asterisks.) For example:

```
DECLARE SUMUP ENTRY ((*) FIXED BINARY);
```

This declaration indicates that SUMUP's argument is a one-dimensional array of fixed-point binary integers that can have any number of elements. Any one-dimensional array of fixed-point binary integers can be passed to this procedure.

All the data type attributes of the array argument and parameter must match.

Arrays are always passed by reference. They cannot be passed by dummy argument.

Structure Parameters

If the name of a structure variable is passed as an argument, the corresponding parameter descriptor or declaration must be identical, in terms of structure levels, members' sizes, and members' data types. The level numbers do not have to be identical, but the levels must be logically equivalent. You can specify array bounds and string lengths with asterisks or with optionally signed integer constants. The following example shows the parameter descriptor for a structure variable:

```
DECLARE SEND_REC ENTRY (1,
                        2 FIXED BINARY(31),
                        2 CHARACTER(40) VARYING,
                        2 PICTURE '999V99');
```

The written argument in the invocation of the external procedure SEND_REC must have the same structure, and its members must have the same data types.

Structures are always passed by reference. They cannot be passed by dummy argument.

Character-String Parameters

If a character-string variable is passed as an argument, the corresponding parameter descriptor or parameter declaration can specify the length using an asterisk (*) or an optionally signed nonnegative integer constant. For example:

```
COPYSTRING: PROCEDURE (INSTRING,COUNT);
DECLARE INSTRING (CHARACTER(*));
```

The asterisk in the declaration of this parameter indicates that the string can have any length. The string is fixed length unless VARYING is also included in the declaration.

Entry, File, and Label Constant Parameters

Entry, file, and label constants can be passed as arguments. The actual parameter is a variable.

6.1.4.2 Argument Passing

This section describes how PL/I passes an argument to procedures written in PL/I.

Number of Arguments

The number of arguments in the argument list must equal the number of parameters of the invoked entry point. The compiler checks that the count matches as follows:

- For an internal procedure, the compiler checks the number of arguments in the argument list against the number of parameters on the PROCEDURE or ENTRY statement for the internal procedure.
- For an external procedure, the compiler checks that the number of parameter descriptors in the ENTRY declaration list matches the number of arguments in the procedure invocation.

Actual Arguments

When a PL/I procedure is invoked, each of its parameters is associated with a variable determined by the corresponding written argument of the procedure call. This variable is the actual argument for this procedure invocation. It can be one of the following:

- A reference to the written argument
- A dummy argument

The data type of the actual argument is the same as that of the corresponding parameter. When a written argument is a variable reference, PL/I matches the variable against the corresponding parameter's data type according to the rules given under the heading "Argument Matching," below. If they match, the actual argument is the variable denoted by the written argument. That is, the parameter denotes the same storage as the written variable reference. If they do not match, the compiler creates a dummy argument and assigns to it the value of the written argument.

Dummy Arguments

A dummy argument is a unique variable allocated by the compiler, which exists only for the duration of the procedure invocation.

When the written argument is a constant or an expression, the actual argument is always a dummy argument. The value of the written argument is assigned to the dummy argument before the call. The data type of the written argument must be valid for assignment to the data type of the dummy argument.

Aggregate Arguments

An array, structure, or area argument must be a variable reference that matches the corresponding parameter. It cannot be a reference to an unconnected array. A dummy argument is never created for an array, structure, or area.

Argument Matching

A written argument that is a variable reference is passed by reference only if the argument and the corresponding parameter have identical data types:

- For an internal procedure, the attributes of the argument must match those specified in the declaration of the parameter.
- For an external procedure or a procedure invoked through an ENTRY variable, the attributes specified in the ENTRY attribute parameter descriptor must match those of the arguments.

When the compiler detects that a scalar variable argument does not match the data type of the corresponding parameter, it issues a warning message, creates a dummy argument, and associates the address of the dummy argument with the corresponding parameter. You can suppress the warning message and force the creation of a dummy argument if you enclose the argument in parentheses. For example, if a parameter requires a character varying string and an argument is a character nonvarying variable, you would enclose the variable in parentheses.

For string lengths and array bounds, an asterisk (*) in the parameter matches any expression. An integer constant matches only an integer constant with the same value.

Conversion of Arguments

When the data type of a written argument is suitable for conversion to the data type of the corresponding parameter descriptor, PL/I performs the conversion of the argument to a dummy argument using the rules described in Section 5.4.3.

6.2 Calling External Procedures

An external procedure is one whose text is not contained in any other block. The source text of an external procedure can be compiled separately from that of a calling procedure. The differences between internal and external procedures are as follows:

- Before an external procedure can be invoked (except through an entry variable), its name must be declared within the procedure that invokes it. The DECLARE statement for the external entry name must also provide a list of parameter descriptors that give the data types of the parameters that the procedure requires, if any, as well as a RETURNS attribute for a function procedure.

  You cannot explicitly declare internal procedures. The procedure name is implicitly declared by its occurrence in the PROCEDURE or ENTRY statement.
- External procedures can reference the same variable only if it is declared with the EXTERNAL attribute in all of them.

  An internal procedure, on the other hand, can reference internal variables declared in any procedure in which it is contained.
- Any procedure can call an external procedure.

  An internal procedure can be called only by the procedure that contains it or by other procedures at the same level of nesting within the containing procedure. The only exception is invocation through an entry variable.

The following example illustrates the use of an external procedure:

```
WINDUP: PROCEDURE;
    .
    .
    .
DECLARE PITCH EXTERNAL ENTRY (CHARACTER(15) VARYING,
                              FIXED BINARY(7) );
    .
    .
    .
CALL PITCH (PLAYER_NAME,NUMBER_OF_OUTS);
```

The procedure WINDUP declares the procedure PITCH with the EXTERNAL and ENTRY attributes. The text of PITCH is in another source program that is separately compiled. When the object module that contains WINDUP is linked, the linker must be able to locate the object module that contains PITCH. You can accomplish this by including both object modules in the LINK command line, or by placing PITCH in an object module library and including the library in the LINK command line.

When a CALL statement or function reference invokes an entry point in an external procedure, the entry constant must be declared with the ENTRY attribute, as in the example above. Such a declaration must also describe the parameters for that entry point, if any. For example:

```
DECLARE PITCH ENTRY (CHARACTER(*), FIXED BINARY(15));
```

The identifier PITCH is declared as an entry constant. When the procedure containing this declaration is linked to other procedures, one of them must define an entry point named PITCH as the label either of a PROCEDURE statement or an ENTRY statement. If the linker cannot locate an external entry point, it issues a warning message.

The parameter descriptors define the data types of the parameters for the entry point PITCH. Arguments of these types must be supplied when PITCH is invoked.

If PITCH is to invoke a function, the DECLARE statement must also include a RETURNS attribute describing the attributes of the returned value, as follows:

```
DECLARE PITCH ENTRY (CHARACTER(*), FIXED BINARY(15))
    RETURNS(FIXED);
```

Within the scope of this DECLARE statement, the entry constant PITCH must be used in a function reference. The function reference will invoke the external entry point, and a returned fixed-point binary value will become the value of the function reference.

A PL/I program can invoke an external procedure that is not written in PL/I. A common instance is the use of a VMS system service by a PL/I program to obtain some system function not available directly through PL/I. Or, a PL/I program can invoke an external procedure written in another language that provides an application-specific function. Such instances are possible because of the VAX Procedure Calling and Condition Handling Standard, which includes a set of conventions for passing arguments among procedures.

6.2.1 Entry Data

Entry constants and variables invoke procedures through specified entry points. An entry value specifies an entry point and a block activation of a procedure.

No conversions are defined between entry data and other data types. An entry variable can be assigned only the value of an entry constant or the value of another entry variable. The only valid operations for entry data are comparisons for equality (=) and inequality (^=); two entry values are equal if they refer to the same entry point in the same block activation.

6.2.1.1 Entry Constants

You declare entry constants implicitly when you write labels on PROCEDURE or ENTRY statements.

Internal entry constants are declared by writing labels on PROCEDURE or ENTRY statements whose procedure blocks are nested in another block. An internal entry constant can be used anywhere within the containing block to invoke its procedure block. You cannot explicitly declare an internal entry constant in the containing block.

You declare external entry constants by writing labels on PROCEDURE or ENTRY statements that belong to external procedures, and by explicitly declaring the name with the ENTRY attribute in the calling procedure. You can use an external entry constant to invoke its procedure block from any program location within its scope, which is either the scope of its declaration (as a label in the external procedure) or the scope of a DECLARE statement for the constant (in the calling procedure).

The declaration of an external entry constant gives the compiler the information it needs to invoke a separately compiled procedure. The declaration must agree with the actual entry point: it must contain parameter descriptors for any parameters specified at the entry point; and, if the entry constant is to be used in a function reference, the declaration must have a returns descriptor describing the returned value.

The following example declares the external entry constant COPYSTRING:

```
DECLARE COPYSTRING ENTRY (CHARACTER (40) VARYING,
                          FIXED BINARY(7))
        RETURNS (CHARACTER(*));
```

This entry has two parameters: a varying-length character string with a maximum length of 40 and a fixed-point binary value. The RETURNS attribute indicates that COPYSTRING is invoked as a function and that it returns a character string with any length. COPYSTRING might look like this:

```
COPYSTRING: PROCEDURE (INSTRING, ITERATIONS)
        RETURNS (CHARACTER (*));
DECLARE INSTRING CHARACTER (40) VARYING,
        ITERATIONS FIXED BINARY (7),
        OUTSTRING CHARACTER (40);
            .
            .
            .
        RETURN (OUTSTRING);
        END;
```

6.2.1.2 Entry Variables

Entry variables are variables (including parameters) that take entry values. If you specify the VARIABLE attribute with the ENTRY attribute in a DECLARE statement, or if the declared identifier occurs in a parameter list, the declared identifier is an entry variable. You can assign an entry constant to an entry variable, or you can assign to it the value of another entry variable.

When you use an entry variable to invoke a procedure, its declaration must agree with the definition of the entry point: the parameter descriptor for the entry variable must match the parameter descriptor on the declaration of the entry constant.

The scope of an entry variable name can be either INTERNAL or EXTERNAL. If you specify neither, the default is INTERNAL.

You can use an entry variable to represent different entry points during the execution of the PL/I program. For example:

```
DECLARE E ENTRY (FIXED BINARY (7)) VARIABLE,
        (A,B) ENTRY (FIXED BINARY (7));

        E = A;
        CALL E (10);
```

The entry constant A is assigned to the entry variable E. The CALL statement results in the invocation of the external entry point A.

6.2.2 Passing Arguments to Non-PL/I Procedures

There are three ways that a PL/I procedure can pass an argument to a non-PL/I procedure:

- By immediate value. The actual value of the argument is passed.
- By reference. The address in storage of the argument is passed.
- By descriptor. The address in storage of a data structure describing the argument is passed.

The following sections describe the requirements for each of these argument-passing mechanisms.

6.2.2.1 Passing Arguments by Immediate Value

To pass an argument by immediate value, use the VALUE attribute in a parameter description. The following declaration of the external entry VHF illustrates a declaration for an external routine that receives its parameter by immediate value.

```
DECLARE VHF ENTRY (FIXED BINARY(31) VALUE);
```

You can also define PL/I procedures that receive arguments by immediate value. To do this, you must specify the VALUE attribute in the declaration of the parameter. For example, the corresponding definition of the procedure VHF would be as follows:

```
VHF: PROCEDURE (LENGTH);
.
.
DECLARE LENGTH FIXED BINARY(31) VALUE;
.
```

Arguments that can be passed by immediate value are limited to the following data types, which can be expressed in 32 bits:

- FIXED BINARY(m), where m <= 31
- FLOAT BINARY(n), where n <= 24
- BIT(o) ALIGNED, where o <= 32
- ENTRY
- OFFSET
- POINTER

VAX PL/I supports the passing of external procedures, but not internal procedures, as entry value parameters. To pass an internal procedure, use an entry parameter.

When you specify the VALUE attribute in a parameter descriptor, you can specify the ANY attribute instead of declaring any data type attributes. For example, the declaration of SYS$SETEF can appear as follows:

```
DECLARE SYS$SETEF ENTRY (ANY VALUE);
```

At the time of the procedure's invocation, PL/I converts the written argument as needed to create a longword dummy argument.

You can use the VALUE built-in function to force an argument to be passed by immediate value to a non-PL/I procedure, regardless of the declaration of the formal parameter. (**See** the entry "VALUE Built-In Function".)

6.2.2.2 Passing Arguments by Reference

By default, PL/I passes all arguments by reference except character strings and arrays with nonconstant extents. The parameter descriptor for an argument to be passed by reference need specify only the data type of the parameter.

For example, the Read Event Flags (SYS$READEF) system service requires that its first argument be passed by immediate value and its second by reference. You could declare this procedure as follows:

```
DECLARE SYS$READEF ENTRY (FIXED BINARY(31) VALUE,
                          BIT (32) ALIGNED);
```

When the procedure is invoked, the second argument must be a variable declared as BIT(32) ALIGNED. PL/I passes the argument by reference.

An argument of any data type can be passed by reference. Bit-string variables, however, must have the ALIGNED attribute.

The data types in the parameter descriptors of all output arguments must match the data types of the written arguments. For convenience, you can specify ANY in the parameter descriptor. To describe an argument to be passed by reference, you can specify the ANY attribute without the VALUE attribute. When you specify ANY for an argument to be passed by reference, you cannot specify data type attributes. Note that if you specify the VALUE attribute in conjunction with the ANY attribute, PL/I passes the argument by immediate value.

The ANY attribute is especially useful when you must specify a data structure as an argument. You need not declare the structure within the parameter descriptor, only the ANY attribute.

When an argument is passed by reference, PL/I passes the address of the actual argument. This address can be interpreted as a pointer value; you can explicitly specify a pointer value as an argument for data to be passed by reference. For example:

```
DECLARE SYS$READEF (ANY VALUE, POINTER VALUE),
        FLAGS BIT(32) ALIGNED;

CALL SYS$READEF (4, ADDR(FLAGS));
```

At this procedure invocation, PL/I places the pointer value returned by the ADDR built-in function directly in the argument list.

6.2.2.3 Passing Arguments by Descriptor

A descriptor is a structure that describes the data type, extents, and address of a data item. When passing an argument by descriptor, PL/I creates the descriptor and places its address in the argument list for the called procedure.

PL/I passes arguments by descriptor when a parameter descriptor specifies the following:

- A character string with an asterisk length or an array with asterisk extents
- An unaligned bit string or an array or structure consisting entirely of unaligned bit strings
- A structure containing any strings or arrays with asterisk extents
- ANY without VALUE, and the corresponding written argument is specified with the DESCRIPTOR built-in function

For example, PL/I passes by descriptor the arguments associated with the following parameter descriptors:

```
DECLARE UNSTRING ENTRY (CHARACTER(*)),
        TESTBITS ENTRY (BIT(3)),
        MODEST ENTRY (1,
                      2 CHARACTER(*),
                      2,
                        3 BIT(3),
                        3 BIT(3));
```

When you declare a non-PL/I procedure that requires a character-string descriptor for an argument, specify the parameter descriptor as CHARACTER(*). For example, the Set Process Name (SYS$SETPRN) system service requires the address of a character-string descriptor as an argument. You can declare this service as follows:

```
DECLARE SYS$SETPRN ENTRY (CHARACTER(*));
```

When a parameter is declared as CHARACTER(*), its written argument can be one of the following:

- A character-string constant or expression.
- A fixed-length character-string variable.
- A varying character-string variable or a variable declared as CHARACTER(*)VARYING.

For any of those arguments, PL/I constructs a character-string descriptor and passes its address.

To force an argument to be passed by descriptor, use the DESCRIPTOR built-in function. For example:

```
DECLARE P ENTRY (ANY);
DECLARE (X,Y) FIXED DECIMAL (7,2);

CALL P(DESCRIPTOR (X));
CALL P(Y);
```

Here, X is passed by descriptor as specified by the DESCRIPTOR built-in function. Y is passed by reference. (**See** the entry "DESCRIPTOR Built-In Function.")

Chapter 7

Program Control

The statements described in this chapter allow your program to repeat sequences of operations, to transfer control or select operations based on the result of a test, and to terminate. They are the DO, BEGIN, END, IF, SELECT, GOTO, LEAVE, STOP, and null statements.

7.1 DO Statement

The DO statement defines the beginning of a sequence of statements to be executed in a group. The group ends with the nonexecutable statement END. DO-groups have several formats, which are described individually in this section:

- Simple DO
- DO WHILE
- DO UNTIL
- Controlled DO
- DO REPEAT

7.1.1 Simple DO

A simple DO statement is noniterative. The statements that appear between the DO statement and its corresponding END statement are executed once, after which control passes to the next executable statement in the program.

For example:

```
IF A < B THEN DO;
   PUT LIST ('More data needed');
   GET LIST (VALUE);
   A = A + VALUE;
   END;
```

The most common use of the simple DO statement is as the action of the THEN clause of an IF statement, as shown above, or of an ELSE option.

7.1.2 DO WHILE

A DO WHILE statement executes a group of statements as long as a particular condition is satisfied. When the condition is not true, the group is not executed and control passes to the next executable statement in the program, after the END statement that terminates the group. A test expression is evaluated before each execution of the DO-group. It must have a true value in order for the DO-group to be executed even once.

The following examples illustrate the use of the DO WHILE statement.

```
DO WHILE (A < B);
    .
    .
    .
END;
```

This DO-group executes as long as the value of the variable A is less than the value of the variable B.

```
DO WHILE (LIST->NEXT ^= NULL());
    .
    .
    .
END;
```

This DO-group executes while a forward pointer in a linked list has a value.

```
DECLARE EOF BIT(1) INITIAL('0'B);
   .
   .
   .
ON ENDFILE(INFILE) EOF = '1'B;

DO WHILE (^EOF);
        READ FILE(INFILE) INTO(INREC);
   .
   .
   .
END;
```

This DO-group reads records from the file INFILE until the end of the file is reached. At the beginning of each iteration of the DO-group, the expression ^EOF is evaluated; the expression is true until the ENDFILE ON-unit sets the value of EOF to '1'B.

7.1.3 DO UNTIL

A DO UNTIL statement executes a group of statements until a particular condition is satisfied. That is, while the condition is false, the group is repeated.

The DO WHILE and the DO UNTIL statements differ in that the WHILE option tests the value of the test expression at the beginning of the DO-group, whereas the UNTIL option tests the value of the test expression at the end of the DO-group. Therefore, a DO-group with the UNTIL option will always be executed at least once, but a DO-group with the WHILE option may never be executed.

The following examples illustrate the use of the DO UNTIL statement.

```
DO UNTIL (K<ALPHA);
    .
    .
    .
END;
```

This DO-group is executed at least once and then repeats as long as the value of the variable K is greater than or equal to the value of the variable ALPHA.

```
DO UNTIL (LIST ->NEXT = NULL())
    .
    .
    .
END;
```

This DO-group is executed until a forward pointer in a linked list has a null value.

```
DECLARE STR BIT (8) CONTROLLED;
   .
   .
   .
ALLOCATE  STR;  /* 1st allocation */
   .
   .
   .
ALLOCATE STR;   /* nth allocation */
   .
   .
   .
DO UNTIL (ALLOCATION(STR)=0);
   PUT SKIP LIST (STR);
   FREE STR;
   END;
END;
```

This DO-group frees bit strings from storage until all generations have been released. Because the UNTIL option is always executed at least once, at least one generation must be allocated; otherwise, the ERROR condition is raised. At the end of each repetition of the DO-group, the status of the generations is checked with the ALLOCATION built-in function. A null string terminates the execution of the group and passes control to the next executable statement after the first END statement.

7.1.4 Controlled DO

A controlled DO statement identifies a variable whose value controls the execution of the DO-group, and defines the conditions under which the control variable is to be modified and tested. When the value of the control variable exceeds the specified end value, control passes out of the DO-group. A WHILE or UNTIL clause can also be included. The WHILE expression is evaluated before each iteration, including the first, but after assignment to the control variable. The UNTIL expression is evaluated after each iteration, including the first, but before assignment to the control variable.

A controlled DO statement that does not specify a TO or BY option results in a single iteration of the following DO-group. Because there is no TO or BY expression to change the value of the variable, the DO-group will not be executed again.

The following examples illustrate the controlled DO statement.

```
DO I = 2 TO 100 BY 2;
    .
    .
    .
END;
```

This DO-group executes 50 times, with values for I of 2, 4, 6, and so on.

```
DO I = LBOUND(ARRAY,1) TO HBOUND(ARRAY,1);
    .
    .
    .
END;
```

This DO-group executes as many times as there are elements in the array variable ARRAY, using the subscript values of the array's elements.

```
DO I = 1 BY 1 WHILE (X < Y);
    .
    .
    .
END;
```

This DO-group continues executing with successively higher values for I until the value of the variable X equals or is greater than the value of the variable Y.

```
DO I = 1 BY -1 UNTIL (X < Y);
    .
    .
    .
END;
```

This DO-group continues executing with successively lower values for I while the value of the variable X is equal to or greater than the value of the variable Y.

7.1.5 DO REPEAT

The DO REPEAT statement executes a DO-group repetitively for different values of a variable. The variable is assigned a start value that is used on the first iteration of the group. The REPEAT expression is evaluated before each subsequent iteration, and its result is assigned to the variable. A WHILE clause can be included; if it is, the WHILE expression is evaluated before each iteration, including the first, but after assignment to the variable. An UNTIL clause can also be included; the UNTIL expression is evaluated after each iteration.

If the WHILE and UNTIL options are omitted, the DO REPEAT statement specifies no means for terminating the group; the execution of the group then must be terminated by a statement or condition occurring within the group, such as a GOTO statement, a LEAVE statement, or an ENDFILE condition.

The following examples illustrate the use of the DO REPEAT statement.

```
DO LETTER='A' REPEAT (BYTE(I));
```

Here, the group will be repeated with an initial LETTER value of 'A' and with subsequent values assigned by the built-in function BYTE(I). The variable I can be assigned new values within the group. The group will iterate endlessly unless terminated by a statement or condition within the group.

```
DO I = 1 REPEAT (I + 2) WHILE ( I <= 100 );

DO I = 1 TO 100 BY 2;
```

The first of these two examples is a DO REPEAT statement, and the second is a controlled DO statement. The two statements would have the same effect.

```
DO P = LIST_HEAD REPEAT (P->LIST.NEXT)
    WHILE ( P ^= NULL() );
```

This example illustrates the manipulation of lists, which is the most common use of DO REPEAT. The pointer P is initialized with the value of the pointer variable LIST_HEAD. The DO-group is executed with this value of P. The REPEAT option specifies that, each time control reaches the DO statement after the first execution of the DO-group, P is to be set to the value of LIST.NEXT in the structure currently pointed to by P.

WHILE and UNTIL can be used in combination to check the status of a DO-group both before and after execution.

7.2 BEGIN Statement

The BEGIN statement denotes the start of a begin block. A begin block is a sequence of statements headed by a BEGIN statement and terminated by an END statement. A begin block can be used wherever a single executable statement is valid, for instance, in an ON-unit. The statements in a begin block can be any PL/I statements, and begin blocks can contain DO-groups, DECLARE statements, procedures, and other (nested) begin blocks.

A begin block provides a convenient way to localize variables. Variables declared as internal within a begin block are not allocated storage until the block is activated. When the block terminates, storage for internal automatic variables is released. A begin block terminates in the following situations:

- When its corresponding END statement is encountered. Control continues with the next executable statement in the program.
- When it executes a nonlocal GOTO to transfer control to a previous block.
- When it executes a RETURN statement.

A begin block differs from a DO-group chiefly in its ability to localize variables. Variables declared within DO-groups are not localized to the group (unless the group contains a begin block or procedure that declares internal variables). Begin blocks are preferable when you want to restrict the scope of variables. Furthermore, there are some cases (such as ON-units) in which DO-groups cannot be used. Otherwise, DO-groups are often more efficient, because they do not have the overhead associated with block activation. In general, you should use a DO-group instead of a begin block unless there are declarations present or you require multiple statements in an ON-unit.

A begin block can designate a series of statements to be executed depending on the success or failure of a test in an IF statement. For example:

```
IF A = B THEN BEGIN ;
   .
   .
   .
   END;
```

A begin block also provides the only way to denote a series of statements to be executed when an ON condition is signaled. For example:

```
ON ERROR BEGIN;
    [statement ...]
    END;
```

7.3 END Statement

The END statement marks the end of the block or group headed by the most recent BEGIN, DO, SELECT, or PROCEDURE statement.

Note that a procedure invoked as a function must execute a RETURN statement before it encounters the END statement marking the end of the procedure.

When the END statement is encountered, one of the following actions is performed, depending on the type of block or group that it terminates:

- When an END statement denotes the end of a procedure, the procedure is terminated. The storage allocated for the block is released, and all automatic variables are made inaccessible. If the current procedure is the main or only procedure, the program terminates. Otherwise, control returns to the statement following the CALL statement that invoked the procedure.
- When an END statement denotes the end of a begin block, the block is terminated. Storage allocated for the block is released, and all automatic variables are made inaccessible. Control passes to the next executable statement.
- When an END statement denotes the end of a DO-group, control returns either to the DO statement that heads the group or to the next executable statement following the END statement. If the DO-group is headed by a simple DO, that is, one that causes the DO-group to be executed only once, control passes to the next executable statement. Otherwise, control returns to the head of the DO-group, where the control variable or expression is tested.

7.4 IF Statement

The IF statement tests an expression and performs the action specified after the keyword THEN if the result of the test is true. If it is not true, the action following THEN is not executed, and control goes to the ELSE clause, if it exists, or to the next executable statement.

The following examples illustrate the use of the IF statement.

```
IF A < B THEN BEGIN;
```

The begin block after this statement is executed if the value of the variable A is less than the value of the variable B.

```
IF ^SUCCESS THEN
        CALL PRINT_ERROR;
     ELSE
        CALL PRINT_SUCCESS;
```

The IF statement defines action to be taken if the variable SUCCESS has a false value (the THEN clause) and an action to be taken otherwise (the ELSE clause).

```
IF ABC
   THEN IF XYZ
           THEN GOTO GBH;
      ELSE GOTO THESTORE;
   ELSE GOTO HOME;
```

You can nest IF statements; that is, the action specified in a THEN or an ELSE clause can be another IF statement. An ELSE clause is matched with the nearest preceding IF/THEN that is not itself matched with a preceding ELSE. Here, the first ELSE clause is executed if ABC is true and XYZ is false. The second ELSE clause is executed if ABC is false.

```
IF ABC
   THEN IF XYZ THEN GOTO HOME;
        ELSE;
   ELSE GOTO THESTORE;
```

In some cases, proper matching of IF and ELSE may require a null statement as the target of an ELSE. Here, the ELSE GOTO THESTORE statement is executed if ABC is false.

7.5 SELECT Statement

The SELECT statement tests a series of expressions and performs a specified action depending on the result of the test. The statement has two forms: in the first form, the expressions are tested for truth or falsity; in the second form, the expressions are tested to see whether any or all have the same value as another, specified expression (here called the "select-expression"). Any of the expressions can be, but need not be, constants. An optional OTHERWISE clause is available to name an action to be performed if none of the preceding expressions have satisfied the condition specified.

The two forms of the SELECT statement and the OTHERWISE clause are described in detail in the entry "SELECT Statement".

The following examples illustrate the use of the SELECT statement.

```
SELECT;
    WHEN ANY (A=10,A=20,A=30) B=B+1;
    WHEN (A=50) B=B+2;
    WHEN (A=60) B=B+3;
    WHEN (A=70) B=B+4;
    WHEN (A=80) B=B+5;
    WHEN (A=90) B=B+6;
    WHEN ALL (A>90,A<500) B=B+10;
    OTHERWISE B=B+C;
END;
```

The SELECT statement defines the action to be taken (B=B+1) if the variable A has any of the values specified in the WHEN ANY clause; failing that, the succeeding WHEN clauses are evaluated until one of them is found to be true, causing the specified action to be taken; failing that, the WHEN ALL clause is tested, causing its action to be taken if A is both greater than 90 and less than 500. If none of the WHEN clauses' conditions is true, the action specified in the OTHERWISE clause (B=B+C) is executed.

```
SELECT(A);
    WHEN  (50) C=C+1;
    WHEN ANY (60,61,62,B+C) C=C+2;
    WHEN ALL (70,D) C=C+3;
    OTHERWISE C=C+D;
END;
```

This example is a SELECT statement with a select-expression specified after the keyword SELECT.

The SELECT statement defines the action to be taken if the select-expression (A in the example) evaluates to any (or all) of the values of the expressions following a WHEN clause. The first action (the assignment statement C=C+1) will be executed if A has a current value of 50. In that case, none of the subsequent WHEN clauses will be evaluated. The second WHEN clause includes the ANY keyword, and so the second action will be executed if A evaluates to or equals 60 or 61 or 62 or the sum of B and C. If neither the first nor the second action is executed, the third WHEN clause's expressions are tested. The third WHEN clause includes the ALL keyword, so the third action will be executed only if A equals both 70 and D. If none of the WHEN clauses causes an action to be executed, then the action in the OTHERWISE clause (the assignment statement C=C+D) will be executed.

7.6 GOTO Statement

The GOTO statement causes control to be transferred to a labeled statement in the current or any outer procedure. A label denotes a statement in the program and a block activation. The specified label cannot be the label of an ENTRY, FORMAT, or PROCEDURE statement.

If the specified label value is not in the current block, the GOTO statement is considered nonlocal. The following can occur:

- The current block, and any blocks intervening between it and the block containing the label value, are released. This rule applies to procedure blocks and begin blocks.
- If a GOTO statement transfers control out of a procedure that is invoked in a function reference, the statement containing the function reference is not evaluated further.

A label consists of any valid identifier terminated by a colon. A name occurring as a statement label is implicitly declared as a label constant, with the attributes LABEL and constant. Label constants cannot be explicitly declared.

The following restrictions apply to the use of labels and label data:

- No statement can have more than one label. However, an executable statement can be preceded by any number of labeled null statements, which have the same effect as would multiple labels.
- Operations on label values are restricted to the operators = and ^=, for testing equality or inequality. Two values are equal if they refer to the same statement in the same block activation.

- Any statement in a PL/I program can be labeled except the following:
  - A DECLARE statement
  - A statement beginning an ON-unit, THEN clause, ELSE clause, WHEN clause, or OTHERWISE clause
- Labels on PROCEDURE, ENTRY, and FORMAT statements are not considered statement labels and cannot be used as the targets of GOTO statements.
- An identifier occurring as a label in a block cannot be declared in that block (except as a structure member) or occur in the block's parameter list.
- Any reference to a label value after its block activation terminates is an error with unpredictable results.

The following example demonstrates the use of the GOTO statement:

```
ON ERROR GOTO ERROR_MESSAGE;
```

The GOTO statement provides a transfer address for the current procedure when the ERROR condition is signaled.

The following subsections describe label array constants, which allow you to write labels with constant subscripts, and label variables, which can be assigned values and then used in GOTO statements to provide flexibility.

7.6.1 Label Array Constants

Any label constant except the label of a PROCEDURE or FORMAT statement can have a single subscript. You must specify subscripts with integer constants or constant identifiers, which must appear in parentheses following the label name. For example:

```
PART(1):
    .
    .
    .
PART(2):
    .
    .
    .
```

When labels are written this way, the unsubscripted label name represents the implicit declaration of a label array constant. In this example, the array is named PART and is treated as if it were declared within the block containing the subscripted labels. Elements of this array can be referenced in GOTO statements that specify a subscript. For example:

```
GOTO PART(I);
```

I is a variable whose value represents the subscript of the element of PART that is the label to be given control.

7.6.2 Label Variables

When an identifier is explicitly declared with the LABEL attribute, it acquires the VARIABLE attribute by default. Such a variable can be used to denote different label values during the execution of the program. The following examples demonstrate the use of label variables.

```
DECLARE PROCESS LABEL;
   .
   .
   .
   IF CODE THEN
      PROCESS = BILLING;
   ELSE
      PROCESS = CHARGE;
   .
   .
   .
GOTO PROCESS;
```

When the GOTO statement evaluates the reference to the label PROCESS, the result is the current value of the variable. The GOTO statement transfers control to either of the labels BILLING or CHARGE, depending on the current value of the Boolean variable CODE.

```
%REPLACE REMOVE_TEXT BY 2;
   .
   .
   .
DECLARE PROCESS(5) LABEL VARIABLE;
   .
   .
   .
GOTO PROCESS(REMOVE_TEXT);
```

The GOTO statement evaluates the label reference and transfers control to the label constant corresponding to the second element of the array PROCESS. PROCESS consists of label variables.

7.7 LEAVE Statement

The LEAVE statement causes control to be transferred out of the immediately containing DO-group or out of the containing DO-group whose label is specified with the statement. The label reference can be a label constant or a subscripted label constant for which the subscript is specified with an integer constant. The label reference cannot be a label variable, nor can it be a subscripted label constant for which the subscript is specified with a variable.

When it is executed, a LEAVE statement with no label reference causes control to be transferred to the first statement following the END statement that terminates the immediately containing DO-group. If the LEAVE statement has a label, control is passed to the first executable statement following the end statement for the corresponding label indicated in the LEAVE statement. Thus, the LEAVE statement provides an alternative means of terminating execution of a DO-group. In the case of a LEAVE statement with a label reference, several nested DO-groups can be terminated as control is transferred outside the referenced DO-group.

The following restrictions apply to the use of the LEAVE statement:

- A LEAVE statement must be contained within a DO-group.
- A LEAVE statement must be in the same block as the DO statement to which it refers.
- A LEAVE statement label reference must refer to a label on a DO statement that heads a DO-group containing the LEAVE statement. The LEAVE statement must be in the same block as the labeled DO statement.
- The label reference specified with a LEAVE statement must be a label constant or a subscripted label constant with an integer constant subscript.

The following example shows a LEAVE statement with a label reference:

```
LOOP1: DO WHILE (MORE);
   .
   .
   .
    LOOP2: DO I = 1 TO 12;
   .
   .
   .
        IF QUAN(I) > 150 THEN LEAVE LOOP1;
    END;          /* loop 2 */
   .
   .
   .
END;              /* loop 1 */
```

In this example, the LEAVE statement transfers control to the first statement beyond the last END statement.

7.8 STOP Statement

The STOP statement terminates execution of a program, regardless of the current block activation, signals the FINISH condition, and closes all open files. If the main procedure has the RETURNS attribute, no return value is obtainable.

7.9 Null Statement

The null statement performs no action. Its format is as follows:

```
;
```

The null statement usually serves as the target statement of a THEN or ELSE clause in an IF statement, as the target of a WHEN or OTHERWISE clause in a SELECT statement, or as an action in an ON-unit. The following examples illustrate these uses.

```
IF A < B THEN GOTO COMPUTE;
     ELSE ;
```

In this example, no action takes place if A is greater than or equal to B; execution continues at the statement following ELSE ;. A construction of this type may be necessary when IF statements are nested (**see** Section 7.4).

```
SELECT;
    WHEN (condition A,B,C) GOTO FILE_READ;
    WHEN (condition D,E) GOTO UPDATE;
    OTHERWISE;
END;
```

In this example, control is passed to the next executable statement after END if conditions A, B, C, D, and E are not true.

```
ON ENDPAGE(SYSPRINT);
```

In this example, no action takes place upon execution of the ON-unit; the I/O operation that caused the ENDPAGE condition continues.

The null statement can also be used to declare two labels for the same executable statement, as in the following example:

```
LABEL1: ;
LABEL2: statement ...
```

Encyclopedic Reference

A

A Format Item

The A format item describes the representation of a character string in the input or output stream. The form of the A format item is as follows:

```
A [(w)]
```

w
A nonnegative integer or an integer expression that specifies the width in characters of the field in the stream. If it is not included (PUT EDIT only), the field width equals the length of the converted output source.

For a general discussion of format items, **see** "Format Item."

■ Input with GET EDIT

The value w must be included when the A format item is used with GET EDIT. If w has a positive value, a character-string value comprising the next w characters in the input stream is acquired and assigned to the input variable. If w is zero, no operation is performed on the input stream, and a null character string is assigned to the input variable.

The acquired character string is converted, if necessary, to the data type of the input target, following the PL/I data conversion rules (**see** "Conversion of Data"). Apostrophes should enclose the stream data only if the apostrophes are intended to be acquired as part of the data.

■ Output with PUT EDIT

The output source associated with an A format item is converted, if necessary, to a string of characters. The result is assigned to a string of w characters, which are placed in the output stream. If w is omitted, the length of the output string equals the length of the converted output source. If w is zero, the A format item and the associated output source are skipped.

Output strings are not surrounded automatically by apostrophes. The converted output source is truncated or appended with trailing spaces, according to the value of w. The conversion of a computational data item to a character string is performed following the PL/I data conversion rules (**see** "Conversion of Data").

■ Examples

The tables below show the relationship between the internal and external representations of characters that are read or written with the A format item.

Input Examples

The input stream shown in the following table is a field of characters beginning at the current position in the stream and continuing to the right. The target type is the type of the variable to which the input value is assigned.

Format Item	Input Stream	Target Type	Target Value
A(10)	ΔΔSHRUBBERYΔ...	CHAR(10)	ΔΔSHRUBBER
A(6)	ΔΔSHRUBBERYΔ...	CHAR(10)	ΔΔSHRUΔΔΔΔ
A(6)	ΔΔSHRUBBERYΔ...	CHAR(10) VAR	ΔΔSHRU
A(10)	ΔΔ1.2345ΔΔΔΔ...	DECIMAL(4,1)	001.2
A(5)	ΔΔ1.2345ΔΔΔΔ...	DECIMAL(4,2)	01.20
A(6)	ΔΔ1.2345ΔΔΔΔ...	DECIMAL(4,2)	01.23

Output Examples

The output source value shown in the table that follows is either a constant or the value of a variable that is written with the associated format item.

Output Source Value	Format Item	Output Value
'STRING'	A(10)	STRINGΔΔΔΔ
'STRING'	A	STRING
1.2345	A(2)	ΔΔ
1.2345	A	ΔΔ1.2345
-1.2345	A(4)	Δ-1.
-1.2345	A	Δ-1.2345
''	A(10)	ΔΔΔΔΔΔΔΔΔΔ
''	A	[no output]
0	A(3)	ΔΔΔ
0	A	ΔΔΔ0
-12345	A(6)	ΔΔ-123
-12345	A	ΔΔ-12345

Abbreviation

A number of the VAX PL/I keywords can be abbreviated. These abbreviations are in Table A–1.

Table A–1: VAX PL/I Keyword Abbreviations

Keyword	Abbreviation	Keyword	Abbreviation
ALLOCATE	ALLOC	INTERNAL	INT
ALLOCATION	ALLOCN	NONVARYING	NONVAR
AUTOMATIC	AUTO	OTHERWISE	OTHER
BINARY	BIN	OVERFLOW	OFL
CHARACTER	CHAR	PARAMETER	PARM
COLUMN	COL	PICTURE	PIC
CONDITION	COND	POINTER	PTR
CONTROLLED	CTL	POSITION	POS
CONVERSION	CONV	PRECISION	PREC
DECIMAL	DEC	PROCEDURE	PROC

Table A–1 (Cont.): VAX PL/I Keyword Abbreviations

Keyword	Abbreviation	Keyword	Abbreviation
DECLARE	DCL	SEQUENTIAL	SEQL
DEFINED	DEF	STRINGRANGE	STRG
DESCRIPTOR	DESC	SUBSCRIPTRANGE	SUBRG
DIMENSION	DIM	UNALIGNED	UNAL
ENVIRONMENT	ENV	UNDEFINEDFILE	UNDF
EXTERNAL	EXT	UNDERFLOW	UFL
FIXEDOVERFLOW	FOFL	VALUE	VAL
GOTO	GO TO	VARYING	VAR
INITIAL	INIT	ZERODIVIDE	ZDIV

For a summary of all the VAX PL/I keywords, see Appendix A. This summary briefly identifies each keyword's use (for example, as an attribute, statement, or built-in function) and also gives abbreviations.

ABS Built-In Function
ABS Preprocessor Built-In Function

The ABS built-in function returns the absolute value of an arithmetic expression x. Its format is as follows:

ABS(x)

■ Examples

```
A = 3.567;
Y = ABS(A);   /*   Y = +3.567   */

A = -3.567;
Y = ABS(A);   /*   Y = +3.567   */

ROOT = SQRT (ABS(TEMP));
```

The last example shows a common use for the ABS built-in function: to ensure that an expression has a positive value before it is used as an argument to the square root (SQRT) built-in function.

ACOS Built-In Function

The ACOS built-in function returns a floating-point value that is the arc (inverse) cosine of an arithmetic expression x. The arc cosine is computed in floating point. The returned value is an angle w such that

$$0 <= w <= \pi$$

The absolute value of x, after its conversion to floating point, must be less than or equal to 1. The format of the function is as follows:

```
ACOS(x)
```

%ACTIVATE Statement

The %ACTIVATE statement makes preprocessor variable and procedure identifiers eligible for replacement. If the compiler encounters the named identifier after executing a %ACTIVATE statement, it initiates variable replacement. The format of the %ACTIVATE statement is as follows:

```
% { ACTIVATE } element [ RESCAN   ] ,...;
  { ACT      }         [ NORESCAN ]
```

element

The name of a previously declared preprocessor identifier and/or a list of identifiers, where the identifiers are separated by commas and the list is enclosed in parentheses.

RESCAN or NORESCAN

Specifies that the preprocessor is to continue or discontinue checking the text for secondary value replacement.

The RESCAN option specifies that preprocessor scanning continue until all possible identifier replacements are completed. RESCAN is the default option.

The NORESCAN option specifies that replacement be done only once; the resulting text is not rescanned for possible further replacement.

An identifier is activated by either a %ACTIVATE statement or a %DECLARE statement. When an activated identifier is encountered by the compiler, in unquoted nonpreprocessor statements, the variable name or procedure reference is replaced by its value. Replacement continues throughout the rest of the source program unless replacement is stopped with the %DEACTIVATE statement.

You can activate several variables with a single statement. For example:

```
%DECLARE (A,B,C) FIXED;
%ACTIVATE (A,B), C NORESCAN;
```

Because RESCAN is the default action, this statement activates A and B with the RESCAN option. C is activated, but is not rescanned.

If an identifier that is not a preprocessor variable or procedure is the target of a %ACTIVATE statement, a warning message is issued and the identifier is implicitly declared as a preprocessor variable with the FIXED attribute. Thereafter, the identifier variable is eligible for replacement when activated.

For example:

```
DECLARE (A,B,C) FIXED;
%DECLARE (A,B) FIXED;
%ACTIVATE (A,B);

%A = 1;
%B = (A + A);

C = A + B;
PUT SKIP LIST (C);    /* C = 3 */
```

In this example, the activated preprocessor variables A and B are assigned values by the preprocessor. Notice that variables A and B are also declared as nonpreprocessor variables; this establishes them as variables within the nonpreprocessor program.

In the following example, the variable B is deactivated by the %DEACTIVATE statement (**see** "%DEACTIVATE Statement").

```
   .
   .
   .
%DEACTIVATE B;
B = 900;
C = A + B;
PUT SKIP LIST (C);    /* C = 901 */
END;
```

Because the preprocessor variable B is deactivated, the preprocessor assignment statement %B = (A + A) is not in effect and the value of B is taken from the run-time assignment of B = 900. However, the value of A remains 1.

For additional preprocessor information, **see** "Preprocessor."

ACTUALCOUNT Built-In Function

The ACTUALCOUNT built-in function allows you to determine how many parameters the current procedure was called with. The function returns a FIXED BINARY(31) result.

The format of an assignment statement using the function is as follows:

```
variable = ACTUALCOUNT();
```

ADD Built-In Function

The ADD built-in function returns the sum of two arithmetic expressions x and y, with a specified precision p and an optionally specified scale factor q. The format of the function is as follows:

```
ADD(x,y,p[,q])
```

p
An unsigned integer constant greater than zero and less than or equal to the maximum precision of the result type (31 for fixed-point data, 34 for floating-point decimal data, and 113 for floating-point binary data).

q
An integer constant less than or equal to the specified precision. The scale factor can be optionally signed when used in fixed-point binary addition. The scale factor for fixed-point binary must be in the range –31 to p. The scale factor for fixed-point decimal data must be in the range 0 to p. If you omit q, the default value is zero. You should not use a scale factor for floating-point arithmetic.

Expressions x and y are converted to their derived type before the addition is performed; **see** "Expression."

For example:

```
ADDBIF: PROCEDURE OPTIONS (MAIN);

DECLARE X FIXED DECIMAL (8,3),
        Y FIXED DECIMAL (8,3),
        Z FIXED DECIMAL (9,3);

X=9500.374;
Y=2278.897;
Z = ADD (X,Y,9,3);

PUT SKIP LIST ('TOTAL =',Z);

END;
```

This program returns the following:

```
TOTAL = 11779.271
```

Addition

The plus sign character (+), when used as an infix operator, indicates an addition operation between two operands in an expression; the result is the sum of the operands. Both operands must be arithmetic or picture data.

The plus sign can also be used as a prefix operator. **See** "Operator."

■ Conversion of Operands

If both operands have the same base, precision, and scale, so has the result. The PL/I compiler converts operands of different data types as follows:

- If one operand has the FLOAT attribute and the other has the FIXED attribute, the fixed-point operand is converted to floating point before the operation is performed.
- If one operand has the DECIMAL attribute and the other has BINARY, the decimal operand is converted to binary before the operation is performed.

For an explanation of the precision of the value resulting from the conversion of an operand, **see** "Expression."

■ Precision of the Result

The precision of the resulting sum is based on the precision (or converted precision) of the two operands. For example, the heading "Floating-Point Operands" below means that the operands were of floating-point types originally or that one was converted to floating point.

Floating-Point Operands

The result takes the greater precision of the two operands.

Fixed-Point Operands

If (p,q) and (r,s) represent the converted precisions and scale factors of the two operands, the resulting precision is

$$min(31, max(p - q, r - s) + max(q, s) + 1)$$

The resulting scale factor is

$$max(q, s)$$

ADDR Built-In Function

The ADDR built-in function returns a pointer to storage denoted by a specified variable. The variable reference must be addressable. The format of the function is as follows:

```
ADDR(reference)
```

If the reference is to a parameter (or any element or member of a parameter), the pointer value obtained must not be used after return from the parameter's procedure invocation. (This could occur, for example, if the pointer were saved in a static variable or returned as a function value.)

See "Based Variable" for a general discussion of pointer values.

ALIGNED Attribute

The ALIGNED attribute controls the storage boundary of bit-string data in storage.

You can specify the ALIGNED attribute in conjunction with the BIT attribute in a DECLARE statement to request alignment of a bit-string variable on a byte boundary. (**See** "Bit-String Data.") If you specify ALIGNED for an array of bit-string variables, each element of the array is aligned.

You can specify ALIGNED in the declaration of a nonvarying character-string variable. However, all character strings are byte-aligned on VAX machines; thus, the specification of ALIGNED is superfluous and is not recommended. (**See** "Character-String Data.")

■ Restrictions

The ALIGNED attribute conflicts with the VARYING attribute and is invalid with all data type attributes other than BIT and CHARACTER. You must specify either BIT or CHARACTER with the ALIGNED attribute.

ALLOCATE Statement

The ALLOCATE statement obtains storage for a based or controlled variable and sets (with based variables) a locator variable equal to the address of the allocated storage. The format of the ALLOCATE statement is as follows:

```
{ ALLOCATE }
{ ALLOC    } allocate-item,...;
```

allocate-item

```
variable-reference [SET(locator-reference)] [IN(area-reference)]
```

variable-reference
A based or controlled variable for which storage is to be allocated. The variable can be any scalar value, array, area, or major structure variable; it must be declared with the BASED or CONTROLLED attribute.

SET(locator-reference)

The specification of a pointer or offset variable (for based variables) that is assigned the value of the location of the allocated storage. If the SET option is omitted, the based variable must have been declared with BASED(locator-reference); the variable designated by that locator reference is assigned the location of the allocated storage.

You cannot use the SET option to allocate controlled variables.

IN(area-reference)

The specification of an area reference (for based variables) in which the storage is to be allocated. If the IN option is omitted, the SET option (or implied SET option if the locator variable is an offset) must be an offset declared with OFFSET(area-reference).

You cannot use the IN option to allocate controlled variables.

■ Examples

```
DECLARE STATE CHARACTER(100) BASED (STATE_POINTER),
        STATE_POINTER POINTER;

ALLOCATE STATE;
```

This ALLOCATE statement allocates storage for the variable STATE and sets the pointer STATE_POINTER to the location of the allocated storage.

The ALLOCATE statement obtains the amount of storage needed to accommodate the current extent of the specified variable. If, for example, a character-string variable is declared with an expression for its length, the ALLOCATE statement evaluates the current value of the expression to determine the amount of storage to be allocated. For example:

```
DECLARE BUFFER CHARACTER (BUFLEN) BASED,
         BUF_PTR POINTER;
    .
    .
    .
BUFLEN = 80;
ALLOCATE BUFFER SET (BUF_PTR);
```

Here, the value of BUFLEN is evaluated when the ALLOCATE statement is executed. The ALLOCATE statement allocates 80 bytes of storage for the variable BUFFER and sets the pointer variable BUF_PTR to its location.

For an additional example of the ALLOCATE statement and a description of based variables, **see** "Based Variable."

The ALLOCATE statement is also used to allocate storage for controlled variables. A controlled variable is one whose actual storage is allocated and freed dynamically in "generations," only the most recent of which is accessible to the program. Unlike based variables, a controlled variable cannot be used in a pointer-qualified reference. For general information and examples, **see** "Controlled Variable."

If the variable being allocated has been declared with initial values, these values are assigned to the variable after allocation.

For more information on allocation and deallocation of variables inside areas, see the *VAX PL/I User Manual.*

ALLOCATION Built-In Function

The ALLOCATION built-in function returns a fixed-point binary integer that is the number of extant generations of a specified controlled variable. (**See** "Controlled Variable"). If no generations of the specified variable exist, the function returns zero. The format of the function is as follows:

```
{ ALLOCATION }
{ ALLOCN     } (reference)
```

reference
The name of a controlled variable.

■ Examples

```
DECLARE INPUT CHARACTER(10) CONTROLLED,
   A CHARACTER(3) VARYING;
        .
        .
        .
    DO UNTIL (INPUT = 'QUIT');
       ALLOCATE INPUT;
       GET LIST(INPUT);
           .
           .
           .
       END;
    A = ALLOCATION(INPUT);
    PUT SKIP LIST('Generations = 'A);
```

This example uses the ALLOCATION built-in function to return the number of generations of the controlled variable INPUT. The example illustrates how input in an interactive program can be stored on a stack for future use.

```
ALLO: PROCEDURE OPTIONS (MAIN);
DECLARE STR CHARACTER (10) CONTROLLED;
        ALLOCATE STR;
        STR='FIRST';
        ALLOCATE STR;
        STR='SECOND';
        ALLOCATE STR;
        STR='THIRD';

DO WHILE (ALLOCATION(STR)^=0);
        PUT SKIP LIST (STR);
        FREE STR;
  END;
END;
```

This example shows how the ALLOCATION built-in function can be used to count generations of controlled variables and therefore control the loop. Strings are freed while generations still exist, but when all generations have been freed, the value of ALLOCATION is zero and the process ends, thus avoiding a fatal run-time error.

AND Operator

The ampersand (&) character is the logical AND operator in PL/I. In a logical AND operation, two bit-string operands are compared bit by bit. If two corresponding bits are 1, the corresponding bit in the result is 1; otherwise, the result is 0.

The result of a logical AND operation is a bit-string value. All relational expressions result in bit strings of length 1; they can therefore be used as operands in an AND operation. If the two operands have different lengths, the shorter operand is converted to the length of the longer operand, and the greater length is the length of the result.

■ Examples

```
DECLARE (BITA, BITB, BITC) BIT (4);
BITA = '0011'B;
BITB = '1111'B;
BITC = BITA & BITB;
```

The resulting value of BITC is '0011'B.

The AND operator can test whether two or more expressions are both true in an IF statement. For example:

```
IF (LINENO(PRINT_FILE) < 60) &
   (MORE_DATA = YES) THEN ...
```

See also "AND THEN Operator," "Bit-String Data," "Logical Operator," and "Operator."

AND THEN Operator

The ampersand-colon token (&:) is the AND THEN operator in PL/I. The AND THEN operator causes the first operand to be evaluated; if it is false, the result returned is '0'B. The second operand will never be evaluated if the first operand is false. If and only if the first operand is true, the second operand is evaluated. If both are true, the result returned is true ('1'B); otherwise, the result is false ('0'B).

The AND THEN operator performs a Boolean truth evaluation, not a bit-by-bit operation, even when the two operands are bit strings. For example, '00001'B &: '10000'B yields '1'B (not '00000'B, which would be the result of an AND operation on these two bit strings). The reason is that each operand is a non-zero bit value, and therefore each evalutes to '1'B.

The AND THEN operator yields the same result as the AND operator (&) when expressions are tested in an IF statement (as in the last example in the "AND Operator" entry). The difference is that the AND operator can have its operands evaluated in either order.

The AND THEN operator is useful in compound test expressions in which the second test should occur only if the first test was successful. For example:

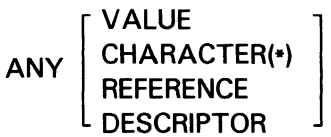
```
IF (P ^= NULL()) &: (P->X ^= 4) THEN ...
```

This statement causes P-> X to be evaluated only if P is not a null pointer. If the AND operator were used instead of AND THEN, this expression could cause an access violation (invalid pointer reference).

See also "AND Operator," "Logical Operator," and "Operator."

ANY Attribute

The ANY attribute specifies that a parameter's corresponding argument can be of any data type. This attribute is applicable only to the declaration of entry names denoting non-PL/I procedures. The format of the ANY attribute is as follows:



For complete details on using the ANY attribute, **see** the *VAX PL/I User Manual*.

■ Restrictions

If you specify ANY for a parameter, you cannot specify any data type attributes for that parameter except CHARACTER(*). If ANY is used by itself, the parameter is passed by reference. If ANY is used with VALUE, the parameter is passed by immediate value. If ANY is used with CHARACTER(*), the parameter is passed by character descriptor. Note that either CHARACTER or CHARACTER VARYING strings can be passed to ANY CHAR(*) parameters without the creation of a dummy argument.

The ANY attribute is valid only in a parameter descriptor.

■ Example

```
DECLARE SYS$SETEF ENTRY (ANY VALUE);
```

This statement identifies the system service procedure SYS$SETEF and indicates that the procedure accepts a single argument, which can be of any data type, to be passed by value. (Note that all system services, RTL routines, and utility routines for the VMS system have declarations in PLI$STARLET, so this feature is rarely needed except to declare entry points for some layered products.)

ANYCONDITION Condition Name

The ANYCONDITION keyword can be specified in an ON, REVERT, or SIGNAL statement. It designates an ON-unit established for all signaled conditions that are not handled by specific ON-units.

The ANYCONDITION keyword is not defined in the PL/I language. It is provided specifically for use in the VMS operating system environment. For complete details on VMS condition handling, **see** the *VAX PL/I User Manual.*

For information on defining ON-units for PL/I-specific conditions and PL/I default condition handling, **see** "ON Conditions and ON-Units" and "ON Statement."

Area

An area is a region of storage in which based variables can be allocated and freed. You define an area by declaring a variable with the AREA attribute. An area variable can belong to any storage class. Areas provide the following programming capabilities:

- Based variables can be allocated within a specific area, and the entire area can be assigned or transmitted in a single operation. The variables can be referred to by offset values within the area; the offset values remain valid throughout assignment or transmission.
- You can control the allocation of storage for related variables by placing them in the same area, thus improving the locality of reference. Also, you can use one operation to recover the storage for all allocations within an area by freeing or initializing the area itself.
- You can use a structure containing an area to represent a disk file that is mapped into a process's virtual memory space.

■ Area Assignment

You can specify an area variable as the target of an assignment statement only in the following case:

```
area-variable-1 = area-variable-2;
```

If the extent of the target area is not large enough to contain the allocated storage in the source area, the AREA condition is raised. Note that you can also use the EMPTY built-in function as the source of an assignment statement.

All other specifications of an area variable as the target of an assignment statement (for example, as a member of a structure in a structure assignment) are invalid. You cannot use an area variable in an expression containing operators.

■ Reading and Writing Areas

An area can be the source or target of data transmission in READ and WRITE record I/O statements. If the area is written by itself (not as a member of a structure) only the currently allocated portion is transmitted unless the SCALARVARYING ENVIRONMENT option was specified when the file was opened.

AREA Attribute

The AREA attribute defines an area variable (**see** "Area"). Its format is as follows:

```
AREA [(extent)]
```

extent
The size of the area in bytes. The extent must be a nonnegative integer. The maximum size is 500 million bytes. The rules for specifying the extent are as follows:

- If AREA is specified for a static variable declaration, extent must be a restricted integer expression (**see** "Restricted Expression").
- If AREA is specified in the declaration of a parameter or in a parameter descriptor, extent can be specified as an integer constant or as an asterisk (*).
- If AREA is specified for an automatic or based variable, extent can be specified as an integer constant or as an expression. For automatic variables, the extent expression must not contain any variables or functions declared in the same block, except for parameters.
- If no extent is specified for the area, a default of 1024 bytes is provided. DIGITAL recommends explicitly specifying a size, because the default varies considerably between PL/I implementations.

■ Restrictions

The AREA attribute is not allowed in a returns descriptor. The AREA attribute conflicts with all other data type attributes.

AREA Condition Name

The AREA condition is raised when various operations fail in relation to areas. For example, it is raised if the extent of an area is not large enough to contain the variable or variables allocated to it, or if the area is incorrectly formatted or is already active.

See the *VAX PL/I User Manual* for complete information on the AREA condition.

Argument

An argument is an expression or variable reference denoting a value to be used by a built-in function or a user-defined procedure or function. The maximum number of arguments that can be passed to a procedure is 253. For full details, **see** "Parameters and Arguments."

■ Argument List

An argument list consists of zero or more arguments specified in the invocation of a procedure, built-in function, or built-in subroutine.

With built-in functions, arguments are expressions that supply values to the built-in function, and the argument types must be those required by the specific function. In general, built-in functions can be considered operators and their arguments can be considered operands. If two arithmetic arguments for a built-in function are of different arithmetic types, they are evaluated and converted to a common type, as are the operands of an arithmetic expression. For further details, **see** "Built-In Function" and "Expression."

With user-defined procedures, arguments correspond to parameters defined in the PROCEDURE or ENTRY statement of the invoked procedure.

■ Argument Passing

In PL/I, a parameter of a procedure is always associated with a variable passed to it by the calling procedure. This variable can be the original argument corresponding to the parameter or a dummy argument created by the compiler and assigned the original argument's value.

■ Dummy Argument

A dummy argument is a variable that is allocated by the compiler to pass an argument to an invoked procedure. The compiler creates a dummy argument when an argument specified in a procedure reference is a constant or an expression, when it is a variable with a data type different from that required by the corresponding parameter, or when it is enclosed in parentheses.

Arithmetic Data Types

Arithmetic data types are used for variables on which arithmetic calculations are to be performed. The following arithmetic data types are supported by VAX PL/I:

- Fixed-point binary or decimal—for binary or decimal data with a fixed number of fractional digits. (**See** "Fixed-Point Binary Data" and "Fixed-Point Decimal Data".)
- Floating-point binary or decimal—for calculations on very large or very small numbers, with the decimal point (number of fractional digits) allowed to "float." (**See** "Floating-Point Data".)
- Picture—for fixed-point decimal data that is stored internally in character form, with special formatting characters. (**See** "Picture".)

Arithmetic Operators

The arithmetic operators perform calculations. Programs that accept numeric input and produce numeric output use arithmetic operators to construct expressions that perform the required calculations. The infix arithmetic operators are as follows:

Operator	Operation
+	Addition
-	Subtraction
*	Multiplication
/	Division
**	Exponentiation

In addition, there are two prefix operators: unary plus (+) and unary minus (-). The unary plus is valid on any arithmetic operand, but it performs no actual operation. The unary minus reverses the sign of any arithmetic operand.

For detailed descriptions of the other operands, **see** "Addition," "Division," "Exponentiation," "Multiplication," and "Subtraction."

For any arithmetic operator, operands must be arithmetic; that is, they must be constants, variables, or other expressions with the data type attribute BINARY, DECIMAL, or PICTURE. Operands of different arithmetic types are converted to a common type before the operation is performed (**see** "Expression").

Arithmetic operators have a predefined precedence that governs the order in which operations are performed. For further information, **see** "Operator." All expressions can be enclosed in parentheses to override the rules of precedence.

Array

Arrays provide an orderly way to manipulate related variables of the same data type. An array variable is defined in terms of its dimensions: the number of variables, or elements, that it contains and the organization of those elements.

The following subsections describe arrays in terms of scalar elements. For information on arrays whose elements are structures, **see** "Arrays of Structures."

■ Format of an Array Declaration

To declare an array, specify its dimensions in a DECLARE statement as follows:

```
DECLARE identifier [DIMENSION] (bound-pair,...) [attribute ...];
```

To declare two or more array variables that have the same dimensions and bounds, use the following format:

```
DECLARE (declaration,...) [DIMENSION] (bound-pair,...)
        [attribute ...];
```

declaration
A simple identifier, the declaration of another array, or the declaration of a structure. (For further details on the syntax of declarations, **see** "DECLARE Statement." **See also** "Arrays of Structures.")

identifier
A valid PL/I identifier to be used as the name of the array.

bound-pair
A specification of the number of elements in each dimension of the array. A bound pair can consist of one of the following:

- Two expressions separated by a colon, giving the lower and upper bounds for that dimension
- A single expression giving the upper bound only (the lower bound is then 1 by default)
- An asterisk (*), used in the declaration of array parameters, and indicating that the parameter can be matched to array arguments with varying numbers of elements in that dimension

Bound pairs in series must be separated by commas, and the list of bound pairs must be enclosed in parentheses. The list of bound pairs must immediately follow the identifier or the optional keyword DIMENSION or the list of declarations.

Figure A–1 shows several forms of bound pairs as used in declarations. Note that all the examples in the figure would be identical in effect if the optional keyword DIMENSION were added.

attribute
One or more data type attributes of the elements of the array. All attributes you specify apply to each of the elements in the array.

Elements of an array can have any data type. If the array has the FILE or ENTRY attribute, it must also have the VARIABLE attribute.

Figure A–1: Specifying Array Dimensions

ARRAY-NAME (Bound)

A single value specifies

- That the array has a single dimension.
- That the dimension has 'bound' number of elements; this is the extent of the dimension.
- That the value specified is the high bound, that is, the largest numbered element. By default, the low bound is 1.

EXAMPLES

```
DECLARE VERBS (6) CHARACTER (12) ;
```

ARRAY-NAME (Low-Bound:High-Bound)

A single range of values specifies

- That the array has a single dimension.
- That the number of elements in the dimension is (high-bound)-(low-bound)+1.
- The index value assigned to the lowest-numbered element and the index value assigned to the highest-numbered element.

```
DECLARE TEMPERATURES (-60:120) ;
```

ARRAY-NAME (Bound1,Bound2,...)

A list of values specifies

- That the array is multidimensional. Each bound value represents a dimension in the array.
- The extent of each dimension. Each bound defines the number of elements in a dimension.
- The high-bound value of each dimension. The low-bound value of each dimension defaults to 1.

```
DECLARE TABLE (10,10) FIXED BINARY ;

DECLARE SETS (5,5,5,5) CHARACTER (80) ;
```

ARRAY-NAME (Low-Bound1:High-Bound1,Low-Bound2:High-Bound2,...)

A set of ranges specifies

- That the array is multidimensional. Each range of values represents a dimension in the array (ranges can be intermixed with single-bound specifications).
- The extent of each dimension.
- The low-bound and high-bound values of each dimension.

```
DECLARE WINDOWS (1:10,-2:32) FIXED ;
DECLARE HISTORIES (10,30:102,50) ...
```

ARRAY-NAME (*,...)

Asterisk extents specify

- The number of dimensions in the array. Each asterisk indicates a dimension.
- That the extent of each dimension will be defined by the actual argument passed to the procedure when it is invoked.

```
ADDIT: PROCEDURE (ARR);
   DECLARE ARR(*,*) FIXED ;
```

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■ Rules for Specifying Dimensions

The following rules apply to specifying the dimensions of an array and the bounds of a dimension:

- An array can have up to eight dimensions.
- The values you can specify for bounds are restricted as follows:
  - If the array has the STATIC attribute, you must specify all bounds as restricted integer expressions in the preprocessor declaration of the array (**see** "Restricted Expression").
  - If the array has the AUTOMATIC, BASED, CONTROLLED, or DEFINED attribute, you can specify the bounds as optionally signed integer constants or as expressions that yield integer values at run time. If the array has the AUTOMATIC, DEFINED, or UNION attribute, the expressions must not contain any variables or functions that are declared in the same block, except for parameters.
  - If an array is a parameter, you can specify the bounds using optionally signed integer constants or asterisks (*). If you specify any bound with an asterisk, you must specify all bounds with asterisks. An array parameter declared this way inherits the dimensions of the corresponding argument. Passing array variables as arguments to a procedure is described below under "Passing Arrays as Arguments."
- The value of the lower bound you specify must be less than or equal to the value of the upper bound.

■ References to Individual Elements

You refer to an individual element in the array by means of subscripts. Because an array's attributes are common to all of its elements, a subscripted reference has the same properties as a reference to a scalar variable with those attributes.

Subscripts must be enclosed in parentheses in a reference to an array element. For example, in a one-dimensional array named ARRAY declared with the bounds (1:10), the elements are numbered 1 through 10 and are referred to as ARRAY(1), ARRAY(2), ARRAY(3), and so on.

The lower and upper bounds that you declare for a dimension determine the range of subscripts that you can specify for that dimension. If only an

upper bound is specified for a dimension, the lower bound (minimum subscript) for that dimension is 1. The number of elements in any dimension of any array is

$$(upperbound) - (lowerbound) + 1$$

The total number of elements in the array, called its "extent," is the product of the numbers of elements in all the dimensions of the array.

For multidimensional arrays, the subscript values represent an element's position with respect to each dimension in the array. Figure A–2 illustrates subscripts for elements of one-, two-, and three-dimensional arrays.

In subscripted references, the number of subscripts must match the number of dimensions of the array, including any dimensions that are inherited when an array results in the declaration of a dimensioned structure (**see** "Arrays of Structures").

■ Variable Subscripts

You can specify the subscript of an array element using any variables or expressions having integer values, that is, values that can be expressed as fixed binary or fixed decimal with a zero scale factor. For example:

```
DECLARE DAYS_IN_MONTH(12) FIXED BINARY;
DECLARE (COUNT, TOTAL) FIXED BINARY;
TOTAL = 0;
DO COUNT = 1 TO 12;
      TOTAL = TOTAL + DAYS_IN_MONTH(COUNT);
      END;
```

Here, the variable COUNT is used as a control variable in a DO-group. As the value of COUNT is incremented from 1 to 12, the value of the corresponding element of the array DAYS_IN_MONTH is added to the value of the variable TOTAL.

■ Initializing Arrays

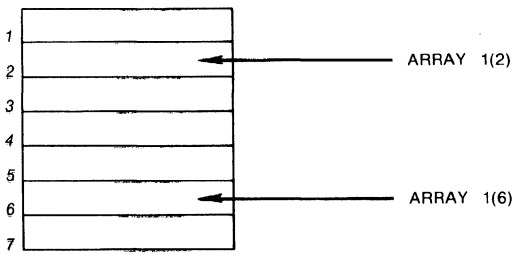
The INITIAL attribute can be specified for arrays. For example:

```
DECLARE MONTHS (12) CHARACTER (9) VARYING
   INITIAL ('January', 'February', 'March', 'April',
      'May', 'June', 'July', 'August',
      'September', 'October', 'November', 'December');
```

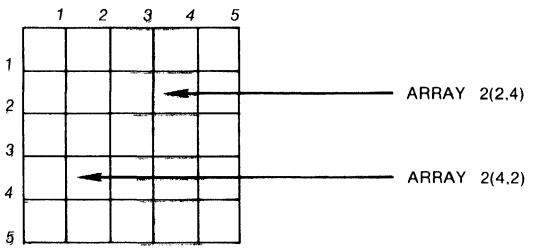
In this example, each element of the array MONTHS is assigned a value according to the order of the character-string constants in the initial list: MONTH(1) is assigned the value 'January'; MONTH(2) is assigned the value 'February'; and so on.

Figure A–2: Specifying Elements of an Array

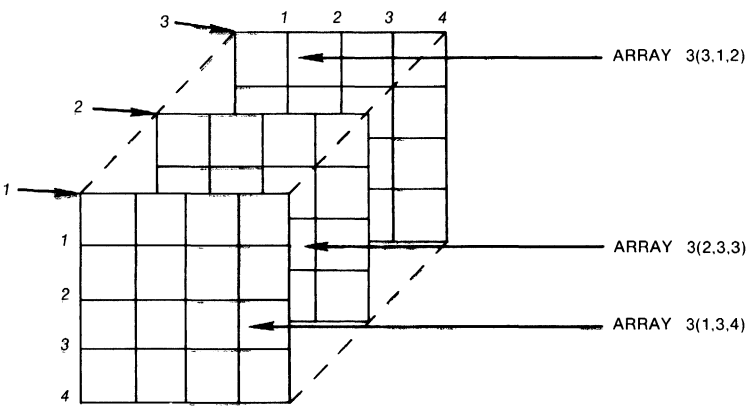
DECLARE ARRAY 1 (7);



DECLARE ARRAY 2 (5,5);



DECLARE ARRAY 3 (3,4,4);



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If the array being initialized is multidimensional, the initial values are assigned in row-major order.

For full details on the use of the INITIAL attribute, **see** "INITIAL Attribute."

Although the VAX PL/I compiler supports the initialization of automatic arrays with the INITIAL attribute, use of this attribute is not always the most efficient way (in terms of program compilation and execution) to initialize array elements. Note the following considerations:

- When you initialize elements in an array that has the AUTOMATIC attribute, the compiler does not check that all elements are initialized until run time (this is also true of the initialization of based and controlled variables). Thus, you do not receive any compile-time checking of initialization, even if you used constants to specify the array bounds and iteration factors.
- Your programs will run more efficiently if you initialize automatic arrays using assignment statements rather than using the INITIAL attribute.
- If the array is not modified in your program, you can increase program efficiency even more by declaring the array with the STATIC and READONLY attributes and by using the INITIAL attribute to initialize its elements. In this case, the compiler will check at compile time that you have initialized all the elements and will check their validity.

■ Iteration Factors

When more than one successive element of an array is to be assigned the same value with the INITIAL attribute, you can specify an iteration factor. An iteration factor indicates the number of times that a specified value is to be used in the assignment of values to elements of an array. You can specify an iteration factor in one of the following formats:

```
(iteration-factor) arithmetic-constant
(iteration-factor) scalar-reference
(iteration-factor) (scalar-expression)
(iteration-factor) *
```

iteration-factor
An unsigned decimal constant indicating the number of times the specified value is to be used in the assignment of an array element. The iteration factor can be zero.

arithmetic-constant
Any arithmetic constant whose data type is valid for conversion to the data type of the array.

scalar-reference
A reference to any scalar variable or to the NULL built-in function.

scalar-expression
Any arithmetic or string expression or string constant. The expression or constant must be enclosed in parentheses.

*
Symbol used to indicate that the corresponding array element is not to be assigned an initial value.

Any of these forms can be used for arrays that have the AUTOMATIC attribute. For arrays with the STATIC attribute, only constants and the NULL built-in function can be used.

For example, the following declaration of the array SCORES initializes all elements of the array to 1:

```
DECLARE SCORES (100) FIXED STATIC INITIAL ((100)1);
```

The next declaration initializes the first 50 elements to 1 and the last 50 elements to –1:

```
DECLARE SCORES(100) FIXED STATIC INITIAL((50)1,(50)-1);
```

The declaration in the next example initializes all 10 elements of an array of character strings to the 26-character value in apostrophes. Note that the string constant is enclosed in parentheses; this is required syntax.

```
DECLARE ALPHABETS (10) CHARACTER(26) STATIC
   INITIAL((10)('ABCDEFGHIJKLMNOPQRSTUVWXYZ'));
```

■ Array Variables in Assignment Statements

You can specify an array variable as the target of an assignment statement in the following cases:

array-variable = expression;

where the expression yields a scalar value. Every element of the array is assigned the resulting value. The array variable must be a connected array whose elements are scalar. (**See** the subsection "Connected Arrays" in "Arrays of Structures.")

Note that the arithmetic operators, such as the addition (+) and the subtraction (-) operators, cannot have arrays as operands. An assignment of the following form is invalid:

```
ARRAYC = ARRAYA + ARRAYB;
```

array-variable-1 = array-variable-2;

where the specified array variables have identical data type attributes and dimensions. Each element in array-variable-1 is assigned the value of the corresponding element in array-variable-2.

In this type of assignment, both arrays must be connected. The actual storage occupied by the arrays must not overlap, unless the arrays are identical.

All other specifications of an array variable as the target of an assignment statement are invalid.

■ Using GET and PUT Statements with Array Variables

When you specify an array variable name in the input-target list of a GET LIST or GET EDIT statement, elements of the array are assigned values from the data items in the input stream. For example:

```
DECLARE VERBS (6) CHARACTER (15) VARYING; GET LIST (VERBS);
```

When this GET LIST statement is executed, it accepts data from the default input stream. Each input field delimited by a blank, tab, or comma is considered a separate string. The values of these strings are assigned to elements of the array VERBS in the order VERBS(1), VERBS(2), . . . VERBS(6). If a multidimensional array appears in an input-target list, input data items are assigned to the array elements in row-major order.

An array can also appear, with similar effects, in the output-source list of a PUT statement. **See** "GET Statement" and "PUT Statement" for information on using these statements with arrays.

■ Order of Assignment and Output for Multidimensional Arrays

When a multidimensional array is initialized without references to specific elements, PL/I assigns the values in row-major order. In row-major order, the rightmost subscript varies the most rapidly. For example, an array can be declared as follows:

```
DECLARE TESTS (2,2,3);
```

If TESTS is specified in a GET statement or in a declaration with the INITIAL attribute, values are assigned to the elements in the following order:

```
TESTS (1,1,1)
TESTS (1,1,2)
TESTS (1,1,3)
TESTS (1,2,1)
TESTS (1,2,2)
TESTS (1,2,3)
TESTS (2,1,1)
TESTS (2,1,2)
TESTS (2,1,3)
TESTS (2,2,1)
TESTS (2,2,2)
TESTS (2,2,3)
```

When an array is output with a PUT statement, PL/I uses the same order to output the array elements. For example:

```
PUT LIST (TESTS);
```

This PUT statement outputs the contents of TESTS in the order shown above.

■ Passing Arrays as Arguments

An array variable can be passed as an argument to another procedure. Within the invoked procedure, the corresponding parameter must be declared with the same number of dimensions. The rules for specifying the bounds in a parameter descriptor for an array parameter are as follows:

- If you specify the bounds with integer constants, they must match exactly the bounds of the corresponding argument.

- You can specify all bounds as asterisks (*). Then, the bounds of the array are determined from the bounds of the corresponding argument when the procedure is actually invoked. If any bound is specified as an asterisk, all bounds must be specified as asterisks.

For example:

```
DECLARE SCAN ENTRY ((5,5,5) FIXED,(*) FIXED),
    MATRIX (5,5,5) FIXED,
    OUTPUT (20) FIXED;

    CALL SCAN (MATRIX,OUTPUT);
```

The procedure SCAN receives two arrays as arguments. The first is a three-dimensional array whose bounds are known. The second is a one-dimensional array whose bounds are not known. The procedure SCAN can declare these parameters as follows:

```
SCAN: PROCEDURE (IN,OUT);
DECLARE IN (*,*,*) FIXED,
        OUT (*) FIXED;
```

An array whose storage is unconnected cannot be passed as an argument, nor can an array whose elements are label constants. Arrays are always passed by reference and cannot be passed by a dummy argument.

For full information on arguments and argument passing, **see** "Parameters and Arguments."

■ Array-Handling Functions

PL/I provides the following built-in functions that return information about the dimensions of an array:

- DIMENSION returns the number of elements in a given dimension.
- HBOUND returns the value of the upper bound of the array in a given dimension.
- LBOUND returns the value of the lower bound of the array in a given dimension.

For the first dimension of an array X, the relationship of these functions can be expressed as follows:

$$DIMENSION(X,1) = HBOUND(X,1) - LBOUND(X,1) + 1$$

The procedure that follows uses the HBOUND and LBOUND built-in functions:

```
ADDIT: PROCEDURE (X);
DECLARE X (*) FIXED BINARY,
        (COUNT,I) FIXED BINARY;

        COUNT = 0;
        DO I = LBOUND (X,1) TO HBOUND(X,1);
            COUNT = COUNT + 1;
            X(I) = COUNT;
            END;
        RETURN;
        END;
```

This procedure receives a one-dimensioned array as a parameter and initializes the elements of the array with integral values beginning with 1.

For more information, **see** the entries for these built-in functions, as well as those for "Function" and "Procedure."

Arrays of Structures

An array of structures is an array whose elements are structures. Each structure has identical logical levels, minor structure names, and member names and attributes.

For example, a structure STATE can be declared an array:

```
DECLARE 1 STATE (50),
          2 NAME CHARACTER (20) VARYING,
          2 POPULATION FIXED (31),
          2 CAPITAL,
            3 NAME CHARACTER (30) VARYING,
            3 POPULATION FIXED (31)
          2 SYMBOLS,
            3 FLOWER CHARACTER (20),
            3 BIRD CHARACTER (20);
```

A member of a structure that is an array inherits the dimensions of the structure. Thus, in this example, the member CAPITAL.NAME of the structure STATE inherits the dimension 50. You must use a subscript whenever you refer to the variable CAPITAL.NAME, as in the following example:

```
PUT LIST (CAPITAL.NAME(I));
```

A subscript for a member of a structure that is an array element can appear after any name within a qualified reference. For example, all of the following references are equivalent:

```
STATE(10).CAPITAL.NAME
STATE.CAPITAL(10).NAME
STATE.CAPITAL.NAME(10)
```

■ Arrays of Structures That Contain Arrays

A structure that is defined with a dimension can have members that are arrays. For example:

```
DECLARE 1 STATE (50),
          2 AVERAGE_TEMPS(12) FIXED DECIMAL (5,2),
              .
              .
              .
```

In this example, the elements of the array STATE are structures. At the second level of the hierarchy of each structure is an array of 12 elements. Because this member of the structure inherits the dimension of the major structure, any of these elements must be referred to by two subscripts: the first subscript references an element in the array STATE, and the second subscript references an element in the array AVERAGE_TEMPS.

These subscripts can appear after any name in the qualified reference. For example, the following references are equivalent:

```
STATE(3).AVERAGE_TEMPS(4)
STATE.AVERAGE_TEMPS(3,4)
```

Note the following rules for specifying subscripts for members of structures containing arrays:

- The number of subscripts specified for any member must include any dimensions inherited from a major or minor structure declaration, as well as those specified for the member itself.
- The subscripts that refer to a member of a structure in an array do not have to immediately follow the name to which they apply. However, the order of subscripts must be preserved.
- The total number of dimensions, including the inherited dimensions, must not exceed eight.

For information on structure declarations, **see** "Structure."

■ Connected Arrays

A connected array is an array whose elements occupy consecutive locations in storage. For example:

```
DECLARE NEWSPAPERS (10) CHARACTER (30);
```

In storage, the 10 elements of the array NEWSPAPERS occupy 10 consecutive 30-byte units. Thus, the array NEWSPAPERS is a connected array.

A connected array is valid as the target of an assignment statement, as long as the source expression is a similarly dimensioned array or is a single scalar value.

An unconnected array is an array whose elements do not occupy consecutive storage locations. A structure with the DIMENSION attribute always results in unconnected arrays. When a structure is dimensioned, each member of the structure inherits the dimensions of the structure and becomes, in effect, an array. For example:

```
DECLARE 1 STATE (50),
          2 NAME CHARACTER (20) VARYING,
          2 POPULATION FIXED (31);
```

In this example, the members NAME and POPULATION of the major structure STATE inherit the dimension 50 from the major structure. When PL/I allocates storage for a structure or a dimensioned structure, each member is allocated consecutive storage locations; thus, the elements of the arrays NAME and POPULATION are not connected.

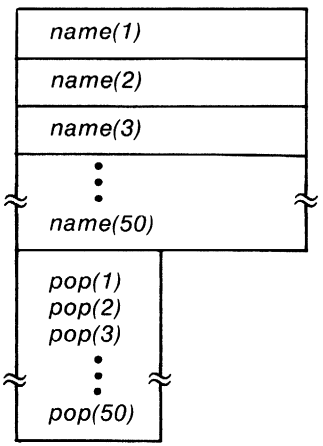
Figure A–3 illustrates the storage of connected and unconnected arrays.

Figure A–3: Connected and Unconnected Arrays

CONNECTED:

```
DECLARE 1 STATE,
          2 NAME (50) CHAR(20),
          2  POP (50) FIXED(10);
```

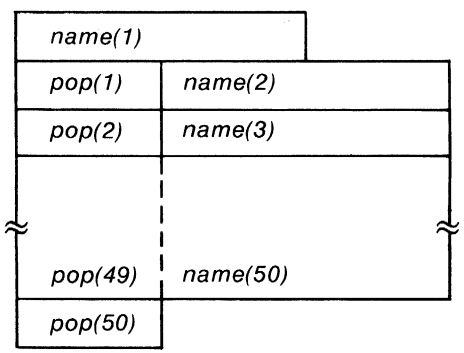
The members NAME and POP of the structure STATE are dimensioned. The elements of each array occupy consecutive storage locations.



UNCONNECTED:

```
DECLARE 1 STATE (50),
          2 NAME CHAR(20),
          2 POP FIXED(10);
```

The array STATE is dimensioned. Its members NAME and POP inherit the dimension: each of these variables is an array of 50 elements, but the elements do not occupy consecutive storage locations.



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ASCII Character Set

The American Standard Code for Information Interchange (ASCII) is a set of 8-bit numeric values that represent the alphabet, numerals, punctuation, and symbols used in text and in communications protocol.

The ASCII character set constitutes the first 128 characters of the DEC Multinational Character Set. See the table in Appendix B for the elements of the set.

Note that in VAX PL/I, you can use the non-ASCII characters in the DEC Multinational Character Set only in string constants and for data with input or output statements.

ASIN Built-In Function

The ASIN built-in function returns a floating-point value that is the arc (inverse) sine of an arithmetic expression x. The arc sine is computed in floating point. The returned value is an angle w such that

$$-\pi/2 <= w <= \pi/2$$

The absolute value of x, after its conversion to floating point, must be less than or equal to 1. The format of the function is as follows:

```
ASIN(x)
```

%Assignment Statement

The preprocessor assignment statement gives a value to a specified preprocessor variable. The format of the assignment statement is as follows:

```
%target = expression;
```

target
The name of the preprocessor variable to be assigned a value. It must be an unsubscripted reference to a preprocessor variable.

expression
Any valid preprocessor expression.

For arithmetic operations, only decimal integer arithmetic of precision (10,0) is performed. Each operand and all results are converted, if necessary, to a fixed decimal value of precision (10,0). Fractional digits are truncated.

Assignment Statement

The assignment statement gives a value to a specified variable. The format of the assignment statement is as follows:

```
target,... = expression;
```

target
A reference to a variable to be assigned the expression's value. If there are two or more targets, they are separated by commas. A target can be any of the following:

- A reference to a scalar variable or scalar array element
- A reference to a pseudovariable (for example, SUBSTR)
- A reference to a major or minor structure name or any member of a structure
- A reference to an array variable

expression
Any valid expression.

PL/I evaluates the targets and the expression in any order. Thus, a program should not depend on the evaluation of the targets before the expression.

PL/I performs the following steps for assignment. Note that the only certain things about the order of steps performed are that step 1 precedes step 3 and that step 4 is performed last.

1. The expression is evaluated, producing a value to be assigned to the targets. An expression can consist of many subexpressions and operations, each of which must be evaluated. **See** "Expression" for a complete description.
2. Each target is evaluated. If a target contains a pseudovariable, any expressions in the argument list are evaluated.
3. If the data type of the result does not match the data type of a target variable, the resulting value is converted to the data type of the target,

if possible. The compiler issues a WARNING message to alert you to the implicit conversion.

4. The value of the expression is assigned to the targets.

Some general rules regarding the types of data you can specify in assignment statements are given below. For the complete rules for data conversion in assignments, **see** "Conversion of Data."

■ Area Data

Only the current extent of an area is moved from the source area to a target. If the target area is not large enough to hold the extent, the AREA condition is raised. Note that the assignment is performed in such a way that all offsets in the source area are valid in the target area after the assignment. Areas cannot be assigned as members of structures.

■ Arithmetic Data

PL/I converts an arithmetic expression to the type of its target if their types are different. If the target is a character- or bit-string variable, PL/I converts the arithmetic expression to its character- or bit-string equivalent.

A character-string expression can be converted to the data type of an arithmetic target only if the string consists solely of characters that have numeric equivalents.

■ Arrays

You can specify an array variable as the target of an assignment statement in only the following ways:

- array-variable = expression;

  where expression yields a scalar value. Every element of the array is assigned the resulting value.

- array-variable-1 = array-variable-2;

  where the specified array variables have identical data type attributes and dimensions. Each element in array-variable-1 is assigned the value of the corresponding element in array-variable-2.

  The storage occupied by the two arrays must not overlap.

Any array variable specified in an assignment statement must occupy connected storage. All other specifications of an array variable as a target of an assignment statement are invalid.

■ Bit Data

When a target of an assignment is a bit-string variable, the resulting expression is truncated or padded with trailing zeros to match the length of the target.

■ Character Data

When a target of an assignment is a fixed-length character string, the resulting expression is truncated on the right or padded with trailing spaces to match the length of the target. If a target is a varying-length character string, the resulting expression is truncated on the right if it exceeds the maximum length of the target.

When one character-string variable is assigned to another, the storage occupied by the two variables cannot overlap.

■ Entry Data

If the specified expression is an entry constant, an entry variable, or a function reference that returns an entry value, the target variable must be an entry variable.

■ Label Data

If the specified expression is a label constant, a label variable, or a function reference that returns a label value, the target variable must be a label variable.

■ Pointer and Offset Data

If the specified expression is a pointer or offset, or a function reference that returns a pointer or offset, the target variable must be a pointer or offset variable.

■ Structures

You can specify the name of a major or minor structure as a target of an assignment statement only if the source expression is an identical structure with members in the same hierarchy and with identical sizes and data type attributes. The storage occupied by the two structures must not overlap.

Any structure variable specified in an assignment statement must occupy connected storage.

ATAN Built-In Function

The ATAN built-in function returns a floating-point value that is the arc tangent of an arithmetic expression y or an arc tangent computed from two arithmetic expressions y and x. The arc tangent is computed in floating point. If two arguments are supplied, they must both have nonzero values after they have been converted to floating point.

The format of the function is as follows:

```
ATAN(y[,x])
```

■ Returned Values

The returned value represents an angle in radians.

If x is omitted, the returned value v equals arc tangent(s), such that

$$-\pi/2 < v < \pi/2$$

where s is the value of expression y after its conversion to floating point.

If x is present, the returned value v equals arc tangent(s/r), such that if $s >= 0$, then $0 <= v <= \pi$, and if $s < 0$, then $-\pi < v < 0$, where s and r are, respectively, the values of expressions y and x after their conversion to floating point.

ATAND Built-In Function

The ATAND built-in function returns a floating-point value that is the arc tangent of a single arithmetic expression y or an arc tangent computed from two arithmetic expressions y and x. The arc tangent is computed in floating point. If two arguments are supplied, they must both have nonzero values after their conversion to floating point.

The format of the function is as follows:

```
ATAND(y[,x])
```

■ Returned Value

The floating-point value returned, which represents an angle in degrees, equals

$$ATAN(y, x) * 180/\pi$$

ATANH Built-In Function

The ATANH built-in function returns a floating-point value that is the inverse hyperbolic tangent of an arithmetic expression x. After its conversion to floating point, the absolute value of the argument x must be less than 1.

The format of the function is as follows:

```
ATANH(x)
```

Attribute

Attributes define and describe the characteristics of data used in a PL/I program. Each data item in a PL/I program has a set of attributes associated with it. Attributes can be specified in any of the following contexts:

- In a DECLARE statement for an identifier. These attributes are specified either by keyword or by syntax. For example:

  ```
  DECLARE SIGNAL CHARACTER (20);
  ```

  In this declaration, the keyword attribute CHARACTER is associated with the identifier SIGNAL. The length attribute of the variable is specified in parentheses following the CHARACTER keyword. In this manual, keyword attributes are shown in format lines in uppercase letters. Attributes given by syntax are shown in lowercase letters.
- In an OPEN statement to describe a particular file. During the opening of a file, these attributes are merged with file description attributes specified in the declaration of the file.
- Within the ENTRY attribute to describe the parameters of an external procedure. These attributes must match the attributes given to corresponding parameters specified in the PROCEDURE or ENTRY statements of the invoked subroutine or function.
- Within the RETURNS attribute of a PROCEDURE or ENTRY statement to describe the value returned by a function.

Attributes can also be implied by the presence of other attributes. For example, if the RETURNS attribute is specified for an identifier, the compiler supplies the ENTRY attribute by default.

The entry for each attribute in this manual gives its syntax and abbreviation (if any) and describes related and conflicting attributes. **See** Table A–2 at the end of this entry for a concise alphabetic summary of PL/I attributes.

■ Computational Data Type Attributes

The attributes that define arithmetic and string data are as follows:

```
CHARACTER [ (length) ] [ VARYING    ]
                       [ NONVARYING ]

BIT [ (length) ] [ ALIGNED   ]
                 [ UNALIGNED ]

{ FLOAT } { BINARY  } [ [PRECISION] (precision
{ FIXED } { DECIMAL }                [,scale-factor]) ]

PICTURE 'picture'
```

These attributes can be specified for all elements of an array and for individual members of a structure.

■ Noncomputational Data Type Attributes

The following attributes apply to program data that is not used for computation:

AREA
CONDITION
ENTRY [VARIABLE]
FILE [VARIABLE]
LABEL
OFFSET
POINTER

■ Non-Data Type Attributes

The following attributes can be applied to data declarations:

ALIGNED
DIMENSION
UNALIGNED

Table A–2: Alphabetic Summary of PL/I Attributes

Attribute	Use
ALIGNED	Requests alignment of bit-string variables in storage
ANY	Indicates that a parameter (of an external procedure not written in PL/I) can have any data type
AREA [(extent)]	Defines an area of storage for the allocation of based variables
{ AUTOMATIC | AUTO }	Requests dynamic allocation of storage for a variable
BASED [(pointer-reference)]	Indicates that a variable's storage is located by a pointer
{ BINARY | BIN } [(precision[,scale-factor])]	Defines a binary base for arithmetic data
BIT [(length)]	Defines bit-string data
BUILTIN	Defines a built-in function name
{ CHARACTER | CHAR } [(length)]	Defines character-string data
{ CONDITION | COND } (condition-name)	Defines an identifier as a condition name
{ CONTROLLED | CTL }	Defines a variable whose storage is allocated and freed in successive and fixed-sequence generations
{ DECIMAL | DEC } [(precision[,scale-factor])]	Defines a decimal base for arithmetic data
{ DEFINED | DEF } (variable-reference)	Indicates that a variable will share the storage allocated for another variable
{ DESCRIPTOR | DESC }	Requests that an argument be passed to an external non-PL/I procedure by descriptor
{ DIMENSION | DIM } (bound-pair, . . .)	Indicates that a variable is an array, and defines the number and extent of its dimensions
DIRECT	Specifies that a file will be accessed only randomly
ENTRY (descriptor, . . .)	Describes an external procedure and its parameters
{ ENVIRONMENT | ENV } (option, . . .)	Specifies system-dependent information about a file
{ EXTERNAL | EXT }	Identifies the name of a variable whose storage is referenced or defined in other procedures
FILE	Identifies a PL/I file constant or file variable

Table A–2 (Cont.): Alphabetic Summary of PL/I Attributes

Attribute	Use
FIXED [(precision[,scale-factor])]	Defines a fixed-point arithmetic variable
FLOAT [(precision)]	Defines a floating-point arithmetic variable
GLOBALDEF [(psect-name)]	Defines an external variable and optionally specifies the program section in which the variable will reside
GLOBALREF	Defines an external variable whose value is defined in an external procedure
{ INITIAL / INIT } (value, . . .)	Provides initial values for variables
INPUT	Specifies that a file will be used for input
{ INTERNAL / INT }	Limits the scope of a variable to the block in which it is defined
KEYED	Specifies that a file can be accessed randomly by key
LABEL	Defines a label variable
LIKE structure-reference	Copies the declaration of a structure to another structure variable
LIST	Specifies that a parameter can accept a list of actual parameters, of arbitrary length
MEMBER	Specifies that an item is a member of a structure
{ NONVARYING / NONVAR }	Specifies that the length of a string is nonvarying
OFFSET [(area-reference)]	Defines an offset variable
OPTIONAL	Specifies, in the declaration of a formal parameter, that the actual parameter need not be specified in a call
OPTIONS (option, . . .)	Specifies attribute options
OUTPUT	Specifies that a file will be used for output
{ PARAMETER / PARM }	Indicates that a variable will be assigned a value when it is used as an argument to a procedure
{ PICTURE / PIC } 'picture'	Specifies the format of numeric data stored in character form
{ POINTER / PTR }	Defines a pointer variable

Table A–2 (Cont.): Alphabetic Summary of PL/I Attributes

Attribute	Use
{ POSITION | POS } (expression)	Specifies the position within a variable at which a defined variable begins
{ PRECISION | PREC } [(precision[,scale-factor])]	Specifies the number of digits in an arithmetic variable and, with fixed-point data, the number of fractional digits
PRINT	Specifies that a file is to be formatted for printing
READONLY	Specifies that a static variable's value does not change during program execution
RECORD	Specifies that a file will be accessed by record I/O statements
REFER refer-item	Defines dynamically self-defining structures
{ REFERENCE | REF }	Requests that an argument be passed to an external non-PL/I procedure by reference
RETURNS (returns-descriptor)	Specifies that an external entry is a function and describes the value returned by it
{ SEQUENTIAL | SEQL }	Specifies that a file can be accessed sequentially
STATIC	Requests static allocation of storage
STREAM	Specifies that a file will be accessed by stream I/O statements
STRUCTURE	Specifies that a variable is a structure variable
TRUNCATE	Specifies, in a declaration of a formal parameter, that the actual parameter list can be truncated at the point where this argument should occur
{ UNALIGNED | UNAL }	Specifies nonalignment for bit-string variables in storage

Table A–2 (Cont.): Alphabetic Summary of PL/I Attributes

Attribute	Use
UNION	Indicates that a variable will share the storage allocated for another variable
UPDATE	Specifies that records in a file can be rewritten or deleted
{ VALUE | VAL }	Requests either that a global symbol be accessed by value rather than by reference, or that an argument be passed to a procedure by immediate value
VARIABLE	Defines variable entry and file data
{ VARYING | VAR }	Defines a varying-length character string

AUTOMATIC Attribute

The AUTOMATIC attribute specifies, for one or more variables, that PL/I is to allocate storage only for the duration of a block. An automatic variable is not allocated storage until the block that declares it is activated. The storage is released when the block is deactivated. The format of the AUTOMATIC attribute is as follows:

{ AUTOMATIC | AUTO }

AUTOMATIC explicitly defines the storage class of a variable, array, or major structure in a DECLARE statement. Because AUTOMATIC is the default for internal variables, you need not specify it.

■ Restrictions

The AUTOMATIC attribute conflicts with the following attributes (the specification of which implies that storage allocation is not to be automatic):

BASED	GLOBALREF
CONTROLLED	PARAMETER
DEFINED	READONLY
EXTERNAL	STATIC
GLOBALDEF	

The AUTOMATIC attribute cannot be applied to minor structures, members of structures, parameters, or descriptions in an ENTRY or RETURNS attribute.

For a discussion of PL/I storage allocation, **see** "Storage Class."

B

B Format Items

The B format items B, B1, B2, B3, and B4—describe representations of bit strings in an input or output stream. Note that the B can be typed lowercase. The form of the B format items is as follows:

```
B[m] [(w)]
```

m

The integer 1, 2, 3, or 4, specifying the radix factor. B and B1 have the same meaning. When the radix factor is omitted or is 1, the bit string is represented by the characters 0 and 1 in the stream. When the radix factor is 2, the bit string is represented by the characters 0, 1, 2, and 3. When the radix factor is 3, the bit string is represented by the characters 0, 1, 2, 3, 4, 5, 6, and 7. When the radix factor is 4, the bit string is represented by the characters 0 through 9 and A through F.

w

A nonnegative integer or integer expression that specifies the width in characters of the field in the stream.

The interpretation of the B format items on input and output is described below. For a general discussion of format items, **see** "Format Item."

■ Input with GET EDIT

The value w must be included when the B format items are used with GET EDIT. If w equals zero, no operation is performed on the input stream, and a null string is assigned to the input variable. The number of characters specified by w is acquired. The input characters are converted to an intermediate bit string of length w*m. If the input target is not a bit-string variable, then this intermediate bit string is converted to the type of the input target, following the PL/I conversion rules (for details, **see** "Conversion of Data").

The string of characters in the stream can be preceded or followed by spaces, which are ignored. All characters in the input field (except any leading and trailing spaces) must be those implied by the radix factor; otherwise, an ERROR condition is signaled. Consequently, input strings should not be enclosed in apostrophes and should not include the suffix Bm.

■ Output with PUT EDIT

The output source is converted, if necessary, to a bit string, following the PL/I rules for converting data to bit strings (**see** "Conversion of Data"). If the length of the resulting bit string is not a multiple of the radix factor (m), the bit string is padded with zeros on the right to make its length the next higher multiple.

The bit string is then converted to a character representation appropriate to the radix factor and placed in the output stream. The character representation is left-justified in the field specified by w and is truncated or padded with spaces on the right if necessary. If w is not included, the output string has the same length as the converted output source. If w is zero, the B format item and its associated output source are skipped.

■ Examples

```
BFORMAT_XM: PROCEDURE OPTIONS(MAIN);
/* This program prints incorrect values for an integer */
DECLARE I FIXED BINARY(31);
DECLARE BFORM STREAM OUTPUT PRINT FILE;
I = 5;
OPEN FILE(BFORM) TITLE('BFORMXM.OUT');
PUT SKIP FILE(BFORM) EDIT ('Decimal:',I) (A,X,F(2));
PUT SKIP FILE(BFORM) EDIT ('Binary:',I) (A,X,B);
PUT SKIP FILE(BFORM) EDIT ('Base 4:',I) (A,X,B2);
PUT SKIP FILE(BFORM) EDIT ('Octal:',I) (A,X,B3);
PUT SKIP FILE(BFORM) EDIT ('Hexadecimal:',I) (A,X,B4);
END BFORMAT_XM;
```

This program produces the following output:

```
Decimal:  5
Binary: 00000000000000000000000000000101
Base 4: 0000000000000022
Octal: 00000000024
Hexadecimal: 0000000A
```

The base 4, octal, and hexadecimal representations of I are incorrect because the precision of I (31) is not a multiple of 2, 3, or 4. For the B2 and B4 format items, an extra zero bit was appended to the intermediate bit string, in effect multiplying the value of the string by 2. For B3, two extra bits were appended to make the string 33 bits long and thus divisible into an exact number of 3-bit segments. To avoid this problem, the precision of the output source must be a number that is evenly divisible by any radix factor with which it is to be written out, as in the following example:

```
BFORMAT_XM: PROCEDURE OPTIONS(MAIN);
/* This program prints correct values for an integer */
DECLARE I FIXED BINARY(24); /* 24 is a multiple of 2*3*4 */
DECLARE BFORM STREAM OUTPUT PRINT FILE;
I = 5;
OPEN FILE(BFORM) TITLE('BFORMXM5.OUT');
PUT SKIP FILE(BFORM) EDIT ('Decimal:',I) (A,X,F(2));
PUT SKIP FILE(BFORM) EDIT ('Binary:',I) (A,X,B);
PUT SKIP FILE(BFORM) EDIT ('Base 4:',I) (A,X,B2);
PUT SKIP FILE(BFORM) EDIT ('Octal:',I) (A,X,B3);
PUT SKIP FILE(BFORM) EDIT ('Hexadecimal:',I) (A,X,B4);
END BFORMAT_XM;
```

This version of the program produces the following output:

```
Decimal:  5
Binary: 00000000000000000000000101
Base 4: 000000000011
Octal: 00000005
Hexadecimal: 000005
```

The output values are correct representations of I because the precision (24) is evenly divisible by 2, 3, or 4.

The tables below show the relationship between the internal and external representations of characters that are read or written with the B format item.

Input Examples

The "input stream" shown in the following table is a field of characters beginning at the current position in the stream and continuing to the right. The target type is the type of the variable to which the input value is assigned.

Format Item	Input Stream	Target Type	Target Value
B(12)	111000111110...	BIT(12)	'111000111110'B
B(12)	ΔΔΔΔΔΔ110011...	BIT(12)	'110011000000'B
B2(6)	123123...	BIT(12)	'011011011011'B
B3(4)	1775...	BIT(12)	'001111111101'B
B4(3)	1FA...	BIT(12)	'000111111010'B

Output Examples

The output source value shown in the following table is either a constant or the value of a variable that is written out with the associated format item.

Output Source Value	Format Item	Output Value
4095	B	111111111111
4095	B(11)	11111111111
4095	B2	333333
4095	B3	7777
4095	B4	FFF

BASED Attribute

The BASED attribute defines a based variable, that is, a variable whose actual storage will be denoted by a pointer or offset reference. For general information, **see** "Based Variable." The format of the BASED attribute is as follows:

```
BASED [ (reference) ]
```

reference
A reference to a pointer or offset variable or pointer-valued function. If the reference is to an offset variable, that variable must be declared with a base area. Each time a reference is made to a based variable without an explicit pointer or offset qualifier, the reference is evaluated to obtain the pointer or offset value.

■ Restrictions

The following attributes conflict with the BASED attribute:

AUTOMATIC	PARAMETER
CONTROLLED	READONLY
DEFINED	STATIC
EXTERNAL	VALUE
GLOBALDEF	
GLOBALREF	

The BASED attribute cannot be applied to minor structures, members of structures, parameters, or descriptions in an ENTRY or RETURNS attribute.

Based Variable

A based variable is a variable that describes storage that will be accessed through a pointer or offset value. PL/I does not automatically allocate any storage for a based variable. Instead, you must explicitly allocate storage.

This entry gives the rules governing references to based variables and the use of pointer values. It also presents examples of dynamic storage allocation, of the use of READ SET, and of the use of the ADDR built-in function.

■ References to Based Variables

A reference to a based variable (except in an ALLOCATE statement) must specify a pointer or offset reference designating the storage to be accessed by the reference. You can specify this qualifying pointer or offset reference implicitly, by giving it the BASED attribute, or explicitly, by prefixing the based variable reference with a locator qualifier. A complete based variable reference (with the locator qualifier) has the following form:

```
qualifying-reference -> base-reference
```

Whether explicit or implicit, the qualifying reference must be a reference to a pointer variable, a pointer-valued function, or an offset variable declared with a base area. The qualifying reference is evaluated each time the complete reference is evaluated and must yield a valid pointer value (**see** "Pointer Values" below). If the qualifying reference is to an offset variable, the offset value is converted to a pointer using the base area specified in

the offset variable's declaration. (For more details on offsets and areas, **see** the *VAX PL/I User Manual* and the entries "Offset" and "Area" in this manual.)

You can use both implicit and explicit qualification with the same based variable; the explicit qualifier overrides the implicit one. For example:

```
DECLARE X FIXED BIN BASED(P);
P = ADDR(A);
X = ADDR(B)->X;
```

In the second assignment statement, the reference to X on the left side of the assignment has the implicit qualifier P, which is the address of the variable A. The reference to X on the right side is explicitly qualified with the address of another variable, B. This assigns the value of B to the variable A.

■ Pointer Values

In VAX PL/I, you can obtain a valid pointer value in any of the following ways:

- Through the SET option of the ALLOCATE statement
- From a user-provided storage allocation routine
- Through the SET option of the READ statement
- Through application of the ADDR built-in function to an addressable variable (**see** "Variable")
- Through conversion of an offset value to a pointer value

A pointer value is valid only as long as the storage to which it applies remains allocated. Moreover, a pointer obtained by the application of ADDR to a parameter is valid only as long as the parameter's procedure invocation exists, even though the storage to which the pointer points can exist longer.

The NULL built-in function returns a null pointer value that can be assigned to pointer and offset variables, but the null value is not valid as the pointer value qualifying a based variable reference.

You can assign an arbitrary value to a pointer variable using the UNSPEC built-in function or based variables. Such a value is invalid even if it denotes allocated storage, and use of such values causes unpredictable program behavior and errors that are difficult to diagnose. For example, the following program attempts to use pointer arithmetic to "alias" two variables X and Y:

```
ALIAS: PROCEDURE OPTIONS(MAIN);

DECLARE INDEX FIXED BINARY(31),
      P POINTER BASED(ADDR(INDEX));
DECLARE (X,Y) FLOAT BINARY(24) STATIC, /* 4 bytes apart (?) */
      (A,B) FLOAT BINARY(24) BASED;

X = 1E0; Y = 2E0;
P = ADDR(X);                          /* INDEX holds the address of X */
P->A = Y + 1;                         /* Expect X = Y+1               */
INDEX = INDEX + 4;                    /* INDEX now holds address of Y (?) */
P->B = Y + 1;                         /* Expect Y = Y + 1             */
PUT SKIP LIST('P->A:',P->A,'P->B:',P->B);
END ALIAS;
```

The program can produce incorrect results in at least two ways:

- It can be assumed that the programmer knows, perhaps from a storage map, that X and Y occupy adjacent storage and that Y can be accessed by the incrementing of INDEX. However, this is not necessarily true for any two variables, and the program does rely on the assumption.
- If common subexpressions are eliminated during the compiler's optimization of this program, incorrect results will occur. The optimization results in the following:

  ```
  T = Y + 1;
  P->A = T;
  P->B = T;
  ```

  The expected result of the program is to give B a value equal to the original value of Y plus 2. However, the assignment to B yields an incorrect result because the assignment to A modified Y, and the compiler had no way to discover that Y was an aliased variable.

■ Data Type Matching for Based Variables

In most applications, the data type of a based variable reference is identical to the data type under which the accessed storage is allocated. (For a discussion of identical data types, **see** "Data and Data Types.") However, it is not required that the data types be identical. In standard PL/I, it is sufficient that the data types match as for overlay defining or that they are left-to-right equivalent. Moreover, in VAX PL/I the data types can be quite different, although the program will then depend on the VAX internal representation of data.

Matching by Overlay Defining

Matching by overlay assigning is in effect if the based variable reference and the variable for which the storage was originally allocated are both suitable for character-string or bit-string overlay defining. (**See** "Defined Variable" and "Union" for a discussion of string overlay defining.) The only further restriction is that the size n (in characters or bits) of the based variable must be less than or equal to the size in characters or bits of the original variable. The based variable reference accesses the first n characters or bits of the storage.

Matching by Left-to-Right Equivalence

Matching by left-to-right equivalence applies to structured variables that are identical only up to a certain point. To test for left-to-right equivalence, examine the declaration of the based variable, and consider only the portion on the left that includes the referenced member and all of the level-2 substructures containing the referenced member (if the member is not itself at level 2). If the original variable's declaration has a similar left part with an identical data type, then the based variable reference and the original reference match. For example:

```
DECLARE 1 S1 BASED (P),
          2 X,
            3 (A,B) FIXED BIN,
          2 Y,
            3 C CHAR(10),
            3 D(5) FLOAT;

DECLARE 1 S2 BASED(P);
          2 X,
            3 (A,B) FIXED BIN,
          2 Y,
            3 C CHAR(10),
            3 E BIT(32);

ALLOCATE S1;

S2.A = 3;    /* valid left-to-right match */

S2.C = 'X';  /* INVALID */
```

In the first assignment, S2.A is a valid reference because S1 and S2 match through the level-2 structure X. In the second assignment, S2.C is invalid in standard PL/I because the level-2 structures S2.Y and S1.Y do not match. However, the reference to S2.C does work in VAX PL/I.

This sort of matching is useful in connection with data structures and files, where the first part of a record contains a value indicating the precise structure of the remainder of the record.

Nonmatching Based Variable References

In VAX PL/I, the base variable in a based variable reference need not match the variable for which the storage was originally allocated. The only requirement is that the size of the based variable in bits be less than or equal to the size of the original variable in bits. However, use of such nonmatching references requires knowledge of the VAX internal representation of data, and you should not expect the resulting code to be transportable to other PL/I implementations. For example:

```
DECLARE X FLOAT BINARY(24);
DECLARE 1 S BASED(ADDR(X)),
          2 FRAC_1 BIT(7),
          2 EXP BIT(8),
          2 SIGN BIT(1),
          2 FRAC_2 BIT(16);

EXP = '0'B;   /* set exponent to 0 */
SIGN = '1'B;  /* set sign negative */
X = X + 1;
```

The declaration of S describes the internal representation of a VAX single-precision floating-point number. The first two assignments set the sign and exponent fields to the reserved operand combination. The assignment to X causes a reserved operand exception.

■ Based Variables and Dynamic Storage Allocation

These subsections discuss the dynamic allocation of storage by the ALLOCATE statement and the READ SET statement.

Using the ALLOCATE Statement

Each time it is executed, the ALLOCATE statement allocates storage for a based variable and, optionally, sets a pointer or offset variable to the location of the storage in memory. The storage allocated can also be assigned values if the variable is declared with the INITIAL attribute.

For example:

```
DECLARE LIST (10) FIXED BINARY BASED,
        (LIST_PTR_A, LIST_PTR_B) POINTER;

ALLOCATE LIST SET (LIST_PTR_A);
ALLOCATE LIST SET (LIST_PTR_B);
```

In this example, the array LIST is declared with the BASED attribute; however, the declaration does not reserve storage for this variable. Instead, the ALLOCATE statements allocate storage for the variable and set the pointers LIST_PTR_A and LIST_PTR_B to the storage locations. LIST_PTR_A and LIST_PTR_B must both be declared with the POINTER attribute.

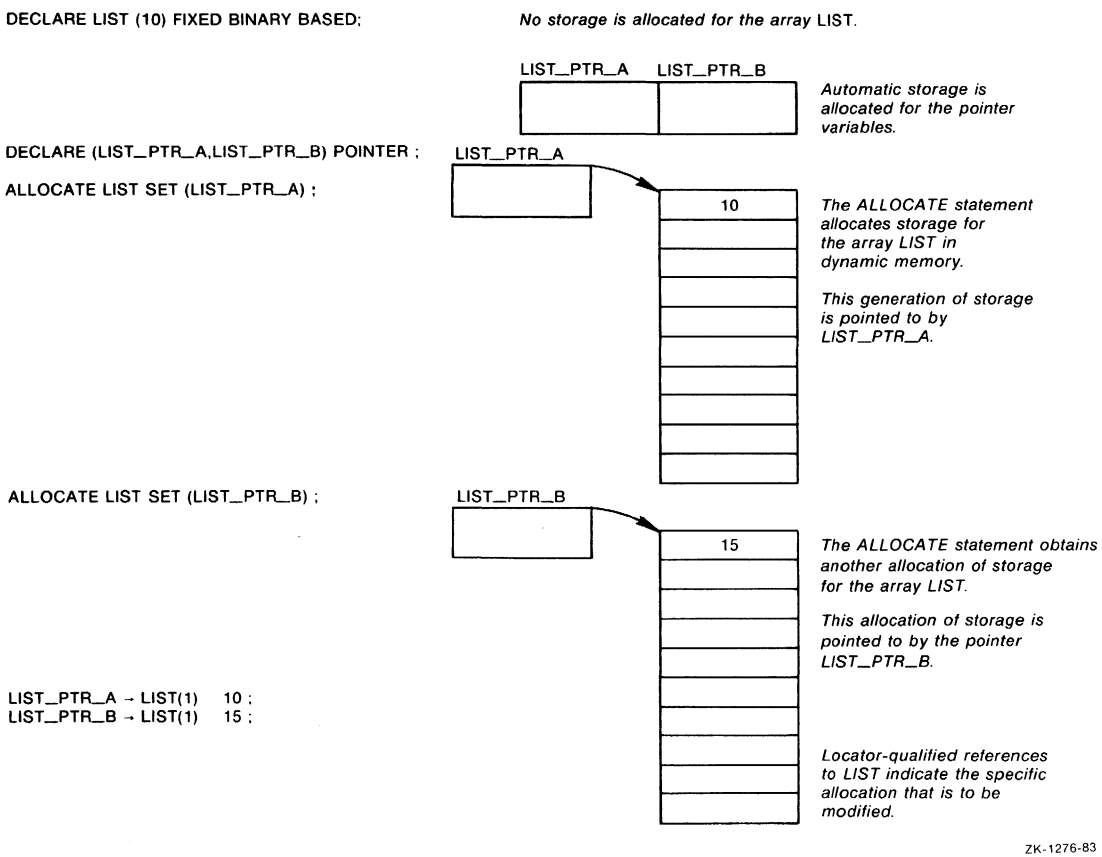
In references, the different allocations of LIST can then be distinguished (unless the pointers are assigned new values) by locator qualifiers that identify the specific allocation of LIST. For example:

```
LIST_PTR_A -> LIST(1) = 10;
LIST_PTR_B -> LIST(1) = 15;
```

The phrase LIST_PTR_A-> is a locator qualifier; it specifies the pointer that locates an allocation of storage for the variable. In this example, the first element of the storage pointed to by LIST_PTR_A is assigned the value 10. The first element of the storage pointed to by LIST_PTR_B is assigned the value 15.

Figure B–1 illustrates this example.

Figure B–1: Using the ALLOCATE Statement



Any extent expressions in the based variable declaration are evaluated each time the variable is allocated or referenced. Therefore, based variables can be used for data aggregates whose size depends on input data. Here is an example of dynamically allocating a matrix that will be accessed by several external procedures:

```
DECLARE 1 MATRIX_CONTROL_BLOCK STATIC EXTERNAL,
          2 MATRIX_POINTER POINTER,
          2 (ROW_SIZE,COL_SIZE) FIXED BINARY;

DECLARE 1 MATRIX(ROW_SIZE,COL_SIZE)
          BASED(MATRIX_POINTER);

GET LIST(ROW_SIZE,COL_SIZE);
ALLOCATE MATRIX;
```

The SET Option of the READ Statement

When you use the READ statement with a based variable, you do not have to define storage areas within your program to buffer records for I/O operations. If you specify the SET option on the READ statement, the READ statement places an input record in a system buffer and sets a pointer variable to the location of that buffer. For example:

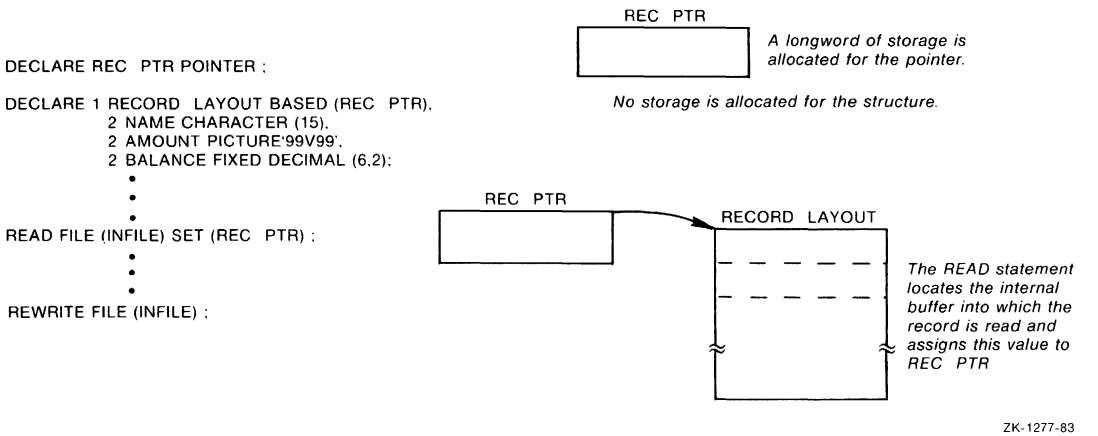
```
DECLARE REC_PTR POINTER,
        INFILE FILE RECORD INPUT SEQUENTIAL;
DECLARE 1 RECORD_LAYOUT BASED (REC_PTR),
          2 NAME CHARACTER (15),
          2 AMOUNT PICTURE '999V99',
          2 BALANCE FIXED DECIMAL (6,2);
   .
   .
   .
READ FILE (INFILE) SET (REC_PTR);
   .
   .
   .
REWRITE FILE (INFILE);
```

In this example, the structure defined to describe the records in a file is declared with the BASED attribute; the declaration does not reserve storage for this structure. When the READ statement is executed, the record is actually read into a system buffer, and the pointer REC_PTR is set to its location.

When the SET option is used with the READ statement, a subsequently executed REWRITE statement need not specify the record to be rewritten. PL/I rewrites the record indicated by the pointer variable specified in the READ statement.

Figure B–2 illustrates this example.

Figure B–2: Using the READ Statement with a Based Variable



■ Examples

The program DEFINED uses based variables and the READ SET statement to process a file of personnel data (PERSONNEL.DAT). The file has two types of valid records: a pay record and a health record. The different record types are identified by a 1-character code in the first position. Both record types are declared as based structures (PAY_RECORD and HEALTH_RECORD), one of which is selected based on the record type character ('P' for pay, 'E' for health). Any record that does not begin with one of these characters is invalid and is written out as a reference to the based character variable INVALID_RECORD.

```
DEFINED: PROCEDURE OPTIONS(MAIN);

DECLARE P POINTER; /* pointer to structures */

DECLARE 1 PAY_RECORD BASED(P),
          2 RECORD_TYPE CHARACTER(1),
          2 NAME CHARACTER(20),
       /* the two structures differ in this member: */
          2 GROSS_PAY PICTURE '999999V.99';

DECLARE 1 HEALTH_RECORD BASED(P),
          2 RECORD_TYPE CHARACTER(1),
          2 NAME CHARACTER(20),
          2 EXAM_DATE CHARACTER(9);

DECLARE INVALID_RECORD CHARACTER(30) BASED(P);
```

```
DECLARE PERSONNEL RECORD FILE;
DECLARE PERSOUT STREAM OUTPUT PRINT FILE;

/* used to control DO group: */
%REPLACE NOTENDFILE BY '1'B;

ON ENDFILE(PERSONNEL) BEGIN;
      PUT FILE(PERSOUT) SKIP LIST
              ('All processing complete.');
      STOP;   /* program stops here */
      END;


OPEN FILE(PERSONNEL) INPUT TITLE('PERSONNEL.DAT');

DO WHILE(NOTENDFILE);
/* terminated by ENDFILE ON-unit */

READ FILE(PERSONNEL) SET(P);
/* P is the location of the
record acquired by the READ statement */

IF P->PAY_RECORD.RECORD_TYPE = 'P' THEN
      PUT FILE(PERSOUT) SKIP LIST
      ('Name=',P->PAY_RECORD.NAME,
      'Gross pay=',P->GROSS_PAY);


ELSE    /* either a health record or an invalid record */
        DO;
        IF P->HEALTH_RECORD.RECORD_TYPE = 'E' THEN
        PUT FILE(PERSOUT) SKIP LIST
        ('Name=',P->HEALTH_RECORD.NAME,
        'Exam date:',P->EXAM_DATE);
        ELSE /* invalid record type */
        PUT FILE(PERSOUT) SKIP LIST
                ('Invalid record:',P->INVALID_RECORD);
        END;

END; /* repeat DO group until ENDFILE is signaled */

END DEFINED;
```

For example, if the file PERSONNEL.DAT contains the following records:

```
PMary A. Ford        125000.55
EMary A. Ford        22July 80
t12345678901234567890pppppp.pp
```

then the output file (PERSOUT.DAT) will contain the following output:

```
Name=   Mary A. Ford            Gross pay=      125000.55
Name=   Mary A. Ford            Exam date:      22July 80
Invalid record: t12345678901234567890pppppp.pp
All processing complete.
```

Notice the other features of the program:

- The references to based variables have a locator qualifier (P–>) for clarity. However, because all were declared with P as their pointer reference, the locator qualifier could have been omitted.
- References to the structure members RECORD_TYPE and NAME must be fully qualified with the name of their containing structures (PAY_RECORD and HEALTH_RECORD) because both structures have members with these names. In contrast, GROSS_PAY and EXAM_DATE are unique to their structures and need not be fully qualified.

Note that the UNION attribute can frequently be used for overlaid records such as those in this program. For example:

```
1 RECORD BASED(P),
  2 RECORD_TYPE CHARACTER(1),
  2 NAME CHARACTER(20),
  2 VARIANTS UNION,
    3 GROSS_PAY PICTURE '999999V.99',
    3 EXAM_DATE CHARACTER(9);
```

This can be used in place of PAY_RECORD and HEALTH_RECORD in the program. However, note that the UNION attribute is not available in many other PL/I implementations.

■ Using the ADDR Built-In Function

The ADDR built-in function returns the storage location of a variable. It can be used to associate the storage occupied by a variable with the description of a based variable. For example:

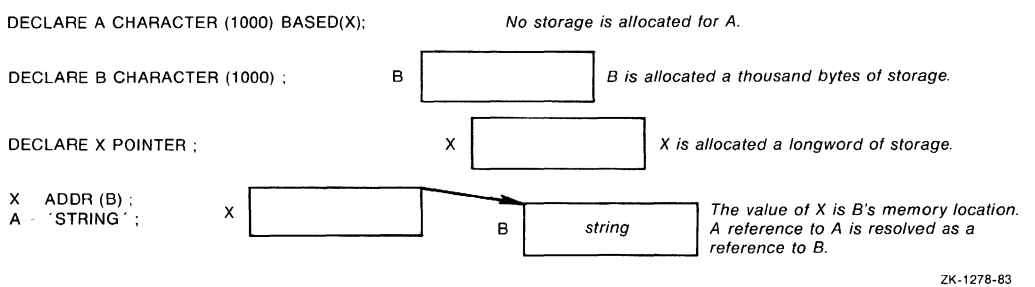
```
DECLARE A FIXED BINARY BASED (X),
        B FIXED BINARY,
        X POINTER;

        X = ADDR (B);
A = 15;
```

In this example, the variable A is declared as a based variable, with the pointer X designated as its pointer. The variable B is an automatic variable; PL/I allocates storage for B when the block is activated. When the ADDR built-in function is referenced, it returns the storage location of the variable B, and the assignment statement gives this value to the pointer X. This assignment associates the variable A with the storage occupied by B. Because A is based on X and X points to B, an assignment statement that gives a value to A actually modifies the storage occupied by the variable B.

Figure B–3 illustrates this example.

Figure B–3: Using the ADDR Built-In Function



■ Based Variables and List Processing

Data structures in which the elements have complex interactions or in which the elements can be added or deleted are normally described with based variables. The simplest such structure is a linked list. For an example, **see** "List Processing."

Begin Block

A begin block is a sequence of statements headed with a BEGIN statement and terminated by an END statement. In general, a begin block can be used wherever a single executable statement is valid, for instance, in an ON-unit.

A begin block can contain any PL/I statements. It can contain DO-groups, SELECT-groups, DECLARE statements, and procedures, as well as other (nested) begin blocks.

A begin block provides a convenient way to localize variables. Internal variables that are declared within a begin block are not allocated storage until the begin block is activated; they have by default the AUTOMATIC attribute. When the begin block terminates, storage for internal automatic variables is released. A begin block is terminated under the following conditions:

- Its corresponding END statement is executed. Control continues with the next executable statement in the program.
- It executes a nonlocal GOTO to transfer control to a previous block.

A begin block differs from a DO-group chiefly in its ability to localize variables. Variables declared within DO-groups are not localized to the group (unless the group contains a begin block or procedure that declares internal variables). Begin blocks are preferable when you want to restrict the scope of variables, and there are some cases (such as ON-units) in which DO-groups cannot be used. Otherwise, DO-groups are often more efficient than begin blocks, because they do not have the overhead associated with block activation.

For more information, **see** "Block."

A begin block can designate a series of statements to be executed depending on the success or failure of a test in an IF statement. For example:

```
IF A = B THEN BEGIN;
    .
    .
    .
END;
```

A begin block also provides the only way to denote a series of statements to be executed when an ON condition is signaled. For example:

```
ON ERROR BEGIN; [statement ...] END;
```

For further information, **see** "ON Conditions and ON-Units."

BEGIN Statement

The BEGIN statement denotes the start of a begin block. The format of the BEGIN statement is as follows:

```
BEGIN;
```

A begin block must be terminated with an END statement.

BINARY Attribute

The BINARY attribute specifies that an arithmetic variable has a binary base. The format of the BINARY attribute is as follows:

```
{ BINARY }
{ BIN    }
```

When you specify the BINARY attribute for an identifer, you can also specify one of the following attributes to define the scale and precision of the data:

```
FIXED [(precision[,scale])]
FLOAT [(precision)]
```

FIXED indicates a fixed-point binary value and FLOAT indicates a floating-point binary value.

For a fixed-point binary value, the precision specifies the number of bits representing an integer and must be in the range 1 through 31. For a fixed-point binary value, the scale factor represents the number of bits to the right of the binary point and must be in the range –31 through 31. The scale factor must be less than or equal to the specified precision. **See** "Scale Attribute" for more information.

For a floating-point value, the precision specifies the number of bits representing the mantissa of a floating-point number and must be in the range 1 through 113. The maximum floating-point binary precision is always 113. The default values applied to the BINARY attribute are as follows.

Attributes Specified	Defaults Supplied
BINARY	FIXED (31,0)
BINARY FIXED	(31,0)
BINARY FLOAT	(24)

■ Restrictions

The BINARY attribute directly conflicts with the DECIMAL attribute and with any other data type attribute.

BINARY Built-In Function

The BINARY built-in function converts an arithmetic or string expression x to its binary representation, with an optionally specified precision p and scale factor q. The returned value is either fixed- or floating-point binary, depending on whether x is a fixed- or floating-point expression.

The format of the function is as follows:

```
{ BINARY } (x[,p[,q]])
{ BIN    }
```

The precision p, if specified, must be an integer constant greater than zero and less than or equal to the maximum precision of the result type (31 if fixed-point binary and 113 if floating-point binary). The precision p must be specified if x is a fixed-point value with fractional digits.

The scale factor q, if specified, must be an integer constant less than or equal to the specified precision and in the range -31 to 31.

■ Returned Value

The result type is fixed- or floating-point binary, depending on whether the argument x is a fixed- or floating-point expression. (If the argument is a bit- or character-string expression, the result type is fixed-point binary.)

The argument x is converted to the result type, giving a value v, following the PL/I rules for conversion (**see** "Conversion of Data").

The returned value is the value v, with precision p, and scale factor q. If p is omitted (integer and floating-point arguments only), the precision of the returned value is the converted precision of x (**see** "Expression"). FIXEDOVERFLOW, OVERFLOW, or UNDERFLOW is signaled if appropriate.

BIT Attribute

The BIT attribute identifies a variable as a bit-string variable. The format of the BIT attribute is as follows:

```
BIT[(length)]
```

length
The number of bits in the variable. If you do not specify a length, the default length is one bit. The length must be in the range 0 through 32767.

The rules for specifying the length are as follows:

- If the attribute is specified for a static variable declaration or in a returns descriptor, length must be a restricted integer expression (**see** "Restricted Expression").
- If the attribute is specified in the declaration of a parameter or in a parameter descriptor, length can be specified as a restricted integer expression or as an asterisk (*).
- If the attribute is specified for an automatic, based, controlled, or defined variable, length can be specified as an expression. In the case of automatic or defined variables, the expression must not contain any variables or functions that are declared in the same block, except for parameters.

If specified, the length in parentheses must follow the keyword BIT.

If you give a variable the BIT attribute, you can also specify the ALIGNED attribute to request alignment of the variable on a byte boundary in storage.

■ Restrictions

The BIT attribute directly conflicts with the CHARACTER and VARYING attributes and with any other data type attribute.

BIT Built-In Function

The BIT built-in function converts an arithmetic or string expression x to a bit string of an optionally specified length. If x is a string expression, it must consist of 0s and 1s. If the length is specified, it must be a nonnegative integer. If the length is omitted, the returned value has a length determined by the PL/I rules for conversion to bit strings (**see** "Conversion of Data").

The format of the function is as follows:

```
BIT(x[,length])
```

Bit-String Data

A bit string consists of a sequence of binary digits, or bits. A bit string can be used as a Boolean value. That is, the string can have the value true, if any bit is 1, or false, if all bits are 0.

Like a fixed-length character string, a bit string has a fixed length defined in the declaration or specified by the number of bits in a bit-string constant; bit-string variables cannot be declared with the VARYING attribute.

This discussion of bit-string data is divided into the following parts:

- Constants
- Variables
- Alignment
- Internal representation

■ Bit-String Constants

To specify a bit-string constant, enclose the string in apostrophes and follow the closing apostrophe with the letter B. Some examples of bit-string constants are as follows:

```
'0101'B
'10101010'B
'1'B
```

The length of a bit-string constant is always the number of binary digits specified; the B does not count in the length of the string. The maximum length of any bit string is 32767 bits. A bit-string constant can be specified with a maximum of 1000 characters between the apostrophes.

You can also specify a bit-string constant using the following syntax:

```
'character-string'Bn
```

Here, n specifies the number of bits to be represented by each character in the specified string. This format allows you to specify bit-string constants that have bases other than base 2. For example:

```
'EF8'B4
'117'B3
'223'B2
```

These constants specify the hexadecimal value EF8, the octal value 117, and the base 4 value 223.

All such constants are stored internally as bit strings. **See** "Internal Representation of Bit Data," below.

Following are the characters that are valid for each type of bit-string constant:

- For B or B1, only the characters 0 and 1 are valid.
- For B2, only the characters 0, 1, 2, and 3 are valid.
- For B3, only the characters 0, 1, 2, 3, 4, 5, 6, and 7 are valid.
- For B4, the characters 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F are valid. (The letters A to F can be either upper- or lowercase.)

Using the B format items, you can also acquire or output bit-string data in binary, base 4, octal, or hexadecimal format. **See** "B Format Items."

■ Bit-String Variables

Use the keyword BIT to declare a bit-string variable. The format is as follows:

```
DECLARE variable-name BIT [(length)];
```

When a program assigns a value to a bit-string variable, the value can be larger or smaller than the defined length of the variable. In such cases, PL/I does the following:

- If the assigned string is shorter than the defined target length, PL/I pads the bit-string value in the direction of least significance with zeros. The "less significant" bits are those shown on the right, as the string is represented by PUT LIST.
- If the assigned string is longer than the target, PL/I truncates the least significant bits from the bit-string value.

If you do not specify a length for a bit-string variable, PL/I uses the default length of one bit.

NOTE

Avoid using bit strings to represent integers. The truncation or padding that occurs in assignments between strings of different lengths results in an implicit division or multiplication of the numeric interpretation of the string; these implicit operations can introduce subtle errors in computations.

■ Alignment of Bit-String Data

PL/I distinguishes between aligned and unaligned bit-string variables. (Bit-string constants are always unaligned.) A bit-string variable is aligned only if it is declared with the ALIGNED attribute, as shown in the following example:

```
DECLARE FLAGS BIT (8) ALIGNED;
```

PL/I allocates storage for an aligned bit-string variable on a byte boundary and reserves an integral number of bytes to contain the variable.

Unaligned bit-string variables always occupy only as many bits as are needed to contain them. They need not be on byte boundaries.

In general, operations involving unaligned bit-string variables are less efficient than operations involving aligned bit-string variables. Unaligned bit-string variables are invalid as the targets of the FROM and INTO options of record I/O statements and as the arguments of the ADDR built-in function. Moreover, most non-PL/I programs that accept bit-string arguments require that the strings be aligned.

Alignment affects argument passing. If a procedure declares a parameter as an aligned bit string, and if the corresponding argument that is passed to it is an unaligned bit-string variable, or vice versa, the actual argument will be a dummy variable. For example:

```
DECLARE GETSTRING ENTRY (BIT (*) ALIGNED);
DECLARE STRING BIT (8);
CALL GETSTRING (STRING);
```

In this example, PL/I constructs a dummy variable to pass the argument STRING to the called procedure GETSTRING, rather than passing the actual argument by reference.

It is recommended that you declare bit-string variables using the ALIGNED attribute in most cases. Use unaligned bit-string variables when bit strings must be packed as tightly as possible, for example, in arrays and in structures.

■ Internal Representation of Bit Data

In this discussion, the term "most significant bit" means the leftmost bit in an external representation of a string, as, for example, when the string is output by the PUT LIST statement. The "least significant bit" is the rightmost bit in the external representation.

The notion of significance has no meaning for bit strings unless they are used to store integers. VAX PL/I permits the use of bit strings for this purpose, and it has defined rules for conversions between bit strings and other data types (**see** "Conversion of Data.") Nevertheless, the use of PL/I bit-string data to store integers is not recommended, for two reasons:

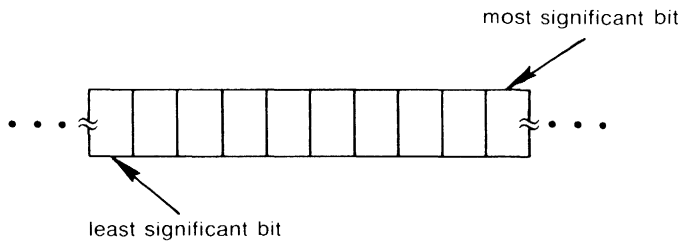
- In assignments involving two bit strings of different lengths, the source string is padded or truncated as required to make a string of the length of the target.
- As shown in the following discussions, the "significance" of bits results in bit strings being stored in the reverse order from actual numeric data. Consequently, conversion of bit strings to arithmetic data is expensive in terms of execution speed, except in the special case of a 1-bit string.

It is recommended instead that you use the UNSPEC built-in function and UNSPEC pseudovariable when you must store integers in a compact form. Otherwise, use the data types FIXED BINARY and FIXED DECIMAL for integer arithmetic.

The way that PL/I allocates storage for a bit-string variable depends on whether the variable is declared with the ALIGNED attribute.

Unaligned Bit Strings

An unaligned bit string is stored beginning at an arbitrary bit location in storage; this location is the location of the most significant bit. The subsequent, less significant, bits are stored in progressively higher locations in memory, as shown here:



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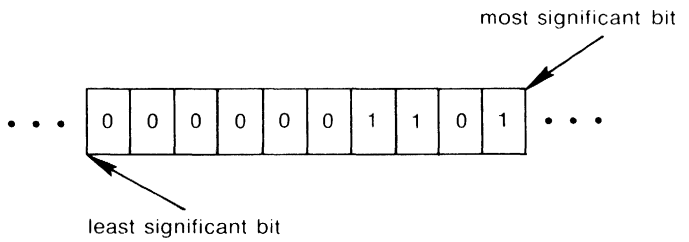
The following programming sequence illustrates how a value for an unaligned bit-string variable is stored:

```
DECLARE ABIT BIT (10);
ABIT = '1011'B;
```

After the assignment, the variable appears in storage like this:



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Aligned Bit Strings

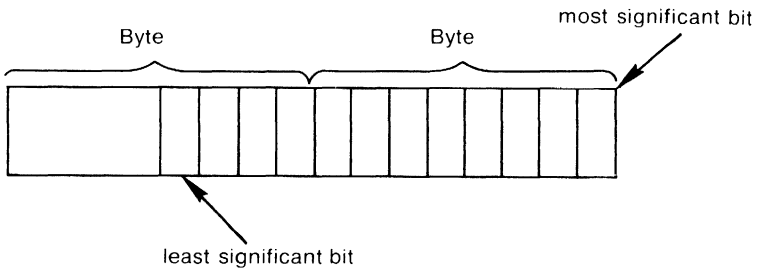
PL/I allocates storage for an aligned bit-string variable on a byte boundary and allocates an integral number of bytes. The number of bytes to be allocated is calculated as follows:

$$ceil(n/8)$$

where n is the length specified for the bit string.

Beginning at bit 0 (the lowest memory location) of the lowest allocated byte, the bit string is stored like unaligned bit-string data; that is, the beginning bit is used to hold the most significant bit in the string. Less significant bits are stored in progressively higher memory locations. Unused bits are set to zero each time the bit-string variable is assigned a value.

The representation is as follows:

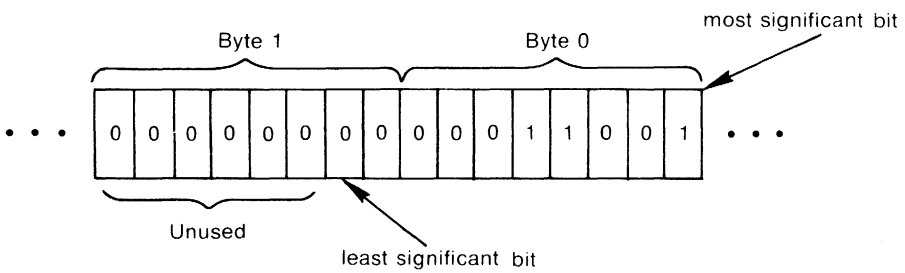


ZK-1281-83

The following programming sequence illustrates how values are stored for aligned bit strings:

```
DECLARE ABIT BIT (10) ALIGNED;
ABIT = '10011'B;
```

In this example, the variable ABIT is aligned. When it is assigned the value 10011, the value is stored as follows:



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Block

A block is a sequence of PL/I statements. There are two types of blocks:

- Procedure blocks. A procedure block begins with a PROCEDURE statement and terminates with an END statement. A procedure is the basic program unit of PL/I; it also defines the scope of names declared within it.

- Begin blocks. A begin block begins with a BEGIN statement and terminates with an END statement. A begin block delimits a portion of a program and defines the scope of names declared within it.

Blocks control the scope of names, the allocation of storage for automatic variables, and the search for ON-units to respond to a particular condition. (**See also** " Scope of Names.")

■ Containment

A block A is said to be contained in another block B if all of A's source text, from label (if any) to END statement inclusive, is between B's BEGIN or PROCEDURE statement and B's END statement. If there is no block C contained in B and containing A, A is also said to be immediately contained in B. For example:

```
B: PROCEDURE OPTIONS(MAIN);
      A: PROCEDURE;
              CALL Q;
              END A;
      Q: PROCEDURE;
         .
         .
         .
              END Q;
      BEGIN;
              CALL A;
      END; /* of begin block */
END B;
```

The procedures A and Q and the begin block all are immediately contained in B.

If block A is contained in block B, then A and B are also said to be nested. The maximum nesting level is 64.

■ Block Activation

A block is activated when program execution flows into it. Then, all automatic variables declared in the block become active. When control leaves the block, the variables become undefined and inaccessible.

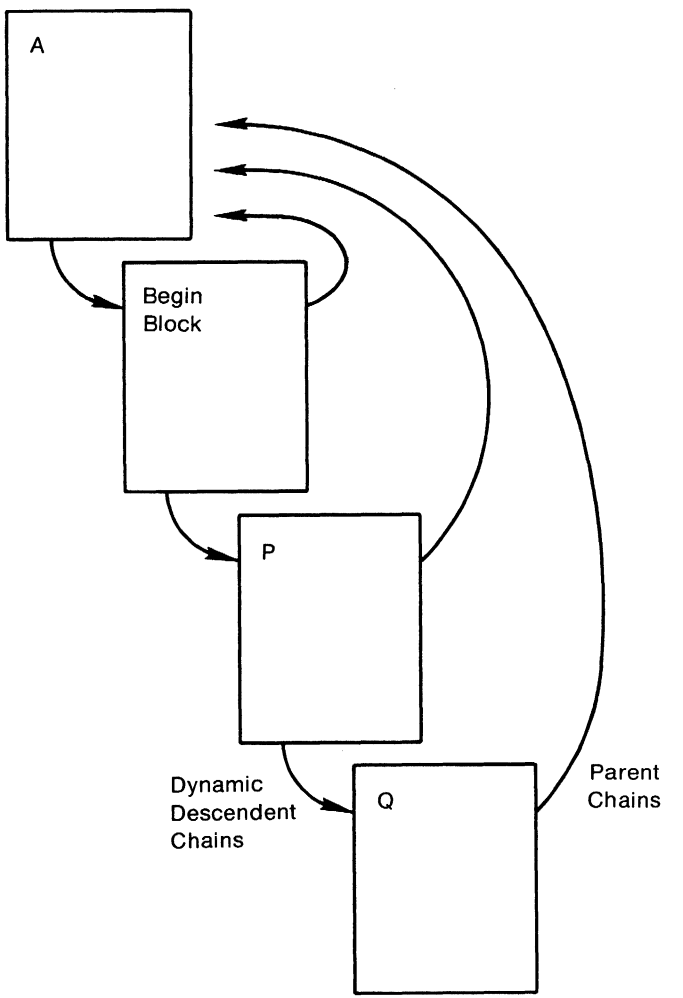
A procedure block can be entered only by a CALL statement or a function reference. If an internal procedure is declared within a source program, control flows around the internal procedure during the normal sequence of execution.

A begin block is entered when it is encountered during the normal flow of execution.

■ Relationship of Block Activations

During the execution of a program, many blocks can be simultaneously active. Two different relationships can be defined among block activations; they are illustrated in Figure B–4.

Figure B–4: Relationship of Block Activations




```
A:  PROCEDURE OPTIONS (MAIN) ;

    P:  PROCEDURE;
        CALL Q;
          •
          •
          •
        END P;
    Q:  PROCEDURE;
          •
          •
          •
        END Q;

    BEGIN;
        CALL P;
        END; /* of begin block */

END A;
```

ZK-1283-83

One relationship is "immediate dynamic descendence." A block activation is the immediate dynamic descendent of the block that invoked it. At a given time, the chain of immediate dynamic descendents includes all existing block activations, starting with the activation of the main procedure and terminating in the current block activation. For example, in Figure B–4, the begin block is the immediate dynamic descendent of procedure A; the complete chain is A, begin block, P, Q. This chain is used for finding the applicable ON-unit when a condition is signaled. (**See also** "ON Conditions and ON-Units.")

The other relationship applies to activations of nested blocks; an activation of a block X that is a begin block or internal procedure has an "immediate parent activation." The immediate parent activation of X is an activation of the block that immediately contains X. The chain of immediate parent activations extends back to an activation of the external procedure containing X. In Figure B–4, the parent chain for each of the begin block, procedure P, and procedure Q leads directly back to the activation of A, because each of these blocks is immediately contained in A. This chain is used in interpreting references. (**See also** "Reference.")

When a block is activated, its immediate parent activation is determined as follows:

- If the block is an external procedure, it has no parent activation.
- If the block is a begin block, its immediate parent activation is the activation that invoked it. Therefore, the begin block is the immediate dynamic descendent of its immediate parent.
- If the block is an internal procedure invoked in block activation A by a reference to an entry constant declared in block B, then the immediate parent of the new block activation is the activation of B in the parent chain starting at A.
- If the block is an internal procedure invoked by an entry variable, the parent activation is taken from the entry value. It was originally set when the complete entry value was generated by the assignment of an entry constant to an entry variable. (**See** "Entry Data.")

■ Block Termination

When a block terminates normally, that is, when an END statement or a RETURN statement is executed, the current block is released and control goes to the preceding block activation. If a nonlocal GOTO statement is executed that transfers control out of the current block, the current block and any blocks between it and the block containing the label that is the target of the GOTO statement are released.

For more information, **see** "Begin Block," "Procedure," "Procedure Block," and "Scope of Names."

BOOL Built-In Function

The BOOL built-in function performs a Boolean operation on two bit-string arguments and returns the result as a bit string with the length of the longer argument. Its format is as follows:

```
BOOL(string-1,string-2,operation-string)
```

string-1
A bit-string expression of any length.

string-2
A bit-string expression of any length.

operation-string
A bit-string expression that is converted to length 4. Each bit in the operation string specifies the result of comparing two corresponding bits in string-1 and string-2. Specify bit positions in the operation string from left to right to define the operation, as in the following truth table:

String-1 Bit	String-2 Bit	Result of Boolean Operation
0	0	Bit 1 of operation string
0	1	Bit 2 of operation string
1	0	Bit 3 of operation string
1	1	Bit 4 of operation string

Thus, an AND operation, for instance, would be specified by the operation-string '0001'B.

If string-1 and string-2 are of different lengths, the shorter is extended on the right with zeros to the length of the longer.

■ Example

```
X = '101010'B;
Y = '110011'B;
CHECK = BOOL (X,Y,'0110'B);
```

The operation string is '0110'B, which defines an EXCLUSIVE OR operation. The operation is performed as follows on the corresponding bits in the strings X and Y: The leftmost bit in X is 1 and the leftmost bit in Y is 1. The truth table above specifies that when the two corresponding bits in the two strings are both 1, then bit 4 of the operation string will be the result; in this case, bit 4 of the operation string '0110'B is 0. Thus, 0 is the first bit of the value to be returned. The second bit of X is 0 and of Y is 1. The truth table specifies that when the bit in the first string is 0 and in the second string is 1, the result will be bit 2 of the operation string. Here, bit 2 of the operation string '0110'B is 1, and so 1 is the second bit of the value to be returned. The operation continues in this manner with each two corresponding bits in the strings. The value returned is '011001'B.

Figure B–5 illustrates this example.

BUILTIN Attribute

The BUILTIN attribute indicates that the name declared is the name of a PL/I built-in function. Within the block in which the name is declared, all references to the name will be interpreted as references to the built-in function or pseudovariable of that name.

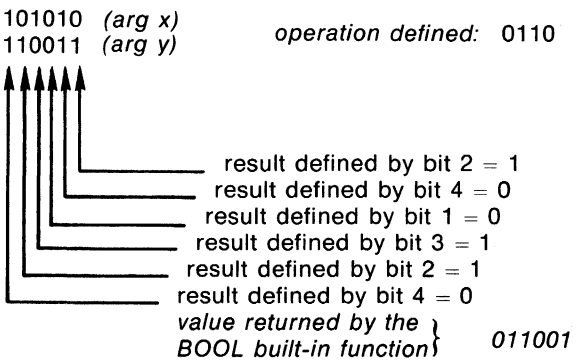
You use the BUILTIN attribute when you want to refer to a built-in function within a block in which the function's name has been used to declare a variable.

You also use the BUILTIN attribute when you want to invoke a built-in function that takes no arguments (such as the DATE function) and you do not want to include a null argument list.

■ Restriction

When you specify the BUILTIN attribute, you cannot specify any other attributes.

Figure B–5: Example of the BOOL Built-In Function



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■ Examples

```
OUTER: PROCEDURE;
DECLARE MAX FIXED BINARY STATIC INITIAL (10);
      .
      .
      .
      INNER: PROCEDURE;
      DECLARE MAX BUILTIN;
            TEST = MAX(A,B);
               .
               .
               .
      END INNER;
END OUTER;
```

The keyword MAX is used here as a variable name. In the internal procedure INNER, the MAX built-in function is invoked. Because the scope of the name MAX includes the internal procedure, the function must be redeclared with BUILTIN.

You can also use the BUILTIN attribute to declare PL/I built-in functions that have no arguments, if you want to invoke them without the empty argument list. For example:

```
DECLARE DATE BUILTIN;
PUT LIST(DATE);
```

Without the declaration, the PUT LIST statement would have to include an empty argument list for DATE:

```
PUT LIST(DATE());
```

Built-In Function

Built-in functions are procedures provided by the PL/I language. You can use them wherever an expression is valid.

■ Built-In Function Arguments

Built-in functions are similar to operators, and their arguments are similar to operands. Built-in function arguments, if arithmetic, are converted to their derived type before the function reference is evaluated. **See also** "Expression." All evaluations of built-in functions are performed in the result type. The arguments are converted again from the derived type to the result type if necessary. The precision of the result is the greater of the precisions of the two arguments.

For instance, all the mathematical functions listed in Table B–1 return floating-point values; their arguments are converted to floating point (binary or decimal, depending on the base of the argument) before the operation is performed.

■ Example

Like all mathematical functions, ATAN returns a floating-point result and is therefore computed in floating point. The base of the result is the same as the base of the converted arguments. For example:

```
DCL J FIXED BINARY(8); FT = ATAN(J,2);
```

Here the derived type of J and 2 is fixed-point binary. The converted precision of 2 is $min(ceil(1/3.32) + 1, 31)$, or 2. The result type is FLOAT BINARY(8). Both arguments are then converted to FLOAT BINARY(8), and the ATAN operation is performed.

■ Restrictions

Note the following restrictions on built-in function arguments:

- All arguments of all built-in functions except the array-handling, storage, file-control, and STRING functions must be scalars of arithmetic, string, or pictured data types, as specified for the individual function.
- A reference to a built-in function that takes no arguments must still contain the pair of enclosing parentheses [example: NULL()] unless the function's name has been declared with the BUILTIN attribute.

■ Conditions Signaled

Built-in functions, like other operations, can signal conditions. The mathematical functions, which are computed in floating point, can signal OVERFLOW and UNDERFLOW under the appropriate conditions. Functions that are computed in fixed point can signal FIXEDOVERFLOW. In general, string and other functions signal ERROR if a result cannot be computed. **See also** the descriptions of individual conditions and built-in functions.

■ Summary

The built-in functions are summarized in Table B–1, according to the following categories:

- Arithmetic built-in functions provide information about the properties of arithmetic values, or perform common arithmetic calculations.
- Mathematical built-in functions perform standard mathematical calculations in floating point.
- String-handling built-in functions process character-string and bit-string values.
- Conversion built-in functions convert data from one data type to another.
- Condition-handling built-in functions provide information about interrupts caused by signaled conditions.
- Array-handling built-in functions provide information about arrays.
- Storage control built-in functions return values concerning based variables.

- Timekeeping built-in functions return the system date and time of day.
- File-control built-in functions return the current line number and page number of a file.
- Preprocessor built-in functions are used only at compile time by the embedded preprocessor.
- Miscellaneous built-in functions check the validity of data, aid in argument passing, and perform other convenient operations

Table B–1: Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
Arithmetic	ABS(x)	Absolute value of x
	ADD(x,y,p[,q])	Value of x+y, with precision p and scale factor q
	CEIL(x)	Smallest integer greater than or equal to x
	DIVIDE(x,y,p[,q])	Value of x divided by y, with precision p and scale factor q
	FLOOR(x)	Largest integer that is less than or equal to x
	MAX(x,y)	Larger of the values x and y
	MIN(x,y)	Smaller of the values x and y
	MOD(x,y)	Value of x modulo y
	MULTIPLY(x,y,p[,q])	Value of x*y, with precision p and scale factor q
	PRECISION(x,p[,q])	Value of expression x, with precision p and scale factor q
	ROUND(x,k)	Value of x rounded to k digits
	SIGN(x)	–1, 0, or 1 to indicate the sign of x
	SUBTRACT(x,y,p[,q])	Value of x-y, with precision p and scale factor q
	TRUNC(x)	Integer portion of x
Mathematical	ACOS(x)	Arc cosine of x (angle, in radians, whose cosine is x)
	ASIN(x)	Arc sine of x (angle, in radians, whose sine is x)

Table B–1 (Cont.): Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
	ATAN(x)	Arc tangent of x (the angle, in radians, whose tangent is x)
	ATAN(x,y)	Arc tangent of x (the angle, in radians, whose sine is x and whose cosine is y)
	ATAND(x)	Arc tangent of x (the angle, in degrees, whose tangent is x)
	ATAND(x,y)	Arc tangent of x (the angle, in degrees, whose sine is x and whose cosine is y)
	ATANH(x)	Hyperbolic arc tangent of x
	COS(x)	Cosine of radian angle x
	COSD(x)	Cosine of degree angle x
	COSH(x)	Hyperbolic cosine of x
	EXP(x)	Base of the natural logarithm, e, to the power x
	LOG(x)	Logarithm of x to the base e
	LOG10(x)	Logarithm of x to the base 10
	LOG2(x)	Logarithm of x to the base 2
	SIN(x)	Sine of the radian angle x
	SIND(x)	Sine of the degree angle x
	SINH(x)	Hyperbolic sine of x
	SQRT(x)	Square root of x
	TAN(x)	Tangent of the radian angle x
	TAND(x)	Tangent of the degree angle x
	TANH(x)	Hyperbolic tangent of x
String-Handling	BOOL(x,y,z)	Result of Boolean operation z performed on x and y
	COLLATE( )	ASCII character set
	COPY(s,c)	c copies of specified string, s
	EVERY(s)	Boolean value indicating whether every bit in bit string s is '1'B

Table B–1 (Cont.): Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
	HIGH(c)	String of length c of repeated occurrences of the highest character in the collating sequence
	INDEX(s,c[,p])	Position of the character string c within the string s, starting at position p
	LENGTH(s)	Number of characters or bits in the string s
	LOW(c)	String of length c of repeated occurrences of the lowest character in the collating sequence
	MAXLENGTH(s)	Maximum length of varying string s
	REVERSE(s)	Reverse of the source character string or bit string
	SEARCH(s,c[,p])	Position of the first character in s, starting at position p, that is found in c
	SOME(s)	Boolean value indicating whether at least one bit in bit string s is '1'B
	STRING(s)	Concatenation of values in array or structure s
	SUBSTR(s,i[,j])	Part of string s beginning at i for j characters
	TRANSLATE(s,c[,d])	String s with substitutions defined in c and d
	TRIM(s[,e,f])	String s with all characters in e removed from the left, and all characters in f removed from the right
	VERIFY(s,c[,p])	Position of the first character in s, starting at position p, which is not found in c
Conversion	BINARY(x[,p[,q]])	Binary value of x with precision p and scale factor q
	BIT(s[,l])	Value of s converted to a bit string of length l

Table B–1 (Cont.): Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
	BYTE(x)	ASCII character represented by the integer x
	CHARACTER(s[,l])	Value of s converted to a character string of length l
	DECIMAL(x[,p[,q]])	Decimal value of x
	DECODE(c,r)	Fixed binary value of the character string c converted to a base r number
	ENCODE(i,r)	Character string representing the base r number that is equivalent to the fixed binary expression i
	FIXED(x,p[,q])	Fixed arithmetic value of x
	FLOAT(x,p)	Floating arithmetic value of x
	INT(x[,p[,l]])	Signed integer value of variable x, located at position p with length l
	POSINT(x[,p[,l]])	Unsigned integer value of variable x, located at position p with length l
	RANK(c)	Integer representation of the ASCII character c
	UNSPEC(x[,p[,l]])	Internal coded form of x, located at position p with length l
Condition-Handling	ONARGSLIST( )	Pointer to argument lists of exception condition
	ONCHAR( )	Character that caused the CONVERSION condition to be raised
	ONCODE( )	Error code of the most recent run-time error
	ONFILE( )	Name of file constant for which the most recent ENDFILE, ENDPAGE, KEY, or UNDEFINEDFILE condition was signaled
	ONKEY( )	Value of key that caused KEY condition

Table B–1 (Cont.): Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
	ONSOURCE( )	Field containing the ONCHAR character when the CONVERSION condition was raised
Array-Handling	DIMENSION(x[,n])	Extent of the nth dimension of x
	HBOUND(x[,n])	Higher bound of the nth dimension of x
	LBOUND(x[,n])	Lower bound of the nth dimension of x
	PROD(x)	Arithmetic product of all the elements in x
	SUM(x)	Arithmetic sum of all the elements in x
Storage	ADDR(x)	Pointer identifying the storage referenced by x
	ALLOCATION(x)	Number of existing generations for controlled variable x
	EMPTY( )	An empty area value
	NULL( )	A null pointer value
	OFFSET(p,a)	An offset into the location in area a pointed to by pointer p
	POINTER(o,a)	A pointer to the location at offset o within area a
	SIZE(x)	Number of bytes allocated to variable x
Timekeeping	DATE( )	System date in the form YYMMDD
	DATETIME( )	System date and time in the form CCYYMMDDHHMMSSXX
	TIME( )	System time of day in the form HHMMSSXX
File Control	LINENO(x)	Line number of the print file identified by x
	PAGENO(x)	Page number of the print file identified by x
Preprocessor	ABS(x)	Absolute value of x
	BYTE(x)	ASCII character represented by integer x
	COPY(s,c)	c copies of specified string s

Table B–1 (Cont.): Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
	DATE( )	Compilation date in the form YYMMDD
	DATETIME( )	System date and time in the form CCYYMMDDHHMMSSXX
	DECODE(c,r)	Fixed binary value of the character string c converted to a base r number
	ENCODE(i,r)	Character string representing the base r number that is equivalent to the fixed binary expression i
	ERROR( )	Count of user-generated diagnostic error messages
	INDEX(s,c[,p])	Position of the character string c within the string s, starting at position p
	INFORM( )	Count of user-generated diagnostic informational messages
	LENGTH(s)	Number of characters or bits in the string s
	LINE( )	Line number in source program that contains the end of the specified preprocessor statement
	MAX(x,y)	Larger of the values x and y
	MIN(x,y)	Smaller of the values x and y
	MOD(x,y)	Value of x modulo y
	RANK(c)	Integer representation of the ASCII character c
	REVERSE(s)	Reverse of the source character string or bit string
	SEARCH(s,c[,p])	Position of the first character in s, starting at position p, that is found in c
	SIGN(x)	–1,0, or 1 to indicate the sign of x
	SUBSTR(s,i[,j])	Part of string s beginning at i for j characters
	TIME( )	Compilation time of the day in the form HHMMSSXX

Table B–1 (Cont.): Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
	TRANSLATE(s,c[,d])	String s with substitutions defined in c and d
	TRIM(s[,e,f])	String s with all characters in e removed from the left and all characters in f removed from the right
	VARIANT( )	String result representing the value of /VARIANT of the PLI command qualifier
	VERIFY(s,c[,p])	Position of the first character in s, starting at position p, which is not found in c
	WARN( )	Count of user-generated diagnostic warning messages
Miscellaneous	ACTUALCOUNT( )	Number of parameters the current procedure was called with
	DESCRIPTOR(x)	Forces its argument to be passed by descriptor to a non-PL/I procedure
	PRESENT(p)	Boolean value indicating whether parameter p was specified in a call
	REFERENCE(x)	Forces its argument to be passed by reference to a non-PL/I procedure
	VALID(p)	Boolean value, indicating whether the pictured variable p has a value consistent with its picture specification
	VALUE(x)	Forces its argument to be passed by value to a non-PL/I procedure

Built-In Subroutine

Built-in subroutines are VAX PL/I-specific routines that provide various added capabilities. These routines can be used in a CALL statement. All arguments are evaluated as for normal subroutines.

The built-in subroutines are summarized in Table B–2, according to the following functional categories:

- Condition-handling built-in subroutines assist in performing condition-related operations.
- File-control built-in subroutines perform file operations not supported by the standard PL/I language.
- Record-locking built-in subroutines allow extended record-locking control in conjunction with the OPTIONS clause of the READ statement.

The built-in subroutines are described in detail in the *VAX PL/I User Manual.*

Table B–2: Summary of PL/I Built-In Subroutines

Category	Routine Reference	Action
Condition-handling	RESIGNAL( )	Allows more processing of a signal
File-control	DISPLAY(f,i)	Returns information on file f into i
	EXTEND(f,b)	Extends file f by b blocks
	FLUSH(f)	Forces all buffers for file f to be flushed
	NEXT_VOLUME(f)	Performs magnetic tape volume processing on file f
	REWIND(f)	Resets file f to the beginning
	SPACE_BLOCK(f,b)	Positions file f forward or backward b blocks
Record-locking	FREE(f)	Frees all locks for file f
	RELEASE(f,r)	Releases locked record r in file f

BY Option

The BY option defines a value by which a control variable in a DO statement specification is modified. For example:

```
DO I = 10 BY 10 WHILE (X < Y) UNTIL (X = 90);
```

The DO-group following this statement is executed with values for I of 10, 20, and so on, until the specification in the WHILE option is no longer true or the UNTIL option is true. If no BY option is specified in a controlled DO statement, the default value of 1 is used. **See** "DO Statement."

BYTE Built-In Function
BYTE Preprocessor Built-In Function

The BYTE built-in function returns the ASCII character whose ASCII code is the integer x; x must not be negative. The returned value is a character equivalent to BYTE(y), where y equals x modulo 256. The format of the function is as follows:

BYTE(x)

■ Example

```
DECLARE CHAR CHARACTER(1);
CHAR = BYTE(65);          /* CHAR = 'A' */
CHAR = BYTE(32);          /* CHAR = ' ' (space) */
```

C

CALL Statement

The CALL statement transfers control to an entry point of a procedure and optionally passes arguments to the procedure. The format of the CALL statement is as follows:

```
CALL entry-name [(argument,...)];
```

entry-name
The name of an external or internal procedure that does not have the RETURNS attribute, or the name of an alternate entry point to a procedure. The entry name can also be an entry variable or a reference to a function that returns an entry value.

argument, . . .
The argument list to be passed to the called procedure. If specified, the arguments must correspond to the parameters specified in the PROCEDURE or ENTRY statement that identifies the entry name of the called procedure.

Unless you specify OPTIONS(VARIABLE) in the declaration of an external entry name, the number of arguments must match the number of parameters in the parameter list of the invoked entry name. OPTIONS(VARIABLE) is valid only for use with non-PL/I procedures.

You must enclose arguments in parentheses. Multiple arguments must be separated by commas.

You can use the CALL statement to call an internal or external procedure. The following example illustrates a main procedure, CALLER, and a call to an internal procedure, PUT_OUTPUT. PUT_OUTPUT has two parameters, INSTRING and OUTFILE, that correspond to the arguments LINE and DEVICE specified in the CALL statement.

```
CALLER: PROCEDURE OPTIONS(MAIN);
   .
   .
   .
        CALL PUT_OUTPUT(LINE,DEVICE);
   .
   .
   .
PUT_OUTPUT:PROCEDURE(INSTRING,OUTFILE);
   .
   .
   .
END PUT_OUTPUT;
END CALLER;
```

For more information, **see** "Entry Data," "Parameters and Arguments," "Procedure," "Procedure Block," and "PROCEDURE Statement"; and the *VAX PL/I User Manual.*

CEIL Built-In Function

The CEIL function returns the smallest integer that is greater than or equal to an arithmetic expression x. Its format is as follows:

CEIL(x)

■ Returned Value

If x is a floating-point expression, a floating-point value is returned with the same precision as x. If x is a fixed-point expression, the returned value is a fixed-point value of the same base as x and with

$$precision = min(31, p - q + 1)$$

$$scalefactor = 0$$

where p and q are the precision and scale factor of x.

■ Examples

```
A = 4.3;
Y = CEIL(A);          /* Y = 5 */

A = -4.3;
Y = CEIL(A);          /* Y = -4 */
```

CHARACTER Attribute

The CHARACTER attribute identifies a variable as a character-string variable. The format of the CHARACTER attribute is as follows:

```
{ CHARACTER } [(length)]
{ CHAR      }
```

length
The number of characters in a fixed-length string or the maximum length of a varying-length string. If not specified, a length of 1 is assumed. The length must be in the range 0 through 32767 characters.

The rules for specifying the length are as follows:

- If the attribute is specified for a static variable declaration or in a returns descriptor, length must be a restricted integer expression (defined in the entry "Restricted Expression").
- If the attribute is specified in the declaration of a parameter or in a parameter descriptor, length can be specified as a restricted integer expression or as an asterisk (*).
- If the attribute is specified for an automatic, based, or defined variable, length can be specified as an expression. In the case of automatic or defined variables, the expression must not contain any variables or functions that are declared in the same block, except for parameters.

If specified, the length must immediately follow the keyword CHARACTER, and it must be enclosed in parentheses.

If you give a variable the CHARACTER attribute, you can also specify the attribute VARYING or NONVARYING.

■ Restriction

The CHARACTER attribute directly conflicts with the BIT attribute and with any other data type attribute.

CHARACTER Built-In Function

The CHARACTER built-in function converts an arithmetic or string expression x to a character string of an optionally specified length. If the length is specified, it must be a nonnegative integer. If the length is omitted, the length of the returned value is determined by the PL/I rules for conversion to character strings (**see** "Conversion of Data"). The format of the function is as follows:

$$\left\{ \begin{array}{l} \text{CHARACTER} \\ \text{CHAR} \end{array} \right\} \text{(x[,length])}$$

■ Example

```
CHAR:  PROCEDURE OPTIONS(MAIN);

DECLARE EXPRES FIXED DECIMAL(7,5);
DECLARE OUTPUT PRINT FILE;

EXPRES = 12.34567;

OPEN FILE(OUTPUT) TITLE('CHAR2.OUT');

PUT SKIP FILE(OUTPUT)
     LIST('No length argument: ',CHARACTER(EXPRES));

PUT SKIP FILE(OUTPUT)
     LIST('Length = 4: ',CHARACTER(EXPRES,4));

END CHAR;
```

The program CHAR produces the following output:

```
No length argument:       12.34567
Length = 4:       12
```

In the first PUT LIST statement, CHARACTER has only one argument, so the entire string is written out. The string '12.34567' is actually preceded by two spaces; this is the case with any nonnegative number converted to a character string (**see** "Conversion of Data"). In the second PUT LIST statement, CHARACTER has a length argument of 4, so the first four characters of the converted string are written out as '␣␣12'.

Character-String Data

A character string is a sequence of characters. The value of a character-string variable is a sequence of ASCII characters. A character-string constant is a sequence of DEC Multinational Character Set characters, and can include non-ASCII characters. The first 128 characters of the DEC Multinational Character Set are the ASCII characters. (**See** Appendix B for the entire character set.)

The maximum length of a character-string value is 32767 bytes.

Every character-string variable has a length attribute that specifies either the length of all values of the variable (fixed-length strings) or the maximum length of a value of the variable (varying-length strings).

This discussion of character-string data is divided into the following parts:

- Constants
- Replication of string constants
- Variables
- Varying character strings
- Alignment of character strings
- Internal representation

■ Character-String Constants

When you use character-string constants in a program, you must enclose the character strings in apostrophes, as shown in the following examples:

```
'Total is:'
'Enter your name and age'
'Error - value is out of range'
```

To specify a string containing a literal apostrophe, use two apostrophes within the string. For example:

```
'Life isn''t fair'
```

The final result contains only a single apostrophe.

■ Replication of String Constants

You can use a replication factor to replicate character-string and bit-string constants in any context of the program. A replication factor is an unsigned integer constant that specifies the number of times a simple string constant is replicated to produce a resulting string constant.

For example:

```
(4)'season  ';
```

In this example, the string is repeated four times. The character constant resulting from this specification looks like this:

```
season  season  season  season
```

You can use a replication factor in combination with the iteration factor in INITIAL. For example, the following two statements are equivalent:

```
INITIAL ((10)('ABCABC'))

INITIAL ((10)((2)'ABC'))
```

The first example uses an iteration factor exclusively, but the second example combines an iteration factor of 10 with a replication factor of 2. Note that an extra set of parentheses is required to separate the iteration factor from the replication factor and the character string.

■ Character-String Variables

The CHARACTER keyword identifies a variable as a character-string variable in a declaration. The format for specifying a fixed-length character-string variable is as follows:

```
DECLARE variable-name CHARACTER [(n)];
```

where n is the length of the variable, that is, the number of bytes needed to contain the value of the variable. If not specified, PL/I uses the default length of one character (one byte).

Fixed-Length Character-String Variables

When a program assigns a value to a fixed-length character-string variable, the value is not always exactly the same as the length defined for the variable. Depending on the size of the value, PL/I does the following:

- If the value is smaller than the length of the character string, PL/I pads the string with spaces on the right. For example:

```
DECLARE STRING CHARACTER (10);
STRING = 'ABCDEF';
```

The final value of the variable STRING in this example is 'ABCDEF␣␣␣␣', that is, the characters ABCDEF followed by four space characters.

- If the value is larger than the length of the variable, PL/I truncates the string on the right. For example:

```
DECLARE STRING CHARACTER (4);
STRING = 'ABCDEF';
```

The final value of the variable STRING in this example is 'ABCD', that is, the first four characters of the value 'ABCDEF'.

Initializing Character-String Variables

You can use the INITIAL attribute to supply an initial value for the variable. For example:

```
DECLARE MESSAGE CHARACTER (20)
   INITIAL('Begin entering text');
```

If the initial value for a variable is longer than the length, the value is truncated. If the initial value is shorter than the specified length, the string is padded with spaces on the right.

■ Varying Character Strings

When you define a character-string variable, you can also specify the VARYING attribute. A varying character-string variable is a variable whose length is not fixed. The length specified in the declaration of the variable defines the maximum length of any value that can be assigned to the variable. Each time a value is assigned to the variable, the current length can change. For example:

```
DECLARE NAME CHARACTER (20) VARYING;
NAME = 'COOPER';
NAME = 'RANDOM FACTOR';
```

The declaration of the variable NAME indicates that the maximum length of any character-string value it can have is 20. Although the maximum length of NAME is 20, the current length becomes 6 when NAME is assigned the value COOPER; the length becomes 13 when NAME is assigned the value RANDOM FACTOR; and so on.

When a varying character string is assigned a value with a length greater than the maximum defined, the value is truncated on the right.

The initial length of a based, controlled, or automatic varying-length character-string variable is undefined. A static variable is initially a null string with a length of zero.

You can use the LENGTH built-in function to determine the current length of any string. **See** "LENGTH Built-In Function."

You can use the MAXLENGTH built-in function to determine the maximum length of a varying character string. **See** "MAXLENGTH Built-In Function."

■ Alignment of Character Strings

The PL/I language makes a distinction between aligned and unaligned (fixed-length) character-string variables. (No such distinction is made for varying character strings or for character-string constants.) A character-string variable is aligned if it is declared with the ALIGNED attribute.

In VAX PL/I, this distinction affects only argument passing. If a procedure declares a parameter as ALIGNED CHARACTER, and if the corresponding argument is an unaligned character-string variable or vice versa, the actual argument will be a dummy variable. For example:

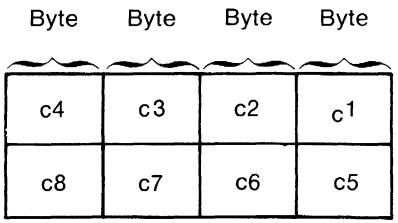
```
DECLARE GETSTRING ENTRY (CHARACTER (*) ALIGNED);
DECLARE STRING CHARACTER (8);
CALL GETSTRING (STRING);
```

PL/I constructs a dummy variable here to pass the unaligned string variable STRING to the called procedure GETSTRING, rather than passing the actual argument by reference. (**See** "Argument Passing.")

Note that all character strings on the VAX hardware are aligned on byte boundaries. Thus, it is recommended that you do not use the ALIGNED attribute to declare character-string variables.

■ Internal Representation of Character Data

PL/I stores fixed-length character-string data from right to left, giving each character a byte of storage, as follows:



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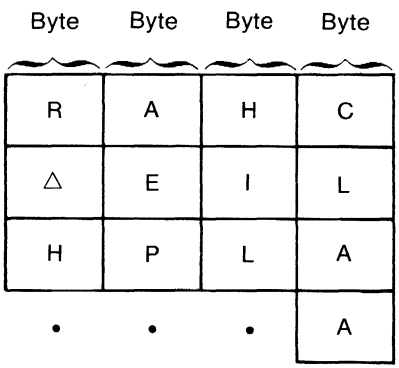
For example, a character string whose value is 'CHARLIE ALPHA' is stored as follows:



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Varying-length strings are stored in a number of bytes equal to n+2, where n is the declared maximum length. The two additional bytes contain the current length of the value in bytes in the first two byte addresses.

CLOSE Statement

The CLOSE statement dissociates PL/I files from the physical files with which they were associated when opened. The format of the CLOSE statement is as follows:

```
CLOSE FILE(file-reference) [ENVIRONMENT(option,...)]
        [,FILE(file-reference) [ENVIRONMENT(option,...)]]...;
```

file-reference
A file to be closed. If the file is already closed, the CLOSE statement has no effect.

ENVIRONMENT(option, . . .)
One or more of the following ENVIRONMENT options, separated by commas:

BATCH
DELETE
REVISION_DATE
REWIND_ON_CLOSE
SPOOL
TRUNCATE

No other ENVIRONMENT options are valid. All ENVIRONMENT options are described in detail in the *VAX PL/I User Manual.*

■ Examples

```
CLOSE FILE(INFILE) ENVIRONMENT(SPOOL);
```

This CLOSE statement closes the file constant INFILE and submits it for printing on the default spooler queue.

```
CLOSE FILE(A) ENV(DELETE), FILE(B) ENV(REVISION_DATE(X));
```

This CLOSE statement closes two files specified in a comma list, each with a different ENVIRONMENT option.

```
DECLARE STATE_FILE FILE KEYED;

OPEN FILE(STATE_FILE) DIRECT UPDATE;
   .
   .
   .
CLOSE FILE(STATE_FILE);
OPEN FILE(STATE_FILE) INPUT SEQUENTIAL;
```

The file STATE_FILE is declared with the KEYED attribute. The first OPEN statement that specifies this file is given the DIRECT and UPDATE attributes and opened for updating; the file can be accessed only by key.

The CLOSE statement closes the file. The second OPEN statement specifies the INPUT and SEQUENTIAL attributes; the file can now be accessed sequentially.

COLLATE Built-In Function

The COLLATE built-in function returns a 256-character string consisting of the ASCII character set in ascending order. Its format is as follows:

```
COLLATE()
```

COLUMN Format Item

The COLUMN format item sets a stream file to a specific character position within a line. In other words, COLUMN determines the position at which the next data will be output or from which the next data will be input. The COLUMN format item refers to an absolute character position in a line; for information on how to refer to a relative position, **see** "X Format Item."

The form of the COLUMN format item is as follows:

```
{ COLUMN } (w)
{ COL    }
```

w

A nonnegative integer or expression that identifies the wth position from the beginning of the current line. The value of the converted expression must be zero or positive. If the value of the converted expression is zero, a value of 1 is assumed.

If the file is already at the specified position, no operation is performed. If the file is already beyond the specified position, the format item is applied to the next line.

The interpretation of the COLUMN format item on input and output is given below. For a general discussion of format items, **see** "Format Item."

■ Input with GET EDIT

The file is positioned at the column specified by w. Characters between the beginning of the line and this column are ignored. If the file is already positioned beyond the specified column, the remainder of the line is skipped and the format item is applied to the next line.

■ Output with PUT EDIT

The file is positioned at the column specified by w. Within the current line, positions between the wth column and the position of the last output data are filled with spaces.

If the file is already positioned beyond the specified column, the format item is applied to the next line. If w exceeds the line size, a value of 1 is assumed. **See also** "LINESIZE Option."

■ Examples

```
COL: PROCEDURE OPTIONS(MAIN);

DECLARE IN STREAM INPUT FILE;
DECLARE OUT STREAM OUTPUT FILE;
DECLARE LETTER CHARACTER(1);

PUT FILE(OUT) SKIP
      EDIT('12345678901234567890123456789O') (A);
PUT FILE(OUT) SKIP
      EDIT('COL1','COL28') (A,COL(28),A);

GET FILE(IN) EDIT (LETTER) (A(1));
PUT FILE(OUT) SKIP(2)
      LIST('Letter in column 1:',LETTER);
```

```
GET FILE(IN)
     EDIT (LETTER) (COL(25),A(1));
PUT FILE(OUT) SKIP
     LIST ('Letter in column 25:',LETTER);

END COL;
```

If the stream input file IN.DAT contains the following text:

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ
```

then the program COL writes the following output to the stream output file OUT.DAT:

```
12345678901234567890123456789O
COL1                          COL28

'Letter in column 1:' 'A'
'Letter in column 25:' 'Y'
```

Comment

A comment is an informational tool for documenting a PL/I program. To insert a comment in a program, enclose the comment within the character pairs slash-asterisk (/*) and asterisk-slash (*/). For example:

```
/* This is a comment.... */
```

Wherever the characters /* appear in a program, the compiler ignores all text until it encounters the characters */. Thus, a comment can span several lines.

The rules for entering comments are as follows:

- A comment can appear anywhere a space can appear:
  - Between any identifiers, keywords, and constants. In this context, a comment separates tokens, or discrete text items, in a statement.
  - Preceding or following any other punctuation marks that normally delimit tokens, for example, spaces, tabs, or commas.
- A comment can contain any character except the pair */; comments cannot be nested.

Some examples of comments are as follows:

```
A = B + C;            /* Add B and C */

/* *********  START OF SECOND PHASE ********* */

DECLARE/*COUNTER*/A FIXED BINARY (7);
```

```
/* This module performs the following steps:
 * 1. Initializes all arrays and data structures.
 * 2. Establishes default condition handlers.
 *
 */
```

Although complete comments cannot be nested, you can "comment out" a statement such as the following:

```
DECLARE EOF BIT(1); /* end-of-file */
```

You can make this statement a comment by preceding the DECLARE keyword with another /*. The compiler will then ignore all text, including the DECLARE statement, until it reaches the */. For example:

```
/* DECLARE EOF BIT(1); /* end-of-file */
```

Common Data Dictionary

The VAX Common Data Dictionary (CDD) is a set of shareable data definitions (language-independent structure declarations) that are defined by a system manager or data administrator. The CDD provides a central storage repository that can be shared and that is protected from unauthorized access. The definitions stored in the CDD help the system manager coordinate an effective data management system.

The advantages to using the CDD are as follows:

- Record declarations are language independent.
- A single, centrally defined and stored declaration helps guarantee the accuracy and reliability of data.

NOTE

The CDD is a layered product, and not all systems that use PL/I use the CDD. If you are not certain if CDD is installed on your system, see your system manager.

CDD data definitions are organized in a hierarchical dictionary in much the same way that files are organized in directories and subdirectories. For example, a dictionary for defining personnel data might have separate directories for each classification of employee. Subdirectories pertaining to employees who are salespeople might include data definitions for records such as salary and commission history or personnel record.

CDD entries are stored in an internal form that is independent of any higher level language; descriptions of data definitions are entered into the dictionary in a unique, general-purpose language called Common Data Dictionary Language (CDDL). Then the CDDL compiler converts the data descriptions to an internal form. When a PL/I program that uses the CDD is compiled, CDD data definitions are drawn into the program (provided the data attributes are consistent). Program listings include CDD data definitions in the same language as the application program (in this case, PL/I).

You can include CDD records in PL/I programs with the %DICTIONARY statement. **See** "%DICTIONARY Statement." **See** the *VAX PL/I User Manual* for an explanation of CDD usage in a PL/I program.

Comparison Operator

See "Relational Operator."

Concatenation Operator

The concatenation operator produces a single string from two strings specified as operands. The concatenation operator is two vertical bars (||).

The operands must both be character strings or both be bit strings. (If not, the appropriate conversion is performed, and you get a warning message about the conversion. **See** "Expression" for information on the various conversions.) The result of the operation is a string of the same type as the operands.

■ Examples

```
CONCAT: PROCEDURE OPTIONS(MAIN);
DECLARE OUTFILE STREAM OUTPUT PRINT FILE;

        PUT FILE(OUTFILE) SKIP LIST('ABC'||'DEF');
        PUT FILE(OUTFILE) SKIP LIST('001'B||'110'B);
        PUT FILE(OUTFILE) SKIP LIST((3)'001'B||'07'B3);

END CONCAT;
```

The program CONCAT writes the following output to the file OUTFILE.DAT:

```
ABCDEF
'001110'B
'001001001000111'B
```

Note that the exclamation point can be used in place of the vertical bar, for compatibility with other PL/I implementations.

CONDITION Attribute

The CONDITION attribute can optionally be used in a declaration to specify that the variable name is a condition name. You can abbreviate CONDITION to COND. You can specify INTERNAL or EXTERNAL scope attributes with the CONDITION attribute. The default scope is external.

See "Condition Handling," "Error and Condition Handling," and "ON Conditions and ON-Units."

CONDITION Condition Name

The CONDITION condition name is used for ON-units to handle programmer-defined conditions. The value returned by the ONCODE built-in function is PLI$_CONDITION. The format of the CONDITION condition name is as follows:

```
CONDITION (cond-name)
```

cond_name
A name declared with the CONDITION attribute.

Condition Handling

A PL/I condition is any occurrence that causes the interruption of a program and a signal. When a condition is signaled, PL/I initiates a search for a user-written program unit called an ON-unit to handle the condition. **See** "ON Conditions and ON-Units" and "Error and Condition Handling."

Constant

A constant is a data item whose value cannot change during the execution of a PL/I program. The converse of a constant is a variable, that is, a data item to which various values can be assigned during the execution of a program.

VAX PL/I allows the following kinds of constants:

- Literal constants, which are actual numbers and strings written in the source program. Literal constant types are restricted to character strings (**see** "Character-String Data"), bit strings, and fixed- or floating-point decimal numbers. Unscaled fixed decimal numbers can be written with or without a decimal point. Arithmetic constants can be signed. String constants can be replicated. (**See** "Replication Factor.")
- Label constants, which are established when you use a label in the source program. Label constants cannot be declared in a DECLARE statement.
- Declared constants (file and entry constants), which generally are established with DECLARE statements. The default file constants SYSIN and SYSPRINT need not be declared.
- Constant identifiers, which are identifiers assigned literal constant values with the %REPLACE statement. Constant identifiers are restricted to the same types as literal constants. **See** "%REPLACE Statement."

PL/I also has the computational types FIXED BINARY, FLOAT BINARY, and PICTURE, but there are no literal constants or constant identifiers associated with these types. Binary variables usually receive values when decimal constants or other binary variables are assigned to them; then PL/I converts the assigned value to binary. Pictured variables usually receive values when fixed-point decimal constants are assigned to them. For further details, **see** "Conversion of Data."

■ Examples

```
445             /* a fixed-point decimal constant */
-445.           /* a fixed-point decimal constant */
16.2            /* a fixed-point decimal constant */
129E-3          /* floating-point decimal constant */

'00101111'B         /* a bit-string constant */
'This is a string'  /* a character-string constant */

DECLARE E ENTRY;    /* an entry constant */
DECLARE F FILE;     /* a file constant */
```

```
STARTUP:              /* a label constant */

%REPLACE PI BY 3.14159
                      /* a fixed-point decimal
                           constant identifier */

STATUS = 25;          /* assignment of a fixed
                           decimal constant to a
                           variable */

C = 3E10;             /* assignment of a floating
                           decimal constant to a
                           variable */
```

CONTROLLED Attribute

The CONTROLLED attribute causes a variable's actual storage to be allocated and freed dynamically in "generations," only the most recent of which is accessible to the program. For general information and examples, **see** "Controlled Variable." The format of the CONTROLLED attribute is as follows:

```
{ CONTROLLED }
{ CTL        }
```

■ Restrictions

The following attributes conflict with the CONTROLLED attribute:

AUTOMATIC
BASED
DEFINED
GLOBALDEF
GLOBALREF
READONLY
STATIC
VALUE
PARAMETER

The CONTROLLED attribute cannot be applied to minor structures, members of structures, parameters, or descriptions in an ENTRY or RETURNS attribute.

Controlled Variable

The declaration of a controlled variable describes storage that will be allocated dynamically during program execution. A controlled variable has no storage assigned to it until an ALLOCATE statement allocates storage for it. This is called a generation of the variable. Further ALLOCATE statements allocate more generations. At any time in the program's execution, a reference to a controlled variable is a reference to the most recent generation of that variable, that is, the generation created by the most recent ALLOCATE statement.

The FREE statement frees the most recent generation of a controlled variable. If an attempt is made to free a controlled variable for which no generation exists (or to refer to such a variable), PL/I signals the ERROR condition.

The following example illustrates the use of controlled variables:

```
CONT: PROCEDURE OPTIONS (MAIN);

DECLARE STR CHARACTER (10) CONTROLLED;

    ALLOCATE STR;
    STR = 'First';
    ALLOCATE STR;
    STR = 'Second';
    ALLOCATE STR;
    STR = 'Third';
    PUT SKIP LIST (STR);
    FREE STR;
    PUT SKIP LIST (STR);
    FREE STR;
    PUT SKIP LIST (STR);
    FREE STR;

END;
```

The output of this program is

```
Third
Second
First
```

Because only the most recent generation of a controlled variable is available to a program, controlled variables provide an easy way to implement a stack. The ALLOCATE statement is equivalent to a push operation, and the FREE statement is equivalent to a pop operation. To test for an empty stack, use the ALLOCATION built-in function, which returns the number of generations of a variable. For example:

```
DECLARE NEXT_MOVE CHARACTER(5) CONTROLLED,
    DIRECTIONS(4) CHARACTER(5) INITIAL(
    'North','East','South','West'),
    D FIXED BINARY (7);
        .
        .
        .
    ALLOCATE NEXT_MOVE;          /* Part of a loop that stores */
    NEXT_MOVE = DIRECTIONS(D);   /* moves in reverse order */
        .
        .
        .
    DO WHILE                     /* Print moves in correct order */
        (ALLOCATION(NEXT_MOVE) ^= 0);
        PUT SKIP LIST ('Go ', NEXT_MOVE);
        FREE NEXT_MOVE;
    END;
```

A controlled variable can be used as the argument of the ADDR built-in function. If no generation of the variable exists, ADDR returns the null pointer. If a generation does exist, ADDR returns a pointer to it. Thus, ADDR can be used to preserve a pointer to a generation of a controlled variable that later becomes "hidden" under more generations, as in the following example:

```
DECLARE STOPS CHARACTER (20) VARYING CONTROLLED,
    MIDPOINT CHARACTER (20) VARYING BASED (P),
    P POINTER;
    .
    .
    .
    ALLOCATE STOPS;
    STOPS = CURRENT_LOC;
    IF I = 5 THEN P = ADDR(STOPS);
    .
    .
    .
    PUT SKIP LIST (
        'End reached!  Halfway point was', MIDPOINT);
```

At a certain point during the execution of this program, the ADDR built-in function captures the address of the current generation of STOPS and assigns it to P. Later, after more generations of STOPS have been allocated, MIDPOINT (which is based on P) has the value of that same intermediate generation of STOPS.

Note, however, that the value of P and therefore of MIDPOINT is valid only if the intermediate generation of STOPS to which P points is allocated. As soon as that generation is freed, the value of P becomes invalid and it must not be used in a pointer-qualified reference until it is reassigned.

A controlled variable cannot be used in a pointer-qualified reference. In the previous example, this reference would be illegal.

```
P->STOPS
```

CONVERSION Condition Name

The CONVERSION condition name can be specified in an ON, SIGNAL, or REVERT statement to designate a CONVERSION condition or ON-unit.

PL/I signals the CONVERSION condition when the source character data in a conversion to bit-string or arithmetic data contains characters that are not valid in the specified context. In particular, the CONVERSION condition is raised when a character string is being converted and one of the following conditions is true:

- The target of the conversion is an arithmetic type, and the source string does not contain a valid, optionally signed arithmetic constant.
- The target of the conversion is a picture, and the source string does not conform to the picture specification.
- The target of the conversion is a bit string, and a character other than 0 or 1 appears in the source string.

The CONVERSION condition can be raised either by a non-I/O conversion, such as an explicit conversion using a built-in function or an implicit conversion generated by the compiler, or by an I/O conversion in a GET statement. For example, A = BIT('1014') would cause the CONVERSION condition to be raised, because 4 is not a valid binary digit. Likewise, a GET statement with an arithmetic target would also cause the CONVERSION condition to be raised if the characters '12K45' appeared in the input field, because 'K' is not a valid numeric character.

You can use the ONSOURCE and ONCHAR built-in functions and pseudovariables inside an ON CONVERSION ON-unit. The ONSOURCE built-in function returns the source string that caused the CONVERSION condition to be raised. The ONCHAR built-in function returns the specific character that caused the conversion to fail. You can use the ONSOURCE pseudovariable to change the value of the conversion. Likewise, you can use the ONCHAR pseudovariable to modify only the single character in error.

If the CONVERSION condition was raised during a conversion required by the GET statement, the ONFILE built-in function returns the name of the file constant inside the CONVERSION ON-unit. If the CONVERSION condition was not raised during a conversion required by the GET statement, the ONFILE built-in function returns a null string.

A normal return from a CONVERSION condition will cause the conversion to be reattempted if the ONSOURCE or ONCHAR pseudovariables have had values assigned to them. If the ONSOURCE value has not been modified, the ERROR condition is raised instead.

For example:

```
/*
* Sample program that displays a 'quick-fix' CONVERSION
* ON-unit.  At the end of this program, TARGET1 contains
* the value 14015, and TARGET2 contains the value '11100'B.
* Note that SOURCE1 and SOURCE2 are not modified.
*/
MAIN: PROCEDURE OPTIONS(MAIN);

    DCL SOURCE1 CHARACTER(5) VARYING INITIAL('14$15');
    DCL SOURCE2 CHARACTER(5) VARYING INITIAL('11100');

    DCL TARGET1 FIXED BINARY(31);
    DCL TARGET2 BIT(5) ALIGNED;

    /*
    * Sample 'quick-fix' CONVERSION ON-unit that replaces
    * erroneous lowercase L's with 1's, and all other
    * erroneous characters with 0's.
    */
    ON CONVERSION BEGIN;

    PUT SKIP EDIT('"',ONSOURCE(),'" "',ONCHAR(),'"')((5)A);

    IF ONCHAR() = 'l'
    THEN
        ONCHAR() = '1';
    ELSE
        ONCHAR() = '0';

    END; /* ON */

    /*
    * Note that the CONVERSION condition is raised for all
    * 3 of the following statements.
    */
    TARGET1 = SOURCE1;
    TARGET1 = SOURCE1;
    TARGET2 = SOURCE2;

    PUT SKIP(2) EDIT(SOURCE1,SOURCE2)(A,X,A);
    PUT SKIP EDIT(TARGET1,TARGET2)(F(8),X,B(5));

    END MAIN;
```

The output from this program is as follows:

```
"14$15" "$"
"14$15" "$"
"11100" "1"

14$15 11100
   14015 11100
```

The first occurrence of the ONCHAR built-in function value in the ONSOURCE built-in function value is not necessarily the character in error. For example, if the statement A = FIXED('++12310') were executed, the CONVERSION condition would be raised with the ONCHAR value being the second plus sign in the string.

The target of the conversion is undefined when the CONVERSION condition is raised.

The retry attempted on a normal return is for the single field that was in error. Attempts to assign a string containing, for example, a comma list of values will not be used for successive data items in a GET statement.

The actual value modified by the ONSOURCE and ONCHAR pseudovariables is a temporary value that is discarded once the conversion is complete, or the control flow cannot return to the point of the error. This means that invalid data stored in a character string variable will cause the CONVERSION condition to be raised each time the value is converted, not just the first time the conversion is attempted, regardless of modifications to the ONSOURCE and ONCHAR pseudovariables inside the CONVERSION ON-unit.

Conversion of Data

Conversion is the changing of a data item from one data type to another. This entry describes the conversions performed in assignments. Conversions are also performed on operands in arithmetic expressions; **see** "Expression" for details of operand conversions.

In assignments, conversions are defined between the noncomputational types POINTER and OFFSET, and between any two computational types. The rules for assignments apply to the following:

- Assignment statements
- Arguments passed to a procedure
- Values specified in a RETURN statement

- An argument converted by the built-in function BINARY, BIT, CHARACTER, DECIMAL, DECODE, ENCODE, FIXED, or FLOAT
- Conversions to and from character strings performed by the PUT and GET statements, respectively

If an attempt is made to assign a value to a target for which there is no defined conversion, the compiler generates a diagnostic message. For example:

```
F = '133.45';
```

If F is a variable with the attributes FIXED DECIMAL (5,2), then the statement assigns the numeric value 133.45 to F, as expected, although the compiler issues a WARNING message about the implicit conversion, stating that the constant '133.45' has been converted to a FIXED DECIMAL target. The warning does not prevent you from linking and running the program. However, note the following example:

```
F = 'ABCD';
```

This statement results not only in a compiler WARNING message, but if you go on to link and run the program, you receive a CONVERSION condition, which will normally be fatal unless it is handled with an ON CONVERSION ON-unit.

Table C–1 illustrates the contexts in which PL/I performs conversions. The table also lists the built-in conversion functions, such as BINARY and CHARACTER, which you can use when you want to explicitly indicate a conversion and to specify such characteristics as the precision or string length of the converted result.

The rest of this section defines the rules and results of the following types of conversion:

- Assignments to arithmetic variables
  - From any arithmetic data type to any other arithmetic data type
  - From pictured to any arithmetic type
  - From bit-string to any arithmetic data type
  - From character-string to any arithmetic data type
- Assignments to bit-string variables
  - From any arithmetic data type to bit-string
  - From pictured to bit-string
  - From character-string to bit-string

- Assignments to character-string variables
  - From any arithmetic data type to character-string
  - From pictured to character-string
  - From bit-string to character-string
- Assignments to pictured variables
  - From any computational type to pictured
- Conversions between offsets and pointers

Table C–1: Contexts in Which PL/I Converts Data

Context	Conversion Performed
target = expression;	In an assignment statement, the given expression is converted to the data type of the target.
entry-name RETURNS (attribute . . .); . . . RETURN (value);	In a RETURN statement, the specified value is converted to the data type specified by the RETURNS option on the PROCEDURE or ENTRY statement.
x + y x – y x * y x / y x**y x||y x & y x | y x&:y x|:y x ^ y x > y x < y x = y x^ = y	In any expression, if operands do not have the required data type, they are converted to a common data type before the operation. For most operators, the data types of all operands must be identical. A warning message is issued in the case of a concatenation conversion. (**See** "Expression.")

Table C–1 (Cont.): Contexts in Which PL/I Converts Data

Context	Conversion Performed
BINARY (expression) BIT (expression) CHARACTER (expression) DECIMAL (expression) FIXED (expression) FLOAT (expression) OFFSET (variable) POINTER (variable)	PL/I provides built-in functions that perform specific conversions.
PUT LIST (item, . . .);	Items in a PUT LIST statement are converted to character-string data.
GET LIST (item, . . .);	Character-string input data is converted to the data type of the target item.
PAGESIZE (expression) LINESIZE (expression) SKIP (expression) LINE (expression) COLUMN (expression) format items A, B, E, F, and X TAB (expression)	Values specified for various options to PL/I statements must be converted to integer values.
DO control-variable . . .	Values are converted to the attributes of the control variable.
parameter	Actual parameters are converted to the type of the formal parameter, if necessary (**see** "Parameters and Arguments" for more information).
INITIAL attribute	Initial values are converted to the type of the variable being initialized.

■ Assignments to Arithmetic Variables

Expressions of any computational type can be assigned to arithmetic variables. The conversion rules for each source type are described in the following sections.

Arithmetic to Arithmetic Conversions

A source expression of any arithmetic type can be assigned to a target variable of any arithmetic type. Note the following qualifications:

- If the target is a variable of type FIXED BINARY or FIXED DECIMAL, then the FIXEDOVERFLOW condition is signaled when the source value has a larger number of integral digits than are specified in the precision of the target. If the target is a fixed-point binary variable, FIXEDOVERFLOW is signaled if the source value exceeds the storage allocated for the target, which can be larger than the target's declared precision (**see** "Fixed-Point Binary Data").
- If the target is a variable of type FIXED DECIMAL(p,q) or FIXED BINARY(p,q) and the source value has more than q fractional digits, then the excess fractional digits of the source are truncated, and no condition is signaled. If the source has fewer than q fractional digits, the source value is padded on the right with zeros.
- If the target value is floating point and the absolute source value is too large to be represented by a VAX floating-point type (**see** "Floating-Point Data"), then the OVERFLOW condition is signaled, and the value of the target is undefined. If the absolute source value is too small to be represented, the value zero is assigned to the target, and, if enabled, the UNDERFLOW condition is signaled.

Conversions to Fixed Point: In the following examples, the specified source values are converted to FIXED DECIMAL(4,1):

Source Value	Converted Value
25.505	25.5
-2.562	-2.5
101	101.0
5365	FIXEDOVERFLOW - value undefined

Conversions to Floating Point: Let p be the precision of the floating-point target. If the source value is an integer that can be represented exactly in p digits, then the source value is converted to floating-point binary with no loss of accuracy.

Otherwise, the source value is converted to floating-point binary with rounding to precision p. For example, the constant 479 will be converted to FLOAT BINARY(24) without loss of accuracy, while the constant 16777217, which cannot be represented exactly in 24 bits, will be rounded during conversion.

Conversions from FIXED BINARY to Other Data Types: Conversions from FIXED BINARY to other data types follow the rules outlined below. Notice that these rules assume both precision and scale.

Precisions of the source and target are (p,q) and (p1,q1), respectively. The precision of the result is (p2,q2).

Target	Result
FIXED DECIMAL(p1,q1)	p2=1+CEIL(p1/3.32) and q2=CEIL(q1/3.32).
FIXED BINARY(p1,q1)	Precision and scale of the source are maintained during conversion; therefore, padding or truncation can occur. If nonzero bits are lost on the left, the result is undefined.
FLOAT DECIMAL(p1)	p2=CEIL(p1/3.32). The exponent indicates any fractional value.
FLOAT BINARY(p1)	p2=p1. The exponent indicates any fractional value.
PICTURE	The target must imply FIXED DECIMAL.
CHARACTER	The binary precision (p,q) is converted to the decimal precision (p1,q1), where p1=1+CEIL(p/3.32) and q1=CEIL(q/3.32). Then the rules for conversion from FIXED DECIMAL to CHARACTER are in effect.
BIT	The binary precision (p,q) is converted to a bit string where MIN(31,p–q). Then the intermediate bit string is converted to BIT(n). If (p–q) is negative or zero, the result is a null bit string.

If the scale factor is negative, substitute the FLOOR value for CEIL in the above calculations.

Pictured to Arithmetic Conversions: In VAX PL/I all pictured values have the associated attributes FIXED DECIMAL(p,q), where p is the total number of characters in the picture specification that specify decimal digits, and q is the total number of these digits that occur to the right of the V character. If the picture specification does not include a V character, then q is zero. This associated fixed-point decimal value is assigned to the target, following the PL/I rules for arithmetic to arithmetic conversion.

Bit-String to Arithmetic Conversions: When a bit-string value is assigned to an arithmetic variable, PL/I treats the bit string as a fixed-point binary value. A string of type BIT(n) is converted to FIXED BINARY(m,0), where $m = min(n, 31)$.

If the converted value is greater than or equal to 2^{31}, then FIXEDOVERFLOW is signaled. The leftmost bit in the bit string (as output by PUT LIST) is the most significant bit in the fixed-point binary value, not its sign. If the bit string is null, the fixed-point binary value is zero.

The intermediate fixed-point binary value is then converted to the target arithmetic type.

Note that bit strings are stored internally with the leftmost bit in the lowest address. The conversion to an arithmetic type must reverse the bits from this representation; therefore, you should avoid this conversion when performance is a consideration.

Examples

```
CONVTB: PROCEDURE OPTIONS(MAIN);

DECLARE STATUS FIXED BINARY(8);
DECLARE STATUS_D FIXED DECIMAL(10);
DECLARE OUT PRINT FILE;


OPEN FILE(OUT) TITLE('CONVTB.OUT');
ON FIXEDOVERFLOW PUT SKIP FILE(OUT)
      LIST('Fixedoverflow:');

STATUS = '1001101'B;
PUT SKIP FILE(OUT) LIST(STATUS);

STATUS_D = '001101'B;
PUT SKIP FILE(OUT) LIST(STATUS_D);

STATUS = '1232'B2;
PUT SKIP FILE(OUT) LIST(STATUS);


STATUS = 'FF'B4;
PUT SKIP FILE(OUT) LIST(STATUS);
```

```
STATUS_D = '10111111111111111111111111111111'B;
PUT SKIP FILE(OUT) LIST(STATUS_D);

END CONVTB;
```

Note that because the program CONVTB performs implicit conversions, the compiler issues WARNING messages. (Linking and running are accomplished successfully because the conversions are valid.)

The program CONVTB produces the following output:

```
    77
          13
   110
   255
Fixedoverflow:
          13
```

The leftmost bit of all the bit-string constants is treated as the most significant numeric bit, not as a sign. For instance, the hexadecimal constant 'FF'B4 is converted to 255 instead of –127. The last assignment to STATUS_D signals the FIXEDOVERFLOW condition because the bit-string constant, when represented as a binary integer, is greater than 2^{31}. The resulting value of STATUS_D is undefined.

Character-String to Arithmetic Conversions: When a character string is assigned to an arithmetic value, PL/I creates an intermediate numeric value based on the characters in the string. The type of this intermediate value is the same as that of an ordinary arithmetic constant comprising the same characters; for example, 342.122E–12 and '342.122E–12' are both floating-point decimal.

The character string can contain any series of characters that describes a valid arithmetic constant. That is, the character string can contain any of the numeric digits 0 through 9, a plus (+) or minus (–) sign, a decimal point (.), and the letter E. If the character string contains any invalid characters, the ERROR condition is signaled. See the following examples.

If the implied data type of the character string does not match the data type of the arithmetic target, PL/I converts the intermediate value to the data type of the target, following the PL/I rules for arithmetic to arithmetic conversions. In conversions to fixed point, FIXEDOVERFLOW is signaled if the character string specifies too many integral digits. Excess fractional digits are truncated without signaling a condition.

If the source character string is null or contains all spaces, the resulting arithmetic value is zero.

Examples

```
DECLARE SPEED FIXED DECIMAL (9,4);

SPEED = '23344.3882';
      /* string converted to 23344.3882 */

SPEED = '32423.23SD';
      /* ERROR condition */

SPEED = '4324324.3933';
      /* FIXEDOVERFLOW condition */

SPEED = '1.33336';
      /* string converted to 1.3333 */
```

■ Assignments to Bit-String Variables

In the conversion of any data type to a bit string, PL/I first converts the source data item to an intermediate bit-string value. Then, based on the length of the target string, it does the following:

- If the length of the target bit-string value is greater than the length of the intermediate string, the target bit string (as represented by PUT LIST) is padded with zeros on the right.
- If the length of the target bit-string value is less than the length of the intermediate string, the intermediate bit string (as represented by PUT LIST) is truncated on the right.

The next sections describe how PL/I arrives at the intermediate bit-string value for each data type.

Arithmetic to Bit-String Assignments: In converting an arithmetic value sv to a bit-string value, PL/I performs the following steps:

1. Let $v = abs(sv)$.
2. Determine a precision p as follows:

Source	Precision p
FIXED BINARY(r,s)	min(31,r–s)
FLOAT BINARY(r)	min(31,r)
FIXED DECIMAL(r,s)	min(31,ceil((r–s)*3.32))
FLOAT DECIMAL(r)	min(31,ceil(r*3.32))

3. If p=0 (for example, when r=s), the intermediate string is a null bit string. Otherwise, the value v is converted to an integer n of type FIXED BINARY(p,0). If $n >= 2p$, the FIXEDOVERFLOW condition is

signaled; otherwise, the intermediate bit string is of length p, and each of its bits represents a binary digit of n.

Bit strings are stored internally with the leftmost bit in the lowest address. The conversion must reverse the bits from this representation and should therefore be avoided when performance is a consideration. Note also that during the conversion, the sign of the arithmetic value and any fractional digits are lost.

Examples

```
CONVB: PROCEDURE OPTIONS(MAIN);

DECLARE NEW_STRING BIT(10);
DECLARE LONGSTRING BIT(16);
DECLARE OUT PRINT FILE;

OPEN FILE(OUT) TITLE('CONVB1.OUT');

NEW_STRING = 35;
PUT FILE(OUT) SKIP
      LIST('35 converted to BIT(10):',NEW_STRING);

NEW_STRING = -35;
PUT FILE(OUT) SKIP
      LIST('-35 converted to BIT(10):',NEW_STRING);

NEW_STRING = 23.12;
PUT FILE(OUT) SKIP
      LIST('23.12 converted to BIT(10):',NEW_STRING);

NEW_STRING = .2312;
PUT FILE(OUT) SKIP
      LIST('.2312 converted to BIT(10):',NEW_STRING);

NEW_STRING = 8001;
PUT FILE(OUT) SKIP
      LIST('8001 converted to BIT(10):',NEW_STRING);

LONGSTRING = 8001;
PUT FILE(OUT) SKIP
      LIST('8001 converted to BIT(16):',LONGSTRING);

END CONVB;
```

Note that because the program CONVB performs implicit conversions, the compiler issues WARNING messages. (Linking and running are accomplished successfully because the conversions are valid.)

The program CONVB produces the following output:

```
35 converted to BIT(10):        '0100011000'B
-35 converted to BIT(10):       '0100011000'B
23.12 converted to BIT(10):     '0010111000'B
*.2312 converted to BIT(10):    '0000000000'B
8001 converted to BIT(10):      '0111110100'B
8001 converted to BIT(16):      '0111110100000100'B
```

The values 35 and –35 produce the same bit string because the sign is lost in the conversion. In the first assignment, 35, which is FIXED DECIMAL(2,0), is converted to FIXED BINARY(7,0) and then to a 7-bit string ('0100011'B). Three additional bits are appended to this intermediate bit string when it is assigned to NEW_STRING. Notice that the low-order bit of 8001 is lost when the constant is assigned to a BIT(10) variable.

Pictured to Bit-String Conversions: If the source value is pictured, its associated fixed-point decimal value is extracted. The fixed-point decimal value is then converted to a bit string, following the previous rules for arithmetic to bit-string conversion.

Character-String to Bit-String Conversions: PL/I can convert a character string of 0s and 1s to a bit string. Any character in the character string other than 0 or 1, including spaces, will signal the ERROR condition.

PL/I converts each 0 or 1 character in the character string to a 0 or a 1 bit in the corresponding position (as represented by PUT LIST) in the intermediate bit string.

If the source is a null character string, the intermediate string is a null bit string.

Examples

```
DECLARE NEW_STRING BIT(4);

NEW_STRING = '0010';
     /* NEW_STRING = '0010'B */

NEW_STRING = '11';
     /* NEW_STRING = '1100'B */

NEW_STRING = 'AS110';
     /* ERROR condition */
```

■ Assignments to Character-String Variables

In the conversion of any data type to a character string, PL/I first converts the source value to an intermediate character-string value. Then it does one of the following:

- If the length of the intermediate string is zero, a null string is assigned to the target.
- If the target is a parameter or return value with an asterisk extent (as in RETURNS CHAR(*)), the intermediate string is assigned to the target.
- If the target is of type CHARACTER, and the intermediate string is shorter than the maximum length of the target, the target is assigned the value of the intermediate string without trailing spaces if the target has the VARYING attribute. If the target does not have the VARYING attribute, the string is padded with trailing spaces.
- If the maximum length of the target character string is less than the length of the intermediate string, the intermediate string is truncated.

The rules for how PL/I arrives at the intermediate string for conversion of each data type are described below. Examples illustrate the intermediate value as well as the resulting value.

Arithmetic to Character-String Conversions: The manner in which PL/I converts an arithmetic data item depends on the data type of the item, as described below.

Conversion from Fixed-Point Binary or Decimal: If the data item source value is of type FIXED BINARY(p1,q1), PL/I first converts it to type FIXED DECIMAL(p2,q2), where

$$p2 = min(ceil(p1/3.32) + 1, 31)$$

$$q2 = max(0, min(ceil(q1/3.32), 31))$$

PL/I converts a value with attributes FIXED DECIMAL(p,q) to an intermediate string of length p+3. The numeric value is right-justified in the string. If the value is negative, a minus sign immediately precedes the value. If q is greater than zero, the value contains a decimal point followed by q digits. When p equals q, a 0 character precedes the decimal point. When q equals zero, a value of zero is represented by the 0 character.

Alternatively, the format of the intermediate string can be described by picture specifications, as follows:

1. If q=0, the intermediate string is the string created by the following picture specification:

```
'BB(p)-9'
```

That is, the first two characters of the string are spaces. The last p characters in the string are the digit characters representing the integer; leading zeros are replaced by spaces except in the last position. If the integer is negative, a minus sign immediately precedes the first digit; if the number is not negative, this position contains a space. At least one digit always appears in the last position in the string.

2. If p=q, the intermediate string is the string created by the following picture specification:

   ```
   '-9V.(q)9'
   ```

   That is, the first three characters are (in order) an optional minus sign if the fraction is negative, the digit 0, and a decimal point. If the number is not negative, the first character is a space. The last q characters in the string are the fractional digits of the number.

3. If p > q, the intermediate string is the string created by the following picture specification:

   ```
   'B(p-q)-9V.(q)9'
   ```

   That is, the first character is always a space; the last q characters are the fractional digits of the number and are preceded by a decimal point; the decimal point is always preceded by at least one digit, which can be zero; all integral digits appear before the decimal point, and leading zeros are replaced by spaces; a minus sign precedes the first integral digit if the number is negative; if the number is not negative, then the minus sign is replaced by a space.

Examples

```
DECLARE STRING_1 CHARACTER (8),
        STRING_2 CHARACTER (4);

STRING_1 = 283472.;
      /* intermediate string = 'ΔΔΔ283472',
      STRING_1 = 'ΔΔΔ28347' */

STRING_2 = 283472.;
      /* intermediate string = 'ΔΔΔ283472',
      STRING_2 = 'ΔΔΔ2' */

STRING_2 = -283472.;
      /* intermediate string = 'ΔΔ-283472',
      STRING_2 = 'ΔΔ-2' */

STRING_2 = -.003344;
      /* intermediate string = '-0.003344',
      STRING_2 = '-0.0' */
```

```
STRING_2 = -283.472;
      /* intermediate string = 'Δ-283.472',
      STRING_2 = 'Δ-28' */

STRING_2 = 283.472;
      /* intermediate string = 'ΔΔ283.472',
      STRING_2 = 'ΔΔ28' */
```

Conversion from Floating-Point Binary or Decimal: If the data item source value is of type FLOAT BINARY(p1), it is converted to FLOAT DECIMAL(p2), where

$$p2 = min(ceil(p1/3.32), 34)$$

For a value of type FLOAT DECIMAL(p), where p is less than or equal to 34, the intermediate string is of length p+6; this allows extra characters for the sign of the number, the decimal point, the letter E, the sign of the exponent, and the 2-digit exponent.

NOTE

If the value is a G-floating-point number, three characters are allocated to the exponent, and the length of the string is p+7. If the value is an H-floating-point number, four characters are allocated to the exponent, and the length of the string is p+8. (**See** "Floating-Point Data.")

If the number is negative, the first character is a minus sign; otherwise, the first character is a space. The subsequent characters are a single digit (which can be 0), a decimal point, p–1 fractional digits, the letter E, the sign of the exponent (always + or –), and the exponent digits. The exponent field is of fixed length, and the zero exponent is shown as all zeros in the exponent field.

Examples

```
CONCH: PROCEDURE OPTIONS(MAIN);

DECLARE OUT PRINT FILE;

OPEN FILE(OUT) TITLE('CONCH.OUT');

PUT SKIP FILE(OUT) EDIT('''',25E25,'''') (A);
PUT SKIP FILE(OUT) EDIT('''',-25E25,'''') (A);
PUT SKIP FILE(OUT) EDIT('''',1.233325E-5,'''') (A);
PUT SKIP FILE(OUT) EDIT('''',-1.233325E-5,'''') (A);

END CONCH;
```

The program CONCH produces the following output:

```
' 2.5E+26'
'-2.5E+26'
' 1.233325E-05'
'-1.233325E-05'
```

The PUT statement converts its output sources to character strings, following the rules described in this section. (The output strings are surrounded with apostrophes to make the spaces distinguishable.) In each case, the width of the quoted output field (that is, the length of the converted character string) is the precision of the floating-point constant plus 6.

Pictured to Character-String Conversion: If the source value is pictured, its internal, character-string representation is used without conversion as the intermediate character string.

Bit-String to Character-String Conversion: When PL/I converts a bit string to a character string, it converts each bit in the bit string (as represented by PUT LIST) to a 0 or 1 character in the corresponding position of the intermediate character string.

If the bit string is a null string, the intermediate character string is also a null string.

Examples

```
DECLARE STRING_1 CHARACTER (4),
        STRING_2 CHARACTER (8);

STRING_1 = '1010'B;
      /* STRING_1 = '1010' */

STRING_2 = '1010'B;
      /* STRING_2 = '1010ΔΔΔΔ' */

STRING_1 = '010011'B;
      /* STRING_1 = '0100' */
```

■ Assignments to Pictured Variables

A source expression of any computational type can be assigned to a pictured variable. The target pictured variable has a precision (p), which is defined as the number of characters in the picture specification that specify decimal digits. The target also has a scale factor (q), which is defined as the number of picture characters that specify digits and occur to the right of the V character in the picture specification. If the picture specification contains no V character, or if all digit-specification characters are to the left of V, then q is zero.

The source expression is converted to a fixed-point decimal value v of precision (p,q), following the PL/I rules for the source data type. This value is then edited to a character string s, as specified by the picture specification (**see also** "Picture"), and the value s is assigned to the pictured target.

When the value v is being edited to the string s, the ERROR condition is signaled if the value of v is less than zero and the picture specification does not contain one of the characters S, +, –, T, I, R, CR, or DB. The value of s is then undefined. FIXEDOVERFLOW is also signaled if the value v has more integral digits than are specified by the picture specification of the target.

■ Conversions Between Offsets and Pointers

Offset variables are given values by assignment from existing offset values or from conversion of pointer values. Pointer variables are given values by assignment from existing pointer values or from conversion of offset values.

The OFFSET built-in function converts a pointer value to an offset value. The POINTER built-in function converts an offset value to a pointer.

PL/I also automatically converts a pointer value to an offset value, and vice versa, in an assignment statement. The following assignments are valid:

```
pointer-variable = pointer-value;
offset-variable = offset-value;
pointer-variable = offset-variable;
offset-variable = pointer-value;
```

In the third and fourth assignments above, the offset variable must have been declared with an area reference. **See also** "Offset," "OFFSET Built-In Function," "Pointer," and "POINTER Built-In Function."

COPY Built-In Function
COPY Preprocessor Built-In Function

The COPY built-in function copies a given string a specified number of times and concatenates the result into a single string. Its format is as follows:

```
COPY(string,count)
```

string
Any bit- or character-string expression. If the expression is a bit string, the result is a bit string. Otherwise, the result is a character string.

count
Any expression that yields a nonnegative integer. The specified count controls the number of copies of the string that are concatenated, as follows:

Value of Count	String Returned
0	A null string
1	The string argument
n	Concatenated copies of the string argument

■ Example

```
COPY('12',3)
```

This function reference returns the character-string value '121212'.

COS Built-In Function

The COS function returns a floating-point value that is the cosine of an arithmetic expression x, where x represents an angle in radians. The cosine is computed in floating point. The format of the function is as follows:

```
COS(x)
```

COSD Built-In Function

The COSD built-in function returns a floating-point value that is the cosine of an arithmetic expression x, where x is an angle in degrees. The cosine is computed in floating point. The format of the function is as follows:

```
COSD(x)
```

COSH Built-In Function

The COSH built-in function returns a floating-point value that is the hyperbolic cosine of an arithmetic expression x. The hyperbolic cosine is computed in floating point. The format of the function is as follows:

```
COSH(x)
```

D

Data and Data Types

All programs process information, or data. The way you choose to represent different items of data in a program depends on how the program will use or manipulate the data.

The data type of a variable or a constant reflects the kind of information that is being processed. For example, names and addresses within a personnel record are character-string data; weekly salaries and taxes and cumulative totals of salaries and taxes are arithmetic data.

Variables that represent single elements or items of data are called scalar variables. Variables can also be grouped into aggregates. There are two types of aggregates:

- An array is an aggregate in which all items, called elements, have the same data type. Individual elements of an array are referred to by subscripts that represent the position, or order, of the elements in the array. Elements can be scalar data items or structures. (**See** "Array.")
- A structure is an aggregate in which individual items, called members, can have different data types. Individual members are referred to with qualified references that give, in general, the names of the structure itself and of the individual member. (**See** "Structure.")

Aggregates can also be formed from arrays whose elements are structures, or from structures whose individual members are arrays.

■ Summary of Data Types

Data types are either computational (with values used in computations) or noncomputational. VAX PL/I supports the following computational data types:

- The arithmetic data types define values that can be used in arithmetic computation. There are two arithmetic data types:
  - Fixed-point (for binary and decimal integers and fractions)

  - Floating-point (binary and decimal)

  See "Fixed-Point Binary Data," "Fixed-Point Decimal Data," and "Floating-Point Data."

- Picture data represents fixed-point decimal values that are stored as character strings; the strings contain the characters representing the numeric value, formatted with special symbols. In computations and other expressions, a data item of this type (that is, a "pictured value") can be used wherever an arithmetic value is valid.

  See "Picture."

- Character-string data consists of a sequence of ASCII characters. VAX PL/I supports two character-string data types:
  - Fixed-length character strings
  - Variable-length character strings

  See "Character-String Data."

- Bit-string data consists of sequences of binary digits. VAX PL/I supports two bit-string data types:
  - Aligned bit strings
  - Unaligned bit strings

  See "Bit-String Data."

The following data types represent noncomputational program values that are used within a PL/I program for control:

- Areas
- Entry data
- File data
- Label data
- Offsets
- Pointers

The following sections discuss declarations and default attributes, including the default attributes of constants, for computational data types. For similar information on the noncomputational types, **see** "Area," "Entry Data," "File," "Label," "Offset," and "Pointer."

■ Declarations

All variables in a PL/I program must be declared. With the exception of entry-point names, statement labels, built-in functions, and the default file constants SYSIN and SYSPRINT, all names referenced must be declared explicitly. You declare a name and its data type attributes in a DECLARE statement. For example:

```
DECLARE AVERAGE FIXED DECIMAL;
DECLARE NAME CHARACTER (20);
```

The keywords DECIMAL, FIXED, and CHARACTER describe characteristics, or attributes, of the variables AVERAGE and NAME. (**See** "DECLARE Statement.")

■ Default Attributes

It is not always necessary to define all the characteristics, or attributes, of a variable; the PL/I compiler makes assumptions about attributes that are not explicitly defined. For example:

```
DECLARE NUMBER FIXED;
```

The FIXED attribute implies the attributes BINARY(31,0). Thus, the variable NUMBER has the attributes FIXED BINARY(31,0).

Table D–1 shows the default attributes implied by each computational data attribute.

Table D–1: Implied Attributes for Computational Data

Specified	Implied
FIXED	BINARY(31,0)
FLOAT	BINARY(24)
BINARY	FIXED(31,0)
DECIMAL	FIXED(10,0)
FIXED BINARY	(31,0)
FLOAT BINARY	(24)
FIXED DECIMAL	(10,0)
FIXED DECIMAL(p)	(p,0)
FLOAT DECIMAL	(7)
BIT [ALIGNED]	(1)
CHARACTER [VARYING]	(1)
PICTURE 'picture'	**See** "Picture"

Attributes of Constants

Constants have attributes implied by the characters used to specify them.

- A series of characters enclosed in apostrophes is assumed to be a string constant:
  - If the letter B is appended after the closing apostrophe, the constant is a bit-string constant, for example, '00010101'B. If the integer 2, 3, or 4 is appended to the letter B, the constant is a bit-string constant with the base 4, 8, or 16, respectively. For example, '17777'B3 is an octal constant that is represented internally as a string of 13 bits. (B can be typed lowercase.)
  - If the constant does not have the letter B appended, it is a character-string constant even when it contains only the characters 0 and 1. (However, a character string of 0s and 1s can be converted by a simple assignment to a bit string.)
- If the constant is an integer, it has the attributes FIXED DECIMAL(n,0), where n is the number of digits in the integer. For example, the constant 1777 is a constant of type FIXED DECIMAL(4,0).
- Constants with an appended or embedded decimal point, but with no following exponent, are of type FIXED DECIMAL(p,q), where p is the total number of digits and q is the number of digits to the right of the decimal point.
- If a fixed-point decimal constant has the following appended characters:

  E [+ / -] digit...

  then it is of type FLOAT DECIMAL(p), where p is the total number of digits in the fixed-point constant (that is, the total number to the left of the letter E).

Note that PL/I has no constants with the attributes FIXED BINARY, FLOAT BINARY, or PICTURE. However, this presents no problems in programming because constants of any computational type can be assigned to variables of any computational type and are converted automatically to the target type (**see** "Conversion of Data" for details).

You usually give values to binary variables by assigning decimal constants to them. For example:

```
I = 1;
```

This converts the decimal integer 1 and assigns the converted value to a fixed-point binary variable I.

```
F = 1.333E-12;
```

This converts the floating-point decimal constant 1.333E–12 and assigns the converted value to a floating-point binary variable F.

Picture variables are usually given values by assigning fixed-point decimal constants. For example:

```
PAY_PIC = 123.44;
```

This assigns the fixed-point decimal value 123.44 to a picture variable PAY_PIC. The value of PAY_PIC is a "pictured value," stored internally as a character string containing the characters 1, 2, 3, 4, and 4, along with any special formatting symbols defined for PAY_PIC (**see** "Picture").

Arithmetic Operands

The implied data types of constants are important primarily because of PL/I's rules for converting operands in an arithmetic operation. (Bit-string and character-string operations must have bit- and character-string operands, respectively.) All operations, including arithmetic operations, must be performed in a single data type, and automatic conversions are performed on arithmetic operands to make this possible. For example:

```
DECLARE X FLOAT DECIMAL (49);
X = X + 1.3;
```

In this example, the fixed-point decimal constant 1.3 is converted to floating-point decimal before the addition is performed. For the detailed definition of operand conversion, **see** "Expression." The rules for operand conversion are as follows:

- If either operand is binary, the operation is performed in binary.
- If either operand is floating point, the operation is performed in floating point.

These rules apply both to the declared attributes of variable operands and to the implied attributes of constant operands. Operands are converted as required to follow these rules; each converted operand then has the type (for instance, floating-point decimal) in which the operation will be performed, but it also has an individual precision based on its own attributes. These "converted precisions" (which include scale factors in fixed-point operations) are used to determine the precision of the result of the operation.

■ Identical Data Types

In PL/I, the notion of identical data types is used in the rules for passing arguments by reference and for based, controlled, defined, or external variables. For two nonstructure variables to have identical data types, the following attributes must agree. That is, if one variable has the attribute, the other must also have it after the application of default rules:

ALIGNED	DIMENSION	OFFSET
AREA	ENTRY	picture
array bounds	FILE	PICTURE
BINARY	FIXED	POINTER
BIT	FLOAT	precision
CHARACTER	LABEL	PRECISION
DECIMAL	length	VARYING

Two pictured variables must have identical pictures after the expansion of iteration factors.

In addition, the following values must be equal:

- Precisions and scale factors for arithmetic data
- String lengths and area sizes
- Number of dimensions for arrays and bounds in each dimension

Two structure variables have identical data types if they have the same number of immediate members and if corresponding members have identical data types.

In general, you can specify string lengths, area sizes, and array bounds with expressions or with asterisks for parameters. The values used to determine whether two variables have identical data types are obtained as follows:

- For static variables, the values must be constants.
- For automatic and defined variables, the expressions are evaluated when the block that contains such a variable's declaration is activated. The resulting values are used for all references to the variable within that block activation.

- For parameters, the declaration specifies any extents either with constants or with asterisks. In the case of asterisks, the extent in a particular procedure invocation is determined by the argument passed to the parameter. The extent remains the same throughout the procedure invocation.
- For based or controlled variables, extent expressions are evaluated each time the variable is referenced.

■ Example

```
/* Example of extent determination */

DATAT: PROCEDURE (PTR1);

DECLARE N FIXED, S CHARACTER(N) BASED(PTR1);
DECLARE PTR1 POINTER;

N = 10;

CALL P(S);

P: PROCEDURE(A);

     DECLARE A CHARACTER(*), B CHARACTER(N);
     N = 20;
     PUT LIST(LENGTH(A),LENGTH(B),LENGTH(S));
     END P;

END DATAT;
```

The PUT statement writes out

```
10     10     20
```

The assignment to N inside the procedure P affects the extent of S, but not the extents of A or B, which were "frozen" when P was invoked.

DATE Built-In Function
DATE Preprocessor Built-In Function

The DATE built-in function returns a 6-character string in the form yymmdd, where

yy	Is the current year (00–99)
mm	Is the current month (01–12)
dd	Is the current day of the month (01–31)

Its format is as follows:

```
DATE()
```

The date returned is the run-time date. However, if DATE is used as a preprocessor built-in function, the date returned is the compile-time date.

DATETIME Built-In Function
DATETIME Preprocessor Built-In Function

The DATETIME built-in function returns a 16-character string in the form ccyymmddhhmmssxx, where

cc	Is the current century (00–99)
yy	Is the current year (00–99)
mm	Is the current month (01–12)
dd	Is the current day of the month (01–31)
hh	Is the current hour (00–23)
mm	Is the minutes (00–59)
ss	Is the seconds (00–59)
xx	Is the hundredths of seconds (00–99)

The format of the function is as follows:

```
DATETIME()
```

The date and time returned is the run-time date and time. However, if DATETIME is used as a preprocessor built-in function, the date and time returned is the compile-time date and time.

Note that the DATETIME function is identical to the century concatenated with DATE() and TIME().

DEC Multinational Character Set

The DEC Multinational Character Set is a set of 8-bit numeric values representing the alphabet, numerals, punctuation, and other symbols. The first 128 characters of the set (with decimal values from 0 through 127) are the American Standard Code for Information Interchange (ASCII) characters. The remaining characters (with values from 128 through 255) are non-ASCII characters and can be used in VAX PL/I only in string constants and data with I/O statements.

See Appendix B for a table showing the characters in the set.

%DEACTIVATE Statement

The %DEACTIVATE statement makes preprocessor variable and procedure identifiers ineligible for replacement. After a variable or procedure has been deactivated, it will not be replaced during preprocessing. Replacement of a deactivated variable or procedure occurs again only after it is reactivated with the %ACTIVATE statement.

The format for the %DEACTIVATE statement is as follows:

```
% { DEACTIVATE } element,...;
  { DEACT      }
```

element
The name of a preprocessor identifier, or a list of identifiers that is enclosed in parentheses. Deactivated elements must have been previously declared preprocessor variables.

For example:

```
TESTF:PROCEDURE OPTIONS (MAIN);
      DECLARE Y FIXED DECIMAL;
      Y = 10;                  /* initial value: Y = 10 */
      %DECLARE Y FIXED;
      %Y = 3;                  /* replacement value: Y = 3 */
      PUT SKIP LIST(Y);        /* output: Y = 3 */
      %DEACTIVATE Y;
      PUT SKIP LIST(Y);        /* output: Y = 10 */
      END;
```

In this example, %Y, when activated, replaces all the occurrences of the variable Y by the value assigned to %Y, until %Y is deactivated by the %DEACTIVATE statement. The identifier %Y is implicitly activated when it is declared as a preprocessor identifier.

It is possible to deactivate several variables with a single statement. For example:

```
%DEACTIVATE (A,B,C,D,E,F);
```

For an example of %ACTIVATE and %DEACTIVATE, **see** "%ACTIVATE Statement." For additional information on the preprocessor, **see** "Preprocessor."

DECIMAL Attribute

The DECIMAL attribute specifies that an arithmetic variable has a decimal base. The format of the DECIMAL attribute is as follows:

```
{ DECIMAL }
{ DEC     }
```

When you specify the DECIMAL attribute for a variable, you can also specify the following attributes to define the scale factor and precision of the data:

```
FIXED (precision[,scale-factor])
FLOAT (precision)
```

where FIXED indicates a fixed-point value, and FLOAT indicates a floating-point decimal value. The precision specifies the number of decimal digits that represent values of the variable. The precision of a fixed-point decimal value is the total number of integral and fractional digits. The precision of a floating-point decimal value is the total number of digits in the mantissa. The precision for a fixed-point decimal value must be in the range 1 through 31; the scale factor, if specified, must be greater than or equal to zero and less than or equal to the specified precision. The precision for a floating-point decimal value must be in the range 1 through 34.

The default values applied to the DECIMAL attribute are as follows:

Attributes Specified	Defaults Supplied
DECIMAL	FIXED (10,0)
DECIMAL FIXED	(10,0)
DECIMAL FIXED (n)	(n,0)
DECIMAL FLOAT	(7)

See "Fixed-Point Decimal Data" and "Floating-Point Data."

■ Restrictions

The DECIMAL attribute conflicts with the BINARY attribute and with any other data type attribute.

DECIMAL Built-In Function

The DECIMAL built-in function converts an arithmetic or string expression x to a decimal value of an optionally specified precision p and scale factor q.

P and q, if specified, must be integer constants. P must be greater than zero and less than or equal to the maximum precision for the result type (31 for fixed-point, 34 for floating-point). If q is specified, x must be a fixed-point expression and p must also be specified; if q is omitted or has a negative value, the scale factor of the result is zero.

The format of the function is as follows:

```
{ DECIMAL }
{ DEC     } (x[,p[,q]])
```

■ Returned Value

The result type is fixed-point or floating-point decimal, depending on whether x is a fixed- or floating-point expression. (If x is a bit- or character-string expression, the result type is fixed-point decimal.)

The expression x is converted to a value v of the result type, following the PL/I rules (**see** "Conversion of Data"). The returned value is v with precision p and scale factor q. If p and q are omitted, they are the converted precision and scale factor of x (**see** "Expression"). FIXEDOVERFLOW, UNDERFLOW, or OVERFLOW is signaled if appropriate.

Declarations

The declaration of a name in a PL/I program consists of a user-specified identifier and the attributes of the name. The attributes describe the following:

- The data type of the name, that is, whether it is a computational data item such as a number or a string, or noncomputational program data
- The storage class to which the name belongs, that is, whether the compiler allocates storage for it, and how the storage is allocated
- The scope of the name, that is, whether the name is known only within the block in which it is declared and its contained blocks, or whether it is known in external blocks

A name is declared either explicitly in a DECLARE statement or implicitly by its appearance in a particular context. Only two types of names can be declared implicitly: entry constants and label constants. You must explicitly declare all other names. For example:

```
CALC: PROCEDURE;
```

This statement is an implicit declaration of the name CALC as an entry constant.

In a PL/I source program, the DECLARE statements that provide the declarations of names to be used in a given block can appear anywhere in that block. However, it is good practice to place all the declarations for a block at the beginning of the block, and follow the declarations with the executable statements of the program. For example:

```
CALC:  PROCEDURE (X,Y);
DECLARE (X,Y) FLOAT,
        COPYSTRING ENTRY (CHARACTER(*)),
        MESSAGE_TEXT CHARACTER(40);
            .
            .
            .
```

See "Attribute," "Data and Data Types," and "DECLARE Statement."

%DECLARE Statement

The %DECLARE statement establishes an identifier as a preprocessor variable, specifies the data type of the variable, and activates the identifier for replacement. %DECLARE can occur anywhere in a PL/I source program.

The format of the %DECLARE statement is as follows:

element

The name of a preprocessor identifier or a list of identifiers, which are separated by commas and enclosed in parentheses. You can give elements the attribute BIT, FIXED, or CHARACTER, but you cannot specify precision or length. The compiler supplies the variables with the following implied attributes:

Specified Attribute	Implied Attributes
BIT	(31) INITIAL ((31)'0'B)
FIXED	DECIMAL (10,0) INITIAL (0)
CHARACTER	VARYING (32767) INITIAL (' ')

If no data type is specified, FIXED is assumed.

When a variable is declared in a preprocessor statement, it is activated for replacement and rescanning. The scope of a preprocessor variable is all of the text following the declaration of the variable, unless the variable is declared inside a preprocessor procedure. Using %DECLARE inside of a preprocessor procedure has the effect of declaring a local variable.

For example:

```
%DECLARE HOUR FIXED;
```

In this example, HOUR is declared as a preprocessor variable identifier with the FIXED attribute. The compiler supplies the default values that make this declaration the equivalent of the following:

```
DECLARE HOUR FIXED DECIMAL (10,0) INITIAL (0);
```

NOTE

In preprocessor declarations, the attribute FIXED implies FIXED DECIMAL. In nonpreprocessor declarations, FIXED implies FIXED BINARY.

Factored declarations are permitted and follow the same usage rules as nonpreprocessor declarations. For example:

```
%DECLARE (A,B) CHARACTER, C BIT;
```

Both A and B are declared with the CHARACTER attribute. The compiler supplies default values that make this declaration the equivalent of the following:

```
%DECLARE (A,B) CHARACTER VARYING(32767) INITIAL(''),
        C BIT(31)INITIAL((31)'0'B);
```

For more information on the preprocessor, **see** "Preprocessor."

DECLARE Statement

The DECLARE statement specifies the attributes associated with names. The format of the DECLARE statement is as follows:

{ DECLARE / DCL } [level] declaration [,[level] declaration,...];

declaration

One or more declarations consisting of identifiers and attributes. A declaration has the following format:

[level] declaration-item

A declaration-item has the following format:

{ identifier / (declaration-item,...) } [(bound-pair,...)] [attribute ...]

The format of the DECLARE statement varies according to the number and nature of the items being declared. The DECLARE statement can list a single identifier, optionally specifying a level, bound-pair list, and other attributes for that identifier. Alternatively, the statement can include, in parentheses, a list of declarations to which the level and all subsequent attributes apply. The declarations in the second case can be simple identifiers or can include attributes that are specific to individual identifiers (**see** "Factored Declarations" below).

Bound pairs are used to specify the dimensions of arrays. If bound pairs are present, they must be in parentheses and must immediately follow the identifier or the list of declarations.

Levels are used to specify the relationship of members of structures; if a level is present in the declaration, it must be written first.

The various formats are described individually, below. **See also** "Array" and "Structure."

■ Simple Declarations

A simple declaration defines a single name and describes its attributes. The format of a simple declaration is as follows:

```
DECLARE identifier [attribute ...] ;
```

identifier

A 1- to 31-character user-supplied name. The name must be unique within the current block.

An identifier can consist of any of the alphanumeric characters A through Z, a through z, 0 through 9, dollar signs ($), and underscores (_), but must begin with an alphabetic letter, dollar sign, or underscore. **See also** "Identifier."

attribute

One or more attributes of the name. Attribute keywords must be separated by spaces. They can appear in any order.

See "Attribute" for a list of the valid attribute keywords and their meanings.

Following are some examples of simple declarations:

```
DECLARE COUNTER FIXED BINARY (7);
DECLARE TEXT_STRING CHARACTER (80) VARYING;
DECLARE INFILE FILE;
```

Names that are not given specific attributes in a DECLARE statement or that are referenced without being declared are given the default attributes BINARY FIXED (31,0) AUTOMATIC.

Note that the compiler issues a warning message whenever it gives these default attributes to a name.

■ Declarations Outside of Procedures

You can declare a variable outside of any procedure. Any variable so declared will be visible within all procedures contained by the module. The format for declarations outside of procedures is the same as for other declarations, except that the storage class cannot be AUTOMATIC. If a storage class is not specified, STATIC is supplied.

The following example illustrates the use of this type of declaration:

```
DECLARE A STATIC FIXED BINARY(31);
   .
   .
   .
FIRST: PROCEDURE;
    DECLARE B FIXED BINARY(31);
        .
        .
        .
END FIRST;

SECOND: PROCEDURE;
    DECLARE C FIXED BINARY(31);
        .
        .
        .
END SECOND;
```

In this example, variable A is visible in both the FIRST and SECOND procedures, but variables B and C are visible only in their containing procedures.

■ Multiple Declarations

Multiple declarations define two or more names and their individual attributes. This format of the DECLARE statement is as follows:

DECLARE identifier [attribute ...] [,identifier [attribute ...]] ...;

When you specify more than one set of names and their attributes, separate each name and attribute set from the preceding set with a comma. A semicolon must follow the last name.

Following is an example of multiple declarations:

```
DECLARE COUNTER FIXED BINARY (7),
        TEXT_STRING CHARACTER (80) VARYING,
        Y FILE;
```

This DECLARE statement defines the variables COUNTER, TEXT_STRING, and Y. The attributes for each variable follow the name of the variable.

■ Factored Declarations

When two or more names have the same attribute, you can combine the declarations into a single, factored declaration. This format of the DECLARE statement is as follows:

DECLARE (identifier[,identifier,...]) [attribute ...];

When you use this format, you must place names that share common attributes within parentheses, and separate them with commas. The attributes that follow the parenthetical list of names are applied to all the named identifiers.

Following are some examples of factored declarations:

```
DECLARE (COUNTER, RATE, INDEX) FIXED BINARY (7) INITIAL (0);
DECLARE (INPUT_MESSAGE, OUTPUT_MESSAGE, PROMPT)
        CHARACTER (80) VARYING;
```

In these declarations, the variables COUNTER, RATE, and INDEX share the attributes FIXED BINARY (7) and are given the initial value of zero. The variables INPUT_MESSAGE, OUTPUT_MESSAGE, and PROMPT share the attributes CHARACTER (80) VARYING.

You can also specify, within the parentheses, attributes that are unique to specific variable names, using the following format:

DECLARE (identifier attribute ..., identifier [attribute ...],...) attribute ...

For example:

```
DECLARE (INFILE INPUT RECORD,
         OUTFILE OUTPUT STREAM) FILE;
```

The DECLARE statement declares INFILE as a RECORD INPUT file and OUTFILE as an OUTPUT STREAM file.

The parentheses can be nested. For example:

```
DECLARE ( (INFILE INPUT, OUTFILE OUTPUT) RECORD,
          SYSFILE STREAM ) FILE;
```

The DECLARE statement declares INFILE as a RECORD INPUT file, OUTFILE as a RECORD OUTPUT file, and SYSFILE as a STREAM INPUT file (STREAM implies INPUT).

■ Array Declarations

The declaration of an array specifies the dimensions of the array and the bounds of each dimension. This format of a DECLARE statement is as follows:

DECLARE { identifier / (declaration,...) } (bound-pair,...) [attribute ...];

where each bound pair has the following format:

{ [lower-bound:]upper-bound / * }

One bound pair is specified for each dimension of the array. The number of elements per dimension is defined by the bound pair. The extent of an array is the product of the numbers of elements in its dimensions. If the lower bound is omitted, the lower bound for that dimension is 1 by default.

The asterisk (*) can be used as the bound pair when arrays are declared as parameters of a procedure. The asterisk indicates that the parameter can accept array arguments with any number of elements. (If one dimension is specified with an asterisk, all must be specified with asterisks.)

For example:

```
DECLARE SALARIES(100) FIXED DECIMAL(7,2);
```

This statement declares a 100-element array with the identifier SALARIES. Each element is a fixed-point decimal number with a total of seven digits, two of which are fractional. The identifier in the statement can

be replaced with a list of declarations, to declare several objects with the same attributes. For instance:

```
DECLARE (SALARIES,PAYMENTS) (100) FIXED DECIMAL(7,2);
```

This declares SALARIES and another array, PAYMENTS, with the same dimensions and other attributes.

For further details on how to specify the bounds of an array, and for examples of array declarations, **see** "Array."

■ Structure Declarations

The declaration of a structure defines the organization of the structure and the names of members at each level in the structure. This format of a DECLARE statement is as follows:

```
{ DECLARE } level declaration [,level declaration,...];
{ DCL     }
```

declaration

One or more declarations consisting of identifiers and attributes. A declaration has the following format:

```
level declaration-item
```

A declaration-item has the following format:

```
{ identifier             } [(bound-pair,...)] [attribute ...]
{ (declaration-item,...) }
```

Each declaration specifies a member of the structure and must be preceded by a level number. As shown, a single variable can be declared at a particular level; or the level can contain one or more complete declarations, including declarations of arrays or other structures. The major structure name is declared as structure level 1; minor members must be declared with level numbers greater than 1. For example:

```
DECLARE 1 PAYROLL,
          2 NAME,
            3 LAST CHARACTER(80) VARYING,
            3 FIRST CHARACTER(80) VARYING,
          2 SALARY FIXED DECIMAL(7,2);
```

This statement declares a structure named PAYROLL. The last name can be accessed with a qualified reference:

```
PAYROLL.NAME.LAST = 'ROOSEVELT';
```

Alternatively, because the last and first names have the same attributes, the same structure can be declared as follows:

```
DECLARE 1 PAYROLL,
          2 NAME,
            3 (LAST,FIRST) CHARACTER(80) VARYING,
          2 SALARY FIXED DECIMAL(7,2);
```

For details and examples of structure declarations, **see** "Structure."

DECODE Built-In Function
DECODE Preprocessor Built-In Function

The DECODE built-in function converts a character string representing a number to a fixed binary number. It takes two arguments: a character string and an integer expression specifying the radix of the number that is to be returned. It converts the string to an unsigned, base r integer, where r is the specified radix. The function returns a FIXED BINARY(31,0) number representing the base ten equivalent of the string.

The syntax of the function is as follows:

```
DECODE(character-expression,radix-expression)
```

The syntax of an assignment statement using the DECODE function is as follows:

```
fixed-binary-variable = DECODE(character-expression,
radix-expression);
```

character-expression

A character-string constant or variable whose component characters can be any of the digits from '0' through '9', from 'a' through 'f', and from 'A' through 'F'. The digits must be within the range of digits valid for the base specified in the radix-expression.

radix-expression

An expression evaluating to any integer from 2 through 16.

■ Example

```
DECLARE (X,Y) FIXED BINARY;
X = DECODE('1010',2);
Y = DECODE('f0',16);
```

The fixed binary variables X and Y are given the values 10 and 240, respectively.

DEFINED Attribute

The DEFINED attribute indicates that PL/I is not to allocate storage for the variable, but is to map the description of the variable onto the storage of a base variable. The DEFINED attribute provides a way to access the same data using different names. Its format is as follows:

{ DEFINED / DEF } (variable-reference)

variable-reference
A reference to a base variable that has storage associated with it. The base variable must not have the BASED, CONTROLLED, or DEFINED attribute. The base variable and the declared variable must satisfy the rules given under "Defined Variable."

The DEFINED attribute can optionally specify a position within the base variable at which the definition begins. For example:

```
DECLARE ZONE CHARACTER(10)
     DEFINED(ZIP) POSITION(4);
```

For more information, see "POSITION Attribute" and "Defined Variable."

■ Restrictions

The following attributes conflict with the DEFINED attribute:

AUTOMATIC	BASED	CONTROLLED
EXTERNAL	GLOBALDEF	GLOBALREF
INITIAL	PARAMETER	READONLY
STATIC	UNION	VALUE

The DEFINED attribute cannot be applied to minor structures, members of structures, parameters, or descriptions in an ENTRY or RETURNS attribute.

For additional information on defined variables, **see** "Defined Variable."

Defined Variable

A defined variable is one for which no storage is allocated. Instead, the variable shares the storage of a specified base variable. A defined variable is declared with the DEFINED attribute, which also specifies the base variable. Any reference to the defined variable is a reference to part or all of the storage of the base variable. For example:

```
DECLARE A(10) FIXED, B FIXED DEFINED(A(I));
```

The variable B is a defined variable, with A as its base reference. A reference to B is a reference to the element of A denoted by the current value of I.

The extents of a defined variable are determined at the time of block activation, but the base reference (and the position, if the POSITION attribute is also specified) is interpreted each time the defined variable is referenced.

For example:

```
DECLARE A(10) FIXED, B FIXED DEFINED(A(I));
DO I = 1 TO 10;
B = I;
END;
```

The DO group assigns I to A(I) for I = 1,2, . . . 10.

The base reference of a defined variable cannot be a reference to a based variable or to another defined variable.

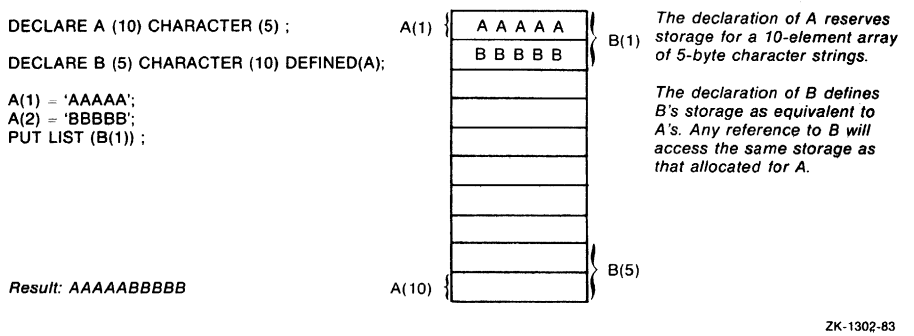
A defined variable and its base reference must satisfy one of the following criteria:

- They must have identical data types (**see** "Data and Data Types").
- They must both be suitable for character-string overlay defining.
- They must both be suitable for bit-string overlay defining.

If the defined variable is specified with the POSITION attribute, then both the defined variable and the base reference must be suitable for bit- or character-string overlay defining.

Generally, a variable is suitable for overlay defining if it consists entirely of characters or bits, and these characters or bits are packed into adjacent storage without gaps. Precise rules are given below. Such a variable can be treated as a string (**see also** "STRING Built-In Function" and "STRING Pseudovariable") or can be interpreted as a set of different types of aggregates. For example, Figure D–1 shows a 50-byte region of storage treated either as a 10-element array (A) of 5-character strings or as a 5-element array (B) of 10-character strings.

Figure D–1: An Overlay Defined Variable



If the defined variable and its base reference have identical data types, a reference to the defined variable is equivalent to the base reference. In the case of overlay defining, the defined variable maps onto part of the base reference's storage as follows:

1. If the POSITION attribute was specified, let position be its value at the moment of reference; otherwise, let position equal 1.
2. Let m be the total number of characters (or bits) specified by the data type of the defined variable. (Note that for pictured data, m is the total number of characters in the picture specification, exclusive of the V character.)

3. A reference to the defined variable accesses m characters (or bits) of the base reference, beginning with the character or bit specified by position. The reference must lie entirely within the base reference; that is, position and m must satisify the following formula:

$$1 <= position <= position + m <= n + 1$$

where n is the total number of characters or bits in the base reference.

■ Rules for Overlay Defining

A variable V is suitable for character-string overlay defining if V is not an unconnected array and if one of the following criteria is satisfied:

- V has the CHARACTER attribute, but not ALIGNED or VARYING.
- V has the PICTURE attribute.
- V is a structure, and each of V's members and submembers that is not a structure satisfies one of the first two criteria.

A variable V is suitable for bit-string overlay defining if V is not an unconnected array and if one of the following criteria is satisfied:

- V has the BIT attribute but not ALIGNED.
- V is a structure, and each of V's members or submembers that is not a structure satisfies the first criterion.

DELETE Statement

The DELETE statement deletes a record from a file. This record can be the current record (**see** "Record Input/Output"), the record specified by the KEY option, or the record specified by the RECORD_ID option. The file must have the UPDATE attribute.

The format of the DELETE statement is as follows:

```
DELETE FILE(file-reference) [KEY (expression)] [OPTIONS(option,...)];
```

file-reference
A reference to the file from which the specified record is to be deleted. If the file is not currently opened, PL/I opens the file with the implied attributes RECORD and UPDATE; these attributes are merged with the attributes specified in the file's declaration.

KEY (expression)
An option specifying that the record to be deleted will be located by the key specified in the expression. The file must have the KEYED attribute.

The nature of the key depends on the file's organization, as follows:

- If it is a relative file, the key is a fixed binary value indicating the relative record number of the record to be deleted.
- If it is an indexed sequential file, the key is contained in the record; its position in the record and its data type are as determined when the file was created.

The value of the specified expression is converted to the data type of the key. If no record with the specified key exists in the file, or if the value specified is not valid for conversion to the data type of the key, the KEY condition is signaled.

OPTIONS(option, . . .)
An option giving one or more of the DELETE statement options listed below:

FAST_DELETE
INDEX_NUMBER (expression)
MATCH_GREATER
MATCH_GREATER_EQUAL
MATCH_NEXT
MATCH_NEXT_EQUAL
RECORD_ID (expression)

Multiple options must be separated by commas.

The MATCH_GREATER, MATCH_GREATER_EQUAL, MATCH_NEXT, and MATCH_NEXT_EQUAL options of the DELETE statement, if set, remain set only for the current statement; they are then reset to FALSE. (MATCH_GREATER and MATCH_GREATER_EQUAL are obsolete synonyms for MATCH_NEXT and MATCH_NEXT_EQUAL.)

These options are described fully in the *VAX PL/I User Manual.*

■ File Positioning

The next record is set to denote the record following the deleted record. The current record is undefined.

Note that a keyed DELETE statement cannot be followed by a sequential operation; you must specify a key.

■ Examples

The program BAD_RECORD, below, deletes an erroneous record in an indexed sequential file containing data about states. The primary key in the file is the name of a state.

```
BAD_RECORD: PROCEDURE OPTIONS(MAIN);

DECLARE STATE_FILE FILE KEYED UPDATE;
      OPEN FILE(STATE_FILE) TITLE('STATEDATA.DAT');
      DELETE FILE(STATE_FILE) KEY('Arklansas');
      CLOSE FILE(STATE_FILE);
RETURN;
END;
```

The file is opened with the UPDATE attribute, and the OPEN statement gives the file specification of the file from which the record is to be deleted.

DESCRIPTOR Attribute

The DESCRIPTOR attribute forces a parameter to be passed by descriptor to a non-PL/I procedure. Its format is as follows:

```
{ DESCRIPTOR }
{ DESC       }
```

You can use the DESCRIPTOR attribute only in parameter descriptors.

DESCRIPTOR Built-In Function

The DESCRIPTOR built-in function forces its argument to be passed by descriptor to a non-PL/I procedure. A reference to the built-in function must occur only as an argument in such a context and has no other use. The format of the function is as follows:

```
{ DESCRIPTOR } (expression)
{ DESC       }
```

expression
The argument to be passed by descriptor. Its data type must be computational but cannot be pictured. It can be an array variable.

For a full discussion of argument passing to non-PL/I procedures, **see** the *VAX PL/I User Manual* and the entry "ANY Attribute" in this manual.

Diagnostic Messages

Diagnostic messages are produced by the PL/I compiler to inform you of programming errors detected by the compiler and to warn you of certain exceptional conditions, such as the compiler's assignment of type and precision to an undeclared variable.

The VAX PL/I embedded preprocessor permits you to generate diagnostic messages for compile-time programming errors and information. **See** "User-Generated Diagnostic Messages."

For full details on diagnostic messages, **see** the *VAX PL/I User Manual.*

%DICTIONARY Statement

The %DICTIONARY statement causes VAX Common Data Dictionary (CDD) data definitions to be incorporated into the current PL/I source file during compilation. The statement can occur anywhere in a PL/I source file. The format of the %DICTIONARY statement is as follows:

```
%DICTIONARY cdd-path;
```

cdd-path
Any preprocessor expression. It is evaluated and converted to a CHARACTER string if necessary. The resulting character string is interpreted as the full or relative path name of a CDD object. The resultant path name must conform to all rules for forming VAX CDD path names. See the *Common Data Dictionary Utilities Manual* for details.

For example, assume that you have a record with the following path name:

```
CDD$TOP.SALES.JONES.SALARY
```

You can then specify a relative path name as follows:

```
%DICTIONARY 'SALARY';
```

Or you can specify an absolute path name as follows:

```
%DICTIONARY '_CDD$TOP.SALES.JONES.SALARY';
```

The compiler extracts the record definition from the CDD and inserts the PL/I structure declaration corresponding to the record description in the PL/I program.

If the %DICTIONARY statement is not embedded in a PL/I language statement, then the resulting structure is declared with the logical level 1 and the BASED storage attribute is furnished. The logical member levels are incremented from 2. For example:

```
DECLARE PRICE FIXED BINARY(31);
%DICTIONARY 'ACCOUNTS';
```

This would result in a declaration of the following form:

```
DECLARE PRICE FIXED BINARY(31);
DECLARE 1 ACCOUNTS BASED,
          2 NUMBER,
            3 LEDGER CHARACTER(3),
            3 SUBACCOUNT CHARACTER(5),
          2 DATE CHARACTER(12),
              .
              .
              .
```

Notice that in the above example, ACCOUNTS is a relative dictionary path name.

If the %DICTIONARY statement is embedded in a PL/I language statement, as in a structure declaration, then the resulting structure is declared with no logical level and no storage attribute. Logical member numbers are supplied and incremented from 100. For example:

```
DECLARE 1 COMMON_INTERFACES STATIC EXTERNAL,
          %DICTIONARY 'ACCOUNTS';   ,
          %DICTIONARY 'ADDRESSES';  ;
```

Notice the syntax in the above %DICTIONARY example. The %DICTIONARY statement is terminated with the preprocessor terminator semicolon before the normal PL/I line punctuation. The normal

PL/I punctuation must also be included so that the final structure declaration will contain proper PL/I punctuation. The previous declaration would result in a declaration of the following form:

```
DECLARE 1 COMMON_INTERFACES STATIC EXTERNAL,
          100 ACCOUNTS,
              101 NUMBER,-
                  102 LEDGER CHARACTER(3),
                  102 SUBACCOUNT CHARACTER (5),
              101 DATE CHARACTER(12),
                  .
                  .
                  .
          100 ADDRESSES,
              .
              .
              .
```

The CDD supports data types that are not native to PL/I. If a data definition contains an unsupported data type, PL/I makes the unsupported data type accessible by declaring it as data type BIT_FIELD or data type BYTE_FIELD. PL/I does not attempt to approximate a data type that is not supported by PL/I. For example, an F_FLOATING_COMPLEX number is declared BYTE_FIELD(8), not (2)FLOAT(24).

Note, however, that use of these two data types is limited. Data declared with the BIT_FIELD or BYTE_FIELD data type can be manipulated only with the PL/I built-in functions ADDR, INT, POSINT, SIZE, and UNSPEC. A variable declared with either of these data types can be passed as a parameter provided the parameter is declared as ANY. Thus, references to data declared as BIT_FIELD or BYTE_FIELD are limited to contexts in which the interpretation of a data type is not applied to the reference.

PL/I ignores CDD features that are not supported by PL/I, but issues error messages when the features conflict with PL/I.

When you extract a record definition from the CDD, you can choose to include this translated record in the program listing by using the /LIST/SHOW=DICTIONARY qualifiers in the PLI command line. Even if you choose not to list the extracted record, the names, data types, and offsets of the CDD record definition are displayed in the program listing allocation map.

CDD data definitions can contain explanatory text in the CDDL DESCRIPTION IS clause. This text is included in the PL/I listing comments, if /LIST/SHOW=DICTIONARY is specified. For example, you could use CDDL comments to indicate the data type of each structure and

member. The punctuation for CDDL comments is the same as for other PL/I programs: the slash-asterisk (/*) and the asterisk-slash (*/).

DIMENSION Attribute

The DIMENSION attribute defines a variable as an array. It specifies the number of dimensions of the array and the bounds of each dimension. The format of the DIMENSION attribute is as follows:

```
[ DIMENSION ]
[ DIM       ] (bound-pair,...)
```

bound-pair
One or two expressions that indicate the number of elements in a single dimension of the array. You must specify the list of bound pairs immediately following the name of the identifier in the array declaration if the optional keyword DIMENSION or DIM is omitted; otherwise, you must specify the list of bound pairs immediately following the keyword DIMENSION or DIM. See the following examples.

The maximum number of dimensions allowed is eight.

A bound pair can be specified as follows:

- [lowerbound:]upperbound

  This format of a bound pair specifies the minimum and maximum subscripts that can be used for the dimension. The number of elements is therefore,

  $$(upperbound - lowerbound) + 1$$

  If the lower bound is omitted, it is assumed to be 1.

- *

  This format of a bound pair, when used to define a parameter for a procedure or function, indicates that the bounds are to be determined from the associated argument. If one bound pair is specified as an asterisk, all bound pairs must be specified as asterisks.

The following two declarations are exactly equivalent:

```
DCL A(10) FIXED BIN;
DCL A FIXED BIN DIMENSION(10);
```

The following two declarations are also equivalent:

```
DCL B(1:5,1:5) FLOAT DEC;
DCL B DIM(1:5,1:5) FLOAT DEC;
```

For the complete rules for specifying dimensions and bounds, **see** "Array."

DIMENSION Built-In Function

The DIMENSION built-in function returns a fixed-point binary integer that is the number of elements in an array dimension. Its format is as follows:

$$\left\{ \begin{array}{l} \text{DIMENSION} \\ \text{DIM} \end{array} \right\} \text{(reference[,dimension])}$$

reference
A reference to an array variable.

dimension
An integer constant specifying the dimension of the array for which the extent is to be determined. If the dimension is not specified, the dimension parameter defaults to 1. Thus, DIMENSION(A) is equivalent to DIMENSION(A,1).

■ Example

```
INIT: PROCEDURE (ARRAY);
DECLARE ARRAY(*) FIXED,
        I FIXED;

        DO I = 1 TO DIM(ARRAY);
            ARRAY(I) = I;
            END;
```

This procedure is passed a one-dimensional array of an unknown extent. The DIMENSION built-in function is used as the end value in a controlled DO statement. This DO-group assigns integral values to each element of the array ARRAY so that the first element has the value 1, the second element has the value 2, and so on to the last element of the array.

(Because the array is one-dimensional, the optional second parameter is omitted and defaults to 1.)

DIRECT Attribute

The DIRECT file description attribute indicates that a file will be accessed only in a nonsequential manner, that is, by key or by relative record number.

The DIRECT attribute implies the RECORD and KEYED attributes.

Specify the DIRECT attribute on a DECLARE statement for a file constant or on an OPEN statement to access the file. A file declared with the DIRECT attribute must be one of the following:

- A relative file
- An indexed sequential file
- A sequential disk file with fixed-length records
- A sequential file opened with ENVIRONMENT(BLOCK_IO)

See "File" and "Record Input/Output."

To be able to access a file both randomly and sequentially, use the SEQUENTIAL attribute instead of DIRECT (**see** "SEQUENTIAL Attribute").

■ Restrictions

The DIRECT attribute conflicts with the SEQUENTIAL, STREAM, and PRINT attributes.

DISPLAY Built-In Subroutine

The DISPLAY built-in subroutine returns information on a file. See the *VAX PL/I User Manual* for more information.

DIVIDE Built-In Function

The DIVIDE built-in function divides an arithmetic expression x by an arithmetic expression y and returns the quotient with a specified precision p and an optionally specified scale factor q. The scale factor q must be an integer following these rules:

- If either x or y is fixed binary, q must be in the range -31 through 31.
- If both x and y are fixed decimal, q must not be negative.
- If either x or y is floating point, q must be zero.
- If q is omitted, it is assumed to be zero.

The expressions x and y are converted to their derived types before the division is performed (**see** "Expression"). If y is zero after this conversion, the ZERODIVIDE condition is signaled. The quotient has the derived type of the two arguments.

The format of the function is as follows:

```
DIVIDE(x,y,p[,q])
```

Division

The slash sign character (/) indicates a division operation in an expression; the result is the quotient of the first operand divided by the second operand. Both operands must be arithmetic or picture data.

■ Precision of the Result

Before the division is performed, the two operands are converted to their derived type (**see** "Expression"). Each converted operand has an individual converted precision, and the two precisions are used to determine the precision of the result.

Floating-Point Operands

The floating-point result has the maximum of the converted precisions of the operands.

Fixed-Point Operands

The resulting precision is 31. (If the quotient exceeds the precision of the result, the least significant digits of the quotient are truncated.) If (p,q) and (r,s) represent the converted precisions and scale factors of the two operands, the resulting scale factor is $31 - p + q - s$.

■ Restrictions

The divisor (the second operand) must not be zero. If the divisor equals zero, the ZERODIVIDE condition is signaled; if no ON-unit exists to handle this condition, the program terminates.

For division of fixed-point decimal operands, the precisions of the operands must be such that the result does not have a negative scale factor.

Another way to perform division is to use the DIVIDE built-in function, which allows you to control precisely the precision of the result. **See** "Divide Built-In Function."

%DO Statement

The %DO statement begins a preprocessor DO-group, a sequence of statements terminating with the %END statement. The preprocessor DO-group must be a simple DO-group and is noniterative, but it can be usefully combined with an %IF statement.

The format of the %DO statement is as follows:

```
%DO;
.
.
.
%END;
```

You can include both preprocessor and nonpreprocessor text in a preprocessor DO-group. For example:

```
%DECLARE T CHARACTER;          /* declare T */
%ACTIVATE T NORESCAN;          /* activate T for replacement */
   .
   .
   .
%IF VARIANT() = 'NONE';
   %THEN
   %DO;
   %T = '''unknown variant'''; /* assign string to T */
   %WARN T;                    /* output unknown variant
                                  warning at compile time */
   INIT_MESSAGE = INIT_MESSAGE||' with '||T; /* assign
                               value of T to nonpreprocessor
                                    variable */
   %END;
```

This preprocessor DO-group performs several steps. First, a string constant is assigned to T. Then the value of T is used in a preprocessor user-generated diagnostic message. This message is issued at compile time to warn the programmer that the program is compiled with an unknown variant. Finally, the value of T is concatenated with a nonpreprocessor string constant. INIT_MESSAGE, including the value of T, is part of the run-time image.

For more information on the preprocessor, **see** "Preprocessor."

DO-Group

A DO-group is a sequence of PL/I statements delimited by a DO statement and its corresponding END statement. The statements in a DO-group are executed as the result of an unconditional DO statement or as the result of the successful test of a conditional DO.

For example:

```
IF A > B THEN DO;
   .
   .
   .
   END;
```

The statements that occur between the DO and the END are a DO-group. After all statements are executed in this unconditional DO-group, execution continues with the next executable statement following the END statement.

Normally, all the statements in the group are executed. However, control can be transferred out of a DO-group in the following ways:

- By execution of a GOTO statement that transfers control outside of the DO-group. The GOTO statement can be present in the DO-group itself, in a procedure invoked from within the DO-group, or in an ON-unit executed while the DO-group is active.
- By execution of a LEAVE statement that transfers control to a label outside of the containing DO-group or to the next executable statement following the END statement that terminates the DO-group.
- By execution of a RETURN or STOP statement that terminates the current procedure or program.

You can nest DO-groups to a maximum level of 64.

DO Statement

The DO statement begins a sequence of statements to be executed in a group; the group ends with the nonexecutable statement END. DO-groups have several formats. These formats are summarized in Figure D–2 and described individually below under the following subheadings:

- Simple DO
- DO WHILE
- DO UNTIL
- Controlled DO
- DO REPEAT

■ Simple DO

A simple DO statement is a noniterative DO. The format of a simple DO statement is as follows:

```
DO;
  .
  .
  .
END;
```

The statements that appear between the DO statement and its corresponding END statement are executed once. After all statements in the group are executed, control passes to the next executable statement in the program.

Examples

```
IF A < B THEN DO;
   PUT LIST ('More data needed');
   GET LIST (VALUE);
   A = A + VALUE;
   END;
```

The simple DO statement is commonly used as the action of the THEN clause of an IF statement, as shown above, or of an ELSE option.

Figure D–2: Forms of the DO Statement

```
DO ;
  •
  •                    The statements in a simple, noniterative DO-group are executed a sin-
  •                    gle time.
END ;

DO WHILE (test-exp) ;
  •
  •                    The statements in the DO-group following a DO WHILE are executed in
  •                    a loop as long as the condition specified in the test expression is satis-
END ;                  fied.

DO UNTIL (test-exp) ;
  •
  •                    The statements in the DO-group following a DO UNTIL are executed in
  •                    a loop as long as the condition specified in the test expression is false.
END ;

DO control-variable = start-value TO end-value [WHILE (test-exp)] [UNTIL (test-exp)];
  •
  •                    Each time the statements in the DO-group are executed, the specified
  •                    control variable has a different value. When the DO statement is evalu-
END ;                  ated at the start of each execution, the control variable is incremented
                       by 1. When its value exceeds the specified end value, control passes
                       out of the DO-group.

                       Optional WHILE and/or UNTIL clauses further control execution of a
                       DO-group.

DO control-variable = start-value BY modify-value [WHILE (test-exp)] [UNTIL (test-exp)];
  •
  •                    The value of the control variable is modified by a specified positive or
  •                    negative value; for each iteration of the DO-group, it has a different
END ;                  value. The DO-loop is terminated by a statement within the loop or, if
                       the optional WHILE clause is specified, when the test expression yields
                       a false value.

DO control-variable = start-value TO end-value BY modify-value [WHILE (test-exp)] [UNTIL (test-exp)];
  •
  •                    The DO statement can specify a range of values to use for the control
  •                    variable as well as a value by which it is to be modified.
END ;
                       Optional WHILE and/or UNTIL clauses further control execution of a
                       DO-group.

DO control-variable = start-value REPEAT expression [WHILE (test-exp)] [UNTIL (test-exp)];
                       The repetition of the statements in the DO-group is controlled by the
                       expression in the REPEAT option. This expression defines how the
                       control variable is to be modified.

                       The WHILE and /or UNTIL clauses provide conditions that terminate
                       execution of the DO-group.
```

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■ DO WHILE

A DO WHILE statement causes a group of statements to be executed as long as a particular condition is satisfied. When the condition is not true, the group is not executed. The format of the DO WHILE statement is as follows:

```
DO WHILE (test-expression);
   .
   .
   .
END;
```

test-expression

Any expression that yields a scalar value. If any bit of the value is a 1, then the test expression is true; otherwise, the test expression is false. The test expression must be enclosed in parentheses. (Comparison operations yield a value with the type BIT(1).)

This expression is evaluated before each execution of the DO-group. It must have a true value in order for the DO-group to be executed. Otherwise, control passes outside of the DO-group to the next executable statement following the END statement that terminates the group.

Examples

```
DO WHILE (A < B);
```

This DO-group is executed as long as the value of the variable A is less than the value of the variable B.

```
DO WHILE (LIST->NEXT ^= NULL());
```

This DO-group is executed until a forward pointer in a linked list has a null value. (**See** "List Processing.")

```
DECLARE EOF BIT(1) INITIAL('0'B);
   .
   .
   .
ON ENDFILE(INFILE) EOF = '1'B;
READ FILE(INFILE) INTO(INREC);
DO WHILE (^EOF);
   .
   .
   .
   READ FILE(INFILE) INTO(INREC);
   END;
```

This DO-group reads records from the file INFILE until the end of the file is reached. At the beginning of each iteration of the DO-group, the expression ^EOF is evaluated; the expression is '1'B until the ENDFILE ON-unit sets the value of EOF to '1'B.

■ DO UNTIL

A DO UNTIL statement causes a group of statements to be executed until a particular condition is satisfied. That is, while the condition is false, the group is repeated. The format of the DO UNTIL statement is as follows:

```
DO UNTIL (test-expression);
.
.
.
END;
```

test-expression
Any expression that yields a scalar value. If any bit of the value is 1, then the test-expression is true; otherwise the test expression is false. The test expression must be enclosed in parentheses. (Comparison operations yield a value having the type BIT(1).)

This expression is evaluated after each execution of the DO-group. It must have a false value for the DO-group to be repeated. Otherwise, control passes to the next executable statement following the END statement that terminates the DO-group. The test expression must be enclosed in parentheses.

NOTE

Both the WHILE and UNTIL options check the status of test expressions, but they differ in that the WHILE option tests the value of the test expression at the beginning of the DO-group, and UNTIL tests the value of the test expression at the end of the DO-group. Therefore, a DO-group with the UNTIL option and no WHILE option will always be executed at least once, but a DO-group with the WHILE option may never be executed.

Examples

```
DO UNTIL (A=0);
```

This DO-group is executed at least once and continues as long as the value of A is not equal to zero.

```
DO UNTIL (K<ALPHA);
```

This DO-group is executed as long as the value of the variable K is greater than or equal to the value of the variable ALPHA.

```
DECLARE STR BIT (8) CONTROLLED;
   .
   .
   .
DO UNTIL (ALLOCATION(STR)=0);
   PUT SKIP LIST (STR);
   FREE STR;
   END;
```

This DO-group frees bit strings from storage until all generations have been released. Because the UNTIL option is always executed at least once, at least one generation must be allocated; otherwise the ERROR condition is signaled. At the end of each repetition of the DO-group, the number of remaining generations is checked with the ALLOCATION built-in function. When no generations remain, execution of the group terminates and control passes to the next executable statement after the first END statement.

■ Controlled DO

A controlled DO statement identifies a variable whose value controls the execution of the DO-group and defines the conditions under which the control variable is to be modified and tested. The format of the controlled DO statement is as follows:

```
DO control-variable = start-value
[ TO end-value [BY modify-value] ]
[ BY modify-value                ]
    [ WHILE (test-expression) ]
    [ UNTIL (test-expression) ]
    ;
        .
        .
        .
END;
```

control-variable
A reference to a variable whose current value as compared to the end value specified in the TO option determines whether the DO-group is executed. If none of the options are specified, the DO-group is executed a single time regardless of the value of the control variable. The control variable must be of an arithmetic data type.

start-value
An expression specifying the initial value to be given to the control variable. Evaluation of this expression must yield an arithmetic value.

end-value
An expression giving the value to be compared with the control variable during successive iterations. Evaluation of this expression must yield an arithmetic value.

modify-value
An expression giving a value by which the control value is to be modified. Evaluation of this expression must yield an arithmetic value. If the BY option is not specified, the modify value is 1 by default.

WHILE (test-expression)
An option specifying a condition that further controls the execution of the DO-group. The condition must be true at the beginning of each DO-group execution for the DO-group to be executed. The specified test expression must yield a scalar value. If any bit in the value is a 1, then the test expression is true; otherwise, the test expression is false. The test expression must be enclosed in parentheses.

UNTIL (test-expression)
An option specifying a condition that further controls the execution of the DO-group. The condition must be false at the end of a DO-group execution for the next DO-group to be executed. The specified test expression must yield a scalar value. If any bit in the value is a 1, then the test expression is true; otherwise, the test expression is false. The test expression must be enclosed in parentheses.

The controlled DO-group is executed by the following steps:

1. The following measures are taken to prevent the allocation of a new control variable during the execution of the DO-group:
   - If the control variable is based, its pointer qualifier is evaluated and a temporary reference of the control variable type is created. The temporary reference is used as the control variable in subsequent steps.
   - If the control variable is subscripted, its subscripts are evaluated and a temporary reference of the control variable type is created. The temporary reference is used as the control variable in subsequent steps.
   - If the control variable is neither based nor subscripted, its reference is used in subsequent steps.
2. The start value expression is evaluated and assigned to the control variable. The expressions specified in the TO and (if specified) BY options are evaluated, and their values are stored. These expressions can contain references to the object referenced by the control variable. If they do, the original reference, not the temporary reference, is used in evaluation of the expressions.
3. If the TO option is present, the value of the control variable is compared with the end value specified in the TO option. Otherwise, this step is skipped. Execution of the DO-group terminates if either of the following is true:
   - The modify value is greater than zero and the control variable is greater than the end value.
   - The modify value is less than zero and the control variable is less than the end value.

   If this step terminates the DO-group on the first iteration, the control variable has a final value assigned by the start value. If the group is terminated on a subsequent iteration, the control variable has a final value assigned by step 6.
4. If a WHILE option is present, its test expression is evaluated. If it does not produce a true value, the execution of the DO-group terminates.
5. The body of the DO-group is executed. The execution of the DO-group can be terminated during this step by the execution of a STOP or RETURN statement or by the execution of a GOTO or LEAVE statement that transfers control out of the DO-group.

The body of the DO-group can also contain statements that change the values of the control variable, modify value, end value, or test expression. Changing the modify value or the end value in the body of the loop will not affect the number of times the loop is iterated. However, changing the value of the control variable or the test expression can affect the number of iterations.

6. If an UNTIL option is present, its test expression is evaluated. If it produces a true value, the execution of the DO-group terminates.
7. Unless none of the options are specified, the value of the control variable is modified as follows:

   control variable = control variable + modify value;

8. Execution continues at step 3 unless none of the options are specified, in which case control passes to the next executable statement in the program.

Examples

```
DO I = 2 TO 100 BY 2;
```

This DO-group is executed 50 times, with values for I of 2, 4, 6, and so on.

```
DO I = LBOUND(ARRAY,1) TO HBOUND(ARRAY,1);
```

This DO-group is executed as many times as there are elements in the array variable ARRAY, using the subscript values of the array's elements for the values of I.

```
DO I = 1 BY 1 WHILE (X < Y);
```

This DO-group continues to be executed with successively higher values for I while the value of X is less than the value of Y.

```
DO I = 1 BY 1 WHILE (X < Y) UNTIL (X = 12);
```

This DO-group resembles the DO-group in the preceding example, except that the DO-group continues to be executed while the value of X is less than the value of Y or until the value of X is equal to 12.

A controlled DO statement that does not specify a TO or BY option results in a single iteration of the following DO-group. For example:

```
DO X = 1 WHILE (A);
```

Even if A is true, this DO-group executes a single time only. Because there is no expression to change the value of X, the DO-group will not be executed again.

```
DO X = 1;
```

This DO-group executes a single time only, regardless of the value of X.

■ DO REPEAT

The DO REPEAT statement executes a DO-group repetitively for different values of a variable. The variable is assigned a start value that is used on the first iteration of the group. The REPEAT expression is evaluated before each subsequent iteration, and its result is assigned to the variable. A WHILE clause can also be included; if it is, the WHILE expression is evaluated before each iteration, including the first. The format of the DO REPEAT statement is as follows:

```
DO variable = start-value REPEAT expression
        [WHILE (test-expression)] [UNTIL (test-expression)];
            .
            .
            .
        END;
```

variable

A reference to a variable. The variable can be any scalar variable.

start-value

An expression specifying the initial value to be given to the variable. The evaluation of this expression must yield a value that is valid for assignment to the variable.

expression

An expression giving the value to be assigned to the variable on reiterations of the DO REPEAT group. The expression is evaluated before each reiteration. Evaluation of this expression must yield a result that is valid for assignment to the variable.

WHILE (test-expression)

An option specifying a condition that controls the termination of the DO REPEAT group. The DO REPEAT group continues while the condition is true. The specified test expression must yield a scalar value. If any bit of the value is 1, then the test expression is true; otherwise, the test expression is false. The test expression must be enclosed in parentheses.

This expression is evaluated each time control reaches the DO statement; the test expression must have a true value in order for the DO-group to be executed. Otherwise, control passes to the next executable statement following the END statement that terminates the DO-group.

UNTIL (test-expression)

An option specifying a condition that further controls the termination of the DO REPEAT group. The DO REPEAT group continues until the condition is true. The specified test expression must yield a scalar value. If any bit in the value is 1, then the test expression is true; otherwise, the test expression is false. The test expression must be enclosed in parentheses.

This expression is evaluated after the first execution of the DO-group; the test expression must have a true value in order for the DO-group to be executed a second time. Otherwise, control passes to the next executable statement following the END statement that terminates the DO-group.

NOTE

If the WHILE and UNTIL options are omitted, the DO REPEAT statement specifies no means for terminating the group; the execution of the group must be terminated by a statement or condition occurring within the group.

A DO REPEAT group is executed by the following steps:

1. The following measures are taken to prevent the allocation of a new variable during the execution of the DO-group:
   - If the variable is based, its pointer qualifier is evaluated and a temporary reference of the variable type is created. The temporary reference is used as the variable in subsequent steps.
   - If the variable is subscripted, its subscripts are evaluated and a temporary reference of the variable type is created. The temporary reference is used as the variable in subsequent steps.
   - If the variable is neither based nor subscripted, its reference is used in subsequent steps.
2. The start value expression is evaluated and assigned to the variable.
3. If a WHILE option is present, its test expression is evaluated. If it does not produce a true value, the execution of the DO-group terminates. If the test expression is not present, execution continues.

4. The body of the DO-group is executed. The execution of the DO-group may be terminated during this step by the execution of a STOP or RETURN statement or by the execution of a GOTO or LEAVE statement that transfers control outside the DO-group. Statements in the group can also modify the values of the control variable, REPEAT expression, and test expression.
5. If an UNTIL option is present, its test expression is evaluated. If it produces a true value, the execution of the DO-group terminates. If the test expression is not present, execution continues.
6. The REPEAT expression is evaluated and its value is assigned to the variable.
7. Execution continues at step 3.

Examples

```
DO LETTER='A' REPEAT (BYTE(I));
```

This example will repeat the group with an initial LETTER value of 'A' and with subsequent values assigned by the built-in function BYTE(I). The variable I can be assigned new values within the group. The group will iterate endlessly unless terminated by a statement or condition within the group.

```
DO I = 1 REPEAT (I + 2) WHILE ( I <= 100 );
```

This example has the same effect as the following controlled DO statement:

```
DO I = 1 TO 100 BY 2;
```

The most common use of the DO REPEAT statement is in the manipulation of lists. For example:

```
DO P = LIST_HEAD REPEAT (P->LIST.NEXT)
    WHILE ( P ^= NULL() );
```

In this example, the pointer P is initialized with the value of the pointer variable LIST_HEAD. The DO-group is then executed with this value of P. The REPEAT option specifies that each time control reaches the DO statement after the first execution of the DO-group, P is to be set to the value of LIST.NEXT in the structure currently pointed to by P. For an expanded example of this technique, **see** "List Processing."

E

E Format Item

The E format item describes the representation of a fixed- or floating-point value as a decimal floating-point number in a stream.

The form of the item is as follows:

```
E(w[,d])
```

w
A nonnegative integer or expression that specifies the total width in characters of the field in the stream.

d
An optional nonnegative integer or expression that specifies the number of fractional digits in the stream representation.

If d is omitted on output, all fractional digits are written out. If d is omitted on input, it is assumed to be zero (no fractional digits). If the input value contains a decimal point, the value of d is ignored.

For a general discussion of format items, **see** "Format Item."

■ Input with GET EDIT

Used with GET EDIT, the E format item acquires a character-string value representing a floating-point decimal value and assigns it, with necessary conversions, to an input target of any computational type. If w is zero, no operation is performed on the input stream, and a null character string is converted and assigned to the input target.

For input, floating-point values can be represented in the stream in the following forms:

Form	Example
mantissa	124333
sign mantissa	-123.333
sign mantissa sign exponent	-123.333-12
sign mantissa E exponent	-123.333E12
sign mantissa E sign exponent	-123.343E-12

The mantissa is a fixed-point decimal constant, the sign is a plus (+) or minus (-) symbol, and the exponent is a decimal integer. A zero exponent is assumed if both the letter E and the exponent are omitted.

If, on input, the mantissa includes a decimal point, it overrides the specification of d. If no decimal point is included, then d specifies the number of fractional digits.

The value of w should be only large enough to include the mantissa, the optional decimal point in the mantissa, the signs on the exponent and mantissa, the optional letter E, and the exponent. If the field width is too narrow, the stream representation is truncated on the right; if the field width is too wide, excess characters are acquired on the right and may contain invalid input.

Spaces can precede or follow the value in the stream and are ignored. If the entire field contains spaces, zero is assigned to the input target. If the stream representation is not one of the acceptable forms, an ERROR condition is signaled.

■ Output with PUT EDIT

Used in a PUT EDIT statement, the E format item converts an output source of any computational type to the following form for representation in the stream:

[-] digit . [fractional-digits] E sign exponent

Typical representations are as follows:

```
1.E+07

3.33E-10

-2.7186E+00
```

If d is omitted from the format item, then d = s - 1, where s is the precision of the output source expressed in decimal. The decimal value is rounded before being written out.

The exponent is ordinarily a 2-digit decimal integer and is always signed. The exponent is adjusted so that the first digit of the mantissa is not zero, except that the value 0 is represented as

```
0.0000...E+00
```

with a number of zeros to the right of the decimal point equal to the specified number of fractional digits.

To account for negative values with fractional digits, the specified width integer should be 6 greater than the number of digits to be represented in the mantissa: one character for the preceding minus sign, one for the decimal point in the mantissa, one for the letter E, one for the sign of the exponent, and two for the exponent itself. (For values of type G-float or H-float, the value of w should be 7 or 8 greater than the number of digits, respectively.)

If the number's representation is shorter than the specified field, the representation is right-justified in the field and the number is extended on the left with spaces.

If the field specified by w is too narrow, an ERROR condition is signaled.

■ Examples

The tables below show the relationship between the internal and external representations of numbers that are read or written with the E format item.

Input Examples

The "input stream" shown in this table is a field of characters beginning at the current position in the stream and continuing to the right. The target type is the type of the variable to which the input value is assigned.

Format Item	Input Stream	Target Type	Target Value
E(6,0)	124333...	DECIMAL(10,2)	124333.00
E(6,0)	-123333...	DECIMAL(10,2)	-12333.00
E(8)	-123.333...	DECIMAL(8,5)	-123.33300
E(11)	-123.333-12...	FLOAT DEC(7)	-1.233330E-10
E(11,3)	-123343E-12...	FLOAT DEC(15)	-1.23342999813758E-07

Output Examples

The output source value shown in the table is either a constant or the value of a variable that is written out with the associated format item.

Output Source Value	Format Item	Output Value
-12234	E(11)	-1.2234E+04
-12234	E(11,2)	ΔΔ-1.22E+04
-12.234	E(11,1)	ΔΔΔ-1.2E+01
-1.23456E3	E(12)	-1.23456E+03
-1.23456E3	E(12,2)	ΔΔΔ-1.23E+03

EDIT Option

The EDIT option is used with the GET and PUT statements to perform edit-directed stream input or output.

The EDIT option allows you to include a format-specification list that matches the list of input targets (GET statement) or output sources (PUT statement). When used with the GET statement, the EDIT option and format-specification list control the interpretation of ASCII characters being input from a stream file. When used with the PUT statement, the two items control the representation of program data as ASCII characters in a stream output file.

For further details, **see** "GET Statement" and "PUT Statement."

%ELSE Keyword

The %ELSE clause can be specified in a %IF statement to define the action to be taken if a given preprocessor expression is false. For further information on the embedded preprocessor, **see** "Preprocessor."

ELSE Keyword

The ELSE clause can be specified in an IF statement to define the action to be taken if a given expression is false. For example:

```
IF ^SUCCESS THEN
        CALL PRINT_ERROR;
     ELSE
        CALL PRINT_SUCCESS;
```

The action following the keyword ELSE can be null. For more information, **see** "IF Statement."

Embedded Preprocessor

See "Preprocessor."

EMPTY Built-In Function

The EMPTY built-in function returns an empty area value for use in initializing areas. Its format is as follows:

EMPTY()

The EMPTY built-in function is useful in initializing the contents of an area. It is normally much faster than the FREE statement is in freeing all the variables in an area (freeing all the area's storage). Note that an area value must be assigned to an area before the area is used.

Following is an example of the use of the EMPTY built-in function in an assignment statement:

```
A = EMPTY();
```

Following is an example of its use in a declaration:

```
DECLARE A AREA(1024) STATIC INITIAL(EMPTY());
```

See "Area," "Area Attribute," "Area Condition Name," and the *VAX PL/I User Manual* for more information on areas.

ENCODE Built-In Function
ENCODE Preprocessor Built-In Function

The ENCODE built-in function converts a decimal integer to a character string. It converts the decimal integer (stored as a FIXED BINARY(31,0) number) to a base r number, where r is the radix you specify, and returns the resulting number as a character string. The function takes two arguments: a decimal integer and a radix; the radix is an integer in the range 2 through 16.

The syntax of the function is as follows:

```
ENCODE(integer-expression,radix-expression);
```

The syntax of an assignment statement using the ENCODE function is as follows:

```
character-variable = ENCODE(integer-expression,radix-expression);
```

character-variable

A character-string variable, either fixed or varying. Its length must be greater than or equal to the number of digits in the number resulting from the conversion of the decimal integer to a number in the specified radix. If the maximum length is too short, the value returned is truncated from the right.

integer-expression

An expression evaluating to a fixed binary number representing a decimal integer. Whether signed or not, this integer is treated by the function as unsigned.

radix-expression

An expression that evaluates to any integer from 2 through 16.

■ Example

```
DECLARE (X,Y) CHARACTER(5) VARYING;
X = ENCODE(53,8);
Y = ENCODE(10,2);
```

The character-string variable X is assigned the value '65', which is the character equivalent of the octal number 65, which is the equivalent of the decimal number 53. The character-string variable Y is assigned the value '1010', which is the character equivalent of the binary number 1010, which is the equivalent of the decimal number 10.

%END Statement

The %END statement terminates a preprocessor procedure or DO-group. The format of the %END statement is as follows:

```
%END;
```

Preprocessing then continues with the next executable preprocessor statement. **See** "Preprocessor."

END Statement

The END statement terminates a block or a group that is headed by the most recent BEGIN, DO, SELECT, or PROCEDURE statement. The format of the END statement is as follows:

```
END [label-reference];
```

label-reference
A reference to the unsubscripted label on the PROCEDURE, BEGIN, SELECT, or DO statement for which the specified END statement is the termination. A label is not required. If specified, the label reference must match only one label, which is the label of the most recent BEGIN, DO, SELECT, or PROCEDURE statement that is not already matched with an END statement. If the label reference is omitted, the most recent statement is matched by default.

The END statement performs one of the following actions, depending on the type of block or group that it terminates:

- When an END statement denotes the end of a procedure, the current procedure is terminated. The storage allocated for the block is released, and all automatic variables are made inaccessible. If the current procedure is the main, or only, procedure, the program terminates. Otherwise, control returns to the point following the CALL statement or function reference that invoked the procedure.
- When an END statement denotes the end of a BEGIN block, the storage allocated for the block is released, and all automatic variables are made inaccessible. Control passes to the next executable statement following the END statement.

- When an END statement denotes the end of a DO-group, control returns either to the DO statement that heads the group or to the next outer statement. If the DO-group is headed by a noniterative DO, that is, a DO-group that is executed only once, control passes to the next executable statement. Otherwise, control returns to the head of the DO-group, where the control variable or expression is tested.
- When an END statement denotes the end of a SELECT-group, the SELECT-group is terminated and control passes to the next executable statement following the end statement.

ENDFILE Condition Name

The ENDFILE condition name can be specified in an ON, SIGNAL, or REVERT statement to designate an end-of-file condition or ON-unit for a specific file.

PL/I signals the ENDFILE condition when a GET or READ statement attempts an input operation on a file or device after the last data item has been input. The format of the ENDFILE condition name is as follows:

```
ENDFILE (file-reference)
```

file-reference
The name of a file constant or file variable for which the ENDFILE ON-unit is established. If the name of a file variable is specified, the variable must be resolved to the name of a file constant when the condition is signaled.

An ENDFILE ON-unit can be established for any input file. For any particular file, the meaning of the end-of-file condition depends on the type of device. For example, end-of-file is signaled for a terminal device when the CTRL/Z character is read.

For a stream file, an end-of-file condition is signaled whenever a GET statement attempts to access an empty file or attempts to access a file whose last input field has been read.

For a record file, an end-of-file condition is signaled when a READ statement is executed with the file at the end-of-file position or when a read is attempted beyond the last record in the file. For example:

```
ON ENDFILE (RECEIPTS) EOF = '1'B;
EOF = '0'B;
OPEN FILE (RECEIPTS) RECORD SEQUENTIAL;
READ FILE (RECEIPTS) INTO (RECORD);
DO WHILE (^EOF);
      .
      .
      .
   READ FILE (RECEIPTS) INTO (RECORD);
   END;
```

In this example, the ON statement establishes the default action to be taken when the last record in the input file has been processed: the flag EOF is set to '1'B.

An ON-unit established to handle end-of-file conditions can reference the ONFILE built-in function to determine the name of the file constant for which the condition was signaled.

■ ON-Unit Completion

If the ON-unit for the ENDFILE condition does not transfer control elsewhere in the program, control returns to the statement following the GET or READ statement that caused the condition to be signaled.

When the ENDFILE condition is signaled, it remains in effect until the file is closed. Subsequent GET or READ statements for the file cause the ENDFILE condition to be signaled repeatedly.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

ENDPAGE Condition Name

The ENDPAGE condition name can be specified in an ON, SIGNAL, or REVERT statement to designate an end-of-page condition or ON-unit for a specific print file. The format of the ENDPAGE condition name is as follows:

ENDPAGE (file-reference)

file-reference

The name of the file constant or file variable for which the ENDPAGE ON-unit is to be established. If the name of a file variable is specified, the variable must be resolved to the name of a file constant when the condition is signaled. The file must have the PRINT attribute.

The maximum number of lines that can be output on a single page is set by the PAGESIZE option of the OPEN statement. The maximum number of lines allowed on a single page is 32767. If not specified, PL/I uses the default page size (**see** "PAGESIZE Option").

PL/I signals the ENDPAGE condition when a PUT statement attempts to output a line beyond the last line specified for an output page. When the ENDPAGE condition is signaled, the current line number associated with the file is the page size plus 1. An ENDPAGE ON-unit allows you to provide special processing before output continues on a new page. For example:

```
ON ENDPAGE (PRINTFILE) BEGIN;
   PUT FILE (PRINTFILE) PAGE;
   PUT FILE (PRINTFILE) LIST(HEADER_LINE);
   PUT FILE (PRINTFILE) SKIP(2);
   END;
```

The ON-unit for the ENDPAGE condition for the file PRINTFILE outputs a page eject and a header line for the new output page.

To cause PL/I to ignore the ENDPAGE condition when a large amount of output is written to a terminal, you can use the following ON-unit, that contains only the null statement:

```
ON ENDFILE(SYSPRINT);
```

An ON-unit established to handle end-of-page conditions can reference the ONFILE built-in function to determine the name of the file constant for which the condition was signaled.

■ ON-Unit Completion

If the ON-unit does not transfer control elsewhere in the program, the line number is set to 1 and the program continues execution of the PUT statement. If the ENDPAGE condition was signaled during data transmission, the data is written on the new current line. If the ENDPAGE condition was caused by a LINE or a SKIP option on the PUT statement, then the action specified by these options is ignored on return.

An ENDPAGE condition can occur only once per page of output. If the ON-unit specified does not specify a new page, then execution and output continue. The current line number can increase indefinitely; PL/I does not signal the ENDPAGE condition again. However, if a LINE option on a PUT statement specifies a line number that is less than that of the current line, a new page is output and the current line is set to 1.

■ Default PL/I Action

If the ENDPAGE condition is signaled during file processing, PL/I starts output on a new page and continues processing. If the ENDPAGE condition is signaled as a result of a SIGNAL statement, the statement following the SIGNAL statement is executed and no page is output by default.

ENTRY Attribute

The ENTRY attribute declares a constant or variable whose value is an entry point and describes the attributes of the parameters (if any) that are declared for the entry point. The format of the ENTRY attribute is as follows:

```
ENTRY [ (parameter-descriptor, ...) ]
      [ OPTIONS (VARIABLE) ]
      [ RETURNS (returns-descriptor) ]
```

parameter-descriptor
A set of attributes describing a parameter of the entry. (**See also** "Procedure.") Attributes describing a single parameter must be separated by spaces; sets of attributes (each set describing a different parameter) must be separated by commas. Parameter descriptors are not allowed if the ENTRY attribute is within a RETURNS descriptor (**see** "RETURNS Attribute and Option" for more information on RETURNS descriptors).

The following rules apply to the specification of a parameter descriptor for an array or structure:

- If the parameter is an array, you must specify the dimensions first; otherwise, you can specify the attributes in any order.
- If the parameter is a structure, the level number must precede the attributes for each member.
- You must specify extents for a parameter using only integer constants, restricted integer expressions, or asterisks (*).

- You cannot specify storage class attributes.

OPTIONS (VARIABLE)

An option indicating that the specified external procedure can be invoked with a variable number of arguments. At least one parameter descriptor must be specified following the ENTRY keyword if OPTIONS(VARIABLE) is specified.

This option is provided for use in calling non-PL/I procedures. For complete details on using OPTIONS (VARIABLE), see the *VAX PL/I User Manual.*

RETURNS (returns-descriptor)

For an entry that is invoked as a function reference, an option giving the data type attributes of the function value returned. (**See also** "RETURNS Attribute and Option.") For entry points that are invoked by function references, the RETURNS attribute is required; for procedures that are invoked by CALL statements, the RETURNS attribute is invalid.

The ENTRY attribute without the VARIABLE attribute implies the EXTERNAL attribute (and implies that the declared item is a constant), unless the ENTRY attribute is used to declare a parameter.

You must declare all external entry constants with the ENTRY attribute. When you declare an external entry constant, you must also specify the RETURNS attribute if the constant will be used to invoke a function. The RETURNS attribute indicates that the entry point is invoked via a function reference and defines the data type of the value it returns.

■ Restrictions

You cannot declare internal entry constants with the ENTRY attribute in the procedure to which they are internal. Internal entry constants are declared implicitly by the labels on the PROCEDURE or ENTRY statements of an internal procedure.

The ENTRY attribute conflicts with all other data type attributes.

■ Example

```
DECLARE COPYSTRING ENTRY (CHARACTER (40) VARYING,
                          FIXED BINARY(7))
        RETURNS (CHARACTER(*));
```

This declaration describes the external entry COPYSTRING. This entry has two parameters: a varying-length character string with a maximum length of 40 and a fixed-point binary value. The RETURNS attribute

indicates that COPYSTRING is invoked as a function and that it returns a character string of any length.

Entry Data

Entry constants and variables are used to invoke procedures through specified entry points. An entry value specifies an entry point and a block activation of a procedure.

■ Entry Constants

You declare entry constants by using labels on PROCEDURE or ENTRY statements.

You declare internal entry constants by using labels on PROCEDURE or ENTRY statements whose procedure blocks are nested in another block. You can use an internal entry constant anywhere within its scope to invoke its procedure block.

You declare external entry constants either by using labels on PROCEDURE or ENTRY statements that belong to external procedures, or by explicitly declaring the constant names with the ENTRY attribute. You can use an external entry constant to invoke its procedure block from any program location that is within its scope. Its scope is either the scope of its declaration (as a label) or the scope of a DECLARE statement for the constant.

In DECLARE statements, you declare external entry constants with the ENTRY attribute. The declaration must agree with the actual entry point. That is, the declaration of the external entry constant must contain parameter descriptors for any parameters specified at the entry point, and, if the entry constant is to be used in a function reference, the declaration must have a returns descriptor describing the returned value. For the syntax and rules governing parameter descriptors, **see** "ENTRY Attribute." For the syntax and rules governing returns descriptors, **see** "RETURNS Attribute and Option."

■ Entry Values

Whenever a reference to an entry constant is interpreted, the result is an entry value. An entry value is the entry point of a procedure, and it serves to activate the block in which the entry point is declared (that is, the block in which the entry point's name appears as the label of a PROCEDURE or ENTRY statement). This block activation is the current block activation if the entry point belongs to the current block. If the entry point belongs to a containing block, the activation is on the chain of parent activations that ends at the current block activation. (For additional details on block activations, **see** "Block.")

No conversions are defined between entry data and other data types. An entry variable can be assigned only the value of an entry constant or the value of another entry variable. The only operations that are valid for entry data are comparisons for equality (=) and inequality (^=). Two entry values are equal if they refer to the same entry point in the same block activation.

VAX PL/I supports the passing of external procedures, but not internal procedures, as entry value parameters. To pass an internal procedure, use an entry parameter.

■ Entry Variables

Entry variables are variables (including parameters) that take entry values. If the VARIABLE attribute is specified with the ENTRY attribute in a DECLARE statement, the declared identifier is an entry variable. You can assign to an entry variable either another entry variable or an entry constant.

When an entry variable is used to invoke a procedure, its declaration must agree with the definition of the entry point. If the value you assign to an entry variable specifies an entry point with parameters, the parameters must be described with parameter descriptors in the declaration of the variable. If the assigned value specifies an entry point that is invoked as a function, then the declaration of the entry variable must have a RETURNS attribute that describes the data type of the returned value.

The scope of an entry variable name can be either internal or external. If neither the EXTERNAL nor the INTERNAL attribute is specified with the entry variable, the default is internal. (**See also** "Scope of Names.")

The entry variable can be used to represent different entry points during the execution of the PL/I program. For example:

```
DECLARE E ENTRY VARIABLE,
        (A,B) ENTRY;

        E = A;
        CALL E;
```

The entry constant A is assigned to the entry variable E. The CALL statement results in the invocation of the external entry point A.

You can also declare arrays of entry variables. The following example shows an array of external functions:

```
DECLARE EXTRACT(10) ENTRY (FIXED,FIXED) VARIABLE RETURNS (FLOAT),

        GETVAL FLOAT;

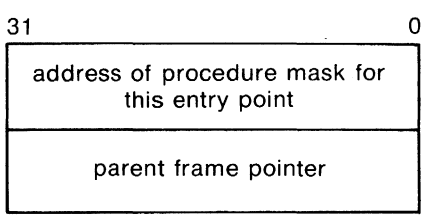
        GETVAL = EXTRACT(3)(1,3);
```

This assignment statement references the third element of the array EXTRACT. When the statement is executed, this array element must contain a valid entry value.

NOTE

Exercise caution using static entry variables. The value of a static entry variable is valid only as long as the block in which that value was declared is active.

The following figure illustrates the internal representation of variable entry data.



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ENTRY Statement

The ENTRY statement defines an alternate entry point to a procedure. Its format is as follows:

```
entry-name: ENTRY [ (parameter,...) ]
                  [ RECURSIVE    ]
                  [ NONRECURSIVE ]
                [ RETURNS (returns-descriptor) ];
```

entry-name

A 1- to 31-character label for the entry point. Specifying the entry name declares the name as an entry constant. The scope of the name is external if the ENTRY statement is contained in an external procedure, and is internal if it is contained in an internal procedure.

parameter, . . .

One or more parameters that the procedure requires at this entry point. Each parameter specifies the name of a variable declared in the block to which this ENTRY statement belongs. The parameters must correspond, one to one, with arguments specified for the procedure when it is invoked via the ENTRY statement.

For more information, **see** "Parameters and Arguments."

RECURSIVE or NONRECURSIVE

An option that indicates (for program documentation) that the procedure will or will not be invoked recursively, that is, activated while it is currently active. In standard PL/I, the RECURSIVE option must be specified for a procedure to be invoked recursively. However, in VAX PL/I, any procedure can be invoked recursively, and the RECURSIVE and NONRECURSIVE options are ignored by the compiler.

RETURNS (returns-descriptor)

For an entry that is invoked as a function reference, an option giving the data type attributes of the function value returned. (**See also** "RETURNS Attribute and Option.") For entry points that are invoked by function references, the RETURNS option is required; for procedures that are invoked by CALL statements, the RETURNS option is invalid.

■ Restrictions

An ENTRY statement is not allowed in a begin block, in an ON-unit, or in a DO group except for a simple DO.

For more information on entry data, **see** "Entry Data." For more information on entry points, **see** "Procedure."

ENVIRONMENT Attribute

The ENVIRONMENT file description attribute is used in DECLARE, OPEN, and CLOSE statements to specify options that define file characteristics specific to the VMS file system and options that request special processing not available in the standard PL/I language.

The format of the ENVIRONMENT attribute is as follows:

```
{ ENVIRONMENT } (option,...)
{ ENV         }
```

option, . . .
One or more keyword options, separated by commas.

■ ENVIRONMENT Attribute Options

The options to the ENVIRONMENT attribute, listed alphabetically below, are described in detail in the *VAX PL/I User Manual.*

Limitations on Use of Options

All ENVIRONMENT options can be specified in OPEN statements. All ENVIRONMENT options except those that require variable references can be specified in DECLARE statements. Certain disposition options (noted in the list) can be specified in CLOSE statements.

Specifying Values for Options

Some ENVIRONMENT options require you to specify a value. In a DECLARE statement, you must use a literal constant to supply the value required. In OPEN and CLOSE statements, however, you can use expressions (including but not limited to literal constants) to supply the values.

Any option that does not require a value can optionally be specified with a Boolean expression that indicates whether the option is to be enabled (if true) or disabled (if false). For example:

```
DECLARE IFDELETE BIT(1);
   .
   .
   .
OPEN FILE (XYZ) ENVIRONMENT(DELETE(IFDELETE));
```

This DELETE option specifies a Boolean variable whose value can be true or false at run time. Boolean values must be specified as constants in DECLARE statements. Boolean values can be specified as expressions (including constants) in OPEN statements and CLOSE statements.

Summary of Options

The items with asterisks (*) are options that can be specified in a CLOSE statement.

APPEND
BACKUP_DATE(variable-reference)
BATCH*
BLOCK_BOUNDARY_FORMAT
BLOCK_IO
BLOCK_SIZE(expression)
BUCKET_SIZE(expression)
CARRIAGE_RETURN_FORMAT
CONTIGUOUS
CONTIGUOUS_BEST_TRY
CREATION_DATE(variable-reference)
CURRENT_POSITION
DEFAULT_FILE_NAME(character-expression)
DEFERRED_WRITE
DELETE*
EXPIRATION_DATE(variable-reference)
EXTENSION_SIZE(expression)
FILE_ID(variable-reference)
FILE_ID_TO(variable-reference)
FILE_SIZE(expression)
FIXED_CONTROL_SIZE(expression)
FIXED_CONTROL_SIZE_TO(variable-reference)
FIXED_LENGTH_RECORDS
GROUP_PROTECTION(character-expression)
IGNORE_LINE_MARKS
INDEX_NUMBER(expression)
INDEXED

INITIAL_FILL
MAXIMUM_RECORD_NUMBER(expression)
MAXIMUM_RECORD_SIZE(expression)
MULTIBLOCK_COUNT(expression)
MULTIBUFFER_COUNT(expression)
NO_SHARE
OWNER_GROUP(expression)
OWNER_ID(expression)
OWNER_MEMBER(expression)
OWNER_PROTECTION(character-expression)
PRINTER_FORMAT
READ_AHEAD
READ_CHECK
RECORD_ID_ACCESS
RETRIEVAL_POINTERS(expression)
REVISION_DATE(variable-reference)*
REWIND_ON_CLOSE*
REWIND_ON_OPEN
SCALARVARYING
SHARED_READ
SHARED_WRITE
SPOOL*
SUPERSEDE
SYSTEM_PROTECTION(character-expression)
TEMPORARY
TRUNCATE
USER_OPEN(entry-name)
WORLD_PROTECTION(character-expression)
WRITE_BEHIND
WRITE_CHECK

%ERROR Statement

The %ERROR statement provides a diagnostic error message during program compilation. The format of the %ERROR statement is as follows:

```
%ERROR preprocessor-expression;
```

preprocessor-expression
A maximum of 64 characters giving the text of the error message to be displayed. Messages of more than 64 characters are truncated.

■ Returned Message

The message displayed by %ERROR is as follows:

```
%PLIG-E-USERDIAG, preprocessor-expression
```

Compilation errors that result in the display of the %ERROR statement increment the informational diagnostic count displayed in the compilation summary, and inhibit production of an object file.

For further information on preprocessor diagnostic messages, **see** "User-Generated Diagnostic Messages."

ERROR Preprocessor Built-In Function

The ERROR preprocessor built-in function returns the number of preprocessor diagnostic error messages issued during compilation up to that particular point in the source program. The format for the ERROR built-in function is as follows:

```
ERROR();
```

The function returns a fixed-point result representing the number of compile-time warning messages that were issued up until the point at which the built-in function was encountered.

Error and Condition Handling

All error conditions that occur during the execution of PL/I run-time procedures cause the program to be interrupted and a signal to be sent that indicates the type of error, or condition, that occurred.

When an error is signaled, PL/I attempts to locate a user-written program unit, called an ON-unit, to handle the condition. An ON-unit is established for a specific condition by means of an ON statement. If no ON-unit exists for a specific condition, PL/I performs a default action, which in most cases results in the termination of the program.

PL/I conditions have language keywords or ON condition names. For example, the keyword ENDFILE is the name of the condition that is signaled when an end-of-file is encountered during an input operation. Thus, a program could handle an end-of-file condition for a given file as follows:

```
DECLARE INFILE FILE RECORD INPUT;

ON ENDFILE (INFILE) GOTO LAST;

OPEN FILE (INFILE);
```

For details on condition handling, **see** "ON Conditions and ON-Units." For additional information on end-of-file handling, **see** "ENDFILE Condition Name."

ERROR Condition Name

The ERROR condition name can be specified in an ON, SIGNAL, or REVERT statement to designate an error condition or ON-unit.

PL/I signals the ERROR condition in the following contexts:

- When a condition occurs for which the default PL/I action is to signal ERROR
- When the SIGNAL ERROR statement signals the condition
- When there is a default PL/I ON-unit and a condition is signaled for which there is no corresponding ON-unit

When any condition is signaled for which no specific ON-unit is established, the default PL/I action for all conditions except ENDPAGE is to signal the ERROR condition.

When any ON-unit is executed, the ON-unit can reference the built-in function ONCODE. This function returns the numeric condition value associated with the specific error that signaled the condition.

■ ON-Unit Completion

If an ERROR ON-unit does not handle the condition, the program is terminated at the completion of the ON-unit.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement." For more details on condition handling in the VMS environment, **see** the *VAX PL/I User Manual.*

EVERY Built-In Function

The EVERY built-in function determines whether every bit in a bit string is '1'B. In other words, it performs a logical AND operation on the elements of the bit string. The format of an assignment statement using the EVERY built-in function is as follows:

bit-flag = EVERY(bit-string)

The function returns the value '1'B if all bits in the bit-string argument are '1'B. It returns '0'B if one or more bits in the argument are '0'B or if the argument is the null bit string.

EXCLUSIVE OR Operator

The EXCLUSIVE OR operator (infix or dyadic ^) causes a bit-by-bit comparison of two bit-string operands. If the two operands are not of equal length, the shorter is padded with 0s until it is the same length as the other, and this length is also the length of the result. If either of two corresponding bits is 1 and the other is 0, the result is 1. If both are 1, or if both are 0, the result is 0.

All relational expressions result in bit strings of length 1, and they can therefore be used as operands in an EXCLUSIVE OR operation.

The result of the EXCLUSIVE OR operation is a bit-string value. For example:

```
DECLARE (BITA, BITB, BITC) BIT (4);
BITA = '0011'B;
BITB = '1011'B;
BITC = BITA ^ BITB;
```

The resulting value of BITC is '1000'B.

The EXCLUSIVE OR operator can be used to test whether one and only one of the expressions in an IF statement is true. For example:

```
IF (A > 0) ^ (B > 0) THEN ...
```

See also "Logical Operator" and "OR Operator."

EXP Built-In Function

The EXP built-in function returns a floating-point value that is the base e to the power of an arithmetic expression x. The computation is performed in floating point. The format of the function is as follows:

```
EXP(x)
```

Exponentiation

Double asterisks (**) indicate exponentiation in an expression; the result is the value of the first operand raised to the power of the second operand. Both operands must have arithmetic data types.

■ Conversion of Operands

If the second operand is not a decimal integer constant, both operands are converted to FLOAT BINARY.

■ Precision of the Result

If the operation is expressed as $x{**}y$, and if y is a positive integer constant, the following rules apply to the result precision based on the data type of x and the value of y:

- Where x is FIXED (p,q) and $((p+1)*y-1) <= 31$, the result has the fixed precision $(p+1)*y-1$, and the scale factor $q*y$.
- In all other cases, the operands are converted to floating point as described above. The result is a floating-point binary value whose precision is the maximum precision of the converted operands.

Expression

An expression is a representation of a value or of the computation of a value. In a PL/I program, you can use expressions for the following purposes:

- To indicate constant values or scalar variables, as in the following statements:

```
A = 55;
NAME = 'HECTOR';
B = A;
```

- To perform algebraic or logical calculations on variables or constants, as in the following statements:

```
B = A + 10;
C = A + B * 40;
B = ^A;
COMMON = A & B;
```

- To compare the values of two or more expressions and obtain a Boolean result, as in the following statements:

```
IF A < B THEN C = 10;
IF NAME = SAVED_NAME THEN GOTO REPEAT;
```

- To concatenate character- or bit-string values, as in the following statement:

```
NAME = FIRST_NAME||LAST_NAME;
```

All expressions except simple constants and references consist of an operator and one or more operands. Each operator requires operands of specific types (either arithmetic, character string, or bit string) and produces a result of a specific type. The operands can be constants, variable references, function references, or other expressions, as long as they are objects of the type required by the operator.

Built-in functions can also be considered operators in this sense, and their arguments, operands.

All PL/I expressions and functions have scalar results.

Arithmetic expressions must have arithmetic operands. **See** "Arithmetic Operators," "Addition," "Subtraction," "Multiplication," "Division," and "Exponentiation."

Logical expressions must have bit-string operands, and all logical expressions have bit-string results. **See** "Logical Operator."

Relational, or comparative, expressions must have two operands of the same type. All relational expressions have Boolean results of type BIT(1), where '0'B signifies "false" and '1'B signifies "true." **See** "Relational Operator."

Concatenation expressions must have two string operands of the same type (bit or character). The result is a string of the operands' type. **See** "Concatenation Operator."

■ Expression Evaluation and Precedence of Operations

The following rules, when applicable, determine the order in which expressions are evaluated. When none of these rules apply, expressions can be evaluated in any order (not necessarily from left to right).

- Some PL/I operators take precedence over others used in the same expression. Operations with higher priority are evaluated first, and their results are used as single operands. The rules of precedence usually guarantee an algebraically correct result without the use of parentheses. All built-in functions are of equal priority. **See** "Operator" for a table listing the priorities of PL/I operators.
- Any expression can be enclosed in parentheses to override the usual rules of precedence. Expressions at the deepest level of nested parentheses are always evaluated first, and their results are used as single operands.
- Exponential operations of the form $A**B**C$ are evaluated from right to left.
- The run-time evaluation of a logical expression can be terminated as soon as its result is known. For instance:

```
A & USER_FUNCTION(ALPHA,BETA)
```

  Evaluation of this expression can be terminated without the USER_FUNCTION reference being evaluated if the evaluation of A results in a "false" Boolean value. (However, the evaluation of A might not occur first, because the order of evaluations is not guaranteed in AND operations. To ensure that the first operand is evaluated first, use &:, which is the AND THEN operator, instead of &. **See** "AND Operator" and "AND THEN Operator.")
- If a function referenced in an expression executes a nonlocal GOTO statement, the expression is not evaluated further.

■ Conversion of Operands in Arithmetic Operations

This section applies only to arithmetic operations, which must always have arithmetic operands. (However, **see also** "Built-In Conversion Functions," below.)

Even though arithmetic operands can be of different arithmetic types, all operations must actually be performed on objects of the same type. Any set of operands of different arithmetic types has an associated derived type, as follows:

- If any operand has the attribute BINARY, the derived base is BINARY. Otherwise, the derived base is DECIMAL.

- If any operand has the attribute FLOAT, the derived scale is FLOAT. Otherwise, the derived scale is FIXED.

Table E–1 gives the derived data type for two arithmetic operands of different types. (Note that the types derived from FIXED DECIMAL in Table E–1 are also derived when one operand is pictured.)

Table E–1: Derived Types

Type of Operand 1	Type of Operand 2	Derived Type
FIXED BINARY	FLOAT BINARY	FLOAT BINARY
FIXED BINARY	FLOAT DECIMAL	FLOAT BINARY
FIXED DECIMAL	FLOAT DECIMAL	FLOAT DECIMAL
FIXED DECIMAL	FLOAT BINARY	FLOAT BINARY
FIXED BINARY	FIXED DECIMAL	FIXED BINARY

Table E–2 gives the precision resulting from the conversion of an operand to its derived type. The values p and q are known as the converted precision of an operand and are based on the values p and q of the source operand.

Table E–2: Converted Precision as a Function of Target and Source Attributes

Target Data Type	Binary Fixed Source[1]	Decimal Fixed Source[1]	Binary Float Source[1]	Decimal Float Source[1]
Binary	p	min(ceil(p*3.32)+1,31)	not applicable	not applicable
Fixed	scale factor:q	scale factor: min(ceil(q*3.32),31)	not applicable	not applicable
Decimal	min(ceil(p/3.32)+1,31)	p	not applicable	not applicable
Fixed	scale factor: max(0,min(ceil(q*3.32),31))	scale factor:q	not applicable	not applicable

[1] The constant 3.32 is an approximation of log2(10), the number of bits required to represent a decimal digit.

Table E–2 (Cont.): Converted Precision as a Function of Target and Source Attributes

Target Data Type	Binary Fixed Source[1]	Decimal Fixed Source[1]	Binary Float Source[1]	Decimal Float Source[1]
Binary	min(p,113)	min(ceil(p*3.32),113)	p	min(ceil(p*3.32),113)
Float				
Decimal Float	min(ceil(p/3.32),34)	min(p,34)	min(ceil(p/3.32),34)	p

[1] The constant 3.32 is an approximation of log2(10), the number of bits required to represent a decimal digit.

All arithmetic operations except exponentiation are performed in the derived type of the two operands. Note that the two converted operands, although they have the same derived base and scale, might have different values for p and q, as shown by Table E–2. Exponential operations are performed in a data type that is based on the derived type of the operands; for details, **see** "Exponentiation."

All operations, including exponentiation, have results of the same type as the type in which the operations are performed. The precision and scale factor of the result differ depending on the operation being performed. For details, **see** "Addition," "Subtraction," "Multiplication," "Division," "Exponentiation," "Built-In Function," or the entry on an individual built-in function.

When the result of an arithmetic operation is assigned to a target variable, the target variable can be of any computational type. The result is converted to the target type, following the rules given in "Conversion of Data."

■ Conversion of Operands in Nonarithmetic Operations

As operations must be performed on operands of the same type, the following conversions are performed when operands do not match in nonarithmetic operations:

- PICTURE is converted to CHARACTER.
- DECIMAL is converted to CHARACTER.
- FIXED BINARY is converted to BIT.
- If either operand is CHARACTER, after other conversions have been performed, the noncharacter operand is converted to CHARACTER.

A warning message is issued about a conversion in a concatenation expression, except for picture to character.

■ Built-In Conversion Functions

The built-in conversion functions FLOAT, FIXED, BINARY, and DECIMAL can take arguments that are either arithmetic or string expressions. These functions are often used to convert an operand to the type required in a certain context—for instance, to convert a bit string to an arithmetic value for use as an arithmetic operand.

For the purpose of these functions, and for use in a few other contexts, derived arithmetic attributes are defined for bit- and character-string expressions: the derived type of a bit string is fixed-point binary, and the derived type of a character string is fixed-point decimal. The converted precision of both of these derived types is 31.

These derived attributes are used to determine the precision of values returned by the conversion functions if no precision is specified in the functions' argument lists. The value of a string argument must also be convertible to the result type; for instance, '1.333' is convertible to an arithmetic type, but 'XYZ' is not. For more information, **see** "Conversion of Data" and the entries on the FLOAT, FIXED, BINARY, and DECIMAL built-in functions.

EXTEND Built-In Subroutine

The EXTEND built-in subroutine allows a file to be extended by a specified number of blocks. See the *VAX PL/I User Manual* for more information.

Extent

An extent gives a length or dimension of a variable. The rules for specifying extents apply to the length of a character-string or bit-string variable, the size of an area, and the dimensions of an array. The length of a character string or a bit string is the number of characters or bits of its value. The dimensions of an array are expressed in terms of bounds. The rules for specifying extents are as follows:

- If an extent is specified in a static variable declaration, the extent must be specified as an integer constant or as a restricted integer expression (**see** "Restricted Expression").
- If an extent is specified in the declaration of a parameter, in a parameter descriptor, or in a returns descriptor, you can specify the extent as an integer constant, as a restricted integer expression, or as an asterisk (*). If one dimension of an array is specified with an asterisk, all dimensions must be specified with asterisks.
- If the extent is specified for an automatic, based, controlled, or defined variable, you can specify it as an integer constant or as an expression.
- The maximum value that can be specified for an extent is 2^{29}bytes.

EXTERNAL Attribute

The EXTERNAL attribute declares an external name, that is, a name whose value can be known to blocks outside the block in which it is declared.

The format of the EXTERNAL attribute is as follows:

```
{ EXTERNAL }
{ EXT      }
```

The EXTERNAL attribute is implied by the FILE, GLOBALDEF, and GLOBALREF attributes. EXTERNAL is also implied by declarations of entry constants (declarations that contain the ENTRY attribute but not the VARIABLE attribute). For variables, the EXTERNAL attribute implies the STATIC attribute.

■ Restrictions

The EXTERNAL attribute directly conflicts with the AUTOMATIC, BASED, and DEFINED attributes.

The EXTERNAL attribute cannot be applied to minor structures, members of structures, parameters, or descriptions in an ENTRY or RETURNS attribute.

The EXTERNAL attribute is invalid for variables that are the parameters of a procedure.

If a variable is declared as EXTERNAL STATIC INITIAL, all blocks that declare the variable must initialize the variable with the same value.

External Procedure

An external procedure is one whose text is not contained within another procedure. An external procedure must be explicitly declared with the ENTRY attribute before it can be invoked or referenced.

See "Procedure."

External Variable

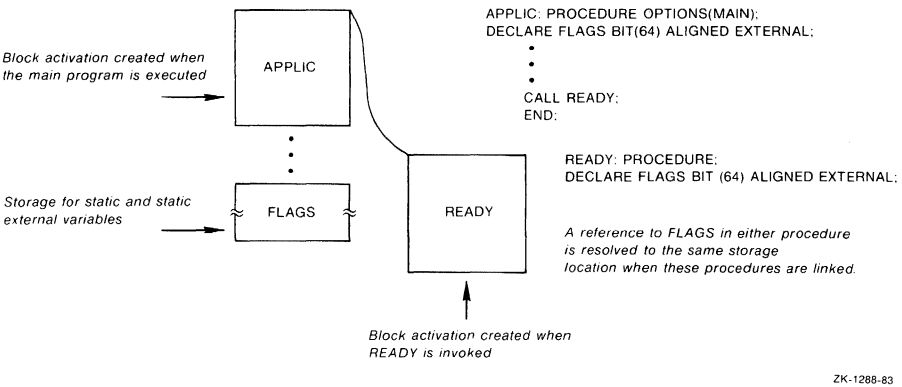
An external variable provides a way for external procedures to share common data. All declarations that refer to an external variable must also declare the variable with the attribute EXTERNAL and with identical data type attributes. Figure E–1 illustrates how procedures can use external variables.

The VMS Linker allows more control than does PL/I over the definition and allocation of external variables. With the GLOBALDEF attribute, you can define the allocation and initialization of an external variable in a single module. Other PL/I modules can then declare the variable with the GLOBALREF attribute and with no INITIAL attribute.

Further control is provided by the VALUE attribute, which can be used in conjunction with GLOBALDEF and GLOBALREF. A variable declared in this way is actually a constant whose value is used immediately in instructions generated by the compiler.

For more information, **see** "GLOBALDEF Attribute," "GLOBALREF Attribute," and "VALUE Attribute." For more information on the use of the linker, **see** the *VAX PL/I User Manual.*

Figure E–1: External Variables



F

F Format Item

The F format item describes the representation of a fixed- or floating-point value as a decimal fixed-point number in a stream.

The form of the item is as follows:

```
F(w[,d])
```

w
A nonnegative integer or expression that specifies the total width in characters of the field in the stream.

d
A nonnegative integer or expression with a value less than or equal to 31 that specifies the number of fractional digits in the stream representation.

The interpretation of the F format item on input and output is given below. For a general discussion of format items, **see** "Format Item."

■ Input with GET EDIT

Used with GET EDIT, the F format item acquires a fixed-point decimal value from the next w characters in the stream and assigns it to an input target of any computational type. Fixed-point decimal values can be represented in the stream in the following forms:

```
number
sign number
```

The number is a fixed-point decimal constant, and the sign is a plus (+) or minus (-) symbol.

The following are valid representations:

```
124333
-123333
-123.333
```

An ERROR condition is signaled if the field is not blank and does not contain a valid representation; otherwise, the fixed-point decimal number is extracted from the field and is assigned to the input target, with any necessary conversions. A decimal point included in the number overrides the specification of d. If no decimal point is included, d specifies the number of fractional digits. If d is omitted, it is assumed to be zero.

The value w should be only large enough to include the number, the optional decimal point in the number, and the optional sign. If w is too small, the stream representation is truncated on the right. If w is too large, extra characters, which might include invalid syntax, are acquired.

If w is zero, a null character string is converted and assigned to the input target, and no operation is performed on the stream.

Spaces can precede or follow the number in the stream and are ignored. If the entire string contains spaces or is a null string, the fixed-point decimal constant 0 is converted and assigned to the input target.

■ Output with PUT EDIT

Used in a PUT EDIT statement, the F format item converts an output source of any computational type to one of the following forms for representation in the stream:

```
integer
integer.fractional-digits
-integer.fractional-digits
```

Typical representations are as follows:

```
3234
0.23432
3.33
-3234.33
```

The decimal value is rounded before being written out. If d is omitted from the format item, the decimal point is not shown, and only the integral part of the number is shown.

If d is larger than the number of fractional digits to be output, trailing zeros are appended to the output number. All leading zeros to the left of the decimal point are suppressed unless the integral part of the number is zero, in which case one zero appears to the left of the decimal point.

To account for negative values with fractional digits, the specified width integer should be 2 greater than the number of digits to be represented: one character for the preceding minus sign and one for the decimal point in the number.

If the number's representation is shorter than the specified field, the representation is right-justified in the field, and the number is extended on the left with spaces.

If the field is too narrow to represent the integral portion of the output number, an ERROR condition is signaled.

■ Examples

The tables below show the relationship between the internal and external representations of numbers that are read or written with the F format item.

Input Examples

The "input stream" shown in this table is a field of characters beginning at the current position in the stream and continuing to the right. The target type is the type of the variable to which the input value is assigned.

Format Item	Input Stream	Target Type	Target Value
F(10,2)	-123456.78...	DECIMAL(10,2)	-123456.78
F(10,4)	-1234.56789...	DECIMAL(10,2)	-1234.56
F(8,5)	-.123456789...	DECIMAL(5,5)	-0.12345
F(10)	1234.56789...	FLOAT DEC(7)	1.234568E+03

Output Examples

The output source value shown in this table is either a constant or the value of a variable that is written out with the associated format item.

Output Source Value	Format Item	Output Value
-12.234	F(3,0)	-12
-12.234	F(6,2)	-12.23
-12.234	F(7,3)	-12.234
-1.23456E3	F(8)	ΔΔΔ-1235
-1.23456E3	F(8,2)	-1234.56
'1000'B3	F(4)	Δ512
'1000000000000000'B	F(5)	32768
'100000'B3	F(5)	32768
'ABCEDF'B4	F(10)	ΔΔ11259615

%FATAL Statement

The %FATAL statement provides a diagnostic fatal message during program compilation. The format of the %FATAL statement is as follows:

```
%FATAL preprocessor-expression;
```

preprocessor-expression
The text of the fatal message you want displayed. The text is a character string with a maximum length of 64 characters. It is truncated if necessary.

■ Returned Message

The message displayed by %FATAL is as follows:

```
%PLIG-F-USERDIAG, preprocessor-expression
```

Compilation errors that result in a fatal error terminate compilation after the message is displayed.

For further information on preprocessor diagnostic messages, **see** "User-Generated Diagnostic Messages."

File

A PL/I file is a source of input data or a target for output data. All I/O operations must specify the name of the PL/I file on which the operation is to be performed; the name of a PL/I file is declared in a DECLARE statement. When a file is opened, it must also be associated with an external, or physical, file or device.

PL/I provides two distinct types of I/O processing, each of which handles input and output data in a different manner, and each of which has a unique set of I/O statements. These types of I/O are as follows:

- Stream (the GET and PUT statements)
- Record (the READ, WRITE, DELETE, and REWRITE statements)

When a file is read or written with stream I/O, the data is treated as if it formed a continuous stream. Individual fields of data within the stream are delimited by commas, spaces, and record boundaries. A stream I/O statement specifies one or more fields to be processed in a single operation.

When a file is read or written with record I/O, however, a single record is processed upon the execution of an I/O statement.

The following subsections discuss I/O concepts that apply to both stream and record I/O. Additional details on each of these forms of I/O can be found under the entries "Stream Input/Output" and "Record Input/Output."

File Declarations

A file declaration specifies an identifier, the FILE attribute, and one or more file description attributes that describe the type of I/O operation that will be used to process the file.

A file is denoted in an I/O statement by the FILE option as follows:

```
FILE(file-reference)
```

file-reference

The name specified in the file's declaration. For example:

```
DECLARE INFILE FILE SEQUENTIAL INPUT;
OPEN FILE(INFILE);
```

Here, INFILE is the name of a file constant. A file constant is an identifier declared with the FILE attribute and without the VARIABLE attribute. Except for the default file constants SYSIN and SYSPRINT, all files must be declared before they can be opened and used.

By default, all file constants have the EXTERNAL attribute. Any external procedure that declares the identifier with the FILE attribute and without the INTERNAL attribute can access the same file constant and, therefore, the same physical file.

■ File Variables

In PL/I, you can also refer to files using file variables and file-valued functions. For example:

```
DECLARE ANYFILE FILE VARIABLE;
   .
   .
   .
ANYFILE = INFILE;
OPEN FILE(ANYFILE);
```

If INFILE is declared as in this example, the OPEN statement opens the file INFILE.

A file variable can also be given a value by receiving a file constant passed as an argument or by receiving a file constant as the value of a function. For example:

```
GETFILE: PROCEDURE (PRINTFILE);
DECLARE PRINTFILE FILE VARIABLE;
```

This file variable is given a value when the procedure GETFILE is invoked.

FILE Attribute

The FILE attribute declares a file constant or file variable.

The FILE attribute is implied by any of the following file description attributes:

DIRECT	OUTPUT	SEQUENTIAL
ENVIRONMENT	PRINT	STREAM
INPUT	RECORD	UPDATE
KEYED		

If the VARIABLE attribute is not specified, the FILE attribute declares a file constant. If the INTERNAL attribute is not specified, the file has the EXTERNAL attribute by default. All external declarations of a file constant are associated with the same file.

■ Restrictions

The FILE attribute conflicts with all other data type attributes. If the FILE attribute is used to declare a variable or parameter, no file description attributes may be specified. If the VARIABLE attribute is not specified, no storage class attributes are allowed.

File Data

A PL/I file, or file constant, is represented by a file control block. A file control block is an internal data structure maintained by PL/I.

A file variable is represented internally as a longword that contains a pointer to a file control block. The value of the file variable, when evaluated, is the address of the file control block for the file with which the variable is currently associated.

No conversions are defined between file data and other data types. A file variable can be assigned only the value of a file constant or the value of another file variable. The only operations that are valid for file data are comparisons for equality (=) and inequality (^=).

File Description Attributes and Options

The operations that can be performed on an open file depend on both the attributes of the file and the physical organization of the file or device that is associated with the PL/I file constant.

You can specify attributes for a file constant in its declaration or its opening. The file description attributes specified in the DECLARE statement for a file are permanent attributes. The file description attributes used in a particular opening of a file are obtained by temporarily merging the permanent attributes and attributes specified at the opening. For example:

```
DECLARE TAPEIO FILE RECORD;
OPEN FILE(TAPEIO) OUTPUT;
```

Here the DECLARE statement specifies that a permanent attribute of the file is RECORD; that is, it will be processed with record I/O statements. The OPEN statement temporarily adds the attribute OUTPUT to the file's description.

See "Opening a File" for the rules governing the merging of attributes during file opening. Implications of using a specific file description attribute are given under the entry for that attribute.

The file description attributes are summarized in Table F–1. These attributes can be specified on DECLARE and OPEN statements.

Table F–1: Summary of File Description Attributes

Attribute	Description
DIRECT	Records in the file will be accessed randomly.
INPUT	The file is an input file and will only be read.
KEYED	Records in the file will be accessed by key.
OUTPUT	The file is an output file and will only be written.
PRINT	The file will be output on a printer or terminal.
RECORD	The file will be accessed with record I/O statements.
SEQUENTIAL	Records in the file will be accessed sequentially.
STREAM	The file will be accessed with stream I/O statements.
UPDATE	The file will be accessed for both reading and writing, and records can be rewritten and deleted.

■ File Access Modes

Most file description attributes relate to the way in which a file will be used, for example, whether it will be an input or an output file, or whether it will be used for record or stream I/O. Table F–2 shows the valid combinations of access modes for files and the relationship of each combination to the file organizations supported by VAX PL/I.

Table F–2: File Access Attributes

Attributes Specified	Attributes Implied	Valid Devices and File Organizations	Usage
PRINT	STREAM OUTPUT	Any output device or file except indexed	Individual data values are written with PUT statements that convert the values to character strings and automatically format the strings into lines, or records. A PUT statement can fill part or all of one or more lines. Data conversion and alignment within lines can use the default processing provided by the PUT LIST form of the PUT statement or can be explicitly controlled by format specifications in the PUT EDIT form of the PUT statement. The output fields can be aligned to specific tab positions. The PAGESIZE and LINESIZE options can be specified to control the formatting of lines on pages. The ENDPAGE condition is signaled when the end-of-page is reached.
STREAM INPUT		Any input device or file except indexed	Individual data items are read by GET statements. A single GET statement can process all or part of one or more lines or records. The format of an input field can be determined by the default processing provided by the GET LIST form of the GET statement or can be explicitly controlled by format specifications in the GET EDIT form of the GET statement.

Table F–2 (Cont.): File Access Attributes

Attributes Specified	Attributes Implied	Valid Devices and File Organizations	Usage
STREAM OUTPUT		Any output device or file except indexed	This form of stream output is similar to that provided when PRINT is specified, except that tab positioning and page formatting are not provided. Moreover, when string values are written with the PUT LIST form of the PUT statement, they are enclosed in apostrophes. Files that are created with these attributes can be read back in with GET LIST statements when the file is opened with the STREAM and INPUT attributes.
SEQUENTIAL OUTPUT	RECORD	Any output device or file except indexed	Records can be added to the end of the file with WRITE statements. Each WRITE statement adds a single record to the file.
SEQUENTIAL INPUT	RECORD	Any input device or file	Records in the file are read with READ statements. Each statement reads a single record.
SEQUENTIAL UPDATE	RECORD	Relative, indexed, sequential disk[1]	READ statements read a file's records in order. PL/I maintains the current record, which is the record just read. This record can be replaced in a REWRITE[2] statement. In a relative or indexed sequential file, the current record can also be deleted with a DELETE statement. Each statement processes a single record.
DIRECT OUTPUT	KEYED RECORD	Relative, indexed, sequential disk[1]	WRITE statements insert records into the file at positions specified by keys. Each statement inserts a single record.
DIRECT INPUT	KEYED RECORD	Relative, indexed, sequential disk[1]	READ statements specify records to be read randomly by key. Each statement reads a single record.

[1] The file must have fixed-length records.

[2] The record being rewritten must have the same length as the record read.

Table F–2 (Cont.): File Access Attributes

Attributes Specified	Attributes Implied	Valid Devices and File Organizations	Usage
DIRECT UPDATE	KEYED RECORD	Relative, indexed, sequential disk[1]	READ, WRITE, and REWRITE statements specify records randomly by key. In a relative or indexed file, records can also be deleted by key.
KEYED SEQUENTIAL OUTPUT	RECORD	Relative, indexed, sequential disk[1]	WRITE statements insert records into the file at positions specified by keys. Each statement inserts a single record. This mode is identical to DIRECT OUTPUT.
KEYED SEQUENTIAL INPUT	RECORD	Relative, indexed, sequential disk[1]	READ statements access records in the file randomly by key or sequentially.
KEYED SEQUENTIAL UPDATE	RECORD	Relative, indexed, sequential disk[1]	Any record I/O operation is allowed except a WRITE statement that does not specify a key or a DELETE statement for a sequential disk file with fixed-length records.

[1] The file must have fixed-length records.

■ Associating a PL/I File with a VMS File

The TITLE option of the OPEN statement specifies the name of the VMS file or device that is associated with the file. The name given in the TITLE option can be a VMS logical name or file specification, or it can be a PL/I variable whose value represents a VMS logical name or file specification. For example:

```
OPEN FILE (TAPEIO) TITLE('MT:');
```

This TITLE option specifies a magnetic tape device. **See** "TITLE Option." **See** the *VAX PL/I User Manual* for additional information on file naming and logical names.

■ ENVIRONMENT Options

The ENVIRONMENT attribute can be used to specify properties of a file that are unique within the context of the VMS operating system. For example, you use the ENVIRONMENT attribute to specify the format of records in a file, the maximum record number for a relative file, and so on. You need to specify the ENVIRONMENT attribute only when you wish to take advantage of some special feature of the VMS file system, for example, if you want to define the number of buffers to be used on I/O operations, or if the defaults applied to new files when they are created are not satisfactory.

For a list of these options, **see** "ENVIRONMENT Attribute." **See** the *VAX PL/I User Manual* for complete details on the meanings of the options.

FILE Option

The FILE option is specified in a stream or record I/O statement to designate the file upon which an operation is to be performed. The FILE option is required on all I/O operations, except the GET and PUT statements, that access the default file constants SYSIN and SYSPRINT. The FILE option has the following format:

```
FILE (file-reference)
```

file-reference
A reference to an identifier declared as a file constant, a scalar reference to a variable with the FILE attribute, or a function that returns a file value.

File Organization

A file organization defines the manner in which the data in a record file is arranged. VAX Record Management Services (RMS) supports the following kinds of file organization:

- Sequential—contains records that are arranged in serial order
- Relative—contains numbered records that can be accessed by specifying the number
- Indexed sequential—contains records that have one or more key fields and indexes that provide access to the records by key specification

Operations on these files are normally performed with record I/O statements. Stream I/O statements can be used for any of these files in which all of the data is ASCII. Operations on files of each type are described individually below. For a general discussion of the access modes that can be applied to each file organization, **see** "File Description Attributes and Options."

For complete details and examples of using various file organizations in VAX PL/I, see the *VAX PL/I User Manual.*

■ Sequential Files

In VAX PL/I, the term "sequential file" applies to the physical organization of the records in the file, and not to the manner in which the records are accessed. The records can contain ASCII or non-ASCII data and can be accessed with record or stream I/O statements.

The records in a sequential file can have any of the following record formats:

- Variable length
- Fixed length
- Variable length with a fixed-length control area

In a sequential file with variable-length records, records may or may not be of the same length. This is the default record format for sequential files. You can optionally specify the maximum length of a record by using the ENVIRONMENT option MAXIMUM_RECORD_SIZE. In the following example, a file VAR_FILE is created with variable-length records having a maximum length of 80 characters:

```
DECLARE VAR_FILE FILE RECORD OUTPUT
        ENVIRONMENT (MAXIMUM_RECORD_SIZE(80));
```

To create a sequential file with fixed-length records, you must specify the ENVIRONMENT options FIXED_LENGTH_RECORDS and MAXIMUM_RECORD_SIZE. A sequential disk file with fixed-length records can be accessed randomly; the key is the relative record number of the record in the file, with the first record in the file being relative record number 1.

When a file with fixed-length records is created with the SEQUENTIAL OUTPUT attributes, records can be written randomly if the file is closed and reopened with the KEYED and UPDATE attributes; you can write the records either sequentially or randomly using the KEYFROM option to specify the relative record number of each record to be written.

Note, however, that when a WRITE statement writes record n, RMS allocates all records in the file up to record n, but does not have a way to determine whether the record is empty (as is the case for relative files). To output a record that is "empty" in a file, you must use a REWRITE statement rather than a WRITE statement.

For example:

```
OPEN FILE(SEQFILE) KEYED OUTPUT /* create sequential file */
                   ENV(FIXED_LENGTH_RECORDS,
                       MAXIMUM_RECORD_SIZE(80));
WRITE FILE(SEQFILE) FROM(SEQREC) KEYFROM(100); /* record 100 */
REWRITE FILE(SEQFILE) FROM(SEQREC) KEYFROM(5); /* record 5 */
```

To create a file of variable-length records with a fixed-length control area, use the ENVIRONMENT option FIXED_CONTROL_SIZE and specify the length in bytes of the control area. Note that this length becomes a permanent attribute of the file and cannot be changed. If you also specify the maximum record length, this maximum applies to the data portion of a record and does not include the fixed-length control area. For example:

```
DECLARE VFC_FILE FILE RECORD ENVIRONMENT (
        MAXIMUM_RECORD_SIZE (250),
        FIXED_CONTROL_SIZE (2));
```

For further discussion of the record formats, see the *VAX PL/I User Manual*.

■ Relative Files

A relative file contains a set of numbered records with numbers between 1 and a maximum record number. A relative file has a fixed-length slot for each possible record number; not all slots need be filled at any one time. The size of each slot is set to the length of the maximum record size when the file is created.

Each record in the file has a unique number. Inserting and deleting records does not change the numbers of the other records.

You can access records randomly or sequentially. Random access of a given record is performed by specifying the record number as a key in the KEY or KEYFROM option of a record I/O statement.

When a relative file is created, you can specify the maximum number of records that can be written to the file with the ENVIRONMENT option MAXIMUM_RECORD_NUMBER. If no maximum number is specified, there is no maximum; that is, the file can be of any size and the record numbers are not checked when new records are added.

When you create a relative file by opening it with the attributes KEYED OUTPUT, you must specify the KEYFROM option on each WRITE statement that outputs a record to the file, even if you are writing the records sequentially.

To write records sequentially to a relative file without specifying a KEYFROM option on each WRITE, you must create the file by opening it with the KEYED OUTPUT attributes, close the file, and then reopen it with the SEQUENTIAL and UPDATE attributes. Then, you can use WRITE statements to write records to the file sequentially and omit the KEYFROM option.

For example:

```
OPEN FILE(RELFILE) KEYED OUTPUT; /* create relative file */
CLOSE FILE(RELFILE);             /* close it */
OPEN FILE(RELFILE) SEQL UPDATE;  /* reopen with UPDATE */
WRITE FILE(RELFILE) FROM(MYREC); /* write record 1 */
```

■ Indexed Sequential Files

An indexed sequential file contains records that have a specifically defined structure and indexes. The structure of all records in the file is defined in terms of one or more key fields, each of which has a position in the record and a data type; no two records can have the same primary key. The key fields are determined when the file is created.

The file has an index for each key field. You can access records in the file randomly by specifying a KEY or KEYFROM option that gives the value of a key. For example:

```
READ FILE(F) KEY('ABC') INTO (X);
```

This READ statement reads the record from the file F that has the character string ABC in the key field of the record.

In an I/O operation, PL/I automatically converts a key value specified in an I/O statement to the data type of the key value in the record.

When records in a file have more than one key field or index, there are a primary index and a number of alternate indexes. In the alternate indexes, but not the primary, duplicate instances of the same key are allowed. For example, in a key of names and addresses, a zip code field could be defined as an alternate key. Many records could have the same value in the zip code key field.

The keys are numbered; the primary index is always numbered 0. To specify the index by which the record is to be located, you specify the INDEX_NUMBER option. For example:

```
READ FILE(F) KEY(12)  INTO(X)
        OPTIONS (INDEX_NUMBER(2));
```

Here, the READ statement uses the index numbered 2; the record with a key of 12 in this alternate index field is transferred into the variable X.

The INDEX_NUMBER option is necessary only to change indexes during file processing. By default, each operation uses the same index that was used for the most recent operation on the file. When a file is initially opened or when a WRITE statement specifies a KEYFROM option, the index number is set to the primary index, 0.

To access an indexed sequential file in PL/I, you can specify random or sequential access, or both. When an indexed sequential file is accessed sequentially, records are read based on the key values of the current index number.

If an index with alternate keys contains duplicate key values in the alternate keys, a random READ or DELETE operation accesses the first such record with the specified key. (You can then use sequential processing to access the records with duplicate keys.) Records are always inserted into an indexed sequential file based on the value of the primary key; thus, records that have duplicate alternate keys are inserted without respect to the values of the alternate keys.

FINISH Condition Name

The FINISH condition name can be specified in an ON, SIGNAL, or REVERT statement to designate a FINISH condition or a FINISH ON-unit.

PL/I signals the FINISH condition in the following contexts:

- When any procedure in the program executes the STOP statement
- When a procedure that specifies OPTIONS(MAIN) executes a RETURN statement, or, if the procedure does not execute a RETURN statement, when its corresponding END statement is executed
- When a program exits as a result of a call to the system procedure SYS$EXIT or SYS$FORCEX (Force Exit), or as a result of an interruption by an external CTRL key function
- When the SIGNAL FINISH statement signals the condition

The ways in which a PL/I program can be caused to exit in the VMS environment are described in the *VAX PL/I User Manual.*

■ ON-Unit Completion

If a FINISH ON-unit that executes as a result of a SIGNAL FINISH statement does not execute a nonlocal GOTO statement, control returns to the statement following SIGNAL FINISH. If the FINISH ON-unit executes as a result of any of the other three causes listed above, the program terminates.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

FIXED Attribute

The FIXED attribute indicates that the variable so declared is an arithmetic value with a fixed number of fractional digits. Such variables are called fixed-point (as opposed to floating-point) variables because the decimal point is fixed relative to the representation of the value.

When you specify the FIXED attribute in a DECLARE statement, you can specify either the BINARY or the DECIMAL attribute to indicate a binary or decimal fixed-point variable. You can specify the precision, which is the number of decimal or binary digits used to represent values of the variable. With fixed-point data, you can also specify a scale factor that indicates how much of the precision is to be used for fractional digits. For example, the attributes FIXED BINARY(31,5) define a variable that takes fixed-point binary values of up to a maximum of 31 bits, 5 of which are fractional. The attributes FIXED DECIMAL(10,2) define a variable that takes fixed-point decimal values of up to 10 decimal digits, 2 of which are fractional. PL/I supplies default attributes for attributes that you do not specify (as shown in the table below and tables in other entries on attributes).

Ordinarily, you use fixed-point binary data to represent integers. However, you can also use fixed-point decimal data, which can represent larger absolute values. The precision of a fixed-point binary variable must be in the range 1 through 31. **See** "Fixed-Point Binary Data."

You use fixed-point data whenever arithmetic values must be precise to a specified number of fractional digits. For a fixed-point decimal value, the precision must be in the range 1 through 31 (decimal digits). The scale factor, if specified, must be greater than or equal to zero and less than or equal to the specified precision.

Fixed-point binary data follows the same precision rules as fixed-point decimal data, but the scale factor can be in the range –31 through 31.

If the scale factor is omitted, zero is used (that is, an integer variable is declared). **See** "Fixed-Point Decimal Data."

The default values given for unspecified related attributes follow:

Attributes Specified	Defaults Supplied
FIXED	BINARY (31,0)
FIXED BINARY	(31,0)
FIXED DECIMAL	(10,0)

■ Restrictions

The FIXED attribute directly conflicts with all data type attributes except BINARY and DECIMAL.

FIXED Built-In Function

The FIXED built-in function converts an arithmetic or string expression x to a fixed-point arithmetic value with a specified precision p and, optionally, a scale factor q.

The format of the function is as follows:

```
FIXED(x,p[,q])
```

p
The number of bits used to represent the arithmetic value. The precision must be greater than zero and less than or equal to 31.

q
An integer in the range 0 through 31 for decimal data, and in the range –31 through 31 for binary data. If q is omitted, it is assumed to be zero. The scale factor q must be less than or equal to the specified precision.

■ Returned Value

The result type is fixed-point binary or decimal, depending on whether x is binary or decimal. (If x is a bit string, the result type is fixed-point binary; if x is a character string, the result type is fixed-point decimal.)

The expression x is converted to a value v of the result type, following the PL/I rules (**see** "Conversion of Data"). The returned value is v with precision p and scale factor q. If q is omitted, the returned value has the converted precision of x and a scale factor of zero (**see** "Expression"). FIXEDOVERFLOW is signaled if appropriate.

Fixed-Point Binary Data

The attributes FIXED BINARY are used to declare binary data in PL/I. The BINARY attribute is implied by FIXED. The format of a declaration of a single fixed-point binary variable is as follows:

```
DECLARE identifier FIXED [BINARY] [(precision[,scale-factor])];
```

identifier
The name used to refer to the variable.

precision
An integer in the range 1 through 31, giving the number of bits used to represent values of the variable. If you do not supply the precision, the default is 31. Depending on the precision you specify, either 8 bits (a byte), 16 bits (a word), or 32 bits (a longword) are allocated; the high-order bit represents the sign of a value. **See** "Precision Attribute" for further details.

scale-factor
An integer in the range –31 through 31, giving the number of bits used to represent the fractional values of the variable. If you do not supply a scale factor, the default is zero. The scale factor must be less than or equal to the specified precision. **See** "Scale Attribute" for further details.

Because fixed binary variables have a maximum precision of 31, fixed binary integers can have values only in the range –2,147,483,648 through 2,147,483,647. An attempt to calculate a binary integer outside this range, in a context that requires an integer value, signals the FIXEDOVERFLOW condition.

There is no form for a fixed-point binary constant, although constants of other computational types are convertible to fixed-point binary. A fixed-point binary variable usually receives given values by being assigned to an expression of another computational type or another fixed-point binary variable. **See** "Constant" and "Conversion of Data."

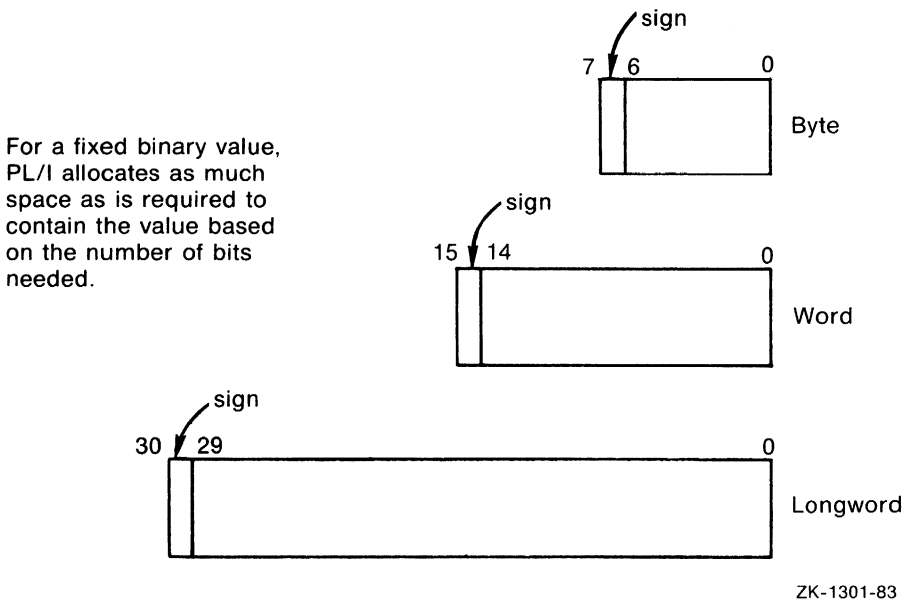
Figure F–1 shows the internal representation of fixed-point binary data. Storage for fixed-point binary variables is always allocated in a byte, word, or longword. For any fixed-point binary value:

- If p is in the range 1 through 7, a byte is allocated.
- If p is in the range 8 through 15, a word is allocated.
- If p is in the range 16 through 31, a longword is allocated.

The binary digits of the stored value go from right to left in order of increasing significance; for example, bit 6 of a FIXED BINARY(7) value is the most significant bit, and bit 0 is the least signficant.

In all cases, the high-order bit (7, 15, or 31) represents the sign.

Figure F–1: Internal Representation of Fixed-Point Binary Data



Fixed-Point Decimal Data

Fixed-point decimal data is used in calculations where exact decimal values must be maintained, for example, in financial applications. You can also use fixed-point decimal data with a scale factor of zero wherever integer data is required.

This discussion is divided into the following parts:

- Constants
- Variables
- Use in expressions
- Internal representation

■ Fixed-Point Decimal Constants

A fixed-point decimal constant can have one or more of the decimal digits 0 through 9 with an optional decimal point and optional sign. If there is no decimal point, PL/I assumes that the decimal point is immediately to the right of the rightmost digit. Following are some examples of fixed-point decimal constants:

```
12
4.56
12345.54
-2
.0004
01.
```

The precision (p) of a fixed-point decimal value is the total number of digits in the value. The scale factor (q) is the number of digits to the right of the decimal point, if any.

■ Fixed-Point Decimal Variables

The format of a declaration of a single fixed-point decimal variable is as follows:

```
DECLARE identifier [FIXED] DECIMAL [(p[,q])];
```

identifier

The name to be used for the variable.

p

An integer constant giving the total number of decimal digits used to represent values of the variable. The maximum precision is 31, and the value must be in the range 1 through 31.

q

An integer constant giving the number of fractional digits in values of the variable. The value must be in the range 0 through p.

If you omit p and q, the default values are 10 for p and 0 for q.

Following are some examples of fixed-point decimal declarations:

```
DECLARE PERCENTAGE FIXED DECIMAL (5,2);
DECLARE TONNAGE FIXED DECIMAL (9);
```

■ Use in Expressions

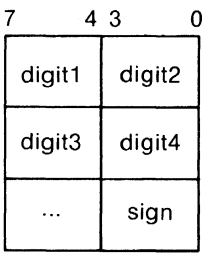
You cannot use fixed-point decimal data with a nonzero scale factor in calculations with binary integer variables. If you must use the two types of data together, use the DECIMAL built-in function to convert the binary value to a scaled decimal value before attempting an arithmetic operation. For example:

```
DECLARE I FIXED BINARY,
        SUM FIXED DECIMAL (10,2);

SUM = SUM + DECIMAL (I);
```

■ Internal Representation of Fixed-Point Decimal Data

Fixed-point decimal data is stored in packed decimal format. Each digit is stored in a half-byte, as illustrated in the following figure. Bits 0 through 3 of the last half-byte contain a value indicating the sign. Normally, the hexadecimal value 'C' indicates a positive value and the hexadecimal value 'D' indicates a negative value.



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FIXEDOVERFLOW Condition Name

The FIXEDOVERFLOW condition name (which can be abbreviated to FOFL) can be specified in an ON, SIGNAL, or REVERT statement to designate a fixed overflow condition or ON-unit.

PL/I signals the FIXEDOVERFLOW condition in the following circumstances:

- When the result of an arithmetic operation on a fixed-point decimal or binary integer value exceeds the maximum precision of the VAX hardware. The maximum precision allowed for a fixed-point decimal or binary value is 31.

- When the source value of a fixed-point expression exceeds the precision of the target variable. For example, PL/I signals FIXEDOVERFLOW when a value that is not in the range –128 through 127 is assigned to a fixed-point binary variable with a precision of 7 bits. Similarly, the condition is signaled if a value assigned to a picture variable has more integral digits than are specified by the picture specification.

The value resulting from an operation that causes this condition is undefined.

■ Value of ONCODE

There are two VAX hardware exceptions that result in the FIXEDOVERFLOW condition. These are SS$_DECOVF (for a fixed-point decimal overflow) and SS$_INTOVF (for a fixed-point binary integer overflow). An ON-unit that receives control when FIXEDOVERFLOW is signaled can reference the ONCODE built-in function to determine which condition is actually signaled.

To define an ON-unit to respond specifically to either of these errors, use the VAXCONDITION condition name. For details on using the ONCODE built-in function and VAXCONDITION, see the *VAX PL/I User Manual.*

■ ON-Unit Completion

If the ON-unit does not transfer control elsewhere in the program, control returns to the point at which the condition was signaled.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

FLOAT Attribute

The FLOAT attribute indicates that a variable is a floating-point arithmetic item.

When you specify the FLOAT attribute in a DECLARE statement, you can specify either the BINARY or the DECIMAL attribute, and you can specify the precision. For a floating-point binary variable, the precision can be in the range 1 through 113; for a floating-point decimal variable, the precision can be in the range 1 through 34.

The default values given for unspecified related attributes are as follows:

Attributes Specified	Defaults Supplied
FLOAT	BINARY (24)
FLOAT BINARY	(24)
FLOAT DECIMAL	(7)

■ Restrictions

The FLOAT attribute directly conflicts with all data type attributes except BINARY and DECIMAL.

FLOAT Built-In Function

The FLOAT built-in function converts a string or arithmetic expression x to floating point, with a specified precision p. The precision p must be an integer constant that is greater than zero and less than or equal to the maximum precision of the result type (34 for floating-point decimal, 113 for floating-point binary).

If x is a character string, it can contain any series of characters that describes a valid arithmetic constant. That is, the character string can contain any of the numeric digits 0 through 9, a plus (+) or minus (-) sign, a decimal point (.), and the letter E. If the character string contains any invalid characters, the CONVERSION condition is signaled.

The format of the function is as follows:

```
FLOAT(x,p)
```

■ Returned Value

The result type is floating-point binary or decimal, depending on whether x is a binary or decimal expression. (If x is a bit-string expression, the result type is floating-point binary; if x is a character-string expression, the result type is floating-point decimal.)

The expression x is converted to a value of the result type, following the PL/I conversion rules (**see** "Conversion of Data"), and of the specified precision; UNDERFLOW or OVERFLOW is signaled if appropriate.

Floating-Point Data

The floating-point data types provide a way to express very large and very small numbers, for example, in scientific calculations.

All floating-point calculations are performed on values in one of the VAX binary floating-point formats. In general, the precision of the result is determined by the maximum precision of any operands in the operation. The numerical result of an operation is rounded to the result precision, so the results of most operations are approximate.

This discussion of floating-point data is divided into the following parts:

- Constants
- Variables
- Use in expressions
- G_FLOAT and H_FLOAT support
- Floating-point data formats
- Internal representation of floating-point data

■ Constants

A floating-point constant can have one or more of the decimal digits 0 through 9 with an optional decimal point, followed by the letter E and one to five decimal digits representing a power of 10. The floating-point value and the integer exponent can both be signed. The first portion of the value, to the left of the letter E, is called the mantissa.

Following are some examples of floating-point constants:

```
2E10
-3E8
32E-8
.45632E16
```

The decimal precision of each of these values is the number of digits in the mantissa.

In VAX PL/I, all floating-point constants are decimal.

■ Variables

The keyword FLOAT identifies a floating-point variable in a declaration. To declare a single floating-point binary variable, specify a DECLARE statement as follows:

```
DECLARE identifier FLOAT [BINARY] [(p)];
```

identifier
The name to be used for the variable.

p
The precision of the variable, that is, the number of digits to be maintained in the mantissa. The precision must be an integer constant in the range 1 through 113. If you do not specify a precision, PL/I uses the default precision of 24.

To declare a decimal floating-point variable, use the following format:

```
DECLARE identifier FLOAT DECIMAL [(p)];
```

identifier
The name to be used for the variable.

p
The decimal precision, which must be an integer constant in the range 1 through 34. If you omit the precision, the default precision is 7.

Following are some examples of floating-point variables:

```
DECLARE S FLOAT BINARY (16);
DECLARE X FLOAT DECIMAL (30);
```

Note that you can use either BINARY or DECIMAL to declare a floating-point value. Because the internal representation of floating-point variables is binary, it is recommended that you use FLOAT BINARY (which is the default) to declare variables, unless you need the properties of FLOAT DECIMAL. (Note that the difference between FLOAT BINARY and FLOAT DECIMAL appears only when a conversion to another type, such as character for doing I/O, is necessary.) In any event, you should declare all floating-point variables using the same base.

■ Using Floating-Point Data in Expressions

You can use both integer and scaled decimal constants freely in floating-point expressions because an arithmetic constant is always converted to the appropriate internal representation for use in a floating-point operation. The target type for the conversion depends on the context. In the following example the constant 1.3 is converted to floating point when the expression is evaluated:

```
DECLARE X FLOAT BINARY (53);
X = X + 1.3;
```

Such a conversion is normally done during compilation, although in some cases the constant is maintained in decimal until run time.

■ Floating-Point Data Formats

VAX PL/I supports four types of floating-point values. Table F–3 summarizes the ranges of precision for each type.

Table F–3: VAX Floating-Point Types

Floating-Point Type[1]	Sign Bits	Exponent Bits	Fractional Bits
F (single precision)	1	8	24
D (double precision)	1	8	53
G (double precision)	1	11	53
H (quadruple precision)	1	15	113

[1] G- and H-floating computations can be performed with software emulation on some older processors. In addition, floating-point hardware is optional on most MicroVAX systems. Refer to the appropriate processor manual for more information.

The PL/I compiler selects the appropriate VAX floating-point type based on the precision you specify and, when you want the G-floating-point type, on a compile-time qualifier on the PLI command. The types are selected as shown in Table F–4.

Table F–4: Floating-Point Types Used by PL/I

Range of p (DECIMAL)	Range of p (BINARY)	Floating-Point Type
1 <= p <= 7	1 <= p <= 24	F
8 <= p <= 15	25 <= p <= 53	D or G[1]
16 <= p <= 34	54 <= p <= 113	H

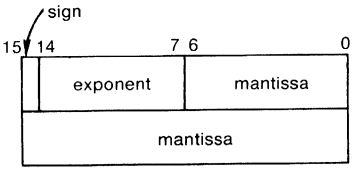
[1] D is used if possible unless you request G at compile time with the /G_FLOAT qualifier.

■ Internal Representation of Floating-Point Data

In all VAX floating-point formats, the value 0 is indicated when the sign bit and all exponent bits are set to zero. In effect, this allows for the representation of a value with a 24-bit fraction and an 8-bit exponent in single precision, even though only 23 bits in the format are allocated for the fraction.

The double-precision and G-floating formats as used by PL/I have the same fractional precision; G-floating format allows an extra three bits for the exponent. Notice that the double-precision format has 56 bits available for the fraction, although only 53 bits are used by PL/I. If you specify a floating-point binary precision in the range 54 to 56, and you do not use the G_FLOAT compiler qualifier, the number is represented in double-precision format. (If the G_FLOAT qualifier is used, numbers with this range of precision are represented by the H-floating format.)

This small reduction in the precision of double-precision numbers is necessary to keep the compiler from selecting H-floating format on machines that lack the necessary hardware. The intent is to preserve the size of a structure containing double-precision data regardless of whether the G_FLOAT qualifier is used.



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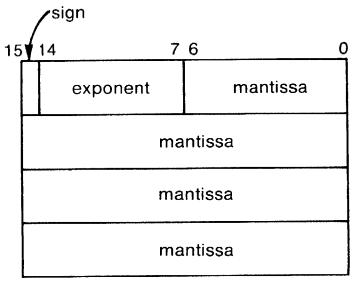

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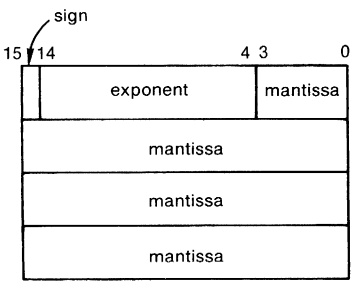

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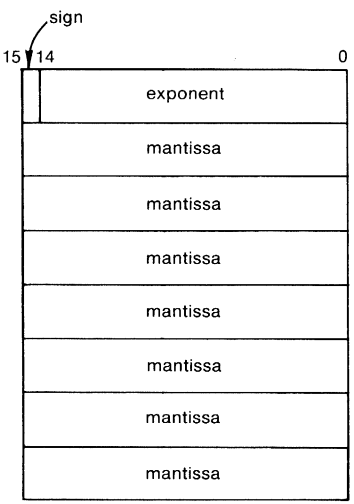

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FLOOR Built-In Function

The FLOOR built-in function returns the largest integer that is less than or equal to an arithmetic expression x. Its format is as follows:

FLOOR(x)

■ Returned Value

If x is a floating-point expression, the returned value is a floating-point value. If x is a fixed-point expression, the returned value is a fixed-point value with the same base as x and with the following attributes:

$$precision = min(31, p - q + 1)$$

and

$$scalefactor = 0$$

where p and q are the precision and scale factor of x.

For example:

```
FLOOR_DEMO: PROC OPTIONS(MAIN);
 PUT LIST (FLOOR(3));
 PUT LIST (FLOOR(-3.323));
 PUT LIST (FLOOR(3.456E9));
END;
```

This program returns the following values:

```
   3      -4     3.456E+09
```

FLUSH Built-In Subroutine

The FLUSH built-in subroutine is used to force all RMS buffers to be written to the I/O device before the program will proceed. **See** the *VAX PL/I User Manual* for more information.

Format Item

In PL/I, formatted input and output data is transferred with the GET EDIT and PUT EDIT statements, which include a format specification made up of format items.

PL/I format items are categorized as follows:

- The data format items, A, B, E, F, and P, are used for input or output of data in various formats. A and B are used for character- and bit-string formats, respectively. E and F are used for floating- and fixed-point formats, respectively. P is used for input or output of data in a specified picture format. All data format items can be used with either the FILE or the STRING option in edit-directed statements.
- The remote format item, R, is used to specify the label of a FORMAT statement, which contains a remote list of format items.
- The control format items, SKIP, LINE, PAGE, TAB, COLUMN, and X, are used to control the position in the input or output stream at which data is placed or from which it is acquired. Of the control format items, only X can be used with the STRING option in edit-directed statements.

Arguments for all format items, except picture (P) and remote (R), can be integer expressions.

The PL/I format items are summarized in Table F–5, and their general uses are discussed in this entry. Each format item also has its own entry in this manual; for example, **see** "A Format Item."

Table F–5: Summary of PL/I Format Items

Format Item	Use
A[(w)]	With GET EDIT, reads w characters from the input stream; with PUT EDIT, converts the value to be output to a w-character string and outputs the resulting string.
B[(w)]	With GET EDIT, reads w binary digits (0s and 1s) from the input stream; with PUT EDIT, the corresponding value converts to a character string of length w, containing 0s and 1s, and writes it to the output stream. The B format item is equivalent to B1.

Table F–5 (Cont.): Summary of PL/I Format Items

Format Item	Use
B1[(w)]	With GET EDIT, reads a character string of length w composed of the characters 0 and 1 from the input stream; with PUT EDIT, the corresponding value converts to a character string of length w, containing 0s and 1s, and writes it to the output stream.
B2[(w)]	With GET EDIT, reads a character string of length w composed of the characters 0, 1, 2, and 3 from the input stream and converts it to a bit string; with PUT EDIT, converts w 2-bit fields within the corresponding value to one of the characters 0, 1, 2, or 3, and writes the w-character string to the output stream.
B3[(w)]	With GET EDIT, reads a character string of length w composed of the characters 0, 1, 2, 3, 4, 5, 6, 7 from the input stream and converts it to a bit string; with PUT EDIT, converts w 3-bit fields within the corresponding value to a string of the characters 0, 1, 2, 3, 4, 5, 6, or 7, and writes the w-character string to the output stream.
B4[(w)]	With GET EDIT, reads a character string of length w composed of the characters 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, or F from the input stream; with PUT EDIT, converts w 4-bit fields within the corresponding value to a string of the characters 0 through F, and writes the w-character string to the output stream.
COLUMN(position)	With GET EDIT, specifies the position at which reading of data is to proceed; with PUT EDIT, outputs spaces up to the specified column position. Can be used with files only.
E(w[,d])	With GET EDIT, converts a field of w characters from the input stream to a floating-point number; with PUT EDIT, converts a value to a w-character floating-point representation with d fractional digits in the mantissa, and writes the w-character string to the output stream.
F(w[,d])	With GET EDIT, converts a field of w characters from the input stream to a fixed-point value; with PUT EDIT, converts a value to a w-character fixed-point representation with d fractional digits, and writes the w-character string to the output stream.
LINE(number)	Valid for print files only. Specifies a line number, relative to the top of the page, at which output is to continue.

Table F–5 (Cont.): Summary of PL/I Format Items

Format Item	Use
P'picture'	With GET EDIT, acquires a character string from stream whose length is specified by the picture specification, and signals ERROR if the string is not a pictured value; with PUT EDIT, converts an expression to a pictured value as specified by the picture, and writes the pictured value to the output stream.
PAGE	Valid for print files only. Specifies that output is to be continued at the top of the next page.
R(label)	Indicates that format items are to be acquired from the FORMAT statement at the specified label.
SKIP[(linecount)]	With GET EDIT, continues reading after *linecount* lines; with PUT EDIT, outputs *linecount* blank lines and continues output. Can be used with files only.
TAB[(n)]	Valid for print files only. Continues output at the nth tab stop relative to the current position.
X[(n)]	With GET EDIT, ignores n characters in the input stream; with PUT EDIT, places n spaces in the output stream. Can be used with either files or character strings.

■ Data Format Items

The data format items refer to a field of characters in the stream. Each data format item specifies the field width in characters and either the manner in which the field is used to represent a value (output) or the manner in which the characters in the field are to be interpreted (input). Because the representation or interpretation is under control of the format items, certain symbols used in the stream with GET LIST and PUT LIST are not used with GET EDIT or PUT EDIT:

- Strings input by the GET EDIT statement should not be enclosed in apostrophes unless the apostrophes are intended to be part of the string. Strings output by PUT EDIT are not enclosed in apostrophes.
- Bit strings input by the GET EDIT statement should not be enclosed in apostrophes, nor should they be followed by the radix factor B, B1, B2, B3, or B4. These factors are not added by the PUT EDIT statement on output.
- The comma and space characters are not interpreted as data separators on input. On output, values are not automatically separated by spaces.

The following guidelines apply to errors and mismatches that occur between the actual data values and the fields specified by data format items:

- On input, the ERROR condition is signaled if the field of characters cannot be interpreted as required by the format item.
- On output, strings are left-justified in the specified field, and numeric data is right-justified. Truncation occurs if the field is too narrow to contain the necessary characters; strings are truncated on the right and numeric data on the left.

■ Format Specifications

In the GET EDIT, PUT EDIT, and FORMAT statements, format items are used singly or in combination to create format specifications. The syntax of a format specification is as follows:

{ format-item
iteration-factor format-item
iteration-factor(format-specification,...) }

The iteration factor is an integer or an integer expression that repeats the following format item or the following list of format specifications. Expressions must be enclosed in parentheses. If an integer iteration factor precedes a single format item that is not in parentheses, the iteration factor and the format item must be separated by a space. For example:

```
PUT EDIT (A) (F(5,2));
```

This statement specifies a 5-character field containing decimal digits, two of which are fractional. Used by itself as a format specification, this item specifies one such field. To specify two such fields, precede the item with the iteration factor 2:

```
PUT EDIT (A,B) (2 F(5,2));
```

An iteration factor can also repeat an entire list of format specifications:

```
PUT EDIT ( (A(I) DO I = 1 TO 10) ) /* 10 array elements */
( 2( F(5,2),2(F(7,2),E(8)) ) );    /* 10 format items   */
```

Expanded into individual format items, this specification looks like this:

```
F(5,2),F(7,2),E(8),F(7,2),E(8),F(5,2),F(7,2),E(8),F(7,2),E(8)
```

If an expression is used as the iteration factor, it must be enclosed in parentheses, but does not require spaces. For example:

```
PUT EDIT (A) ((Z*4)F(5,2));
```

In general, data listed in the GET EDIT or PUT EDIT statement is matched to the expanded list of data format items, from left to right, until the end of the input-target or output-source list is reached. Matching occurs only between I/O data and data format items; control format items are executed only if they are encountered while the matching is in progress. **See also** "Format-Specification List."

Format-Specification List

Format-specification lists are used in GET EDIT, PUT EDIT, and FORMAT statements to control the conversion of data between the program and the input or output stream and to precisely control positioning within the input or output stream. This entry describes the syntax of format-specification lists and the manner in which a format list is processed to acquire or transmit data.

■ Rules for Use

This section briefly describes rules and constraints for format-specification lists. For a general discussion of format items, **see** "Format Item." Each format item is defined in detail, for both input and output, in an individual entry (for instance, the entry "F Format Item").

- A GET EDIT or PUT EDIT statement must include one and only one format-specification list and also one and only one list of input targets or output sources. The input-target or output-source list must immediately follow the keyword EDIT and must be immediately followed by the format-specification list.
- The same set of data format items is used for input and output. The F and E format items are used for I/O in fixed-point and floating-point formats, respectively. The A and B format items are used for I/O in character-string and bit-string formats, respectively. The P format item is used for both input and output of data, with the format specified by a picture contained in the format item.
- Of the control format items, only X can be used when the input or output stream is a character string.
- Unlike the statement options PAGE, LINE, and SKIP, the format items PAGE, LINE, and SKIP are executed in the order in which they occur.

■ How Edit-Directed Operations Are Performed

This section describes the manner in which format items are matched to input targets or output sources. **See also** "Examples" at the end of this entry.

All edit-directed input statements include the following syntax:

```
EDIT (input-target,...) (format-specification,...)
```

All edit-directed output statements include the following syntax:

```
EDIT (output-source,...) (format-specification,...)
```

format-specification
One of the following:

- A single control or data format item.
- A construct containing an iteration factor followed by one or more format items (for an explanation of iteration factors, **see** "Format Item").
- An R format item, which specifies the label of a FORMAT statement. In effect, the entire format-specification list in the FORMAT statement is acquired and inserted at the position of the R format item.

Except for picture (P) and remote (R) format items, arguments to format items can be integer expressions.

input-target
One of the following:

- A variable reference, which can be to a scalar or aggregate variable of any computational data type
- A construct with the following syntax:

```
(input-target,... DO reference=expression[TO expression]
[BY expression] [WHILE(expression)][UNTIL(expression)] )
```

- A construct with the following syntax:

```
(input-target,... DO reference=expression[REPEAT
expression] [WHILE (expression)][UNTIL(expression)] )
```

output-source
One of the following:

- Any expression with a computational value, including references to scalar or aggregate variables of any computational type
- A construct containing a DO specification, as shown for input targets

When PL/I performs an edit-directed operation, it examines the list of input targets or output sources, beginning with the first in the list. If the target or source is an array or structure or contains a DO specification, it is expanded to form a list of individual data items; an array is expanded in row-major order, a structure is expanded in the order of its declaration, and items preceding a DO specification are expanded according to the DO specification.

Within a single target or source, items at the innermost level of parentheses are processed first.

Given a list of one or more data items contained in the first target or source, PL/I processes the data items from left to right. Beginning with the leftmost data item, and for each subsequent item, PL/I executes format items until the data item has been either assigned a value from the input stream, or converted to a character representation and placed in the output stream. Control format items are therefore executed in the order in which they occur in the format-specification list. With the first target or source, the execution of format items begins with the leftmost format item in the format-specification list. If the end of the format-specification list is reached, PL/I returns to the leftmost format item and continues.

When all items contained in the first target or source have been processed, PL/I operates on the next target or source. The target or source is evaluated, and PL/I then examines the format-specification list, beginning where the previous operation stopped.

This processing continues until all data items in the input-target or output-source list have been processed, at which point the edit-directed statement terminates. If this occurs while PL/I is in the middle of the list of format items, the format items to the right are not executed.

■ Examples

The following examples show typical edit-directed operations. All cases shown are for input (GET EDIT), but the operations for PUT EDIT are similar. The simple cases, shown first, are with input targets that are scalar variable references. The next cases shown are with aggregate (array and structure) references. The last cases shown are with DO specifications.

Scalar Variables

The following examples have input targets that are scalar variables:

```
GET EDIT (A,B,C,D) (A(12),F(5,2),F(6,2),A(14));
```

This statement acquires four values from the input stream: a 12-character string, a 5-digit fixed-point decimal number, a 6-digit fixed-point decimal number, and a 14-character string, and assigns these values, with any necessary conversions, to the target variables A, B, C, and D, respectively. (For details of the conversions to the targets' types, **see** "Conversion of Data.")

```
GET EDIT (A,B,C,D) (A(12));
```

This statement acquires four 12-character strings and assigns them (with conversions, if necessary) to the targets A, B, C, and D.

```
GET EDIT (A,B,C,D) (A(12), 2 F(5,2), A(14));
```

This statement acquires a 12-character string, two fixed-point decimal numbers, and a 14-character string, in that order, and assigns them to A, B, C, and D. (You can use embedded spaces in format lists, as elsewhere, for clarity; the space between "2" and "F(5,2)" is required.)

```
GET EDIT (A,B,C,D,E) ( 2( A(12),A(14) ), A(20) );
```

This statement acquires, in order, a 12-character string, a 14-character string, another 12-character string, another 14-character string, and a 20-character string, and assigns the strings, in that order, to A, B, C, D, and E.

```
GET EDIT (A,B,C,D,E) ( 2( A(12),A(14) ), SKIP, A(20) );
```

This statement performs the same operation as in the previous example, but acquires the 20-character string from the next line.

Aggregates

The following examples have input targets that are references to array and structure variables:

```
GET EDIT (A) ( 2( A(12),A(14) ), A(20) );
```

A is an array of five elements or a structure with five scalar members. This statement expands A to a list of individual data items. Then it acquires, in order, a 12-character string, a 14-character string, another 12-character string, another 14-character string, and a 20-character string, and assigns the strings, in that order, to the elements A(1) through A(5) (if an array) or to the five members of structure A in the order in which the members are declared.

```
GET EDIT (A,B) ( 2( A(12),A(14) ), A(20) );
```

Both A and B are aggregates with five elements or members. For A, this statement performs the same operation as in the previous example, and then repeats the operation for B, using the same format list each time. Because there are five format items specified, and the aggregates both have five elements or members, strings of the same length are acquired for corresponding elements of A and B.

```
GET EDIT (NAME) (SKIP,A(20),SKIP,A(80));
```

NAME is a structure declared as follows:

```
DECLARE 1 NAME
          2 FIRST CHARACTER(20) VARYING,
          2 LAST  CHARACTER(80) VARYING;
```

This statement skips to the next line and acquires a 20-character string. It assigns the string to NAME.FIRST. This statement skips to the next line and acquires an 80-character string. This statement assigns that string to NAME.LAST.

```
GET EDIT (A,B) ( 2( A(12),A(14) ), SKIP, A(20) );
```

Both A and B are 4-element arrays. From the current line, this statement executes A(12), A(14), A(12), and A(14), in that order, and assigns the results to A(1) through A(4). This statement then skips to the next line and executes A(20), A(12), A(14), and A(12), in that order, and assigns the results to B(1) through B(4); the list of data items is now exhausted, so this statement does not execute SKIP a second time.

DO Specifications

The following examples have input targets that include DO specifications. The DO specifications control the assignment of input values to variables that are arrays and based structures.

```
GET EDIT ( (B(I) DO I=10 TO 4 BY -2) , B(1) )
 ( 2( A(12),A(14) ), A(20) );
```

B is a 10-element array. Notice that the parentheses surrounding the first input target are in addition to the parentheses surrounding the entire input-target list. This statement executes the format items A(12), A(14), A(12), and A(14), in that order, and assigns the resulting strings to elements B(10), B(8), B(6), and B(4), respectively. This statement then executes A(20) and assigns the result to B(1).

```
GET EDIT ( ( (A(I,J) DO J=1 TO 10) DO I=1 TO 20) )
 (F(5),F(6));
```

A is a two-dimensional array of 20 rows and 10 columns. Two hundred decimal integers are acquired and assigned to the array elements in the order A(1,1), A(1,2), . . . ,A(20,10). Elements with odd-numbered columns receive 5-digit integers, and those with even-numbered columns, 6-digit integers. Because the DO specifications specify row-major order, the same operation is performed by the next example.

```
GET EDIT (A) (F(5),F(6));
```

Because row-major order is the default, nested DO specifications are used to change the order in which values are assigned.

The example has the same effect as the following DO-group:

```
DO I = 1 TO 20;
   DO J = 1 TO 10;
      GET EDIT(A(I,J)) (F(5),F(6));
      END;
   END;
```

Compared with a DO construct in the input-target list, however, the use of nested DO groups is much less efficient in execution speed. In addition, the identical effect is not generally true for all stream I/O statements. For instance:

GET SKIP EDIT(input-target,...) (format-specification,...);

This statement has different effects in the two cases. If it occurs in a pair of nested DO groups, as shown previously, the SKIP option is executed on each iteration of the innermost DO group. If instead the DO specifications are in the input-target list, the SKIP option is executed only once, before any other input processing is performed.

```
GET EDIT  ( ( CURRENT->PERSON.NAME
   DO CURRENT = FIRST
   REPEAT CURRENT->PERSON.NEXT
   WHILE (CURRENT ^= NULL) ) )
       (A(80));
```

CURRENT and FIRST are pointers, and PERSON is a based structure declared as follows:

```
DECLARE /* Based structure for list elements: */
        1 PERSON BASED,
          2 NEXT POINTER,   /* Pointer to next element: */
          2 NAME CHARACTER(80) VARYING;

DECLARE /* NULL function and pointers to first and
           current list elements: */
         NULL BUILTIN,
         (FIRST,CURRENT) POINTER;
```

The GET EDIT statement acquires 80-character strings from the input stream and assigns each to a list member PERSON.NAME. On the first input operation, the string is assigned to FIRST–> PERSON.NAME. On subsequent iterations of the DO specification, the pointer to the next element, PERSON.NEXT, is assigned to CURRENT before the input operation. Before each input operation, including the first, the WHILE clause tests to determine whether the end of the queued list has been reached (indicated by the null pointer).

The DO REPEAT construct is often used in this type of application. You should provide a WHILE or UNTIL clause in this or any DO REPEAT construct to be sure that the operation has a defined termination. However, the WHILE or UNTIL clause is not required.

FORMAT Statement

The FORMAT statement describes a remote format-specification list to be used by GET EDIT or PUT EDIT statements. The FORMAT statement and remote (R) format item are useful when the same format specification is used by a large number of GET EDIT or PUT EDIT statements, or both. In this case, a change to the format specification can be made in the single FORMAT statement, rather than in each GET or PUT statement.

The form of the FORMAT statement is as follows:

label: FORMAT (format-specification,...);

label

A valid PL/I label. A label is required and is specified in the GET EDIT or PUT EDIT statement that contains an R format item in its format-specification list.

format-specification

A list of one or more format items that match corresponding input targets in a GET EDIT statement, or output sources in a PUT EDIT statement. For further information, **see** "Format-Specification List" and "Format Item."

FREE Built-In Subroutine

The FREE built-in subroutine is used to free all locks associated with a given file. This built-in subroutine is normally used in conjunction with the extended VMS record-locking options of the READ statement. **See** the *VAX PL/I User Manual* for more information.

FREE Statement

The FREE statement releases the storage that was allocated for a based or controlled variable. The format of the FREE statement is as follows:

```
FREE free-item,...;
```

free-item

```
variable-reference [IN(area-reference)]
```

variable-reference
A reference to the based or controed variable whose storage is to be released.

If you do not explicitly free the storage acquired by the variable, the storage is not freed until the program terminates.

If you free a variable that is explicitly associated with a pointer, the pointer variable becomes invalid and must not be used to reference storage.

IN(area-reference)
The specification of an area reference (for based variables) in which the storage is to be freed. If the IN option is omitted, the variable reference must be either implicitly or explicitly based on an offset variable with a base area.

You cannot use the IN option in conjunction with controlled variables.

■ Examples

```
FREE LIST;
FREE P->INREC;
```

These statements release the storage acquired for the based variable LIST and for the allocation of INREC pointed to by the pointer P.

```
ALLOCATE STATE SET (STATE_PTR);
    .
    .
    .
FREE STATE;
```

This FREE statement releases the storage for the based variable STATE and makes the value of STATE_PTR undefined.

FROM Option

The FROM option is specified on a REWRITE or WRITE statement to designate the variable whose contents are to be written to a record file. This option has the following format:

FROM (variable-reference)

variable-reference
A reference to a variable whose contents are to be written to the record file.

For example:

```
WRITE FILE (STATE_FILE) FROM (STATE_BUFFER);
```

This WRITE statement performs a sequential output operation to the file STATE_FILE. The contents of the variable STATE_BUFFER are used to create a new record at the end of the file.

See "REWRITE Statement" and "WRITE Statement."

Function

A function is a procedure that returns a scalar value. A function receives control when its name is referenced in the context of an expression. There are two types of functions:

- PL/I built-in functions
- User-written functions

The PL/I built-in functions are available in all programs and generally need not be declared. (**See also** "Built-In Function" and "BUILTIN Attribute.")

A user-written function must do the following:

- Contain the RETURNS option on the PROCEDURE statement.
- Specify a value on the RETURN statement that terminates the procedure. The value specified must be of a data type that is valid for conversion to the data type specified on the RETURNS option.

For example:

```
ADDER: PROCEDURE (X,Y) RETURNS (FLOAT);
DECLARE (X,Y) FLOAT;
        RETURN (X+Y);
        END;
```

This function has two parameters, X and Y. They are floating-point binary variables declared within the function. When invoked by a function reference, this function must be passed two arguments to correspond to these parameters. It returns a floating-point binary value representing the sum of the arguments it is passed.

■ Function Reference

The format of a function reference is as follows:

entry-name ([argument,...])

entry-name
The name of an entry constant or variable used to invoke the function. (**See** "Procedure" and "Entry Data.")

argument, . . .
One or more arguments to be passed to the function. If specified, the arguments must correspond to the parameters specified in the PROCEDURE or ENTRY statement that identifies the entry name of the function.

Arguments must be enclosed in parentheses. Multiple arguments must be separated by commas.

For example, you can invoke the function ADDER, discussed previously, as follows:

```
TOTAL = ADDER(5,6);
```

Arguments for a function must be separated by commas. An argument can be an expression of any data type.

If a function has no parameters, you must specify a null argument list; otherwise, the compiler treats the reference as a reference to an entry constant. Specify a null argument list as follows:

```
GETDATE = TIME_STAMP();
```

This assignment statement contains a reference to TIME_STAMP, a function that has no parameters. This rule applies to PL/I built-in functions as well; however, if you declare a PL/I built-in function explicitly with the BUILTIN attribute, you need not specify the empty argument list.

For more information, **see** "Built-In Function" and "Procedure."

G

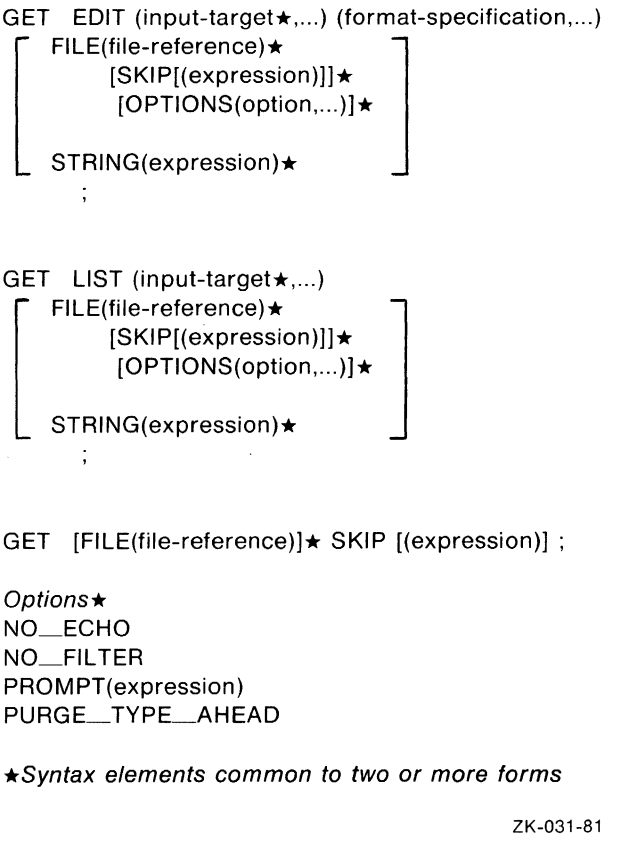
GET Statement

The GET statement acquires data from an input stream, which is either a stream file or a character-string expression. The input file can be a file declared with the STREAM attribute or the default file SYSIN, usually associated with the user's default input device. (**See also** "Terminal Input/Output.")

This entry describes the syntax and options of GET statements. For a detailed description of the execution of a GET statement, **see** "Stream Input/Output."

The GET statement has several forms; they are summarized in Figure G–1.

Figure G–1: Forms of the GET Statement



■ GET EDIT

The GET EDIT statement acquires fields of character-string data from an input stream, which can be a stream file or a character-string expression. The stream file can be a declared file or the default file SYSIN. GET EDIT converts the character strings under control of a format specification and assigns the resulting values to a specified list of input targets (variables). It also allows input of characters from selected positions in the input stream.

The form of the GET EDIT statement is as follows:

```
GET EDIT (input-target,...) (format-specification,...)
[ FILE(file-reference)                  ]
[         [SKIP[(expression)]]          ]
[         [OPTIONS(option,...)]         ]
[ STRING(expression)]                   ]
[     ;                                 ]
```

input-target

The names of one or more variables to be assigned values from the input stream. Multiple input targets must be separated by commas.

An input target has one of the following forms:

```
reference
```

The reference is to a scalar or aggregate variable of any computational type. If the reference is to an array, data is assigned to array elements in row-major order. If the reference is to a structure, data is assigned to structure members in the order of their declaration.

```
(input-target,... DO reference=expression [TO expression]
[BY expression] [WHILE(expression)] [UNTIL(expression)])
```

The input target can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of input target are in addition to the parentheses surrounding the entire input list.

```
(input-target,... DO reference=expression
[REPEAT expression] [WHILE (expression)] [UNTIL(expression)])
```

The input target can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of input target are in addition to the parentheses surrounding the entire input list.

For a discussion of the matching of format items to input targets and of the use of DO specifications, **see** "Format-Specification List."

format-specification

A list of format items to control the conversion of data items in the input list. You can use data format items, control format items, or remote format items. For each variable name in the input-target list, there is a corresponding data format item in the format-specification list that specifies the width of the field and controls the data conversion. **See** "Format-Specification List" and "Format Item."

FILE(file-reference)

An option specifying that the input stream is a file; the reference is to a declared file variable or constant. If neither the FILE option nor the STRING option is specified, PL/I assumes the file SYSIN. This file is associated with the default system input file SYS$INPUT.

If a file is specified and is not currently open, PL/I opens it with the attributes STREAM and INPUT. The UNDEFINEDFILE condition is signaled if the file cannot be opened.

STRING(expression)

An option specifying that the input stream is a character-string expression. The STRING option cannot be used with the FILE, OPTIONS, or SKIP option.

SKIP [(expression)]

An option that advances the input file a specified number of lines before processing the input list. This option can be used only with the implied or explicit FILE option. If the expression is specified, it indicates the number of lines to be advanced; if it is omitted, the default is to skip to the next line. The SKIP option is always executed first, before any other input or positioning of the input file, regardless of its position in the statement.

OPTIONS (option, . . .)

An option that specifies one or more of the following options. This option can be used only with the default or explicit FILE option; it cannot be used with the STRING option. Multiple options must be separated by commas.

NO_ECHO
NO_FILTER
PROMPT (string-expression)
PURGE_TYPE_AHEAD

The options are described fully in the *VAX PL/I User Manual.*

■ Examples

```
GET EDIT (FIRST,MID_INITIAL,LAST)
 (A(12),A(1),A(20));
```

This statement reads the next three character strings from the default stream input file (SYSIN) and assigns the strings to FIRST, MID_INITIAL, and LAST, respectively.

```
GET EDIT (SOCIAL_SECURITY) (A(12))
 FILE (SOCIAL) SKIP (12);
```

This statement opens the stream file SOCIAL if the file was closed, advances 12 lines, reads the first 12 characters of the line, and assigns the characters to the variable SOCIAL_SECURITY.

```
GET EDIT (N, (A(I) DO I=1 TO N))
 (F(4),SKIP,100 F(10,5));
```

where the dimension of A is less than or equal to 100. This reads the value of N from the input stream using the format item F(4). The process then skips to the next line (record). It reads N elements into the array A, using the format item F(10,5) for each element.

```
GET EDIT (NAME.FIRST,NAME.LAST)
 (A(10),X(3),A(20))
 STRING('Philip    A. Rothberg           ');
```

This statement assigns 'Philip␣␣␣␣' to the structure member NAME.FIRST, skips the middle initial, period, and space, and assigns 'Rothberg␣␣␣␣␣␣␣␣␣␣␣␣' to NAME.LAST.

For more examples, **see** "Format-Specification List."

■ GET LIST

The GET LIST statement acquires character-string data from an input stream, which can be a stream file or a character-string expression. The stream file can be a declared file or the default file SYSIN. The acquired character strings are assigned to input targets named in the GET LIST statement, after being converted automatically to the targets' data types.

Use the GET LIST statement to read "unformatted" data from a stream file or character string. Because GET LIST does not require that data be aligned in specific columns, it is useful for acquiring input from a terminal.

The form of the GET LIST statement is as follows:

```
GET LIST (input-target,...)
  [ FILE(file-reference)                ]
  [       [SKIP[(expression)]]          ]
  [       [OPTIONS(option,...)]         ]
  [ STRING(expression)                  ]
;
```

input-target, . . .
The names of one or more variables to be assigned values from the input stream. Multiple input targets must be separated by commas.

An input target has one of the following forms:

```
reference
```

The reference is to a scalar or aggregate variable of any computational type. If the reference is to an array, data is assigned to array elements in row-major order. If the reference is to a structure, data is assigned to structure members in the order of their declaration.

```
(input-target,... DO reference=expression[TO expression]
[BY expression] [WHILE(expression)][UNTIL(expression)])
```

The input target can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of input target are in addition to the parentheses surrounding the entire input list.

```
(input-target,... DO reference=expression [REPEAT expression]
[WHILE (expression)][UNTIL(expression)])
```

The input target can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of input target are in addition to the parentheses surrounding the entire input list.

The DO specifications described for GET EDIT in the entry "Format-Specification List" are also applicable to GET LIST in most respects.

FILE(file-reference)
An option specifying that the input stream is a file; the reference is to a declared file variable or constant. If neither the FILE option nor the STRING option is specified, PL/I assumes the file SYSIN. This file is associated with the default system input file SYS$INPUT.

If a file is specified and is not currently open, PL/I opens it with the attributes STREAM and INPUT. The UNDEFINEDFILE condition is signaled if the file cannot be opened.

STRING(expression)

An option specifying that the input stream is a character-string expression. The STRING option cannot be used with the FILE option, nor can it be used with the OPTIONS or SKIP option.

Note that, as with list-directed input from a file, input fields must be separated by a space or comma. (**See** "Examples" below.)

SKIP [(expression)]

An option that advances the input file a specified number of lines before processing the input list. It can be used only with the implied or explicit FILE option. If the expression is specified, it indicates the number of lines to advance; if it is omitted, the default is to skip to the next line. The SKIP option is always executed first, before any other input or positioning of the input file, and regardless of its position in the statement.

OPTIONS (option, . . .)

An option specifies one or more of the following options. You can use this option only with the default or explicit FILE option; you cannot use it with the STRING option. Multiple options must be separated by commas.

NO_ECHO
NO_FILTER
PROMPT (string-expression)
PURGE_TYPE_AHEAD

The options are described fully in the *VAX PL/I User Manual.*

■ Specifying Input Data

The items to be read into the input targets are separated by a space or a single comma. Multiple spaces are treated as a single space, and a comma can be surrounded by spaces. The following rules apply:

- No items can be split across lines unless the split occurs inside a quoted string.
- Character strings do not have to be enclosed in apostrophes unless they contain a space or comma or are written on more than one line. When a character string is enclosed in apostrophes, n apostrophes

within the string are written as n+1 apostrophes; for instance, the word *isn't* would be specified as follows:

```
isn''t
```

- When a line begins with a comma or when two commas appear in the line without intervening nonspace characters, the item in the input-target list corresponding to that item is not updated. The target retains whatever value it contained before GET LIST was executed.
- Every input field, including the last input field in a line, must be terminated by a space or a comma. On input from a terminal, a space is appended to the last input field when a carriage return is typed (unless ENVIRONMENT(IGNORE_LINE_MARKS) is used or the carriage return is inside a quoted string).
- Input fields are also terminated by the end-of-file (FILE option) or end-of-string (STRING option), unless the end is encountered inside a quoted string.
- If an input request from GET LIST encounters a null record, the null character string (' ') is assigned, with appropriate conversion, to the corresponding input target. A null input record means a null record in a file or, if the input is from a terminal, a carriage return with no other input. **See** "Terminal Input/Output" for examples. If ENVIRONMENT(IGNORE_LINE_MARKS) is used for the input file, record terminators such as the carriage return are ignored, and the GET LIST statement waits until the input request is satisfied.
- The ERROR condition is signaled whenever a data item in the stream cannot be converted to the data type of the corresponding item in the input-target list.
- The ENDFILE condition is signaled if the end of the file is encountered during file input. The ERROR condition is signaled if the expression in the STRING option does not contain enough characters to complete processing of the input-target list.

Examples

```
GETS: PROCEDURE OPTIONS(MAIN);

DECLARE NAME CHARACTER(80) VARYING;
DECLARE AGE FIXED;
DECLARE (WEIGHT,HEIGHT) FIXED DECIMAL(5,2);
DECLARE SALARY PICTURE '$$$$$$V.$$';
DECLARE DOSAGE FLOAT;

DECLARE INFILE STREAM INPUT FILE;
DECLARE OUTFILE PRINT FILE;
```

```
GET FILE(INFILE)
 LIST(NAME,AGE,WEIGHT,HEIGHT,SALARY,DOSAGE);

PUT FILE(OUTFILE)
 LIST(NAME,AGE,WEIGHT,HEIGHT,SALARY,DOSAGE);
END GETS;
```

If the file INFILE.DAT contains the following data:

```
'Thomas R. Dooley',33,150.60,5.87,15000.50,5E-6,
```

then the program GETS writes the following output to OUTFILE.DAT:

```
Thomas R. Dooley 33 150.60  5.87  $15000.50  4.9999999E-06
```

In the input file (INFILE.DAT), the string 'Thomas R. Dooley' is surrounded by apostrophes so that the spaces between words will not be interpreted as field separators.

```
GSTR: PROCEDURE OPTIONS(MAIN);

DECLARE STREXP CHARACTER(80) VARYING;
DECLARE (A,B,C,D,E) FIXED;
DECLARE OUTFILE STREAM OUTPUT FILE;

OPEN FILE(OUTFILE) TITLE('GSTR.OUT');

STREXP = '1,2,3,4,5';
GET STRING(STREXP) LIST(A,B,C,D,E);
PUT FILE(OUTFILE) LIST(A,B,C,D,E);

END GSTR;
```

The program GSTR writes the following output to GSTR.OUT:

```
    1     2     3     4     5
```

For other examples, **see** "Terminal Input/Output."

■ GET SKIP

The GET SKIP statement positions the input file at the start of a new line. The format of this GET statement is as follows:

GET [FILE(file-reference)] SKIP [(expression)] ;

file-reference

The name of the file to be advanced one or more lines. If no file is specified, PL/I assumes the default file SYSIN. This file is associated with the default system input file SYS$INPUT.

If a file is specified and is not currently opened, PL/I opens it with the attributes STREAM and INPUT.

expression
An integer expression giving the number of lines to be advanced; the default is one line.

GLOBALDEF Attribute

The GLOBALDEF attribute declares an external variable or an external file constant. It can optionally control the program section in which the data is allocated.

The format of the GLOBALDEF attribute is as follows:

```
GLOBALDEF [ (psect-name) ]
```

psect-name
The name of a program section. A program section name can have up to 31 characters, which can consist of the alphanumeric characters, dollar signs ($), and underscores (_). The first character cannot be numeric (0 through 9).

If you do not specify a program section name, PL/I places the definition for the name in the default program section associated with the variable.

The GLOBALDEF attribute implies the EXTERNAL attribute. The GLOBALDEF attribute also implies STATIC except when used for file constants.

For complete details on using the GLOBALDEF attribute to declare global external symbols, **see** the *VAX PL/I User Manual.*

■ Restrictions

The GLOBALDEF attribute conflicts with the GLOBALREF and INTERNAL attributes. GLOBALDEF cannot be used with ENTRY constants.

Only one procedure in a program can declare a particular external variable with the GLOBALDEF attribute.

GLOBALREF Attribute

The GLOBALREF attribute indicates that the declared name is a global symbol defined in an external procedure.

The GLOBALREF attribute implies the EXTERNAL attribute. The corresponding name must be declared in another procedure with the GLOBALDEF attribute or, if the external procedure is written in another programming language, with its equivalent in that language.

For complete details on using the GLOBALREF attribute to declare global external symbols, **see** the *VAX PL/I User Manual.*

■ Restrictions

The GLOBALREF attribute conflicts with the INITIAL, GLOBALDEF, and INTERNAL attributes. If GLOBALREF is specified with the FILE attribute, you cannot specify any other file description attributes.

%GOTO Statement

The %GOTO statement causes the preprocessor to interrupt its sequential processing of source text and continue processing at the point specified in the %GOTO statement. A %GOTO is useful for avoiding large segments of text in the source program. The format of the %GOTO statement is as follows:

```
%GOTO label-reference;
```

label-reference
A label of a preprocessor statement. The label reference determines the point to which the compiler processing will be transferred.

Nonlocal %GOTOs are not permitted. In other words, if a %GOTO is used within a preprocessor procedure, control must not be passed out of the containing procedure. Also, a %GOTO must not transfer control into a preprocessor procedure.

The following example illustrates transfers (forward and backward) and the use of %GOTO:

```
%TEXT:PROCEDURE RETURNS(CHARACTER);
          .
          .
          .
%CHANG_TEXT: DO;
    .
    .
    .
%IF WARN() = 5
    %THEN
         %GOTO CHANG_TEXT;
    %ELSE;
         %GOTO INSERT_TEXT;
              .
              .
              .

%INSERT_TEXT: DO;
    .
    .
    .
%END;
```

Depending on the status of the %IF statement in this example, program compilation takes one of two courses. Control is transferred either forward to the statement labeled INSERT_TEXT or backward to the statement labeled CHANG_TEXT. The compiled program will then include one of the two blocks, but not both. Notice also in this example that the preprocessor built-in function WARN is used to determine preprocessor action, which makes the program self-diagnostic.

If program text is not compiled because the %GOTO statement transferred control over it, the compiler still checks the basic syntax of all statements. Therefore, comment delimiters and parentheses must balance, apostrophes must be paired correctly, and all statements must end with a semicolon.

For more information, **see** "Preprocessor."

GOTO Statement

The GOTO statement causes control to be transferred to a labeled statement in the current procedure or in any outer procedure. The format of the GOTO statement is as follows:

{ GOTO / GO TO } label-reference ;

label-reference

A label constant or an expression that, when evaluated, yields a label value. A label value denotes a statement in the program and a block activation. (**See** "Label.")

The specified label cannot be the label of an ENTRY, FORMAT, or PROCEDURE statement. The label reference specified in a GOTO statement can be any of the following:

- An unsubscripted label constant. For example:

```
    GOTO ALPHA;
       .
       .
       .
ALPHA:
```

- A subscripted label constant, for which the subscript is specified with an integer constant or a variable expression. For example:

```
    GOTO PROCESS(1);
       .
       .
       .
PROCESS(1):
```

- A label variable that, when evaluated, yields a label value. For example:

```
DECLARE PROCESS LABEL VARIABLE;
   .
   .
   .
PROCESS = BILLING;
   .
   .
   .
GOTO PROCESS;
```

- A subscripted label variable that, when evaluated, yields a label value. For example:

```
DECLARE X(5) LABEL;
X(1) = NEXT;

GOTO X(1);
```

In the case of a label variable, the resulting label value must designate an existing block activation. (Similarly, a label constant must designate an existing block activation.) If the designated block activation is the current block activation, the GOTO statement causes a local GOTO. No special processing occurs.

■ Nonlocal GOTO

If the specified label value is not in the current block, the GOTO statement is considered a nonlocal GOTO. The following can occur:

- The current block, and any blocks intervening between it and the block containing the label value, are released. This rule applies both to procedure blocks and to begin blocks.
- If a GOTO statement transfers control out of a procedure that is invoked in a function reference, the statement containing the function reference is not evaluated further.

See also "Procedure".

■ Examples

```
ON ERROR GOTO ERROR_MESSAGE;
```

The GOTO statement provides a transfer address for the current procedure when the ERROR condition is signaled.

```
DECLARE PROCESS(5) LABEL VARIABLE;
    .
    .
    .
GOTO PROCESS(2);
```

The GOTO statement evaluates the label reference and transfers control to the label constant corresponding to the second element of the array PROCESS. PROCESS consists of label variables.

For more information, **see** "Label."

H

HBOUND Built-In Function

The HBOUND built-in function returns a fixed-point binary integer that is the upper bound of an array dimension. Its format is as follows:

```
HBOUND(reference[,dimension])
```

reference
A reference to an array variable.

dimension
An integer constant indicating a dimension of the specified array. If the dimension is not specified, the dimension parameter defaults to 1. Thus, HBOUND(A) is equivalent to HBOUND(A,1).

See "Array" for an example.

HIGH Built-In Function

The HIGH built-in function returns a string of specified length that consists of repeated appearances of the highest character in the collating sequence. Its format is as follows:

```
HIGH(length)
```

length
The specified length of the returned string. The maximum length of the returned string is 32767 characters.

■ Returned String

The string returned is of the length specified. The rank of the highest character that can appear in the collating sequence for VAX PL/I is ASCII 255.

IDENT Option

The IDENT option, used with the PROCEDURE statement, places an identifying character string in the upper left corner of the listing file and in the object file, thus marking the module's "version" for the linker. The option format is as follows:

```
OPTIONS(IDENT(string)[,option,...])
```

string
A character-string constant giving the identifying label for the listing. Only the first 31 characters of the string are placed in the object module.

option
Other procedure options.

Identifier

An identifier is a user-supplied name for a procedure, a statement label, or a variable that represents a data item. The rules for forming identifiers are as follows:

- An identifier can have from 1 to 31 characters.
- An identifier can consist of any of the following characters:
  - The alphabetic letters A through Z and a through z. PL/I converts all lowercase letters to uppercase when it compiles a source program. Thus, the identifiers abc, ABC, Abc, and so on, all refer to the same identifier.
  - The numeric digits 0 through 9.
  - The underscore character (_).
  - The dollar sign character ($).

- An identifier cannot contain any blanks.
- An identifier must begin with an alphabetic letter, a dollar sign ($), or an underscore (_).

Following are some examples of valid identifiers:

```
STATE
total
FICA_PAID_YEAR_TO_DATE
ROUND1
SS$_UNWIND
```

%IF Statement

The %IF statement controls the flow of program compilation according to the scalar bit value of a preprocessor expression. The %IF statement tests the preprocessor expression and performs the specified action if the result of the test is true. The format of the %IF statement is as follows:

```
%IF test-expression %THEN action [%ELSE action];
```

test-expression
Any valid preprocessor expression that yields a scalar bit value. If any bit of the value is 1, then the expression is true; otherwise, the expression is false.

action
A single, unlabeled preprocessor statement, %DO-group, %GOTO statement, or a preprocessor null statement. The specified action must not be an %END statement.

The %IF statement evaluates the preprocessor test expression. If the expression is true, the action specified following the keyword %THEN is compiled. Otherwise, the action, if any, following the %ELSE keyword is compiled. In either case, compilation resumes at the first executable statement following the termination of the %IF statement, unless a %GOTO in one of the action clauses causes compilation to resume elsewhere.

If an action is not compiled because the alternative action was compiled instead, the compiler still checks the basic syntax of all statements. Therefore, comment delimiters and parentheses must balance, apostrophes must be paired correctly, and all statements must end with a semicolon.

For more information on the preprocessor, **see** "Preprocessor."

IF Statement

The IF statement tests an expression and performs a specified action if the result of the test is true. The format of the IF statement is as follows:

```
IF test-expression THEN action [ELSE action];
```

test-expression
Any valid expression that yields a scalar bit-string value. If any bit of the value is 1, then the test expression is true; otherwise, the test expression is false.

action
Any of the following:

- Any unlabeled statement except a DECLARE, END, ENTRY, FORMAT, or PROCEDURE statement
- An unlabeled DO-group or begin block

The IF statement evaluates the test expression. If the expression is true, the action specified following the keyword THEN is executed. Otherwise, the action, if any, specified following the ELSE keyword is executed.

■ Examples

```
IF A < B THEN BEGIN;
```

The begin block following this statement is executed if the value of the variable A is less than the value of the variable B.

```
IF ^SUCCESS
THEN
    CALL PRINT_ERROR;
ELSE
    CALL PRINT_SUCCESS;
```

The IF statement defines the action to be taken if the variable SUCCESS has a false value (the THEN clause) and the action to be taken otherwise (the ELSE clause).

For details on the syntax of specifying expressions, **see** "Expression."

■ Nested IF Statements

The action specified in a THEN or an ELSE clause can be another IF statement.

An ELSE clause is matched with the nearest preceding IF/THEN that is not itself matched with a preceding ELSE. For example:

```
IF ABC
THEN
    IF XYZ
    THEN
        GOTO GBH;
    ELSE
        GOTO THESTORE;
ELSE
    GOTO HOME;
```

In this example, the first ELSE clause is executed if ABC is true and XYZ is false. The second ELSE clause is executed if ABC is false.

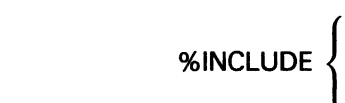
In some cases, proper matching of IF and ELSE can require a null statement (a semicolon) as the target of an ELSE. For example:

```
IF ABC
THEN
    IF XYZ
    THEN
        GOTO HOME;
    ELSE;
ELSE
    GOTO THESTORE;
```

In this example, the ELSE GOTO THESTORE statement is executed if ABC is false.

%INCLUDE Statement

The %INCLUDE statement incorporates text from other files into the current source file during compilation. It can occur anywhere in a PL/I source file; it need not be part of a procedure. The format of the %INCLUDE statement is as follows:



file-spec
A file specification enclosed in apostrophes. The specification is subject to logical name translation and the application of default values by the VMS operating system.

module-name
The 1- to 31-character name of a text module in a library of included files and/or other text modules.

library-name
The library containing the specified text module. Enclose the library and module in apostrophes. If you do not specify the library in the %INCLUDE statement, and if the text module is not in PLI$STARLET or in the text library pointed to by PLI$LIBRARY, you must specify the name of the library containing the module in the PLI compilation command.

When you include a text file or a text module from a library, you can choose to include this INCLUDE file in the program's listing by using the /LIST/SHOW=INCLUDE qualifiers in the PLI command line. Included text is noted in the listing with an "I" in the column to the right of the line numbers.

For details on the specification of files and libraries to be included in a PL/I compilation, **see** the *VAX PL/I User Manual.*

■ Examples

```
%INCLUDE 'SUM.PLI';
```

This statement copies the contents of the file SUM.PLI into the current file during compilation.

```
%INCLUDE SYSTEM_PROCEDURES;
```

This statement includes a module from a text module library. The library containing the module SYSTEM_PROCEDURES must be present in the command that compiles this program, or the logical name PLI$LIBRARY can point to the library that contains it.

```
%INCLUDE 'PROJECT_LIBRARY(MY_MODULE)';
```

This statement includes module MY_MODULE from the text library PROJECT_LIBRARY.TLB in the default directory.

■ Restrictions

%INCLUDE statements can be nested up to a maximum of four levels.

INDEX Built-In Function
INDEX Preprocessor Built-In Function

The INDEX built-in function returns a fixed-point binary integer that indicates the position of the leftmost occurrence of a specified substring within a string. If the substring is not found, or if the length of either argument is zero, the INDEX function returns zero. This function is case-sensitive.

The format of the function is as follows:

INDEX(string,substring[,starting-position])

string
The string to be searched for the given substring. It can be either a character-string or a bit-string expression.

substring
The substring to be located. It must have the same string data type as the string argument.

starting-position
A positive integer in the range 1 to n+1, where n is the length of the string. It specifies the leftmost position from which the search is to begin. (By default, the search begins at the left end of the string.)

■ Examples

1. ```
   DECLARE RESULT FIXED BINARY(31);
   RESULT = INDEX ('ABCDEF','DEF');
   ```

   RESULT is given the value 4 because the substring 'DEF' begins at the fourth position in 'ABCDEF'.

2. ```
   RESULT = INDEX('SHARP FORTUNE','R');
   ```

   RESULT is given the value 4 because the leftmost occurrence of 'R' is at the fourth position in 'SHARP FORTUNE'.

3. ```
   RESULT = INDEX('SHARP FORTUNE','R',5);
   ```

   The optional starting-position parameter specifies that the search begins at the fifth position of 'SHARP FORTUNE'. Thus, RESULT is given the value 9: the first R is ignored, so the first recognized occurrence of 'R' is found in the ninth position.
   ```

4.
```
NEW_STRING = '315-54-3159';
IF INDEX(NEW_STRING,'-')=4 THEN
  PUT LIST('SOCIAL SECURITY NUMBER');
```

The INDEX function is used to determine whether or not a string is a Social Security number. The function finds the location of the first hyphen in the string.

%INFORM Statement

The %INFORM statement specifies a user-written diagnostic informational message to be displayed during program compilation. The format of the %INFORM statement is as follows:

```
%INFORM preprocessor-expression;
```

preprocessor-expression
The text of the informational message displayed. The text is a character string of up to 64 characters. The string is truncated if necessary.

■ Returned Message

The format of the message to be displayed by %INFORM is as follows:

```
%PLIG-I-USERDIAG, preprocessor-expression
```

The %INFORM statement increments the informational diagnostic count displayed in the compilation summary.

For further information on preprocessor diagnostic messages, **see** "User-Generated Diagnostic Messages."

INFORM Preprocessor Built-In Function

The INFORM preprocessor built-in function returns the number of diagnostic informational messages issued during compilation up to that point in the source program. The format for the INFORM built-in function is as follows:

```
INFORM();
```

The function returns a FIXED result representing the number of compile-time warning messages that were issued up until the INFORM built-in function was encountered.

INITIAL Attribute

The INITIAL attribute provides an initial value for a declared variable. The format of the INITIAL attribute is as follows:

```
{ INITIAL } { (initial-element[,initial-element...]) }
{ INIT    } { ((*) valid-expression)                 }
```

initial-element

A construct that supplies a value for the initialized variable. The value must be valid for assignment to the initialized variable. If the initialized variable is an array, a list of initial elements separated by commas is used to initialize individual elements. The number of initial elements must be 1 for a scalar variable and must not exceed the number of elements of an array variable. Each initial element must have one of the following forms:

- string-constant
- (replication-factor) string-constant
- (iteration-factor) (string-constant)
- (iteration-factor) ((replication-factor) string-constant)
- [(iteration-factor)] arithmetic-constant
- [(iteration-factor)] scalar-reference
- [(iteration-factor)] (scalar-expression)
- [(iteration-factor)] *

The iteration factors are nonnegative integer-valued expressions that specify the number of successive array elements to be initialized with the following value.

An asterisk following the iteration factor specifies that the corresponding array elements are to be skipped during the initialization.

You can use a replication factor in combination with an iteration factor in initializing a string constant. For example, the following two statements are equivalent:

```
INITIAL ((10)('ABCABC'))

INITIAL ((10)((2)'ABC'))
```

The first statement uses an iteration factor exclusively; the second statement combines an iteration factor of 10 with a replication factor of 2.

Note that a string constant must be parenthesized if it is used with an iteration factor, because this set of parentheses prevents the iteration factor from being interpreted as a string replication factor. The initial value

```
INITIAL ((10)'ABC')
```

is interpreted as a string replication factor, not an iteration factor, and cannot be used to initialize a whole array. (**See** "Replication Factor.")

(*) valid-expression

A construct that initializes all elements of an array to the same value by means of the asterisk iteration factor. The expression must evaluate to a value that is valid for assignment to the initialized array. If the expression is a string constant, it must be parenthesized so that the asterisk iteration factor is not interpreted as a string replication factor. The possible expressions are as follows:

- (string-constant)
- ((replication-factor) string-constant)
- arithmetic-constant
- scalar-reference
- (scalar-expression)
- *

An asterisk following the asterisk iteration factor results in no initializations being performed.

■ Examples

Following are some examples of declarations including the INITIAL attribute:

```
DECLARE RATE FIXED DECIMAL (2,2) STATIC INITIAL (.04);

DECLARE SWITCH BINARY STATIC INITIAL ('1'B);

DECLARE BELL_CHAR BINARY STATIC INITIAL ('07'B4);

DECLARE OUTPUT_MESSAGE CHARACTER(20) STATIC
           INITIAL ('GOOD MORNING');

DECLARE (A INITIAL ('A'), B INITIAL ('B'),
     C INITIAL ('C')) STATIC CHARACTER;

DECLARE QUEUE_END POINTER STATIC INITIAL(NULL());

DECLARE X(10,5) FIXED BIN(31) INITIAL ((*) -2);  /* Initializes all 50
                                                    elements to -2    */
```

```
DECLARE 1 A(10),
         2 B(10),
           3 C(10) FIXED BIN(31) INITIAL ((*) 4);  /* Initializes all
                                                      1000 elements
                                                      to 4          */

DECLARE A(10) FIXED INIT ((5) 1,(5) 2);           /* Initializes the first
                                                      5 elements to 1 and
                                                      the second 5 elements
                                                      to 2          */
```

Note that the following declaration is not valid, because the asterisk iteration factor cannot be used to initialize part of an array; it can only be used to initialize all elements of the array to the same value.

```
DECLARE A(10) FIXED INIT ((5) 1,(*)2);            /* Invalid use of asterisk
                                                      iteration factor  */
```

■ Restrictions

You cannot specify the INITIAL attribute for a structure variable. You must individually initialize the members of the structure.

You cannot specify the INITIAL attribute for a variable or member of a structure that has any of the following attributes:

DEFINED
ENTRY
FILE
LABEL
PARAMETER
UNION

You cannot specify the INITIAL attribute for a member of a structure unless the entire structure has the STATIC, AUTOMATIC, BASED, or CONTROLLED attribute.

If the initialized variable is STATIC, only constants, restricted expressions, (**see** "Restricted Expression") and references to the NULL or EMPTY built-in functions are allowed. These initial values can be used with a constant iteration factor.

Variables and functions (except for parameters) occurring in an initial element (for automatic variables) must not be declared in the same block as the variable being initialized.

INPUT Attribute

The INPUT file description attribute indicates that the associated file is to be an input file; that is, the file represents an external source of data.

Specify the INPUT attribute on a DECLARE statement for a file constant or on an OPEN statement to access the file for reading.

You can specify the INPUT attribute with either the STREAM or the RECORD attribute. For a stream file, INPUT indicates that the file will be accessed with GET statements. For a record file, INPUT indicates that the file will be accessed only with READ statements.

For example:

```
DECLARE INFILE RECORD INPUT;

OPEN FILE(INFILE);
READ FILE(INFILE) INTO(RECORD_BUFFER);
```

These statements declare, open, and access the first record in the input file INFILE.

For a description of the attributes that can be applied to files and the effects of combinations of those attributes, **see** "File Description Attributes and Options."

The INPUT attribute can be supplied by default for a file, depending on the context of its opening. **See** "Opening a File."

■ Restrictions

The INPUT attribute conflicts with the OUTPUT, UPDATE, and PRINT attributes and with any data type attribute other than FILE.

Input/Output Processing

The VAX PL/I compiler's I/O routines are independent of I/O routines for compilers of other VMS languages. Thus, it is not possible for a routine written in PL/I to share an input or output device with a routine written in a different language.

PL/I provides extensive facilities for transmitting data between variables in a PL/I program and RMS files or communication devices such as terminals. There are two basic types of I/O in PL/I:

- Stream I/O, where the external data (which can be an RMS file or a device) is treated as a stream of ASCII characters divided into fields

delimited by spaces, tabs, or commas, or by other field specifications. Stream I/O is performed by the GET and PUT statements. These statements also perform conversion between the internal representation of data and the ASCII representation of the data.

- Record I/O, where an operation transmits an entire record. Record I/O is performed by the READ, WRITE, DELETE, and REWRITE statements. These statements can be used to process files with the sequential, relative, and indexed sequential file organizations.

Each of these types of I/O is described individually in this manual (**see** "Stream Input/Output" and "Record Input/Output"). For an overview of how to declare and reference files in PL/I, **see** the entry "File."

INT Built-In Function

The INT built-in function treats specified storage as a signed integer, and returns the value of the integer. Its format is as follows:

```
INT(expression[,position[,length]])
```

expression

A scalar expression or reference to connected storage. This reference cannot be an array, structure, or named constant. If position and length are not specified, the length of the referenced storage must not exceed 32 bits. If it exceeds 32 bits, a FATAL run-time error results.

position

A positive integer value that denotes the position of the first bit in the field. If omitted, position defaults to 1, signifying the first bit of storage denoted by the expression. If specified, position must satisfy the following condition:

$$1 <= position <= size(expression)$$

where size(expression) is the length in bits of the storage denoted by expression. A position equal to size(expression) implies a zero-length field.

length

An integer value in the range 0 through 32 that specifies the length of the field. If omitted, length is the number of bits from the bit denoted

by position through the end of the storage denoted by expression. If specified, length must satisfy the following condition:

$$0 <= length <= size(expression) - position$$

where size(expression) is the length in bits of the storage denoted by expression.

■ Returned Value

The value returned by INT is of the type FIXED BINARY (31). If the field has a length of zero, INT returns zero.

■ Examples

The following example shows the use of the INT built-in function to interpret the storage occupied by a bit string as an integer:

```
B16 = '0000000000001101'B;      /* 16-bit string */

I = BIN(B16);                   /* I = 13 */
I = INT(B16);                   /* I = -20480 */

B64 = '5076ABCD00000000'B4;     /* 64-bit string */

I = INT(B64,1,32);              /* First 32 bits; I = -1277858294 */
I = INT(B64,33);                /* Second 32 bits; I = 0 */
I = INT(B64);                   /* Field too large, run-time error */
```

Notice that, unlike the BIN built-in function, the INT built-in function performs no conversion. It simply treats the contents of the designated storage as a signed integer. Therefore, the value returned by INT depends on the data type (and therefore the internal representation) of the variable occupying the storage. For example:

```
INTEXM: PROCEDURE OPTIONS (MAIN);

DECLARE D FIXED DECIMAL (3,2),
        C CHARACTER (4),
        F FLOAT;

    D = 2.54;
    C = '2.54';
    F = 2.54;

    PUT SKIP LIST ( INT(D),
                    INT(C),
                    INT (F) );

    END;
```

The output of this example is as follows:

```
19493      875900466      -1889779422
```

INT Pseudovariable

The INT pseudovariable assigns a signed integer value to specified storage. Its format is as follows:

```
INT(reference[,position[,length]]) = expression;
```

reference
A reference to connected storage. This reference must not be an array, structure, or named constant. If position and length are not specified, the length of the referenced storage must not exceed 32 bits. If it exceeds 32 bits, a FATAL run-time error results.

position
A positive integer value that denotes the position of the first bit in the field. If omitted, position defaults to 1, signifying the first bit of the storage denoted by reference. If specified, position must satisfy the following condition:

$$1 <= position <= size(reference)$$

where size(reference) is the length in bits of the storage denoted by reference. A position equal to size(reference) implies a zero-length field.

length
An integer value in the range 0 through 32 that specifies the length of the field. If omitted, length is the number of bits from the bit denoted by position through the end of the storage denoted by reference. If specified, length must satisfy the following condition:

$$0 <= length <= size(reference) - position$$

where size(reference) is the length in bits of the storage denoted by reference.

The INT pseudovariable is valid only in an assignment statement. You cannot use it as the target of an input statement or in other instances where pseudovariables are normally acceptable.

The expression to be assigned to the pseudovariable is first converted to the data type FIXED BINARY (31); then, the internal representation of the resulting integer value is assigned to the storage specified by the arguments to INT. If the representation of the value is too large for assignment to the storage, the most significant bits of the integer are removed and no error is signaled.

■ Examples

```
DECLARE F FLOAT INITIAL (123.45);

     INT(F,8,8) = 25;      /* Alter the exponent */
     PUT SKIP LIST (F);    /* New value */
```

In this example, the INT pseudovariable is used to modify the exponent field of a floating-point variable. This example prints the following value:

```
9.5102418E-32
```

Proper interpretation of this result requires understanding of the internal representation of floating-point numbers.

The next example demonstrates how the INT pseudovariable treats cases in which the value is too large for the specified storage:

```
INTOVER: PROCEDURE OPTIONS (MAIN);

DECLARE I15 FIXED BINARY (15),
        I31 FIXED BINARY (31);

ON FIXEDOVERFLOW PUT SKIP LIST ('FIXEDOVERFLOW signaled');

    I31 = -876543;        /* Too big for I15 */

    I15 = I31;            /* Arithmetic assignment */
    INT(I15) = I31;       /* No error signaled */
    PUT SKIP LIST (I15);

    END;
```

This example produces the following output:

```
FIXEDOVERFLOW signaled
   -24575
```

The arithmetic assignment to I15 signals FIXEDOVERFLOW because the value of I31 is outside the range of a FIXED BINARY (15) variable. However, the assignment using the INT pseudovariable does not signal an error; it just copies the low-order 16 bits of the value of I31 into the storage for I15.

Integer Data

Integer data is used for values that can be expressed in integers: counters, array subscripts, record numbers, and so on.

■ Constants

An integer constant can contain one or more of the decimal digits 0 through 9 and, optionally, a sign. Some examples of integer constants are as follows:

```
1
245
-88
```

All integer constants have fixed decimal values.

■ Variables

Integer variables can be declared as fixed-point binary or fixed-point decimal with a zero scale factor.

The format of a declaration of a fixed binary integer variable is as follows:

```
DECLARE identifier FIXED [BINARY] [(p)];
```

identifier
The name to be used for the variable.

p
An integer constant representing the precision, that is, the number of binary digits used to represent values of the variable. The precision must be in the range 1 through 31. If you do not specify a precision, PL/I uses the default precision of 31.

Because fixed binary variables have a maximum precision of 31, fixed binary integers can have values only in the range of –2,147,483,648 through 2,147,483,647. An attempt to calculate a binary integer outside this range in a context that requires an integer value signals the FIXEDOVERFLOW condition.

Specify a fixed-point decimal integer variable as follows:

```
DECLARE identifier [FIXED] DECIMAL [(p)];
```

identifier
The name to be used for the variable.

p
The precision of the variable in decimal digits. The maximum precision you can specify for a fixed-point decimal variable is 31. If you omit the precision, 10 is the default.

For the internal representation and other details of binary and decimal integers, **see** "Fixed-Point Binary Data" and "Fixed-Point Decimal Data."

INTERNAL Attribute

The INTERNAL attribute limits the scope of an identifier to the block in which the identifier is declared and its dynamic descendents. The format of the INTERNAL attribute is as follows:

```
{ INTERNAL }
{ INT      }
```

You need use the INTERNAL attribute only to explicitly declare the scope of a file constant as internal. File constants, by default, have the EXTERNAL attribute. All other variables are internal by default.

■ Restrictions

The INTERNAL attribute directly conflicts with the EXTERNAL, GLOBALDEF, and GLOBALREF attributes.

Internal Procedure

An internal procedure is a procedure contained within another procedure. The name of the internal procedure is declared by its use as the label of the PROCEDURE statement.

See "Procedure."

Internal Representation of PL/I Data

This entry describes the internal representations used by VAX PL/I for PL/I data types. For additional information, refer to the entries on individual data types; for examples, **see** "Bit-String Data."

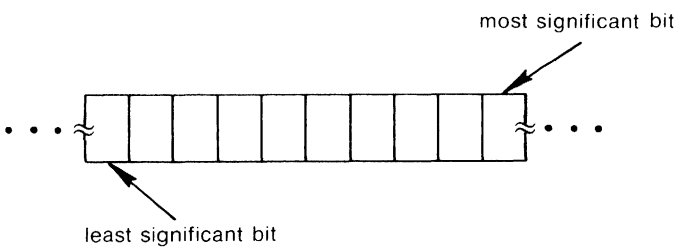
■ Internal Representation of Bit Data

The way that PL/I allocates storage for a bit-string variable depends on whether the variable is declared with the ALIGNED attribute.

In this discussion, the term "most significant bit" means the leftmost bit in an external representation of the string, as, for example, when the string is output by the PUT LIST statement. The "least significant bit" is the rightmost bit in the external representation.

Unaligned Bit Strings

An unaligned bit string is stored beginning at an arbitrary bit location in storage; this location marks the most significant bit. The subsequent, less significant, bits are stored in progressively higher locations in memory, as shown here:



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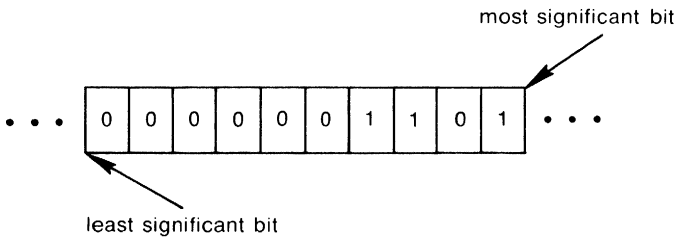
The following programming sequence illustrates how a value for an unaligned bit-string variable is stored:

```
DECLARE ABIT BIT (10);
ABIT = '1011'B;
```

After the assignment, the variable appears in storage as follows:



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Aligned Bit Strings

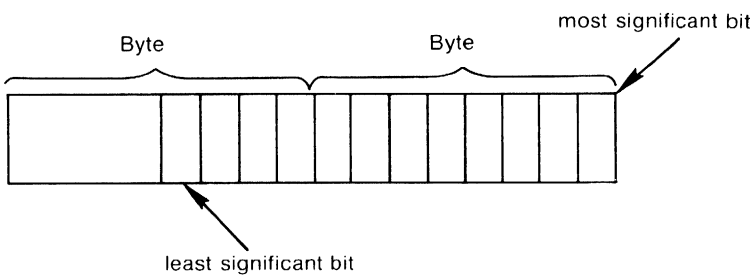
PL/I allocates an integral number of bytes for an aligned bit-string variable, beginning on a byte boundary. The number of bytes to be allocated is calculated as follows:

$$ceil(n/8)$$

Here, n is the length specified for the bit string.

Beginning at bit 0 (the lowest memory location) of the lowest allocated byte, the bit string is stored like unaligned bit-string data; that is, the beginning bit is used to hold the most significant bit in the string. Less significant bits are stored in progressively higher memory locations. Unused bits are set to zero each time the bit-string variable is assigned a value.

The representation is as follows:



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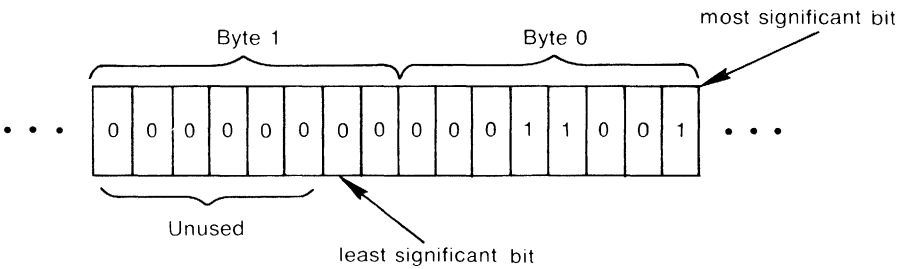
The following programming sequence illustrates how values are stored for aligned bit strings:

```
DECLARE ABIT BIT (10) ALIGNED;
ABIT = '10011'B;
```

In this example, the variable ABIT is aligned. When it is assigned the value 10011, its storage appears as follows:



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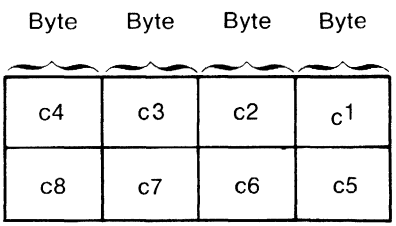
■ Internal Representation of Character Data

PL/I stores fixed-length character-string data from right to left, with each character occupying a byte of storage, as shown here:



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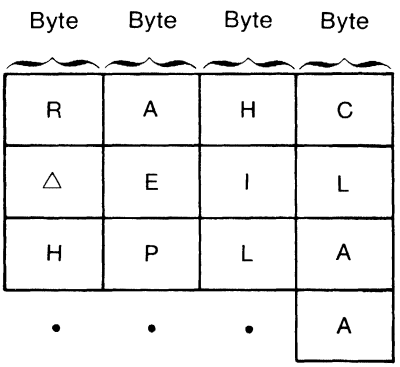
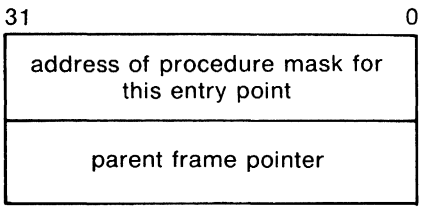
For example, a character string whose value is 'CHARLIE␣ALPHA' appears as follows in storage:



Varying-length strings are stored in a number of bytes equal to n+2, where n is the declared maximum length. The two additional bytes contain, in the first two byte addresses, the current length of the value (in bytes).

■ Internal Representation of Variable Entry Data

The following figure illustrates the internal representation of variable entry data.



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■ Internal Representation of File Data

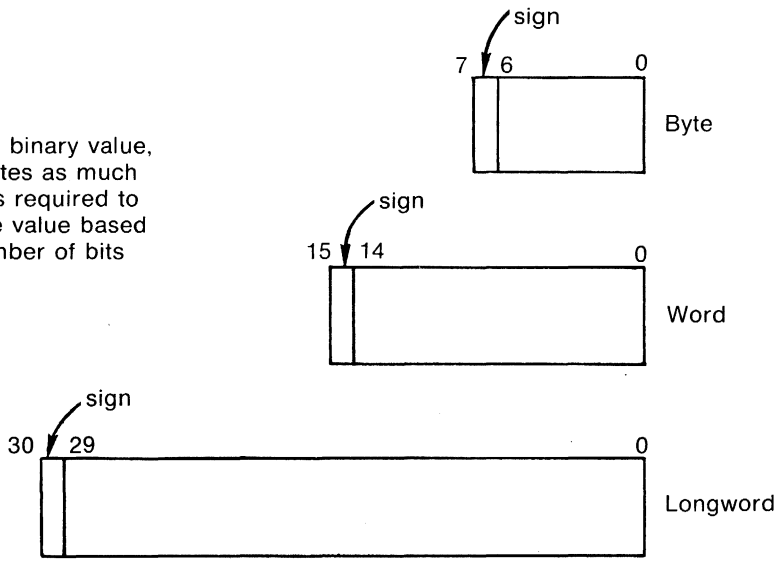
A PL/I file or file constant is represented internally by a file control block. A file control block is an internal data structure maintained by PL/I.

A file variable is represented internally as a longword that contains a pointer to a file control block. The value of the file variable, when evaluated, is the address of the file control block for the file with which the variable is currently associated.

■ Internal Representation of Fixed-Point Binary Data

The following figure illustrates the internal representation of fixed-point binary data.

For a fixed binary value, PL/I allocates as much space as is required to contain the value based on the number of bits needed.



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Storage for fixed-point binary variables is always allocated in a byte, word, or longword. For any fixed-point binary value:

- If the value is in the range 1 through 7, a byte is allocated.
- If the value is in the range 8 through 15, a word is allocated.
- If the value is in the range 16 through 31, a longword is allocated.

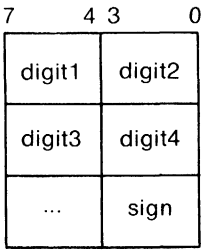
The binary digits of the stored value go from right to left in order of increasing significance; for example, bit 6 of a FIXED BINARY(7) value is the most significant bit and bit 0 is the least significant.

In all cases, the high-order bit (7, 15, or 31) is used for the sign.

■ Internal Representation of Fixed-Point Decimal Data

Fixed decimal data is stored in packed decimal format. Each digit is stored in a half-byte, as illustrated below. The last half-byte contains, in bits 0 through 3, a value indicating the sign. Normally, the hexadecimal value C indicates a positive value and the hexadecimal value D indicates a negative value.

The following figure illustrates the internal representation of fixed-point decimal data.



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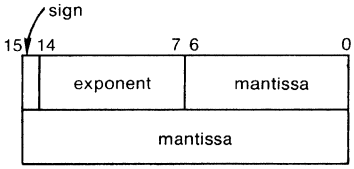
■ Internal Representation of Floating-Point Data

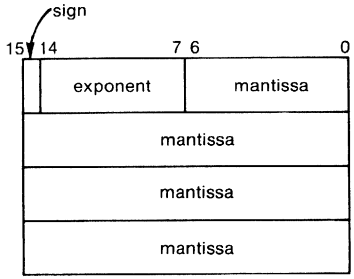
In all VAX floating-point formats, the value 0 is indicated by a zero sign bit and all-zero exponent bits. Thus, for example, a value with a 24-bit fraction and an 8-bit exponent can be represented in single-precision format, even though only 23 bits in the format are allocated for the fraction.

The double-precision and G-floating formats, as used by PL/I, have the same fractional precision; G-floating format allows an extra three bits for the exponent. Notice that the double-precision format has 56 bits available for the fraction, although only 53 bits are used by PL/I. If you specify a floating-point binary precision in the range 54 to 56, and you do not use the G_FLOAT compiler qualifier, the number is represented in double-precision format. (If the G_FLOAT qualifier is used, numbers with this range of precision are represented by the H-floating format.) This small reduction in the precision of double-precision numbers is necessary so that the compiler does not select H-floating format on machines that lack the necessary hardware. The intent is that the size of a structure containing double-precision data is preserved regardless of whether the G_FLOAT qualifier is used.

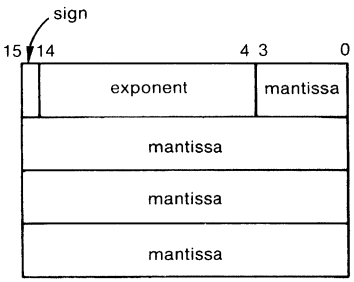
The following figure illustrates the internal representation of floating-point data.



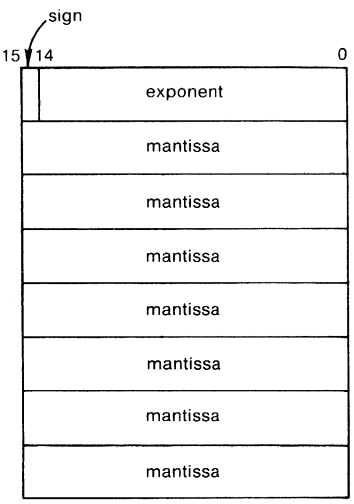
ZK-1297-83



ZK-1298-83



ZK-1299-83



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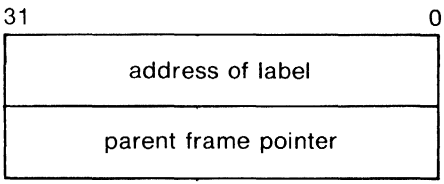
■ Internal Representation of Variable Label Data

The following figure illustrates the internal representation of variable label data.



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■ Internal Representation of Pointer Data

A pointer occupies a longword (32 bits) of storage and represents a virtual memory address.

Internal Variable

An internal variable is a variable that is known only within the block in which it is defined and within all contained blocks. By default, PL/I gives all variables the internal attribute.

See "Block" and "Scope of Names."

INTO Option

The INTO option is specified in a READ statement to designate a variable into which the contents of a record from a record file are to be copied. This option is specified in the format as follows:

```
INTO (variable-reference)
```

variable-reference
A reference to a variable into which the contents of the record are to be copied.

For example:

```
READ FILE (INFILE) INTO (RECORD_BUFFER);
```

This READ statement reads the next sequential record in the file INFILE and copies the contents of the record into the variable RECORD_BUFFER.

See "READ Statement."

Iteration Factor

An iteration factor is a syntactical method of requesting a specific operation or function more than once. In most cases, an iteration factor is an integer constant that specifies the number of times a particular item is to be repeated.

Iteration factors are allowed in the following contexts:

- Format-specification lists (**see** "Format-Specification List")
- Initialization of array elements (**see** "INITIAL Attribute" and "Array")
- Picture character specifications (**see** "Picture")

K

Key

A key is a value that identifies a specific record in a relative file, in a sequential disk file with fixed-length records, or in an indexed sequential file. The nature of the key depends on the file's organization, as follows:

- If the file is a relative file or a sequential disk file with fixed-length records, the key is a fixed binary value indicating the relative number of the record.
- If the file is an indexed sequential file, the key specifies a key that is contained within a record. The data type of the key and its location within the record are as specified when the file was created.

See individual entries for the READ, WRITE, DELETE, and REWRITE statements for details on how these statements interpret and use keys. For details on defining key fields for the creation of an indexed sequential file, **see** the *VAX PL/I User Manual.*

KEY Condition Name

The KEY condition name can be specified in an ON, SIGNAL, or REVERT statement to designate a key error condition or ON-unit for a specific file.

The format of the KEY condition name is as follows:

```
KEY (file-reference)
```

file-reference
A reference to the file constant or file variable for which the ON-unit is to be established. If the name of a file variable is specified, the variable must be resolved to the name of a file constant when the condition is signaled.

PL/I signals the KEY condition during an operation on a keyed file when an error occurs in processing a key. Some examples of errors for which PL/I signals the KEY condition follow:

- The record indicated by the specified key cannot be found.
- The key specification requires conversion from one data type to another and the conversion is not valid.
- The key is not correctly specified.
- The key of a relative file exceeds the maximum record number specified when the file was created.

An ON-unit established to handle the KEY condition can obtain information about the condition by invoking the following built-in functions:

- The ONFILE built-in function returns the name of the file being processed when the condition was signaled.
- The ONCODE built-in function returns the specific condition value associated with the error.
- The ONKEY built-in function returns the key value that caused the condition to be signaled.

■ ON-Unit Completion

If the ON-unit does not execute a nonlocal GOTO, control returns to the statement immediately following the statement that caused the KEY condition.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

KEY Option

The KEY option can be specified in a READ, REWRITE, or DELETE statement to indicate a specific record in a file that is opened with the KEYED attribute. This option is specified in the format as follows:

```
KEY (expression)
```

expression
An expression giving the key value that identifies the record of interest.

For example:

```
DELETE FILE (CUST_ACCT) KEY (NAME);
```

This DELETE statement deletes the record in the file CUST_ACCT that has the key value represented by the variable NAME.

KEYED Attribute

The KEYED file description attribute indicates that records in the specified file can be accessed randomly. The KEYED attribute implies the RECORD attribute.

Specify KEYED in a DECLARE statement to identify a file or in an OPEN statement to open the file. For a description of the attributes that can be applied to files and the effects of combinations of these attributes, **see** "File Description Attributes and Options."

■ Restrictions

The KEYED attribute conflicts with the STREAM attribute and with any data type attributes other than FILE.

KEYFROM Option

The KEYFROM option can be specified in a WRITE statement to write a record to a file opened with the KEYED attribute. The KEYFROM option designates the key associated with the record. This option is specified in the format as follows:

KEYFROM (expression)

expression
An expression giving the key value that indicates the record of interest. The specified value must have one of the computational data types.

For example:

```
WRITE FILE (EMPLOYEE_REC) FROM (EMP_DATA)
      KEYFROM (EMPLOYEE_NUMBER);
```

This WRITE statement writes a record to the file EMPLOYEE_REC by specifying the KEYFROM option.

See "WRITE Statement."

KEYTO Option

The KEYTO option can be specified in a READ statement to obtain the key associated with a record that was read sequentially. This option is specified in the format as follows:

KEYTO (variable-reference)

variable-reference
A reference to a computational variable to be assigned the value of the key.

For example:

```
READ FILE (STATE_FILE) INTO (STATE_BUFFER)
          KEYTO (SAVE_NAME);
```

This READ statement reads the next sequential record in the file STATE_FILE into the variable STATE_BUFFER. The key associated with the record that is read is copied into the variable SAVE_NAME.

See "READ Statement."

Keyword

A keyword is a name that has a special meaning to PL/I when used in a specific context. In PL/I, keywords identify the language elements, including the following:

- Statements—for example, DECLARE, END, or READ
- Attributes—for example, DECIMAL, CHARACTER, or FILE
- Options—for example, KEYFROM, SKIP, or REPEAT

PL/I recognizes keywords when they appear in the correct context. You can also use keywords as identifiers. For example:

```
DECLARE DECLARE FIXED BINARY (6);
```

In this statement, PL/I interprets the first occurrence of DECLARE as the keyword DECLARE because of its position in the statement. It interprets the second occurrence of DECLARE as an identifier because of its position.

■ Abbreviating Keywords

You can abbreviate some PL/I keywords. For the valid abbreviations of PL/I keywords, **see** "Abbreviation," Appendix A, or the entry for an individual keyword.

L

Label

A label identifies a statement so that it can be referred to elsewhere in the program, for example, as the target of a GOTO statement. A label precedes a statement and consists of any valid identifier terminated by a colon. Some examples are as follows:

```
TARGET: A = A + B;
READ_LOOP: READ FILE (TEXT) INTO (TEMP);
```

These statements contain the implicit declarations of the names TARGET and READ_LOOP as label constants.

No statement can have more than one label. A statement can, however, be preceded by any number of labeled null statements. For example:

```
A: ;
B: DO I = 1 TO 5;
```

Other statements in the program can refer to the DO statement in this example by specifying either label A or label B.

A name occurring as a statement label is implicitly declared as a label constant. It has the attributes LABEL and constant. You cannot explicitly declare label constants.

■ Label Array Constants

Any label constant except the label of a PROCEDURE or FORMAT statement can have a single subscript. Subscripts must be specified with integer constants; a subscript must appear in parentheses following the label name. For example:

```
PART(1):
   .
   .
   .
PART(2):
   .
   .
   .
```

When labels are written this way, the unscripted label name represents the implicit declaration of a label array constant. In this example, the array is named PART and is treated as if it were declared within the block containing the subscripted labels. Elements of this array can be referenced in GOTO statements that specify a subscript, for example:

```
GOTO PART(I);
```

where I is a variable whose value represents the subscript of the element of PART that is the label to be given control.

Within a single block, you cannot use the same subscript value in two different subscripted references with the same name. For example:

```
PART(1):
```

This label array constant can be used only once in a block. However, the subscript values are not constrained to be in any particular order or to be consecutive. For example, you can use the array constants PART(1) and PART(3) without using PART(2).

If a name is used as a label array constant in two or more different blocks, each declaration of the name is treated as an internal declaration. For example:

```
LIST(2): RETURN;
BEGIN;
   GOTO LIST (ELEMENT);
   LIST(1):;
   LIST(3):
   END;
```

In this example, the value of ELEMENT cannot cause control to pass to the RETURN statement labeled LIST(2) in the containing block. The subscripted LIST labels in the begin block restrict the scope of the name to that block. (**See** "Scope of Names" for a further illustration of the scope of internal names.)

■ Label Values

Whenever a reference to a label constant is interpreted, the result is a label value. A label value has two components:

- The first component designates the statement identified by the label constant.
- The second component designates an activation of the block in which the label was declared (that is, to which the labeled statement belongs). If the label belongs to the current block, this block activation is the current block activation. If the label belongs to a containing block, the activation is found on the chain of parent block activations ending with the current block. (For additional details on block activations, **see** "Block.")

The GOTO statement with a label reference transfers control to the designated statement in the designated block activation. If the target block activation is different from the block activation in which the GOTO statement is executed, then the GOTO is nonlocal. For example:

```
DECLARE LV LABEL; /* LABEL variable */
    .
    .
    .
LV = L;           /* assigns a bound label value to LV */

BEGIN;
    .
    .
    .
GOTO LV;          /* nonlocal GOTO */
END;

L: RETURN;
```

Operations on label values are restricted to the operators = and ^=, for testing the equality or inequality of two values. Two values are equal if they refer to the same statement in the same block activation.

Any reference to a label value after its block activation ceases to exist is an error with unpredictable results.

■ Preprocessor Labels

You can use labels on preprocessor statements. As with other labels in PL/I, they are used as the target of program control statements. A preprocessor label must be an unsubscripted label constant. The format for a preprocessor label is as follows:

```
%label: preprocessor-statement;
```

A percent sign (%) is required before the label. The percent sign alerts the compiler that all subsequent text, until the line is terminated with a semicolon, is preprocessor text. Therefore, no other percent signs are required on that line. For complete descriptions of preprocessor statements, **see** the individual entries.

■ Label Variables

When an identifier is explicitly declared with the LABEL attribute, it acquires the VARIABLE attribute by default. Such a variable can be used to denote different label values during the execution of the program. For example:

```
DECLARE PROCESS LABEL;
   .
   .
   .
   IF CODE THEN
      PROCESS = BILLING;
   ELSE
      PROCESS = CHARGE;
   .
   .
   .
GOTO PROCESS;
```

When the GOTO statement evaluates the reference to the label PROCESS, the result is the current value of the variable. The GOTO statement transfers control to either of the labels BILLING or CHARGE, depending on the current value of the Boolean variable CODE.

You can also give values to label variables by passing label values as arguments or by returning a label value as the value of a function (although the latter method can lead to programming errors that are difficult to diagnose). For example:

```
CALL COMPUTER(ERROR_EXIT, YVAL, XVAL);
    .
    .
    .
ERROR_EXIT:
```

In this example, the actual argument that is passed for ERROR_EXIT is a dummy argument whose value consists of the following:

- The location in memory of the statement labeled ERROR_EXIT
- A pointer to the stack frame for the block in which the CALL statement is executed

■ Restrictions

Any statement in a PL/I program can be labeled except the following:

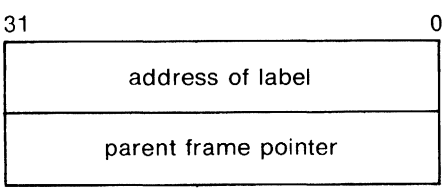
- A DECLARE statement
- A statement beginning an ON-unit or THEN, ELSE, WHEN, or OTHERWISE clauses

Labels on PROCEDURE, ENTRY, and FORMAT statements are not considered statement labels and cannot be used as the targets of GOTO statements.

An identifier occurring as a label in a block cannot be declared in that block (except as a structure member), and cannot occur in a parameter list of that block.

■ Internal Representation of Variable Label Data

The following figure illustrates the internal representation of variable label data:



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LABEL Attribute

The LABEL attribute declares a label variable; it indicates that values given to the variable will be statement labels.

■ Restrictions

You cannot specify the LABEL attribute with any other data type attribute, the INITIAL attribute, or any file description attributes.

LBOUND Built-In Function

The LBOUND built-in function returns a fixed-point binary integer that is the lower bound of an array dimension. Its format is as follows:

```
LBOUND(reference[,dimension])
```

reference
A reference to an array variable.

dimension
An integer constant indicating the dimension of the specified array. If the dimension is not specified, the dimension parameter defaults to 1. Thus, LBOUND(A) is equivalent to LBOUND(A,1).

See "Array" for an example.

LEAVE Statement

The LEAVE statement causes control to be transferred out of the immediately containing DO-group or out of the containing DO-group whose label is specified with the statement. The format of the LEAVE statement is as follows:

```
LEAVE [label-reference];
```

label-reference
A reference to a label on a DO statement that heads a containing DO-group. The label reference can be a label constant or a subscripted label constant for which the subscript is specified with an integer constant. The label reference cannot be a label variable, nor can it be a subscripted label constant for which the subscript is specified with a variable.

On execution, a LEAVE statement with no label reference causes control to be transferred to the first statement following the END statement that terminates the immediately containing DO-group. If the LEAVE statement has a label, control is passed to the first executable statement following the end statement for the corresponding label indicated in the LEAVE statement. Thus, the LEAVE statement provides an alternative means of terminating execution of a DO-group. In the case of a LEAVE statement with a label reference, several nested DO-groups can be terminated as control transfers outside the referenced DO-group.

■ Restrictions

The following restrictions apply to the use of the LEAVE statement:

- A LEAVE statement must be contained within a DO-group.
- A LEAVE statement must be in the same block as the DO statement to which it refers.
- If a LEAVE statement has a label reference, it must refer to a label on a DO statement that heads a DO-group that contains the LEAVE statement. The LEAVE statement must be in the same block as the labeled DO statement.
- The label reference specified with a LEAVE statement must be a label constant or a subscripted label constant with an integer constant subscript.

■ Examples

The following example shows a LEAVE statement without a label reference:

```
DO I = 1 TO 100;
   .
   .
   .
   IF COMMAND = 'QUIT' THEN LEAVE;
   .
   .
   .
END;
PUT LIST ('Job finished');
```

In this example, the LEAVE statement transfers control directly to the PUT statement if the condition in the IF statement is satisfied.

The next example shows a LEAVE statement with a label reference:

```
LOOP1: DO WHILE (MORE);
    .
    .
    .
    LOOP2: DO I = 1 TO 12;
    .
    .
    .
        IF QUAN(I) > 150 THEN LEAVE LOOP1;
    END;    /* Loop 2 */
    .
    .
    .
END;        /* Loop 1 */
```

In this example, the LEAVE statement transfers control to the first statement beyond the END statement that terminates LOOP1.

The following examples show some invalid uses of the LEAVE statement:

```
LEAVE;                      /* LEAVE statement must be in */
                            /* DO-group */

DO;
    BEGIN;
        LEAVE;              /* LEAVE statement must be in */
    END;                    /* same block as DO statement */
END;

ON ENDFILE(SYSIN) LEAVE;    /* ON-unit is separate block */

DECLARE LABVAR LABEL VARIABLE;
LABVAR = LOOP;
LOOP: DO I = 1 TO 10;
    LEAVE LABVAR;           /* Label reference cannot be a variable */
END;

LAB(1): DO;
    LAB(2): DO;
        I = 1;
        LEAVE LAB(I);       /* Subscript must be a constant */
    END;
END;
```

Length Attribute

The length attribute is applied to character-string and bit-string data. The length of a string is the number of characters or bits in the string, or the maximum length of the string if the string has the CHARACTER VARYING attributes.

For the rules for specifying the length of a character- or bit-string variable, **see** "Extent."

LENGTH Built-In Function
LENGTH Preprocessor Built-In Function

The LENGTH built-in function returns a fixed-point binary integer that is the number of characters or the number of bits in a specified character- or bit-string expression. If the string is a varying-length character string, the function returns its current length. (To determine the maximum length of a varying-length character string, use the MAXLENGTH built-in function.)

The format of the function is as follows:

```
LENGTH(string)
```

See also "MAXLENGTH Built-In Function."

LIKE Attribute

The LIKE attribute copies the member declarations contained within a major or minor structure declaration into the structure variable to which it is applied. The format of the LIKE attribute is as follows:

```
level-number identifier [attributes] LIKE reference
```

level-number
The level number to which the declarations in the reference are copied.

identifier
The variable to which the declarations in the reference are to be copied. The identifier must be preceded by a level number.

attributes
Storage class or dimensions appropriate for the level number. You can specify a storage class and dimensions with a major structure, or you can specify dimensions with a minor structure.

reference
The name of a major or minor structure that is known in the current block.

The LIKE attribute causes the structuring and member declarations of its reference to be copied, but not the name, storage class, or dimensioning (if any) of the reference. The exception to this rule is that the UNION attribute is propagated in a LIKE declaration. While logical structuring is copied, the level numbers themselves are not copied.

You can use the LIKE attribute on a structure already containing the LIKE attribute.

LINE Format Item

The LINE format item sets a print file to a specific line. It can be used only with print files and the PUT EDIT statement. If necessary, blank lines are inserted between the current file position and the specified line, and subsequent output begins on the specified line.

The LINE format item identifies an absolute line position on the current output page; to specify a line position relative to the current line, **see** "SKIP Format Item."

The form of the LINE format item is as follows:

```
LINE(w)
```

w
An integer, or an expression, that specifies a line on the current page, where line 1 is the first line. The maximum value for a print file's line number is 32767. If a program generates a value in excess of 32767, a run-time error occurs.

When the LINE format item is executed, the current line is determined. The current line is 1 if the file is at the beginning of a new page. Otherwise, the current line is n+1, where n is the number of complete lines already on the page. The position in the file is then changed as follows:

- If line w is the current line, and the file is either at the beginning of a new line or at the beginning of a new page, then no operation is performed.
- If line w is beyond the current line and is less than or equal to the current page size, then the file is positioned at line w, and the lines between the current line and line w are filled with blank lines. (**See also** "PAGESIZE Option.")
- If line w is at or before the current line, the current line is not beyond the current page size, and the file is not at the beginning of a line or page, then the remainder of the page (the portion between the current line and the current page size) is filled with blank lines, and the ENDPAGE condition is signaled. The same actions occur when the current line is less than or equal to the page size and w is greater than the page size.
- Otherwise (for instance, when w is zero), the file is positioned at the beginning of a new page, and the page number is incremented by 1.

LINE Option

The LINE option is used with the PUT statement to output data to a specific line in a print file. The output file is positioned at the beginning of the specified line.

The LINE option refers to an absolute line position relative to the beginning of the current page. To refer to a line position relative to the current line, use the SKIP option.

For further information on the LINE and SKIP options, **see** "PUT Statement."

LINE Preprocessor Built-In Function

The LINE preprocessor built-in function returns the line number of the source program text containing the end of the preprocessor statement that calls the LINE built-in function.

The format of the function within a preprocessor expression is as follows:

```
LINE()
```

For information on preprocessor expressions, **see** "Preprocessor."

LINENO Built-In Function

The LINENO built-in function returns a FIXED BINARY(15) integer that is the current line number of the referenced print file. Its format is as follows:

```
LINENO(reference)
```

If the referenced print file is closed, the returned value is the last value from the previous opening. If the file was never opened, the returned value is zero.

LINESIZE Option

The LINESIZE option specifies the maximum number of characters that can be output in a single line when the PUT statement writes data to a file with the STREAM and OUTPUT attributes. The format of the LINESIZE option is as follows:

```
LINESIZE(expression)
```

expression
A fixed-point binary expression in the range 1 to 32767, giving the number of characters per line.

The value specified in the LINESIZE option is used as the output line length for all subsequent output operations on the stream file, and it overrides the system default line size.

The default line size is as follows:

- If the output is to a physical record-oriented device, such as a line printer or terminal, the default line size is the width of the device.
- If the output is to a print file, the default line size is 132.
- If the output is to a nonrecord device (magnetic tape), the default line size is 510.

The line size is used by output operations to determine whether output will be placed on the current line or on the next line.

LIST Attribute

The LIST attribute is used in the declaration of a formal parameter to indicate that the parameter can accept a list of actual parameters, of arbitrary length. This list must contain at least one argument. To allow a list of zero or more arguments, you must declare the formal parameter with both the TRUNCATE attribute and the LIST attribute.

The LIST attribute is valid only on formal parameters of external procedures. It is not supported for PL/I procedures. (To simulate list parameters in PL/I, use asterisk-extent arrays.)

The LIST attribute can be used only for the last formal parameter in an argument list.

For example:

```
DCL NUMBER FIXED BINARY;
DCL LIST_PROC1 ENTRY (FIXED BINARY,FIXED BINARY LIST);
DCL LIST_PROC2 ENTRY (FIXED BINARY,FIXED BINARY LIST TRUNCATE);

CALL LIST_PROC1 (NUMBER,NUMBER);
CALL LIST_PROC1 (NUMBER,NUMBER,NUMBER);

CALL LIST_PROC2 (NUMBER);
CALL LIST_PROC2 (NUMBER,NUMBER,NUMBER,NUMBER);
```

LIST Option

The LIST option is used with the GET and PUT statements to perform list-directed input or output to a stream file or character-string expression.

When the LIST option is used with the GET statement, strings of ASCII characters are acquired from the stream file and assigned to a list of input targets (variables). Conversions to the data types of the input targets, if necessary, are performed automatically. If the end of the input file is encountered, the ENDFILE condition is signaled. For additional details, **see** "GET Statement" and "Stream Input/Output."

When the LIST option is used with the PUT statement, a list of output sources (expressions) is evaluated and converted automatically to strings of ASCII characters, which are then written out. If the output file is a print file, character strings are not enclosed in apostrophes, and all output items are separated by tabs. All output data is appended at the current end-of-file. For additional details, **see** "PUT Statement" and "Stream Input/Output."

%LIST Statement

The %LIST statement enables the selective listing display of INCLUDE file contents, extracted Common Data Dictionary (CDD) record descriptions, machine code, and source code. The %LIST statement has a number of forms, each of which enables or disables listing control for specific portions of the source text. The format of the %LIST statement is as follows:

```
{ %LIST_ALL;
  %LIST_DICTIONARY;
  %LIST_INCLUDE;
  %LIST_MACHINE;
  %LIST_SOURCE; }
```

You must compile the program with the appropriate value specified for the /SHOW qualifier before the above statements can be effective.

The %LIST form of each statement enables the appearance of the specified information starting with the listing line following the %LIST statement. If you previously specified %NOLIST, the %LIST statement has the effect of reenabling the display.

The text displayed with each form of %LIST statement is summarized as follows:

- %LIST_ALL displays all of the following information.
- %LIST_DICTIONARY displays the PL/I translation of an included Common Data Dictionary record.
- %LIST_INCLUDE displays the contents of INCLUDE files and modules in the program listing.
- %LIST_MACHINE displays the machine code generated during compilation.
- %LIST_SOURCE displays source program statements in the program listing.

To disable a %LIST statement, specify %NOLIST at the appropriate line in the source text.

%LIST statements cannot be nested.

See also "%NOLIST Statement."

List Processing

Linked lists or queues are processed in PL/I by using based variables and pointers or offsets. The principal language facilities are

- The BASED, POINTER, AREA, and OFFSET attributes
- The ADDR, NULL, POINTER, and OFFSET built-in functions
- The ALLOCATE and FREE statements, and the DO REPEAT form of the DO statement
- The locator qualifier (->)

Each of these elements is described under its own entry in this manual. This section provides examples of simple procedures that create and process a linked list.

Figure L–1 illustrates a simple program that reads data from a terminal and constructs a linked list from the data.

Figure L–1: Creating a Linked List

```
MAKE_LIST: PROCEDURE;

DECLARE (FIRST, CURRENT, SAVE) POINTER;
DECLARE 1 LIST BASED,
          2 NEXT POINTER,
          2 DATA CHARACTER(120) VARYING;
DECLARE PRINT_LIST ENTRY(POINTER, FIXED BINARY);

/* Declare a bit variable to test for end of stream input */
/* and set an ON-unit to finish processing                */
DECLARE EOF BIT(1) STATIC INITIAL('0'B);
ON ENDFILE(SYSIN) EOF = '1'B;

          FIRST = NULL();                /* initialize queue head */

          ALLOCATE LIST SET(CURRENT);    /* set storage */
          GET LIST (CURRENT->DATA);      /* get data    */
          DO WHILE (^EOF);

              IF FIRST = NULL THEN       /* first time through queue */
                  FIRST = CURRENT;       /* set queue head */
              ELSE                       /* all other times */
                  SAVE->NEXT = NULL;     /* set forward pointer */

              CURRENT->NEXT = NULL;      /* set forward pointer */
              SAVE = CURRENT;            /* save pointer to this allocation */

              ALLOCATE LIST SET(CURRENT); /* set storage */
              GET LIST (CURRENT->DATA);   /* get data    */
              END;

          CALL PRINT_LIST(FIRST,120);
          RETURN;

END MAKE_LIST;
```

Figure L–2 illustrates the use of pointers to step through a linked list and to print the data in each list element. The example in this figure uses the REPEAT option of the DO statement to modify the value of the pointer used to access each element in the list. This example can also be applied to a linked list within an area. Based variables in an area are referenced by offset values that indicate the locations of the variables with respect to the beginning of the area.

Figure L–2: Processing a Linked List

```
PRINT_LIST: PROCEDURE (QUEUE_HEAD, DATA_LENGTH);

DECLARE QUEUE_HEAD POINTER,            /* start queue    */
        DATA_LENGTH FIXED BINARY(31);  /* length of data */
DECLARE 1 LIST BASED(P),               /* structure of queue elements */
          2 NEXT POINTER,
          2 DATA CHARACTER(DATA_LENGTH);
DECLARE P POINTER;

/* Start output at queue head, repeat with next pointers */

        DO P = QUEUE_HEAD REPEAT P->LIST.NEXT

/* until end of list (null) encountered */

            WHILE (P ^= NULL());
            PUT SKIP LIST(P->LIST.DATA);
        END;

        RETURN;
END PRINT_LIST;
```

Locator Qualifier

A locator qualifier is an operator that specifies the storage associated with a based variable. The locator qualifier consists of the following two symbols:

```
->
```

No blanks are allowed between the minus sign (–) and the greater than symbol (>).

The format for specifying a locator-qualified reference to a variable is as follows:

```
locator -> based-variable
```

locator

One of the following:

- The name of a pointer whose current value represents the storage associated with a variable

- The name of an offset variable that was declared with an area reference and whose current value represents the storage of a based variable within the area
- Any other pointer-valued expression, such as a reference to the POINTER or ADDR built-in function

based-variable

The name of the based variable whose storage is to be referenced.

You must use a locator qualifier when you refer to a based variable for which more than one allocation of storage may exist. For example:

```
DECLARE NAMES (10) CHARACTER (20) BASED,
        (CLASS_PTR, GRADE_PTR) POINTER;

ALLOCATE NAMES SET (CLASS_PTR);
ALLOCATE NAMES SET (GRADE_PTR);
```

Any reference to the array NAMES in this example must specify the pointer associated with the storage allocated for the variable, as follows:

```
CLASS_PTR -> NAMES(1) = 'SMITH';
CLASS_PTR -> NAMES(2) = 'JONES';
```

These assignment statements refer to the storage allocated for the array NAMES that is pointed to by the pointer CLASS_PTR. The assignments set the first two elements of the array to the strings SMITH and JONES.

You must also use a locator qualifier to associate a based variable with the storage of another variable. For example:

```
DECLARE DATA CHARACTER(10) BASED,
        DP POINTER,
        LINE CHARACTER(10);

LINE = 'string';
DP = ADDR(LINE);
PUT LIST( DP->DATA );
```

The locator qualifier in this PUT statement associates the based variable DATA with the storage occupied by the variable LINE and pointed to by the pointer DP. For more information, **see** "Based Variable," "Offset," and "Pointer."

LOG Built-In Function

The LOG built-in function returns a floating-point value that is the base e (natural) logarithm of an arithmetic expression x. The computation is performed in floating point. The expression x must be greater than zero after its conversion to floating point.

The format of the function is as follows:

```
LOG(x)
```

LOG10 Built-In Function

The LOG10 built-in function returns a floating-point value that is the base 10 logarithm of arithmetic expression x. The computation is performed in floating point. The expression x must be greater than zero after its conversion to floating point.

The format of the function is as follows:

```
LOG10(x)
```

LOG2 Built-In Function

The LOG2 built-in function returns a floating-point value that is the base 2 logarithm of an arithmetic expression x. The computation is performed in floating point. The expression x must be greater than zero after its conversion to floating point.

The format of the function is as follows:

```
LOG2(x)
```

Logical Operator

The logical operators perform logical operations on one or two operands. The operands of the logical operators must be bit-string expressions, except that the operand of the NOT operator can be a bit-string expression or a single relational operator. All relational expressions result in bit-string values of length 1, and they can therefore be used as operands in logical operations.

Except when the NOT operator is used as the prefix of a relational operator, the result of a logical operation is always a bit string.

Except for AND THEN and OR ELSE, logical operations are performed on their operands bit by bit. If bit-string operands are not the same length, PL/I extends the smaller of the operands on the right (that is, in the direction of the least significance) with zeros to match the length of the larger operand. This length is always the length of the result.

There are five infix operators and one prefix operator:

Prefix Operator	Operation
^ (circumflex)	Logical NOT. In a logical NOT operation, the value of the operand is complemented; that is, a 1 bit becomes a 0 and a 0 bit becomes a 1. The value of a relational expression is also complemented; that is ^(A < B) is equivalent to (A > = B).

Infix Operator	Operation
& (ampersand)	Logical AND. In a logical AND operation, two operands are compared. If both corresponding bits are 1, the result is 1; otherwise, the result is 0.
| (vertical bar) or ! (exclamation point)	Logical OR. In a logical OR operation, two operands are compared. If either or both of two corresponding bits are 1, the result is 1; otherwise the result is 0. (The | and the ! characters can be used interchangeably.)

Infix Operator	Operation
&: (ampersand and colon)	Logical AND THEN. The operation is like AND except that the second operand is evaluated only if the first operand is true, and except that AND THEN does not do bit-by-bit operations on bit-string operands.
^ (circumflex)	Logical EXCLUSIVE OR. Two operands are compared, and the result is 1 if one of the corresponding bits is 1 and the other is 0.
|: (vertical bar and colon)	Logical OR ELSE. The operation is like OR except that the second operand is evaluated only if the first operand is false, and except that OR ELSE does not do a bit-by-bit operation on bit-string operands.

You can define additional operations on bit strings with the BOOL built-in function.

Logical expressions cannot be completely evaluated in some cases. If the result of the total expression can be determined from the value of one or more individual operands, the evaluation can be terminated. For example:

```
A & B & C & D & E
```

In this expression, evaluation can stop when any operand or the result of any operation is a bit string containing all zeros.

■ Examples

```
DECLARE (BITA,BITB,BITC) BIT(4);
BITA = '0001'B;
BITB = '1001'B;
BITC = ^BITA;            /* BITC equals '1110'B */

BITC = BITA | BITB;      /* BITC equals '1001'B */

BITC = BITA & BITB;      /* BITC equals '0001'B */

BITC = ^(BITA & BITB);   /* BITC equals '1110'B */

BITC = ^(BITA > BITB);   /* BITC equals '1000'B (true) */
```

In the last assignment statement, the relational expression yields '1'B; when this value is assigned to BITC, a BIT(4) variable, the value is padded with zeros and becomes '1000'B.

LOW Built-In Function

The LOW built-in function returns a string of specified length that consists of repeated appearances of the lowest character in the collating sequence. Its format is as follows:

```
LOW(length)
```

length
The specified length of the returned string. The maximum length permitted is 32767 characters.

■ Returned String

The string returned is of the length specified. The rank of the lowest character that can appear in the collating sequence for VAX PL/I is ASCII 0.

M

MAIN Option

The MAIN option can be specified with the OPTIONS keyword on the PROCEDURE statement. It indicates that the specified entry name is the primary invocation point of the program. It is specified as follows:

```
entry-name: PROCEDURE OPTIONS (MAIN);
```

One, and only one, procedure in a program can specify the MAIN option. If no procedure specifies the MAIN option, the invocation point of the program is the first procedure in the image. (For details on binding procedures into an executable program image, **see** the *VAX PL/I User Manual.*)

VAX PL/I provides a default ON-unit for the procedure declared with the MAIN option. **See** "ON Conditions and ON-Units."

Main Procedure

The main procedure in a program is the procedure declared with the MAIN option. Execution of a PL/I program begins with the main procedure.

See also "MAIN Option" and "Procedure."

MAX Built-In Function
MAX Preprocessor Built-In Function

The MAX built-in function returns the larger of two arithmetic expressions x and y. The format of the function is as follows:

```
MAX(x,y)
```

■ Returned Value

The expressions x and y are converted to their derived type before the operation is performed (for a discussion of derived types, **see** "Expression".) If the derived type is floating point, the value returned is also floating point, with the larger precision of the two converted arguments. If the derived type is fixed point, the returned value is a fixed-point value with the base of the derived type and with the following attributes:

$$precision = min(31, max(px - qx, py - qy) + max(qx, qy))$$

and

$$scalefactor = max(qx, qy)$$

where px,qx and py,qy are the converted precisions and scale factors of x and y, respectively.

The MAX built-in function is also a preprocessor built-in function; however, the preprocessor does not permit scale factors.

MAXLENGTH Built-In Function

The MAXLENGTH built-in function returns a fixed binary number representing the maximum possible length of a varying-length character string. Its format is as follows:

```
MAXLENGTH (string)
```

string
A reference to a character string or a bit string. If it is anything other than a varying-length character string, the MAXLENGTH function returns a result identical to the result that would be returned by the LENGTH built-in function.

For example:

```
MAXLENGTH_EXAMPLE: PROCEDURE OPTIONS(MAIN);
  DCL CHAR_VAR CHARACTER(10) VARYING;
  CHAR_VAR = 'String';
  CALL SAMPLE(CHAR_VAR);
END MAXLENGTH_EXAMPLE;
SAMPLE: PROCEDURE(STRING);
  DCL STRING CHAR(*) VARYING;
  PUT LIST(LENGTH(STRING),MAXLENGTH(STRING));
END SAMPLE;
```

The program returns the following:

```
       6             10
```

Also see "LENGTH Built-In Function."

MEMBER Attribute

The MEMBER attribute can optionally be specified in the declaration of a structure member (minor structure).

The MEMBER attribute cannot be used with a major structure (that is, a structure variable with level 1). **See** "Structure" for information on structures and members.

MIN Built-In Function
MIN Preprocessor Built-In Function

The MIN built-in function returns the smaller of two arithmetic expressions x and y. Its format is as follows:

```
MIN(x,y)
```

■ Returned Value

The expressions x and y are converted to their derived type before the operation is performed (for a discussion of derived types, **see** "Expression".) If the derived type is floating point, the value returned is also floating point, with the larger precision of the two converted arguments. If the derived type is fixed point, the returned value is a fixed-point value with the base of derived type and with the following attributes:

$$precision = min(31, max(px - qx, py - qy) + max(qx, qy))$$

$$scalefactor = max(qx, qy)$$

where px,qx and py,qy are the converted precisions and scale factors of x and y.

The MIN built-in function is also a preprocessor built-in function; however, the preprocessor does not permit scale factors.

MOD Built-In Function
MOD Preprocessor Built-In Function

The MOD built-in function returns, for an arithmetic expression x and nonnegative arithmetic expression y, the value r that equals x modulo y. That is, r is the smallest positive value that must be subtracted from x to make the remainder exactly divisible by y.

The format of the function is as follows:

```
MOD(x,y)
```

■ Returned Value

The expressions x and y are converted to their derived type before the operation is performed (**see** "Expression" for a discussion of derived types).

If the derived type is unscaled fixed point, then the precision of the result is the precision of the second operand.

If the derived type is floating point, the returned value is an approximation in floating point, with the larger of the precisions of the two converted arguments.

The value returned is as follows:

$$u - w * floor(u/w)$$

U and w are the arguments x and y, respectively, after conversion to their derived type. If w is zero, u is converted to the precision described below, which can signal FIXEDOVERFLOW.

If x and y are fixed-point expressions, a fixed-point value is returned with the following attributes:

$$precision = min(31, pw - qw + max(qu, qw))$$

and

$$scalefactor = max(qu, qw)$$

where qu is the scale factor of u, pw is the precision of w, and qw is the scale factor of w. The FIXEDOVERFLOW condition is signaled if the following is true:

$$pw - qw + max(qu, qw) > 31$$

The MOD built-in function is also a preprocessor built-in function; however, the preprocessor does not permit scale factors.

■ Examples

```
MODEX: PROCEDURE OPTIONS(MAIN);

DECLARE OUTMOD PRINT FILE;

ON FIXEDOVERFLOW PUT FILE(OUTMOD)
      SKIP LIST('FIXEDOVERFLOW signaled');

PUT FILE(OUTMOD) SKIP LIST(MOD(28,128));
PUT FILE(OUTMOD) SKIP LIST(MOD(130,128));
PUT FILE(OUTMOD) SKIP LIST(MOD(-28,128));
PUT FILE(OUTMOD) SKIP LIST(MOD(4.5,.758));
PUT FILE(OUTMOD) SKIP LIST(MOD(-4.5,.758));
PUT FILE(OUTMOD) SKIP LIST(MOD(1.5E-3,-1.4E-3));
PUT FILE(OUTMOD) SKIP LIST(MOD(28,0));

END MODEX;
```

The program MODEX writes the following output to OUTMOD.DAT:

```
    28
     2
   100
 0.710
 0.048
-1.3E-03

FIXEDOVERFLOW signaled     8
```

The last PUT statement attempts to take MOD(28,0). The constants 28 and 0 are both fixed-point decimal expressions, with precisions (2,0) and (1,0), respectively. Therefore, the attributes of the returned value are determined to be FIXED DECIMAL, with the following attributes:

$$precision = min(31, 1 - 0 + max(0,0)) = 1$$

and

$$scalefactor = max(0,0) = 0$$

Although 28 modulo 0 is 28, MOD(28,0) signals FIXEDOVERFLOW because 28 cannot be represented in the result precision. (The value of the function is therefore undefined.)

Multiplication

The asterisk character (*) indicates a multiplication operation in an expression; the result is the product of the operands. Both operands must be arithmetic or picture data.

■ Conversion of Operands

If both operands have the same base, precision, and scale factor, so has the result of the operation. The compiler converts operands of different data types as follows:

- If one operand has the FLOAT attribute and the other has the FIXED attribute, the fixed-point operand is converted to floating point before the operation is performed.
- If one operand is DECIMAL and the other is BINARY, the decimal operand is converted to binary.

The precision of the values resulting from conversion of operands is described under "Expression."

■ Precision of the Result

For floating-point and fixed-point operands, the precision of the result is determined as follows:

Floating-Point Operands

The result has the maximum of the converted precisions of the operands.

Fixed-Point Operands

If (p,q) and (r,s) represent the converted precisions and scale factors of the two operands, the resulting precision and scale factor are as follows:

$$precision = min(31, p + r + 1)$$

and

$$scalefactor = q + s$$

MULTIPLY Built-In Function

The MULTIPLY built-in function multiplies two arithmetic expressions x and y, and returns the product of the two values with a specified precision p and an optionally specified scale factor q.

The format of the function is as follows:

```
MULTIPLY(x,y,p[,q])
```

p

An integer constant greater than zero and less than or equal to the maximum precision of the result type (31 for fixed-point binary data, 31 for fixed-point decimal data, 34 for floating-point decimal data, and 113 for floating-point binary data).

q

An integer in the range –31 through p when used with fixed-point binary multiplication. The scale factor for fixed-point decimal multiplication has a range 0 through p. A scale factor is not to be used with floating-point arithmetic. If no scale factor is designated, q defaults to zero.

Expressions x and y are converted to their derived type before the multiplication is performed. **See** "Expression."

For example:

```
MULT:   PROCEDURE OPTIONS (MAIN);

DECLARE I_RATE  FIXED DECIMAL(31,4),
        PRINCIPAL  FIXED DECIMAL(31,2),
        OWED FIXED DECIMAL(31,6);

I_RATE = .1514;


PRINCIPAL = 27688.25;

OWED = MULTIPLY (I_RATE,PRINCIPAL,31,6);

PUT SKIP LIST ('INTEREST OWED =',OWED);

END;
```

Interest rates are calculated to six decimal places and the following string is returned:

```
INTEREST OWED = 4192.001050
```

N

NEXT_VOLUME Built-In Subroutine

The NEXT_VOLUME built-in subroutine can be used to process additional magnetic tape volumes for a file. **See** the *VAX PL/I User Manual* for more information.

%NOLIST Statement

The %NOLIST statement disables the selective listing display of INCLUDE file contents, extracted Common Data Dictionary (CDD) record descriptions, machine code, and source code. The %NOLIST statement has a number of forms; each enables or disables listing control for specific portions of the source text. The format of the %NOLIST statement is as follows:

```
{ %NOLIST_ALL;        }
{ %NOLIST_DICTIONARY; }
{ %NOLIST_INCLUDE;    }
{ %NOLIST_MACHINE;    }
{ %NOLIST_SOURCE;     }
```

You must compile the program with the /SHOW qualifier before any of these statements can be effective.

The %NOLIST form of each statement disables the appearance of the specified information starting with the listing line following the %NOLIST statement. If you previously specified %LIST, the %NOLIST statement has the effect of disabling the display.

The following summarizes the text suppressed with each form of %NOLIST statement:

- %NOLIST_ALL does not display any of the following information.

- %NOLIST_DICTIONARY does not display the PL/I translation of an included Common Data Dictionary record.
- %NOLIST_INCLUDE does not display the contents of INCLUDE files and modules in the program listing.
- %NOLIST_MACHINE does not display the machine code generated during compilation.
- %NOLIST_SOURCE does not display source program statements in the program listing.

To cancel the effect of any of the %NOLIST statements, specify %LIST at the appropriate line in the source text.

See also "%LIST Statement".

NONRECURSIVE Option

The NONRECURSIVE option can be specified on a PROCEDURE or ENTRY statement to indicate (for program documentation) that the procedure will not invoke itself. For example:

```
TEST: PROCEDURE( T1, T2, T3 ) NONRECURSIVE;
```

The NONRECURSIVE option can be specified to inform the compiler that the procedure is not recursive, which is the default. Note that all procedures in VAX PL/I can be invoked recursively regardless of the NONRECURSIVE or RECURSIVE options, and both options are currently ignored by the compiler. For more information, **see** "Procedure."

NONVARYING Attribute

The NONVARYING attribute keyword explicitly states that a bit-string or character-string variable has a fixed length, not a varying length. Because NONVARYING is the default for bit and character strings, it need not be specified.

The keyword NONVARYING can be abbreviated to NONVAR.

See "VARYING Attribute", "CHARACTER Attribute", and "Character-String Data."

NORESCAN Option

The NORESCAN option of the %ACTIVATE preprocessor statement stops the rescanning of the text which replaces preprocessor variable identifiers when they are replaced. When the values of the variable identifiers are replaced during compilation, the new text remains the same.

The format for the NORESCAN option is as follows:

RESCAN is the default option of the %ACTIVATE statement. For further details on the NORESCAN option, **see** "%ACTIVATE Statement."

NOT Operator

The logical NOT operator in PL/I is the circumflex character (^), used as a prefix operator. In a logical NOT operation, the value of a bit is reversed. If a bit is 1, the result is 0; if a bit is 0, the result is 1.

The NOT operator can be used on expressions that yield bit-string values (bit-string, relational, and logical expressions). It can also be used to negate the meanings of the relational operators (<, > , =). For example:

```
IF A ^> B THEN ...
   /* equivalent to IF A <= B THEN ... */
```

The result of a logical NOT operation on a bit-string expression is a bit-string value. For example:

```
DECLARE (BITA, BITB) BIT (4);
BITA = '0011'B;
BITB = ^BITA;
```

The resulting value of BITB is 1100.

The NOT operator can test the falsity of an expression in an IF statement. For example:

```
IF ^(MORE_DATA) THEN ...
```

See "Logical Operator" and "Operator."

Nonlocal GOTO

See "GOTO Statement."

%Null Statement

The %Null statement performs no action. Its format is as follows:

```
%;
```

The most common use for the %Null statement is as the target statement of a %THEN or %ELSE clause in an %IF statement. For example:

```
%IF
   ERROR() > 0;
%THEN
   %GOTO FIXIT;
%ELSE
   %;
```

In this example, no action is taken if the program does not generate a user-diagnostic error message. If the %GOTO does not change the flow of compilation, control passes to the next executable preprocessor statement in the source text.

NULL Built-In Function

The NULL built-in function returns a null pointer value. Its format is as follows:

```
NULL()
```

■ Example

```
IF NEXT_POINTER = NULL() THEN CALL FINISH;
```

The IF statement checks whether the pointer variable NEXT_POINTER is null; if so, the CALL statement is executed.

The NULL built-in function can be used for offset variables as well as pointer variables, because the compiler automatically performs conversions between pointer and offset values.

For more information, **see** "Based Variable," "List Processing," and "Pointer."

Null Statement

The null statement performs no action. Its format is as follows:

```
;
```

The most common uses for the null statement are as the target statement of a THEN or ELSE clause in an IF statement or a WHEN or OTHERWISE clause in a SELECT statement, or as an action in an ON-unit. For example:

```
ON ENDPAGE(SYSPRINT);
```

The null statement can also be used to declare two labels for the same executable statement, as in the following example:

```
LABEL1: ; LABEL2: statement ...
```

O

Offset

An offset is a value indicating the location of a based variable within an area relative to the beginning of the area. An offset variable must be declared with the OFFSET attribute.

When an area is transmitted or assigned, the offset values associated with variables within the area remain valid.

■ Offset Assignment

Offset variables are assigned values from existing offset values or from converted pointer values. The OFFSET built-in function converts a pointer value to an offset value. PL/I also automatically converts a pointer value to an offset value, and vice versa, in an assignment statement. The following assignments are valid:

```
pointer-variable = pointer-value;

offset-variable = offset-value;

pointer-variable = offset-variable;

offset-variable = pointer-value;
```

In the second method, any area references are ignored in the assignment; therefore, the offset value and variable can refer to different areas. In the last two methods, offset variable must have been declared with an area reference. Note that the POINTER and OFFSET built-in functions are available for use in the last two methods if the offset value was not declared with a base area.

■ Offset Variables in Expressions

Expressions containing offset variables are restricted to the following operators:

Operator	Meaning
=	Equal
^=	Not equal

For more information on offset values, **see** "Area." For specific details on how to allocate variables within areas, **see** "ALLOCATE Statement."

OFFSET Attribute

The OFFSET attribute declares a variable that will be used to reference a based variable within an area. Its format is as follows:

OFFSET [(area-reference)]

area-reference
The name of a variable with the AREA attribute. The value of the offset variable will be interpreted as an offset within the specified area.

■ Example

```
DECLARE MAP_SPACE AREA (40960),
        MAP_START OFFSET (MAP_SPACE),
        MAP_LIST(100) CHARACTER(80) BASED (MAP_START);
```

These declarations define an area named MAP_SPACE, an offset value that will contain offset values within that area, and a based variable whose storage is located by the value of the offset variable MAP_START.

■ Restrictions

The area reference must be omitted if the OFFSET attribute is specified within a returns descriptor, parameter declaration, or a parameter descriptor. The OFFSET attribute conflicts with all other data type attributes.

OFFSET Built-In Function

The OFFSET built-in function converts a pointer to an offset relative to a designated area. If the pointer is null, the result is null. The format of the function is as follows:

```
OFFSET(pointer,area)
```

pointer
A reference to a pointer variable whose current value either represents the location of a based variable within the specified area or is null.

area
A reference to a variable declared with the AREA attribute. If the specified pointer is not null, it must designate a storage location within this area.

■ Example

```
DECLARE MAP_SPACE AREA (2048),
        START OFFSET (MAP_SPACE),
        QUEUE_HEAD POINTER;
            .
            .
            .
START = OFFSET (QUEUE_HEAD,MAP_SPACE);
```

The offset variable START is associated with the area MAP_SPACE. The OFFSET built-in function converts the value of the pointer to an offset value.

ON Conditions and ON-Units

An ON condition is any one of several named conditions whose occurrence during the execution of a program interrupts the program. When a condition occurs or is signaled, a statement or sequence of statements, called an ON-unit, is executed, unless the SYSTEM option is specified in the ON statement, causing the default system condition handling to be executed.

This entry discusses the following topics:

- Summary of ON Conditions
- Default PL/I ON-Unit
- Establishment of ON-Units
- Contents of an ON-Unit

- Search for ON-Units
- Completion of ON-Units

■ Summary of ON Conditions

Most, but not all, ON conditions are associated with errors. The types of conditions for which you can establish ON-units are grouped in the following categories.

- Conditions that occur during I/O operations:
  - ENDFILE, to take action when the end-of-file occurs while a file is being read
  - ENDPAGE, to take action when the last line on a page is printed
  - KEY, to take action when an error occurs when a record is accessed by key
  - UNDEFINEDFILE, to respond to any file-specific errors that can occur during the opening of a file
- Conditions that indicate arithmetic conditions related to hardware violations:
  - FIXEDOVERFLOW, to respond when integer or fixed-point values become too large to be expressed
  - OVERFLOW, to respond when floating-point values become too large to be expressed
  - UNDERFLOW, to respond when floating-point values become too small to be expressed
  - ZERODIVIDE, to respond when the divisor in a division operation has a value of zero
- Other conditions:
  - AREA, to respond when an error has been detected during performance of an operation on an area (various subconditions can be determined through use of the ONCODE built-in function)
  - CONDITION, to respond to programmer-defined conditions
  - CONVERSION, to respond to data conversion errors from CHARACTER to any arithmetic data type or bit string
  - STORAGE, to respond when an error has been detected during allocation of a controlled variable or a based variable other than in an area
  - STRINGRANGE, to respond to substring references that are beyond the length of the string

  - SUBSCRIPTRANGE, to respond to array references with out-of-bound subscripts
- General classes of exceptional conditions:
  - ANYCONDITION, to respond to all conditions for which no specific ON-unit is established in the current block
  - ERROR, to respond to language-specific and run-time-specific errors
  - FINISH, to respond when a STOP statement is executed
  - VAXCONDITION, to respond to condition values that are specific to the operating system

Each condition is described individually in this manual under its own entry.

Table O–1: Summary of ON Conditions

Condition Name	Function
ANYCONDITION	Handles any condition not specifically handled by another ON-unit
AREA	Handles a condition that occurs during an operation on an area
CONDITION	Handles programmer-defined conditions
CONVERSION	Handles data conversion errors
ENDFILE	Handles end-of-file for a specified file
ENDPAGE	Handles end-of-page for a specified file with PRINT attribute
ERROR	Handles miscellaneous error conditions and conditions for which no specific ON-unit exists
FINISH	Handles program exit when the main procedure executes a RETURN statement, when any block executes a STOP statement, or when the program exits due to an error that is not handled by an ON-unit
FIXEDOVERFLOW	Handles fixed-point decimal and integer overflow exception conditions
KEY	Handles any error involving the key during keyed access to a specified file
OVERFLOW	Handles floating-point overflow exception conditions

Table O–1 (Cont.): Summary of ON Conditions

Condition Name	Function
STORAGE	Handles a condition that occurs during allocation of a controlled variable or a based variable other than in an area
STRINGRANGE	Handles out-of-bound substring references
SUBSCRIPTRANGE	Handles out-of-bound array references
UNDEFINEDFILE	Handles any errors in opening a specified file
UNDERFLOW	Handles floating-point underflow exception conditions
VAXCONDITION	Handles a specifically signaled condition value
ZERODIVIDE	Handles divide-by-zero exception conditions

■ Default PL/I ON-Unit

PL/I defines a default ON-unit for the procedure that is designated as the main procedure. This default ON-unit performs the following actions:

- If the signal is the ENDPAGE condition, the default PL/I handler executes a PUT PAGE for the file, and then continues the program at the point at which ENDPAGE was signaled.
- If the signal is the ERROR condition and the severity is fatal, the default handler signals the FINISH condition. Then, one of the following occurs:
  - If a FINISH ON-unit is found, it is given a chance to execute. If it executes a nonlocal GOTO or if it signals another condition, program execution continues.
  - If no FINISH ON-unit is found or if a FINISH ON-unit completes execution by handling the condition, then PL/I resignals the condition to the default VMS condition handler. This handler prints a message, displays a traceback, and terminates the program.
- If the signal is any condition other than ENDPAGE or ERROR with a fatal severity, the default PL/I handler signals the ERROR condition with the severity of the original condition. Then, one of the following occurs:
  - If an ERROR ON-unit is found, it is executed. If it completes execution by handling the condition, the program continues.

— If an ERROR ON-unit is not found, the default PL/I handler resignals the condition. If this resignal results in return of control to the system, the default VMS condition handler prints a message and a traceback. If the error is a fatal error, the default handler terminates the program; if the error is nonfatal, the program continues.

■ Establishment of ON-Units

An ON-unit is established for a specific ON condition or conditions following the execution of an ON statement that specifies the condition name(s). For example:

```
ON ENDFILE (ACCOUNTS) GOTO CLOSE_FILES;
```

This ON statement defines an ON-unit for an ENDFILE (end-of-file) condition in the file specified by the name ACCOUNTS. The ON-unit consists of a single statement, a GOTO statement.

After an ON-unit is established by an ON statement for a condition, it remains in effect for the activation of the current block and all its dynamically descendent blocks, unless one of the following occurs:

- Another ON statement is specified for the same condition in a descendent block. The ON-unit established within the descendent block remains in effect as long as the descendent block is active.
- A REVERT statement is executed for the specified condition. A REVERT statement nullifies the most recent ON-unit for the specified condition.
- Another ON statement is specified for the same condition within the current block. Within the same block, an ON statement for a specific condition cancels the previous ON-unit.
- The block or procedure within which the ON-unit is established terminates. When a block exits, any ON-units it has established are canceled.

■ Contents of an ON-Unit

An ON-unit can consist of a single simple statement, a group of statements in a begin block, or a null statement.

Simple Statements in ON-Units

The following ON statement specifies a single statement in the ON-unit:

```
ON ERROR GOTO WRITE_ERROR_MESSAGE;
```

This ON statement specifies a GOTO statement that transfers control to the label WRITE_ERROR_MESSAGE in the event of the ERROR condition.

A simple statement must not be labeled and must not be any of the following:

DECLARE	FORMAT	RETURN
DO	IF	SELECT
END	ON	
ENTRY	PROCEDURE	

Begin Blocks in ON-Units

An ON-unit can also consist of a sequence of statements in a begin block. For example:

```
ON ENDFILE (SYSIN) BEGIN;
   CLOSE FILE (TEMP);
   CALL PRINT_STATISTICS(TEMP);
   END;
```

This ON-unit consists of CLOSE and CALL statements that request special processing when the end-of-file condition occurs during reading of the default system input file, SYSIN.

If a BEGIN statement is specified for the ON-unit, the BEGIN statement must not be labeled. The begin block can contain any statement except a RETURN statement.

Null Statements in ON-Units

A null statement specified for an ON-unit indicates that no processing is to occur when the condition occurs. Program execution continues as if the condition had been handled. For example:

```
ON ENDPAGE(SYSPRINT);
```

This ON-unit causes PL/I to continue output on a terminal regardless of the number of lines that have been output.

■ Search Path for ON-Units

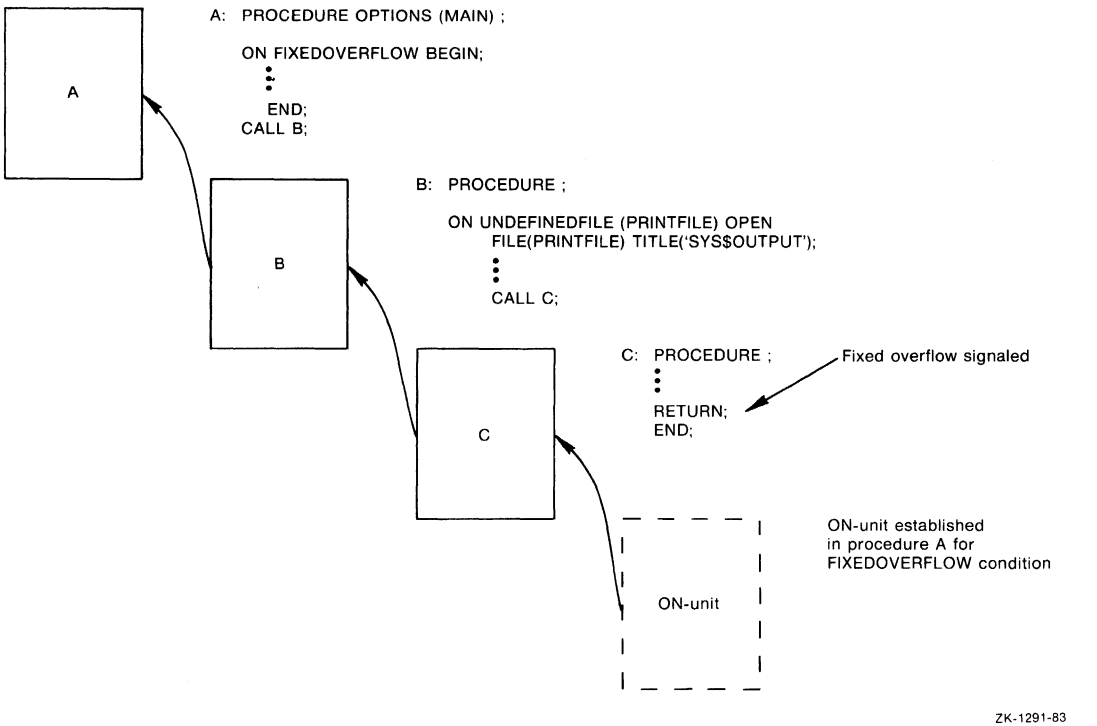
When a condition is signaled during the execution of a PL/I procedure, PL/I searches for an ON-unit to respond to the condition (unless you have used the SYSTEM option in an ON statement for the condition; the SYSTEM option causes the system default action to be executed regardless of the existence of any ON-unit). PL/I first searches the current block, that is, the block in which the condition occurred. If no ON-unit exists in this block for the specific condition, it searches the block that activated the current block (its "parent"), and then the block that activated that block, and so on.

PL/I executes the first ON-unit it finds, if any, that can handle the specified condition. If no ON-unit for the specific condition is found, default PL/I condition handling is performed.

Figure O–1 illustrates a program with ON-units established at several levels of block activation and shows the sequence in which the ON-units are located.

For more information on blocks and block activation, **see** "Block." For a more detailed explanation of the search for ON-units and a description of how PL/I ON-units relate to condition-handling routines that can be written in other programming languages, **see** the *VAX PL/I User Manual.*

Figure O–1: Search Path for ON-Units



■ Completion of ON-Units

PL/I executes an ON-unit as if the unit were a procedure with no parameters; that is, it creates a block activation for the ON-unit and links it to the block in which the condition occurred. The ON-unit can complete its execution in any of the following ways:

- If the ON-unit executes a nonlocal GOTO statement, or if it invokes a subroutine or function that executes a nonlocal GOTO, program control is transferred to that statement and continues sequentially at that point in the program.
- If the ON-unit executes a STOP statement, then the FINISH condition is signaled. If no FINISH ON-unit exists, the program is terminated.

- An ON-unit can use the RESIGNAL built-in subroutine to request that PL/I continue to search for an ON-unit to handle a specific condition. For a description of this built-in subroutine and an explanation of the effects of a nonlocal GOTO and resignaling in the VMS environment, **see** the *VAX PL/I User Manual.*
- When any ON-unit (except for ERROR or FINISH) completes normally as a result of image exit, control returns either to the statement that caused the condition or to the statement immediately following the statement that caused the condition.

Descriptions of each ON condition in this manual indicate the action that PL/I takes on completion of an ON-unit associated with the condition.

ON Statement

The ON statement defines the action to be taken when a specific condition or conditions are signaled during the execution of a program. The ON statement is an executable statement. It must be executed before the statement that signals the specified condition. The format of the ON statement is as follows:

ON condition-name,... [SNAP] { on-unit / SYSTEM; }

condition-name, . . .
The name or names of the specific conditions for which an ON-unit or the SYSTEM option is specified. There is a keyword name associated with each condition. Successive keyword names must be separated by commas. The conditions are summarized in Table O–1; each condition is described in an individual entry in this manual.

SNAP
An option that invokes the debugger and causes a traceback of all active routines to be displayed when the condition is raised. If you use the SNAP option, you should specify the /DEBUG qualifier on both the PLI command and the LINK command in order to have all the debugger symbol table information accessible.

If you want to run a program containing the SNAP option in a batch job, and cause the program to resume execution after any display of traceback

information, you can define DBG$INIT to point to a debug initialization file that contains the following line:

```
WHILE PC ^= 0 DO(GO)
```

on-unit

The action to be taken when the specified condition or conditions are signaled. An ON-unit can be any single, unlabeled statement except DECLARE, DO, END, ENTRY, FORMAT, IF, ON, PROCEDURE, RETURN, or SELECT. It can also be an unlabeled begin block. It can be a null statement (a semicolon alone), which causes program execution to continue as if the condition had been handled.

If no ON-unit is established for a particular condition, the default PL/I ON-unit, if any, is executed.

SYSTEM

An option that invokes the default system condition handling for the specified condition, overriding any existing ON-unit for the condition.

For information on ON-units and the default PL/I ON-unit, **see** "ON Conditions and ON-Units."

ONARGSLIST Built-In Function

The ONARGSLIST built-in function returns a pointer to the location in memory of the argument list for an exception condition. If the ONARGSLIST built-in function is referenced in any context outside of an ON-unit, it returns a null pointer. Its format is as follows:

```
ONARGSLIST()
```

See the *VAX PL/I User Manual* for the format of the argument list and the information available to an ON-unit from the argument list.

ONCHAR Built-In Function

The ONCHAR built-in function returns the character that caused a CONVERSION condition to be raised. If there is no active CONVERSION condition, the return value is a single space.

The format of the function is as follows:

```
ONCHAR()
```

The ONCHAR value is actually a single character substring of the ONSOURCE built-in function value, unless there is no active CONVERSION condition.

See "CONVERSION Condition Name" for more information.

ONCHAR Pseudovariable

The ONCHAR pseudovariable can be used to replace the single character in the ONSOURCE value that caused a CONVERSION condition to be raised. An attempt to assign a value to the ONCHAR pseudovariable when there is no active CONVERSION condition would be an error, causing the ERROR condition to be raised.

The format of the pseudovariable is as follows:

```
ONCHAR()
```

See "CONVERSION Condition Name" for more information.

ONCODE Built-In Function

The ONCODE built-in function returns a fixed-point binary integer that is the status value of the most recent run-time error that signaled the current ON condition. You can use the function in any ON-unit to determine the specific error that caused the condition. If the function is used within any context outside an ON-unit, it returns a zero. Its format is as follows:

```
ONCODE()
```

For details on the condition values returned by ONCODE and examples of using the ONCODE built-in function, **see** the *VAX PL/I User Manual.*

ONFILE Built-In Function

The ONFILE built-in function returns the name of the file constant for which the current file-related condition was signaled. Its format is as follows:

```
ONFILE()
```

This built-in function can be used in an ON-unit established for any of the following conditions:

- An ON-unit for the KEY, ENDFILE, ENDPAGE, and UNDEFINEDFILE conditions
- A VAXCONDITION ON-unit established for I/O errors that can occur during file processing
- An ERROR ON-unit that receives control as a result of the default PL/I action for file-related errors, which is to signal the ERROR condition
- A CONVERSION ON-unit that was entered because of an error that occurred during conversion of data in a GET statement

■ Returned Value

The returned value is a varying-length character string. The ONFILE function returns a null string if referenced outside an ON-unit, within an ON-unit that is executed as a result of a SIGNAL statement, or within a CONVERSION ON-unit that was not entered because of a conversion in a GET statement.

ONKEY Built-In Function

The ONKEY built-in function returns the key value that caused the KEY condition to be signaled during an I/O operation to a file that is being accessed by key. Its format is as follows:

```
ONKEY()
```

This built-in function can be used in an ON-unit established for these conditions:

- KEY, ENDFILE, or UNDEFINEDFILE

- An ERROR ON-unit that receives control as a result of the default PL/I action for the KEY condition, which is to signal the ERROR condition

■ Returned Value

The returned key value is a varying-length character string. The ONKEY built-in function returns a null string if referenced outside an ON-unit or within an ON-unit executed as a result of the SIGNAL statement.

ONSOURCE Built-In Function

The ONSOURCE built-in function returns the source string that was being converted when the CONVERSION condition was raised. If no CONVERSION condition is active, the return value is a null string.

The format of the function is as follows:

```
ONSOURCE()
```

See "CONVERSION Condition Name" for more information.

ONSOURCE Pseudovariable

The ONSOURCE pseudovariable can be used to replace the entire ONSOURCE value that caused a CONVERSION condition to be raised. An attempt to assign a value to the ONSOURCE pseudovariable when there is no active CONVERSION condition is an error, causing the ERROR condition to be raised.

The format of the pseudovariable is as follows:

```
ONSOURCE()
```

The ONSOURCE value is a fixed-length string value. An assignment of a longer string is truncated, and an assignment of a shorter string is padded with blanks on the right to the necessary length.

See "CONVERSION Condition Name" for more information.

OPEN Statement

The OPEN statement explicitly opens one or more PL/I files with a specified set of attributes that describe the file and the method for accessing it. The format of the OPEN statement is as follows:

```
OPEN FILE(file-reference) [file-description-attribute ...]
        [,FILE(file-reference) [file-description-attribute ...]]...;
```

file-reference

A reference to the file to be opened. If the file is already open, the OPEN statement has no effect.

file-description-attribute

The attributes of the file. The attributes specified are merged with the permanent attributes of the file specified in its declaration, if any. Then, default rules are applied to the union of these sets of attributes to complete the set of attributes in effect for this opening.

The attributes and options you can specify with the OPEN statement are as follows:

DIRECT	PRINT
ENVIRONMENT(option, . . .)	RECORD
INPUT	SEQUENTIAL
KEYED	STREAM
LINESIZE(expression)	TITLE(expression)
OUTPUT	UPDATE
PAGESIZE(expression)	

Each of these attributes is described in its own entry. For a summary of the valid combinations of these attributes and their meanings, **see** "File Description Attributes and Options." Merging of attributes and default attributes supplied are described under "Opening a File."

■ Examples

```
DECLARE INFILE FILE;
        STATE_FILE FILE KEYED;

OPEN FILE (INFILE),
     FILE (STATE_FILE) UPDATE;
          .
          .
          .
CLOSE FILE (STATE_FILE);
OPEN FILE (STATE_FILE) INPUT SEQUENTIAL;
```

The DECLARE and OPEN statements for INFILE do not specify any file description attributes; PL/I applies the default attributes STREAM and INPUT. If any statement other than GET is used to process this file, the ERROR condition is signaled.

The file STATE_FILE is declared with the KEYED attribute. With the first OPEN statement that specifies this file, it is given the UPDATE attribute and opened for updating; that is, READ, WRITE, REWRITE, and DELETE statements can be used to operate on records in the file. The KEYED attribute implies the SEQUENTIAL attribute; thus, records in the file can be accessed sequentially or by key.

The second OPEN statement specifies the INPUT and SEQUENTIAL attributes. During this opening, the file can be accessed by sequential and keyed READ statements; REWRITE, DELETE, and WRITE statements cannot be used.

```
DECLARE COPYFILE FILE OUTPUT;
OPEN FILE(COPYFILE) TITLE('COPYFILE.DAT');
```

The file constant COPYFILE is opened for output. Each time this program is run, it creates a new version of the file COPYFILE.DAT.

Opening a File

A file is opened explicitly by an OPEN statement or implicitly by a READ, WRITE, REWRITE, DELETE, PUT, or GET statement issued for a file that is not open. In either case, opening a file in PL/I has the following effects:

- Any permanent attributes specified in a DECLARE statement of a file constant are merged with the attributes specified in the OPEN statement, if any, or with the attributes implied by the context of the opening. (For example, if no attributes are specified for a file in its declaration, and the first reference to the file is a GET statement, PL/I opens the file with the INPUT and STREAM attributes.) The rules

that PL/I follows in applying default attributes are described below, under "Establishing the Attributes."

- The merged attributes apply to the file for the duration of this opening only. When the file is closed, only its permanent attributes remain in effect.
- The file specification of the file is determined, using the value of the TITLE option.
- If the file already exists, it is located and its attributes are checked for compatibility with the attributes specified or implied by the OPEN statement.
- If the file does not exist, and if the attempted access does not require that the file exist, PL/I creates a new file using the attributes specified or implied to determine the file's organization.
- If the file is opened successfully, the file is positioned.

Each of these steps is described in more detail below. If an error occurs during the opening of a file, the UNDEFINEDFILE condition is signaled. (**See** "UNDEFINEDFILE Condition Name.")

■ Establishing the File's Attributes

The description attributes specified when a file is opened are merged with the file's permanent attributes. Duplicate specification of an attribute is allowed only for an attribute that does not specify a value.

An incomplete set of attributes is augmented with implied attributes. Table O–2 summarizes the attributes that can be added to an incomplete set.

Table O–2: File Description Attributes Implied when a File is Opened

Attribute	Implied Attributes
DIRECT	RECORD KEYED
KEYED	RECORD
PRINT	STREAM OUTPUT
SEQUENTIAL	RECORD
UPDATE	RECORD

If the set of attributes is still not complete, PL/I uses the following steps to complete the set:

1. If neither STREAM nor RECORD is present, STREAM is supplied.
2. If neither INPUT, nor OUTPUT, nor UPDATE is present, INPUT is supplied.
3. If RECORD is specified, but neither SEQUENTIAL nor DIRECT is present, SEQUENTIAL is supplied.
4. If the file is associated with the external file constant SYSPRINT, and the attributes STREAM and OUTPUT are present but the attribute PRINT is not, PRINT is supplied.
5. If the set contains the LINESIZE option, it must contain STREAM and OUTPUT. If it contains these attributes and does not contain LINESIZE, the default system line size value is supplied.
6. If the set contains the PAGESIZE option, it must contain PRINT. If PRINT is present but PAGESIZE is not, the default system page size is supplied.
7. If the set does not contain TITLE, a default option TITLE(name) is supplied, where name is the name of the file constant associated with the file.

The completed set of attributes applies only for the current opening of the file. The file's permanent attributes, specified in the declaration of the file, are not changed.

■ Determining the File Specification

PL/I uses the value of the TITLE option to determine the file specification, that is, the actual name of the file or device on which the I/O is to be performed. The determination of the file specification depends on the following system-specific functions:

1. The value of the TITLE option can be a logical name, or a portion of it can contain a logical name. In either case, the logical name is translated. If the resulting name is a logical name, that name is also translated, to a maximum of 10 translations.
2. After logical name translation, VAX PL/I applies any default values specified in the DEFAULT_FILE_NAME option of the ENVIRONMENT attribute list.
3. If the file specification is still not complete, system defaults are applied to the incomplete portions of the file specification. Defaults are provided for node, device, directory, file type, and version number. If a file name is not specified, PL/I uses the default name supplied in the TITLE option.

The rules for logical name translation and for the application of system defaults are described in detail in the *VAX PL/I User Manual.*

■ Accessing an Existing File

A file opening accesses an existing file if the file specified by the TITLE option actually exists and if the following attributes are present:

- The file is opened for INPUT or UPDATE.
- The file is opened with the OUTPUT attribute and with the ENVIRONMENT(APPEND) option.

Whenever PL/I accesses an existing file, the file's organization is checked for compatibility with the PL/I attributes specified. If any incompatibilities exist, the UNDEFINEDFILE condition is signaled.

■ Creating a File

A file opening creates a new file if the following are all true:

- The OUTPUT attribute is specified.
- The TITLE option, after logical name translation and the application of system defaults, specifies a mass storage device, for example, a disk or a tape.
- The ENVIRONMENT(APPEND) option is not specified.

You can specify the organization and record format of a new file with ENVIRONMENT options. If no ENVIRONMENT options are given, the new file's organization is determined as follows:

- If the KEYED attribute is present, PL/I creates a relative file with a maximum record size of 512 bytes and a maximum record number of 0.
- If the PRINT attribute is present, PL/I creates a sequential stream file with variable-length records, no maximum record length, and a fixed-control field used by PL/I to store carriage-control information.
- If neither KEYED nor PRINT is specified, PL/I creates a sequential file with variable-length records and no maximum record size.

When a file is opened with the RECORD and OUTPUT attributes, only WRITE statements can be used to access the file. If the file has the KEYED attribute as well, the WRITE statements must include the KEYFROM option.

■ File Positioning

When PL/I opens a file, the initial positioning of the file depends on the type of file (record or stream), the access mode, and certain ENVIRONMENT options.

For a definition of the file-positioning information for record files, **see** "Record Input/Output." For a definition of file-positioning information for stream files, **see** "Stream Input/Output."

Operator

An operator is a symbol that requests a unique operation. It can be a prefix operator or an infix operator.

■ Prefix Operator

A prefix operator precedes a single operand. The prefix operators are the unary plus (+), the unary minus (-), and the logical NOT (^).

- The plus sign can prefix an arithmetic value or variable. However, it does not change the sign of the operand.
- A minus sign reverses the sign of an arithmetic operand.
- The ^ prefix operator performs a logical NOT operation on a bit-string operand.

Following are some examples of expressions containing prefix operators:

```
A = +55;
B = -88;
BITC = ^BITB;
```

■ Infix Operator

An infix (or dyadic) operator appears between two operands. It indicates the operation to be performed on the operands. PL/I has infix operators for arithmetic operations, logical operations, relational (comparison) operations, and string concatenations. Following are some examples of expressions containing infix operators:

```
RESULT = A / B;

IF NAME = FIRST_NAME || LAST_NAME THEN GOTO NAME_OK;
```

An expression can contain both prefix and infix operators. For example:

```
A = -55 * +88;
```

Prefix and infix operators can be applied to expressions contained in parentheses.

■ Operands

The expressions on which an operation is performed are called operands. All operators must yield scalar values. Therefore, operands cannot be arrays or structures. The data type that you can use for an operand in a specific operation depends on the operator.

- Arithmetic operators must have arithmetic operands.
- Logical operators must have bit-string operands.
- Relational operators must have two operands of the same type (arithmetic, bit string, or character string).
- The concatenation operator must have two bit-string operands or two character-string operands.

If arithmetic operands are of different arithmetic types, they are converted to a single type before the operation is performed. Similarly, operands of different types in nonarithmetic operations are converted to a single type. **See** "Expression" and "Conversion of Data."

The categories of operators and the operator characters are listed in Table O–3.

Table O–3: Operators

Category	Symbol	Operation
Arithmetic operators	+	Addition or prefix plus
	-	Subtraction or prefix minus
	/	Division
	*	Multiplication
	**	Exponentiation

Table O–3 (Cont.): Operators

Category	Symbol	Operation
Relational (or comparison) operators	>	Greater than
	<	Less than
	=	Equal to
	^>	Not greater than
	^<	Not less than
	^=	Not equal to
	>=	Greater than or equal to
	<=	Less than or equal to
Bit-string (or logical) operators	^ (prefix)	Logical NOT
	&	Logical AND
	|	Logical OR
	&:	Logical AND THEN
	|:	Logical OR ELSE
	^ (infix)	Logical EXCLUSIVE OR
Concatenation operator	||	String concatenation

NOTE

For any of the operators, the tilde character (~) can be used instead of the circumflex character (^), and the exclamation point (!) can be used instead of the vertical bar (\|).

■ Precedence of Operations

A PL/I expression can consist of many subexpressions and operands. When an expression contains more than one operator, PL/I uses a defined set of rules to determine which operation to perform first, second, and so on. If the expression contains parentheses, PL/I evaluates expressions within the parentheses (according to the rules of priority) first and then uses the resulting value as a single operand. Unparenthesized operations of equal priority are performed from left to right.

Table O–4 gives the priority of PL/I operators. In Table O–4, low numbers indicate high priority. For example, the exponentiation operator (**) has the highest priority (1), so it is performed first, and the OR ELSE operator (\|:) has the lowest priority (9), so it is performed last.

Table O–4: Precedence of Operators

Operator	Priority	Operator	Priority
**	1	<	5
+ (prefix)	1	^>	5
– (prefix)	1	^ <	5
^ (prefix)	1	=, ^=	5
*	2	<=	5
/	2	> =	5
+ (infix)	3	&	6
– (infix)	3	|, ^ (infix)	7
||	4	&:	8
>	5	|:	9

OPTIONAL Attribute

The OPTIONAL attribute indicates that an actual parameter need not be specified in a call. If the actual parameter is not specified, a placeholder for it must be specified, and PL/I will pass a longword zero as the actual parameter in that position.

For example:

```
DCL E ENTRY (FIXED,FIXED OPTIONAL);
CALL E(1,2);
CALL E(1,);
```

OPTIONS Option

The OPTIONS option specifies special processing in certain PL/I statements. OPTIONS (MAIN) is necessary in the PROCEDURE statement if the procedure is the main part of a program. Other than MAIN, the lower-level options that can follow OPTIONS are implementation-specific and not part of the standard PL/I language.

The statements that have the OPTIONS option are as follows:

- The DECLARE statement with the ENTRY attribute
- The I/O statements DELETE, GET, PUT, READ, REWRITE, and WRITE

- The PROCEDURE statement

The format of the OPTIONS option is as follows:

```
OPTIONS (option,...)
```

For a list of the valid options, see the entry for the individual statement or attribute.

For example:

```
APPLIC: PROCEDURE OPTIONS (MAIN, IDENT('APPLIC'));
```

This is a PROCEDURE statement with the OPTIONS option. The OPTIONS option itself has two options here: MAIN and IDENT.

OR Operator

The vertical bar character (|) represents the logical OR operation in PL/I. In a logical OR operation, two bit-string operands are compared bit by bit. If the two operands are of different lengths, the shorter operand is converted to the length of the longer operand, and this is the length of the result. If either of two corresponding bits is 1, the resulting bit is 1; otherwise, the resulting bit is 0.

All relational expressions result in bit strings of length 1, and they can therefore be used as operands in an OR operation.

The result of the OR operation is a bit-string value. For example:

```
DECLARE (BITA, BITB, BITC) BIT (4);
BITA = '0011'B;
BITB = '1111'B;
BITC = BITA | BITB ;
```

The resulting value of BITC is '1111'B.

The OR operator can test whether one of the expressions in an IF statement is true. For example:

```
IF (LINENO(PRINT_FILE) < 60) |
   (MORE_DATA = YES) THEN ...
```

You can use the exclamation point (!) in place of the vertical bar, for compatibility with other PL/I implementations.

See also "Logical Operator," "EXCLUSIVE OR Operator," and "OR ELSE Operator."

OR ELSE Operator

The vertical bar and colon characters (|:) together are the OR ELSE operator in PL/I. The OR ELSE operator causes the first operand to be evaluated. If it is true, the result returned is '1'B. If and only if the first operand is false, the second operand is evaluated. If either or both operands are true, the result returned is '1'B; otherwise, the result is '0'B.

The OR ELSE operator performs a Boolean truth evaluation, not a bit-by-bit operation, even when the two operands are bit strings. For example, '00001'B |: '10000'B yields '1'B (not '10001'B, which would be the result of an OR operation on these two bit strings). The reason is that each operand is a nonzero bit value, and therefore each evalutes to '1'B.

The OR ELSE operator yields the same result as the OR operator (|) when expressions are tested in an IF statement (as in the last example in the "OR Operator" entry). The difference is that the OR operator can have its operands evaluated in any order.

The OR ELSE operator is useful in compound test expressions in which the second test should occur only if the first test failed. For example:

```
IF (A=0) |: (B/A > 1) THEN ...
```

This results in the second expression (B/A > 1) being evaluated only if the first expression is false. Thus, the OR ELSE operator prevents an attempt to divide by zero.

See also "OR Operator," "Logical Operator," and "Operator."

OTHERWISE Keyword

The OTHERWISE clause is optionally specified in a SELECT statement to define the action to be taken if none of the preceding conditions in the statement is satisfied. The action following the OTHERWISE keyword can be a null statement. **See** "SELECT Statement."

OTHERWISE can be abbreviated to OTHER.

OUTPUT Attribute

The OUTPUT file description attribute indicates that data is to be written to, and not read from, the associated external device or file.

Specify the OUTPUT attribute on a DECLARE statement for a file constant or on an OPEN statement to access the file for writing. You can specify the OUTPUT attribute with either the STREAM or the RECORD attribute. For a stream file, OUTPUT indicates that the file will be accessed with PUT statements. For a record file, OUTPUT indicates that the file will be accessed with only WRITE statements.

For example:

```
DECLARE OUTFILE RECORD OUTPUT;

OPEN FILE(OUTFILE);
WRITE FILE(OUTFILE) FROM(RECORD_BUFFER);
```

These statements declare, open, and write a record to the output file OUTFILE.

For a description of the attributes that can be applied to files and the effects of combinations of these attributes, **see** "File Description Attributes and Options."

The OUTPUT attribute can be supplied by default for a file, depending on the context of its opening. **See** "Opening a File."

■ Restrictions

The OUTPUT attribute conflicts with the INPUT and UPDATE attributes and with any data type attributes other than FILE.

OVERFLOW Condition Name

The OVERFLOW condition name can be specified in an ON, REVERT, or SIGNAL statement to designate an ON condition or ON-unit for floating-point overflow conditions. OVERFLOW can be abbreviated to OFL.

The exponent of a floating-point value is adjusted, if possible, to represent the value with the specified precision. That is, the precision is maximized and the exponent is minimized. The maximum precision allowed for a binary floating-point value is 113; the maximum precision of a decimal floating-point value is 34. PL/I signals the OVERFLOW condition when

the result of an arithmetic operation on a floating-point value exceeds the maximum exponent size allowed by the VAX hardware.

The value resulting from an operation that causes this condition is undefined.

■ ON-Unit Completion

Control returns to the point of the interruption.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

P

P Format Item

The picture format item (P) describes a field of characters in the input or output stream. The field can be an input field acquired with GET EDIT or an output field transmitted by PUT EDIT. With GET EDIT, the P format item acquires a pictured value from the input stream. With PUT EDIT, the P format item edits an output source to a specified picture format.

The form of the P format item is as follows:

```
P 'picture'
```

'picture'
A picture of the same syntax as for the PICTURE data attribute. The syntax is summarized in "PICTURE Attribute." The field width is the total number of characters, exclusive of V, in the picture. For full details, **see** "Picture."

The interpretation of the P format item, for input and output, is given below. For a general discussion of format items, **see** "Format Item."

■ Input with GET EDIT

Used with the GET EDIT statement, the P format item acquires a pictured value (a field of characters) from the stream file, extracts its fixed-point decimal value, and assigns the value to an input target of any computational type. The picture describes a field of w characters, where w is the total number of picture characters in the picture, exclusive of the V character.

A string of w characters is acquired from the input stream and validated against the picture specified in the format item. The string is valid if it corresponds to an internal representation that would be created by the specified picture if the picture were used to declare a variable of type PICTURE. If the string is valid, its fixed-point decimal value is extracted and assigned to the input target. If necessary, the value is converted to

the type of the input target, following the usual rules (**see** "Conversion of Data"). If the string is not valid, the ERROR condition is signaled.

When no decimal point appears in the input stream item, the scale factor of the item is assumed to be the number of digit positions specified to the right of the V character in the picture. If no V character appears, the scale factor is zero.

■ Output with PUT EDIT

Used with the PUT EDIT statement, the P format item outputs a source of any computational type in the specified format. If necessary, the output source is first converted to a fixed-point decimal value, following the PL/I conversion rules (**see** "Conversion of Data"). The fixed-point decimal value is then edited by the picture specified in the format item. The P format item therefore describes an output field of w characters, where w is the total number of characters in the picture, exclusive of the V character. If the output source is a pictured value, then its extracted fixed-point decimal value must be capable of being edited by the picture specified in the P format item. Otherwise, the ERROR condition is signaled.

■ Examples

The tables below show the relationship between the internal and external representations of numbers that are read or written with the P format item.

Input Examples

The input stream shown in this table is a field of characters beginning at the current position in the stream and continuing to the right. The target type is the type of the variable to which the input value is assigned.

Format Item	Input Stream	Target Type	Target Value
P '$$$,$$$,$$9V.99DB'	$10,987,654.00DB...	DECIMAL(10,2)	-10987654.00
P '$$$,$$$,$$9V.99DB'	ΔΔΔΔΔΔΔΔ$10.99ΔΔ...	DECIMAL(10,2)	10.99
P 'SSSSV.SSSSS'	ΔΔ--1.12345...	DECIMAL(8,5)	-1.12345
P 'SSSSV.SSSSS'	+100.12345...	DECIMAL(8,5)	100.12345
P 'SSSSV.SSSSS'	Δ100.12345...	DECIMAL(8,5)	[ERROR]
P 'SSSSV.SSSSS'	+1001.2345...	DECIMAL(8,5)	[ERROR]

The last two cases signal the ERROR condition. In the first case, the input field has a space instead of a plus symbol or minus symbol in the first position. In the second case, the input field has four digits to the left of

the period, and the P format item specifies a maximum of three. The P format item in both cases uses "drifting strings" of S characters, and, if used to declare a picture variable, the specification could create several different character representations. However, the specification could not have created the last two input fields shown, and they are therefore invalid values, as described under "Input with GET EDIT" above.

Note that in the second line in the table, the characters "$10.99" must be surrounded with the number of spaces shown. The drifting dollar signs and the comma insertion characters always specify either digits, the characters themselves, or spaces. Similarly, the characters "DB" in the picture specification specify either these characters or the same number of spaces. If the pictured input value did not contain these spaces, it would be invalid.

Output Examples

The output source value shown in this table is either a constant or the value of a variable that is written out with the associated format item.

Output Source Value	Format Item	Output Value
-12234	P '$$$$$$DB'	$12234DB
-12234	P 'SSSSSSV.SS'	-12234.00
-12.234	P 'T9V.999'	J2.234
-1.23456E3	P '-9999V.99'	-1234.56
-1.23456E3	P '+ZZZ9V.99'	Δ1234.56

%PAGE Statement

The %PAGE statement provides listing pagination without inserting form-feed characters into the source text.

The format of %PAGE is as follows:

```
%PAGE;
```

The first source record following the record that contains the %PAGE statement is printed on the first line of the next page of the source listing.

PAGE Format Item

The PAGE format item is used with print files to begin a new page.

The form of the PAGE format item is as follows:

```
PAGE
```

Subsequent output begins on line 1 of the next page, and the current page number for the print file is incremented by 1 (**see also** "PAGENO Built-In Function" and "Print File").

PAGE Option

The PAGE option is used with the PUT statement to advance a print file to the top of the next page before beginning output. The output file must be a print file, that is, it must be declared with the PRINT attribute.

For further information, **see** "PUT Statement," "PRINT Attribute," and "Print File."

PAGENO Built-In Function

The PAGENO built-in function returns a FIXED BINARY(15) integer that is the current page number in the referenced print file. The print file must be open. The format of the function is as follows:

```
PAGENO(reference)
```

PAGENO Pseudovariable

The PAGENO pseudovariable refers to the page number of the referenced print file. Assignment to the pseudovariable modifies the current page number. **See also** "Pseudovariable" for general rules. The format of the PAGENO pseudovariable in an assignment statement is as follows:

```
PAGENO(reference) = expression;
```

reference
A reference to a file for which the page number is to be set. The file must be open and must be a print file.

PAGENO(reference) is a FIXED BINARY(15) variable; however, values assigned to it must not be negative.

PAGESIZE Option

The PAGESIZE option is used in the OPEN statement to specify the maximum number of lines that can be written to a print file without signaling the ENDPAGE condition. The format of the PAGESIZE option is as follows:

```
PAGESIZE(expression)
```

expression
A fixed-point binary expression in the range 1 through 32767, giving the number of lines per page. If a program generates a value in excess of 32767, a run-time error occurs.

The value specified in the PAGESIZE option is used as the output page length for all subsequent output operations on the print file, and overrides the system default page size. The default page size is as follows:

- If the logical name SYS$LP_LINES is defined, the default page size is the numeric value of SYS$LP_LINES minus 6.
- If SYS$LP_LINES is not defined, or if its value is less than 30 or greater than 99, or if its value is not numeric, the default page size is 60.

During output operations, the ENDPAGE condition is signaled the first time that the specified page size is exceeded.

■ Restrictions

The PAGESIZE option is valid only for print files.

PARAMETER Attribute

A variable occurring in the parameter list of a PROCEDURE or ENTRY statement has the PARAMETER attribute implicitly. The PARAMETER keyword can optionally be used in the declaration of a variable name to state explicitly that it is a parameter.

PARAMETER can be abbreviated PARM.

Following is an example of the use of the PARAMETER keyword:

```
TEST: PROC( A, B );
    DCL A CHAR(*) PARAMETER;
    DCL B FIXED BIN PARM;
        .
        .
        .
```

For more information, **see** "Parameters and Arguments."

Parameter Descriptor

See "ENTRY Attribute."

Parameters and Arguments

A PL/I procedure can invoke other procedures and can transmit values to and receive them from the invoked procedure. Values are transmitted to an invoked procedure by means of arguments written in the procedure invocation. Values are returned to the invoking procedure by means of parameters and also, in the case of functions, by specifying a value in the function's RETURN statement.

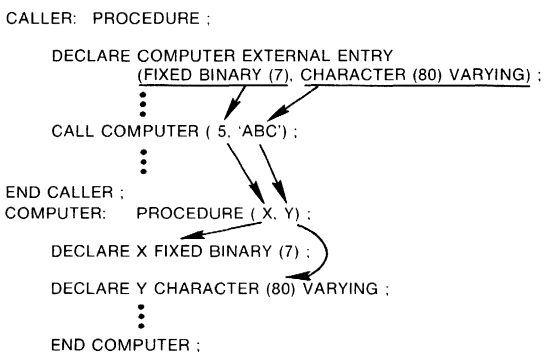
You can specify arguments for a subroutine (invoked by a CALL statement) or for a function (invoked by a function reference). Subroutines and functions return values by different means.

- A subroutine can return values only through a list of parameters. A subroutine must not specify a return value in its RETURN statement, and the declaration of an external entry point must not include the RETURNS attribute if the entry point is to be invoked as a subroutine. Instead, you can return values by assigning them, within the invoked subroutine, to the variables listed as parameters. (**See also** "Argument Passing" below.)

- A function can return values through its parameter list and, in addition, must return a single value that becomes the value of the function reference in the invoking procedure; this value is specified in the function's RETURN statement. The attributes of this returned value are specified within the invoking procedure, in the function's PROCEDURE or ENTRY statement, or in the declaration of the external entry constant or entry variable used to invoke the function. (**See also** "RETURN Statement".)

Figure P–1 illustrates the relationship between arguments (specified on a CALL statement or function reference) and parameters (specified on a PROCEDURE statement).

Figure P–1: Parameters and Arguments



The ENTRY attribute in a DECLARE statement provides a parameter descriptor for each parameter of the called procedure. A parameter descriptor is a set of data type attributes.

In a CALL statement or a function reference, arguments appear in parentheses following the name of the procedure. Arguments can be variables, expressions, aggregates, or (as in this example) constants.

The data type of each argument is matched with the corresponding parameter descriptor in the declaration of the entry.

The PROCEDURE statement for the called procedure specifies the parameters of the procedure. These parameters correspond, in the order specified, to the arguments specified in the CALL statement.

Each parameter specified in the PROCEDURE statement must be declared within the procedure.

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■ Parameter List

A parameter is a variable that occurs in the parameter list of a PROCEDURE or ENTRY statement. When the entry point is invoked, each parameter in the parameter list is associated with an argument variable. Within the procedure invocation, any reference to the parameter is equivalent to a reference to the associated argument variable.

If the invoked entry point is external to the invoking procedure, the attributes of the parameters must be described in parameter descriptors, which are part of the declaration of the external entry point.

Procedures can have more than one entry point (**see** "Procedure"). Each entry point that will be invoked with an argument list must have a parameter list. Multiple entry points in a procedure do not need to have identical parameters, but a reference to a parameter is valid only if the procedure was invoked through an entry point that specified that parameter.

■ Argument List

An argument is an expression or variable reference denoting a value to be passed to the invoked procedure. A procedure must be invoked with the same number of arguments as it has parameters. The maximum number of arguments that can be passed to a procedure is 253. The argument variable associated with a parameter, or "actual argument," can be a variable written in the argument list or a dummy argument created by the compiler. A dummy argument is created when the specified argument is a constant or expression and exists only for the duration of the procedure invocation. Therefore, references in the invoked procedure to the parameter associated with a dummy argument do not modify any storage in the invoking procedure. (For additional details, **see** "Argument Passing.")

An argument list consists of zero or more arguments specified in the invocation of a procedure, built-in function, or built-in subroutine. Arguments to a built-in function are expressions that supply values to the built-in function, and the argument types must be those required by the function. Arguments to user-defined procedures correspond to parameters defined on the PROCEDURE or ENTRY statement of the invoked procedure.

Arguments in an argument list must be separated by commas, and the list enclosed in parentheses. For example:

```
CALL XYZ(STRING, 5, INDEX(ABC, STRING));
```

The CALL statement in this example invokes the procedure XYZ with an argument list consisting of three arguments:

- A variable named STRING
- An integer constant, 5

- A function reference (the INDEX built-in function is invoked with the variable arguments ABC and STRING; the value returned by INDEX is passed as the third argument to the procedure XYZ)

An empty argument list is required in the invocation of a user-defined function with no parameters. An empty argument list can be used in the invocation of a subroutine or built-in function that has no parameters. Examples:

```
X = F();    /* user-defined procedure--argument list required */
S = DATE(); /* built-in function--argument list optional */
CALL P();   /* subroutine--argument list optional */
```

■ Rules for Specifying Parameters

The general rules listed below for specifying parameters are followed by specific rules that pertain only to certain data types.

- A parameter must be declared explictly in a DECLARE statement (to give it a data type) within the invoked procedure. This declaration must not be part of a structure.
- A parameter must not be declared with any of the following attributes:

AUTOMATIC	EXTERNAL	READONLY
BASED	GLOBALDEF	STATIC
CONTROLLED	GLOBALREF	
DEFINED	INITIAL	

- A maximum of 253 parameters can be specified for an entry point.
- The parameters of an external entry must be explicitly specified by parameter descriptors in the declaration of the entry constant. The parameters of a procedure that is invoked through an ENTRY variable must be specified by parameter descriptors in the ENTRY attribute of the variable's declaration. The parameters of an internal entry must not be declared. For details on entries and parameter descriptors, **see** "Entry Data."
- Each parameter must have a corresponding argument at the time of the procedure's invocation. PL/I matches the data type of the parameter with the data type of the corresponding argument and creates a dummy argument if they do not match. (**See** "Argument Passing" below.)

Array Parameters

If the name of an array variable is passed as an argument, the corresponding parameter descriptor or parameter declaration must specify the same number of dimensions as the argument variable. You can specify the bounds of a dimension using asterisks (*) or optionally signed integer constants. If the bounds are specified with integer constants, they must match exactly the bounds of the corresponding argument. An asterisk indicates that the bounds of a dimension are not known. (If one dimension contains an asterisk, all the dimensions must contain asterisks.) For example:

```
DECLARE SUMUP ENTRY ((*) FIXED BINARY);
```

This declaration indicates that SUMUP's argument is a one-dimensional array of fixed-point binary integers that can have any number of elements. Any one-dimensional array of fixed-point binary integers can be passed to this procedure.

All the data type attributes of the array argument and parameter must match.

Structure Parameters

If the name of a structure variable is passed as an argument, the corresponding parameter descriptor or declaration must be identical in terms of structure levels, members' sizes, and members' data types. Array bounds and string lengths can be specified with asterisks or with optionally signed integer constants. The level numbers do not have to be identical. The following example shows the parameter descriptor for a structure variable:

```
DECLARE SEND_REC ENTRY (1,
                        2 FIXED BINARY(31),
                        2 CHARACTER(40) VARYING,
                        2 PICTURE '999V99');
```

The written argument in the invocation of the external procedure SEND_REC must have the same structure, and its members must have the same data types.

Structures are always passed by reference. They cannot be passed by dummy argument.

Character-String Parameters

If a character-string variable is passed as an argument, the corresponding parameter descriptor or parameter declaration can specify the length with an asterisk (*) or an optionally signed nonnegative integer constant. For example:

```
COPYSTRING: PROCEDURE (INSTRING,COUNT);
DECLARE INSTRING CHARACTER(*);
```

The asterisk in the declaration of this parameter indicates that the string can have any length.

Entry, File, and Label Constant Parameters

Entry, file, and label constants can be passed as arguments. The actual argument is a variable.

■ Argument Passing

The following paragraphs describe the precise rules that PL/I uses to determine how to pass an argument.

There are different rules for passing arguments to procedures written in PL/I and for passing arguments to procedures written in other languages. This manual describes only the conventions for passing arguments to procedures that are written in PL/I. For complete rules and details on passing arguments to procedures written in other languages, **see** the *VAX PL/I User Manual.*

Number of Arguments

The number of arguments in the argument list must equal the number of parameters of the invoked entry point. The compiler checks that the count matches as follows:

- For an internal procedure, the compiler checks the number of arguments specified in the argument list against the number of parameters specified on the PROCEDURE or ENTRY statement for the internal procedure.
- For an external procedure, the compiler checks that the number of parameter descriptors in the parameter descriptor list of the ENTRY declaration matches the number of arguments specified in the procedure invocation. This argument checking can be overridden for an external procedure declared with the LIST option or the TRUNCATE option; LIST is restricted to non-PL/I procedures, whereas TRUNCATE is allowed with procedures written in PL/I. With the LIST option, there can be more arguments than parameter descriptors. With the TRUNCATE option, there can be fewer arguments than parameter descriptors. **See** the *VAX PL/I User Manual* for information on how to use these options.

Actual Arguments

When a PL/I procedure is invoked, each of its parameters is associated with a variable determined by the corresponding written argument of the procedure call. This is the actual argument for the procedure invocation. This actual argument can be either a reference to the written argument or a dummy argument.

The data type of the actual argument is the same as the data type of the corresponding parameter. When a written argument is a variable reference, PL/I matches the variable against the corresponding parameter's data type according to the rules given under the heading "Argument Matching," below. If it matches, the actual argument is the variable denoted by the written argument. That is, the parameter denotes the same storage as the written variable reference. If it does not match, the compiler creates a dummy argument and assigns the value of the written argument to the dummy argument.

Dummy Arguments

A dummy argument is a unique variable allocated by the compiler, and it exists only for the duration of the procedure invocation.

When the written argument is a constant or an expression, the actual argument is always a dummy argument. The value of the written argument is assigned to this dummy argument before the call. The data type of the written argument must be valid for assignment to the data type of the dummy argument.

Aggregate Arguments

An array, structure, or area argument must be a variable reference that matches the corresponding parameter. It cannot be a reference to an unconnected array. A dummy argument is never created for an array or structure.

Argument Matching

A written argument that is a variable reference is passed by reference only if the argument and the corresponding parameter have identical data types. (For the definition of identical data types, **see** "Data and Data Types.")

For an internal procedure, the attributes of the argument must match the attributes specified in the declaration of the parameter. For an external procedure or a procedure invoked through an ENTRY variable, the attributes specified in the ENTRY attribute parameter descriptor must match the attributes of the arguments.

When the compiler detects that a scalar variable argument does not match the data type of the corresponding parameter, it issues a warning message, creates a dummy argument, and associates the address of the dummy argument with the corresponding parameter. You can suppress the warning message and force the creation of a dummy argument if you enclose the argument in parentheses. For example, if a parameter requires a CHARACTER VARYING string and an argument is a CHARACTER nonvarying variable, enclose the variable in parentheses.

For string lengths and array bounds, an asterisk (*) in the parameter matches any size. An integer constant matches only an integer constant with the same value.

Conversion of Arguments

When the data type of a written argument is suitable for conversion to the data type of the corresponding parameter descriptor, PL/I performs the conversion of the argument to a dummy argument using the rules described under "Conversion of Data."

Picture

Pictured data is used when you want to manipulate a quantity arithmetically and then print or display its value using a special output format. This entry discusses the following topics:

- Pictured variables—variables declared with the PICTURE data attribute
- Editing by picture—the process by which a value is assigned to a pictured variable or written out with the P format item
- Extracting values from pictured data—the process by which a pictured value is assigned to other variables or acquired with the P format item
- Picture characters—the special characters that make up a picture specification in the PICTURE attribute and in the P format item

"Picture Characters" below gives a detailed description of each picture character. For a brief description of the characters and for the required picture syntax, **see** "PICTURE Attribute." For a description of the P format item, **see** "P Format Item."

■ Pictured Variables

A pictured variable has the attributes of a fixed-point decimal variable, but values assigned to it are stored internally as character strings. Such a character string contains digits representing the variable's numeric value as well as special symbols such as the dollar sign. When the value of a pictured variable is written out, for example, by the PUT LIST statement, the internally stored character string is placed in the output stream. The value that appears on a line printer or terminal thus contains a fixed-point decimal number that has been "edited" with the requested special symbols.

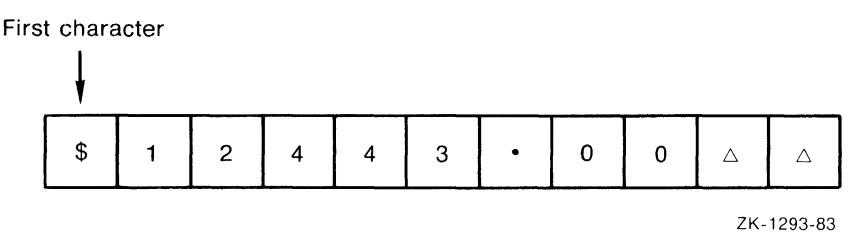
The formatting possible with pictured data is useful in many applications, but pictured data is much less efficient than fixed-point decimal data for strictly computational use.

The numeric attributes of a pictured variable and its output format are both described in a picture specification, or simply, a picture. A simple picture looks like this in a DECLARE statement:

```
DECLARE CREDIT PICTURE '$99999V.99DB';
```

The variable CREDIT is declared as a pictured variable; its picture comprises the characters between the apostrophes.

The assignment `CREDIT = 12443.00;` stores the following data internally, as a character string, where the delta (Δ) represents a space:



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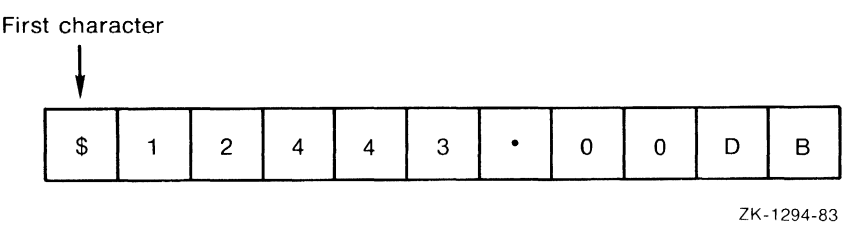
The assignment `CREDIT = -12443.00;` stores the following data internally:



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In situations that call for a character representation of a pictured data item (such as output with PUT LIST), this internal representation is used, including the nonnumeric characters. On output, the values assigned to CREDIT would look like this:

```
$12443.00    /* a positive value (credit) */
$12443.00DB  /* a negative value (debit)  */
```

■ Editing by Picture

Any computational value or expression can be assigned to a pictured variable, as long as it meets these two qualifications:

- The value either is a fixed-point decimal value or can be converted to a fixed-point decimal value (**see also** "Conversion of Data").
- The fixed-point decimal value can be represented with the precision and scale factor of the picture specified for the target pictured variable.

When a value is assigned to a pictured variable, the value is edited to construct a character string that meets the picture specification. Editing also occurs when a value is output with the PUT EDIT statement and the P format item. Editing was performed in the previous examples in which fixed-point decimal values were assigned to the pictured variable CREDIT.

Because a picture specifies a fixed-point decimal value, the FIXEDOVERFLOW condition is signaled in the same circumstances as for assignment of an expression to a FIXED DECIMAL variable.

In addition, two programming errors are common in assignments to pictured variables:

```
CREDIT = '$12443.00';
```

This example signals the ERROR condition because the character string contains a dollar sign and is therefore not convertible to fixed-point decimal. The value assigned to CREDIT should be either '12443.00' or simply 12443.00, both of which result in the same value assigned to CREDIT.

If a negative value is assigned to a pictured variable, the picture must include one of the sign picture characters (such as DB). If, for example, the picture of CREDIT did not contain the DB characters, then the assignment `CREDIT = -12443.00;` would signal the FIXEDOVERFLOW condition, because the sign would be lost.

In some circumstances (for example, with the READ statement), it is possible to assign a value to a pictured variable that is not valid with respect to the variable's picture specification. In such cases, the VALID built-in function can be used to validate the contents of the variable. **See** "VALID Built-In Function."

■ Extracting Values from Pictured Data

When a pictured value is used in an arithmetic context (for example, when it is assigned to an arithmetic variable), the picture is used to extract the fixed-point decimal number from the character string that is the internal representation of the pictured value. Extraction also occurs when a pictured value is input with the GET EDIT statement and the P format item.

Assume that the following is the picture for CREDIT:

```
DECLARE CREDIT PICTURE '$99999V.99DB';
```

The 9 character specifies the position of a decimal digit; because the picture contains seven of these, the fixed-point decimal precision of CREDIT is 7.

The V character separates the integral and fractional digits; because there are two 9 characters to the right of the V, the scale factor of CREDIT is 2. The V character is unique among picture characters in that it specifies only a numeric property; it does not cause a decimal point (or any other character) to appear in the internal representation of CREDIT. Therefore, a period picture character (.) should be included after the V to ensure that the output value has a decimal point in the correct place.

The period and dollar sign are always inserted in the internal representation and the output value regardless of CREDIT's numeric value.

The picture character DB appears only when the value of CREDIT is less than zero; otherwise, two spaces appear in the indicated positions. The DB character also indicates that a value of CREDIT is numerically negative, so that if CREDIT is later assigned to an arithmetic variable, the variable will be given a negative value.

■ Picture Characters

The picture is a string made up of special characters. (For a full list of PL/I picture characters, **see** Table P–2 in "PICTURE Attribute.") An individual picture character and its position in the picture indicate the interpretation of an associated position in the pictured value. All picture characters are shown here in uppercase, although the lowercase equivalents can be used.

The picture characters fall into three categories:

- Characters that affect only the numeric interpretation of the value. The decimal place character (V) is the only one in this category.
- Characters that affect both the numeric interpretation and character representation of the value:
  - The digit characters (9, Z, *, Y)
  - The encoded-sign characters (T, I, R)
  - The drifting characters ($, +, –, S)
- Characters that affect only the character representation of the value:
  - The insertion characters (comma, period, slash, space)
  - The credit (CR) and debit (DB) characters

Any picture character that can appear more than once in a picture can be preceded by an iteration factor. The iteration factor must be a positive integer constant enclosed in parentheses. For example:

```
'(4)9'
```

This picture is the same as the following:

```
'9999'
```

Decimal Place Character (V)

The V character shows the position of the "assumed" decimal point, or, in other words, the scale factor for the fixed-point decimal value. The V character has no effect on the internal representation of the pictured value and does not cause a decimal point to appear in the internal representation. (The period insertion character is used for this purpose—**see** "Insertion Characters," below.) The following additional rules apply to the V character:

- Only one V character can appear in a picture.
- If a picture does not contain the V character, a V character is assumed to be at the right end of the picture. That is, the pictured value has a scale factor of zero.
- When a fixed-point value is assigned to a pictured variable, the integral portion of the assigned value is described by the picture characters to the left of the V; the fractional portion of the assigned value is described by the picture characters to the right of the V.
  - If the assigned value has fewer integral digits than are indicated by the picture characters to the left, then the integral value of the pictured variable is extended on the left with zeros. If the assigned

value has too many integral digits, the value of the pictured variable is undefined and the FIXEDOVERFLOW condition is signaled.

- If the assigned value has fewer fractional digits than are indicated in the picture, then the fractional value of the pictured variable is extended on the right with zeros. If the assigned value has too many fractional digits, then the excess fractional digits are truncated on the right; no condition is signaled. Thus, if the V character is the last character in the picture or is omitted, assigned fixed-point values are truncated to integers.

*Digit Characters (9, Z, *, Y)*

All of these characters mark the positions occupied by decimal digits. The number of these characters present in a picture specifies the number of digits, or precision, of the fixed-point decimal value of the pictured variable. These characters also describe the internal character representation of the digits; they allow zeros in a number to be represented either by the character 0 or by an alternative character. Specifically:

- The position occupied by 9 always contains a decimal digit, whether or not the digit is significant in the numeric interpretation of the pictured value.
- The position occupied by Z contains a decimal digit only if the digit is significant in the integral portion of the numeric interpretation; if the digit is an insignificant, or "leading," zero, it is replaced by a space in the internal representation.
  - The Z character must not appear in the same picture with the asterisk character (*). It must not appear to the right of the characters 9, T, I, or R, nor to the right of a drifting string (**see** "Drifting Characters" below).
  - If the Z character appears to the right of the V character, then all digits to the right of the V must be indicated by Z characters. Fractional zeros are then suppressed only if all fractional digits are zero and all of the integral digits are suppressed; in that case, the internal representation contains only spaces in the digit positions.
- The position occupied by the asterisk (*) character functions identically with the Z character, except that leading zeros are replaced in the internal representation by asterisks instead of spaces. The asterisk (*) character must not appear in the same picture as Z, nor to the right of the characters 9, T, I, or R, nor to the right of a drifting string (**see** "Drifting Characters" below).

- The position occupied by the Y character contains a decimal digit only if the digit is not zero. All zeros in the indicated positions, whether significant or not, are replaced by spaces in the internal representation.

Encoded-Sign Characters (T, I, R)

The characters T, I, and R are digit characters that can be used wherever 9 is valid. One of these characters represents a digit that has the sign of the pictured value encoded in the same position.

Only one of these characters can be used in a picture.

An encoded-sign character cannot be used in a picture that contains an S, plus sign (+), minus sign (-), CR, or DB (described later in this section).

The meanings of the characters are as follows:

- The T character indicates that the position contains an encoded minus sign if the numeric value is less than zero, and an encoded plus sign if the numeric value is greater than or equal to zero. These encoded-sign digits are represented internally and in output by the ASCII characters shown in Table P–1.
- The I character indicates an encoded plus sign if the numeric value is greater than or equal to zero. Otherwise, the position contains an ordinary digit.
- The R character indicates an encoded minus sign if the numeric value is less than zero. Otherwise, the position contains an ordinary digit.

Table P–1 shows the ASCII characters used to indicate digits with encoded signs. In the table, the notation +digit represents the digit with an encoded plus sign, and -digit represents the digit with an encoded minus sign. The characters in Table P–1 are used in the internal representation of a pictured value and must be used for input of an encoded-sign digit from a stream file.

Table P–1: ASCII Representation of Encoded-Sign Digits

Digit	ASCII Character	Digit	ASCII Character
+0	{	-0	}
+1	A	-1	J
+2	B	-2	K
+3	C	-3	L

Table P–1 (Cont.): ASCII Representation of Encoded-Sign Digits

Digit	ASCII Character	Digit	ASCII Character
+4	D	–4	M
+5	E	–5	N
+6	F	–6	O
+7	G	–7	P
+8	H	–8	Q
+9	I	–9	R

Drifting Characters ($, +, –, S)

The drifting characters can be used to indicate digits, and they also indicate a symbol to be inserted in the internal representation. The inserted symbol then appears when, for example, a pictured value is written out by PUT LIST.

- The dollar sign ($) causes a dollar sign to be inserted.
- The plus sign (+) causes a plus sign to be inserted if the numeric value is greater than or equal to zero.
- The minus sign (–) causes a minus sign to be inserted if the numeric value is less than zero.
- The S character causes a plus sign to be inserted if the numeric value is greater than or equal to zero, and a minus sign if the value is less than zero.

If one of these characters is used alone in the picture, it marks the position at which a special symbol or space is always inserted, and it has no effect on the value's numeric interpretation. In this case, the character must appear either before or after all characters that specify digit positions.

However, if a series of n of these characters appears, then the rightmost n–1 of the characters in the series also specify digit positions. If the digit is a leading zero, the leading zero is suppressed, and the leftmost character "drifts" to the right; in the internal representation, the character appears either in the position of the last drifting character in the series or immediately to the left of the first significant digit, whichever comes first. Used this way, the n–1 drifting characters also define part of the numeric precision of the pictured variable, because they describe at least some of the positions occupied by decimal digits. The following additional rules apply to drifting characters:

- A drifting string is a series of more than one of the same drifting character. If a drifting string appears in the picture, it must be the only drifting string; the other drifting characters can be used only singly and therefore designate insertion characters and not digits.
- The Z and asterisk characters cannot appear to the right of a drifting string.
- A digit position cannot be specified (for instance, with a 9) to the left of a drifting string.
- A drifting string can contain the V character and one of the insertion characters (defined below). The following additional rules apply to insertion characters that are embedded in a drifting string:
  - If the drifting string contains an insertion character, the insertion character is inserted in the internal representation only if a significant digit appears to its left. In the position of the insertion character, a space appears if the leftmost significant digit is more than one position to the right; the drifting symbol appears if the next position to the right contains the leftmost significant digit.
  - If the drifting string contains a V character, all digit positions to the right of the V (the fractional digits) must also be part of the drifting string. In this case, insignificant fractional digits are suppressed if and only if all integral and fractional digits are zeros; if so, they are replaced by spaces in the internal representation. If any digit is not zero, all fractional digits appear as actual digits.
  - Any insertion characters that are immediately to the right of a drifting string are considered part of the drifting string.

Insertion Characters

The insertion characters indicate that characters are inserted in the internal representation of the pictured value. They are inserted between digits. The insertion characters are the comma (`,`), the period (`.`), the slash (`/`), and the space (`B`). The B character indicates that a space is always inserted at the indicated position.

The drifting characters also function as insertion characters when used singly (that is, when not part of a drifting string).

The following rules describe the actual characters inserted by the comma, period, and slash insertion characters.

- In general, the insertion character itself is inserted in the internal representation of the pictured value. In particular, this is true if the insertion character is the first character in the picture, or if all the

picture characters to its left are characters that do not specify decimal digits.

- If zero suppression occurs, the insertion character is inserted only in these cases:
  - A significant digit appears immediately to the left of the insertion character.
  - The V character appears immediately to the left, and the fractional part of the numeric value contains significant digits.
- If the position preceding the insertion character is occupied by an asterisk or drifting string and the preceding position is taken by a leading zero, then the preceding character also indicates the character to be inserted in the position of the insertion character. If, however, the preceding position is taken by a leading zero and does not have an asterisk or drifting string, then the insertion character's position is a space in the internal representation of the pictured value.
- To guarantee that the decimal point is in the same position in both the numeric and character interpretations, the V and period characters must be immediately adjacent. Note, however, that if the period precedes the V, then it is suppressed if there are no significant integral digits, even though all the fractional digits are significant. This property can make fractions appear to be integers when the internal (character) value is displayed. Consequently, the period should immediately follow the V character; the period will then be in the correct location and will appear whenever any fractional digit is significant.
- Other insertion characters, such as the comma, can be used to separate the integral and fractional portions of a number. However, the comma should not be used with GET LIST input, because a comma is used in that context to separate different data items in the input stream.

Credit (CR) and Debit (DB) Characters

These picture characters are always specified in the pairs CR and DB. If either of these character pairs is included, the character pair appears in the internal representation if the numeric value is less than zero. In each case, the associated positions in the internal representation contain two spaces if the numeric value is greater than or equal to zero.

The characters are always inserted with the same case used in the picture; if the lowercase form cr is used in the picture, lowercase letters are inserted in the pictured value; if the combination Cr is used, then Cr is inserted.

The credit and debit characters cannot be used in the same picture, nor can they be used in the same picture with any other character that specifies the sign of the value (that is, the S, the plus sign (+), the minus sign (-), and the encoded-sign characters). In addition, they must appear to the right of all picture characters that specify digits.

PICTURE Attribute

The PICTURE attribute is used to declare a pictured variable. Pictured variables have fixed-point decimal attributes, but values of the variable are stored internally as character strings. The character string contains decimal digits representing the numeric value of the variable, plus special editing symbols described in the picture.

The PICTURE attribute conflicts with the FIXED, FLOAT, DECIMAL, and all other data type attributes.

The format of the PICTURE attribute is as follows:

```
{ PICTURE }
{ PIC     } 'picture'
```

picture
A string of picture characters that define the representation of the variable.

These characters are described in Table P–2. A brief description of picture syntax and examples follow. For precise definitions of picture characters, **see** "Picture."

Table P–2 shows the uppercase form of picture characters; lowercase letters can also be used.

Table P–2: Picture Characters

Character	Meaning
9	Decimal digit, including leading zeros
Z	Decimal digit with leading-zero suppression
*	Decimal digit with asterisk for leading zero
Y	Decimal digit with space for any zero
V	Position of assumed decimal point

Table P–2 (Cont.): Picture Characters

Character	Meaning
(n)	Iteration factor for subsequent character
T	Position of digit and encoded plus sign or minus sign
I	Position of digit and encoded plus sign if number > = 0
R	Position of digit and encoded minus sign if number < 0
.	Position at which decimal point is inserted
,	Position at which comma is inserted
/	Position at which slash is inserted
B	Position at which space is inserted
$	Position(s) of (drifting) dollar sign
+	Position(s) of (drifting) plus sign if number > = 0
–	Position(s) of (drifting) minus sign if number < 0
S	Position(s) of (drifting) plus sign or minus sign
CR	Positions at which 'CR' is inserted if number < 0
DB	Positions at which 'DB' is inserted if number < 0

■ Picture Syntax

After all its iterations are expanded and all its insertion characters are removed, a picture must satisfy the following syntax rules (the notation character, or ellipsis (. . .), indicates a series of the same character, with no embedded characters).

Picture:

'[left-part]center-part[right-part]'

Left-part:

{ $ + – S }

Right-part:

```
{ $  }
{ +  }
{ -  }
{ S  }
{ CR }
{ DB }
```

Center-part:

```
{ 9 . . . [V[9 . . . ]]          }
{ V9 . . .                       }
{ Z . . . [9 . . . [V[9 . . . ]]] }
{ Z . . . [V[9 . . . ]]          }
{ [Z . . . ]VZ . . .             }
{ * . . . [9 . . . [V[9 . . . ]]] }
{ * . . . [V[9 . . . ]]          }
{ [* . . . ]V* . . .             }
{ ++ . . . [9 . . . [V[9 . . . ]]] }
{ ++ . . . [V[9 . . . ]]         }
{ - - . . . [9 . . . [V[9 . . . ]]] }
{ - - . . . [V[9 . . . ]]        }
{ SS . . . [9 . . . [V[9 . . . ]]] }
{ SS . . . [V[9 . . . ]]         }
{ $$ . . . [9 . . . [V[9 . . . ]]] }
{ $$ . . . [V[9 . . . ]]         }
{ +[+ . . . ]V+ . . .            }
{ -[- . . . ]V- . . .            }
{ S[S . . . ]VS . . .            }
{ $[$ . . . ]V$ . . .            }
```

NOTE

The character Y, T, I, or R can appear wherever 9 is valid, with the following restrictions. Only one character T, I, or R can appear in a picture. A picture cannot contain T, I, or R if it also contains S, +, –, CR, or DB.

■ Examples

Valid Pictures

```
'S99V.99'
```

The picture specifies a signed fixed-point number with p=4, q=2. The sign of the number is always included in its representation, in the first position. A period is inserted at the position of the assumed decimal point.

```
'****99'
```

The picture specifies a 6-digit integer, with the first four leading zeros replaced by asterisks.

```
'****V.**'
```

The picture specifies a fixed-point number with p=6, q=2. The first four leading zeros are replaced by asterisks in the integral portion. Both fractional digits always appear unless all six digits are zero. A period is inserted at the position of the assumed decimal point.

```
'ZZ99V.99'
```

The picture specifies a fixed-point number with p=6, q=2. The first two digits in the integral portion are replaced with spaces if they are zeros. Two digits always appear on either side of the decimal point.

```
'(4)SV.99'
```

The picture specifies a fixed-point number with p=5, q=2. (The iteration factor 4 specifies a string of four S characters, one of which specifies a sign and three of which specify digits.) A plus (+) or minus (−) symbol is inserted to the immediate left of the first significant integral digit, or to the left of the decimal point if no integral digit is significant. Any insignificant integral digits are replaced with spaces or with the sign symbol.

```
'ZZZ,ZZZV.99'
```

The picture specifies a fixed-point number with p=8, q=2. If the integral portion has four or more significant digits, a comma is inserted between the third and fourth; otherwise, both the leading zeros and the comma are suppressed. The decimal point always appears followed by two fractional digits.

```
'ZZZ.ZZZV,99'
```

The picture specifies a fixed-point number with p=8, q=2. If the integral portion has four or more significant digits, a period is inserted between the third and fourth; otherwise, both the leading zeros and the period are suppressed. The decimal point (indicated by a comma) always appears followed by two fractional digits.

```
'ZZZ/ZZZ/ZZZ'
```

The picture specifies a fixed-point number with p=9, q=0. A slash is inserted between the 3-digit groups unless the digit preceding the slash is a suppressed zero.

Invalid Pictures

```
'999ZZZZV.99'
```

The picture is invalid because a 9 occurs to the left of Z.

```
'$$$--99v.99'
```

The picture is invalid because it contains two drifting strings ('$$$' and '--').

```
'(4)-V.ZZZ'
```

The picture is invalid because fractional digits in this case must be pictured either with a drifting minus sign or with 9s.

Pointer

A pointer is a variable whose value represents the location in memory of another variable or data item.

All pointers must be declared with the POINTER attribute before they can be referenced in a BASED attribute or an ALLOCATE statement with the SET option. For example:

```
DECLARE X POINTER,
        BUFFER CHARACTER(80) BASED (X);
```

The variable X is given the POINTER attribute. Then it is used as the target pointer in another declaration, which defines a buffer to be based on X. Pointers are used to qualify references to based variables, that is, variables for which storage is explicitly allocated at run time by the ALLOCATE statement. For example:

```
DECLARE LIST_POINTER POINTER;
DECLARE 1 LIST_STRUCTURE BASED,
          2 FORWARD_PTR POINTER,
          2 MEMBER_NAME CHAR(20) VAR;

ALLOCATE LIST_STRUCTURE SET (LIST_POINTER);
LIST_POINTER -> LIST_STRUCTURE.MEMBER_NAME = 'newname';
```

When these statements are executed, the ALLOCATE statement allocates storage for a variable LIST_STRUCTURE and sets the pointer LIST_POINTER to the address in memory of the allocated storage. This dynamically created variable is called an allocation of the variable LIST_STRUCTURE.

In the assignment statement, the locator qualifier (->) and the identifier LIST_POINTER distinguish this allocation of LIST_STRUCTURE from allocations created by other ALLOCATE statements, if any.

■ Pointer Variables in Expressions

Expressions containing pointer variables are restricted to the following relational operators:

Operator	Meaning
=	Equal
^=	Not equal

For example, to test whether a pointer is null, that is, to determine whether it is currently pointing to valid storage, you can write the following statement:

```
IF LIST_POINTER = NULL() THEN
   DO;
```

The NULL built-in function always returns a null pointer value.

Pointer variables can be used in simple assignment statements that assign a pointer value to a pointer variable. For example:

```
LIST_POINTER_1 = LIST_POINTER_2;

LIST_END = NULL();
```

A pointer variable can also be used as the source or target in an assignment statement involving an offset variable or offset value. **See** "Offset."

■ Internal Representation of Pointer Data

A pointer occupies a longword (32 bits) of storage and represents a virtual memory address.

For more information, **see** "ALLOCATE Statement," "Based Variable," "FREE Statement," "List Processing," "Locator Qualifier," "Offset," and "Storage Class."

POINTER Attribute

The POINTER attribute indicates that the associated variable will be used to identify locations of data. The format of the POINTER attribute is as follows:

```
{ POINTER }
{ PTR     }
```

■ Restrictions

The POINTER attribute conflicts with all other data type attributes.

POINTER Built-In Function

The POINTER built-in function returns a pointer to the location identified by the referenced offset and area. Its format is as follows:

```
{ POINTER } (offset,area)
{ PTR     }
```

offset
A reference to an offset variable whose current value either represents the offset of a based variable within the specified area or is null.

area
A reference to a variable that is declared with the AREA attribute and with which the specified offset value is associated.

■ Returned Value

The returned value is of type POINTER. If the offset value is null, the result is null.

■ Example

```
DECLARE MAP_SPACE AREA (2048),
        START OFFSET (MAP_SPACE),
        P POINTER;
            .
            .
            .
P = POINTER (START,MAP_SPACE);
```

The POINTER built-in function converts the value of the offset variable START (in the area MAP_SPACE) to a pointer value.

POSINT Built-In Function

The POSINT built-in function treats specified storage as an unsigned integer, and returns the value of the integer. Its format is as follows:

POSINT(expression[,position[,length]])

expression
A scalar expression or reference to connected storage. This reference must not be an array, structure, or named constant. If position and length are not specified, the length of the referenced storage must not exceed 32 bits. (If it exceeds 32 bits, a FATAL run-time error results.)

position
A positive integer value that denotes the position of the first bit in the field. If omitted, position defaults to 1, signifying the first bit of the storage denoted by the expression. If specified, position must satisfy the following condition:

$$1 <= position <= size(expression)$$

Size(expression) is the length in bits of the storage denoted by expression. A position equal to size(expression) implies a zero-length field.

length
An integer value in the range 0 through 32 that specifies the length of the field. If omitted, length is the number of bits from the bit denoted by position through the end of the storage denoted by expression. If specified, length must satisfy the following condition:

$$0 <= length <= size(expression) - position$$

Size(expression) is the length in bits of the storage denoted by expression.

■ Returned Value

The value returned by POSINT is of the type FIXED BINARY (31). If the field has a length of zero, POSINT returns zero.

Because the POSINT built-in function treats storage as if it contained an unsigned integer, the value returned can be larger than the maximum positive value that can be contained in the signed integer that is stored in the same number of bits. For example, if the argument to POSINT is 32 bits long and has the high-order (sign) bit set, then the resulting value is too large for assignment to a FIXED BIN (31) variable, the largest integer available in PL/I. The result of such an operation is undefined.

■ Example

The use of the POSINT built-in function is identical to the use of the INT built-in function, except that POSINT treats its argument as an unsigned integer. The following example illustrates this difference. For more general examples, **see** "INT Built-In Function."

```
DECLARE (X15,Y15,I15,P15) FIXED BIN (15),
        P31 FIXED BIN (31);

    X15 = 585;
    Y15 = -585;
    I15 = INT(X15);     /* I15 = 585      */
    I15 = INT(Y15);     /* I15 = -585     */
    P15 = POSINT(X15); /* P15 = 585      */
    P31 = POSINT(Y15); /* P31 = 64951    */
    P15 = POSINT(Y15); /* ERROR signaled */
```

In this example, POSINT first assigns the storage referenced by X15 to P15. Because this storage is occupied by a positive integer and therefore has the sign bit clear, POSINT behaves exactly like INT. However, when POSINT is applied to storage occupied by a negative integer, it interprets the set sign bit as representing part of the integer. When the resulting value is assigned to a FIXED BIN (31) variable, it is seen to be larger than the largest possible FIXED BIN (15) value, 32767. An attempt to assign the same value to a FIXED BIN (15) variable results in PL/I signaling an ERROR condition.

POSINT Pseudovariable

The POSINT pseudovariable assigns an integer value to specified storage. Unlike other pseudovariables, it can be used only in an assignment statement. The format is as follows:

```
POSINT(expression1[,position[,length]]) = expression2;
```

expression1

A reference to connected storage. This reference must not be an array, structure, or named constant. If position and length are not specified, the length of the referenced storage must not exceed 32 bits. (If it exceeds 32 bits, a FATAL run-time error results.)

position

A positive integer value that denotes the position of the first bit in the field. If omitted, position defaults to 1, signifying the first bit of the storage denoted by expression. If specified, position must satisfy the following condition:

$$1 <= position <= size(expression)$$

Size(expression) is the length in bits of the storage denoted by expression. A position equal to size(expression) implies a zero-length field.

length

An integer value in the range 0 through 32 that specifies the length of the field. If omitted, length is the number of bits from the bit denoted by position through the end of the storage denoted by expression. If specified, length must satisfy the following condition:

$$0 <= length <= size(expression) - position$$

Size(expression) is the length in bits of the storage denoted by expression.

expression2

Any expression that evaluates to an integer.

The POSINT pseudovariable is valid only in an assignment statement. It cannot be used as the target of an input statement or in other instances where pseudovariables are normally acceptable.

The expression to be assigned to the pseudovariable is first converted to the data type FIXED BINARY (31); then, the internal representation of the resulting integer value is assigned to the storage specified by the arguments to POSINT. If the representation of the value is too large for assignment to the storage, the most significant bits of the integer are removed and no error is signaled.

The POSINT pseudovariable is identical in operation and use to the INT pseudovariable. For examples, **see** "INT Pseudovariable."

POSITION Attribute

The POSITION attribute specifies the character or bit position in a defined variable's base at which the defined variable begins. Its format is as follows:

```
{ POSITION } (expression)
{ POS      }
```

expression
An integer expression that specifies a position in the base. A value of 1 indicates the first character or bit.

■ Restrictions

You can specify the POSITION attribute only in connection with DEFINED and only when the defined variable satisfies the rules for string overlay defining (**see also** "Defined Variable").

Precedence

The precedence, or priority, of operators defines the order in which expressions are evaluated when they contain more than one operator.

PL/I defines the precedence of arithmetic operators with respect to each other and with respect to other types of operators. In general, the rules for precedence produce "expected" results without the need for parenthesized expressions. For details, **see** "Expression" and "Operator."

PRECISION Attribute

The PRECISION attribute applies to binary and decimal data; the precision of an item is the number of decimal or binary digits used to represent a value. The precision of an arithmetic variable can be specified in any of the following formats, depending on the numeric base of the data item:

```
BINARY [ FIXED ] [ [PRECISION] (precision[,scale-factor]) ]
[BINARY] FLOAT [ [PRECISION] (precision) ]
DECIMAL [ FIXED ] [ [PRECISION] (precision[,scale-factor]) ]
DECIMAL FLOAT [ [PRECISION] (precision) ]
```

The keyword PRECISION can be abbreviated to PREC, or it can be omitted entirely. If the keyword is used, the precision (and optional scale factor, if used) must immediately follow the keyword, which can be placed before or after any other attributes in the declaration. If the keyword is omitted, the precision (and scale factor, if used) must follow the other attributes. For example, the following declarations are equivalent:

```
DCL A FIXED BIN(31);          DCL A FIXED BIN PRECISION(31);

DCL B FLOAT BIN(53);          DCL B PREC(53) FLOAT BIN;

DCL C FIXED DEC(5,2);         DCL C FIXED DEC PREC(5,2);
```

In each case, the precision is the number of bits or decimal digits used to represent values of the variable. Only fixed-point data has a scale factor. The scale factor specifies that all values of the fixed-point decimal variable are "scaled" by the factor 10^{-q}; and all values of the fixed-point binary variable are "scaled" by the factor 2^{-q}, where q is the specified scale factor; in other words, all values have q fractional digits. The scale factor must be less than or equal to the precision specified for the fixed-point variable, and it must be greater than or equal to zero for fixed-point decimal data. Fixed-point binary data can have a scale factor within the range –31 through 31.

The precision of a floating-point data item is the number of decimal or binary digits in the mantissa of the floating-point representation.

■ Restrictions

The ranges of values you can specify for the precision of each arithmetic data type, and the defaults applied if you do not specify a precision, are summarized as follows:

Data Type Attributes	Precision	Scale Factor	Default Precision
BINARY FIXED	1 <= p <= 31	p> = q> = -31	31
BINARY FLOAT	1 <= p <= 113	—	24
DECIMAL FIXED	1 <= p <= 31	p> = q> = 0	10
DECIMAL FLOAT	1 <= p <= 34	—	7

If no scale factor is specified with fixed-point data, the default is zero.

■ Precision of Expressions

The precision of the result of an expression is determined by the precisions and data types of the variables and constants used in the expression, and by the rules governing the specific operation being performed by the expression.

For the rules governing the conversion of operands in an expression, **see** "Expression." The conversion of operands in an expression produces converted operands of the same data type but with individual precisions. These individual precisions are then used to determine the precision of the result, which depends on the operation being performed. For example, **see** "Subtraction."

See also "Scale Attribute."

Preprocessor

The VAX PL/I preprocessor permits you to alter a source program at compile time. Preprocessor statements can be mixed with nonpreprocessor statements in the source program, but preprocessor statements are executed only at compile time. Any resulting source program changes are then used for further compilation.

The preprocessor is embedded in the compiler, and so is also called the "embedded preprocessor."

During compilation, the preprocessor performs two types of preprocessing:

- It interprets preprocessor statements, including preprocessor expression evaluation.
- It replaces the value of preprocessor variables and procedures.

Preprocessor statements allow you to include text from alternative sources (INCLUDE libraries and the VAX Common Data Dictionary), control the course of compilation (%DO, %GOTO, %IF, and %PROCEDURE), issue user-generated diagnostic messages, and selectively control listings and formats. The preprocessor statements are summarized in Table P–3.

■ Preprocessor Compilation Control

At compile time, preprocessor variables, procedures, and variable expressions are evaluated in the order that they appear in the source text, and the new values are substituted in the source program in the same order. Thus, the course of compilation becomes conditional, and the resulting executable program can have a variety of features. Note that preprocessor variables must be declared and activated before replacement occurs.

For example:

```
PREP: PROCEDURE OPTIONS(MAIN);
%DECLARE HOUR FIXED;
%HOUR = SUBSTR(TIME(),1,2);

%IF HOUR > 7 & HOUR < 18
%THEN
    %FATAL 'Please compile this outside of prime time';
%DECLARE T CHARACTER;
%ACTIVATE T NORESCAN;
%T = '''Compiled on '||DATE()||'''';

DECLARE INIT_MESSAGE CHARACTER(40) VARYING INITIAL(T);
```

```
    %IF VARIANT() = '' | VARIANT() = 'NORMAL'
    %THEN
        %INFORM 'NORMAL';
    %ELSE
        %IF VARIANT() = 'SPECIAL'
        %THEN
            %INFORM 'SPECIAL';
        %ELSE
            %IF VARIANT() = 'NONE'
            %THEN %;
            %ELSE
                %DO;
                %T = '''unknown variant''';
                %WARN T;
                INIT_MESSAGE = INIT_MESSAGE||' with '||T;
                %END;
    %END;
PUT LIST (INIT_MESSAGE);
END PREP;
```

This example illustrates several aspects of the preprocessor. First, the programmer specified that this program must be compiled outside of prime time. Second, the value of /VARIANT (as specified in the PLI command line) is used by the VARIANT built-in function to determine which variant is used in the program at compile time. Third, user-generated preprocessor messages remind the programmer which value was given to VARIANT.

Notice the number of apostrophes around the string constant assigned to T. Apostrophes are sufficient if the value of T is used only in a preprocessor user-generated diagnostic message. However, the value of T is concatenated with nonpreprocessor text and assigned to INIT_MESSAGE. During preprocessing, apostrophes are stripped off string constants. In order to ensure that the run-time program also has apostrophes around the string, additional apostrophes are needed.

■ Preprocessor Statements

All preprocessor statements are preceded by a percent sign (%) and terminated by a semicolon (;). All text that appears within these delimiters is considered part of the preprocessor statement and is executed at compile time. For example:

```
%DECLARE HOUR FIXED;   /* declaration of a preprocessor
                                    single variable */

%DECLARE (A,B) CHARACTER; /* a factored preprocessor
                                      declaration  */
```

```
%HOUR = SUBSTR(TIME(),1,2);  /* preprocessor assignment
                                statement using two built-in
                                                functions  */

%STATE: PROCEDURE (X) RETURNS (BIT); /* preprocessor
                                                procedure */
```

Notice that a percent sign is required only at the beginning of the statement. The percent sign alerts the compiler that until the line is terminated with a semicolon, all subsequent text is preprocessor text. Therefore, no other percent signs are required on the line. However, when you include Common Data Dictionary record definitions, you may need to include the usual PL/I punctuation. **See** "%Dictionary Statement" for details.

Labels (preceded by a percent sign) are permitted on preprocessor statements and required on preprocessor procedures. As with other labels, preprocessor labels are used as the target of program control statements.

A preprocessor label must be an unsubscripted label constant. The format for a preprocessor label is as follows:

```
%label: preprocessor-statement;
```

If program source is not compiled because of a %GOTO or %IF statement, the compiler still checks the basic syntax of all statements. Therefore, comment delimiters and parentheses must balance, apostrophes must be paired correctly, and all statements must end with a semicolon.

See Table S–1 for a summary of the preprocessor statements.

■ Preprocessor Built-In Functions

A number of PL/I built-in functions are available for use at compile time. Preprocessor built-in functions work the same way as run-time PL/I built-in functions.

The built-in functions are summarized in Table P–3 according to the following functional categories:

- Arithmetic built-in functions provide information about the properties of arithmetic values, or perform common arithmetic calculations.
- String-handling built-in functions process character-string and bit-string values.
- Conversion built-in functions convert data from one data type to another.
- Timekeeping built-in functions return the system date and time of day.

- Miscellaneous built-in functions are specifically preprocessor built-in functions.

Table P–3: Summary of PL/I Preprocessor Built-In Functions

Category	Function Reference	Value Returned
Arithmetic	ABS(x)	Absolute value of x
	MAX(x1,x2)	Larger of the values x1 and x2
	MIN(x1,x2)	Smaller of the values x1 and x2
	MOD(x,y)	Value of x modulo y
	SIGN(x)	-1, 0, or 1 to indicate the sign of x
String-Handling	COPY(s,c)	c copies of specified string s
	INDEX(s,c[,p])	Position of the character string c within the string s, starting at position p
	LENGTH(s)	Number of characters or bits in the string s
	REVERSE(s)	Reverse of the source character string or bit string
	SEARCH(s,c[,p])	Position of the first character in s, starting at position p, that is found in c
	SUBSTR(s,i[,j])	Part of string s beginning at i for j characters
	TRANSLATE(s,c[,d])	String s with substitutions defined in c and d
	TRIM(s[,e,f])	String s with all characters in e removed from the left and all characters in f removed from the right
	VERIFY(s,c[,p])	Position of the first character in s, starting at position p, which is not found in c
Conversion	BYTE(x)	ASCII character represented by the integer x
	DECODE(c,r)	Fixed binary value of the character string c converted to a base r number
	ENCODE(i,r)	Character string representing the base r number that is equivalent to the fixed binary expression i
	RANK(c)	Integer representation of the ASCII character c
Timekeeping	DATE( )	System date of compilation in the form YYMMDD

Table P–3 (Cont.): Summary of PL/I Preprocessor Built-In Functions

Category	Function Reference	Value Returned
	DATETIME( )	System date and time of compilation in the form CCYYMMDDHHMMSSXX
	TIME( )	System time of day of compilation in the form HHMMSSXX
Miscellaneous	ERROR( )	Count of user-generated diagnostic error message
	INFORM( )	Count of user-generated diagnostic informational message
	LINE( )	Line number in source program that contains the end of a specified preprocessor statement
	VARIANT( )	String result representing the value of the /VARIANT PLI command qualifier
	WARN( )	Count of user-generated diagnostic warning message

PRESENT Built-In Function

The PRESENT built-in function allows you to determine whether a given parameter was specified in a call. It can simplify the task of writing procedures with optional parameters.

The PRESENT built-in function takes one argument, the parameter name. It returns the bit value '1'B if the parameter was specified and '0'B if it was not.

The format of an assignment statement including this function is as follows:

```
bit-flag = PRESENT(parameter-name);
```

Note that the result returned by the PRESENT built-in function for an optional parameter passed by value is unpredictable (if a zero is passed, '0'B is returned). A warning is generated for this use.

PRINT Attribute

The PRINT attribute is used to declare a print file. The file SYSPRINT, used as the default output by PUT statements, is a print file.

Print files are stream output files with special formatting characteristics (**see** "Print File"). The PRINT attribute implies the OUTPUT and STREAM attributes.

■ Restrictions

The PRINT attribute conflicts with the INPUT, RECORD, UPDATE, KEYED, SEQUENTIAL, and DIRECT attributes.

Print File

A print file is a stream output file that is intended for output on a terminal, line printer, or other output device. You can declare any stream output file to be a print file by using the PRINT attribute. The default stream output file, SYSPRINT, is a print file.

The following list describes the special features of print files, as opposed to ordinary stream output files (**see also** "Stream Input/Output"):

- Character strings are not enclosed in apostrophes on list-directed output.
- List-directed output data items are separated by tabs instead of spaces. Tab stops occur at 8-column increments beginning with column 1. With the PUT EDIT statement and the TAB format item, you can begin output at a specified tab stop.
- An internal record is kept of the current line in a print file. The LINENO built-in function returns the current line number for a specified file. This function allows you to keep track of the number of lines being written to a file and to decide where page advances should occur.
- Print files are divided into both lines and pages. An internal record is kept of the number of lines per page. You can specify a page size when the print file is created (**see** "PAGESIZE Option").
- During output of data to a print file, the ENDPAGE condition is signaled when the output exceeds the page size.

- New pages are started by the PUT PAGE statement, the PAGE format item, and certain other format items. Each of these operations increments the current page number by 1. The PAGENO built-in function returns the current page number from a print file. This function allows you to keep track of the number of pages being written to a file. You can set the current page number to a specific value by assigning the value to the PAGENO pseudovariable.
- If the print file is a terminal, the output is written to the terminal at the conclusion of each PUT statement.
- A print file is created with PRN-format carriage control. PRN format is efficient for both terminals and line printers because blank lines do not require individual records. (PRN format is discussed in the *VAX Record Management Services Reference Manual.*)
- Print files usually cannot be read properly with GET LIST or GET EDIT.

Procedure

A procedure is the basic executable program unit in PL/I. It consists of a sequence of statements, headed by a PROCEDURE statement and terminated by an END statement, that define an executable set of program instructions. Two types of procedures can be invoked by another procedure during its execution:

- Subroutines, which must be invoked with a CALL statement. Subroutines return values to the invoking procedure only by means of their parameter lists; they cannot include an expression in their RETURN statements and cannot include a RETURNS option on their PROCEDURE or ENTRY statements.
- Functions, which must be invoked by a function reference. A function reference can appear in place of a scalar value in any appropriate context in a PL/I statement. A function returns to the invoking procedure a single value that becomes the value of the function reference in the invoking procedure. Functions can also return values through their parameter lists. Functions must include a RETURNS option to describe the attributes of the returned value and must specify an expression in their RETURN statements.

Each type of procedure can be passed data or information from the invoking procedure by means of an argument list.

A procedure can have multiple entry points, and it is permissible for some entry points to be subroutine entry points and some to be function entry points. When a procedure has multiple entry points, it is treated as a subroutine or function in accordance with the entry point through which it is invoked. Note that when a procedure is invoked as a function, any RETURN statement executed in the procedure must specify a return value.

■ External and Internal Procedures

An internal procedure is one whose text is contained within another block. An external procedure is one whose text is not contained in any other block.

The source text of an external procedure can be separately compiled.

The primary coding differences between internal and external procedures follow:

- Before an external procedure can be invoked (except through an entry variable), its name must be declared within the procedure that invokes it. The DECLARE statement for the external entry name must also provide a list of parameter descriptors that give the data type(s) of the procedure's parameters, if any, and the DECLARE statement must provide a RETURNS attribute if the procedure is a function.

  Internal procedures cannot be explicitly declared. The procedure name is implicitly declared by its occurrence in the PROCEDURE or ENTRY statement of the internal procedure.
- External procedures can reference the same variable only if the variable is declared with the EXTERNAL attribute in all procedures that reference it.

  An internal procedure, on the other hand, can reference internal variables declared in any procedure in which it is contained.
- Any procedure can call an external procedure.

  An internal procedure can be called only by the procedure that contains it or by other procedures at the same level of nesting within the containing procedure. The only exception is invocation through an entry variable.

Figures P–2 and P–3 illustrate invoking internal and external procedures.

Figure P–2: Invoking an Internal Procedure

```
MAINP: PROCEDURE OPTIONS (MAIN);
   .
   .
   .
   COMPUTE: PROCEDURE;
      .
      .
      .
      ADD_NUMBERS: PROCEDURE;
         .
         .
         .
      END ADD_NUMBERS;
      .
      .
      .
   END COMPUTE;
   .
   .
   .
   PRINT_REPORT: PROCEDURE;
      .
      .
      .
   END PRINT_REPORT;
   .
   .
   .
END MAINP;
```

In Figure P–2, the procedures COMPUTE and PRINT_REPORT are internal to the procedure MAINP, and the procedure ADD_NUMBERS is internal to the procedure COMPUTE. MAINP can invoke the procedures COMPUTE and PRINT_REPORT, but not ADD_NUMBERS. COMPUTE and PRINT_REPORT can invoke one another. ADD_NUMBERS can call COMPUTE and PRINT_REPORT. (**See also** "Scope of Names.")

In Figure P–3, the procedure WINDUP declares the procedure PITCH with the EXTERNAL and ENTRY attributes. The text of the procedure PITCH is in another source program that is separately compiled.

For information on compiling and linking together separately compiled procedures, **see** the *VAX PL/I User Manual.*

Figure P–3: Invoking an External Procedure

```
WINDUP: PROCEDURE;
      .
      .
      .
   DECLARE PITCH EXTERNAL ENTRY (CHARACTER(15) VARYING,
                                 FIXED BINARY(7));
      .
      .
      .
   CALL PITCH (PLAYER_NAME,NUMBER_OF_OUTS);
      .
      .
      .
```

■ Terminating Procedures

Subroutines and functions can be terminated with the following statements:

- END statement

  If an END statement closes the procedure block of a subroutine before a RETURN or STOP statement is executed, the END statement has the same effect as RETURN. A function cannot be terminated without a RETURN statement.

- Nonlocal GOTO statement

  A GOTO statement that transfers control to a label that is outside the current block terminates a subroutine or a function. The label specified on the GOTO statement must be known within the block that contains the GOTO statement, and the block containing the specified label must be active when the GOTO is executed.

- RETURN statement

  A RETURN statement provides a normal termination for a subroutine or function. For a function, a RETURN statement must specify a return value.

- STOP statement

  A STOP statement ends the entire program execution. It does not pass a return value.

■ Passing Arguments to Subroutines and Functions

You specify arguments for a subroutine or function by enclosing the arguments in parentheses following the procedure or entry-point name. Arguments correspond to parameters specified on the PROCEDURE or ENTRY statement of the invoked procedure. For example, a procedure call can be written as follows:

```
CALL COMPUTER (A,B,C);
```

The variables A, B, and C in this example are arguments to be passed to the procedure COMPUTER. The procedure COMPUTER might have a parameter list like this:

```
COMPUTER: PROCEDURE (X, Y, Z);
DECLARE (X,Y,Z) FLOAT;
```

The parameters X, Y, and Z, specified in the PROCEDURE statement for the subroutine COMPUTER, are the parameters of the subroutine. PL/I establishes the equivalence of the arguments A, B, and C to the parameters X, Y, and Z.

For more information, **see** "Parameters and Arguments."

■ Entry Points

The entry points of a procedure are the points at which it can be invoked. One entry point is specified by the PROCEDURE statement that begins the procedure block. Additional entry points can be specified with ENTRY statements in the procedure block. ENTRY statements are allowed anywhere except within a begin block, an ON-unit, SELECT-group, or a DO-group (except a simple, noniterative DO-group).

The labels used on PROCEDURE and ENTRY statements implicitly declare entry constants. (**See also** "Entry Data" and "ENTRY Statement.") The scope of these declarations is internal if the PROCEDURE and ENTRY statements appear in internal procedures and external if they appear in external procedures.

Note that the declaration of an entry name is made in the block containing the procedure to which the entry point belongs. For example:

```
P: PROCEDURE;

Q: PROCEDURE
DECLARE E FIXED BINARY;
E: ENTRY;
END Q;
```

The entry names E and Q are declared in the procedure P. Within the procedure Q, E is declared as a fixed-point binary variable.

You can invoke an entry point by using the appropriate entry constant as the reference in a CALL statement or function reference. Invoking an entry point enters a procedure at the specified point and activates the procedure block that contains the entry point.

If the CALL statement or function reference invokes an entry point in an external procedure, the entry constant must be declared with the ENTRY attribute, as in Figure P–3 above. The declaration of an external constant must also describe the parameters for that entry point, if any. For example:

```
DECLARE PITCH ENTRY (CHARACTER(*), FIXED BINARY(15));
```

The identifier PITCH is declared as an entry constant. When the procedure containing this declaration is linked to other procedures, one of the external procedures must define an entry point named PITCH, either as the label of a PROCEDURE statement or as the label of an ENTRY statement.

The data type attributes in parentheses (known as "parameter descriptors") are the data types of the parameters that are defined elsewhere for the entry point PITCH. Arguments of these types must be supplied when PITCH is invoked. **See also** "Parameters and Arguments" and "ENTRY Attribute."

If PITCH is to be used to invoke a function, the DECLARE statement must also include a RETURNS attribute to describe the attributes of the returned value, as in the following example:

```
DECLARE PITCH ENTRY (CHARACTER(*), FIXED BINARY(15))
  RETURNS(FIXED);
```

Within the scope of this DECLARE statement, the entry constant PITCH must be used in a function reference. The function reference will invoke the external entry point, and a returned fixed-point binary value will become the value of the function reference.

■ Multiple Entry Points

A procedure can be entered at more than one point. However, only one entry point can be specified by a PROCEDURE statement; additional entry points are declared with ENTRY statements.

The rules governing the declaration of multiple entry points follow:

- A particular parameter need not be specified in all of a procedure's entry points (including the point defined by the PROCEDURE statement). However, a reference to the parameter is valid only if the procedure was invoked through one of the entries specifying the parameter.
- In a procedure that has multiple entry points, a RETURN statement must be compatible with the entry point by which the procedure was invoked. If the entry point does not have a RETURNS option, the RETURN statement must not specify a return value. (In addition, it must be invoked as a "subroutine"—that is, with the CALL statement.) If the entry point has a RETURNS option, the RETURN statement must specify a return value that is valid for conversion to the data type specified in the RETURNS option.
- An ENTRY statement is not executable. If control reaches it sequentially, control immediately continues to the next statement.

The following example shows a procedure with two alternative entry points:

```
QUEUES: PROCEDURE(ELEMENT,QUEUE_HEAD);
    .
    .
    .
ADD_ELEMENT: ENTRY(ELEMENT);
    .
    .
    .
REMOVE_ELEMENT: ENTRY(ELEMENT);
```

This procedure can be entered by CALL statements that reference QUEUES, ADD_ELEMENT, or REMOVE_ELEMENT. If invoked at QUEUES, the procedure must be passed two parameters. If invoked at either of the alternative entries ADD_ELEMENT or REMOVE_ELEMENT, the procedure must be passed only one parameter.

When this procedure is entered at either alternative entry point, the entire block beginning at QUEUES is activated, but execution begins with the first executable statement following the entry point.

■ Recursive Procedures

In VAX PL/I, you can invoke any procedure recursively—that is, by a statement within itself or within a dynamically descendent block (**see also** "Block"). A recursive invocation of a procedure is similar to any invocation: a recursive invocation creates a new block activation, allocates new storage for automatic variables, and so forth.

In standard PL/I, the RECURSIVE option must be used on a PROCEDURE statement if the procedure is to be invoked recursively. In VAX PL/I, the RECURSIVE or NONRECURSIVE option is needed only for program documentation, because all procedures (regardless of the RECURSIVE or NONRECURSIVE option) can be recursive.

Procedure Block

A procedure block defines a unit of a PL/I program. The block begins with a PROCEDURE statement and ends with an END statement. The OPTIONS(MAIN) option identifies the main procedure that is activated when the program begins. A procedure block can be activated only by a CALL statement or a function reference unless it is the main procedure. The CALL statement or function reference can activate the procedure block by invoking either the label of its PROCEDURE statement or the label of an ENTRY statement within the procedure.

For information on procedure block activation, **see** "Block." For a definition and examples of procedures, **see** "Procedure" and "PROCEDURE Statement."

%PROCEDURE Statement

A preprocessor procedure is a sequence of preprocessor statements headed by a %PROCEDURE statement and terminated by a %END statement. A preprocessor procedure executes only at compile time. Invocation is similar to a function reference and occurs in two ways:

- Preprocessor statements can invoke preprocessor procedures. In addition, preprocessor statements from within preprocessor procedures can invoke other preprocessor procedures.
- Statements from the source program can invoke preprocessor procedures.

The format of the %PROCEDURE statement is as follows:

```
%label:PROCEDURE [(parameter-identifier,...)]
[STATEMENT]
                 { CHARACTER }
RETURNS ( (data-type) { FIXED     } );
                 { BIT       }
        .
        .
        .
[%]RETURN (preprocessor-expression);
        .
        .
        .
[%]END;
```

label

An unsubscripted label constant. A preprocessor procedure is invoked by the appearance of the label name on the %PROCEDURE statement and terminated by the corresponding %END statement. The label name must be active if invoked from a nonpreprocessor statement.

Preprocessor label names can be activated and deactivated, but cannot be specified in a %DECLARE statement.

parameter-identifier

The name of a preprocessor identifier. Each identifier is a parameter of the procedure.

RETURNS

A preprocessor procedure attribute. The RETURNS attribute defines the data type to be returned to the point of invocation in the source code. If you specify a data type that is inconsistent with the returned value, a conversion error may result.

STATEMENT

A preprocessor procedure option. The STATEMENT option permits the use of a keyword argument list followed by an optional positional argument list in the preprocessor procedure invocation. The STATEMENT option returns strings that can be used as PL/I statements at run time. For further information, **see** "Using the STATEMENT Option" below.

preprocessor-expression

Value to be returned to the invoking source code. The preprocessor expression must be specified. The preprocessor expression is converted to the data type specified in the RETURNS option and is returned to the point of invocation. Therefore, the expression must be capable of being converted to CHARACTER(32767), FIXED(10), or BIT(31).

The %PROCEDURE statement defines the beginning of a preprocessor procedure block and specifies the parameters, if any, of the procedure. Because the preprocessor procedure is always invoked as a function, the %PROCEDURE statement must also specify (via the RETURNS option) the data type attributes of the value that is returned to the point of invocation.

For example:

```
%A_VAR = A_PROC();
```

In this statement, the preprocessor procedure A_PROC is invoked and evaluated, and the result is returned and assigned to the preprocessor variable A_VAR.

As with other PL/I procedures, a parenthesized parameter list specifies the parameters that the preprocessor procedure expects when it is invoked. Each preprocessor parameter specifies the name of a variable declared in the preprocessor procedure. The preprocessor parameters must correspond one-to-one with arguments specified for the preprocessor procedure when it is invoked, except when the STATEMENT option is used.

The value to be returned to the invoking source code is converted to the data type specified in the RETURNS option. The return value replaces the preprocessor procedure reference in the invoking source code. Preprocessor procedures cannot return values through their parameter list. The return value must be capable of being converted to one of the data types CHARACTER, FIXED, or BIT. The maximum precision of the value returned by the %RETURNS statement is BIT(31), CHARACTER(32767), or FIXED(10).

Preprocessor procedures cannot be nested. The scope of a preprocessor procedure is the procedure itself; that is, variables, labels, and any %GOTO statements used inside of the procedure must be local.

A preprocessor procedure is invoked by the appearance of its entry-name and list of arguments. If the reference occurs in a nonpreprocessor statement, the entry name must be active before the preprocessor procedure is invoked. If the entry name is activated with the RESCAN option, the

value of the preprocessor procedure is rescanned for further possible preprocessor variable replacement and procedure invocation. You can invoke preprocessor procedures recursively.

When a preprocessor procedure (with or without the STATEMENT option) is invoked from a preprocessor statement, each argument is treated as an expression and the result of executing the preprocessor procedure is returned to the statement containing the invocation.

When a preprocessor procedure is invoked from nonpreprocessor source text, the arguments are interpreted as character strings and are delimited by the appearance of a comma or a right parenthesis occuring outside of balanced parentheses. For example, the positional argument list (Q(E,D), XYZ) has two arguments; the strings 'Q(E,D)' and 'XYZ'.

Examples

```
%A1: PROCEDURE RETURNS(FIXED);
     DECLARE (A,B,C) FIXED;

        A = 2;
        B = 10;
        C = A + B;
        RETURN(C);
     END;
```

This example declares the preprocessor procedure A1 and specifies that the procedure return a fixed decimal result after the preprocessor statements within the procedure have been executed.

The procedure returns the value 12 to the point of invocation. Note that the leading percent signs, normally associated with preprocessor statements, are not required within a preprocessor procedure.

```
PPFIB: PROCEDURE OPTIONS (MAIN);
       DECLARE Y CHAR(14) INITIAL('Fibonacci Test'); ❶
       %DECLARE Y FIXED; ❷
       %F: PROCEDURE(X) RETURNS (FIXED); ❸
           DECLARE X FIXED;
           IF (X <= 1)
              THEN RETURN(1);
              ELSE RETURN(F(X-1)+F(X-2));
           END;              /* End preprocessor procedure */
       %Y = F(10); ❹
       PUT SKIP LIST(Y);
       %Y = F(11); ❺
       PUT SKIP LIST(Y);
       %Y = F(12); ❻
       PUT SKIP LIST(Y);
       %DEACTIVATE Y; ❼
       PUT SKIP LIST(Y); ❽
       END;                  /* End run-time procedure */
```

This example uses a preprocessor procedure to return a Fibonacci number. The recursive preprocessor procedure labeled %F is invoked to return a single value, a Fibonacci number, to the point of invocation. The following notes correspond to the example:

❶ The run-time variable Y is declared with the CHARACTER attribute and initialized to Fibonacci Test.

❷ The preprocessor variable Y is declared with the FIXED attribute, which implies FIXED DECIMAL (10,0). This declaration automatically activates the preprocessor variable Y.

❸ The preprocessor procedure F is defined. The percent sign for the END statement is optional in a preprocessor procedure.

Note that this procedure is recursive.

❹ The preprocessor procedure is called, passed the value 10, and the 10th number in the Fibonacci series is calculated. The resulting value is assigned to the preprocessor variable Y.

Because the preprocessor variable Y is active by default, the compiler replaces the occurrence of Y in the PUT statement with the new preprocessor Y value.

❺ Step 4 is repeated for the value 11.

❻ Step 4 is repeated for the value 12.

❼ The preprocessor variable Y is deactivated. No more scanning or replacement occurs. The preprocessor variable Y retains its final replacement value, 233.

❽ The run-time value of Y (Fibonacci Test) is output.

The output from this program is as follows:

```
89
144
233
Fibonacci Test
```

■ Using the STATEMENT Option

All preprocessor procedures (with or without the STATEMENT option) return a value to the invoking source code; that is, they are function procedures. Through the use of the STATEMENT option, the argument list to a preprocessor procedure can be a keyword argument list. Keyword argument lists are unique to preprocessor procedures and provide a powerful tool for manipulating PL/I.

A keyword argument list ends with a semicolon rather than the right parenthesis. In this way, the STATEMENT option permits you to use a preprocessor procedure as if it were a statement. Consequently, preprocessor procedures using the STATEMENT option permit you to extend the PL/I language by simulating features that may not otherwise be available.

Preprocessor procedures can have one of two distinctly different types of argument lists: positional or keyword. Positional argument lists (ending with a right parenthesis) use parameters sequentially, as in a parenthesized list. You can use positional argument lists in any preprocessor procedure. Keyword argument lists (ending with a semicolon) use parameters in any order, as long as each keyword matches the name of a parameter. This permits the option of specifying the order in which parameters are passed. You can use keyword argument lists only when the preprocessor procedure contains the STATEMENT option and is invoked from a nonpreprocessor statement.

When a preprocessor procedure is invoked from a nonpreprocessor statement, the STATEMENT option permits the use of a keyword argument list that follows the optional positional argument list in a preprocessor procedure invocation.

When you use keyword arguments in nonpreprocessor statements, the keywords can be used in any order. The following reference examples would produce a variety of results with positional arguments, because values would be used sequentially. Keyword arguments produce consistent results because keyword parameters are matched with keyword arguments.

```
%B: PROCEDURE (ALPHA, BETA, GAMMA) STATEMENT...;
    DECLARE (ALPHA, BETA, GAMMA) FIXED;
        .
        .
        .
    END;

B(1,2,3);
B ALPHA(1) GAMMA(3) BETA(2);
B(1) GAMMA(3) BETA(2);
B (,2,3) ALPHA(1);
```

The next example shows a more common use of the STATEMENT option; to generate PL/I source statements that define a unique run time feature. The preprocessor procedure APPEND returns a string, which is incorporated into the source program at compile time. At run time, the returned string is used as a PL/I function.

This preprocessor procedure permits a varying string to accumulate text up to its maximum size without danger of undetected truncation. Normally, strings that exceed their maximum size are truncated. The text returned by the preprocessor procedure provides the run-time program with a way to handle truncation. If the string would be truncated, a message is printed and the FINISH condition is signaled.

```
%APPEND: PROCEDURE (string,to) STATEMENT RETURNS(CHARACTER); ❶

    %DECLARE (string,to) CHARACTER; ❷
    %RETURN (
        'DO;'|| ❸
        'IF LENGTH('||string||')+LENGTH('||to||') > SIZE('||to||')-2'||
        ' THEN DO;'||
           'PUT SKIP LIST (''Buffer overflowed appending to '||to||''');'||
           'SIGNAL FINISH;'|| ❹
           'END;'||
        'ELSE '||to||' = '||to||'||'||string||';'||
        'END;'
             );
     %END;
```

The following notes are keyed to this example:

❶ The preprocessor procedure APPEND is defined with the parameters 'string' and 'to' and the STATEMENT option.

❷ 'String' and 'to' are declared as parameters within the preprocessor procedure.

❸ The %RETURN statement returns the value contained by the parentheses. This text then becomes part of the PL/I nonpreprocessor source program.

Notice the punctuation within the character string returned by %RETURN. At compile time, single quotes are stripped when the text is incorporated into the run-time PL/I program. In addition, the semicolon that delimits the invocation is not retained when the replacement takes place. All customary PL/I punctuation must be included in the character string.

❹ If the current varying string and the additional string together are greater than the maximum length of the varying string, an informational message is printed and the FINISH condition is signaled.

The following invocations of the preprocessor procedure APPEND are all equivalent:

```
APPEND STRING('New String') TO (My_string);
APPEND TO(My_string) STRING('New String');
APPEND('New String') TO(My_string);
```

Notice that if you have a preprocessor procedure (A) with a label that is the same as the name of a keyword argument in another preprocessor procedure (B) with the STATEMENT option, then when B is invoked the keyword argument is treated as a call to procedure A, and not as a keyword parameter in B.

PROCEDURE Statement

The PROCEDURE statement defines the beginning of a procedure block and specifies the parameters, if any, of the procedure. If the procedure is invoked as a function, the PROCEDURE statement also specifies the data type attributes of the value that the function is to return to its point of invocation.

The PROCEDURE statement can denote the beginning of an internal or external subroutine or function. The format of the PROCEDURE statement is as follows:

```
entry-name: { PROCEDURE } [ (parameter,...) ]
            { PROC      }
            [ OPTIONS (option,...) ]
            [ RECURSIVE    ]
            [ NONRECURSIVE ]
            [ RETURNS (value-descriptor) ];
```

entry-name
A 1- to 31-character identifier denoting the entry label of the procedure. The label cannot be subscripted. The PROCEDURE statement declares the entry name as an entry constant. The scope of the name is INTERNAL if the procedure is internal, and EXTERNAL if the procedure is external.

parameter, . . .
One or more parameters (separated by commas) that the procedure expects when it is activated. Each parameter specifies the name of a variable declared in the procedure headed by this PROCEDURE statement. The parameters must correspond, one-to-one, with arguments specified for the procedure when it is invoked with a CALL statement or in a function reference. **See also** "Parameters and Arguments" for details.

OPTIONS (option, . . .)
An option that specifies one or more options, separated by commas:

IDENT(string)
An option specifying a character-string constant giving the identifying label for the listing and the module's version for the linker. Only the first 31 characters of the string are placed in the object module.

MAIN
An option specifying that the named procedure is the initial procedure in a program. The identifier of the procedure is the primary entry point for the program. The MAIN option is not allowed on internal procedures, and only one procedure in a program can have the MAIN option.

UNDERFLOW
An option that requests that the run-time system signal underflow conditions when they occur. By default, the run-time system does not signal these conditions. **See also** "UNDERFLOW Condition Name."

RECURSIVE or NONRECURSIVE
An option that indicates (for program documentation) that the procedure will or will not be invoked recursively, that is, activated while it is currently active. In standard PL/I, the RECURSIVE option must be specified for a procedure to be invoked recursively. However, in VAX PL/I, any procedure can be invoked recursively, and the RECURSIVE and NONRECURSIVE options are ignored by the compiler.

RETURNS (returns-descriptor)
An option specifying that the procedure can be invoked only by a function reference, as well as specifying the attributes of the function value returned. **See** "RETURNS Attribute and Option" for syntax and details.

RETURNS must be specified for functions. It is invalid for procedures that are invoked by CALL statements.

For general information on procedures, **see** "Procedure."

PROD Built-In Function

The PROD built-in function takes an array as an argument and returns the arithmetic product of all the elements in the array. The array must have the FIXED or the FLOAT attribute. The format of an assignment statement containing the PROD built-in function is as follows:

```
numeric-variable = PROD(array-variable);
```

The array can be a part of a structure, but cannot be part of a union. If the array has the attributes FIXED(p,0), the result will have the attributes FIXED(31,0). If the array has the attributes FLOAT(p), the result will also have the attributes FLOAT(p). If the array has the attributes FIXED(p,q) with q not equal to 0, the result will have the attributes FLOAT(p).

The result will have the same base attribute as the array, either DECIMAL or BINARY.

Note that the PROD built-in function does not perform matrix multiplication of two arrays.

Program Structure

A PL/I program consists of a series of statements, which perform the following tasks:

- Define the data to be used for program input and output
- Define the operations to be performed on the data during the execution of the program
- Control the environment within which the program executes
- Define the order of execution or control flow for a program

A statement comprises user-specified identifiers, constants, and PL/I keywords, separated by blanks, comments, and punctuation marks. Statements themselves can be organized into structural sequences of groups or blocks. Figure P–4 illustrates the structure of a PL/I program.

Figure P–4: Structure of a PL/I Program

```
SAMPLE: PROCEDURE OPTIONS(MAIN);

DECLARE (X,Y,Z) FIXED,
        MESSAGE CHARACTER(80),
        CALC ENTRY (FLOAT) RETURNS(FLOAT),
        TOTAL FLOAT;

        X = 0;
        PUT SKIP LIST(MESSAGE);

FINISH: PROCEDURE;
DECLARE TEXT (5) CHARACTER(20);

END FINISH;
END SAMPLE;
```

A PROCEDURE is the basic executable program unit.

The declarations of variables in a procedure are usually, but not necessarily, placed at the beginning of the procedure.

Executable statements are placed following variable declarations.

Internal procedures may be placed anywhere.

All procedures must terminate with END statements.

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■ Source Program Format

The source text of a PL/I program is freeform. As long as you terminate every statement with a semicolon (;), individual statements can begin in any column, spill over onto additional lines, or be written with more than one statement to a line.

Individual keywords or identifiers of a statement cannot be split onto more than one line, however. Only a character string constant (which must be enclosed in apostrophes) can spill over onto more than one line.

PL/I programs are easier to read and comprehend if a standard formatting pattern is followed. For example:

- Write source statements with no more than one statement per line
- Use indention to show the nesting level of blocks and DO-groups

For information on the punctuation marks used in PL/I statements, **see** "Punctuation Marks." For information on blocks, **see** "Block."

Pseudovariable

VAX PL/I has the pseudovariables INT, ONSOURCE, ONCHAR, PAGENO, POSINT, STRING, SUBSTR, and UNSPEC.

A pseudovariable can be used, in certain assignment contexts, in place of an ordinary variable reference. For example:

```
SUBSTR(S,2,1) = 'A';
```

assigns the character 'A' to a 1-character substring of S, beginning at the second character of S.

A pseudovariable can be used wherever the following three conditions are true:

- The syntax specifies a variable reference.
- The context is one that explicitly assigns a value to the variable.
- The context does not require the variable to be addressable.

The principal contexts in which pseudovariables are used are as follows:

- The left side of an assignment statement
- The input target of a GET statement

Note that a pseudovariable cannot be used in preprocessor statements or in an argument list. In the following example, SUBSTR is not interpreted as a pseudovariable:

```
CALL P(SUBSTR(S,2,1));
```

Here, SUBSTR is interpreted as a built-in function reference, rather than as a pseudovariable. The actual argument passed to procedure P is a dummy argument containing the second character of string S.

Punctuation Marks

PL/I recognizes punctuation marks in statements. The punctuation marks serve the following purposes:

- They specify arithmetic or relational operations to be performed on expressions in a statement.
- They delimit and separate identifiers, keywords, and constants in PL/I statements.

For example, in the following statement the equal sign (=) representing the assignment statement, the addition operator (+), and the semicolon (;) are valid punctuation:

```
A = B + C;
```

These punctuation marks separate the identifiers A, B, and C, and define the operation to be performed.

Whenever you use a punctuation mark in a PL/I statement, you can precede or follow the character with any number of spaces. For example, the following two statements are equivalent:

```
DECLARE (A,B) FIXED DECIMAL (7,0);
DECLARE(A,B)FIXED DECIMAL(7,0);
```

In the second statement, the spaces preceding and following parenthetical expressions are omitted; the parentheses themselves are sufficient to distinguish elements in the statement. The only space required in this statement is the space that separates the two keywords FIXED and DECIMAL.

Table P–4 summarizes the punctuation marks that the PL/I compiler recognizes. Note that operators consisting of two characters (for example, ** and > =) must be entered without intervening spaces in a PL/I program.

Table P–4: Punctuation Marks Recognized by PL/I

Category	Symbol	Meaning
Arithmetic operators	+	Addition or prefix plus
	-	Subtraction or prefix minus
	/	Division
	*	Multiplication
	**	Exponentiation
Relational (or comparison) operators	>	Greater than
	<	Less than
	=	Equal to
	^>	Not greater than
	^<	Not less than
	^=	Not equal to
	>=	Greater than or equal to
	<=	Less than or equal to
Logical operators	^	Logical NOT (prefix) and EXCLUSIVE OR (infix)
	&	Logical AND
	&:	Logical AND THEN
	|	Logical OR
	|:	Logical OR ELSE
Concatenation operator	||	String concatenation
Separators	,	Delimits elements in a list
	;	Terminates a PL/I statement
	.	Separates identifiers in a structure name; specifies a decimal point

Table P–4 (Cont.): Punctuation Marks Recognized by PL/I

Category	Symbol	Meaning
	:	Terminates a procedure name or a statement label
	()	Encloses lists and extents; defines the order of evaluation of expressions; separates statement and option names from specific keywords
	'	Delimits character strings and bit strings
Locator qualifier	->	Pointer resolution

Note that VAX PL/I recognizes the tilde (~) as equivalent to the circumflex (^), and the exclamation point (!) as equivalent to the vertical bar (|).

■ Spaces, Tabs, and Line-End Characters

In addition to punctuation marks, PL/I accepts spaces, tabs, and line-end characters between identifiers, constants, and keywords.

The line-end character is a valid punctuation mark between items in a PL/I statement except when it is embedded in a string constant. In a string constant, the line-end character is ignored. For example:

```
A = 'THIS IS A VERY LONG STRING THAT MUST BE CONTI
NUED ON MORE THAN ONE LINE IN THE SOURCE FILE';
```

This assignment statement gives the variable A the value of the specified character-string constant. (The line-end character in the constant is ignored.)

PUT Statement

The PUT statement transfers data from the program to the output stream. The output stream can be either a stream file or a character-string variable. The output file can be a declared file or the default file SYSPRINT.

This entry describes the syntax and options of PUT statements. For a detailed description of the execution of a PUT statement, **see** "Stream Input/Output."

The PUT statement has several forms. These forms are summarized in Figure P–5 and described individually below.

■ PUT EDIT

The PUT EDIT statement takes output sources (variables and expressions) from the program, converts the results to characters under control of a format specification, and places the resulting character strings in the output stream. The output stream is either a stream file or a character-string variable.

With PUT EDIT, the format of the output data is controlled by the program.

The form of the PUT EDIT statement is as follows:

```
PUT EDIT (output-source,...) (format-specification,...)
          [ FILE(file-reference)                    ]
          [      [PAGE] [LINE(expression)]          ]
          [       [SKIP[(expression)]]              ]
          [         [OPTIONS(option,...)]           ] ;
          [                                         ]
          [ STRING(reference)                       ]
```

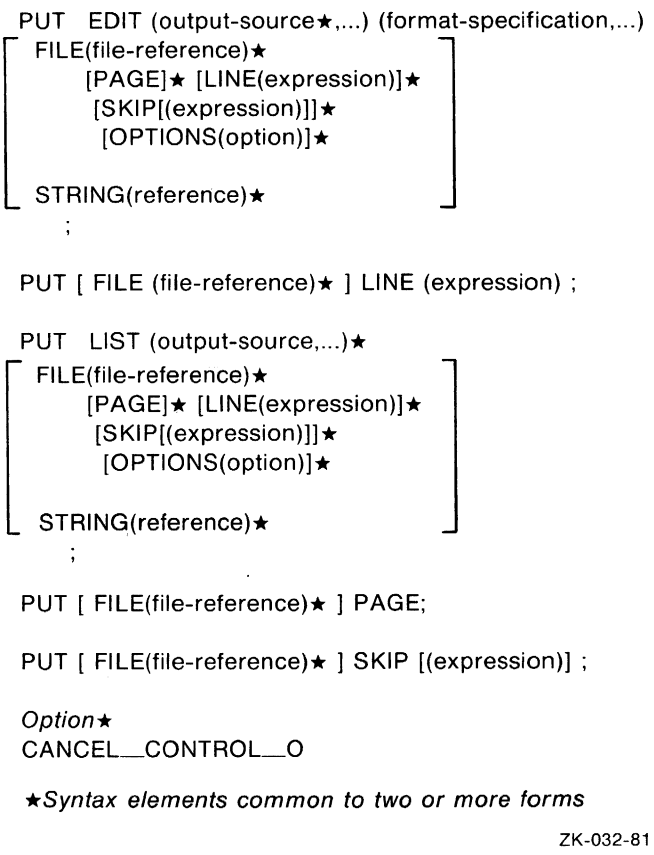
output-source
A construct that specifies one or more expressions to be placed in the output stream. Multiple output sources must be separated by commas.

An output source has the following forms:

```
expression
```

The expression is of any computational type, including a reference to a scalar or aggregate variable. If the reference is to an array, data is output from array elements in row-major order. If the reference is to a structure, data is output from structure members in the order of their declaration.

Figure P–5: Forms of the PUT Statement



(output-source,... DO reference=expression
[TO expression][BY expression][WHILE(expression)][UNTIL(expression)])

The output source can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of output source are in addition to the parentheses surrounding the entire output-source list.

(output-source,... DO reference=expression
[REPEAT expression][WHILE (expression)][UNTIL(expression)])

The output source can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of output source are in addition to the parentheses surrounding the entire output-source list.

For a discussion of the matching of format items to output sources and of the use of DO specifications, **see** "Format-Specification List."

format-specification
A list of format items to control the conversion of data items in the output list. Format items can be data format items, control format items, or remote format items. For each variable name in the output-source list, there is a corresponding data format item in the format-specification list that specifies the width of the output field and controls the data conversion. (**See** "Format-Specification List" and "Format Item.")

FILE(file-reference)
An option that specifies that the output stream be a stream file; the reference is to a declared file variable or constant. If neither the FILE option nor the STRING option is specified, PL/I uses the default file SYSPRINT; this print file is associated with the default system output file SYS$OUTPUT, which in turn is generally associated with the user's terminal.

If a file is specified, and it is not currently open, PL/I opens the file with the attributes STREAM and OUTPUT.

PAGE
An option that advances the output file to a new page before any data is transmitted. The PAGE option can be used only with implied or explicit print files. The file is positioned at the beginning of the next page, and the current page number is incremented by 1. The PAGE, LINE, and SKIP options are always executed, in that order, before any other output or file-positioning operations. The page size is either the default value or the specific value that you have established for the file (**see** "PAGESIZE Option"). The PAGESIZE option can be used only with print files.

LINE (expression)
An option that advances the output file to a specified line. You can use the LINE option only with implied or explicit print files. The expression must yield an integer i. Blank lines are inserted in the output file such that the next output data appears on the ith line of a page.

If the file is currently positioned at the beginning of line i, no operation is performed by the LINE option.

If the file is currently positioned before line i, and i is less than or equal to the page size, then blank lines are inserted following the current line until line i is reached.

If the file is currently positioned at or beyond line i, and the file is not at the beginning of line i, then the remainder of the page (the portion between the current line and the current page size) is filled with blank lines. The ENDPAGE condition is signaled.

When the LINE option is used within an ENDPAGE ON-unit, it causes a skip to the next page.

SKIP [(expression)]

An option that advances a specified number of lines from the current line. You can use the SKIP option only with the implied or explicit FILE option. The expression must yield an integer i, which must not be negative and must be greater than zero except for print files. If the expression is omitted, i equals 1.

If the file is not a print file, i–1 blank lines are inserted following the current line, and subsequent output of data begins at the beginning of (current line)+i.

If the file is a print file, i=0 causes a return to the beginning of the current line. If i is greater than zero, and either the current line exceeds the page size or the page size is greater than or equal to the current line plus i, then i–1 blank lines are inserted. Otherwise, the remainder of the current page is filled with blank lines, and the ENDPAGE condition is signaled.

On output devices with the space-suppression feature, SKIP(0) can be used to cause overprinting, underscoring, and so forth. For further information on lines and pages in stream files, **see** "Stream Input/Output" and "Print File."

OPTIONS (CANCEL_CONTROL_O)

A statement option that can be included only with the implied or explicit FILE option. The option is described fully in the *VAX PL/I User Manual.*

STRING(reference)

An option that specifies that the output stream be the referenced character-string variable. The STRING option cannot be used in the same statement with FILE, OPTIONS, PAGE, LINE, or SKIP.

■ Examples

```
PUTE: PROCEDURE OPTIONS(MAIN);

DECLARE SOURCE FIXED DECIMAL(7,2);

DECLARE OUTFILE PRINT FILE;

OPEN FILE(OUTFILE) TITLE('PUTE.OUT');

SOURCE = 12345.67;

PUT SKIP FILE(OUTFILE) EDIT(SOURCE) (F(8,2));
PUT SKIP FILE(OUTFILE) EDIT(SOURCE) (E(13));
PUT SKIP FILE(OUTFILE) EDIT(SOURCE) (A);
PUT SKIP FILE(OUTFILE) EDIT('American: ',SOURCE)
      (A,P'ZZ,ZZZV.ZZ');
PUT SKIP FILE(OUTFILE) EDIT('European: ',SOURCE)
      (A,P'ZZ.ZZZV,ZZ');

END PUTE;
```

The program PUTE writes the following output to PUTE.OUT:

```
12345.67
 1.234567E+04
  12345.67
American: 12,345.67
European: 12.345,67
```

■ PUT LINE

The PUT LINE statement advances a print file to a specified line. Its format is as follows:

PUT [FILE (file-reference)] LINE (expression);

file-reference

A reference to the file to which the statement applies. The file must be a print file.

If the FILE option is not specified, PL/I uses the default file SYSPRINT. This print file is associated with the default system output file SYS$OUTPUT, which in turn is generally associated with the user's terminal.

expression

An expression giving a line in the print file, relative to the top of the current page. The expression must yield an integer i.

If the file is currently positioned at the beginning of line i, no operation is performed by the LINE option. If the file is currently positioned before line i, and i is less than or equal to the page size, then blank lines are inserted following the current line until line i is reached.

If the file is currently positioned at or beyond line i, and the file is not at the beginning of line i, then the remainder of the page (the portion between the current line and the current page size) is filled with blank lines. The ENDPAGE condition is signaled.

When the PUT LINE statement is used within an ENDPAGE ON-unit, it causes a skip to the next page.

■ PUT LIST

The PUT LIST statement specifies a list of output sources (variables and expressions) whose results are converted to character strings and transmitted to the output stream. If the output file is a print file, the output character strings are separated by tabs. Otherwise, the strings are separated by spaces.

With PUT LIST, the conversion of the output sources and formatting of the output data are automatic.

The form of the PUT LIST statement is as follows:

```
PUT LIST (output-source,...) [ FILE(file-reference)
                                 [PAGE] [LINE(expression)]
                                   [SKIP[(expression)]]
                                     [OPTIONS(option,...)]

                               STRING(reference)          ] ;
```

output-source
A construct that specifies one or more expressions to be placed in the output stream. Multiple output sources must be separated by commas.

An output source has the following forms:

```
expression
```

The expression is of any computational type, including a reference to a scalar or aggregate variable. If the reference is to an array, data is output from array elements in row-major order. If the reference is to a structure, data is output from structure members in the order of their declaration.

(output-source,... DO reference=expression
[TO expression][BY expression][WHILE(expression)][UNTIL(expression)])

The output source can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of output source are in addition to the parentheses surrounding the entire output-source list.

(output-source,... DO reference=expression
[REPEAT expression][WHILE (expression)][UNTIL(expression)])

The output source can be any of these forms, and the references and expressions are as for the DO statement. Notice that the parentheses surrounding this form of output source are in addition to the parentheses surrounding the entire output-source list.

FILE(file-reference)

An option that specifies that the output stream be a file; the reference is to a declared file variable or constant. If neither the FILE option nor the STRING option is specified, PL/I uses the default file SYSPRINT; this print file is associated by default with the system output file SYS$OUTPUT.

If a file is specified, and it is not currently open, PL/I opens the file with the attributes STREAM and OUTPUT.

PAGE

An option that advances the output file to a new page before any data is transmitted. You can use the PAGE option only with implied or explicit print files. The file is positioned at the beginning of the next page, and the current page number is incremented by 1. The PAGE, LINE, and SKIP options are always executed, in that order, before any other output or file-positioning operations. The page size is either the default value or the specific value that you have established for the file (**see** "PAGESIZE Option"). You can use the PAGESIZE option only with print files.

PL/I does not skip automatically to a new page; you must use the PAGE option to perform this function.

LINE (expression)

An option that advances to a specified line in the output file. The LINE option can be used only with implied or explicit print files. The expression must yield an integer i.

If the file is currently positioned at the beginning of line i, no operation is performed by the LINE option.

If the file is currently positioned before line i, and i is less than or equal to the page size, then blank lines are inserted following the current line until line i is reached.

If the file is currently positioned at or beyond line i, and the file is not at the beginning of line i, then the remainder of the page (the portion between the current line and the current page size) is filled with blank lines. The ENDPAGE condition is signaled.

When the LINE option is used within an ENDPAGE ON-unit, it causes a skip to the next page.

SKIP [(expression)]

An option that advances a specified number of lines from the current line. You can use the SKIP option only with the implied or explicit FILE option. The expression must yield an integer i, which must not be negative and must be greater than zero except for print files. If the expression is omitted, i equals 1.

If the file is not a print file, i–1 blank lines are inserted following the current line, and subsequent output of data begins at the beginning of (current line)+i.

If the file is a print file, i=0 causes a return to the beginning of the current line. If i is greater than zero, and either the current line exceeds the page size or the page size is greater than or equal to the current line plus i, then i–1 blank lines are inserted. Otherwise, the remainder of the current page is filled with blank lines, and the ENDPAGE condition is signaled.

On output devices with the space-suppression feature, SKIP(0) can be used to cause overprinting, underscoring, and so forth. For further information on lines and pages in stream files, **see** "Stream Input/Output" and "Print File."

OPTIONS (CANCEL_CONTROL_O)

The only valid statement option for PUT statements is CANCEL_CONTROL_O. The option is described fully in the *VAX PL/I User Manual.*

STRING(reference)

An option that specifies that the output stream be the referenced character-string variable. The STRING option cannot be used in the same statement with FILE, OPTIONS, PAGE, LINE, or SKIP.

■ Examples

```
PUTL: PROCEDURE OPTIONS(MAIN);

DECLARE I FIXED BINARY,
       F FLOAT,
       P PICTURE '99V.99',
       S CHAR(10);

DECLARE INFILE STREAM INPUT FILE;
DECLARE OUTFILE PRINT FILE;

OPEN FILE(INFILE) TITLE('PUTL.IN');
OPEN FILE(OUTFILE) TITLE('PUTL.OUT');

GET FILE(INFILE) LIST (I,F,P,S);
PUT FILE(OUTFILE) SKIP LIST (I,F,P,S);

END PUTL;
```

Assume that the file PUTL.IN contains the following data:

```
2,3.54,22.33,'A string'
```

Then the program PUTL writes the following output to PUTL.OUT:

```
 2  3.5400000E+00  22.33  A string
```

For print files, each output item is written at the next tab position. Floating-point values are represented in floating-point notation. Character values are not enclosed in apostrophes.

■ PUT PAGE

The PUT PAGE statement positions the output file at the start of a new page. This statement is valid only for print files, that is, files that have been opened with the PRINT attribute.

The form of the PUT PAGE statement is as follows:

PUT [FILE(file-reference)] PAGE;

file-reference

A reference to a print file that is to be advanced to the next output page. If no file is specified, PL/I assumes the default file SYSPRINT. This file is associated with the default system output file SYS$OUTPUT.

■ Example

```
PUT FILE(REPORT) PAGE SKIP LINE(2);
```

The PUT statement advances the file REPORT to the beginning of the next page, advances to line 2, and skips to the beginning of the next line (3).

■ PUT SKIP

The PUT SKIP statement positions the output file at the start of a new line.

The form of the PUT SKIP statement is as follows:

```
PUT [FILE(file-reference)] SKIP [(expression)];
```

file-reference
A reference to the file to which the SKIP option applies. If no file is specified, PL/I assumes the file SYSPRINT. This file is associated with the default system output file SYS$OUTPUT.

If a file is specified, and it is not currently opened, PL/I opens the file with the attributes STREAM and OUTPUT.

expression
An expression giving the number of lines to be advanced. The expression must yield an integer i, which must not be negative and must be greater than zero except for print files. If the expression is omitted, i equals 1.

If the file is not a print file, i–1 blank lines are inserted following the current line, and subsequent output of data begins at the beginning of (current line)+i.

If the file is a print file, i=0 causes a return to the beginning of the current line. If i is greater than zero, and either the current line exceeds the page size or the page size is greater than or equal to the current line plus i, then i–1 blank lines are inserted. Otherwise, the remainder of the current page is filled with blank lines, and the ENDPAGE condition is signaled.

On output devices with the space-suppression feature, SKIP(0) can be used to cause overprinting, underscoring, and so forth. For further information on lines and pages in stream files, **see** "Stream Input/Output" and "Print File."

R

R Format Item

The R (remote) format item specifies the label of a FORMAT statement from which some or all of a format specification is obtained by a GET EDIT or PUT EDIT statement.

The form of the R format item is as follows:

R (label)

label
The label of a FORMAT statement within the same block as the GET EDIT or PUT EDIT statement. If the item occurs in a recursive procedure, the R item and FORMAT statement must occur in the same recursion.

Although the FORMAT statement can contain another R format item, the following restrictions apply:

- The FORMAT statement cannot designate its own label with an R format item.
- The FORMAT statement cannot begin a chain of remote format items that leads back to the original FORMAT statement.

■ Examples

```
RFRM: PROCEDURE OPTIONS(MAIN);

DECLARE SYSIN STREAM INPUT FILE;
DECLARE SYSPRINT PRINT FILE;
DECLARE SALARY PICTURE '$$$$$$$$9V.99';
DECLARE (FIRST,MID,LAST) CHARACTER(80) VARYING;
DECLARE 1 HIRING,
          2 DATE CHARACTER(20) VARYING,
          2 EXPERIENCE FIXED,
          2 SALARY PICTURE '$$$$$$$$9V.99';

OPEN FILE(SYSIN) TITLE('RFRM.IN');
OPEN FILE(SYSPRINT) TITLE('RFRM.OUT');
```

```
GET EDIT(SALARY,FIRST,MID,LAST,DATE,EXPERIENCE,HIRING.SALARY)
     (F(8,2),R(PERSONNEL_FORMAT));

PUT SKIP LIST(LAST||', '||FIRST||' '||MID||':',
     'Hired '||DATE||' at '||HIRING.SALARY);
PUT SKIP LIST(EXPERIENCE,' years prior experience');
PUT SKIP LIST('Present salary: '||SALARY);

PERSONNEL_FORMAT: FORMAT(R(NAME),A(20),SKIP,F(2),X,F(8,2));
NAME: FORMAT(3(SKIP,A(80)));

END RFRM;
```

Assume the file RFRM.IN contains the following data:

```
 25005.50
Thomasina
A.
Delacroix
6 July 1976
 2 15003.65
```

The following output, with spacing as shown, will be written to the print file RFRM.OUT:

```
Delacroix, Thomasina A.:        Hired 6 July 1976 at    $15003.65
            2   years prior experience
Present salary:    $25005.50
```

RANK Built-In Function
RANK Preprocessor Built-In Function

The RANK built-in function returns a fixed-point binary integer that is the ASCII code for the designated character. The precision of the returned value is 15. The format of the function is as follows:

```
RANK(character)
```

character
Any expression yielding a 1-character value.

■ Examples

```
CODE = RANK('A');  /* CODE = 65 */
CODE = RANK('a');  /* CODE = 97 */
CODE = RANK('$');  /* CODE = 36 */
```

The ASCII characters are the first 128 characters of the DEC Multinational Character Set. **See** Appendix B for a table of these characters and their corresponding numeric codes.

READ Statement

The READ statement reads a record from a file, either the next record or a record specified by the KEY option. The file must have either the INPUT or the UPDATE attribute.

■ Format

```
READ FILE (file-reference)

{ INTO (variable-reference) }
{ SET (pointer-variable)    }

   [ KEY (expression)             ]
   [ KEYTO (variable-reference)   ]

      [ OPTIONS (option,...) ];
```

file-reference
The file from which the record is to be read. If the file is not currently open, PL/I opens the file with the implied attributes RECORD and, if the file does not have the UPDATE attribute, INPUT. The implied attributes are merged with the attributes specified in the file's declaration. (**See also** "Opening a File.")

INTO (variable-reference)
An option that specifies that the contents of the record are to be assigned to the specified variable name. The variable must be an addressable variable. The INTO and SET options are mutually exclusive.

If the variable has the VARYING attribute and the file does not have the attribute ENVIRONMENT(SCALARVARYING), the entire record is treated as a string value and assigned to the variable; if the record is larger than the variable, it is truncated and the ERROR condition is signaled. If the variable has the AREA attribute and the file does not have the attribute ENVIRONMENT(SCALARVARYING), the entire record is treated as an area value and assigned to the variable; if the extent of the area in the record is larger than the variable, the AREA condition is signaled and the target area is unmodified. For any other type of variable, the record is copied into the variable's storage. If the record is not exactly the same size as the target variable, as much of the record as will fit is copied into the variable and the ERROR condition is signaled.

SET (pointer-variable)

An option that specifies that the record should be read into a buffer allocated by PL/I and that the specified pointer variable should be assigned the value of the location of the buffer in storage. The SET and INTO options are mutually exclusive.

This buffer remains allocated until the next operation on the file but no longer. Therefore, do not use either the pointer value or the buffer after the next operation on the file. The only valid use of the buffer during a subsequent I/O operation is in a REWRITE statement. In this case, you can rewrite the record from the buffer before the buffer is deallocated.

KEY (expression)

An option that specifies that the record to be read is to be located using the key specified by the expression. The file must have the KEYED attribute. The key value must have a computational data type. The KEY and KEYTO options are mutually exclusive.

The nature of the key depends on the file's organization, as follows:

- If the file is a relative file or a sequential disk file with fixed-length records, the key is a fixed binary value indicating the relative record number of the record to be read.
- If the file is an indexed sequential file, the key specifies a key that is contained within a record. The data type of the key and its location within the record are as specified when the file was created.

The value of the specified expression is converted to the data type of the key. If no record with the specified key exists in the file, or if the value specified is not valid for conversion to the data type of the key, the KEY condition is signaled.

KEYTO (variable-reference)

An option that specifies that the key of the record being read is to be assigned to the designated variable. The value of the key is converted from the data type implied by the file's organization to the data type of the variable. The variable must have a computational data type but cannot be an unaligned bit string or an aggregate consisting entirely of unaligned bit strings. The KEYTO and KEY options are mutually exclusive.

KEYTO is specified only for a file that has both the KEYED and SEQUENTIAL attributes.

OPTIONS (option, . . .)

An option that specifies one or more of the following READ statement options, separated by commas:

FIXED_CONTROL_TO (variable-reference)
INDEX_NUMBER (expression)
LOCK_ON_READ
LOCK_ON_WRITE
MANUAL_UNLOCKING
MATCH_GREATER
MATCH_GREATER_EQUAL
MATCH_NEXT
MATCH_NEXT_EQUAL
NOLOCK
NONEXISTENT_RECORD
READ_REGARDLESS
RECORD_ID (variable-reference)
RECORD_ID_TO (variable-reference)
TIMEOUT_PERIOD (variable-reference)
WAIT_FOR_RECORD

All these options except INDEX_NUMBER remain in effect for the current statement only.

These options are described fully in the *VAX PL/I User Manual.*

■ File Positioning Following a READ Statement

If the file is accessed sequentially, the READ statement reads the file's next record. If the next-record position is at the end-of-file, the ENDFILE condition is signaled.

After a successful read operation, the file's current record position denotes the record that was just read. The next-record position denotes the following record or, if there is no following record, the end-of-file.

If any error other than an incorrect record size occurs, the current record becomes undefined and the next record is the same as it was before the read operation was attempted.

■ Examples

```
COPY: PROCEDURE;
DECLARE INREC CHARACTER(80) VARYING,
        ENDED BIT(1) STATIC INIT('0'B),
        (INFILE,OUTFILE) FILE;

      OPEN FILE (INFILE) RECORD INPUT
               TITLE('RECFILE.DAT');
      OPEN FILE (OUTFILE) RECORD OUTPUT
               TITLE('COPYFILE.DAT');

      ON ENDFILE(INFILE) ENDED = '1'B;

      READ FILE(INFILE) INTO (INREC);
      DO WHILE (^ENDED);
               WRITE FILE (OUTFILE) FROM (INREC);
               READ FILE (INFILE) INTO (INREC);
               END;
      CLOSE FILE(INFILE);
      CLOSE FILE(OUTFILE);
      RETURN;
      END;
```

The program COPY reads a file with variable-length records into a character string with the VARYING attribute and writes the records to a new output file.

It uses a DO-group to read the records in the file sequentially until the end-of-file is reached. It uses the ON statement to establish the action to be taken when the end-of-file occurs: it sets the bit ENDED to '1'B so that the DO-group will not be executed again.

The VARYING character-string variable INREC has a maximum length of 80 characters. If any record in the file is more than 80 characters, the ERROR condition is signaled. If no ERROR ON-unit exists, the program exits.

```
DECLARE 1 STATE,
          2 NAME CHARACTER(30),
          2 CAPITAL,
            3 NAME CHARACTER(20),
                .
                .
                .
          2 SYMBOLS,
            3 FLOWER CHARACTER(30),
            3 BIRD CHARACTER(30),
        STATE_FILE FILE,
```

```
      INPUT_NAME CHARACTER(30) VARYING;
         .
         .
         .
OPEN FILE(STATE_FILE) KEYED;
    PUT SKIP LIST('State?');
    GET LIST(INPUT_NAME);
    READ FILE(STATE_FILE) INTO(STATE) KEY(INPUT_NAME);
    PUT SKIP LIST('The flower of',STATE.NAME,'is the',FLOWER);
```

This example shows the use of a keyed READ statement to access a record in an indexed sequential file. The file STATE_FILE is opened for keyed access, and the READ statement specifies the key of interest in the KEY option. The value for this option is determined at run time by a GET statement. In the READ statement, the contents of a record from the file STATE_FILE are read into the structure STATE.

```
PRINT_DATA: PROCEDURE OPTIONS(MAIN);

DECLARE 1 EMPLOYEE BASED (EP),
          2 NAME,
            3 LAST CHAR(30),
            3 FIRST CHAR(20),
            3 MIDDLE_INIT CHAR(1),
          2 DEPARTMENT CHAR(4),
          2 SALARY FIXED DECIMAL (6,2),
    EP POINTER,
    EMP_FILE FILE;

DECLARE EOF BIT(1) STATIC INIT('0'B),
      NUMBER FIXED BIN(31);

      ON ENDFILE(EMP_FILE) EOF = '1'B;
      OPEN FILE(EMP_FILE) INPUT SEQUENTIAL KEYED;

      READ FILE(EMP_FILE) SET(EP) KEYTO(NUMBER);
      DO WHILE (^EOF);
         PUT SKIP LIST('EMPLOYEE',NUMBER,
              NAME.FIRST,NAME.LAST,MIDDLE_INIT);
         READ FILE(EMP_FILE) SET(EP) KEYTO(NUMBER);
         END;
      CLOSE FILE(EMP_FILE);

END;
```

This program accesses a relative file sequentially with READ statements and obtains the key value of each record, that is, the relative record number. The records in the file EMP_FILE are arranged according to employee numbers. Each employee number corresponds to a relative record number in the file. The READ statements read records into the based structure EMPLOYEE and set the pointer EP to the location of the allocated buffer. The READ statements specify the KEYTO option to obtain the record number of each record. The procedure prints the

employee numbers and names. When the last record has been read, the program closes the input file and exits.

READONLY Attribute

You can apply the READONLY attribute to any static computational variable whose value does not change during program execution.

When you specify READONLY in conjunction with the declaration of a static variable, the PL/I compiler allocates storage for the variable based on the fact that its value does not change. A static variable with the READONLY attribute is given an initial value with the INITIAL attribute.

The READONLY attribute is described in detail in the *VAX PL/I User Manual.*

■ Restrictions

You can apply the READONLY attribute only to static computational variables. You must declare the variables with the EXTERNAL, STATIC, GLOBALREF, or GLOBALDEF attribute.

The value of a variable with the READONLY attribute cannot be modified. An attempt to modify a variable declared with the READONLY attribute will result in a run-time error.

The READONLY attribute conflicts with the ENTRY, FILE, LABEL, POINTER, and VALUE attributes.

RECORD Attribute

The RECORD file description attribute indicates that data in an input or output file consists of separate records and that the file will be processed by record I/O statements.

The RECORD attribute is implied by the DIRECT, SEQUENTIAL, KEYED, and UPDATE attributes.

You can specify this attribute in a DECLARE statement for a file constant or in the OPEN statement that accesses the file. For a description of the attributes that can be applied to files and the effects of combinations of these attributes, **see** "File Description Attributes and Options."

■ Restrictions

The RECORD attribute conflicts with the STREAM and PRINT attributes.

Record Input/Output

Record I/O is performed by the READ, WRITE, DELETE, and REWRITE statements. In record I/O, each I/O statement processes an entire record. (In stream I/O, more than one line or record can be processed by a single statement; **see** "Stream Input/Output" for details.) Table R–1 summarizes the PL/I file description attributes that apply to record I/O. For an overview of how to declare and reference files in PL/I, **see** "File."

Table R–1: Attributes and Access Modes for Record Files

Attributes Specified	Attributes Implied	Valid Devices and File Organizations	Usage
SEQUENTIAL OUTPUT	RECORD	Any output device or file except indexed	Records can be added to the end of the file with WRITE statements. Each WRITE statement adds a single record to the file.
SEQUENTIAL INPUT	RECORD	Any input device or file	Records in the file are read with READ statements. Each statement reads a single record.
SEQUENTIAL UPDATE	RECORD	Relative, indexed, sequential disk	READ statements read a file's records in order. PL/I maintains the current record, which is the record just read. This record can be replaced in a REWRITE statement.[1] In a relative or indexed sequential file, the current record can also be deleted with a DELETE statement. Each statement processes a single record.
DIRECT OUTPUT	KEYED RECORD	Relative, indexed, sequential disk[2]	WRITE statements insert records into the file at positions specified by keys. Each statement inserts a single record.

[1] For a file with sequential organization, the record being written must have the same length as the one that was read.

[2] The file must have fixed-length records.

Table R–1 (Cont.): Attributes and Access Modes for Record Files

Attributes Specified	Attributes Implied	Valid Devices and File Organizations	Usage
DIRECT INPUT	KEYED RECORD	Relative, indexed, sequential disk[2]	READ statements specify records to be read randomly by key. Each statement reads a single record.
DIRECT UPDATE	KEYED RECORD	Relative, indexed, sequential disk[2]	READ, WRITE, and REWRITE statements specify records randomly by key. In a relative or indexed file, records can also be deleted by key.
KEYED SEQUENTIAL OUTPUT	RECORD	Relative, indexed, sequential disk[2]	WRITE statements insert records into the file at positions specified by keys. Each statement inserts a single record. This mode is identical to DIRECT OUTPUT.
KEYED SEQUENTIAL INPUT	RECORD	Relative, indexed, sequential disk[2]	READ statements access records in the file randomly by key or sequentially.
KEYED SEQUENTIAL UPDATE	RECORD	Relative, indexed, sequential disk[1]	Any record I/O operation is allowed except a WRITE statement that does not specify a key or a DELETE statement for a sequential disk file with fixed-length records.

[1] For a file with sequential organization, the record being written must have the same length as the one that was read.

[2] The file must have fixed-length records.

■ Position Information for a Record File

When a record file is open, PL/I maintains the following position information:

- The next record, for files with the SEQUENTIAL INPUT or SEQUENTIAL UPDATE attributes. The next record designates the record that will be accessed by a READ statement that does not specify the KEY option. The next record may contain the end-of-file.
- The current record, for a file with the UPDATE attribute. The current record designates either of the following:
  - The record that will be modified by a REWRITE statement that does not specify the KEY option

— The record that will be deleted by a DELETE statement that does not specify the KEY option

The value of the current record may be undefined.

When a file is opened the current record is undefined and the next record designates the first record in the file or, if the file is empty, the end-of-file.

After a sequential read operation, the current record designates the record just read. The next record indicates the following record or, if there are no more records, the end-of-file.

After a keyed I/O statement, that is, an I/O statement that specifies the KEY or KEYFROM option, the current record and next record are set as follows, where X is the record specified by key and X+1 is the next record or, if there are no more records, the end-of-file:

Statement	Current Record	Next Record
READ	X	X+1
WRITE	X	X+1
REWRITE	X	X+1
DELETE	undefined	X

RECURSIVE Option

The RECURSIVE option is specified on a PROCEDURE or ENTRY statement to indicate (for program documentation) that the procedure will invoke itself. For example:

```
HANOI: PROCEDURE (T1, T2, T3, RINGS)
       RECURSIVE;
```

In standard PL/I, the RECURSIVE option is required for a recursive procedure. However, in VAX PL/I any procedure can be invoked recursively, and the RECURSIVE option is ignored by the compiler. For more information, **see** "Procedure."

REFER Attribute

The REFER attribute defines dynamically self-defining structures.

See "REFER Option."

REFER Option

The REFER option is provided in PL/I to create self-defining BASED structures. That is, the value of one member of a based structure is used to determine the size of the storage space allocated for another member of the same structure. The REFER option is used in a DECLARE statement to specify array bounds, the length of a string, or the size of an area. The format of the REFER option is as follows:

```
refer-element REFER (refer-object-reference)
```

refer-element
An expression that represents the value assigned to the refer object when the structure is allocated. The refer element must satisfy the following conditions:

- It must be an expression that produces a FIXED BINARY(31) value or a value that can be converted to FIXED BINARY (31).
- It cannot reference storage in the structure containing the refer element.

refer-object-reference
A reference to a scalar variable. The refer object reference must satisfy the following conditions:

- It cannot be a subscripted variable reference.
- It cannot be locator qualified.
- It must reference a refer object that is a previous member of the structure containing the REFER option.

refer-object
A scalar variable contained by the structure. The refer object must satisfy the following conditions:

- It must be a previous member of the structure containing the REFER option which references the refer object.
- It must be scalar; it cannot be dimensioned, or a dimensioned array.

- It must have a computational data type.

A structure declaration containing the REFER option has the following components:

```
DECLARE 1 STRUCTURE S BASED(P),
          2 I FIXED BINARY(31),
          2 A CHARACTER(20 REFER(I)),
```

I is the refer object, 20 is the refer element, and REFER(I) is the refer object reference.

For the allocation of storage for a BASED structure, the structure must have a known size. In the example, the initial length for A is taken from the refer element, 20. However, the REFER option permits the size of the structure to change at run time as the value of the refer object changes. After allocation, the length of A is determined by the refer object, I.

Multiple REFER options are permitted within a structure.

The following example and diagrams illustrate storage mapping using the REFER option.

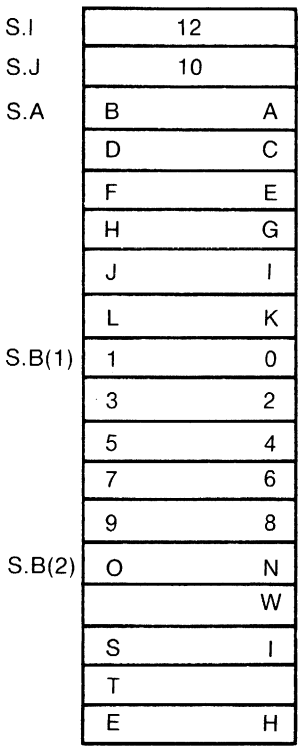
```
DECLARE 1 S BASED (POINTER),
          2 I FIXED BINARY(15),
          2 J FIXED BINARY(15),
          2 A CHARACTER ((X*2+2) REFER(I)),
          2 B(2) CHARACTER (Y REFER(J));

X = 5;
Y = 10;
ALLOCATE S;

S.A = 'ABCDEFGHIJKL';
S.B(1) = '0123456789';
S.B(2) = 'NOW IS THE';
    .
    .
    .
END;
```

When this structure is allocated, the refer elements, (X*2+2) and Y, are evaluated and used to determine the length of the associated string. The evaluated refer element value (X*2+2) is assigned to the refer object I, and Y is assigned to J. Thereafter, the size of strings A and B is determined by the value of the refer objects I and J.

Storage for the above structure would look like this:



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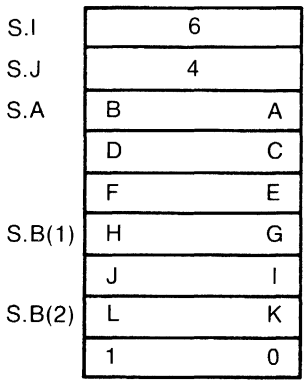
Assume that the refer objects, I and J, were assigned the following values:

```
I = 6;
J = 4;
```

The resulting storage would remap to this:



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Note that VAX PL/I does not restrict the use of the REFER option within structure declarations. Therefore, you should exercise caution in its use. If you change a value that causes the size of one or more structure members to decrease, then some storage at the end of the allocated storage becomes inaccessible for future reference.

If the scalar variable (the refer object) does not satisfy the following conditions, the results are undefined:

- It must not be assigned a value that is less than zero or greater than the refer element value used for structure allocation.
- It must have the value used for allocation, if the structure is freed.

The following additional rules apply to structures containing the REFER option:

- A structure containing the REFER option cannot be the target of a LIKE reference.
- When a BASED structure is allocated, the order in which the refer elements are selected for evaluation is undefined.
- When a BASED structure is allocated, the order in which the refer objects are selected for initialization is undefined.

The following examples are illegal uses of the REFER option:

```
DECLARE 1 S1 BASED (P),
          2 N(2) FIXED BIN(15),
          2 A CHAR(8) VARYING,
          2 B CHAR(X REFER (N));

DECLARE (X,Y) FIXED BIN(31);
DECLARE P POINTER;

  /* Illegal --- 'N' used in a context
      that requires a scalar value */


DECLARE 1 S1 BASED (P),
          2 A(N) CHAR(8) VARYING,
          2 B CHAR(X REFER (N)),
          2 N FIXED;

DECLARE (X,Y) FIXED BINARY(31);
DECLARE P POINTER;

  /* Illegal --- 'B' contains a REFER option
      and precedes the refer object */


DECLARE 1 S1 BASED (P),
          2 A(N) CHAR(8) VARYING,
          2 B CHAR(X REFER (N));

DECLARE (X,Y,N) FIXED BINARY(31);
DECLARE P POINTER;

  /* Illegal --- 'B' contains a REFER option
      and precedes the refer object */


DECLARE A CHAR(X REFER(N));
DECLARE (X,N) FIXED BIN(31);

  /* Illegal --- 'A' contains a REFER option,
     but is not a member of a structure */
```

Reference

In this manual, the term *reference* means a reference to a named constant or variable. This entry gives the complete syntax for references and explains in detail how a reference is interpreted. Because of the flexibility of PL/I, this explanation is complex and is probably of interest to only a few programmers. For information on how to write references to accomplish a specific operation, **see**, for example, "Built-In Function," "Expression," and "Procedure."

The complete syntax of a reference is as follows:

```
[locator-qualifier] [structure-qualifier]... identifier
        [(subscript-list)] [(argument-list)]
```

The referenced identifier is the declared name of the constant or variable.

The locator qualifier has the following form:

```
reference->
```

reference
A reference to a pointer variable, a pointer-valued function, or an offset variable that was declared with a base area. (**See** "Based Variable" and "Offset.")

The structure qualifier has the following form:

```
identifier [(subscript-list)]
```

identifier
The name of a structure declaration containing (at some level) a declaration of the referenced identifier.

subscript list
A list of integer expressions separated by commas. The argument list is either empty or is a list of expressions, separated by commas, that determine the arguments of a procedure or built-in function. If, ignoring structure qualifiers, only one of the subscript list or argument list is included, the listed items are interpreted as subscripts or arguments depending on the declaration of the referenced identifier.

■ Complete Interpretation of a Reference

Complete interpretation of a reference follows this sequence of steps:

1. Determine the initial block, B, of interpretation. This is the block in which the search for the referenced declaration starts. The initial block, B, is always the block in which the reference textually occurs. This is usually the current block, but it can be a parent block when references from declarations are to be interpreted. For example:

```
P: PROC;
  DCL X(N) FIXED BASED(R);
      .
      .
      .
Q: PROC;
X(1)=0;
```

   When the assignment statement X(1)=0 is executed, the reference X(1) is interpreted in the block Q. However, interpreting X(1) requires interpreting the references N and R in X's declaration, and this is done in block P, the block of X's declaration.

2. Find the referenced declaration, D, and the block to which it belongs. This block becomes the block, B, for further interpretation. To find the declaration, make a qualifying list containing any identifiers in the structure qualifiers and the identifiers in the reference, taken in left-to-right order. Search the declarations in block B for any declaration whose complete list of qualifying names matches the reference's qualifying list, as follows:

   a. If the reference's qualifying list of names is the same as the declaration's list, the reference completely matches the declaration. In this case, the declaration is the reference's governing declaration; no further searching of declarations is done.

   b. If the reference's qualifying list is a sublist (in order) of the declaration's, and the last occurring identifiers are the same, then the reference is partially qualified. If the reference does not completely match any declaration as in 2(a), and it does partially match exactly one declaration in B, then that declaration is the governing declaration. If the reference does not completely match as in 2(a), and it partially matches two or more declarations in B, then the reference is ambiguous, and the compiler issues an error message.

c. If the reference does not match any declaration in B, B is replaced by its immediate parent block, and the search for matching declarations is performed again. This process continues until a match is found or there is no parent block (the outermost block has been searched). In the latter case, if the identifier in the reference is SYSIN or SYSPRINT, or the name of a built-in function, the compiler creates an appropriate declaration in the external procedure. Otherwise, it issues an error message.

For example, suppose the block being searched contains only the following structure declaration:

```
DECLARE 1 STATE,
          2 NAME CHAR(20) VAR,
          2 POPULATION FIXED,
          2 CAPITAL,
            3 NAME CHAR(30) VAR,
            3 POPULATION FIXED,
          2 SYMBOLS,
            3 FLOWER CHAR(20),
            3 BIRD CHAR(20);
```

The references STATE, STATE.NAME, and STATE.CAPITAL.NAME match completely. The references NAME and POPULATION are ambiguous. The reference CAPITAL.NAME partially matches exactly one declaration.

3. Find the block activation, BA, associated with the block B. If B is the current block, BA is the current block activation. Otherwise, PL/I locates BA by searching the chain of parent block activations that ends at the current block. BA is used to determine the value of a reference to an automatic variable, the actual argument associated with a parameter, the extents of automatic or defined variables, and the block-activation component of a label or entry value when a label or entry constant is interpreted.
4. Evaluate the locator qualifier. If the reference contains a locator qualifier, it is evaluated to obtain a pointer value. In this case, the reference must be to a based variable or to a member of a based structure. If the reference is to a based variable or to a member of a based structure, and if the reference does not contain a locator qualifier, the level-1 variable must have been declared with the attribute BASED(reference), and that reference is evaluated as a locator qualifier. Note that the pointer value obtained must satisfy the rules given in "Based Variable."
5. Evaluate the base reference and position. If the reference is to a defined variable, the base reference and any POSITION attribute are evaluated.

6. Determine all extents of the referenced variable. Any extents are given in the declaration. Those that are not constant are determined as follows:
   a. If the variable is automatic or defined, the extents were evaluated at the time of block activation and the resulting values saved at that time. These saved values are used.
   b. If the variable is a parameter, the extents were passed along with the argument to which the parameter corresponds.
   c. If the variable is a based variable, the extents are evaluated now. This includes all extent expressions in the referenced declaration and all array bounds of containing structures.
7. Interpret subscripts. This step depends on the total number of dimensions of the referenced declaration, D; that is, the number of dimensions in D itself plus the number in each containing structure declaration. The subscripts are evaluated as follows:
   a. All subscripts in the structure qualifiers (if any) are gathered together in one list (in order). If the reference itself contains both a subscript list and an argument list [for example, S.Y(1,1,1)(7)], those subscripts are added to the list. If the reference contains a single list, which could be either subscripts or arguments, its elements are treated as subscripts and added to the list unless the number of subscripts already collected equals D's number of dimensions. If the single list is not interpreted as a subscript list, it is an argument list. Note that an empty argument list is never interpreted as a subscript list.
   b. The complete list of subscripts is now compared with the number of dimensions of D and with each declaration of an array of structures containing D. The number of subscripts must be zero or equal to the total number of dimensions of one of these declarations. If it is not, the compiler issues an error message. The array properties of the reference are then determined as follows:
      - If the number of subscripts equals the total number of dimensions of D, then it is not an array reference.
      - If D is an array declaration and the number of subscripts equals the inherited dimensionality of D (that is, D's total dimensionality minus the dimensionality of D itself), then it is a connected array reference.
      - If the number of subscripts is less than the inherited dimensionality of D, then it is an unconnected array reference.

For example, consider the following declaration:

```
DECLARE 1 S(5),
          2 A(10,20),
            3 X(50) FLOAT,
            3 Y ENTRY(FIXED),
            3 Z FLOAT,
          2 B ENTRY(FLOAT,FLOAT);
```

Now consider the following series of references in relation to this declaration:

```
S.A(1,1)
```

This reference is invalid, because the number of subscripts is too large for S and too small for S.A.

```
S(1).A(1,1).Y(3)
S.A.Y(1,1,1)(3)
```

These are equivalent. The value of S.A.Y(1,1,1) is an entry value. The entry is invoked with the argument list (3).

```
S(1).A(1,1).X
```

This is a reference to a connected one-dimensional floating-point array whose bounds are (1:50).

```
S.A.X(3,10,20,2)
```

This is a reference to a floating-point variable that is an element of the array S.A.X.

```
S(1).A.X
```

This is a reference to an unconnected array. It is three-dimensional, with bounds (1:10,1:20,1:50).

c. All subscript values must lie within the corresponding bounds. If the compiler option CHECK is used, all subscript values are checked either at compile time or at run time. If CHECK is not in effect, some constant subscripts can still be checked at compile time.

8. Invoke the procedure. If the reference contains an argument list or was the reference in a CALL statement, the referenced procedure is invoked with the specified arguments. (**See also** "Procedure.") In this case, the reference must not be an array reference and must have data type ENTRY. If the reference is to an entry variable, the procedure is invoked using the current value of the variable. Note that the ENTRY attribute and RETURNS attribute (if any) in the declaration D are used

to interpret the argument list and to determine if this is a function or a procedure invocation.

REFERENCE Attribute

The REFERENCE attribute forces a parameter to be passed by reference. Its format is as follows:

```
{ REFERENCE }
{ REF       }
```

By default, most parameters are passed by reference in PL/I. However, the REFERENCE attribute is needed for passing an asterisk-extent array or character string by reference, because asterisk-extent parameters are passed by descriptor by default. For example:

```
DECLARE E ENTRY((*) FIXED BIN(31) REFERENCE, FIXED BIN(31));
```

This is a declaration of a non-PL/I entry point that takes an asterisk-extent parameter by reference. The first parameter of the external procedure is an arbitrarily large array of longwords, and the second parameter is the size of the array. The external procedure should have some method of determining the size of the array being passed.

Note that the REFERENCE attribute can only be used in parameter descriptors.

Also see "Reference" and "REFERENCE Built-In Function."

REFERENCE Built-In Function

The REFERENCE built-in function is used to force a parameter to be passed by reference, rather than by whatever mechanism is specified by the declaration of the formal parameter.

The type of the argument specified with the REFERENCE built-in function is used for the parameter; thus, the type of the parameter declaration is ignored when the REFERENCE built-in function is used.

The format of the REFERENCE built-in function is as follows:

```
{ REFERENCE }
{ REF       } (variable-reference)
```

variable-reference
The name of a scalar or aggregate variable.

See "Reference" and "REFERENCE Attribute."

Relational Operator

The relational, or comparison, operators test the relationship of two operands; the result is always a Boolean value (that is, a bit string of length 1). If the comparison is true, the resulting value is '1'B; if the comparison is false, the resulting value is '0'B. The relational operators are all infix operators. The following table describes all the relational operators:

Operator	Operation
<	Less than
^ <	Not less than
<=	Less than or equal to
=	Equal to
^=	Not equal to
> =	Greater than or equal to
>	Greater than
^>	Not greater than

Note that VAX PL/I recognizes the tilde symbol (~) as synonymous with the circumflex (^).

Relational operators compare any of the following data types: arithmetic (decimal or binary); bit-string; character-string; and entry, pointer, label, or file data. Specific results of operations on each type of data are elaborated below. The following general rules apply:

- All operands must be scalar.
- Both operands must be arithmetic, or they must have the same data type.

■ Arithmetic Comparisons

Arithmetic and picture operands are compared algebraically. If the operands have a different base, scale, or precision, PL/I converts them according to the rules for arithmetic operand conversion (**see** "Expression").

■ Bit-String Comparisons

When two bit strings are compared, they are compared bit by bit from the most significant bit to the least significant bit (as represented by PUT LIST). If the operands have different lengths, PL/I extends the smaller operand with zeros in the direction of the least significance. Null bit strings are equal.

■ Character-String Comparisons

When two character strings are compared, they are compared character by character in a left-to-right order. The comparison is based on the ASCII collating sequence. The ASCII characters are the first 128 characters of the DEC Multinational Character Set, which is in Appendix B.

Note the following characteristics of the collating sequence:

- Uppercase letters are less than any lowercase letters.
- Numeric characters are less than any letters.

If the operands do not have the same length, PL/I extends the smaller operand on the right with blanks for the comparison. Either or both of the strings can have the attribute VARYING; PL/I uses the current length of a varying character string when it makes the comparison.

■ Comparing Noncomputational Data

Only the following operators are valid, or meaningful, for comparisons of any of the noncomputational data types except areas (entry, file, label, offset, and pointer):

Operator	Operation
=	Equal
^=	Not equal

The results of the comparisons provide the information indicated below for each data type.

Entry Data

Two entry values are equal if they identify the same entry point in the same block activation of a procedure.

File Data

Two values defined with the FILE attribute are equal if they identify the same file constant.

Label Data

Two label values are equal if they identify the same statement in the same block activation.

A label that identifies a null statement is not equal to the label of any other statement.

Pointer Data

Two pointer values are equal if they identify the same storage location or if they are both null.

Offset Data

Two offset values are equal if they identify the same storage location or if they are both null.

RELEASE Built-In Subroutine

The RELEASE built-in subroutine allows a specific record in a file to be unlocked. This built-in subroutine is normally used in conjunction with the extended VMS record-locking options of the READ statement. See the *VAX PL/I User Manual* for more information.

REPEAT Option

The REPEAT option is specified in a DO statement to specify values to be assigned to the control variable. The input-target and output-source lists of GET and PUT statements can also have a DO construct with the REPEAT option. The REPEAT option is most often used to step though a list that is linked by pointer or offset values. For example:

```
DO P = LIST_HEAD REPEAT P->LIST_ELEMENT.NEXT
       WHILE (P ^= NULL());
```

For more information, **see** "DO Statement," "GET Statement," "List Processing," and "PUT Statement."

%REPLACE Statement

The preprocessor %REPLACE statement specifies that an identifier is a constant of a given value. It can be used anywhere within a procedure or anywhere in a PL/I source file.

Beginning at the point at which a %REPLACE statement is encountered, PL/I replaces all occurrences of the specified identifier with the specified constant value, until the end of compilation.

The format of the %REPLACE statement is as follows:

```
%REPLACE identifier BY constant-value;
```

identifier
Any valid PL/I identifier. PL/I keywords are not valid identifiers in a %REPLACE statement. The identifier must not be the name of a declared preprocessor or program variable. VAX PL/I permits multiple %REPLACE statements and %REPLACE statements that redefine the %REPLACE identifier.

constant-value
Any valid character-string, bit-string, or arithmetic constant.

Integer constants that are given values by %REPLACE statements are valid in constant expressions. For example:

```
%REPLACE PREFIX BY 8;

DECLARE BUFFER CHARACTER( 80 + PREFIX);
```

When the program containing these lines is compiled, the variable BUFFER is declared with a length of 88 characters.

Replication Factor

A replication factor is an unsigned integer constant that specifies the number of times that a simple string constant is replicated. A replication factor permits repetition of character strings and bit strings in any context where a simple string constant is permissible, including format items and assignment, string, and arithmetic operations. The format of a replication factor is as follows:

```
(r)'string'
```

r
An unsigned integer that represents the number of times that the string is to be replicated.

string
A simple string constant to be replicated. The string is enclosed in apostrophes.

■ Examples

For example:

```
(4)'season   '
```

This example replicates the string four times. The resulting character constant looks like this:

```
season   season   season   season
```

For example:

```
DECLARE (A) BIT (800);
     A = (400) '2'B2;
     PUT SKIP LIST ((A));
END;
```

In this example, the constant will be replicated to a length of 800 characters.

The resulting character constant looks like this:

```
'10101010101010101010101010101010
                .
                .
                .
10101010101010101010101010'B
```

A replication factor can be used in combination with an iteration factor in INITIAL. For example, the following two statements are equivalent:

```
INITIAL ((10)('ABCABC'))

INITIAL ((10)((2)'ABC'))
```

The first statement uses an iteration factor exclusively; the second statement combines an iteration factor of 10 with a replication factor of 2.

RESCAN Option

The RESCAN option of the %ACTIVATE statement specifies when the value of the variable identifiers is replaced during compilation, the new replacement text is scanned for further preprocessor identifiers that also are replaced.

The format of the %ACTIVATE statement with the RESCAN option is as follows:

```
% { ACTIVATE } element [ RESCAN   ] ,...;
  { ACT      }         [ NORESCAN ]
```

RESCAN is the default option of the %ACTIVATE statement. For further details, **see** "%ACTIVATE Statement."

RESIGNAL Built-In Subroutine

The RESIGNAL built-in subroutine is used in an ON-unit to "pass" a signaled condition so that the run-time system will attempt to locate another ON-unit to handle the condition. RESIGNAL sets up the internal mechanism for passing the signal. However, it does not by itself cause an exit from the ON-unit that calls it. It returns to the next statement in the ON-unit. Resignaling does not occur until execution of the ON-unit completes. The format of a call to the RESIGNAL built-in subroutine is as follows:

```
CALL RESIGNAL();
```

When an ON-unit has determined that it cannot or should not respond to a condition, RESIGNAL permits the ON-unit to pass the signal along.

This subroutine is not provided in the standard PL/I language. It is provided specifically for use in the VMS operating system environment. For complete details on condition handling in the VMS system, **see** the *VAX PL/I User Manual.*

Restricted Expression

A restricted integer expression is one that yields only integral results and has only integral operands. Such an expression can use only the addition (+), subtraction (-), and multiplication (*) operators. In VAX PL/I, you can use a restricted integer expression in certain contexts (such as in the specification of array bounds) where an integer constant is ordinarily used.

%RETURN Statement

The %RETURN statement terminates execution of the current preprocessor procedure. The format of the %RETURN statement is as follows:

```
[%]RETURN (preprocessor-expression);
```

preprocessor-expression
Value to be returned to the invoking procedure. The preprocessor expression must be specified. The preprocessor expression is converted to the data type specified in the RETURNS option, and the value of the expression is returned to the point of invocation. Therefore, the expression must be capable of being converted to CHARACTER (32767) VARYING, FIXED (10), or BIT (31).

The value returned by a preprocessor procedure cannot contain preprocessor statements.

When the value of the evaluated preprocessor expression is passed back to the point of invocation, control returns to the evaluation of the statement that contained the reference to the preprocessor procedure.

Within a preprocessor procedure, the leading percent sign (%) is optional.

Multiple %RETURN statements are permitted in preprocessor procedures. **See** "%PROCEDURE Statement" for more information.

RETURN Statement

The RETURN statement terminates execution of the current procedure. The format of the RETURN statement is as follows:

```
RETURN [ (return-value) ];
```

return-value
The value to be returned to the invoking procedure. If the current procedure was invoked by a function reference, a return value must be specified. If the current procedure was invoked by a CALL statement, a return value is invalid.

A return value can be any scalar arithmetic, bit-string, or character-string expression; it can also be an entry, pointer, or label expression or other noncomputational expression. The return value must be valid for conversion to the data type specified in the RETURNS option of the function.

The actual action taken by the RETURN statement depends on the context of the procedure activation, as follows:

- If the current procedure is the main or only active procedure, the RETURN statement terminates the program.
- If the current procedure was activated by a CALL statement, the next executable statement in the calling procedure is executed.
- If the current procedure was activated by a function reference, control returns to continue the evaluation of the statement that contained the function reference.
- If the RETURN statement is executed in a begin block, control returns from the containing procedure to the calling procedure.

■ Restrictions

The RETURN statement must not be immediately contained in an ON-unit or in a begin block that is immediately contained in an ON-unit.

RETURNS Attribute
RETURNS Option

The RETURNS option must be specified on the PROCEDURE or ENTRY statement if the corresponding entry point is invoked as a function. (**See also** "Procedure.") The RETURNS attribute is specified with the ENTRY attribute to give the data type of a value returned by an external function. The format of the option and attribute is as follows:

```
RETURNS (returns-descriptor...)
```

returns-descriptor

One or more attributes that describe the value returned by the function to its point of invocation. The returned value becomes the value of the function reference in the invoking procedure. The attributes must be separated by spaces, except for attributes (the precision, for example) that are enclosed in parentheses.

■ Restrictions

The data types you can specify for a returns descriptor are restricted to scalar elements of either computational or noncomputational types. Areas are not allowed.

The extent of a character-string value can be specified as an asterisk (*) to indicate that the string can have any length. Otherwise, extents must be specified with restricted expressions.

You cannot use the RETURNS option or RETURNS attribute for procedures that are invoked by the CALL statement.

The attributes specified in a returns descriptor in a RETURNS attribute must correspond to those specified in the RETURNS option of the PROCEDURE statement or ENTRY statements in the corresponding procedure. For example:

```
CALLER: PROCEDURE OPTIONS (MAIN);
        DECLARE COMPUTER ENTRY (FIXED BINARY)
           RETURNS (FIXED BINARY); /* RETURNS attribute */
        DECLARE TOTAL FIXED BINARY;
           .
           .
           .
        TOTAL = COMPUTER (A+B);
```

The first DECLARE statement declares an entry constant named COMPUTER. COMPUTER will be used in a function reference to invoke an external procedure, and the function reference must supply a fixed-point binary argument. The invoked function returns a fixed-point binary value, which then becomes the value of the function reference.

The function COMPUTER contains the following:

```
COMPUTER: PROCEDURE (X) RETURNS (FIXED BINARY); /* RETURNS option */
          DECLARE (X, VALUE) FIXED BINARY;
             .
             .
             .
          RETURN (VALUE);                      /* RETURN statement */
```

In the PROCEDURE statement, COMPUTER is declared as an external entry constant, and the RETURNS option specifies that the procedure return a fixed-point binary value to the point of invocation. The RETURN statement specifies that the value of the variable VALUE be returned by COMPUTER. If the data type of the returned value does not match the data type specified in the RETURNS option, PL/I converts the value to the correct data type according to the rules given under "Conversion of Data."

REVERSE Built-In Function
REVERSE Preprocessor Built-In Function

The REVERSE built-in function reverses the characters or bits in a string. It takes one argument, which is either a character string (fixed or varying) or a bit string. It returns a string of the same type and size as its argument, with all the characters (bytes) or bits reversed.

The syntax of the function is as follows:

```
REVERSE(string-expression);
```

The syntax of an assignment statement using the REVERSE function is as follows:

```
string-variable = REVERSE(string-expression);
```

string-variable
A variable whose data type (either character or bit string) and length match the type and length of the string-expression.

string-expression
An expression that evaluates to a character string or a bit string.

For example:

```
DECLARE X CHARACTER(4) VARYING,
        Y BIT(8);
X = REVERSE('abc')
Y = REVERSE('00010101'B)
```

The character-string variable X is assigned the value 'cba'. The bit-string variable Y is assigned the value '10101000'B.

REVERT Statement

The REVERT statement cancels an ON-unit established for a specified condition or conditions in the current block. The format of the REVERT statement is as follows:

```
REVERT condition-name,...;
```

condition-name, . . .
The keyword name or names associated with the condition or conditions for which the ON-unit is to be reverted. Successive names must be separated by commas. The valid condition names are the same as for the ON statement (**see** "On Statement".)

If no ON-unit is established for a specified condition for the current block, the REVERT statement has no effect. When the REVERT statement is executed for a specific condition for which an ON-unit exists, then one of the following actions is taken:

- If a previous block activation specified an ON-unit for the indicated condition, that ON-unit will be executed if the condition is signaled.
- If no previous block activation specified on ON-unit for the specified condition, the default PL/I condition handling is reestablished.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

REWIND Built-In Subroutine

The REWIND built-in subroutine is used to position a file to the first record. See the *VAX PL/I User Manual* for more information.

REWRITE Statement

The REWRITE statement replaces a record in a file. The record is either the current record or the record specified by the KEY option. The file must have the UPDATE attribute. The format of the REWRITE statement is as follows:

```
REWRITE FILE (file-reference)
    [ FROM (variable-reference) [ KEY (expression) ]]
    [ OPTIONS (option,...) ];
```

file-reference

The file that contains the record to be replaced. If the file is not open, it is opened with the implied attributes RECORD and UPDATE; these attributes are merged with the attributes specified in the file's declaration. (**See also** "Opening a File.")

FROM (variable-reference)

An option giving the variable whose value is to be used to rewrite the specified record. The variable must be an addressable variable. (**See** "Variable.")

If the FROM option is not specified, there must be a currently allocated buffer from an immediately preceding READ statement that specifies the SET option, and this file must have the SEQUENTIAL attribute. In this case, the record is rewritten from the buffer containing the record that was read. Note that if the file organization is sequential, the record being rewritten must be the same length as the one read.

If the variable has the VARYING or the AREA attribute and the file does not have the attribute ENVIRONMENT(SCALARVARYING), the REWRITE statement writes only the current value of the varying string or area into the specified record. In all other cases, the REWRITE statement writes the variable's entire storage.

KEY (expression)

An option specifying that the record to be rewritten is to be located using the key specified by expression. The file must have the KEYED attribute. The expression must have a computational data type. The FROM option must be specified.

The nature of the key depends on the file's organization, as follows:

- If the file is a relative file or a sequential disk file with fixed-length records, the key is a fixed binary value indicating the relative record number of the record to be rewritten.
- If the file is an indexed sequential file, the key specifies a key that is contained within a record. The data type of the key and its location within the record are as specified when the file was created. The primary key field in the record cannot be modified.

The value of the specified expression is converted to the data type of the key. If no record with the specified key exists, if the value specified is not valid for conversion to the data type of the key, or if the primary key in a record in an indexed sequential file has been modified, the KEY condition is signaled.

OPTIONS (option, . . .)

An option giving one or more of the following REWRITE statement options. Multiple options must be separated by commas.

FIXED_CONTROL_FROM(variable-reference)
INDEX_NUMBER (expression)
MATCH_GREATER
MATCH_GREATER_EQUAL
MATCH_NEXT
MATCH_NEXT_EQUAL
RECORD_ID (expression)
RECORD_ID_TO (variable-reference)

If the MATCH_GREATER, MATCH_GREATER_EQUAL, MATCH_NEXT, and MATCH_NEXT_EQUAL options of the REWRITE statement, are set, they remain set only for the current statement. They are then reset to FALSE. (MATCH_GREATER and MATCH_GREATER_EQUAL are obsolete synonyms for MATCH_NEXT and MATCH_NEXT_EQUAL.)

These options are described fully in the *VAX PL/I User Manual.*

■ File Positioning

The next record position is set to denote the record immediately following the record that was rewritten or, if there is no following record, the end-of-file.

The current record is set to designate the record just rewritten.

■ Examples

The procedure NEW_SALARY, below, updates the salary field in a relative file containing employee records. The procedure receives two input parameters: the employee number and the new salary. The employee number is the key value for the records in the relative file.

```
NEW_SALARY: PROCEDURE (EMPLOYEE_NUMBER,PAY);

DECLARE EMPLOYEE_NUMBER FIXED DECIMAL(5,0),
     PAY FIXED DECIMAL (6,2);

DECLARE 1 EMPLOYEE,
          2 NAME,
            3 LAST CHAR(30),
            3 FIRST CHAR(20),
            3 MIDDLE_INIT CHAR(1),
          2 DEPARTMENT CHAR(4),
          2 SALARY FIXED DECIMAL (6,2),
    EMP_FILE FILE;

    OPEN FILE(EMP_FILE) DIRECT UPDATE;
    READ FILE(EMP_FILE) INTO(EMPLOYEE)
         KEY (EMPLOYEE_NUMBER);
    EMPLOYEE.SALARY = PAY;
    REWRITE FILE(EMP_FILE) FROM(EMPLOYEE)
         KEY(EMPLOYEE_NUMBER);
    CLOSE FILE(EMP_FILE);
    RETURN;
    END;
```

In this example, the KEY option is specified in the READ statement that obtains the record of interest and in the REWRITE statement that replaces the record, with its new information, in the file. The FROM and KEY options must both be specified on the REWRITE statement.

The sample program CHANGE_HEADER, below, changes the contents of the first record in the sequentially organized file TITLE_PAGE. The file consists of 80-byte, fixed-length records.

```
CHANGE_HEADER: PROCEDURE OPTIONS(MAIN);

DECLARE TITLE_PAGE FILE SEQUENTIAL UPDATE,
        INREC CHARACTER(80) BASED(P),
        P POINTER;

     OPEN FILE(TITLE_PAGE);
     READ FILE(TITLE_PAGE) SET(P);
```

```
    INREC = 'Summary of Courses for Fall 1980';
    REWRITE FILE(TITLE_PAGE);
    CLOSE FILE(TITLE_PAGE);
    RETURN;
END;
```

In this example, the READ statement specifies the SET option. The input record is read into a buffer, INREC, that is a based character-string variable. The assignment statement modifies the buffer, and the REWRITE statement rewrites the record. Because the REWRITE statement does not specify a FROM option, PL/I uses the contents of the buffer to rewrite the current record in the file (that is, the record that was just read).

ROUND Built-In Function

The ROUND built-in function rounds a fixed-point decimal expression to a specified number of decimal places. Its format is as follows:

ROUND(expression,position)

expression
An arithmetic expression that yields a fixed-point decimal value with a nonzero scale factor; or a pictured value with fractional digits.

position
A nonnegative integer constant specifying the number of decimal places in the rounded result.

■ Returned Value

Where the arguments are an expression of type FIXED DECIMAL(p,q) and position k, the returned value is the rounded value with the following attributes:

$$precision = max(1, min(p - q + k + 1, 31))$$

and

$$scalefactor = k$$

The rounded value is as follows:

$$ROUND(x, k) = sign(x) * (10^{-k}) * floor(abs(x) * (10^{k}) + 0.5)$$

■ Examples

```
A = 1234.567;
Y = ROUND(A,1);     /*   Y = 1234.6    */

Y = ROUND(A,0);     /*   Y = 1235      */

A = -1234.567;
Y = ROUND(A,2);     /*   Y = -1234.57  */
```

%SBTTL Statement

The %SBTTL statement allows specification of an arbitrary compile-time string for the listing subtitle line. PL/I uses the procedure IDENT, or V002 if no IDENT was specified. If %SBTTL is used, the specified subtitle appears to the right of IDENT or V002.

The format of the %SBTLL statement is as follows:

```
%SBTTL preprocessor-expression
```

preprocessor-expression
A character string with a maximum length of 30 characters. It is truncated if necessary.

Scale Attribute

The precision p is the total number of bits or decimal digits used to represent values of the variable. The scale attribute is the number of fractional bits or digits contained within the specified precision. That is, the scale factor q specifies that all values of the fixed-point variable are "scaled" by the factor 2^{-q} for binary data or 10^{-q} for decimal data, where q is the specified scale factor.

If no scale factor is specified with fixed-point data, the default is zero.

For fixed-point decimal data, the scale factor must be greater than or equal to zero and less than or equal to the specified precision. For example:

```
DECLARE X FIXED DECIMAL(10,3);
X = 1.234;
```

This declaration indicates that the value of x contains a maximum of 10 decimal digits, but 3 of those are fractional. When a value is assigned to the variable, its internal representation does not include the decimal point;

the above value for X is stored as 1234, and the decimal point is inserted when the number is output. The scale factor has the effect of multiplying the internal representation of the decimal number by a factor of 10^{-q}.

For fixed-point binary data, the scale factor must be within the range -31 through 31 and less than or equal to the specified precision. Positive scale factors for fixed binary numbers function according to the same principles as those for fixed decimal. That is, a positive scale factor is similar to multiplying the internal representation binary number by a factor of 2^{-q}.

A negative scale factor indicates that the number of fractional bits are shifted in the opposite direction. In effect, this is similar to multiplying the binary number by a factor of 2^{q}. For example:

```
DECLARE (A,B) FIXED BINARY(31,-3),
        (C,D) FIXED BINARY(31,3);
A = 128;      /* output = 128   */
B = 7;        /* output =   0   */
C = 128;      /* output = 128.0 */
D = 7;        /* output =   7.0 */

PUT SKIP LIST (A,B,C,D);
END;
```

Internally, binary numbers undergo an implicit conversion and are represented as powers of 2. For instance, in the above example variable A is first divided by 2^3 because it is declared with a scale factor of -3. The stored number is 16. On output, the number 16 is multiplied by 2^3 and the number is again 128. However, when variable B is first divided by 2^3, the result is zero, which is the value of the stored number. Therefore, on output, zero is multiplied by 2^3 and the output is zero.

Note that integer variables declared with a positive scale factor are output as input, but are followed on the right with a decimal point and a zero.

Even though arithmetic operands can be of different arithmetic types, all operations must actually be performed on objects of the same type. Consequently, the compiler can convert operands to a derived type, as above. Therefore, when you declare a fixed binary number with a scale factor and assign it a decimal value, the results may not be as you expect because the binary scale factor left-shifts the specified number of bits to the right of the decimal point to the left. During conversion to a decimal representation, the difference between the resulting binary number and its decimal representation is not the equivalent of dividing or multiplying the decimal number by 10. Instead, the binary number is first converted to its internal representation and then this representation converted to its decimal representation.

When excess fractional digits are truncated, no condition is signaled. If there is any resulting loss of precision, it may be difficult to detect because truncated fractional digits do not signal a condition.

For example:

```
A: PROCEDURE OPTIONS (MAIN);
   DECLARE A FIXED BIN (31,3),
           B DECIMAL (10,5),
           C DECIMAL (10,5);
A = .3;
B = 34.8;

C = MULTIPLY(A,B,10,5);

PUT SKIP LIST (A,B,C);
END;
```

Before the multiplication is performed, the variables are converted to fixed decimal, so that the operands share a common data type. However, after conversion, variable A is output as 0.2 rather than 0.3. The output from the above program is as follows:

```
0.2     34.80000     8.6875
```

If variable A were declared with the attributes FIXED DECIMAL(10,5), the output would have been as follows:

```
0.3     34.80000     10.44000
```

See also "Precision Attribute."

Scope of Names

The scope of a declaration of a name is that region of the program in which the name has meaning. A name has meaning in the following locations:

- The block in which it is declared
- Any blocks contained within the declaring block, as long as the name is not redeclared in the contained block
- Any procedure contained in the program, if the name is declared outside of a procedure

Two declarations of the same name denote distinct objects unless both specify the EXTERNAL attribute. All EXTERNAL declarations of a particular name denote the same variable or constant, and all must agree as to the properties of the variable or constant. Note that EXTERNAL is supplied by default for declarations of ENTRY and FILE constants. It must be specified explicitly for variables.

Figure S–1 illustrates the scope of internal names.

Figure S–1: Scope of Internal Names

```
                                        Name              Scope
DECLARE Z STATIC FIXED;                 Z                 MAINP, ALPHA, BETA, and CALC

MAINP: PROCEDURE OPTIONS (MAIN);        MAINP             MAINP, ALPHA, BETA, and CALC

DECLARE (X, Y, VALUE) FIXED;            X, Y              MAINP, ALPHA, BETA, and CALC
|                                       VALUE (MAINP)     MAINP, ALPHA, and CALC
|   ALPHA: PROCEDURE;                   ALPHA             MAINP, BETA, and CALC
|   |
|   |   BETA: BEGIN;                    BETA              ALPHA
|   |   DECLARE VALUE FLOAT;            VALUE (BETA)      BETA
|   |   |
|   |   |   GOTO ERROR;
|   |   |
|   |   END BETA;
|   |
|   |   ERROR:                          ERROR             ALPHA, BETA
|   END ALPHA;
|
|   CALC: PROCEDURE;                    CALC              MAINP, ALPHA
|   DECLARE (SUM,TOTAL) FLOAT;          SUM, TOTAL        CALC
|   |
|   END CALC;
END MAINP;
```

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SEARCH Built-In Function
SEARCH Preprocessor Built-In Function

The SEARCH built-in function takes two character-string arguments and attempts to locate the first character in the first string that is also present in the second string. The search for a match is carried out from left to right. If one character is matched, the function returns the position of that character in the first string. This function is case sensitive.

Its format is as follows:

SEARCH(string-1,string-2[,starting-position])

string-1
A character-string expression. One character in the string is to be matched, if possible, in the second string.

string-2
A character-string expression to be compared, character by character, with each character in the first string, in order, until one matching character is found.

starting-position
A positive integer in the range 1 to n+1, where n is the length of the first string. It specifies the leftmost character in the first string from which the search is to begin. If starting-position is specified, any characters to the left of that position in the first string are ignored. (By default, the search begins with the leftmost character in the first string.)

■ Returned Value

The returned value is a positive integer representing the position in string-1 of the first character that is also found in string-2. If no match is found, the returned value is zero.

■ Examples

```
DECLARE STR1 CHARACTER(20) VARYING,
        STR2 CHARACTER(10) INITIAL ('ABCDEFGHIJ'),
        X FIXED DECIMAL(2);
STR1 = 'BARBARA';
X = SEARCH (STR1,STR2);
```

In this example, X is given the value 1 because the first character ('B') in STR1 ('BARBARA') is found in STR2 ('ABCDEFGHIJ').

```
STR1 = '12-GEORGE';
X = SEARCH (STR1,STR2);
```

Here, X is given the value 4. 'G' is in the fourth position in '12-GEORGE' and is the first character in STR1 that is also present in STR2 ('ABCDEFGHIJ').

```
X = SEARCH (STR1,STR2,6);
```

X is given the value 8. The starting-position parameter, 6, causes the search to begin with the sixth character in '12-GEORGE', and thus the first matching character is the second 'G', which is in the eighth position.

```
PUT LIST (SEARCH('ZZZBAD','ABCD'));
```

The function returns the value 4 because the position of 'B' in 'ZZZBAD' is 4, and 'B' is the leftmost matching character. Here, constants are used instead of variables.

```
PUT LIST (SEARCH('ABCD','ZZZBAD'));
```

This statement is the same as the preceding one except that the parameters are reversed. Now the value returned is 1 instead of 4 because 'A', the first character in 'ABCD', is matched. Note that the order in which the parameters are given is crucial. Note also that duplicate characters in the second string never change the result.

```
PUT LIST (SEARCH ('  TEST  123','0123456789'));
```

The function returns the value 9 because '1', which is in the ninth position, is the first character matched in the second string.

SELECT Statement

The SELECT statement tests a series of expressions and performs a specified action depending on the result of the test. The statement has two forms: in the first form, the expressions are tested for truth or falsity; in the second form, the expressions are tested to see whether any or all have the same value as another specified expression (here called the "select-expression"). Any of the expressions can be, but need not be, constants. An optional OTHERWISE clause is available to name an action to be performed if none of the preceding expressions have satisfied the condition specified.

The two forms of the SELECT statement and the OTHERWISE clause are described in more detail below.

The general form of the SELECT statement is as follows:

```
SELECT [(select-expression)];
     [WHEN [ANY|ALL] (expression,...) [action];]...
     [{OTHERWISE|OTHER} [action];]

END;
```

select-expression
An expression that can be evaluated to any type of value.

expression, . . .
One or more expressions to be tested, evaluating to bit-string values, or, if a select-expression is used, with values that will be compared to the select-expression's value.

action
Any statement (including a null statement, another SELECT statement, a DO-group, or a BEGIN-END block) except a DECLARE, END, ENTRY, FORMAT, or PROCEDURE statement.

■ The Two Forms of the SELECT Statement

Depending on whether you use a select-expression or not, SELECT has two different forms, which are explained in detail below.

SELECT Without a Select-Expression

The first form of the SELECT statement omits the select-expression. In this form, the expressions in a WHEN clause are evaluated, and a specified action is performed if the result of any test is true (or, if ALL is specified, the results of all tests are true); an expression is "true" if it evaluates to a bit string containing any bit with the value of '1'B. In the usual case, the test for truth results in a bit string containing one bit: '1'B for true or '0'B for false.

When the keyword ANY (the default) appears in the WHEN clause, then if any one of the expressions evaluates to true the corresponding action is performed. No further expressions in that WHEN clause or in subsequent WHEN clauses are evaluated (and thus the expressions need not have unique values), and no subsequent actions are performed.

The WHEN clauses are checked in the order listed. However, the expressions within one WHEN clause might be evaluated in any order, and not all these expressions are necessarily evaluated.

If the keyword ALL appears in the WHEN clause, the action is performed only if all expressions in that WHEN clause evaluate to true. Once one action is performed, no subsequent WHEN clauses are evaluated and no subsequent actions are performed. If any expression in the WHEN clause does not result in a true value, no further expressions in that clause are evaluated and the action is not performed.

Following is an example of the first form of SELECT:

```
SELECT;
    WHEN ANY (A=10,A=20,A=30) B=B+1;
    WHEN (A=50) B=B+2;
    WHEN (A=60) B=B+3;
    WHEN (A=70) B=B+4;
    WHEN (A=80) B=B+5;
    WHEN (A=90) B=B+6;
    WHEN ALL (A>90,A<500) B=B+10;
    OTHERWISE B=B+C;
END;
```

The SELECT statement defines the action to be taken if the variable A has any of the values specified in the WHEN clauses (or, in the case of the WHEN ALL clause, if A is both greater than 90 and less than 500). If none of the WHEN clauses is true, the action specified in the OTHERWISE clause (B=B+C) is performed.

SELECT With a Select-Expression

The second form of the SELECT statement has a select-expression after the keyword SELECT. This form of the SELECT statement evaluates expressions in the WHEN clauses and then compares their values to the value of the select-expression (instead of testing the expressions for truth or falsity, as in the first form of SELECT). It performs a specified action if any expression has the same value as the select-expression (or, if ALL is used, all expressions have the same value as the select-expression). In this form of the SELECT statement, as in the previous form, the expressions in a WHEN clause might be evaluated in any order, and not all the expressions are necessarily evaluated.

Following is an example of the second form of SELECT:

```
SELECT(A);
    WHEN  (50) C=C+1;
    WHEN ANY (60,61,62,B+C) C=C+2;
    WHEN ALL (70,D) C=C+3;
    OTHERWISE C=C+D;
END;
```

The SELECT statement defines the action to be taken if the select-expression (A in the example) evaluates to any or all of the values of the expressions following a WHEN clause. The first action (the assignment statement C=C+1) will be performed if A has a current value of 50. In that case, none of the subsequent WHEN clauses will be evaluated. The second WHEN clause includes the ANY keyword, and so the second action will be performed if A evaluates to or equals 60 or 61 or 62 or the sum of B and C. If neither the first nor the second action is performed,

the third WHEN clause's expressions are tested. The third WHEN clause includes the ALL keyword, so the third action will be performed only if A equals both 70 and D. If none of the WHEN clauses causes an action to be performed, then the action in the OTHERWISE clause (the assignment statement C=C+D) will be performed.

■ OTHERWISE Clause

If none of the WHEN clauses causes the corresponding action to be performed, the action specified in the optional OTHERWISE clause is performed; but if the OTHERWISE clause is omitted, an ERROR condition is reported. OTHERWISE can be followed by a semicolon (a null statement) to cause execution to continue and avoid an ERROR condition when you do not want to specify an action after OTHERWISE. For example:

```
OTHERWISE;
```

After an action is performed following a WHEN or OTHERWISE clause, control passes to the next executable statement following the END statement that terminates the SELECT statement, unless normal flow is altered within the action.

■ Nested SELECT Statements

Note that the action specified in a WHEN or OTHERWISE clause can be another SELECT statement, resulting in nested SELECT statements, as in the following example:

```
SELECT;
   WHEN (condition A)
        SELECT;
           WHEN (condition A1) statement 1;
           WHEN (condition A2) statement 2;
           END;
   WHEN (condition B)
        SELECT;
           WHEN (condition B1) statement 3;
           WHEN (condition B2) statement 4;
           OTHERWISE statement 5;
           END;
   OTHERWISE statement 6;
END;
```

In this example, statement 1 is executed when both condition A and condition A1 are true. Statement 2 is executed when both condition A and condition A2 are true and A1 is false. If A is true but neither A1 nor A2 is true, an ERROR condition is reported because no OTHERWISE clause exists within this SELECT statement.

If condition A is false, condition B is checked. If B is true but B1 and B2 are both false, statement 5 (in the corresponding OTHERWISE clause) is executed. If conditions A and B are both false, statement 6 (in the outermost OTHERWISE clause) is executed.

If you want to avoid the possibility that execution could be stopped by an ERROR condition, which occurs in this example if condition A is true and A1 and A2 are false, you can put in an OTHERWISE clause with a null statement (a semicolon) as its target, which would cause control to pass to the first executable statement following the end of the outermost SELECT statement.

An END statement must follow each SELECT statement.

SEQUENTIAL Attribute

The SEQUENTIAL file description attribute indicates that records in the file will be accessed in a sequential manner. The format of the SEQUENTIAL attribute is as follows:

```
{ SEQUENTIAL }
{ SEQL       }
```

If you specify SEQUENTIAL, the RECORD attribute is implied.

Specify the SEQUENTIAL attribute in a DECLARE statement for a file constant or in the OPEN statement that accesses the file.

The SEQUENTIAL attribute can be applied to files with sequential, relative, or indexed sequential file organizations.

■ Restrictions

The SEQUENTIAL attribute conflicts with the DIRECT, STREAM, and PRINT attributes.

SET Option

The SET option can be specified in an ALLOCATE or READ statement. In an ALLOCATE statement, it sets a pointer variable to the memory location of storage acquired for a based variable. In a READ statement, it sets a pointer variable to the location of the input buffer.

■ Examples

```
ALLOCATE X SET (P);
READ FILE (STATE) SET (READBUF);
```

See also "ALLOCATE Statement" and "READ Statement."

SIGN Built-In Function
SIGN Preprocessor Built-In Function

The SIGN built-in function returns 1, –1, or 0, indicating whether an arithmetic expression is positive, negative, or zero, respectively. The returned value is a fixed-point binary integer. The format of the function is as follows:

```
SIGN(expression)
```

SIGNAL Statement

The SIGNAL statement causes a specified condition to be signaled. The format of the SIGNAL statement is as follows:

```
SIGNAL condition-name;
```

condition-name
The name of the condition to be signaled. It must be one of the keywords listed below. Each of these conditions is described under its own entry.

ANYCONDITION
AREA
CONDITION (cond-name)
CONVERSION
ENDFILE (file-reference)
ENDPAGE (file-reference)
ERROR
FINISH

FIXEDOVERFLOW
KEY (file-reference)
OVERFLOW
STORAGE
STRINGRANGE
SUBSCRIPTRANGE
UNDEFINEDFILE (file-reference)
UNDERFLOW
VAXCONDITION (expression)
ZERODIVIDE

Most conditions occur as a result of a hardware trap or fault, or as a result of signaling by PL/I run-time procedures. You can use the SIGNAL statement within a program as a general-purpose communication technique. In particular, the CONDITION condition lets you signal unique user-defined condition values.

For details on condition handling, **see** "ON Conditions and ON-Units."

SIN Built-In Function

The SIN built-in function returns a floating-point value that is the sine of an arithmetic expression x, where x is an angle in radians. The sine is computed in floating point. The format of the function is as follows:

```
SIN(x)
```

SIND Built-In Function

The SIND built-in function returns a floating-point value that is the sine of an arithmetic expression x, where x represents an angle in degrees. The sine is computed in floating point. The format of the function is as follows:

```
SIND(x)
```

SINH Built-In Function

The SINH built-in function returns a floating-point value that is the hyperbolic sine of an arithmetic expression x. The hyperbolic sine is computed in floating point. The format of the function is as follows:

```
SINH(x)
```

SIZE Built-In Function

The SIZE built-in function returns a fixed-point binary integer that is the number of bytes allocated to a referenced variable. Its format is as follows:

```
SIZE (reference)
```

reference
The name of a variable known to this block. The reference can be to a scalar variable, an array or structure, or a structure member. The reference cannot be to a constant or expression. Although references to individual array elements are allowed, the returned value in this instance is the size of the entire array, not the element.

■ Returned Value

The returned value is the variable's allocated size in bytes. For bit strings that do not exactly fill an integral number of bytes, the value is rounded up to the next byte.

For varying character-string variables, note that the returned value is two bytes greater than the declared length of the string. These extra two bytes are allocated by PL/I to contain the current length of the string. (If you want the value of the maximum length of a varying character string, use the MAXLENGTH built-in function. If you want the value of the current length of a varying character string, use the LENGTH built-in function.)

■ Examples

The following example illustrates the use of the SIZE built-in function on some scalar variables.

```
DECLARE S FIXED BINARY(31),
        INT FIXED BINARY(15),
        CHAR1 CHARACTER(5),
        CHAR2 CHARACTER(5) VARYING,
        BITSTRING BIT(10),
        P POINTER;

    S = SIZE(INT);          /* S = 2 */
    S = SIZE(CHAR1);        /* S = 5 */
    S = SIZE(CHAR2);        /* S = 7 */
    S = SIZE(BITSTRING);    /* S = 2 */
    S = SIZE(P);            /* S = 4 */
```

Note the difference between the allocated size for the fixed-length and varying character strings. Note also that the returned value for the bit string is rounded up to 2 bytes, the integral number of bytes required to contain 10 bits.

```
DECLARE 1 STRUC,
          2 CHARSTR CHARACTER(5),
          2 BITSTR BIT(10),
        ARRAY(5) FIXED BINARY(31),
        S FIXED BINARY(31);

    S = SIZE(STRUC);        /* S = 7  */
    S = SIZE(CHRSTR);       /* S = 5  */
    S = SIZE(ARRAY);        /* S = 20 */
    S = SIZE(ARRAY(2));     /* S = 20 */
```

In this example, the SIZE built-in function is applied to a structure, to one of its members, to an array, and to an element of the array. Note that a reference to an array element returns the same value as a reference to the entire array.

```
DECLARE 1 TARGET,
          2 A BIT(9),
          2 B BIT(10),
          2 C BIT(1),
        1 ALIGNED_TARGET,
          2 A BIT(9) ALIGNED,
          2 B BIT(10) ALIGNED,
          2 C BIT(1) ALIGNED,
        S FIXED BINARY(31);

    S = SIZE(TARGET);         /* S = 3 */
    S = SIZE(ALIGNED_TARGET); /* S = 5 */
```

This example illustrates the difference in PL/I's storage of unaligned and aligned bit strings. The structure TARGET consists of three bit strings that are unaligned (the default storage mechanism). The three bit strings occupy 20 consecutive bits in memory. Therefore, only three bytes are required to hold the structure. The structure ALIGNED_TARGET consists

of the same three strings, except each is declared with the ALIGNED attribute, forcing the structure to start on a byte boundary. In this structure, A and B each require two bytes while C requires one byte, for a total of five bytes. A similar situation exists with arrays of bit strings.

```
T: PROC OPTIONS(MAIN);

DCL P PTR;
DCL 1 S BASED(P),
    2 I FIXED,
    2 A(10 REFER(I)) FIXED;

ALLOCATE S;
PUT SKIP LIST(SIZE(S));          /* Returns 44 */
I = 5;
PUT SKIP LIST(SIZE(S));          /* Returns 24 */
END;
```

This example shows how the SIZE built-in function works on a structure containing the REFER option. SIZE returns the current size.

```
DECLARE STR CHARACTER(10) VARYING;
    .
    .
    .
    CALL SUB(STR);
    .
    .
    .
SUB: PROCEDURE(X);
DECLARE X CHARACTER(*) VARYING;

    PUT SKIP LIST (SIZE(X));
```

Here, the SIZE built-in function is used to determine the size of a parameter that is passed to a procedure. This PUT statement prints the value 12.

```
    CALL MACRO_ROUTINE(
        ADDR(OUTSTRING),SIZE(OUTSTRING) );
```

Here, the SIZE built-in function is used to supply an argument to a procedure (possibly one written in another language) that requires the size in bytes of a data structure.

SKIP Format Item

The SKIP format item sets a stream file to a new position relative to the current line. It is used with input and output files.

The form of the SKIP format item is as follows:

```
SKIP [(w)]
```

w
An integer, or an expression, giving the number of lines to be skipped; the expression must not convert to a negative integer and must be greater than zero, except for print files. If w is omitted, a value of 1 is assumed.

If w is 1 or is omitted, the file is positioned at the beginning of the next line. If w is greater than 1, w–1 lines are skipped on input, but the ENDFILE condition is signaled if the end of the file is encountered first. On output, w–1 blank lines are inserted. In both cases, the new position is the beginning of (current line)+w.

■ Use with Print Files

If w is zero, the file is repositioned at the beginning of the current line, allowing overprinting of the line. If w is greater than zero, and either the current line exceeds the page size or the page size is greater than or equal to the current line plus w, then w–1 blank lines are inserted. Otherwise, the remainder of the page (the portion between the current line and the page size) is filled with blank lines, and the ENDPAGE condition is signaled.

SKIP Option

The SKIP option is used with the GET and PUT statements to advance the stream file to a new line before beginning a data transfer.

The SKIP option specifies a line number relative to the current line. In some cases, this line number can be zero, which causes a return to the beginning of the current line. With the PUT statement, the option SKIP(0) allows overprinting of a line in a PRINT file.

For further information, **see** "GET Statement," "PUT Statement," and "Stream Input/Output."

SOME Built-In Function

The SOME built-in function allows you to determine whether at least one bit in a bit string is '1'B. In other words, it performs a logical OR operation on the elements of the bit string. The format of an assignment statement using the SOME built-in function is as follows:

```
bit-flag = SOME(bit-string)
```

The function returns the value '1'B if one or more bits in the bit-string argument are '1'B. It returns '0'B if every bit in the argument is '0'B or if the argument is the null bit string.

Space

A space (or blank) character is used to separate elements in a PL/I statement. You must use spaces to separate keywords and identifiers that are not separated by other delimiters. For example:

```
DECLARE A FIXED BINARY;
```

Spaces are required between the keyword DECLARE and the identifier A, between the identifier A and the keyword FIXED, and between the keywords FIXED and BINARY.

You can insert spaces preceding or following any other type of delimiter to improve the readability of the source text. For example:

```
A = B + C;
```

None of the spaces in this statement are required.

You cannot, however, insert spaces within identifiers, between two characters that function as one operator (for example > =), or in constants other than character-string constants.

SPACE_BLOCK Built-In Subroutine

The SPACE_BLOCK built-in subroutine is used to position a block-mode file. See the *VAX PL/I User Manual* for more information.

SQRT Built-In Function

The SQRT built-in function returns a floating-point value that is the square root of an arithmetic expression x. The square root is computed in floating point. After its conversion to floating point, x must be greater than or equal to zero.

The format of the function is as follows:

```
SQRT(x)
```

Statement

A statement is the basic element of a PL/I procedure. Statements perform the following tasks:

- Define and identify the structure of the program and the data that it acts upon
- Request specific action to be performed on data
- Control the flow of execution in a program

All PL/I statements are included in this manual under individual entries. The description of each statement gives its syntax, abbreviation (if any), and options.

Table S–1 and Table S–2 provide summaries of PL/I statements.

■ Statement Formats

The general format of a PL/I statement consists of an optional statement label, the body of the statement, and the required semicolon terminator.

The body of the statement consists of user-specified identifiers, literal constants, or PL/I keywords. Each element must be properly separated, either by special characters that punctuate the statement or by spaces or comments.

■ Statement Labels

A label identifies a statement so that it can be referred to elsewhere in the program, for example, as the target of a GOTO statement. A label precedes a statement; it consists of any valid identifier terminated by a colon. Following are some examples:

```
TARGET: A = A + B;

READ_LOOP: READ FILE (TEXT) INTO (TEMP);
```

A statement cannot have more than one label.

For more information on labels and rules for specifying them, **see** "Label."

■ Simple Statements

A simple statement contains only one action to be performed. There are three types of simple statements:

- Keyword statements
- Assignment statements
- Null statements

Keyword Statements

Keyword statements are identified by the PL/I keyword that requests a specific action. Following are some examples of keyword statements:

```
READ FILE (A) INTO (B);
GOTO LOOP;
DECLARE PRICE PICTURE '$$$99V.99';
```

In these examples, READ, GOTO, and DECLARE are keywords that identify these statements to PL/I.

Assignment Statements

PL/I identifies an assignment statement by syntax: an assignment statement consists of two identifiers separated by an equal sign (=).

```
TOTAL = TOTAL + PRICE;
COUNTER = 0;
```

Null Statements

A null statement consists of only a semicolon; it indicates that PL/I is to perform no operation. For example:

```
;
IF A < B THEN GOTO COMPUTE;
     ELSE;
```

This IF statement illustrates a common use of the null statement: as the target of an ELSE clause.

■ Compound Statements

A compound statement contains more than one PL/I statement within the statement body; it is terminated by the semicolon that terminates the final statement. The PL/I compound statements are IF and ON. For example:

```
IF COMMAND = 'QUIT' THEN LEAVE;
ON ENDFILE (SYS$INPUT) GOTO FINISH;
IF (A + B) < (D + E) THEN C = A*D;
```

■ Preprocessor Statements

VAX PL/I supports an embedded lexical preprocessor, which recognizes a specific set of statements that are executed at compile time. These statements cause the PL/I compiler to include additional text in the source program or to change the values of constant identifiers at compile time.

Preprocessor statements are identified by a leading unquoted percent sign (%) and are terminated by an unquoted semicolon (;), except for %THEN and %IF statements. You can freely intermix preprocessor statements with the rest of the source program statements.

Table S–1 lists the preprocessor statements. For additional information on the VAX PL/I preprocessor, **see** "Preprocessor."

Table S–1: Summary of PL/I Preprocessor Statements

Statement	Use
%Assignment	Evaluates a preprocessor expression and gives its value to a preprocessor identifier
%	Null statement, specifies no preprocessor operation
%ACTIVATE	Makes the value of declared preprocessor variables eligible for replacement

Table S–1 (Cont.): Summary of PL/I Preprocessor Statements

Statement	Use
%DEACTIVATE	Makes the value of declared preprocessor variables ineligible for replacement
%DECLARE	Defines the preprocessor variable names and identifiers to be used in a PL/I program and specifies the data attributes associated with them
%DICTIONARY	Specifies data definitions to be included from the VAX Common Data Dictionary (CDD)
%DO	Denotes the beginning of a group of preprocessor statements to be executed as a unit
%END	Denotes the end of a block or group of statements that started with a %PROCEDURE or a %DO statement
%ERROR	Generates a user-defined diagnostic error message
%FATAL	Generates a user-defined fatal diagnostic message
%GOTO	Transfers control to a labeled preprocessor statement
%IF	Tests a preprocessor expression and establishes action to be performed based on the results
%INCLUDE	Copies the text of an external file into the source file at compile time
%INFORM	Generates a user-defined informational diagnostic message
%[NO]LIST_ALL	Does or does not include CDD records, INCLUDE files, machine code, and source statements in the listing from that point on
%[NO]LIST_DICTIONARY	Does or does not include CDD records in the listing from that point on
%[NO]LIST_INCLUDE	Does or does not include INCLUDE files in the listing from that point on

Table S–1 (Cont.): Summary of PL/I Preprocessor Statements

Statement	Use
%[NO]LIST_MACHINE	Does or does not include machine code in the listing from that point on
%[NO]LIST_SOURCE	Does or does not include source code in the listing from that point on
%PAGE	Provides listing pagination without form feeds in the source text
%PROCEDURE	Begins a preprocessor procedure
%REPLACE	Assigns a constant value to an identifier at compile time
%RETURN	Returns a value from execution of a preprocessor procedure to the point of invocation
%SBTTL	Allows specification of a listing subtitle line
%TITLE	Allows specification of a listing title line
%WARN	Generates a user-defined warning diagnostic message

■ Begin Blocks and DO-Groups

A begin block is a group of statements begun by a BEGIN statement and ended by an END statement:

```
BEGIN; statement ... END;
```

A begin block can generally be used wherever a single statement is valid—for example, as an ON-unit. Begin blocks can also define variables that are local, or internal, to the begin block. **See also** "Begin Block."

A DO-group is a group of statements begun by a DO statement and ended by an END statement. For example:

```
DO WHILE(A<B) statement ... END;
```

DO-groups "conditionalize," or provide control over, the execution of statements in the group (whereas statements in a begin block are always executed when the BEGIN statement is executed).

If the DO statement has a WHILE option (a "DO WHILE" statement), the statements in the group are executed if and only if a specified expression is true. When the closing END statement is reached, the entire group of statements is reiterated if the WHILE expression is still true.

If the DO statement has an UNTIL option (a "DO UNTIL" statement), the statements in the group are repeated if and only if a specified expression is false. When the closing END statement is reached, the entire group of statements is reiterated if the UNTIL expression is still false.

The DO statement can also have TO, BY, and REPEAT options that assign new values to a control variable on successive iterations. These options are used to reiterate the group a given number of times and to assign new values to variables used in the group's statements. For details, **see** "DO Statement" and "DO-Group."

■ Summary of Statements by Function

The PL/I statements can be grouped by function into the following categories.

Data Definition and Assignment Statements

The DECLARE statement defines variable names:

```
DECLARE identifier [attribute ...];
```

The assignment statement gives a value to a variable:

```
reference = expression;
```

Input/Output Statements

These statements identify files and data formats and perform input and output operations:

CLOSE	GET	READ
DELETE	OPEN	REWRITE
FORMAT	PUT	WRITE

Program Structure Statements

These statements define the organization of the program into procedures, blocks, and groups:

BEGIN	ENTRY
DO	PROCEDURE
END	null

Flow Control Statements

These statements change or interrupt the normal sequential flow of execution in a PL/I program:

CALL	ON	SIGNAL
GOTO	RETURN	STOP
IF	REVERT	
LEAVE	SELECT	

Storage Allocation Statements

These statements acquire and control the use of storage in a PL/I program:

ALLOCATE
FREE

Table S–2 gives a summary of the PL/I statements and their uses.

Table S–2: Summary of PL/I Statements

Statement	Use
Assignment	Evaluates an expression and gives its value to an identifier
null	Specifies no operation
ALLOCATE	Allocates storage for a based or controlled variable
BEGIN	Denotes the beginning of a block of statements to be executed as a unit
CALL	Transfers control to a subroutine or external procedure
CLOSE	Terminates association of a file control block with an input or output file
DECLARE	Defines the variable names and identifiers to be used in a PL/I program and specifies the data attributes associated with them
DELETE	Removes an existing record from a file
DO	Denotes the beginning of a group of statements to be executed as a unit
END	Denotes the end of a block or group of statements begun with a BEGIN, DO, or PROCEDURE statement
ENTRY	Specifies an alternative point at which a procedure can be invoked

Table S–2 (Cont.): Summary of PL/I Statements

Statement	Use
FORMAT	Specifies the format of data that is being read or written with GET EDIT and PUT EDIT statements and defines the conversion, if any, to be performed
FREE	Releases storage of a based or controlled variable
GET	Obtains data from an external stream file or from a character-string expression
GOTO	Transfers control to a labeled statement
IF	Tests an expression and establishes actions to be performed based on the result of the test
LEAVE	Transfers control out of a DO-group
ON	Establishes the action to be performed when a specified condition is signaled
OPEN	Establishes the association between a file control block and an external file
PROCEDURE	Specifies the point of invocation for a program, subroutine, or user-defined function
PUT	Transfers data to an external stream file or to a character-string variable
READ	Obtains a record from a file
RETURN	Gives back control to the procedure from which the current procedure was invoked
REVERT	Cancels the effect of the most recently established ON-unit
REWRITE	Replaces a record in an existing file
SELECT	Tests a series of expressions and establishes action to be performed based on the result of the test
SIGNAL	Causes a specific condition to be signaled
STOP	Halts the execution of the current program
WRITE	Copies data from the program to an external record file

STATIC Attribute

The STATIC attribute specifies the way that PL/I is to allocate storage for a variable. Static storage is allocated when an external procedure is loaded into memory and is not released until the procedure terminates.

The STATIC attribute is implied by the EXTERNAL attribute. For more information on STATIC and on other storage-class attributes, **see** "Storage Class."

■ Restrictions

The STATIC attribute directly conflicts with the BASED, CONTROLLED, DEFINED, and parameter attributes. The STATIC attribute cannot be applied to members of structures, parameters, or descriptions in an ENTRY or RETURNS attribute.

STOP Statement

The STOP statement terminates execution of the program. The format of the STOP statement is as follows:

```
STOP;
```

The STOP statement terminates the program regardless of the current block activation. The STOP statement signals the FINISH condition and closes all open files. If the main procedure has the RETURNS attribute, no return value is obtainable.

Storage Class

The storage class to which a variable belongs determines whether PL/I allocates storage for it at compile time or dynamically during the execution of the program. This entry summarizes the characteristics of storage classes of variables in PL/I programs. For more information on the attributes that define the class to which a variable belongs, see the individual entries for the attributes. For more information on how the linker arranges variables in an executable image, **see** the *VAX PL/I User Manual*. For information on specifying extent in declarations of variables of the various storage classes, **see** "Extent."

■ Automatic Storage

The default storage class attribute for PL/I variables is AUTOMATIC. PL/I does not allocate storage for an automatic variable until the block that declares the variable is activated. When the block is deactivated, the storage is released. For example:

```
CALC: BEGIN;
DECLARE TEMP FIXED BINARY (31);
   .
   .
   .
END;
```

Each time the block labeled CALC is activated, storage is allocated for the variable TEMP. When the END statement is executed, the block is deactivated, and all storage for TEMP and all other automatic variables is released. The value of TEMP becomes undefined.

The storage requirements of an automatic variable are evaluated each time the block is activated. Thus, you can specify an extent as follows:

```
DECLARE STRING_LENGTH FIXED;
   .
   .
   .
COPY: BEGIN;
DECLARE TEXT CHARACTER(STRING_LENGTH);
```

When this begin block is activated, the extent of TEXT is evaluated. The variable is allocated storage depending on the value of STRING_LENGTH, which must have a valid value.

■ Static Storage

A static variable is allocated storage when the program is activated, and it exists for the duration of the program. A variable has the static attribute if it is declared with any of the storage class attributes STATIC, GLOBALDEF, or GLOBALREF. (Note that the EXTERNAL scope attribute implies static storage for variables.)

If a block that declares a static variable is entered more than once during the execution of the program, the value of the static variable remains valid. For example:

```
UNIQUE_ID: PROCEDURE RETURNS (FIXED BINARY(31));
DECLARE ID STATIC INTERNAL FIXED INITIAL (0);
        ID = ID + 1; /* Increment ID */
        RETURN (ID);
        END;
```

The function UNIQUE_ID declares the variable ID with the STATIC attribute and specifies an initial value of zero for it. The variable is initialized to this value when the program is activated. The storage for the variable is preserved, and the function returns a different integer value each time it is referenced.

A variable that has the STATIC attribute can also have external scope: its definition and value can be accessed by any other procedure that declares it with the STATIC and EXTERNAL attributes. For more information, **see** "External Variable."

■ Based Variables

The BASED attribute defines a variable whose storage is accessed by means of a pointer. When you declare a based variable, you provide PL/I with a description of the data that will be accessed by the variable. The actual data must be referenced by a pointer that contains the address of the storage location of the data. For example:

```
DECLARE BUFFER CHARACTER(80) BASED (BUF_PTR),
        LINE CHARACTER(80),
        BUF_PTR POINTER;

BUF_PTR = ADDR(LINE);
```

The declaration of the variable BUFFER does not result in the allocation of any storage for the variable. Rather, PL/I associates the declaration of the variable with the pointer variable BUF_PTR. During the execution of the program, the value of the pointer variable is set to the location (address) in storage of the variable LINE. In effect, the description of the variable BUFFER is associated with the actual data value of the variable LINE.

You can associate a based variable with a storage location using the ADDR built-in function, as in the preceding example; with the ALLOCATE statement; with a locator-qualified reference to the based variable; with the SET option of the READ statement; or by explicit allocation within an area. For more information on processing based variables, **see** the entries for those items or the entry "Based Variable."

■ Controlled Variables

The CONTROLLED attribute defines a variable whose storage is allocated and freed dynamically in generations. Declaration of a controlled variable provides PL/I with a description of the data that will be accessed by the variable. Storage for the variable is allocated on a stack with the ALLOCATE statement. Generations of the variable are used by the program on a last-in/first-out basis. Variables are freed from storage with the FREE statement. For example:

```
DECLARE STRING CHARACTER(10) CONTROLLED;

ALLOCATE STRING;
STRING = 'First';

ALLOCATE STRING;
STRING = 'Second';

ALLOCATE STRING;
STRING = 'Third';
   .
   .
   .
DO WHILE (ALLOCATION(STRING) ^=0);
PUT SKIP LIST (STRING);
FREE STRING;
END;
```

In this example the ALLOCATION built-in function is used as a counter for the generations of controlled variables that are released by a DO-loop: the function counts the variables as they are freed from the stack and used by the program. After all controlled variables are freed, control passes out of the DO-loop and to the next statement past the END statement, thus reducing the possibility of errors with controlled variable generations. For more information, see "Controlled Variable."

■ Defined Variables

When you use the DEFINED attribute in the declaration of a variable, PL/I associates the description of the variable in the declaration with the storage allocated for the variable on which the declaration is defined. For example:

```
DECLARE NAMES(10) CHARACTER(5) DEFINED (LIST),
        LIST(10) CHARACTER(5);
```

In this example, the variable NAMES is a defined variable; its data description is mapped to the storage occupied by the variable LIST. Any reference to NAMES or to LIST is resolved to the same location in memory.

With certain defined variables, the POSITION attribute can be used to specify the position in the base variable at which the definition begins. For more information, **see** "Defined Variable."

■ Parameter Storage Class

A parameter variable is a variable that is declared in a procedure and that receives a value when the procedure is invoked. For example:

```
FUNC: PROCEDURE (X);
   DECLARE X FIXED BINARY;
```

In this example, X is implicitly declared a parameter variable because its name appears in the parameter list of the PROCEDURE statement. PL/I does not allocate storage for X, but rather uses storage associated with the actual argument specified when the procedure is invoked.

For more information on parameters, **see** "Parameters and Arguments."

STORAGE Condition Name

The STORAGE condition is raised when an error has been detected during allocation of a controlled variable or a based variable other than to an area. The ONCODE value is the error returned by LIB$GET_VM. The most common cause is the exhaustion of virtual memory; another cause might be an erroneous attempt to allocate a negative amount of storage.

Storage Sharing

Variables that have any of the attributes BASED, DEFINED, UNION, or PARAMETER can share physical storage locations with one or more other variables.

A based variable is not allocated any storage when it is declared. Instead, storage is either located by a locator-qualified reference to the variable or allocated by the ALLOCATE statement. The BASED attribute thus allows you to describe the characteristics of a variable, which can then be located by a reference that qualifies the variable's name with any valid pointer value. Based variables are useful when the program must control the allocation of storage for several variables with identical attributes. The creation and processing of a queued, or linked, list is a common case. For full details on based variables and valid pointer values, **see** "Based Variable."

A defined variable uses the storage of a previously declared variable, which is referenced in the DEFINED attribute. The referenced variable is known as the base of the defined variable. The base can be a character- or bit-string variable, a technique called string overlay defining. When the base is a string variable, the POSITION attribute can also be specified for the defined variable, giving the position within the base variable's storage at which the overlay defining begins. Defined variables are useful when the program must refer to the same storage by different names. For full details, **see** "Defined Variable."

Unions provide capabilities similar to those of defined variables, but the rules governing unions are less restrictive. A union is a variation of a structure in which all immediate members occupy the same storage.

The UNION attribute, which is used only in conjunction with a level number in a structure declaration, signifies that all immediate members of the major or minor designated structure occupy the same storage. Immediate members are those members having a level number one higher than the major or minor structure with the union attribute. For more details, **see** "Union."

Parameters of a procedure share storage with their associated arguments. The associated argument is either a variable written in the argument list or a dummy variable allocated by the compiler. When the written argument is a variable, the sharing of storage by the parameter and argument allows a procedure to "return" values to the invoking procedure by changing the value of the parameter. For instance, a function can return values in this manner, in addition to returning the value specified in its RETURN statement. For details, **see** "Parameters and Arguments" and "Procedure."

STREAM Attribute

The STREAM file description attribute indicates that the file consists of ASCII characters and that it will be processed using GET and PUT statements.

The STREAM attribute is implied by the PRINT attribute. It is also supplied by default for a file that is implicitly opened with a GET or PUT statement.

Specify the STREAM attribute in a DECLARE statement for a file identifier or in the OPEN statement that opens the file.

■ Restrictions

The STREAM attribute directly conflicts with the RECORD, KEYED, DIRECT, SEQUENTIAL, and UPDATE attributes.

Stream Input/Output

Stream I/O is one of the two general kinds of I/O performed by PL/I (**see also** "Record Input/Output.") Stream input and output are performed by the statements GET and PUT, respectively. Both statements can perform either list-directed or edit-directed operations.

In stream I/O, more than one record or line can be processed by a single statement, and, conversely, multiple statements can process a single line or record. In contrast, record I/O only processes one record of a file in each READ or WRITE statement.

Successive GET statements acquire their input from the same line or record until all the characters in the line have been read, unless the program explicitly skips to the next line. When necessary, a single GET statement will read multiple lines to satisfy its input-target list. A single input data item cannot cross a line unless it is a character string enclosed in apostrophes or unless the ENVIRONMENT option IGNORE_LINE_MARKS is in effect for the input file. This option produces stream input operations that match exactly with standard PL/I. However, the option is usually not necessary; most programs produce the expected results without it. (For more information on ENVIRONMENT, **see** the *VAX PL/I User Manual.*)

Successive PUT statements write their output to the same line or record until the line size is reached or until the program explicitly skips to a new line. A single PUT statement will write as many records as necessary to satisfy its output-source list. Any single data item that will not fit on the current line is split across lines.

This entry describes the following aspects of stream I/O:

- "Input by the GET Statement" describes the execution of GET statements (**see also** "GET Statement" and "Terminal Input/Output").
- "Output by the PUT Statement" describes the execution of PUT statements (**see also** "PUT Statement," "Print File," and "Terminal Input/Output").
- "Processing and Positioning of Stream Files" describes the characteristics and use of stream files with the GET and PUT statements.

- "Processing and Positioning of Character Strings" describes the characteristics and use of character-string expressions with GET STRING and PUT STRING statements.
- "Examples" gives general examples that use stream I/O statements (**see also** "GET Statement," "PUT Statement," "Terminal Input/Output," and the entries for most format items).

■ Input by the GET Statement

When a GET statement is executed, the first action is to evaluate the FILE option, if there is one. For example:

```
GET FILE(INFILE) LIST(A);
```

PL/I looks for an existing file referenced by INFILE. Then the following actions are taken:

- If INFILE is a reference to an existing file, and the file is not open, the file is opened implicitly with the attributes STREAM and INPUT. Note that if INFILE is declared as a STREAM INPUT file but was not opened explicitly with the TITLE option, then INFILE is assumed to be a logical name defined by the user or, if no logical name was defined, an existing file named INFILE.DAT.
- If INFILE is not associated with a file, or if the associated file does not exist, or if for any reason the associated file cannot be opened, the UNDEFINEDFILE condition is signaled.

If the statement has a STRING option instead of a FILE option, the reference in the STRING option is evaluated.

If the statement has neither a FILE option nor a STRING option, it is taken to refer to the default file constant SYSIN. SYSIN is declared by default with the STREAM INPUT attributes, and it is normally used for input from a terminal. **See also** "Terminal Input/Output."

If the input stream is a file, the next action is to execute the SKIP option, if there is one. For details, **see** "Processing and Positioning of Stream Files" below, or the entry "GET Statement." The SKIP option cannot be used with the STRING option. Note that a GET statement can perform a SKIP operation even if it performs no data input. For example:

```
GET FILE(INFILE) SKIP(2);
```

This statement repositions the file referenced by INFILE to the second line following the current line in the file.

A GET statement that has the EDIT or LIST option performs input from the stream to a list of input targets, which must be variables of computational data types. If the input target is an aggregate variable, then input is assigned to each element of the aggregate; input values are assigned to array elements in row-major order and to structure members in the order of their declaration. An input target can also contain a DO construct that further controls the assignment; for details, **see** "GET Statement." Because a stream consists only of ASCII characters, and the input targets are not necessarily character-string variables, an input field must be selected from the input stream for each target and must be converted, if necessary, to the type of the target.

In edit-directed (GET EDIT) statements, the selection and assignment of the input field are controlled by a format item that corresponds to the input target. In the default case, which applies to terminal input and to input from most stream files, a data format item assumes that the end of the input field has occurred if it encounters the end of a record in an input file or the end of a line when the input is from a terminal.

For example, a common technique for reading lines of varying length from a terminal is to deliberately use a format item that specifies a field wider than the column width of the terminal. An example is shown in the entry "X Format Item." If a carriage return is typed in response to an input request for GET EDIT, or if the end of a record is immediately encountered, the requested field width is filled with spaces and assigned to the input target under the control of the corresponding format item. (Note that all spaces will cause an error for B format items.) However, if the input stream is a character-string expression (GET STRING), the ERROR condition is signaled if the format item causes the end of the input string to be reached in the middle of an input field. If the input stream is a file declared or opened with ENVIRONMENT(IGNORE_LINE_MARKS), the search for characters to complete the input field continues at the next record.

Details on the matching of format items to input targets are given in "Format-Specification List." The execution of individual format items is described in individual entries—**see**, for example, "F Format Item." IGNORE_LINE_MARKS and other ENVIRONMENT options are described in the *VAX PL/I User Manual.*

In list-directed (GET LIST) statements, an input field is acquired by examining the input stream for the next character that is not a space character. The following actions are taken depending on the character found:

- If the next nonspace character is an apostrophe, the input field is assumed to contain a bit- or character-string constant, in the same format as that used to write a string constant in a program. The constant is acquired and can span the end of a record or line. However, the ERROR condition is signaled if the end of the file is reached before the terminating apostrophe is found; if the input stream is a character-string expression rather than a file, the ERROR condition is signaled if the end of the string is reached. The apostrophes and B suffix are removed from the constant, and any double apostrophe within a character-string constant is changed to a single apostrophe. (If the field contains a bit-string constant in base 4, octal, or hexadecimal radix, its binary equivalent is found.) The resulting character- or bit-string value is then assigned to the corresponding input target. If the input target is not of the same data type, the input value is converted according to the PL/I conversion rules (**see** "Conversion of Data").
- If the next nonspace character is a comma, and the previous operation on the input file was by GET LIST, and the previous input field was terminated by a space, carriage return, or end-of-record, the scan continues. If the next nonspace character is a comma, and the previous nonspace character was also a comma, the corresponding input target is skipped; the input target retains whatever value it had before the GET LIST statement.
- If the input line or record is empty (that is, a carriage return or end-of-record is encountered immediately after the beginning of a line), The null character string ('') is assigned to the input target with appropriate type conversion. However, if the input file was opened with ENVIRONMENT(IGNORE_LINE_MARKS), the carriage return or end-of-record is ignored.
- If the next nonspace character is neither a comma nor an apostrophe, the input field is then assumed to begin with this character and to be terminated by the next space, comma, carriage return or end-of-record [if ENVIRONMENT(IGNORE_LINE_MARKS) was not used], end-of-file (if the input stream is a file), or end-of-string (if the input stream is a character string). All the characters in the field are acquired and assigned, with appropriate type conversion, to the input target.

If the GET LIST statement attempts to read a file after its last input field has been read, or if it attempts to read an empty file, the ENDFILE condition is signaled. If the GET LIST statement attempts to read a character string after its last field has been read, or if it attempts to read a null string, the ERROR condition is signaled.

■ Output by the PUT Statement

When a PUT statement is executed, the first action is to evaluate the FILE or STRING option, if there is one. If the statement has a file option, the referenced file is either opened or created with the attributes STREAM and OUTPUT, if it is not already open. For example:

```
PUT FILE(OUTFILE) LIST(A);
```

If the file referenced in this statement was not previously declared or opened with the TITLE option, the reference is assumed to be a logical name defined by the user or, if no logical name is defined, an existing file named OUTFILE.DAT. If a STRING option is present instead, the referenced character-string variable is assigned the null character string.

If neither the FILE option nor the STRING option is present, the output stream is assumed to be the default file SYSPRINT.

If the output stream is a file, the next action is to execute any of the options PAGE, LINE, and SKIP that occur in the statement, in that order. The output stream must be a file if any of these options are included, and it must be a print file if LINE or PAGE is included. Note that a PUT statement can contain one or more of these options even if it performs no data output. For example:

```
PUT FILE(OUT) PAGE LINE(20);
```

This statement skips to a new page in the file referenced by OUT (which must be a print file), moves to line 20 of the file, and then terminates.

However, if the statement also has a LIST or EDIT option, it then writes out a list of output sources, which must be variables, constants, or other expressions of computational data types. If the output source is a reference to an aggregate variable, all the variable's elements are written out; array elements are written out in row-major order, and structure members are written out in the order of their declaration. (For more information on output sources, **see** "PUT Statement.") Because a stream consists only of ASCII characters, each output source is converted to a character string before being written out, as follows:

- If the PUT statement is list directed, the output source is converted according to the PL/I rules for converting a computational value to a character string (**see** "Conversion of Data").
- If the PUT statement is edit directed, the output source is converted as specified by a corresponding format item. For details, **see** the entries for individual format items or "Format Item."

- If the output stream is a character-string variable or file with the attributes STREAM and OUTPUT (but not PRINT), the statement is list directed, and the output source is of type CHARACTER, the output source value is surrounded by apostrophes, and any apostrophe within the value is replaced by a double apostrophe.
- If the output source is of type BIT, and the statement is list directed, the converted output source is surrounded by apostrophes, and the letter 'B' is appended.

The converted output source is then written to the output stream, as follows:

- If the statement is list directed and the output stream is a file with the attributes STREAM and OUTPUT (but not PRINT), then the converted output source is written beginning at the end of the file and followed by a single space. If the output stream is a print file, the converted output source is written out beginning at the end of the file, after enough spaces have been written out to move to the next tab stop. In either case, if the converted output source does not fit on the remainder of the current line, as much as possible is written on the current line, and the rest is written on the next line. The ENDPAGE condition can be signaled if the output stream is a print file. For more information on print files, **see** "Print File."
- If the statement is edit directed, the exact number of characters specified by the format item is written out, and no space follows. As much output as possible is written on the remainder of the current line, and it is continued, if necessary, on the next line. Any additional positioning, such as on tab stops in a print file, is performed by control format items.
- If the output stream is a character-string variable, the output process is identical to that for a STREAM OUTPUT file except that the first output source written out by a PUT statement is placed at the beginning of the variable's storage, and any previous value in the variable is erased. Note that the X format item, which can be used with PUT STRING, performs positioning by writing out spaces, not by "skipping" characters in the previous value of the variable. Note also that list-directed output to a character variable, followed by list-directed output of the variable itself, can result in a proliferation of apostrophes in the value finally written to a file.

■ Processing and Positioning of Stream Files

A stream file is a file of ASCII text, divided into lines. For every stream file used in a program, PL/I maintains the following information:

- The locations of the beginning and end of the file. On input operations, the ENDFILE condition is signaled on the first attempt to read past the end of the file.
- For output files, the maximum number of ASCII characters in a line, or the line size. The line size is either a default value or the specific value you have established for the file (**see** "LINESIZE Option"). The line size is used to determine when to skip to the next line (for example, **see** "X Format Item"). On input, a single data item cannot cross a line unless it is a character string enclosed in apostrophes or unless the file was opened with ENVIRONMENT (IGNORE_LINE_MARKS). On output, data items are continued on the next line.
- The current position in the file. Essentially, this is the point in the file at which the last input or output operation stopped. It is the exact character position (sometimes in the middle of a line) at which the next output item is written or from which the next input item is read.

Input operations can begin at any position from the current position onward. The default is the current position. To acquire data from a different position, you can do the following:

- Use the SKIP option of the GET statement to advance by a specified number of lines before reading data.
- Use control format items to move to a specified position before reading data. With the GET statement, control format items are restricted to SKIP (the same operation as the SKIP option), COLUMN (advance to a specified character position), and X (advance by a specified number of character positions from the current position). Note that the control format items, unlike the SKIP option, are executed during, not before, the input of data. **See also** "Format Item." The control format items can signal the ENDFILE and ERROR conditions if the end-of-file is encountered.
- Close and then reopen the file, which sets the current position to the first character in the file.

Because stream files are sequential files, output operations always place data at the end of the file. You can do the following additional formatting of output with any stream output file:

- Use the SKIP option of the PUT statement to skip lines following the current position. If the current position is the beginning of a line, the SKIP option inserts null lines in the file between the current position and the position of the next output. The SKIP option can reposition the file even though no data is output.
- Use the control format items to advance to a specified line or character position, or to a new page. The control format items are COLUMN (move to a specified character position), SKIP (the same effect as the SKIP option), and X (skip a specified number of characters following the current position). As with the input case, control format items are executed only during the output of data; if only part of the format list is used, the excess control format items are ignored.

If the output file is a print file (that is, has the attributes STREAM, OUTPUT, and PRINT, or is the default file SYSPRINT), the following additional information is maintained for the file:

- The current page number. The first output to a print file is written to page 1. The current page number is incremented by the PAGE option, the PAGE format item, and, in some circumstances, by the LINE option and LINE format item. You can evaluate the current page number for a specified print file with the PAGENO built-in function. You can also set it to a new value by assigning a value to the PAGENO pseudovariable.
- The page size. This is an integer that specifies the number of lines on a page. The page size is either the default value or the specific number that you have established for the print file (**see** "PAGESIZE Option.") When the last line on a page is filled, the first attempt to write (or position the file) beyond that position signals the ENDPAGE condition. The ENDPAGE condition is signaled only on the first such attempt; if no ON-unit is established for the condition, a PUT PAGE is executed. For example, the ON-unit for the ENDPAGE condition can write a trailer at the bottom of the current page, or a header at the top of the next page, before printing a new page of data.
- The current line number. This is an integer specifying the line currently being used for output, relative to the top of the page. The first line on the page is line 1. The LINENO built-in function can evaluate the current line of a specified print file. The LINE option of the PUT statement, and the LINE format item, can reposition the file to a specified line.

- Position of tab stops. Tab stops always occur at 8-column increments on every line of a print file, beginning with column 1. The TAB format item can reposition a print file to a specified tab stop relative to the current position.

Terminals should always be declared as print files when used for output. **See** "Terminal Input/Output."

■ Processing and Positioning of Character Strings

If the input or output stream is a character string, the processing is similar to the processing of files, but the positioning options are more limited:

- Input can begin either at the beginning of the string or at a specified character position. The ERROR condition is signaled if the end of the string is encountered. Only the X format item is used for positioning.
- The first output by a PUT statement always occurs at the beginning of the string, and subsequent output by the same statement follows the previous output. The ERROR condition is signaled if the maximum length of the string is exceeded. Only the X format item is used for positioning.

On input, the value of the character-string expression specified in the STRING option must include commas or spaces to separate input fields, as with any stream input. For an example, **see** "GET Statement."

■ Examples

```
LOI: PROCEDURE OPTIONS(MAIN);

DECLARE (I,J) FIXED BINARY;

GET LIST(I);
GET LIST(J);

PUT SKIP LIST('I=',I);
PUT LIST('J=',J);

END LOI;
```

The input data for the two GET statements can appear on the same line:

```
3,4 RET
```

Because the first PUT statement contains a SKIP option, the output begins on a new line. The second PUT statement does not contain a SKIP option, so the output appears on the same line as that of the first statement:

```
I=        3 J=     4
```

For another example showing terminal input and output, **see** "Terminal Input/Output."

```
PUTSTR: PROCEDURE OPTIONS(MAIN);

DECLARE SOURCE CHARACTER(80) VARYING;

DECLARE OUTFILP PRINT FILE;

    SOURCE = 'Old string';
    PUT FILE(OUTFILP) LIST(SOURCE);
    PUT FILE(OUTFILP) EDIT(SOURCE) (A);
    PUT STRING(SOURCE) LIST('New string');
    PUT FILE(OUTFILP) LIST(SOURCE);
    PUT FILE(OUTFILP) EDIT(SOURCE) (A);

END PUTSTR;
```

The program PUTSTR writes the following output to the print file OUTFILP.DAT:

```
Old string Old string   'New string'  'New string'
```

The last two strings are surrounded by apostrophes because the apostrophes were added by the PUT STRING statement.

```
PUTSTR: PROCEDURE OPTIONS(MAIN);

DECLARE SOURCE CHARACTER(80) VARYING;

DECLARE OUTFILS STREAM OUTPUT FILE;

    SOURCE = 'Old string';
    PUT FILE(OUTFILS) LIST(SOURCE);
    PUT FILE(OUTFILS) EDIT(SOURCE) (X,A);
    PUT STRING(SOURCE) LIST('New string');
    PUT FILE(OUTFILS) LIST(SOURCE);
    PUT FILE(OUTFILS) EDIT(SOURCE) (X,A);

END PUTSTR;
```

This version of PUTSTR writes the following output to the stream file OUTFILS.DAT:

```
'OldΔstring'ΔΔOldΔstring''NewΔstring''Δ'ΔΔ'NewΔstring'Δ
```

Here, every PUT LIST has added a new pair of apostrophes to the output value. First, the characters "Old string" are assigned to SOURCE. When SOURCE is written out with PUT LIST, the characters are surrounded by apostrophes (because OUTFILS is not a print file) and written out followed by a space:

```
'Old string'Δ
```

The following PUT EDIT statement writes out a space (because of the X format item) followed by the characters in SOURCE:

```
Δ0ld string
```

Then, the PUT STRING statement writes the characters "New string" to SOURCE; here, SOURCE behaves like a stream output file, and the resulting value in SOURCE is as follows:

```
'New string'Δ
```

Now, when SOURCE is written out by another PUT LIST statement, every apostrophe in SOURCE's value is replaced by two apostrophes, and the resulting value is again surrounded by apostrophes and written out followed by a space:

```
'''New string''Δ'Δ
```

When, instead, SOURCE is written out by PUT EDIT, no additional apostrophes are added, and the output is as follows:

```
Δ'New string'Δ
```

The initial space was created by the X format item, and the terminating space was already in the value of SOURCE.

STRING Built-In Function

The STRING built-in function concatenates the elements of an array or structure and returns the result. Elements of a string array are concatenated in row-major order. Members of a structure are concatenated in the order in which they were declared.

The format of the STRING built-in function is as follows:

```
STRING(reference)
```

reference
A reference to a variable that is suitable for bit-string or character-string overlay defining. Briefly, a variable is suitable if it consists entirely of characters or bits, and these characters or bits are packed into adjacent storage locations, without gaps. For a precise definition, **see** "Defined Variable."

■ Returned Value

The string returned is of type CHARACTER or BIT, depending on whether the reference is suitable for character- or bit-string overlay defining. The length of the string is the total number of characters or bits in the base reference.

■ Examples

```
STRING_BIF_EXAMPLE: PROCEDURE;
DECLARE NEW_NAME CHARACTER(40);
DECLARE 1 FULL_NAME,
          2 FIRST_NAME CHARACTER(10),
          2 MIDDLE_INITIAL CHARACTER(3),
          2 LAST_NAME CHARACTER(27);
FIRST_NAME = 'MABEL';
MIDDLE_INITIAL = 'S.';
LAST_NAME = 'MERCER';
NEW_NAME = STRING(FULL_NAME);
      /* NEW_NAME =
   'MABELΔΔΔΔΔΔS.ΔMERCERΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔ'
      where Δ is a space       */
END STRING_BIF_EXAMPLE;
```

String Handling

VAX PL/I provides the following facilities for handling strings. Each is described in its own entry in this manual.

- The concatenation operator (|| or !!), which concatenates two strings
- The bit-string operators AND (&), OR (| or !), and EXCLUSIVE OR (infix ^ or ~), which perform logical operations on two bit-string operands
- The bit-string operator NOT (prefix ^ or ~), which complements the bits in the string
- The built-in functions:
  - BIT, which converts an expression to a bit string
  - BOOL, which specifies a "truth table" to be used in comparing two bit strings and returns the resulting bit string
  - BYTE, which returns the ASCII character corresponding to a given integer code
  - CHARACTER, which converts an expression to a character string
  - COLLATE, which returns a string of the ASCII characters in collating sequence

- COPY, which replicates a bit or character string and concatenates the replications into a single string
- DATE, which returns a character string giving the date
- DECODE, which converts a character string to an integer in a specified radix
- ENCODE, which converts an integer to a character string that represents the integer's value in a specified radix
- EVERY, which returns the result of a logical AND operation on the bits in a bit string ('1'B if all bits are '1'B)
- HIGH, which returns a string of repeated occurrences of the highest character in a collating sequence
- INDEX, which returns the position at which a specified substring is found in a specified bit or character string
- LENGTH, which returns the current length of a bit or character string
- LOW, which returns a string of repeated occurrences of the lowest character in a collating sequence
- MAXLENGTH, which returns the maximum possible length of a varying character string
- RANK, which returns the ASCII code for a given character
- REVERSE, which returns the reverse of a bit string or character string
- SEARCH, which compares two strings and returns the string position of the first string in the first character that appears in both strings
- SOME, which returns the result of a logical OR operation on the bits in a bit string ('1' if one or more of the bits are '1'B)
- STRING, which concatenates an array or structure of strings into a single string
- SUBSTR, which returns a specified portion of a bit or character string
- TIME, which returns a character string giving the current time of day
- TRANSLATE, which replaces occurrences of a specified character with a new character
- TRIM, which returns a string with specified characters removed from the beginning or end

  - UNSPEC, which returns, as a bit string, the internally coded form of a scalar expression
  - VERIFY, which compares two character strings and returns the position of a mismatched character
- Character- and bit-string assignments, such as the following:

```
NAME = 'HAROLD'
STATUS = '0001011'B
```

- Character- and bit-string relational expressions, such as the following:

```
IF 'ARTHUR' < 'HAROLD' THEN...
```

- The GET STRING and PUT STRING statements, which transfer data between character strings and program variables
- The replication factor, which duplicates a string x number of times
- The STRING pseudovariable, which assigns parts of a string to an array or structure
- The SUBSTR pseudovariable, which replaces a specified substring with a specified character-string expression
- The INT pseudovariable, which assigns a signed integer value to specified storage
- The POSINT pseudovariable, which assigns an unsigned integer value to specified storage

STRING Option

The STRING option is used with the GET and PUT statements to perform data transfers from or to a character-string variable in the program instead of to an external file.

The STRING option is used with either the LIST option or the EDIT option, depending on whether type conversions are to be automatic or under program control.

In most respects, stream I/O to a character-string expression is performed as if the string were a file with the attributes STREAM and, as appropriate, INPUT or OUTPUT.

The GET STRING statement acquires a string from a character-string variable and assigns it to one or more input targets. If more than one input target is listed, the characters in the string should include any punctuation (comma or space separators or apostrophes) that would be required if the character string were in an external file.

The PUT STRING statement evaluates a list of output sources (expressions), converts the results to characters if necessary, and assigns the concatenated results to a character-string variable declared in the program. The concatenated results include any punctuation (space separators or apostrophes) that would result if the character string were being sent to a STREAM OUTPUT file. For example, apostrophes are added to character-string output, and every output value is followed by a space.

For further details, **see** "GET Statement" and "PUT Statement."

STRING Pseudovariable

The STRING pseudovariable interprets a suitable reference as a reference to a fixed-length string. By using it, you can modify an entire aggregate with a single string assignment or assign the aggregate to a pictured variable as if it were a character-string variable. The format of the pseudovariable (in an assignment statement) is as follows:

```
STRING(reference) = expression;
```

reference
A reference to a variable that is suitable for character-string (or bit-string) overlay defining. The length of the pseudovariable is equal to the total number of characters (or bits) in the scalar or aggregate denoted by the reference. This length must be less than or equal to the maximum length for character-string (or bit-string) data.

Assignment to the STRING pseudovariable modifies the entire storage denoted by the reference.

■ Examples

```
STRING_PSD_EXAMPLE: PROCEDURE;
DECLARE 1 NAME,
          2 FIRST CHARACTER(10),
          2 MIDDLE_INITIAL CHARACTER(3)
          2 LAST CHARACTER(10);
STRING(NAME)='FRANKLIN D. ROOSEVELT';
      /* NAME.FIRST - 'FRANKLIN D';
         NAME.MIDDLE_INITIAL = '. R';
         NAME.LAST = 'OOSEVELT '; */
```

```
END STRING_PSD_EXAMPLE;
   .
   .
   .
DECLARE 1 FLAGS,
         2 (A,B,C) BIT(1);
STRING(FLAGS) = '0'B; /* sets all three flags false */
   .
   .
   .
DECLARE P PICTURE /Z.ZZZV,ZZDB';
GET EDIT (STRING(P)) (A(10));
      /* assigns 10 characters from SYSIN to P,
      without conversion */
```

STRINGRANGE Condition Name

The STRINGRANGE condition is raised when a substring reference is beyond the length of the string. The error is detected either by compiled code or by a run-time library routine.

STRINGRANGE can be abbreviated STRG.

Any one of several subconditions can cause the STRINGRANGE condition to be raised. You can use the ONCODE built-in function to determine which one. Following are the possible values of the ONCODE built-in function for the STRINGRANGE condition:

ONCODE value	Raised by
PLI$_STRRANGE	SIGNAL STRINGRANGE
PLI$_SUBSTR2	Out-of-range SUBSTR 2nd argument
PLI$_SUBSTR3	Out-of-range SUBSTR 3rd argument
PLI$_BIFSTAPOS	Out-of-range starting position for an INDEX, SEARCH, or VERIFY built-in function

Note that STRINGRANGE is always enabled in RTL code (which is currently used for more complex cases of INDEX, SEARCH, and VERIFY), but in-line checking is only performed if /CHECK=BOUNDS is used to compile the code in which the condition would be raised.

An example of the use of the STRINGRANGE condition and the ONCODE built-in function follows.

```
%INCLUDE $PLIDEF;
ON STRINGRANGE BEGIN;
            /*
             * The THEN clause below will be executed for all
             * SUBSTR starting-position range errors.  All other
             * STRINGRANGE errors will be resignaled.  Note that
             * SUBSTR is processed in-line, so the code must be
             * compiled with /CHECK=BOUNDS for this ON-unit
             * be effective.
             */
            IF ONCODE() = PLI$_SUBSTR2
            THEN
                ...
            ELSE
                CALL RESIGNAL();
            END;
```

Structure

A structure is a data aggregate consisting of one or more members. The members can be scalar data items, arrays of scalar data items, structures, or arrays of structures; different members can have different data types.

A structure declaration defines a structure variable by means of level numbers. For example:

```
DECLARE 1 TRANSACTION,
          2 PART_NUMBER,
            3 FACTORY CHARACTER (3),
            3 ITEM CHARACTER (5);
```

The level number 1 indicates that TRANSACTION is a structure variable. TRANSACTION is the name of the entire, or "major," structure. The higher numbers 2 and 3 indicate that the associated identifiers are the names of members of the structure TRANSACTION or its "minor" structure, PART_NUMBER.

The following sections define the rules for specifying level numbers and attributes for members in a structure.

■ Level Numbers for Structures

You must precede each variable in the structure declaration with a level number indicating the position of the variable in the structure. The following rules apply:

- The level number of the major structure must be 1.
- Level numbers must be specified with decimal integer constants.

- A level number must be separated from its associated variable name by at least one space or tab character.
- Level numbers after level 1 can be any integer values, as long as each level number is equal to or greater than the level number of the preceding level. (There can be only one level 1.)
- Each identifier in the structure must be separated from the declaration of the previous identifier by a comma.
- Substructures at the same logical level of nesting do not have to have the same level number.
- The deepest possible logical level is 15.
- The largest possible level number constant is 32767.
- A substructure at level n contains all following items declared with level numbers greater than n, up to but not including the next item declared with a level number less than or equal to n.

■ Attributes for Structure Variables

Within a structure, only members at the lowest level of each substructure can be declared with data type attributes. Additional rules for specifying attributes for the various components of a structure are listed below.

- Only the following attributes are valid for the major structure name:

AUTOMATIC	GLOBALREF
BASED	INTERNAL
CONTROLLED	READONLY
DEFINED	STATIC
EXTERNAL	STRUCTURE
GLOBALDEF	UNION

- The major structure, or a minor structure, or any member of the structure can be dimensioned: that is, there can be arrays of structures and structures whose members are arrays. **See** "Arrays of Structures."
- Member names cannot have any of the following attributes:

AUTOMATIC	GLOBALREF
BASED	READONLY
CONTROLLED	STATIC
DEFINED	VALUE
EXTERNAL	UNION
GLOBALDEF	

- If a structure has the STATIC attribute, the extents of all members (that is, lengths for character- and bit-string variables, dimensions for array variables, and area extents) must be specified with optionally signed decimal integer constants.

■ Structure-Qualified References

To refer to a structure in a program, you use the major structure name, minor structure names, and individual member names. Member names need not be unique even within the same structure. To refer to names of members or minor structures, you must ensure only that the reference uniquely identifies the minor structure name or member. You can qualify the variable name by preceding it with the names of higher-level variables in the structure; names in this format, called a qualified reference, must be separated by periods (.).

The following sample structure definition illustrates the rules for identifying names of variables within structures:

```
DECLARE 1 STATE,
          2 NAME CHARACTER (20),
          2 POPULATION FIXED (10),
          2 CAPITAL,
            3 NAME CHARACTER (30),
            3 POPULATION FIXED (10,0),
          2 SYMBOLS,
            3 FLOWER CHARACTER (20),
            3 BIRD CHARACTER (20);
```

The rules for selecting and specifying variable names for structures are as follows:

- The name of the major structure is subject to the rules for the scope of variables in a program.

- The name of any minor structure or member in a structure can be qualified by the names of higher-level members in the structure. You must specify the variable names from left to right in order of increasing level numbers, separated by periods. The members of the sample structure, completely qualified, are as follows:

  STATE.NAME
  STATE.POPULATION
  STATE.CAPITAL.NAME
  STATE.CAPITAL.POPULATION
  STATE.SYMBOLS.FLOWER
  STATE.SYMBOLS.BIRD

- Names of minor structures or members within structures do not have to be qualified if they are unique within the scope of the name. The following names in the sample structure can be referred to without qualification (as long as there are no other variables with these names):

  CAPITAL
  SYMBOLS
  FLOWER
  BIRD

- You can omit intermediate qualification names if the reference remains unambiguous. The following references to members in the sample structure are valid:

  STATE.FLOWER
  STATE.BIRD

If a name is ambiguous, the compiler cannot resolve the reference and issues a message. In the sample structure definition above, the names POPULATION and NAME are ambiguous.

■ Using the LIKE Attribute

You can use the LIKE attribute to copy the declaration of a major or minor structure to another structure variable. The LIKE attribute copies the logical structuring and member declarations from the major or minor structure to the target variable, but does not copy any storage class attributes or dimensioning (except for dimensioning that is applied to members; and it also copies the UNION attribute).

The format for using the LIKE attribute in declarations is as follows:

```
level-number identifier [attributes] LIKE reference
```

The identifier names the variable to which the declarations in the reference are copied. The reference is the name of a major or minor structure known to this block. Note that the identifier must be preceded by a level number. Any attributes which are used with a structure variable at that level can be used with the identifier; for example, a major structure can specify a storage class and dimensions, and a minor structure can specify dimensions.

The following example illustrates the LIKE attribute:

```
DECLARE 1 RES_DATA BASED (RPTR),
          2 DATE CHAR(8),
          2 HOTEL_CODE CHAR(3),
          2 PARTY_NAME,
            3 LAST CHAR(20),
            3 FIRST CHAR(10),
          2 STAY FIXED BIN(7),
        1 NEW_RESER LIKE RES_DATA;
            .
            .
            .
    GET LIST (NEW_RESER.DATE,NEW_RESER.HOTEL_CODE);
            .
            .
            .
    RES_DATA = NEW_RESER;
```

In this example, the declaration of NEW_RESER includes the LIKE attribute to create a set of member declarations that duplicate those in RES_DATA. The declaration of NEW_RESER is equivalent to the following:

```
DECLARE 1 NEW_RESER,
          2 DATE CHAR(8),
          2 HOTEL_CODE CHAR(3),
          2 PARTY_NAME,
            3 LAST CHAR(20),
            3 FIRST CHAR(10),
          2 STAY FIXED BIN(7);
```

After the various members of NEW_RESER are assigned data and that data is validated, the entire contents of NEW_RESER are assigned to RES_DATA. This assignment is possible because the two structures are identical, which is a result of using the LIKE attribute.

You can use the LIKE attribute to copy a minor structure to a major structure and vice versa; neither the level numbers nor the logical levels must match. For example:

```
DECLARE 1 SPOUSE_NAME LIKE PARTY_NAME;
```

Given the declarations in the preceding example, this declaration is equivalent to the following:

```
DECLARE 1 SPOUSE_NAME,
          2 LAST CHAR(20),
          2 FIRST CHAR(10);
```

You can also apply dimensions or, for a major structure, storage class attributes to a structure variable declared with the LIKE attribute:

```
DECLARE 1 KID_NAMES (10) LIKE PARTY_NAME;
```

or

```
DECLARE 1 DAILY_DATA,
          2 DATE CHAR(8),
          2 TODAYS_RESERS (NO_OF_RES) LIKE RES_DATA;
             .
             .
             .
```

■ Initializing Structures

You can initialize a structure by giving the INITIAL attribute to its members. Not all members need be initialized. For example:

```
DECLARE 1 COUNTS,
          2 FIRST FIXED BIN(15) INITIAL(0),
          2 SECOND FIXED BIN(15),
          2 THIRD (5) FIXED BIN(15) INITIAL (5(1));
```

The first and third members of the structure COUNTS are initialized.

The INITIAL attribute cannot be applied, however, to a major or a minor structure name.

■ Using Structure Variables in Expressions

You can specify the name of a major or minor structure in an assignment statement only if the source expression and the target variable are identical in size and structure, and all corresponding members have the same data types.

■ Passing Structure Variables as Arguments

A structure variable can be passed as an argument to another procedure. The relative structuring of the structure variable specified as the argument and the corresponding parameter must be the same. The level numbers do not have to be identical. The following example shows the parameter descriptor for a structure variable:

```
DECLARE SEND_REC ENTRY (1,
                        2 FIXED BINARY(31),
                        2 CHARACTER(40),
                        2 PICTURE '999V99');
```

The written argument in the invocation of the external procedure SEND_REC must have the same structure, and its corresponding members must have the same data types.

When structures are passed as arguments, they must match the corresponding parameters. They cannot be passed by dummy argument. For information on arguments and argument passing, **see** "Parameters and Arguments."

STRUCTURE Attribute

The STRUCTURE attribute can optionally be specified in the declaration of a structure. **See** "Structure" and "MEMBER Attribute" for information on structures and members.

Subroutine

A subroutine is a procedure that is invoked by another procedure by means of a CALL statement. The subroutine can be internal or external to the procedure that calls it. **See** "Procedure."

SUBSCRIPTRANGE Condition Name

The SUBSCRIPTRANGE condition is raised in response to out-of-bounds subscripts in references to arrays. The value returned by the ONCODE built-in function for the SUBSCRIPTRANGE condition is PLI$_SUBRANGE or PLI$_SUBRANGEn, where n is the number of the subscript, in the range 1 through 8.

SUBSTR Built-In Function
SUBSTR Preprocessor Built-In Function

The SUBSTR built-in function returns a specified substring from a string. Its format is as follows:

```
SUBSTR(string,position[,length])
```

string
A bit- or character-string expression.

position
An integer expression that indicates the position of the first bit or character in the substring. The position must be greater than or equal to 1 and less than or equal to LENGTH(string) + 1.

length
An integer expression that indicates the length of the substring to be extracted. If not specified, length is as follows:

$$LENGTH(string) - position + 1$$

In other words, if length is not specified, the substring is extracted beginning at the indicated position and ending at the end of the string.

The length must satisfy the following condition:

$$0 <= length <= LENGTH(string) - position + 1$$

If it does not, and the module was compiled with /CHECK=BOUNDS, the STRINGRANGE condition is raised.

■ Returned Value

The returned substring is of type BIT(length) or CHARACTER(length), depending on the type of the string argument. If the length argument is zero, the result is a null string.

■ Examples

```
DECLARE (NAME,LAST_NAME) CHARACTER(20),
      START FIXED BINARY(31);

NAME = 'ISAK DINESEN';
      /* NAME = 'ISAKΔDINESENΔΔΔΔΔΔΔΔ' */

START = INDEX(NAME,' ')+1;
      /* START = 6 */

LAST_NAME = SUBSTR(NAME,START);
      /* default length = LENGTH(NAME)-START+1 =15 */
      /* LAST_NAME = 'DINESENΔΔΔΔΔΔΔΔΔΔΔΔΔΔΔ' */
```

SUBSTR Pseudovariable

The SUBSTR pseudovariable refers to a substring of a specified string variable reference. (**See also** "Pseudovariable" for general rules.) Assignment to the pseudovariable modifies only the substring. The format of the pseudovariable (in an assignment statement) is as follows:

SUBSTR(reference,position[,length]) = expression;

reference

A reference to a bit- or character-string variable. If the reference is to a varying-length character string, the substring defined by the position and length arguments must be within the current value of the string. Assignment to the SUBSTR pseudovariable does not change the length of a varying string.

position

An integer expression indicating the position of the first bit or character in the substring. The position must be greater than or equal to 1 and less than or equal to LENGTH(reference)+1.

length

An integer expression that indicates the length of the substring. If not specified, length is as follows:

$$length = LENGTH(reference) - position + 1$$

In other words, if length is not specified, the substring begins at the indicated position and ends at the end of the string. The length must satisfy the following condition:

$$0 <= length <= LENGTH(reference) - position + 1$$

Note that the following two lines are equivalent:

```
SUBSTR(r,p,1) = v;

r = SUBSTR(r,1,p-1)||v||SUBSTR(r,p+1);
```

■ Examples

```
DECLARE (NAME,NEW_NAME) CHARACTER(20) VARYING;

NAME = 'ISAK DINESEN';
NEW_NAME = NAME;
SUBSTR(NEW_NAME,4) = 'AC NEWTON';
/* NEW_NAME = 'ISAAC#NEWTON' */
```

SUBTRACT Built-In Function

The SUBTRACT built-in function returns the difference of two arithmetic expressions x and y, with a specified precision p and an optionally specified scale factor q. The format of the function is as follows:

```
SUBTRACT(x,y,p[,q])
```

p
An unsigned integer constant greater than zero and less than or equal to the maximum precision of the result type (31 for fixed-point data, 34 for floating-point decimal data, and 113 for floating-point binary data).

q
An integer constant less than or equal to the specified precision. The scale factor can be optionally signed when used in fixed-point binary subtraction. The scale factor for fixed-point binary must be in the range –31 through p. The scale factor for fixed-point decimal data must be in the range 0 through p. If you omit q, the default value is zero. Do not use a scale factor for floating-point arithmetic.

Expressions x and y are converted to their derived type before the subtraction is performed; **see** "Expression."

For example:

```
SUBTRACTBIF: PROCEDURE OPTIONS (MAIN);

DECLARE X FIXED DECIMAL (8,3),
        Y FIXED DECIMAL (8,3),
        Z FIXED DECIMAL (9,3);

X=9500.374;
Y=2278.897;
Z = SUBTRACT (X,Y,9,3);

PUT SKIP LIST ('DIFFERENCE =',Z);

END;
```

This program returns

```
DIFFERENCE = 7221.477
```

Subtraction

The minus sign character (-) indicates a subtraction operation in an expression; the result is the difference between the operands. Both operands must be arithmetic or picture data.

■ Conversion of Operands

If both operands have the same base, precision, and scale factor, so has the result of the operation. The PL/I compiler converts operands of different data types as follows:

- If one operand has the FLOAT attribute and the other has the FIXED attribute, the fixed-point operand is converted to floating point before the operation is performed.
- If one operand is DECIMAL and the other is BINARY, the decimal operand is converted to binary.

The precision of the values resulting from conversion of operands is described under "Expression."

■ Precision of the Result

Floating-Point Operands

The result has the maximum of the converted precisions of the operands.

Fixed-Point Operands

If (p,q) and (r,s) represent the converted precisions and scale factors of the two operands, the resulting precision and scale factor are as follows:

$$precision = min(31, max(p - q, r - s) + max(q, s) + 1)$$

and

$$scalefactor = max(q, s)$$

SUM Built-In Function

The SUM built-in function takes an array as an argument and returns the arithmetic sum of all the elements in the array. The array must have the FIXED or the FLOAT attribute. The format of an assignment statement containing the SUM built-in function is as follows:

```
numeric-variable = SUM(array-variable);
```

The array can be a part of a structure, but cannot be a union. If the array has the attributes FIXED(p,q), the result will have the attributes FIXED(31,q). If the array has the attributes FLOAT(p), the result will also have the attributes FLOAT(p).

The result will have the same base attribute as the array, either DECIMAL or BINARY.

SYSIN Default File

SYSIN is the default input file for GET statements. SYSIN is normally associated with a user's default input device (SYS$INPUT). For example:

```
GET LIST (A,B,C);
```

This GET statement does not include the FILE option. Thus, when the program containing this line is executed, this statement reads data from the file SYSIN.

For more information, **see** "GET Statement" and "Terminal Input/Output." For information on the relationship between the PL/I file SYSIN and the default input device, **see** the *VAX PL/I User Manual.*

SYSPRINT Default File

SYSPRINT is the default output file for PUT statements. Unless it is explicitly declared with other attributes, SYSPRINT has the attributes STREAM OUTPUT PRINT. (If you declare an external file constant named SYSPRINT with the STREAM and OUTPUT attributes, PRINT is added by the compiler.) SYSPRINT is normally associated with a user's default output device (SYS$OUTPUT). For example:

```
PUT LIST (A,B,C);
```

This PUT statement does not include the FILE option. Thus, when the program containing this line is executed, this statement writes data to the file SYSPRINT.

For more information, **see** "PUT Statement" and "Terminal Input/Output." For information on the relationship between the PL/I file SYSPRINT and the default output device, **see** the *VAX PL/I User Manual.*

T

TAB Format Item

The TAB format item sets a print file to a specified tab stop. It is used only for output to print files. Within a line, tab stops always occur every eight columns, starting at column 1. The form of the TAB format item is as follows:

```
TAB [(w)]
```

w
An integer, or an expression, that identifies the wth tab stop from the current position; w must not be negative. If w equals zero, no operation is performed. If w is omitted, a value of 1 is assumed.

When the TAB format item is executed, the current column (cc) is determined. If the current position is the beginning of a line, page, or file, then cc is zero. Otherwise, cc is the column in the current line at which the next output character would appear. For example, if seven characters have already been written on a line, then the cc is column 8; this is where the next output would occur. The file is then repositioned in one of the following ways:

- If there are at least w tab stops between (cc+1) and the end of the line, then the file is moved to the wth tab stop from the current column, and the intervening positions are filled with spaces. The end of the line is at one column after the current line size, which is either the default value or the specific value that you have established for the file (**see** "LINESIZE Option").
- If there are fewer than w tab stops on the remainder of the current line, the file is skipped to the beginning of the next line and positioned at the first tab stop (column 1). If, before the skip operation, the current line was the last line on the page, the ENDPAGE condition is signaled, and the current line becomes (page size)+1. The page size is either the default value or the specific value that you have established for the file (**see** "PAGESIZE Option").

■ Examples

```
TAB: PROCEDURE OPTIONS(MAIN);

DECLARE OUT STREAM OUTPUT PRINT FILE;

OPEN FILE(OUT) LINESIZE(60);

PUT FILE(OUT) SKIP
              EDIT('12345678901234567890123456789O') (A);
PUT FILE(OUT) SKIP EDIT('COL1','?') (A,TAB(2),A);
PUT FILE(OUT) EDIT('!') (TAB(20),A);
PUT FILE(OUT) SKIP EDIT('*') (TAB(1),A);
PUT FILE(OUT) EDIT('abcdefg') (A); /* cc now = 17 */
PUT FILE(OUT) EDIT('&') (TAB(6),A);

END TAB;
```

The program TAB writes the following output to the print file OUT.DAT:

```
12345678901234567890123456789O
COL1            ?
!
        *abcdefg
&
```

The question mark appears in column 17, which is the second tab stop following the string 'COL1'. The exclamation point appears in column 1 of the next line because there are fewer than 20 tab stops on the remainder of the line. In the third PUT EDIT statement, the SKIP option first resets the current column to zero. When the TAB format item is executed, it must position the file to the first tab stop that is between column 1 (cc+1) and the end of the line; therefore, the file is positioned, and the asterisk appears, in column 9. Similarly, the fourth statement writes out the string 'abcdefg', after which the current column is 17, a tab stop. Because the line size has been established as 60, there are only five tab stops between cc+1 and the end of the line: 25, 33, 41, 49, and 57. Therefore, the format item TAB(6) in the last PUT EDIT statement causes a skip to the next line, and the ampersand appears in column 1.

TAN Built-In Function

The TAN built-in function returns a floating-point value that is the tangent of an arithmetic expression x, where x represents an angle in radians. The tangent is computed in floating point. After its conversion to floating point, x must not be an odd multiple of $\pi/2$.

The format of the function is as follows:

TAN(x)

TAND Built-In Function

The TAND built-in function returns a floating-point value that is the tangent of an arithmetic expression x, where x represents an angle in degrees. The tangent is computed in floating point. After its conversion to floating point, x must not be an odd multiple of 90.

The format of the function is as follows:

```
TAND(x)
```

TANH Built-In Function

The TANH built-in function returns a floating-point value that is the hyperbolic tangent of an arithmetic expression x. The hyperbolic tangent is computed in floating point. The format of the function is as follows:

```
TANH(x)
```

Terminal Input/Output

In most applications, the terminal is treated as a stream file. You can explicitly declare a stream file to be associated with a user's terminal. The stream input and output statements, GET and PUT, use the default PL/I files SYSIN (the terminal) and SYSPRINT, respectively, when no file reference is included in the statement. For general information on stream input and output, **see** "Stream Input/Output," "GET Statement," and "PUT Statement."

In VAX PL/I, SYSIN is associated with the default system input file SYS$INPUT, which in turn is usually assigned to the user's terminal. The PL/I print file SYSPRINT is associated with the default system file SYS$OUTPUT, which, in interactive mode, is also assigned to the user's terminal. For further information, **see** the *VAX PL/I User Manual.*

The discussions and examples in this section use the GET and PUT statements for terminal input and output. The statements use the default files SYSIN and SYSPRINT instead of specific file references.

VAX PL/I also provides statement options that are useful in terminal input and output. For full details on the GET and PUT options, **see** the *VAX PL/I User Manual.*

■ Simple Input from a Terminal

Simple input from a terminal is accomplished with the GET LIST statement, which in its simple form has the following format:

```
GET LIST (input-target,...);
```

Because this statement has no reference to a specific file, the default file SYSIN (the terminal) is assumed. When this GET LIST statement is executed in a program, the program pauses until enough values are typed by the user to satisfy the input-target list.

The user must separate the values with the RETURN key, spaces, or commas. The user must press the RETURN key to send the typed line to the program. VAX PL/I always appends a space to the end of any input line terminated by a RETURN unless the RETURN is inside a quoted string. You can disable the appending of spaces by using the IGNORE_LINE_MARKS ENVIRONMENT option; **see** the *VAX PL/I User Manual.*

In the context of simple terminal input, the input targets are usually simple variable references. For example:

```
GET LIST (SALARY,CONTRIBUTION(42),PAYROLL.DEDUCTION);
```

This statement gets three character strings from the terminal. The strings are converted automatically to the target data types and assigned to the scalar variable SALARY, element 42 of the array CONTRIBUTION, and member DEDUCTION of the structure PAYROLL. There are several sequences with which the user can type the needed values, including the following:

```
15500,500,1200 [RET]

15500 [RET]
500 [RET]
1200 [RET]

15500,500 [RET]
1200 [RET]
```

If you press RETURN in response to an input request from GET LIST, the null character string '' is assigned to the input target. If you press RETURN in response to an input request from GET EDIT, the requested field width is filled with spaces and assigned to the input target under control of the corresponding format item. (Note that an all-space field causes an error for B formats.)

For full details on input targets, **see** "GET LIST Statement."

■ Simple Output to a Terminal

You can send data to a terminal with the PUT LIST statement. A simple form of PUT LIST is as follows:

```
PUT LIST (output-source,...);
```

The output sources in simple cases are expressions, including variable references. The PUT LIST statement converts the results of the expressions to the appropriate character representations and sends the character strings to the terminal. For instance:

```
PUT LIST (A,B,C);
```

This statement converts the values of the variables A, B, and C to character strings and sends the results to the terminal. In this simple case, the displayed strings are separated by tabs.

The file SYSPRINT, used as the default output stream by PUT LIST, is a print file, and the terminal has the characteristics of print files (**see** "Print File"). For example, the ENDPAGE condition is signaled when the terminal's page size is exceeded.

■ Examples

```
SIMPLE_INPUT: PROCEDURE OPTIONS (MAIN);
      /* Simple input from user's terminal */
DECLARE
      BADGE_NUMBER FIXED DECIMAL (5),
      SOCIAL_SECURITY_NUMBER CHARACTER(11);

GET LIST (BADGE_NUMBER,SOCIAL_SECURITY_NUMBER);

PUT LIST (BADGE_NUMBER,SOCIAL_SECURITY_NUMBER);

END SIMPLE_INPUT;
```

VAX PL/I does not display a prompt character on the terminal when a program executes a GET or READ statement. Consequently, it is difficult to tell that a program is trying to read data unless the program executes an output statement containing a prompting message. The program SIMPLE_INPUT would be easier to use if the following statement appeared immediately before GET LIST:

```
PUT SKIP
LIST('Enter badge number, social security number:');
```

The cursor remains on the same line after the prompt is displayed, so the input can be entered on the same line. The completed line might be as follows:

```
Enter badge number, social security number:7,116-40-0482 RET
```

The GET statement also has a PROMPT statement option that displays a prompt on the user's terminal. **See** the *VAX PL/I User Manual* for details.

```
TIN: PROCEDURE OPTIONS(MAIN);

DECLARE STRING CHAR(10) VARYING,
      I FIXED BINARY STATIC INITIAL(0),
      A FLOAT BINARY;
DECLARE EOF BIT STATIC INITIAL('0'B);

ON ENDFILE(SYSIN) EOF = '1'B;

PUT SKIP LIST('Enter string, integer, float>');
GET LIST(STRING,I,A);
DO WHILE(^EOF); /* stop when CTRL/Z is typed */

      PUT SKIP LIST(STRING,I,A);
      PUT SKIP LIST('Enter string, integer, float>');
      GET LIST(STRING,I,A);
END;

END TIN;
```

Here, the user is prompted to enter three values from the default file SYSIN. The three values are immediately written out to the default file SYSPRINT. This sequence continues until the user answers the prompt with a CTRL/Z, which signals the ENDFILE condition for SYSIN; the program then terminates. A sample dialog with the program is as follows:

```
$ R TIN RET

Enter string, integer, float> JONES,27,3.75 RET
JONES                27   3.7500000E+00
Enter string, integer, float> JONES 27 3.75 RET
JONES                27   3.7500000E+00
Enter string, integer, float> JONES RET
27 RET
3.75 RET
JONES                27   3.7500000E+00
Enter string, integer, float> DOOLEY RET
 RET
3E-6 RET
DOOLEY                0   3.0000001E-06
Enter string, integer, float>  CTRL/Z
$
```

Notice that input fields are separated by commas, spaces, or the RETURN key. Notice also that entering a blank line after 'DOOLEY' causes the program to set the value of I to zero.

■ Other Topics

The following topics are of interest in terminal I/O applications:

- For using GET STRING and certain built-in functions for string handling, **see** "GET Statement" and "String Handling."
- For using GET EDIT and PUT EDIT to control the format of input or output data, **see** "GET Statement" and "PUT Statement."
- For using PUT SKIP, PUT LINE, and PUT PAGE to create formatted displays, **see** "PUT Statement."
- For using the OPTIONS keyword with GET and PUT to override default operations, **see** the *VAX PL/I User Manual.*

THEN Keyword

The THEN clause is specified in an IF statement to define the action to be taken if a given expression is true. For example:

```
IF (A < B) THEN BEGIN;
```

The action following the keyword THEN can be null.

TIME Built-In Function
TIME Preprocessor Built-In Function

The TIME built-in function returns an 8-character string representing the current time of day in the following form:

```
hhmmssxx
```

hh
The current hour (00–23)

mm
The minutes (00–59)

ss
The seconds (00–59)

xx
Hundredths of seconds (00–99)

The format of the TIME built-in function is as follows:

```
TIME()
```

■ Returned Value

If TIME is used as a preprocessor built-in function, the time returned is the time when the program was compiled; otherwise the function returns the time at run time.

%TITLE Statement

The %TITLE statement allows specification of an arbitrary compile-time string for the listing title line. If %TITLE is used, the specified title appears to the right of the customary title. (If no TITLE option is specified, PL/I uses the name of the first level-1 procedure in the source program as the title.)

The format of the %TITLE statement is as follows:

```
%TITLE preprocessor-expression
```

preprocessor-expression
A character string with a maximum length of 30 characters. It will be truncated if necessary.

TITLE Option

The TITLE option is specified in an OPEN statement to designate the external file specification of the file to be associated with the PL/I file. The TITLE option is specified only on the OPEN statement for a file. Its format is as follows:

```
TITLE(expression)
```

expression
A character-string expression of up to 128 characters, which represents an external file specification for the file.

The file specification can be any valid VMS file specification, device name, or logical name.

When the name given in the TITLE does not fully specify a VMS file or device, VAX PL/I takes the following actions:

1. Performs logical name translation.
2. Applies default values given in the DEFAULT_FILE_NAME option of the ENVIRONMENT attribute.
3. Applies system defaults.

For complete details on how the file specification is interpreted, **see** the *VAX PL/I User Manual.*

TO Option

The TO option defines an end value for a controlled DO statement specification. For example:

```
DO I = 1 TO 10;
```

The DO-group following this statement is executed until the value of I exceeds 10. **See** "DO Statement."

TRANSLATE Built-In Function
TRANSLATE Preprocessor Built-In Function

Given a character-string argument, the TRANSLATE built-in function replaces occurrences of an old character with a corresponding translation character and returns the resulting string. Its format is as follows:

TRANSLATE(original,translation[,old-chars])

original
A character-string expression in which specific characters are to be translated.

translation
A character-string expression giving replacement characters for corresponding characters in old-chars.

old-chars
A character-string expression indicating which characters in the original are to be replaced. If old-chars is not specified, the default is COLLATE( ).

If the translation is shorter than old-chars, the translation is padded on the right with spaces to the length of old-chars before any translation occurs. If the translation is longer than old-chars, its excess characters (on the right) are ignored.

The following steps are performed for each character (beginning at the left) in the original:

1. Let original(i) be the current character in the original string, and let result(i) be the corresponding character in the resulting string.
2. Search old-chars for the leftmost occurrence of original(i).
3. If old-chars does not contain original(i), then let result(i) equal original(i). Otherwise, let j equal the position of the leftmost occurrence of original(i) in old-chars, and let result(i) equal translation(j).
4. Return to step 1.

■ Returned Value

The string returned is of type CHARACTER(length), where length is the length of the original string. If the original string is a null string, the returned value is a null string.

■ Examples

```
TRANSLATE_XM: PROCEDURE OPTIONS(MAIN);

DECLARE NEWSTRING CHARACTER(80) VARYING;
DECLARE TRANSLATION CHARACTER(128);
DECLARE I FIXED;
DECLARE COLLATE BUILTIN;

              /* translate space to '0': */
NEWSTRING = TRANSLATE('1 2','0',' ');
PUT SKIP LIST(NEWSTRING);
```

```
                /* translate letter 'F' to 'E': */
NEWSTRING = TRANSLATE('BFFLZFBUB','E','F');
PUT SKIP LIST(NEWSTRING);

/* change case of letters in sentence */
TRANSLATION = COLLATE;

DO I=66 TO 91;  /* replace upper with lower */
SUBSTR(TRANSLATION,I,1) = SUBSTR(COLLATE,I+32,1);
END;
DO I=98 TO 123; /* replace lower with upper */
SUBSTR(TRANSLATION,I,1) = SUBSTR(COLLATE,I-32,1);
END;
NEWSTRING =
TRANSLATE('THE QUICK BROWN fox JUMPS OVER THE LAZY dog',TRANSLATION);

PUT SKIP LIST(NEWSTRING);

END TRANSLATE_XM;
```

The first reference translates the string '1 2' to '102'. The second reference translates 'BFFLZFBUB' to 'BEELZEBUB'. The third reference produces the following new sentence:

```
'the quick brown FOX jumps over the lazy DOG'
```

TRIM Built-In Function
TRIM Preprocessor Built-In Function

The TRIM built-in function accepts a character string as an argument and returns a character string that consists of the input string with specified characters removed from the left and right. If you supply only one argument, TRIM removes blanks from the left and right of the argument. If you supply second and third arguments, TRIM removes characters specified by those arguments from the left and right of the string, respectively.

The format of the TRIM built-in function is as follows:

TRIM (input-string,[beginning-chars,end-chars])

input-string

A character-string variable or constant. This argument supplies the string from which characters are to be trimmed.

beginning-chars
A character-string variable or constant. This argument specifies characters to be trimmed from the left of the input string. If a character that is in the first position in the input string is also present anywhere in beginning-chars, that character is removed from the input string. This process is repeated until a character is encountered on the left of the input string that is not present in beginning-chars, or until the characters in the input string are exhausted.

end-chars
A character-string variable or constant. This argument specifies characters to be trimmed from the right of the input string. The process of removing characters from the right is identical to that of removing characters from the left, except that the character in the last position is examined.

The TRIM built-in function accepts either one or three arguments. Any of the arguments can consist of a null string; specifically, if beginning-chars or end-chars is null, no characters are removed from the corresponding end of the input string.

When only one argument is supplied, TRIM removes blanks from both ends of that argument. In other words, the following two expressions are equivalent:

```
TRIM(S)

TRIM(S,' ',' ')
```

■ Returned Value

The returned value is a character string with characters removed from the ends.

■ Examples

The following examples illustrate the use of the TRIM built-in function.

Text	Returned String
TRIM ('ABC')	'ABC'
TRIM(' ABC')	'ABC'
TRIM(' ABC ')	'ABC'
TRIM('ABC ')	'ABC'
TRIM(' ABCDEF','','E')	' ABCDEF'
TRIM(' ABCDEF','','FE')	' ABCD'
TRIM(' ABCDEF ','ABC','EDF')	' ABCDEF '
TRIM('ABCDEF','CADB','FE')	''
TRIM(' ABCDEF ','ABC ',' EDF')	''
TRIM('AAAABCCXCCDDDDEFFFF','AC','DF')	'BCCXCCDDDDE'

TRUNC Built-In Function

The TRUNC built-in function changes all fractional digits in an arithmetic expression x to zeros and returns the resulting integer value. Its format is as follows:

TRUNC(x)

■ Returned Value

If x is a floating-point expression, the returned value is a floating-point value. If x is a fixed-point expression, the returned value is a fixed-point value with the same base as x and with the following attributes:

$$precision = min(31, p - q + 1)$$

$$scalefactor = 0$$

Here, p and q are the precision and scale factor of x.

TRUNCATE Attribute

The TRUNCATE attribute is used in the declaration of a formal parameter to indicate that the actual parameter list can be truncated at the point where this argument should occur.

If you use the TRUNCATE attribute, you must specify every actual parameter that follows the parameter with this attribute in the argument list, unless it also has the TRUNCATE attribute.

For example:

```
DCL E ENTRY (FIXED OPTIONAL,FIXED TRUNCATE,FIXED OPTIONAL);
CALL E(1);
CALL E(1,2,);
CALL E(,2,);
```

The following call, however, would be invalid:

```
CALL E(1,2);
```

This call is invalid because the second parameter has the TRUNCATE attribute, and therefore the third parameter must be specified, at least with a placeholder.

U

UNALIGNED Attribute

The UNALIGNED attribute is used in conjunction with the BIT attribute to specify that a bit-string variable should not be aligned on a byte boundary. Because UNALIGNED is the default for bit strings, it need not be specified.

The UNALIGNED attribute can be used in the declaration of character strings. On a VAX machine, however, all character strings are aligned on byte boundaries; therefore, the UNALIGNED attribute has no effect on the actual storage of a character string. The use of the UNALIGNED keyword for character strings is thus superfluous and potentially misleading, and is not recommended.

See "Character-String Data" and "ALIGNED Attribute."

■ Restrictions

The UNALIGNED attribute conflicts with the VARYING attribute and is invalid with all data type attributes other than BIT and CHARACTER NONVARYING.

UNDEFINEDFILE Condition Name

The UNDEFINEDFILE condition name can be specified in an ON, SIGNAL, or REVERT statement to designate an undefined file condition or ON-unit for a specific file. The format of the UNDEFINEDFILE condition name is as follows:

```
{ UNDEFINEDFILE }
{ UNDF          } (file-reference)
```

file-reference
A reference to a file constant or file variable for which the ON-unit is established.

If the name of a file variable is specified, the variable must be resolved to the name of a file constant when the condition is signaled.

PL/I signals the UNDEFINEDFILE condition when a file cannot be opened. Following are some examples of errors that cause the UNDEFINEDFILE condition:

- The value specified by the TITLE option is an invalid file specification.
- The file is opened for input or update and the specified file does not exist.
- An existing file is accessed with PL/I file description attributes that are inconsistent with the file's actual organization.
- Any system-detected file error prevents the file from being accessed.

The UNDEFINEDFILE condition lets you establish an ON-unit to provide processing when a file cannot be opened, for example, to provide a default file if no file is specified at run time.

```
X: PROCEDURE (FILENAME);
DECLARE FILENAME CHARACTER (128) VARYING;
DECLARE INPUT_FILE FILE INPUT;
    ON UNDEFINEDFILE (INPUT_FILE)
           OPEN FILE (INPUT_FILE)
           TITLE ('SYS$INPUT');
    OPEN FILE (INPUT_FILE) TITLE (FILENAME);
```

In this example, the procedure X expects a file specification string to be passed as an argument. If no argument is passed, or if the argument is not a valid file specification, the OPEN statement fails. The UNDEFINEDFILE ON-unit provides a default OPEN statement with the file specification SYS$INPUT.

An ON-unit established to handle the UNDEFINEDFILE condition can obtain information about the condition by invoking the following built-in functions:

- The ONFILE built-in function returns the name of the file being processed when the condition was signaled.
- The ONCODE built-in function returns the specific status value associated with the error.

■ ON-Unit Completion

The action taken on a normal return from the UNDEFINEDFILE condition depends on whether the file was opened explicitly or implicitly.

If the UNDEFINEDFILE condition was signaled following an explicit OPEN statement for a file, then the normal action following the ON-unit execution is for the program to continue. If the ON-unit does not transfer control elsewhere in the program, control returns to the statement following the OPEN statement that caused the condition to be signaled.

If the UNDEFINEDFILE condition was signaled during an implicit open attempt, the run-time system tests the state of the file. If the file is not open, the ERROR condition is signaled. If the file was opened by the ON-unit, execution of the I/O statement continues.

If an ON-unit receives control when an explicit OPEN results in the UNDEFINEDFILE condition, and the ON-unit does not handle the condition by opening the file or by transferring control elsewhere in the program, control returns to the statement following the OPEN. Then, if an attempt is made to access the file with an I/O statement, the UNDEFINEDFILE condition is signaled again when PL/I attempts the implicit open of the file. This time, PL/I signals the ERROR condition on completion of the ON-unit.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

UNDERFLOW Condition Name

The UNDERFLOW condition name can be specified in an ON, REVERT, or SIGNAL statement to designate a floating-point underflow condition or ON-unit.

PL/I signals the UNDERFLOW condition when the absolute value of the result of an arithmetic operation on a floating-point value is smaller than the minimum value that can be represented by the VAX hardware.

On completion of the ON-unit, control is returned to the point of the interrupt. Continued execution is unpredictable.

This condition is signaled by PL/I only in procedures in which the UNDERFLOW option is enabled. The option is enabled when you specify UNDERFLOW in the procedure options. (**See** "Underflow Option.")

The value resulting from an operation that causes the UNDERFLOW condition is undefined. (The value would be set to zero only if UNDERFLOW were not specified in the procedure options.)

UNDERFLOW can be abbreviated UFL.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

UNDERFLOW Option

The UNDERFLOW option in PROCEDURE statements causes the run-time system to signal floating-point underflow conditions that occur during the execution of the procedure. The resulting value is undefined; in the absence of the UNDERFLOW option, the value would be set to zero. **See** "UNDERFLOW Condition."

In a procedure named COMPUTE, for example, you would specify the UNDERFLOW option as follows:

```
COMPUTE: PROCEDURE OPTIONS (UNDERFLOW);
```

The UNDERFLOW option affects the procedure in which it is specified. You must specify it in each procedure for which underflow conditions are to be signaled.

UNION Attribute

The UNION attribute, which can be used only in conjunction with a level number in a structure declaration, signifies that all immediate members of the major or minor structure so designated occupy the same storage. Immediate members are those members having a level number 1 higher than the major or minor structure with the UNION attribute. For example, if the UNION attribute were associated with level n, then all members or minor structures at level n+1 up to the next member at level n would be immediate members and would occupy the same storage.

The format for the UNION attribute is as follows:

```
level-number identifier [storage-class] UNION
```

level-number
The level number of the variable with which the declarations in the reference share storage.

identifier
Names the variable with which the declarations in the reference share storage. A variable declared with the UNION attribute must be a major or minor structure. All members of a UNION must have a constant size.

storage-class
The storage class specified for the structure. You can specify the storage class only on level 1.

Union

A union is a variation of a structure in which all immediate members occupy the same storage. The UNION attribute (which must be associated with a level number in a structure declaration) declares a union. All immediate members of the union—that is, all members having a level number one higher—occupy the same storage. A reference to one member of a union refers to storage occupied by all members of the union. Therefore, a union provides a convenient way to look at a large entity (such as a character string or a bit mask) as a series of smaller entities (such as component character strings or individual flag bits).

The following example illustrates unions:

```
DECLARE 1 CUSTOMER_INFO,
          2 PHONE_DATA UNION,
            3 PHONE_NUMBER CHARACTER (13),
            3 COMPONENTS,
              4 LEFT_PAREN CHARACTER (1),
              4 AREA_CODE CHARACTER (3),
              4 RIGHT_PAREN CHARACTER (1),
              4 EXCHANGE CHARACTER (3),
              4 HYPHEN CHARACTER (1),
              4 SPECIFIC_NUMBER CHARACTER (4),
          2 ADDRESS_DATA,
              .
              .
              .
```

The UNION attribute associated with the declaration of PHONE_DATA signifies that PHONE_DATA's immediate members (PHONE_NUMBER and COMPONENTS) occupy the same storage. Any modification of PHONE_NUMBER also modifies one or more members of COMPONENTS; conversely, modification of a member of COMPONENTS also modifies PHONE_NUMBER. Note, however, that the UNION attribute does not apply to the members of COMPONENTS, because they are not immediate members of PHONE_DATA. The members of COMPONENTS occupy separate storage in the normal fashion for structure members.

Unions provide capabilities similar to those provided by defined variables (**see** "Defined Variable"). However, the rules governing defined variables are more restrictive than those governing unions. The following example demonstrates a use of a union that would not be possible with a defined variable:

```
DECLARE 1 X UNION,
          2 FLOAT_NUM FLOAT BINARY (24),
          2 BREAKDOWN,
            3 FRAC_1 BIT (7),
            3 EXPONENT BIT (8),
            3 SIGN BIT (1),
            3 FRAC_2 BIT (16);
```

The union X has two immediate members, FLOAT_NUM (a floating-point variable) and BREAKDOWN. The members of BREAKDOWN are bit-string variables that overlay the storage occupied by FLOAT_NUM and provide access to the individual components of its internal representation. Assignment to FLOAT_NUM modifies the members of BREAKDOWN, and vice versa. For example:

```
EXPONENT = '0'B;
SIGN = '1'B;

FLOAT_NUM = FLOAT_NUM + 1;
```

The first two assignment statements set the exponent and sign fields of FLOAT_NUM to the reserved operand combination; the expression FLOAT_NUM + 1 causes a reserved operand exception to occur.

Note that, unlike the character-string example that preceded it, the example above depends on the VAX internal representation of data.

UNSPEC Built-In Function

The UNSPEC built-in function returns a bit string representing the internal coded value of the referenced variable, or a specified part of that variable. The variable can be an aggregate or a scalar variable of any type. The format of the function is as follows:

UNSPEC(reference[,position[,length]])

■ Returned Value

The returned value is a bit string whose length is the number of bits occupied by the referenced variable or by that part of the variable specified by the optional parameters, position and length. The length of the bit string must be less than or equal to the maximum length for bit-string data. The returned bit string contains the contents of the storage of the referenced variable (or the specified part of the variable), the first bit in storage being the first bit in the returned value. The actual value is specific to VAX PL/I and may differ from other PL/I implementations. Note that if the referenced variable is a binary integer (FIXED BINARY), the first bit in the returned value is the lowest binary digit.

■ Example

```
DECLARE X CHARACTER(2), Y BIT(16);

X = 'AB';
Y = UNSPEC(X);
    .
    .
    .
DECLARE I FIXED BINARY(15);
I = 2;
PUT LIST(UNSPEC(I));
```

As a result of the first UNSPEC reference, Y contains the ASCII codes of 'A' and 'B'. The PUT LIST statement containing UNSPEC(I) prints the following string:

```
'0100000000000000'B
```

UNSPEC Pseudovariable

The UNSPEC pseudovariable interprets a reference to a scalar or aggregate variable as a reference to a bit string. **See also** "Pseudovariable" for general rules. The format of the pseudovariable (in an assignment statement) is as follows:

```
UNSPEC(reference[,position[,length]]) = expression;
```

reference
A reference to a scalar or aggregate variable. The length of its storage in bits must be less than or equal to the maximum length for bit-string data.

In an assignment of the form

```
UNSPEC(reference) = expression;
```

the value of the expression is converted to a bit string if necessary and copied into the storage of the reference. The value is truncated or zero-extended as necessary to match the length of the storage.

To prevent zero-extending a value that is shorter than the variable, you can use the position parameter or both the position parameter and the length parameter. Then only the specified bits in the variable will be assigned a new value, and the other bits will remain as they were. Note that a position parameter of 1 refers to the low-order bit of the variable's storage, not the high-order bit.

■ Examples

```
DECLARE X FIXED BINARY (15);
UNSPEC(X) = '110'B;
```

The use of the constant '110'b, which appears to be 6 in binary, actually assigns 3 to X. The two low-order bits of X (that is, X's first two bits of storage) are set; all other bits of X are cleared.

```
UNSPEC(X,1,3) = '101'B;
```

The optional parameters position and length are specified, causing the first three, low-order bits of the variable X to be assigned the value '101'B; the other bits are unaffected.

UNTIL Option

A DO UNTIL statement executes a group of statements at least once and continues until a particular condition is true. While the condition is false, the group is repeated. The format of the DO UNTIL statement is as follows:

```
DO UNTIL (test-expression);
.
.
.
END;
```

test-expression
Any expression that yields a scalar bit-string value. If any bit of the value is 1, then the test expression is true; otherwise the test expression is false. The test expression must be enclosed in parentheses.

The test expression is evaluated after each execution of the DO-group. It must have a false value in order for the DO-group to be repeated. Otherwise, control passes outside of the DO-group to the next executable statement following the END statement that terminates the group.

■ Examples

```
DO UNTIL (K<ALPHA)
```

The DO-group is executed at least once and then repeats as long as the value of the variable K is greater than or equal to the value of the variable ALPHA.

```
DO UNTIL (LIST ->NEXT = NULL())
```

The DO-group is executed until a forward pointer in a linked list has a null value. (**See** "List Processing.")

```
DECLARE STR BIT (8) CONTROLLED;
   .
   .
   .
ALLOCATION 1
   .
   .
   .
ALLOCATION N
   .
   .
   .
DO UNTIL (ALLOCATION(STR)=0);
   PUT SKIP LIST ('STR');
   FREE STR;
   END;

END;
```

The DO-group frees bit strings from storage until all generations have been released. In this example, at least one generation must be allocated; otherwise the ERROR condition is raised. At the end of each repetition of the DO-group, the status of the generations is checked with the ALLOCATION built-in function. A null string terminates the execution of the group and passes control to the next executable statement after the first END statement.

UPDATE Attribute

The UPDATE attribute is a file description attribute that indicates that the associated file is to be used for both input and output. The UPDATE attribute can be applied to relative files, indexed sequential files, and sequential disk files with fixed-length records.

Specify the UPDATE attribute on a DECLARE statement for a file constant or on an OPEN statement to access the file for update. The UPDATE attribute implies the RECORD attribute.

For a description of the attributes that are applied to files and the effects of combinations of these attributes, **see** "File Description Attributes and Options."

The UPDATE attribute can be supplied by default for a file, depending on the context of its opening. **See** "Opening a File."

■ Restrictions

The UPDATE attribute directly conflicts with the INPUT, OUTPUT, STREAM, and PRINT attributes and with any data type attribute other than FILE.

User-Generated Diagnostic Messages

The VAX PL/I embedded preprocessor provides four statements that permit user-generated diagnostic capability: %INFORM, %WARN, %ERROR, and %FATAL. Preprocessor diagnostic messages are compile-time messages, but you define the circumstances that invoke the message and the text displayed. The format of all four statements is similar:

```
%INFORM preprocessor-expression;
%WARN preprocessor-expression;
%ERROR preprocessor-expression;
%FATAL preprocessor-expression;
```

preprocessor-expression
The text of the diagnostic message to be displayed. The text is a character string of up to 64 characters; strings are truncated if necessary.

The action of each statement is to generate a diagnostic message of the appropriate severity level, with the preprocessor expression as the text of the message.

■ Examples

The first example shows how %INFORM can be used to return the value of VARIANT.

```
%IF VARIANT() = '' | VARIANT() = 'NORMAL'
%THEN
      %INFORM 'NORMAL';
```

If the value of VARIANT is not specified at compile time or if the value is 'NORMAL', then the following informational message is issued:

```
%PLIG-I-USERDIAG, NORMAL
```

In this example, the %INFORM diagnostic message is used to let the programmer know that compilation is continuing according to a "normal" plan.

```
DECLARE INIT_MESSAGE CHAR(40) VARYING INITIAL (T);
    .
    .
    .
%IF VARIANT() = 'NONE';
%THEN %;
%ELSE
      %DO;
      %T = '''unknown variant''';
      %WARN T;
      INIT_MESSAGE = 'Compiled with '||T;
      %END;
PUT SKIP LIST (INIT_MESSAGE);
```

In this example, an unknown variant is included at compile time. The %WARN statement issues a compile-time warning diagnostic message and saves the message so that when the program is run, the appropriate text is output by the program.

The preprocessor built-in functions INFORM, WARN, and ERROR return the number of user-generated diagnostics issued at any specified point during compilation. Therefore, you can use user-generated diagnostics to control the course of compilation. For example:

```
%IF WARN() > 5
%THEN
     %GOTO change_text;
%ELSE;
```

This example specifies that compilation take a different course if there are more than five warning messages at that point in program compilation. If there are fewer than five warnings, then compilation proceeds along the current path.

```
%IF ERROR() >= 1
%THEN
     %FATAL 'Ending Compilation';
```

This example stops compilation if there is an error that would inhibit the production of an object file.

User-generated diagnostic messages increment the count displayed in the diagnostic summary.

See the individual entries for the preprocessor built-in functions.

V

VALID Built-In Function

The VALID built-in function determines whether the argument x, a pictured variable, has a value that is valid with respect to its picture specification. A value is valid if it is any of the character strings that can be created by the picture specification. The function returns '0'B if x has an invalid value and '1'B if it has a valid value. The function can be used whenever a data item is read in with a record input (READ) statement, to ensure that the input data is valid. The format of the function is as follows:

```
VALID(x)
```

x
A reference to a variable declared with the PICTURE attribute.

Note that pictured data is always validated (and thus, the VALID function is unnecessary) when it is read in with the GET EDIT statement and the P format item; the CONVERSION condition is signaled if the data does not conform to the picture given in the P format item. If GET LIST is used (or GET EDIT with a format item other than P), the input value is converted to conform to the pictured input target. (**See** "Conversion of Data" for details.)

■ Example

```
VALP: PROCEDURE OPTIONS(MAIN);

DECLARE INCOME PICTURE '$$$$$$V.$$';
DECLARE MASTER RECORD FILE;
DECLARE I FIXED;

DO I = 1 TO 2;
READ FILE(MASTER) INTO(INCOME);
IF VALID(INCOME) THEN;
      ELSE PUT SKIP LIST('Invalid input:',INCOME);
END;

END VALP;
```

Asume that the file MASTER.DAT contains the following data:

```
$15000.50
Δ50000.50
```

The program VALP will write out the following:

```
Invalid input:   Δ50000.50
```

The picture '$$$$$$V.$$' specifies a fixed-point decimal number of up to seven digits, two of which are fractional. To be valid, a pictured value must consist of nine characters: the first digit must be immediately preceded by a dollar sign, the number must contain a period before the fractional digits, and each position specified by a dollar sign must contain either that sign, a digit, or a space. The second record in MASTER.DAT can be assigned by the READ statement because it has the correct size; however, the pictured value is invalid because it does not contain a dollar sign.

VALUE Attribute

The VALUE attribute is provided for passing parameters by value rather than by reference. For complete details on using the VALUE attribute, see the *VAX PL/I User Manual.*

The format of the VALUE attribute is as follows:

```
{ VALUE } { GLOBALDEF[(psect-name)][INITIAL(value)] }
{ VAL   } { GLOBALREF                               }
```

The VALUE attribute serves two purposes:

- It specifies, for global external variables, that the variable has a constant value that the compiler can use as an immediate value in generating instructions for the VAX hardware. No storage is allocated for the variable. For this use, VALUE must be specified in conjunction with the GLOBALREF or GLOBALDEF attribute.
- It specifies, in a parameter descriptor in an ENTRY declaration, that the corresponding argument is to be passed using the VAX-specific convention for passing arguments by value. For this usage, VALUE must be specified in conjunction with one of the following attributes:

  ANY
  FIXED BINARY(m) where m is less than or equal to 31
  FLOAT BINARY(n) where n is less than or equal to 24

BIT(o) ALIGNED where o is less than or equal to 32
ENTRY
OFFSET
POINTER

The VALUE attribute, when specified with the BIT attribute, implies the ALIGNED attribute.

VALUE Built-In Function

The VALUE built-in function is used to force a parameter to be passed by immediate value, rather than by whatever mechanism is specified by the declaration of the formal parameter.

The syntax of the function is as follows:

{ VALUE / VAL } (expression)

expression
An expression or scalar variable that is valid to be passed by value. It must fit into a longword (32 bits). The valid data types are as follows:

FIXED BINARY (m) where m is less than or equal to 31
FLOAT BINARY (n) where n is less than or equal to 24
BIT (o) ALIGNED where o is less than or equal to 32
ENTRY
OFFSET
POINTER

■ Example

```
DECLARE FOO ENTRY (ANY) EXTERNAL;
DECLARE X FIXED BINARY (31);
X = 15;
   .
   .
   .
CALL FOO(VALUE(X));
```

As with the REFERENCE and DESCRIPTOR built-in functions, VALUE is not designed for use with other PL/I procedures; it is intended for use only with routines written in languages other than PL/I.

For more detailed information, **see** "VALUE Attribute" and the *VAX PL/I User Manual* on passing arguments by immediate value.

Variable

A variable is a named data item that can be assigned various values in the program. The converse of a variable is a constant, that is, a data item whose value cannot be changed.

Normally, a variable's value will change during the execution of the program. However, it is sometimes convenient to declare a static variable whose value will never change. For example:

```
DECLARE MONTHS (12) CHARACTER (12) VARYING
      STATIC INITIAL ('JANUARY', 'FEBRUARY', ...
               'DECEMBER') ;
```

The term *variable* is used in this manual to mean any of the following:

- A name declared as a variable
- The storage associated with such a name
- A reference to all or part of the storage, as in MONTHS(2)

■ Addressable Variable

A requirement in some contexts, such as in argument lists of certain built-in functions, is that a variable be addressable. A variable is addressable if it has the following properties:

- It is not suitable for bit-string overlay defining; that is, it does not consist entirely of unaligned bit data. (**See** "Defined Variable" for a definition of string overlay defining.)
- It is not an unconnected array. (**See** "Arrays of Structures.")
- It is not declared with the VALUE attribute. (**See** "VALUE Attribute.")

These rules ensure that the variable can occupy contiguous storage beginning on a byte boundary. (Note that constants are not addressable in PL/I.)

VARIABLE Attribute

The VARIABLE attribute indicates that the associated identifier is a variable. VARIABLE is implied by all computational data type attributes and by all noncomputational attributes except FILE and ENTRY.

If you specify the FILE or ENTRY attribute in a DECLARE statement without the VARIABLE attribute, the defined object is assumed to be a file or entry constant.

The VARIABLE attribute is implied by the LABEL attribute. You can declare label constants only by using the label identifier in the program; you cannot define a label constant in a DECLARE statement.

See "Entry Data," "File," and "Label " for descriptions of variables of these data types.

■ Restrictions

The VARIABLE attribute is not valid in a returns descriptor or in a parameter descriptor.

VARIABLE Option

The VARIABLE option specifies that an external procedure can be invoked with argument lists of different lengths or that default arguments will not be specified in the invocation of an external procedure. It is specified in the declaration of an external entry as in the following example:

```
DECLARE SYS$FAO ENTRY (ANY) OPTIONS (VARIABLE);
```

This attribute is applicable only in the declaration of external procedures that are not written in PL/I. For complete details on using OPTIONS (VARIABLE), **see** the *VAX PL/I User Manual.*

■ Restrictions

The VARIABLE option is valid only in conjunction with the ENTRY attribute.

VARIANT Preprocessor Built-In Function

The VARIANT preprocessor built-in function returns a string representing the value of the /VARIANT qualifier in the PLI command that invoked the compilation.

Its format in a preprocessor expression is as follows:

```
VARIANT()
```

The /VARIANT qualifier permits specification of compilation variants. The value specified with /VARIANT is available to the VARIANT preprocessor built-in function at compile time. The format of compilation variants is as follows:

```
/VARIANT { [ =alphanumeric-string ]   }
         { [ ="alphanumeric-string"] }
```

For example, if a program is to be compiled with one of three different INCLUDE files, you can use the /VARIANT command qualifier to specify which file is to be included. In the following example, the file SPECIAL.SRC is included in the program only if /VARIANT=SPECIAL appears in the PLI command line.

For example:

```
%IF VARIANT() = 'SPECIAL'
%THEN
    %INCLUDE 'SPECIAL.SRC';
%IF VARIANT() = 'NONE'
%THEN;
```

No action is taken if /VARIANT=NONE appears on the PLI command line.

If /VARIANT is not specified, or if it is specified without a value, the default value is /VARIANT ="".

For information on the format of the /VARIANT qualifier, **see** the *VAX PL/I User Manual.*

VARYING Attribute

The VARYING attribute indicates that a character-string variable does not have a fixed length, but that its length changes according to its current value.

You must specify a length attribute in conjunction with VARYING (which can be abbreviated to VAR), giving the maximum length allowed for the variable. The current length is stored with the value and can be determined at any time with the LENGTH built-in function. If you need to determine the maximum declared length of a varying- length character string, use the MAXLENGTH built-in function. (The SIZE built-in function would return the maximum length plus 2; the reason is that the amount of storage allocated for varying-length strings is two bytes longer than the maximum length declared, the first two bytes containing the current length of the string.)

The value of an uninitialized CHARACTER VARYING variable is undefined.

Special rules apply to reading and writing record files into and from variables that have the VARYING attribute. See the *VAX PL/I User Manual.*

■ Restrictions

The VARYING attribute directly conflicts with any data type attribute other than CHARACTER.

■ Examples

```
DECLARE STRING CHARACTER(80) VARYING;
```

A variable named STRING is declared as a varying-length character string with a maximum length of 80 characters.

```
S: PROCEDURE OPTIONS(MAIN);
DECLARE STRING CHARACTER(80) VARYING;
    STRING = 'PIE';
    PUT LIST (LENGTH(STRING));
    PUT LIST (MAXLENGTH(STRING));
    PUT LIST (SIZE(STRING));
END;
```

The value returned by the built-in function LENGTH is 3, the length of the current value of the string. The value returned by the built-in function MAXLENGTH is 80, the maximum declared length. The value returned by the built-in function SIZE is 82, the maximum declared length plus two (for the two bytes that hold the value of the current length).

VAXCONDITION Condition Name

The VAXCONDITION condition name can be specified in an ON, RESIGNAL, REVERT, or SIGNAL statement. The VAXCONDITION condition name provides a way to signal and handle operating-system or programmer-specified condition values. The format of the VAXCONDITION condition name is as follows:

```
VAXCONDITION (expression)
```

expression
An expression yielding a fixed binary value. The expression is evaluated when the ON statement is executed, not when the condition is signaled.

The VAXCONDITION condition name is provided specifically for PL/I procedures that interact with VMS operating system routines. For details on using the VAXCONDITION condition name and the meanings of system- and user-defined values that you can specify, see the *VAX PL/I User Manual.*

VERIFY Built-In Function
VERIFY Preprocessor Built-In Function

The VERIFY built-in function compares a string with a character-set string and verifies that all characters appearing in the string also appear in the character-set string. The function returns the value zero if they all appear. If not, the function returns a fixed-point binary integer that indicates the position of the first character in the string that is not present in the character-set string. The comparison is done character by character and left to right, and as soon as one nonmatching character is found in the first string, no more characters are compared. The function is case sensitive.

The format of the function is as follows:

```
VERIFY(string,character-set-string[,starting-position])
```

string
A character-string expression representing the string to be checked.

character-set-string
A character-string expression containing the set of characters with which the characters in the first string are to be compared.

starting-position

A positive integer in the range 1 to n+1, where n is the length of the first string. It specifies the leftmost position in the first string to be compared with the character-set-string. (By default, the comparison starts at the left end of the first string.)

■ Examples

1.
```
STRING = 'HOW MUCH IS 1 PLUS 2';
ALPHABET = 'abcdefghijklmnopqrstuvwxyz
           ABCDEFGHIJKLMNOPQRSTUVWXYZ ';
A = VERIFY(STRING,ALPHABET);
```

The value of the variable ALPHABET is a string containing the 26 lowercase letters, the 26 uppercase letters, and the space character. The function returns a value of 13, indicating the position of the character '1', which is the first nonalphabetic and nonspace character in STRING.

2.
```
A = VERIFY(STRING,' ');
```

This example finds the first nonspace character in a string by using the space character as a test string. Note that constants can be used as the string parameters.

3.
```
NEWSTRING = 'ALL LETTERS';
A = VERIFY(NEWSTRING,ALPHABET);
```

VERIFY returns a value of zero because all characters in the string NEWSTRING are present in the string ALPHABET.

4.
```
NEWSTRING = '9 LETTERS';
A = VERIFY (NEWSTRING,ALPHABET,2);
```

The optional starting-position parameter specifies that the comparison begins at position 2 in NEWSTRING. VERIFY returns a value of zero because all characters beginning with the second character in the string NEWSTRING are present in the string ALPHABET. If the starting-position parameter had not been specified, VERIFY would have returned a value of 1, because the first character ('9') in NEWSTRING is not present in ALPHABET.

W

%WARN Statement

The %WARN statement provides a diagnostic warning message during program compilation. The format of the %WARN statement is as follows:

```
%WARN preprocessor-expression;
```

preprocessor-expression
The text of the warning message to be displayed. The text is a character string with a maximum length of 60 characters. It is truncated if necessary.

■ Returned Message

The message displayed by %WARN is as follows:

```
%PLIG-W-USERDIAG, preprocessor-expression
```

The %WARN statement increments the warning diagnostic count displayed in the compilation summary.

For further information on preprocessor diagnostic messages, **see** "User-Generated Diagnostic Messages."

WARN Preprocessor Built-In Function

The WARN preprocessor built-in function returns the number of diagnostic warning messages issued during compilation up to that particular point in the source program. The format for the WARN built-in function is as follows:

```
WARN();
```

The function returns a fixed result representing the number of compile-time warning messages that were issued up to the point at which the WARN built-in function was encountered.

WHEN Keyword

The WHEN clause is specified in a SELECT statement to define the action to be taken if a given expression is true. For example:

```
SELECT;
    WHEN (A = 2) X = Y**A;
    WHEN (A = 3) X = Y*A;
    OTHERWISE X = Y;
END;
```

An expression must follow the keyword WHEN, but the action can be null. For example:

```
WHEN (A = 2);
```

For more information, **see** "SELECT Statement."

WHILE Option

The WHILE option can be specified in a DO statement to define a condition that must be met for the DO-group to be executed. It has the following format:

WHILE (expression)

expression
A bit-string expression of any length. If any bit in the expression is 1, the expression is considered true.

For example:

```
DO WHILE (A < B);
```

The subsequent DO-group is executed while the value of the expression A <B is true.

For more information, **see** "DO Statement."

WRITE Statement

The WRITE statement adds a record to a file, either at the end of a file that has the SEQUENTIAL and OUTPUT attributes, or in a specified key position in a file that has the KEYED and OUTPUT attributes or the KEYED and UPDATE attributes. The format of the WRITE statement is as follows:

```
WRITE FILE(file-reference) FROM (variable-reference)
                    [ KEYFROM (expression) ]
                    [ OPTIONS (option,...) ];
```

file-reference

A reference to the file to which the record is to be written. If the file is not currently open, the WRITE statement opens the file with the implied attributes RECORD, OUTPUT, and SEQUENTIAL; these attributes are merged with the attributes specified in the file's declaration. **See also** "Opening a File."

variable-reference

A reference to the variable containing data for the output record. The variable must be addressable.

If the variable has the VARYING or the AREA attribute and the file does not have the attribute ENVIRONMENT(SCALARVARYING), the WRITE statement writes only the current value of the varying string or the area into the specified record. In all other cases, the WRITE statement writes the entire storage of the variable. If the contents of the variable do not fit the specified record size, the WRITE statement outputs as much of the variable as will fit, and the ERROR condition is signaled.

KEYFROM (expression)

An option specifying that the record to be written is to be positioned in the file according to the key specified by the expression. The file must have the KEYED attribute.

The nature of the key depends on the file's organization, as follows:

- If the file is a relative file or a sequential disk file with fixed-length records, the key value is a fixed binary value indicating the relative record number of the record to be written.

- If the file is an indexed sequential file, the key specifies the record's primary key. PL/I copies the key value specified into the correct key field position (or positions, if segmented keys are used). PL/I also sets the key number to the primary index.

The value of the specified expression is converted to the data type of the key. If no record with the specified key exists, or if the specified key value cannot be converted to the data type of the key, the KEY condition is signaled.

OPTIONS (option, . . .)

An option specifying one or more of the following WRITE statement options, separated by commas:

FIXED_CONTROL_FROM (variable-reference)
RECORD_ID_TO (variable-reference)

These options are described fully in the *VAX PL/I User Manual.*

■ File Positioning

If the file has the UPDATE attribute, the current record is set to designate the record just written, and the next record is set to designate the record following the record just written. If there is no such record following the record just written, the next record is set to the end-of-file.

■ Examples

```
TRUNC: PROCEDURE;
DECLARE INREC CHARACTER(80) VARYING,
        OUTREC CHARACTER(80),
        ENDED BIT(1) STATIC INIT('0'B),
        (INFILE,OUTFILE) FILE;

      OPEN FILE (INFILE) RECORD INPUT
             TITLE('RECFILE.DAT');
      OPEN FILE (OUTFILE) RECORD OUTPUT
             TITLE('TRUNCFILE.DAT')
             ENVIRONMENT(FIXED_LENGTH_RECORDS,
                         MAXIMUM_RECORD_SIZE(80));

      ON ENDFILE(INFILE) ENDED = '1'B;
```

```
      READ FILE(INFILE) INTO (INREC);
      DO WHILE (^ENDED);
              OUTREC = INREC;
              WRITE FILE (OUTFILE) FROM (OUTREC);
              READ FILE (INFILE) INTO (INREC);
              END;
      CLOSE FILE(INFILE);
      CLOSE FILE(OUTFILE);
      RETURN;
      END;
```

This program reads a file with variable-length records into a character string with the VARYING attribute and creates a sequential output file in which each record has a fixed length of 80 characters.

The ENVIRONMENT attribute for the file OUTFILE specifies the record format and length of each fixed-length record.

When records are written to a file with fixed-length records, the variable specified in the FROM option must have the same length as the records in the target output file. Otherwise, the ERROR condition is signaled. Thus, in this example, each record read from the input file is copied into a fixed-length character-string variable for output.

Each time this program is executed, it creates a new version of the file TRUNCFILE.DAT.

```
ADD_EMPLOYEE: PROCEDURE;

DECLARE 1 EMPLOYEE,
          2 NAME,
            3 LAST CHAR(30),
            3 FIRST CHAR(20),
            3 MIDDLE_INIT CHAR(1),
          2 DEPARTMENT CHAR(4),
          2 SALARY FIXED DECIMAL (6,2),
      EMP_FILE FILE;

DECLARE MORE_INPUT BIT(1) STATIC INIT('1'B),
      NUMBER FIXED DECIMAL (5,0);

      OPEN FILE(EMP_FILE) DIRECT UPDATE;

      DO WHILE (MORE_INPUT);
         PUT SKIP LIST('Employee Number');
         GET LIST (NUMBER);

         PUT SKIP LIST
          ('Name (Last, First, Middle Initial)');
         GET LIST
          (EMPLOYEE.NAME.LAST,EMPLOYEE.NAME.FIRST,
              EMPLOYEE.NAME.MIDDLE_INIT);
```

```
      PUT SKIP LIST('Department');
      GET LIST (DEPARTMENT);

      PUT SKIP LIST('Starting salary');
      GET LIST(EMPLOYEE.SALARY);

      WRITE FILE (EMP_FILE)
          FROM (EMPLOYEE) KEYFROM(NUMBER);

      PUT SKIP LIST('More?');
      GET LIST(MORE_INPUT);
      END;
   CLOSE FILE(EMP_FILE);
   RETURN;
   END;
```

This procedure adds records to the existing relative file EMP_FILE. The file is organized by employee numbers, and each record occupies the relative record number in the file that corresponds to the employee number.

The file is opened with the DIRECT and UPDATE attributes, because records to be written will be chosen by key number. Within the DO-group, the program prompts for data for each new record that will be written to the file. After the data is input, the WRITE statement specifies the KEYFROM option to designate the relative record number. The number itself is not a part of the record but will be used to retrieve the record when the file is accessed for keyed input.

X

X Format Item

The X format item sets a stream file or character-string expression to a column relative to the current position. It is the only control format item that can be used with either the FILE or STRING option of GET EDIT and PUT EDIT. The form of the X format item is as follows:

```
X [(w)]
```

w
An integer, or an expression, that specifies a number of consecutive character positions in the stream; w must not yield a negative integer value. If w yields zero, no operation is performed. If the w is omitted, its value is assumed to be 1.

■ Input with GET EDIT

On input, the next w columns after the current column are skipped.

■ Output with PUT EDIT

On output, w spaces are inserted following the current column.

When the output stream is a file, and the end of the current line is reached, the output of spaces continues on the next line until w spaces have been output. The size of the current line is either the default value or the specific value you have established for the file (**see** "LINESIZE Option"). If the file is a print file, the ENDPAGE condition is signaled if the page size is reached; on normal return from the ENDPAGE ON-unit, output of spaces continues at the top of the next page until w spaces have been output.

If the output stream is a character-string variable, w spaces are written to the variable. The ERROR condition is signaled if the maximum length of the string is exceeded.

■ Examples

```
XFOR: PROCEDURE OPTIONS(MAIN);

DECLARE INLINE CHARACTER(80) VARYING;
DECLARE FIRSTWORD CHARACTER(80) VARYING;
DECLARE OUTFILE PRINT FILE;
DECLARE SPACE1 FIXED;

GET EDIT(INLINE) (A(1000)) OPTIONS(PROMPT('Line>'));

SPACE1 = INDEX(INLINE,' '); /* position of first wordbreak */

FIRSTWORD = SUBSTR(INLINE,1,SPACE1-1);

PUT STRING(FIRSTWORD) EDIT (FIRSTWORD,'-FIRST WORD TYPED') (A,X(2),A);

PUT SKIP FILE(OUTFILE) LIST(FIRSTWORD);

END XFOR;
```

The GET EDIT statement in the program XFOR inputs a complete line from a user's terminal, after issuing and receiving an answer to the prompt 'Line> '. Assume that the interaction is as follows:

```
Line> beautiful losers RET
```

The following output will be written to OUTFILE.DAT:

```
beautiful  -FIRST WORD TYPED
```

The X format item has correctly inserted two spaces between 'beautiful' and '—FIRST WORD TYPED'.

```
XFOR2: PROCEDURE OPTIONS(MAIN);

DECLARE INLINE CHARACTER(80) VARYING;
DECLARE OUTFILE2 PRINT FILE;

GET EDIT(INLINE) (X(10),A(1000))
  OPTIONS(PROMPT('Line>'));


PUT SKIP FILE(OUTFILE2) LIST(INLINE);
END XFOR2;
```

In the program XFOR2, the GET EDIT statement skips the first 10 characters typed after the prompt and then inputs the remainder of the line. Assume that the interaction is as follows:

```
Line> ABCDEFGHIJKLMNOPQRSTUVWXYZ RET
```

The following output will be written to OUTFILE2.DAT:

```
KLMNOPQRSTUVWXYZ
```

The first 10 letters (A to J) have been ignored on input.

Z

ZERODIVIDE Condition Name

The ZERODIVIDE condition name can be specified in an ON, REVERT, or SIGNAL statement to designate a divide-by-zero condition or ON-unit.

PL/I signals the ZERODIVIDE condition when the divisor in a division operation has a value of zero. The value resulting from such an operation is undefined.

■ ON-Unit Completion

Control returns to the point of the interruption.

For more information, **see** "ON Conditions and ON-Units" and "ON Statement."

Appendix A

Alphabetic Summary of Keywords

A summary of all of the VAX PL/I keywords follows. This alphabetic summary includes both the options for the ENVIRONMENT attribute and the options for I/O statements.

Keyword	Abbreviation	Use
A		Format item
ABS		Preprocessor built-in function, Built-in function
ACOS		Built-in function
%ACTIVATE		Preprocessor statement
ACTUALCOUNT		Built-in function
ADD		Built-in function
ADDR		Built-in function
ALIGNED		Attribute
ALLOCATE	ALLOC	Statement
ALLOCATION	ALLOCN	Built-in function
ANY		Attribute
ANYCONDITION		Condition name
APPEND		Environment option
AREA		Data attribute, Condition name
ASIN		Built-in function
ATAN		Built-in function

Keyword	Abbreviation	Use
ATAND		Built-in function
ATANH		Built-in function
AUTOMATIC	AUTO	Attribute
B		Format item
B1		Format item
B2		Format item
B3		Format item
B4		Format item
BACKUP_DATE		Environment option
BASED		Attribute
BATCH		Environment option
BEGIN		Statement
BINARY	BIN	Data attribute, Built-in function
BIT		Data attribute, Built-in function
BLOCK_BOUNDARY_ FORMAT		Environment option
BLOCK_IO		Environment option
BLOCK_SIZE		Environment option
BOOL		Built-in function
BUCKET_SIZE		Environment option
BUILTIN		Attribute
BY		DO option
BYTE		Preprocessor built-in function, Built-in function
CALL		Statement
CANCEL_CONTROL_ O		PUT OPTIONS option
CARRIAGE_RETURN_ FORMAT		Environment option
CEIL		Built-in function
CHARACTER	CHAR	Data attribute, Built-in function

Keyword	Abbreviation	Use
CLOSE		Statement
COLLATE		Built-in function
COLUMN	COL	Format item
CONDITION	COND	Attribute, Condition name
CONTIGUOUS		Environment option
CONTIGUOUS_BEST_TRY		Environment option
CONTROLLED	CTL	Attribute
CONVERSION	CONV	Condition name
COPY		Preprocessor built-in function, Built-in function
COS		Built-in function
COSD		Built-in function
COSH		Built-in function
CREATION_DATE		Environment option
CURRENT_POSITION		Environment option
DATE		Preprocessor built-in function, Built-in function
DATETIME		Preprocessor built-in function, Built-in function
%DEACTIVATE		Preprocessor statement
DECIMAL	DEC	Data attribute, Built-in function
%DECLARE	%DCL	Preprocessor statement
DECLARE	DCL	Statement
DECODE		Preprocessor built-in function, Built-in function
DEFAULT_FILE_NAME		Environment option
DEFERRED_WRITE		Environment option
DEFINED	DEF	Attribute
DELETE		Statement, Environment option
DESCRIPTOR	DESC	Attribute, Built-in function

Keyword	Abbreviation	Use
%DICTIONARY		Preprocessor statement
DIMENSION	DIM	Attribute, Built-in function
DIRECT		File attribute, OPEN option
DISPLAY		Built-in subroutine
DIVIDE		Built-in function
%DO		Preprocessor statement
DO		Statement, GET and PUT I/O specifier
E		Format item
EDIT		GET option, PUT option
%ELSE		Keyword of the %IF statement
ELSE		Keyword of the IF statement
EMPTY		Built-in function
ENCODE		Preprocessor built-in function, Built-in function
%END		Preprocessor statement
END		Statement
ENDFILE		Condition name
ENDPAGE		Condition name
ENTRY		Statement, Attribute
ENVIRONMENT	ENV	File attribute, OPEN option, CLOSE option
%ERROR		Preprocessor statement
ERROR		Condition name, Preprocessor built-in function
EVERY		Built-in function
EXP		Built-in function
EXPIRATION_DATE		Environment option
EXTEND		Built-in subroutine
EXTENSION_SIZE		Environment option
EXTERNAL	EXT	Attribute

Keyword	Abbreviation	Use
F		Format item
FAST_DELETE		DELETE OPTIONS option
%FATAL		Preprocessor statement
FILE		Attribute, Option of the GET, PUT, READ, WRITE, DELETE, REWRITE, OPEN, and CLOSE statements
FILE_ID		Environment option
FILE_ID_TO		Environment option
FILE_SIZE		Environment option
FINISH		Condition name
FIXED		Data attribute, Built-in function
FIXEDOVERFLOW	FOFL	Condition name
FIXED_CONTROL_ FROM		REWRITE OPTIONS option, WRITE OPTIONS option
FIXED_CONTROL_SIZE		Environment option
FIXED_CONTROL_ SIZE_TO		Environment option
FIXED_CONTROL_TO		READ OPTIONS option
FIXED_LENGTH_ RECORDS		Environment option
FLOAT		Data attribute, Built-in function
FLOOR		Built-in function
FLUSH		Built-in subroutine
FORMAT		Statement
FREE		Statement, Built-in subroutine
FROM		WRITE option, REWRITE option
GET		Statement
GLOBALDEF		Attribute
GLOBALREF		Attribute
%GOTO		Preprocessor statement
GOTO	GO TO	Statement

Keyword	Abbreviation	Use
GROUP_PROTECTION		Environment option
HBOUND		Built-in function
HIGH		Built-in function
IDENT		PROCEDURE OPTIONS option
%IF		Preprocessor statement
IF		Statement
IGNORE_LINE_MARKS		Environment option
IN		ALLOCATE option, FREE option
%INCLUDE		Preprocessor statement
INDEX		Preprocessor built-in function, Built-in function
INDEXED		Environment option
INDEX_NUMBER		DELETE OPTIONS option, READ OPTIONS option, REWRITE OPTIONS option, Environment option
%INFORM		Preprocessor statement
INFORM		Preprocessor built-in function
INITIAL	INIT	Attribute
INITIAL_FILL		Environment option
INPUT		File attribute, OPEN option
INT		Built-in function, Pseudovariable
INTERNAL	INT	Attribute
INTO		READ option
KEY		Condition name, READ option, DELETE option, REWRITE option
KEYED		File attribute, OPEN option
KEYFROM		WRITE option
KEYTO		READ option
LABEL		Attribute
LBOUND		Built-in function

Keyword	Abbreviation	Use
LEAVE		Statement
LENGTH		Preprocessor built-in function, Built-in function
LIKE		Attribute
LINE		PUT option, Preprocessor built-in function, Format item
LINENO		Built-in function
LINESIZE		OPEN option
%LIST		Preprocessor statement
LIST		Attribute, GET option, PUT option
LOCK_ON_READ		READ OPTIONS option
LOCK_ON_WRITE		READ OPTIONS option
LOG		Built-in function
LOG10		Built-in function
LOG2		Built-in function
LOW		Built-in function
MAIN		PROCEDURE OPTIONS option
MANUAL_UNLOCKING		READ OPTIONS option
MATCH_GREATER		DELETE OPTIONS option, READ OPTIONS option, REWRITE OPTIONS option
MATCH_GREATER_ EQUAL		DELETE OPTIONS option, READ OPTIONS option, REWRITE OPTIONS option
MATCH_NEXT		DELETE OPTIONS option, READ OPTIONS option, REWRITE OPTIONS option
MATCH_NEXT_EQUAL		DELETE OPTIONS option, READ OPTIONS option, REWRITE OPTIONS option
MAX		Preprocessor built-in function, Built-in function

Keyword	Abbreviation	Use
MAXIMUM_RECORD_ NUMBER		Environment option
MAXIMUM_RECORD_ SIZE		Environment option
MAXLENGTH		Built-in function
MEMBER		Attribute
MIN		Preprocessor built-in function, Built-in function
MOD		Preprocessor built-in function, Built-in function
MULTIBLOCK_COUNT		Environment option
MULTIBUFFER_COUNT		Environment option
MULTIPLY		Built-in function
NEXT_VOLUME		Built-in subroutine
%NOLIST		Preprocessor statement
NOLOCK		READ OPTIONS option
NONEXISTENT_ RECORD		READ OPTIONS option
NONRECURSIVE		PROCEDURE option, ENTRY option
NONVARYING	NONVAR	Attribute
NORESCAN		Option of the %ACTIVATE statement
NO_ECHO		GET OPTIONS option
NO_FILTER		GET OPTIONS option
NO_SHARE		Environment option
NULL		Built-in function
OFFSET		Data attribute, Built-in function
ON		Statement
ONARGSLIST		Built-in function
ONCHAR		Built-in function, Pseudovariable
ONCODE		Built-in function

Keyword	Abbreviation	Use
ONFILE		Built-in function
ONKEY		Built-in function
ONSOURCE		Built-in function, Pseudovariable
OPEN		Statement
OPTIONAL		Attribute
OPTIONS		File attribute, Option of the GET, PUT, READ, WRITE, DELETE, REWRITE, and PROCEDURE statements
OTHERWISE	OTHER	Keyword of the SELECT statement
OUTPUT		File attribute, OPEN option
OVERFLOW	OFL	Condition name
OWNER_GROUP		Environment option
OWNER_ID		Environment option
OWNER_MEMBER		Environment option
OWNER_PROTECTION		Environment option
P		Format item
%PAGE		Preprocessor statement
PAGE		PUT option, Format item
PAGENO		Built-in function, Pseudovariable
PAGESIZE		OPEN option
PARAMETER	PARM	Attribute
PICTURE	PIC	Data attribute
POINTER	PTR	Data attribute, Built-in function
POSINT		Built-in function, Pseudovariable
POSITION	POS	Attribute
PRECISION	PREC	Attribute
PRESENT		Built-in function
PRINT		File attribute, OPEN option
PRINTER_FORMAT		Environment option
%PROCEDURE	%PROC	Preprocessor statement

Keyword	Abbreviation	Use
PROCEDURE	PROC	Statement
PROD		Built-in function
PROMPT		GET OPTIONS option
PURGE_TYPE_AHEAD		GET OPTIONS option
PUT		Statement
R		Format item
RANK		Preprocessor built-in function, Built-in function
READ		Statement
READONLY		Attribute
READ_AHEAD		Environment option
READ_CHECK		Environment option
READ_REGARDLESS		READ OPTIONS option
RECORD		File attribute, OPEN option
RECORD_ID		DELETE OPTIONS option, READ OPTIONS option, REWRITE OPTIONS option
RECORD_ID_ACCESS		Environment option
RECORD_ID_TO		READ OPTIONS option, REWRITE OPTIONS option, WRITE OPTIONS option
RECURSIVE		PROCEDURE option, ENTRY option
REFER		Attribute
REFERENCE		Attribute, Built-in function
RELEASE		Built-in subroutine
REPEAT		DO option
%REPLACE		Preprocessor statement
RESCAN		Option of the %ACTIVATE statement
RESIGNAL		Built-in subroutine
RETRIEVAL_POINTERS		Environment option

Keyword	Abbreviation	Use
%RETURN		Preprocessor statement
RETURN		Statement
RETURNS		Entry attribute, PROCEDURE option, ENTRY option
REVERSE		Preprocessor built-in function, Built-in function
REVERT		Statement
REVISION_DATE		Environment option
REWIND		Built-in subroutine
REWIND_ON_CLOSE		Environment option
REWIND_ON_OPEN		Environment option
REWRITE		Statement
ROUND		Built-in function
%SBTTL		Preprocessor statement
SCALARVARYING		Environment option
SEARCH		Preprocessor built-in function, Built-in function
SELECT		Statement
SEQUENTIAL	SEQL	File attribute, OPEN option
SET		READ option, ALLOCATE option
SHARED_READ		Environment option
SHARED_WRITE		Environment option
SIGN		Preprocessor built-in function, Built-in function
SIGNAL		Statement
SIN		Built-in function
SIND		Built-in function
SINH		Built-in function
SIZE		Built-in function
SKIP		GET option, PUT option, Format item

Keyword	Abbreviation	Use
SNAP		ON statement option
SOME		Built-in function
SPACEBLOCK		Built-in subroutine
SPOOL		Environment option
SQRT		Built-in function
STATEMENT		Option of the %PROCEDURE statement
STATIC		Attribute
STOP		Statement
STORAGE		Condition name
STREAM		File attribute, OPEN option
STRING		GET option, PUT option, Built-in function, Pseudovariable
STRINGRANGE	STRG	Condition name
STRUCTURE		Attribute
SUBSCRIPTRANGE	SUBRG	Condition name
SUBSTR		Preprocessor built-in function, Built-in function, Pseudovariable
SUBTRACT		Built-in function
SUM		Built-in function
SUPERSEDE		Environment option
SYSIN		Default input file
SYSPRINT		Default output file
SYSTEM		ON statement option
SYSTEM_PROTECTION		Environment option
TAB		Format item
TAN		Built-in function
TAND		Built-in function
TANH		Built-in function
TEMPORARY		Environment option
%THEN		Keyword of the %IF statement

Keyword	Abbreviation	Use
THEN		Keyword of the IF statement
TIME		Built-in function
TIMEOUT_PERIOD		READ OPTIONS option
%TITLE		Preprocessor statement
TITLE		OPEN option
TO		DO option
TRANSLATE		Preprocessor built-in function, Built-in function
TRIM		Preprocessor built-in function, Built-in function
TRUNC		Built-in function
TRUNCATE		Attribute, Environment option
UNALIGNED	UNAL	Attribute
UNDEFINEDFILE	UNDF	Condition name
UNDERFLOW	UFL	Condition name, PROCEDURE OPTIONS option
UNION		Attribute
UNSPEC		Built-in function, Pseudovariable
UNTIL		DO option
UPDATE		File attribute, OPEN option
USER_OPEN		Environment option
VALID		Built-in function
VALUE	VAL	Attribute, Built-in function
VARIABLE		Attribute, OPTIONS Option
VARIANT		Preprocessor built-in function
VARYING	VAR	Attribute
VAXCONDITION		Condition name
VERIFY		Preprocessor built-in function, Built-in function
WAIT_FOR_RECORD		READ OPTIONS option
%WARN		Preprocessor statement

Keyword	Abbreviation	Use
WARN		Preprocessor built-in function
WHEN		Keyword of the SELECT statement
WHILE		DO option
WORLD_PROTECTION		Environment option
WRITE		Statement
WRITE_BEHIND		Environment option
WRITE_CHECK		Environment option
X		Format item
ZERODIVIDE	ZDIV	Condition name

Appendix B

DEC Multinational Character Set

The DEC Multinational Character Set is a set of 8-bit numeric values representing the alphabet, numerals, punctuation, and other symbols. The first 128 characters of the set (with decimal values from 0 through 127) are the American Standard Code for Information Interchange (ASCII) characters. The remaining characters (with values from 128 through 255) are non-ASCII characters and can be used in VAX PL/I only in string constants and data with I/O statements.

The following table shows the first half of the DEC Multinational Character Set, which is the ASCII character set. The first half of each of the numbered columns identifies the character as you would enter it on a VT200 or VT100 series terminal or as you would see it on a printer (except for the nonprintable characters). The remaining half of each column identifies the character by the binary value of the byte; the value is stated in three radixes—octal, decimal, and hexadecimal. For example, the uppercase letter A has, under ASCII conventions, a storage value of hexadecimal 41 (a bit configuration of 01000001), equivalent to 101 in octal notation and 65 in decimal notation.

	COLUMN	0		1		2		3		4		5		6		7	
ROW	BITS b8 b7 b6 b5 b4 b3 b2 b1	0 0 0 0		0 0 0 1		0 0 1 0		0 0 1 1		0 1 0 0		0 1 0 1		0 1 1 0		0 1 1 1	
0	0 0 0 0	NUL	0 0 0	DLE	20 16 10	SP	40 32 20	0	60 48 30	@	100 64 40	P	120 80 50	`	140 96 60	p	160 112 70
1	0 0 0 1	SOH	1 1 1	DC1 (XON)	21 17 11	!	41 33 21	1	61 49 31	A	101 65 41	Q	121 81 51	a	141 97 61	q	161 113 71
2	0 0 1 0	STX	2 2 2	DC2	22 18 12	"	42 34 22	2	62 50 32	B	102 66 42	R	122 82 52	b	142 98 62	r	162 114 72
3	0 0 1 1	ETX	3 3 3	DC3 (XOFF)	23 19 13	#	43 35 23	3	63 51 33	C	103 67 43	S	123 83 53	c	143 99 63	s	163 115 73
4	0 1 0 0	EOT	4 4 4	DC4	24 20 14	$	44 36 24	4	64 52 34	D	104 68 44	T	124 84 54	d	144 100 64	t	164 116 74
5	0 1 0 1	ENQ	5 5 5	NAK	25 21 15	%	45 37 25	5	65 53 35	E	105 69 45	U	125 85 55	e	145 101 65	u	165 117 75
6	0 1 1 0	ACK	6 6 6	SYN	26 22 16	&	46 38 26	6	66 54 36	F	106 70 46	V	126 86 56	f	146 102 66	v	166 118 76
7	0 1 1 1	BEL	7 7 7	ETB	27 23 17	'	47 39 27	7	67 55 37	G	107 71 47	W	127 87 57	g	147 103 67	w	167 119 77
8	1 0 0 0	BS	10 8 8	CAN	30 24 18	(	50 40 28	8	70 56 38	H	110 72 48	X	130 88 58	h	150 104 68	x	170 120 78
9	1 0 0 1	HT	11 9 9	EM	31 25 19	)	51 41 29	9	71 57 39	I	111 73 49	Y	131 89 59	i	151 105 69	y	171 121 79
10	1 0 1 0	LF	12 10 A	SUB	32 26 1A	*	52 42 2A	:	72 58 3A	J	112 74 4A	Z	132 90 5A	j	152 106 6A	z	172 122 7A
11	1 0 1 1	VT	13 11 B	ESC	33 27 1B	+	53 43 2B	;	73 59 3B	K	113 75 4B	[	133 91 5B	k	153 107 6B	{	173 123 7B
12	1 1 0 0	FF	14 12 C	FS	34 28 1C	,	54 44 2C	<	74 60 3C	L	114 76 4C	\	134 92 5C	l	154 108 6C	|	174 124 7C
13	1 1 0 1	CR	15 13 D	GS	35 29 1D	-	55 45 2D	=	75 61 3D	M	115 77 4D	]	135 93 5D	m	155 109 6D	}	175 125 7D
14	1 1 1 0	SO	16 14 E	RS	36 30 1E	.	56 46 2E	>	76 62 3E	N	116 78 4E	^	136 94 5E	n	156 110 6E	~	176 126 7E
15	1 1 1 1	SI	17 15 F	US	37 31 1F	/	57 47 2F	?	77 63 3F	O	117 79 4F	_	137 95 5F	o	157 111 6F	DEL	177 127 7F

KEY

CHARACTER | ESC | 33 OCTAL / 27 DECIMAL / 1B HEX

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The following table shows the second half of the DEC Multinational Character Set (the non-ASCII characters, with decimal values 128 through 255). The first half of each of the numbered columns identifies the character as you would see it on a VT200 series terminal or printer; these characters cannot be output on a VT100 series terminal.

8		9		10		11		12		13		14		15		COLUMN	
1 0 0 0		1 0 0 1		1 0 1 0		1 0 1 1		1 1 0 0		1 1 0 1		1 1 1 0		1 1 1 1		b8 b7 BITS b6 b5 b4 b3 b2 b1	ROW
	200 128 80	DCS	220 144 90		240 160 A0	°	260 176 B0	À	300 192 C0		320 208 D0	à	340 224 E0		360 240 F0	0 0 0 0	0
	201 129 81	PU1	221 145 91	¡	241 161 A1	±	261 177 B1	Á	301 193 C1	Ñ	321 209 D1	á	341 225 E1	ñ	361 241 F1	0 0 0 1	1
	202 130 82	PU2	222 146 92	¢	242 162 A2	2	262 178 B2	Â	302 194 C2	Ò	322 210 D2	â	342 226 E2	ò	362 242 F2	0 0 1 0	2
	203 131 83	STS	223 147 93	£	243 163 A3	3	263 179 B3	Ã	303 195 C3	Ó	323 211 D3	ã	343 227 E3	ó	363 243 F3	0 0 1 1	3
IND	204 132 84	CCH	224 148 94		244 164 A4		264 180 B4	Ä	304 196 C4	Ô	324 212 D4	ä	344 228 E4	ô	364 244 F4	0 1 0 0	4
NEL	205 133 85	MW	225 149 95	¥	245 165 A5	µ	265 181 B5	Å	305 197 C5	Õ	325 213 D5	å	345 229 E5	õ	365 245 F5	0 1 0 1	5
SSA	206 134 86	SPA	226 150 96		246 166 A6	¶	266 182 B6	Æ	306 198 C6	Ö	326 214 D6	æ	346 230 E6	ö	366 246 F6	0 1 1 0	6
ESA	207 135 87	EPA	227 151 97	§	247 167 A7	·	267 183 B7	Ç	307 199 C7	Œ	327 215 D7	ç	347 231 E7	œ	367 247 F7	0 1 1 1	7
HTS	210 136 88		230 152 98	¤	250 168 A8		270 184 B8	È	310 200 C8	Ø	330 216 D8	è	350 232 E8	ø	370 248 F8	1 0 0 0	8
HTJ	211 137 89		231 153 99	©	251 169 A9	1	271 185 B9	É	311 201 C9	Ù	331 217 D9	é	351 233 E9	ù	371 249 F9	1 0 0 1	9
VTS	212 138 8A		232 154 9A	a	252 170 AA	o	272 186 BA	Ê	312 202 CA	Ú	332 218 DA	ê	352 234 EA	ú	372 250 FA	1 0 1 0	10
PLD	213 139 8B	CSI	233 155 9B	«	253 171 AB	»	273 187 BB	Ë	313 203 CB	Û	333 219 DB	ë	353 235 EB	û	373 251 FB	1 0 1 1	11
PLU	214 140 8C	ST	234 156 9C		254 172 AC	¼	274 188 BC	Ì	314 204 CC	Ü	334 220 DC	ì	354 236 EC	ü	374 252 FC	1 1 0 0	12
RI	215 141 8D	OSC	235 157 9D		255 173 AD	½	275 189 BD	Í	315 205 CD	Ý	335 221 DD	í	355 237 ED	ý	375 253 FD	1 1 0 1	13
SS2	216 142 8E	PM	236 158 9E		256 174 AE		276 190 BE	Î	316 206 CE		336 222 DE	î	356 238 EE		376 254 FE	1 1 1 0	14
SS3	217 143 8F	APC	237 159 9F		257 175 AF	¿	277 191 BF	Ï	317 207 CF	ß	337 223 DF	ï	357 239 EF		377 255 FF	1 1 1 1	15

KEY

CHARACTER | ESC | 33 OCTAL / 27 DECIMAL / 1B HEX

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Appendix C

Compatibility with PL/I Standards

This appendix describes the relationship of VAX PL/I to the various PL/I language standards that have recently been in force, that are currently in force, or that will shortly be in force. The following topics are discussed in this appendix:

- Section C.1 describes the features in the ANSI X3.74-1981 PL/I General Purpose Subset. VAX PL/I has all of the features in this standard.
- Section C.2 describes VAX PL/I in relation to the new ANSI X3.74-198x PL/I General Purpose Subset. VAX PL/I has almost all of the features described by this standard that are shared with the ANSI X3.53-1976 full language standard. In addition, VAX PL/I has some of the new features described by this language that are not in the ANSI X3.74-1981 language.
- Section C.3 describes features from the ANSI X3.53-1976 PL/I (full language) standard beyond those in ANSI X3.74-198x that are included in VAX PL/I.
- Section C.4 describes miscellaneous features from other implementations that have been included in VAX PL/I and that are not in the ANSI standards.
- Section C.5 describes VAX PL/I-specific extensions that have been provided for VMS system integration.
- Section C.6 lists the implementation-defined values that are used in VAX PL/I.

In summary, VAX PL/I is a strict superset of the ANSI X3.74-1981 PL/I General Purpose Subset. VAX PL/I contains many features from larger or more recent PL/I standards and implementations. Most of the features implemented in VAX PL/I that go beyond the language defined by ANSI X3.74-1981 are contained in either the ANSI X3.53-1976 (full) PL/I language standard or the new ANSI X3.74-198x PL/I General Purpose Subset.

C.1 Relation to the 1981 PL/I General-Purpose Subset

The 1981 PL/I General-Purpose Subset (ANSI X3.74-1981) was designed to be useful in scientific, commercial, and systems programming, especially on small and medium-size computer systems. Among the primary goals of the design of the subset were the following:

- To include features that were easy to learn and to use and to exclude features that were difficult to learn or prone to error
- To provide a subset that would be easily portable from one computer system to another
- To exclude features that were not often used and whose implementation greatly increased the complexity of the run-time support required by the compiler

The essential elements of the subset are described below. These descriptions are extracted from the ANSI X3.74-1981 standard.

C.1.1 Program Structure

The General-Purpose Subset includes a complete character set, with comments, identifiers, decimal arithmetic constants, and simple string constants.

Begin blocks and DO-groups are included in the subset. Each block or group in the program must be terminated with an END statement.

C.1.2 Program Control

The following program control statements are included in the subset: CALL, RETURN, IF, DO, GOTO, null, STOP, ON, REVERT, and SIGNAL.

The DO statement options supported are TO, BY, WHILE, and REPEAT.

An IF statement can contain unlabeled THEN and ELSE clauses.

An ON statement can specify a single condition. The condition names supported are ERROR, ENDFILE, ENDPAGE, FIXEDOVERFLOW, KEY, OVERFLOW, UNDEFINEDFILE, UNDERFLOW, and ZERODIVIDE.

C.1.3 Storage Control

The subset includes the assignment statement and the assignment of array and structure variables whose dimensions and data types match. The subset also permits aggregate promotion, that is, the assignment of a scalar expression to every element or member of an aggregate variable.

In the subset, only static variables can be initialized.

The ALLOCATE statement with the SET option and the FREE statement are included in the subset.

C.1.4 Input/Output

The I/O statements are as follows:

- OPEN and CLOSE
- READ, WRITE, DELETE, and REWRITE for record I/O
- GET and PUT, with FILE, STRING, EDIT, LIST, PAGE, SKIP, and LINE options for stream I/O

The file attributes, specified in DECLARE or OPEN, are DIRECT, ENVIRONMENT, INPUT, KEYED, OUTPUT, PRINT, RECORD, SEQUENTIAL, STREAM, and UPDATE.

The FORMAT statement is included. The format items are E, F, P, A, B, X, R, PAGE, SKIP, COLUMN, TAB, and LINE.

C.1.5 Attributes and Pictures

The DECLARE statement is included in the subset. All names must be declared, either by means of a DECLARE statement or by means of a label prefix.

The attributes supported are as follows: ALIGNED, AUTOMATIC, BASED, BINARY, BIT, BUILTIN, CHARACTER, DECIMAL, DEFINED, DIRECT, ENTRY, ENVIRONMENT, EXTERNAL, FILE, FIXED, FLOAT, INITIAL, INPUT, INTERNAL, KEYED, LABEL, OPTIONS, OUTPUT, PICTURE, POINTER, PRINT, RECORD, RETURNS, SEQUENTIAL, STATIC, STREAM, UPDATE, VARIABLE, and VARYING.

The picture characters included are CR, DB, S, V, Z, 9, –, +, $, and *. The picture insertion characters (. , / B) are also included.

C.1.6 Built-In Functions and Pseudovariables

The built-in functions in the subset are as follows: ABS, ACOS, ADDR, ASIN, ATAN, ATAND, ATANH, BINARY, BIT, BOOL, CEIL, CHARACTER, COLLATE, COPY, COS, COSD, COSH, DATE, DECIMAL, DIMENSION, DIVIDE, EXP, FIXED, FLOAT, FLOOR, HBOUND, INDEX, LBOUND, LENGTH, LINENO, LOG, LOG2, LOG10, MAX, MIN, MOD, NULL, ONCODE, ONFILE, ONKEY, PAGENO, ROUND, SIGN, SIN, SIND, SINH, SQRT, STRING, SUBSTR, TAN, TAND, TANH, TIME, TRANSLATE, TRUNC, UNSPEC, VALID, and VERIFY.

The pseudovariables are PAGENO, STRING, SUBSTR, and UNSPEC.

C.1.7 Expressions

The subset supports all infix and prefix operators, the locator qualifier, parenthesized expressions, subscripts, and function references. Implicit conversion from one data type to another is restricted to those contexts in which the conversion is likely to produce the desired results.

C.2 198x PL/I General-Purpose Subset Features Supported

The 198x PL/I General-Purpose Subset (ANSI X3.74-198x) was designed to extend the previous subset standard on the basis of experience with subset implementations and the desire for more capabilities in subset-conforming implementations.

The following sections describe features in this standard that have been implemented to date in VAX PL/I.

C.2.1 Lexical Constructs

The character pair /* is permitted within comments.

Both uppercase and lowercase characters are permitted in source programs.

No space is required after the P for picture constants.

C.2.2 Program Control

RETURNS(CHAR(*)) is supported.

The statements following THEN and ELSE can be labeled.

The NONRECURSIVE procedure option is supported.

The SELECT statement is supported.

The LEAVE statement is supported.

The UNTIL clause for DO groups and clauses is supported.

C.2.3 Storage Control

The IN option can be used for the ALLOCATE and FREE statements, and language controlled allocation in areas is supported.

The SET option is optional for ALLOCATE if the based variable being allocated was declared with a base pointer.

The ALLOCATE and FREE statements can specify a comma list of items.

String assignment can have the source and target overlapped.

C.2.4 Input/Output

Expressions can be used in GET and PUT FORMAT lists.

You can use, as the source or target of a file I/O statement, a function reference that performs I/O on the same file and then returns to the original statement.

The OPEN and CLOSE statements can contain a list of file specifications.

The FROM option of the REWRITE statement can be omitted.

C.2.5 Attributes and Pictures

The INITIAL attribute is allowed with AUTOMATIC storage. The initial items can contain asterisks to denote uninitialized values. The initial values can be expressions. The NULL built-in function can be used in both STATIC and AUTOMATIC INITIAL attributes. The initial iteration factor can be an asterisk.

Restricted expressions can be used for static extents, parameter extents, and returns descriptor extents.

The AREA and OFFSET data types are supported.

The REFER attribute can be used at the end of a structure.

The DIMENSION, PARAMETER, and NONVARYING keywords can be specified.

The UNALIGNED attribute can be specified, but only for BIT and CHARACTER variables.

SYSIN and SYSPRINT can be contextually declared as files.

The CONDITION attribute is supported.

The UNION attribute is supported.

C.2.6 Program Control

The AREA, CONDITION, CONVERSION, FINISH, and STORAGE conditions are supported.

Multiple conditions can be specified for ON and REVERT.

The SNAP and SYSTEM options of the ON statement are supported.

C.2.7 Built-In Functions and Pseudovariables

The following built-in functions are supported: ADD, DATETIME, EMPTY, EVERY, HIGH, LOW, MAXLENGTH, MULTIPLY, OFFSET, ONSOURCE, POINTER, PROD, REVERSE, SEARCH, SOME, SUBTRACT, SUM, and TRIM.

The ONSOURCE pseudovariable is supported.

The DIMENSION, HBOUND, and LBOUND built-in functions have a default of one for the second parameter if it is not specified.

The INDEX and VERIFY built-in functions have an optional starting position parameter.

The UNSPEC built-in function and pseudovariable can be used on aggregates.

C.2.8 Expressions

The operators AND THEN (short-circuiting AND, specified as &:) and OR ELSE (short-circuiting OR, specified as |:) are supported.

EXCLUSIVE OR (infix or dyadic ^) is supported.

C.3 Full PL/I Features Supported

The items discussed in this section are features that are explicitly excluded from both the old subset standard (ANSI X3.74-1981) and the new subset standard (ANSI X3.74-198x) but that have been implemented in VAX PL/I. These features all exist in full PL/I.

C.3.1 Program Structure

The STRINGRANGE and SUBSCRIPTRANGE conditions are supported.

Replication factors for string constants are supported.

A comma list can be specified on the left-hand side of an assignment statement.

C.3.2 Program Control

The ENTRY statement is supported.

C.3.3 Storage Control

CONTROLLED storage is supported.

C.3.4 Attributes and Pictures

The CONTROLLED, LIKE, MEMBER, POSITION, PRECISION, REFER, and STRUCTURE attributes are supported. (The REFER attribute is restricted to BASED and CONTROLLED variables.)

The picture characters Y, T, I, and R are supported, and pictures can include iteration factors.

Scaled fixed binary numbers are supported. They can have a scale factor within the range –31 through 31.

C.3.5 Built-In Functions and Pseudovariables

The OFFSET and POINTER built-in functions are not restricted to ADDR.

The ALLOCATION and ONCHAR built-in functions are supported.

The ONCHAR pseudovariable is supported.

C.3.6 Expressions

The expression in a WHILE or UNTIL clause or in an IF statement can be a bit string of any length. When evaluated, the expression results in a true value if any bit of the string expression is a 1 and in a false value if all bits in the string expression are 0s.

The control variable and the expressions in the TO, BY, and REPEAT options of the DO statement are not restricted to integers and pointers.

C.4 Nonstandard Features from Other Implementations

The features discussed in this section are not described in any ANSI PL/I standard. They are, however, provided by some other implementations.

C.4.1 Preprocessor

VAX PL/I supports an embedded lexical preprocessor for compilation control. The following preprocessor statements are included: %ACTIVATE, %DEACTIVATE, %DECLARE, %DICTIONARY, %DO, %END, %ERROR, %FATAL, %GOTO, %INFORM, %IF, %PAGE, %PROCEDURE, %RETURN, %SBTTL, %TITLE, and %WARN.

An %IF statement can contain unlabeled %THEN and %ELSE clauses.

The following preprocessor built-in functions are included: ABS, BYTE, COPY, DATE, DATETIME, DECODE, ENCODE, ERROR, INDEX, INFORM, LENGTH, LINE, MAX, MIN, MOD, RANK, REVERSE, SEARCH, SIGN, SUBSTR, TIME, TRANSLATE, TRIM, VARIANT, VERIFY, and WARN.

C.4.2 LIKE Extension

VAX PL/I allows LIKE of a structure containing LIKE.

C.4.3 Declarations

Variables can be declared outside of procedures.

C.5 VAX PL/I-Specific Extensions

The extensions in the following sections are enhancements for PL/I programs executing on a VMS operating system. These extensions are provided for procedure calling, condition handling, support of VAX Record Management Services, compilation control, and miscellaneous purposes.

C.5.1 Procedure-Calling and Condition-Handling Extensions

The following extensions to PL/I were made to allow VAX PL/I procedures to call procedures written in any other programming language that also supports the VAX calling standard.

- The ANY, VALUE, REFERENCE, and DESCRIPTOR attributes describe how data is to be passed to a called procedure.
- The OPTIONAL attribute indicates that a parameter need not be specified in a call; and the TRUNCATE attribute indicates the point at which an actual parameter list can be truncated.
- The LIST attribute can be used for the parameter descriptor in an external entry declaration to denote that a list of parameters may be specified.
- The ACTUALCOUNT built-in function returns the number of parameters the current procedure was called with; and the PRESENT built-in function determines whether a parameter was specified in a call.
- The VARIABLE option for the ENTRY attribute permits a PL/I procedure to call a non-PL/I procedure with an argument list of variable length. It also permits a procedure to omit arguments in an argument list.
- The VALUE, REFERENCE, and DESCRIPTOR built-in functions can be used to pass an argument by the specified mechanism to a non-PL/I procedure.

The following new attributes provide storage classes for PL/I variables. These attributes permit PL/I programs to take advantage of features of the VMS Linker and to combine PL/I procedures with other procedures that use these storage classes.

- The GLOBALDEF and GLOBALREF attributes let you define and access external global variables and optionally place all external global definitions in the same program section.
- The READONLY attribute can be applied to a static computational variable whose value does not change.
- The VALUE attribute defines a variable that is, in effect, a constant whose value is supplied by the linker. The value attribute can also be used to allow a procedure to receive constants passed by immediate value.

The following extensions to condition handling provide support for condition handling in the VMS environment:

- The ANYCONDITION condition name can be used in an ON-unit to handle any condition that is signaled that does not explicitly have an ON-unit of its own.
- The VAXCONDITION condition name can be used in ON, SIGNAL, and REVERT statements to process VMS-specific conditions.
- The RESIGNAL built-in subroutine permits an ON-unit to keep a signal active.
- The ONARGSLIST built-in function provides an ON-unit with access to the mechanism and signal arguments of an exception condition.

C.5.2 Support of VAX Record Management Services

The options of the ENVIRONMENT attribute provide support for many of the features and control values of the VAX Record Management Services (RMS). Additional extensions have been made to the PL/I language to augment this support:

- The USER_OPEN ENVIRONMENT option allows access to the RMS FAB and RAB control structures during a PL/I file open.
- The OPTIONS option is supported on the GET, PUT, READ, WRITE, REWRITE, and DELETE statements.
- The following built-in subroutines provide file handling and control functions: DISPLAY, EXTEND, FLUSH, NEXT_VOLUME, REWIND, and SPACEBLOCK.

C.5.3 Miscellaneous Extensions

VAX PL/I supports the VAX Common Data Dictionary. Data definitions are included in source programs with the %DICTIONARY statement.

The following built-in functions are supported: BYTE, DECODE, ENCODE, INT, POSINT, RANK, and SIZE.

C.6 Implementation-Defined Values and Features

The following values and features are implementation-defined:

- VAX PL/I supports the full 256-character DEC Multinational Character Set (a superset of ASCII) for CHARACTER data (including character string constants in PL/I source programs). All identifiers in a source program are restricted to the ASCII character set.
- The default precisions for arithmetic data are as follows:

  FIXED BINARY (31)
  FIXED DECIMAL (10)
  FLOAT BINARY (24)
  FLOAT DECIMAL (7)
- The maximum record size for SEQUENTIAL files is 32767 bytes minus the length of any fixed-length control area.
- The maximum key size is 255 bytes for character keys.
- The default value for the LINESIZE option is as follows:
  - If the output is to a physical record-oriented device, such as a line printer or terminal, the default line size is the width of the device.
  - If the output is to a print file, the default line size is 132.
  - If the output is to a nonrecord device (magnetic tape), the default line size is 510.
- The default value for the PAGESIZE option is as follows:
  - If the logical name SYS$LP_LINES is defined, the default page size is 6, the numeric value of SYS$LP_LINES.
  - If SYS$LP_LINES is not defined, or if its value is less than 30 or greater than 90, or if its value is not numeric, the default page size is 60.
- The values for TAB positions are columns beginning with column 1 and every eight columns thereafter.

- The maximum length allowed for a file title is 128 characters.
- The maximum number of digits in editing fixed-point data is 34.
- The maximum numbers of digits for each combination of base and scale are as follows:

  FIXED BINARY—31
  FIXED DECIMAL—31
  FLOAT BINARY—113
  FLOAT DECIMAL—34
- The maximum length of CHARACTER, CHARACTER VARYING, and BIT strings is 32767.
- The default precision for integer values is 31.
- The maximum number of arguments that can be passed to an entry point is 253.
- The second parameter of the F format item (the optional parameter specifying the number of fractional digits in the stream representation) must have a value less than or equal to 31.

Appendix D
Migration Notes

This appendix contains notes and comments about migration issues. In particular, it lists and describes keywords and functions of the PL/I language that are available in other implementations of PL/I but are not included in VAX PL/I.

The information in this appendix is not intended to represent either a complete or a formal description of migration issues. The information is presented informally, and has not been subjected to extensive testing and verification.

The following topics are discussed in this appendix:

- Section D.1 lists keywords that are not supported by VAX PL/I.
- Section D.2 covers some of the miscellaneous differences between VAX PL/I and other PL/I compilers.
- Section D.3 provides an overview of implicit data conversions performed by the PL/I compiler.
- Section D.4 presents a program for a hexadecimal dump because dump printing routines for other hardware architectures are not transportable to VAX.

D.1 Keywords Not Supported

The following table summarizes PL/I keywords used in other implementations of PL/I that are not used in VAX PL/I. The table does not include ENVIRONMENT keywords or implementation-specific language extensions.

Keyword	Abbreviation	Use
AFTER		Built-in function
ALL		Built-in function
ANY		Built-in function
ATTENTION	ATTN	Condition
BACKWARDS		Attribute, Option of OPEN statement
BEFORE		Built-in function
BUFFERED	BUF	Attribute, Option of OPEN statement
BY NAME		Option of assignment statement
C		Format item
CALL		Option of INITIAL attribute
CASE		Option of DO statement
CHECK		Statement, Condition, Condition prefix
COMPLETION	CPLN	Built-in function, Pseudovariable
COMPLEX	CPLX	Attribute, Built-in function, Pseudovariable
CONJG		Built-in function
CONNECTED	CONN	Attribute
CONSTANT		Attribute
CONVERSION	CONV	Condition prefix
COPY		Option of GET statement
COUNT		Built-in function
CURRENTSTORAGE	CSTG	Built-in function

Keyword	Abbreviation	Use
DATA		Stream I/O transmission mode
DATAFIELD		Built-in function
DECAT		Built-in function
DEFAULT	DFT	Statement
DELAY		Statement
DESCRIPTORS		Option of DEFAULT statement
DISPLAY		Statement
DOT		Built-in function
ERF		Built-in function
ERFC		Built-in function
EVENT		Attribute, Option of several statements
EXCLUSIVE	EXCL	Attribute
EXIT		Statement
FETCH		Statement
FORMAT		Attribute
GENERIC		Attribute
HALT		Statement
IGNORE		Option of READ statement
IMAG		Built-in function, pseudovariable
IRREDUCIBLE	IRRED	Attribute
LIST		Option of OPEN statement
LOCAL		Attribute
LOCATE		Statement
NAME		Condition
NOCHECK		Statement, Condition prefix
NOCONVERSION	NOCONV	Condition prefix
NOFIXEDOVERFLOW	NOFOFL	Condition prefix
NOLOCK		Option of READ statement
NONE		Option of DEFAULT statement

Keyword	Abbreviation	Use
NOOVERFLOW		Condition prefix
NOSIZE		Condition prefix
NOSTRINGRANGE	NOSTRG	Condition prefix
NOSTRINGSIZE	NOSTRZ	Condition prefix
NOSUBSCRIPTRANGE	NOSUBRG	Condition prefix
NOZERODIVIDE	NOZDIV	Condition prefix
ONCOUNT		Built-in function
ONFIELD		Built-in function
ONLOC		Built-in function
ORDER		Option of BEGIN and PROCEDURE statements
OVERFLOW	OFL	Condition prefix
PENDING		Condition
POLY		Built-in function
PRIORITY		Option of CALL statement, Built-in function, Pseudovariable
RANGE		Option of DEFAULT statement
REAL		Attribute, Built-in function, Pseudovariable
RECORD		Condition
REDUCIBLE	RED	Attribute
REENTRANT		Option of OPTIONS option
RELEASE		Statement
REORDER		Option of BEGIN and PROCEDURE statements
REPEAT		Built-in function
REPLY		Option of DISPLAY statement
SAMEKEY		Built-in function
SIZE		Condition, Condition prefix
SNAP		Option of PUT statement
STATUS		Built-in function, Pseudovariable

Keyword	Abbreviation	Use
STORAGE	STG	Built-in function
STRINGRANGE	STRG	Condition prefix
STRINGSIZE	STRZ	Condition, Condition prefix
SUB		Dummy variable of DEFINED attribute
SUBSCRIPTRANGE	SUBRG	Condition prefix
SYSTEM		Option of DECLARE statement
TAB		Option of OPEN statement
TASK		Attribute, Option of OPTIONS option, Option of CALL statement
TRANSIENT		Attribute, option of OPEN statement
TRANSMIT		Condition
UNBUFFERED	UNBUF	Attribute, Option of OPEN statement
UNLOCK		Statement
WAIT		Statement

D.2 Miscellaneous Differences

The following list summarizes a number of minor differences between VAX PL/I and other PL/I compilers that require you to modify your source files to avoid compilation errors. In some cases, differences require reprogramming.

- The at sign (@) and number sign (#) characters are not allowed in identifiers; thus, you must change all identifiers that contain either of these characters.
- You must explicitly declare all names (except internal procedure and label constants). There is no "I through N rule" that provides an implicit declaration of FIXED BINARY to undeclared names. In fact, the VAX PL/I compiler defaults all undeclared names to FIXED BINARY and issues a warning message to that effect.

- If the attribute FLOAT is specified and neither of the attributes BINARY or DECIMAL is specified with it, the VAX PL/I compiler provides a default of BINARY. This should not present a problem; however, if a precision was specified under the assumption that the default floating-point base was DECIMAL, overflow conditions can result if you do not correct the declaration.
- You cannot explicitly declare internal entry constants and subscripted label constants: in VAX PL/I, these names are implicitly declared by their appearance. You must remove the declarations from the source file.
- You must reprogram ON-units for unsupported conditions. For example, ON-units for SIZE, RECORD, and TRANSMIT should be modified so that they are invoked for the ERROR condition, which is the condition that is signaled in VAX PL/I for any of these errors.
- You cannot specify the ALIGNED and UNALIGNED attributes for a structure in which string variables are to be aligned or unaligned. The attribute must be specified in the declaration of each variable that is to be aligned.
- You cannot pass parameters directly to main procedures from the command stream. For examples of techniques for passing values or data to a main procedure, **see** the *VAX PL/I User Manual.*

D.3 Implicit Conversions

The VAX PL/I compiler issues warning-level messages when it performs implicit conversions between arithmetic and string data types and between bit-string and character-string data types. It issues these messages for all such conversions, not just those excluded by the PL/I General-Purpose Subset.

You can avoid the messages by compiling your programs with the /NOWARNINGS qualifier. Or you can edit your program, locate the occurrences of implied conversions, and change them to explicit conversions, as follows:

- Arithmetic to character-string—use the CHARACTER built-in function.
- Arithmetic to bit-string—use the BIT built-in function.[1]
- Bit-string to arithmetic—use the BINARY built-in function.

[1] Note that this conversion is based on the way bit strings are printed by PUT LIST (the first bit of the string is the high-order bit if the printed string is viewed as a binary integer) rather than being based on the internal representation (the first bit of the string is then in the low-order digit position in memory).

- Bit-string to character string—use the CHARACTER built-in function.
- Character-string to arithmetic—use the BINARY, DECIMAL, FIXED, or FLOAT built-in function, according to the target data type.
- Character-string to bit string—use the BIT built-in function.

D.4 Printing a Hexadecimal Memory Dump

Dump printing routines written for other hardware architectures are not transportable to VAX. Because the order in which bits are stored on VAX machines is reversed on some other machines, these routines must be entirely rewritten. The program HEXDUMP that follows illustrates one technique for outputting the contents of memory in hexadecimal:

```
/*
  This procedure illustrates the dumping of VAX memory in
  hexadecimal.  The output format is consistent with other
  VMS memory dump utilities.
*/

HEXDUMP: PROCEDURE OPTIONS(MAIN);

    DECLARE DUMP_LOCATION POINTER;
    DECLARE (I,J) FIXED BINARY(31);

/* declare and initialize fake memory to dump */

    DECLARE MEMORY(0:255) FIXED BINARY(7);

    DO I = 0 TO 127;
        MEMORY(I) = I;
        MEMORY(I + 128) = I - 128;
        END;

/* dump the pseudomemory on the user's terminal */

    DO I = 0 TO 255 BY 16;
        PUT SKIP;
    DO J = 12 TO 0 BY -4;
    DUMP_LOCATION = ADDR(MEMORY(I+J));
    CALL OUTPUT_HEX(DUMP_LOCATION);
    END;
        PUT EDIT(' ')(A(1));
        CALL OUTPUT_HEX(ADDR(I));
        END;
    STOP;
```

```
/* subroutine to output a hexadecimal longword */

OUTPUT_HEX: PROCEDURE(ADDRESS);

    DECLARE ADDRESS POINTER;
    DECLARE F FIXED BIN(31) BASED(ADDRESS);

    PUT EDIT(REVERSE(UNSPEC(F))) (B4(8));

    END OUTPUT_HEX;

END HEXDUMP;
```

Appendix E

VAX PL/I Language Summary

This appendix briefly describes VAX PL/I statements, attributes, expressions, data conversions, built-in functions, pseudovariables, and built-in subroutines. For more information on each of these topics, refer to the individual entries in this manual.

E.1 Statements

%activate-statement

% { ACTIVATE / ACT } element [RESCAN / NORESCAN] , . . . ;

allocate-statement

{ ALLOCATE / ALLOC } allocate-item, . . . ;

allocate-item:

variable-reference [SET(locator-reference)][IN(area-reference)]

%assignment-statement

%target = expression;

assignment-statement

target, . . . = expression;

begin-statement

BEGIN;

call-statement

CALL entry-name [(argument, . . .)];

close-statement

CLOSE FILE(file-reference) [ENVIRONMENT(option, . . .)]
[,FILE(file-reference) [ENVIRONMENT(option, . . .)]] . . .

%deactivate-statement

% { DEACTIVATE / DEACT } element, . . . ;

element:

{ identifier / (identifier, . . .) }

%declare-statement

% { DECLARE / DCL } element [FIXED / CHARACTER / BIT] , . . . ;

element:

{ identifier / (identifier, . . .) }

declare-statement

{ DECLARE / DCL } [level] declaration [,[level] declaration, . . .];

declaration:

[level] declaration-item

declaration-item:

{ identifier / (declaration-item, . . .) } [(bound-pair, . . .)] [attribute . . .]

delete-statement

DELETE FILE(file-reference) [KEY (expression)][OPTIONS(option, . . .)]

%dictionary-statement

%DICTIONARY cdd-path;

%do-statement

```
%DO;
.
.
.
%END;
```

do-statement

```
     [reference=expression]
     [TO expression [BY expression]]
DO   [REPEAT expression]
     [WHILE(expression)]
     [UNTIL(expression)];
```

%end-statement

```
%END;
```

end-statement

```
END [label-reference];
```

entry-statement

```
entry-name: ENTRY [ (parameter, . . . ) ]
                  [ RECURSIVE    ]
                  [ NONRECURSIVE ]
                [ RETURNS (returns-descriptor) ];
```

%error-statement

```
%ERROR preprocessor-expression;
```

%fatal-statement

```
%FATAL preprocessor-expression;
```

format-statement

```
label:

FORMAT (format-specification, . . . );
```

free-statement

```
FREE variable-reference [IN area-reference], . . . ;
```

get-statement

```
GET EDIT (input-target, . . . )(format-specification, . . . )
  [ FILE(file-reference)                  ]
  [       [SKIP[(expression)]]            ]
  [       [OPTIONS(option, . . . )]       ]
  [ STRING(expression)                    ]
    ;
GET LIST (input-target, . . . )
  [ FILE(file-reference)                  ]
  [       [SKIP[(expression)]]            ]
  [       [OPTIONS(option, . . . )]       ]
  [ STRING(expression)                    ]
    ;
GET [FILE(file-reference)] SKIP [(expression)];
```

%goto-statement

```
%GOTO label-reference;
```

goto-statement

```
{ GOTO  } label-reference ;
{ GO TO }
```

%if-statement

```
%IF test-expression %THEN action [%ELSE action];
```

if-statement

```
IF test-expression THEN action [ELSE action];
```

%include-statement

```
                  { 'file-spec'                    }
%INCLUDE          { module-name                    } ;
                  { 'library-name(module-name)'    }
```

%inform-statement

```
%INFORM preprocessor-expression;
```

leave-statement

```
LEAVE [label-reference];
```

%[no]list-statement

%NOLIST_ALL; %NOLIST_DICTIONARY; %NOLIST_INCLUDE;
%NOLIST_MACHINE; %NOLIST_SOURCE;

%null-statement

%;

null-statement

;

on-statement

ON condition-name, . . . [SNAP] { on-unit / SYSTEM; }

open-statement

OPEN FILE(file-reference) [file-description-attribute . . .]
[,FILE(file-reference) [file-description-attribute . . .]] . . .

%page-statement

%PAGE;

%procedure-statement

%label: { PROCEDURE / PROC } [(parameter-identifier, . . .)][STATEMENT]
RETURNS ({ CHARACTER / FIXED / BIT });
.
.
.
[%]RETURN (preprocessor-expression);
.
.
.
[%]END.

procedure-statement

```
entry-name: { PROCEDURE } [ (parameter, . . . ) ]
            { PROC      }
              [ OPTIONS (option, . . . ) ]
                [ RECURSIVE    ]
                [ NONRECURSIVE ]
              [ RETURNS (value-descriptor) ];
```

put-statement

```
PUT EDIT (output-source, . . . ) (format-specification, . . . )
  [ FILE(file-reference)      ]
  [      [PAGE]               ]
  [      [LINE(expression)]   ]
  [      [SKIP[(expression)]] ]
  [      [OPTIONS(option)]    ]
  [ STRING(reference)         ]
  ;

PUT [FILE(file-reference)] LINE(expression);

PUT LIST (output-source, . . . )
  [ FILE(file-reference)      ]
  [      [PAGE]               ]
  [      [LINE(expression)]   ]
  [      [SKIP[(expression)]] ]
  [      [OPTIONS(option)]    ]
  [ STRING(reference)         ]
  ;

PUT [ FILE(file-reference)] PAGE;

PUT [ FILE(file-reference)] SKIP [(expression)];
```

read-statement

```
READ FILE (file-reference)

  { INTO (variable-reference) }
  { SET (pointer-variable)    }

    [ KEY (expression)          ]
    [ KEYTO (variable-reference) ]

      [ OPTIONS (option, . . . ) ];
```

%replace-statement

%REPLACE identifier BY constant-value;

%return-statement

[%]RETURN (preprocessor-expression);

return-statement

RETURN [(return-value)];

revert-statement

REVERT condition-name, . . . ;

rewrite-statement

```
REWRITE FILE (file-reference)
    [ FROM (variable-reference) [ KEY (expression) ]]
    [ OPTIONS (option, . . . ) ];
```

%sbttl-statement

%SBTTL preprocessor-expression

select-statement

```
SELECT [(select-expression)];
    [WHEN [ANY|ALL] (expression, . . . ) [action];] . . .
    [{OTHERWISE|OTHER} [action];]
     END;
```

signal-statement

SIGNAL condition-name;

stop-statement

STOP;

%title-statement

%TITLE preprocessor-expression

%warn-statement

```
%WARN preprocessor-expression;
```

write-statement

```
WRITE FILE(file-reference) FROM (variable-reference)
                  [ KEYFROM (expression) ]
                  [ OPTIONS (option, . . . ) ];
```

E.2 Attributes

Computational Data Type Attributes

The following attributes define arithmetic and string data:

```
CHARACTER [ (length) ] [ VARYING    ]
                       [ NONVARYING ]
BIT [ (length) ] [ ALIGNED   ]
                 [ UNALIGNED ]
{ FLOAT } { BINARY  } [ [PRECISION] (precision
{ FIXED } { DECIMAL }                [,scale-factor]) ]
PICTURE 'picture'
```

These attributes can be specified for all elements of an array and for individual members of a structure.

Noncomputational Data Type Attributes

The following attributes apply to program data that is not used for computation:

```
AREA
CONDITION
ENTRY [VARIABLE]
FILE [VARIABLE]
LABEL [VARIABLE]
OFFSET
POINTER
```

Storage Class and Scope Attributes

The following attributes control the allocation and use of storage for a data variable and define the scope of the variable:

```
AUTOMATIC [INITIAL(initial-element, . . . )]
BASED [(pointer-reference)][INITIAL(initial-element, . . . )]
CONTROLLED [INITIAL(initial-element, . . . )]
DEFINED(variable-reference) [POSITION(expression)]
STATIC [READONLY] [INITIAL(initial-element, . . . )]
PARAMETER
EXTERNAL [ GLOBALDEF [(psect-name)] [ VALUE    ] ]
         [ GLOBALREF               [ READONLY ] ]
INTERNAL
```

Member Attributes

The following attributes can be applied to the major or minor members of a structure:

```
LIKE
MEMBER
REFER
STRUCTURE
UNION
```

File Description Attributes

The following attributes can be applied to file constants and used in OPEN statements:

```
ENVIRONMENT(option, . . . )

{ RECORD [KEYED] } { INPUT          }
{ STREAM         } { OUTPUT [PRINT] }
                   { UPDATE         }

{ DIRECT     }
{ SEQUENTIAL }
```

Entry Name Attributes

The following attributes can be applied to identifiers of entry points:

```
ENTRY [VARIABLE] [OPTIONS (VARIABLE)]
   [RETURNS (returns-descriptor)]
BUILTIN
```

Non-Data Type Attributes

The following attributes can be applied to data declarations:

ALIGNED
DIMENSION
UNALIGNED

E.3 Expressions and Data Conversions

The following table lists the categories of operators, their symbols, and their meanings.

Operators

Category	Symbol	Operation
Arithmetic operators	+	Addition or prefix plus
	-	Subtraction or prefix minus
	/	Division
	*	Multiplication
	**	Exponentiation
Relational (or comparison) operators	>	Greater than
	<	Less than
	=	Equal to
	^>	Not greater than
	^<	Not less than
	^=	Not equal to
	>=	Greater than or equal to
	<=	Less than or equal to
Bit-string (or logical) operators	^ (prefix)	Logical NOT
	&	Logical AND
	|	Logical OR
	&:	Logical AND THEN
	|:	Logical OR ELSE
	^ (infix)	Logical EXCLUSIVE OR
Concatenation operator	||	String concatenation

NOTE

For any of the operators, the tilde character (~) can be used instead of a circumflex (^), and an exclamation point (!) can be used instead of a vertical bar (|).

The following table gives the priority of PL/I operators. Low numbers indicate high priority. For example, the exponentiation operator (**) has the highest priority (1), so it is performed first, and the OR ELSE operator (|:) has the lowest priority (9), so it is performed last.

Precedence of Operators

Operator	Priority	Operator	Priority
**	1	<	5
+ (prefix)	1	^>	5
- (prefix)	1	^<	5
^ (prefix)	1	=, ^=	5
*	2	<=	5
/	2	>=	5
+ (infix)	3	&	6
- (infix)	3	|, ^ (infix)	7
||	4	&:	8
>	5	|:	9

The following table discusses the contexts in which PL/I performs data conversion.

Contexts in Which PL/I Converts Data

Context	Conversion Performed
target = expression;	In an assignment statement, the given expression is converted to the data type of the target.
entry-name RETURNS (attribute . . .); . . . RETURN (value);	In a RETURN statement, the specified value is converted to the data type specified by the RETURNS option on the PROCEDURE or ENTRY statement.
x + y x - y x * y x / y x**y x||y x & y x | y x&:y x|:y x ^ y x > y x < y x = y x^=y	In any expression, if operands do not have the required data type, they are converted to a common data type before the operation. For most operators, the data types of all operands must be identical. A warning message is issued in the case of a concatenation conversion. (See "Expression.")
BINARY (expression) BIT (expression) CHARACTER (expression) DECIMAL (expression) FIXED (expression) FLOAT (expression) OFFSET (variable) POINTER (variable)	PL/I provides built-in functions that perform specific conversions.
PUT LIST (item, . . .);	Items in a PUT LIST statement are converted to character-string data.

Context	Conversion Performed
GET LIST (item, . . .);	Character-string input data is converted to the data type of the target item.
PAGESIZE (expression) LINESIZE (expression) SKIP (expression) LINE (expression) COLUMN (expression) format items A, B, E, F, and X TAB (expression)	Values specified for various options to PL/I statements must be converted to integer values.
DO control-variable . . .	Values are converted to the attributes of the control variable.
parameter	Actual parameters are converted to the type of the formal parameter if necessary.
INITIAL attribute	Initial values are converted to the type of the variable being initialized.

E.4 Built-In Functions

A built-in function reference can be used wherever a reference of the same type is valid. The following table summarizes these functions.

Summary of PL/I Built-In Functions

Category	Function Reference	Value Returned
Arithmetic	ABS(x)	Absolute value of x
	ADD(x,y,p[,q])	Value of x+y, with precision p and scale factor q
	CEIL(x)	Smallest integer greater than or equal to x
	DIVIDE(x,y,p[,q])	Value of x divided by y, with precision p and scale factor q
	FLOOR(x)	Largest integer that is less than or equal to x
	MAX(x,y)	Larger of the values x and y

Category	Function Reference	Value Returned
	MIN(x,y)	Smaller of the values x and y
	MOD(x,y)	Value of x modulo y
	MULTIPLY(x,y,p[,q])	Value of x*y, with precision p and scale factor q
	PRECISION(x,p[,q])	Value of expression x, with precision p and scale factor q
	ROUND(x,k)	Value of x rounded to k digits
	SIGN(x)	-1, 0, or 1 to indicate the sign of x
	SUBTRACT(x,y,p[,q])	Value of x-y, with precision p and scale factor q
	TRUNC(x)	Integer portion of x
Mathematical	ACOS(x)	Arc cosine of x (angle, in radians, whose cosine is x)
	ASIN(x)	Arc sine of x (angle, in radians, whose sine is x)
	ATAN(x)	Arc tangent of x (the angle, in radians, whose tangent is x)
	ATAN(x,y)	Arc tangent of x (the angle, in radians, whose sine is x and whose cosine is y)
	ATAND(x)	Arc tangent of x (the angle, in degrees, whose tangent is x)
	ATAND(x,y)	Arc tangent of x (the angle, in degrees, whose sine is x and whose cosine is y)
	ATANH(x)	Hyperbolic arc tangent of x
	COS(x)	Cosine of radian angle x
	COSD(x)	Cosine of degree angle x
	COSH(x)	Hyperbolic cosine of x
	EXP(x)	Base of the natural logarithm, e, to the power x
	LOG(x)	Logarithm of x to the base e
	LOG10(x)	Logarithm of x to the base 10
	LOG2(x)	Logarithm of x to the base 2
	SIN(x)	Sine of the radian angle x

Category	Function Reference	Value Returned
	SIND(x)	Sine of the degree angle x
	SINH(x)	Hyperbolic sine of x
	SQRT(x)	Square root of x
	TAN(x)	Tangent of the radian angle x
	TAND(x)	Tangent of the degree angle x
	TANH(x)	Hyperbolic tangent of x
String-Handling	BOOL(x,y,z)	Result of Boolean operation z performed on x and y
	COLLATE( )	ASCII character set
	COPY(s,c)	c copies of specified string, s
	EVERY(s)	Boolean value indicating whether every bit in bit string s is '1'B
	HIGH(c)	String of length c of repeated occurrences of the highest character in the collating sequence
	INDEX(s,c[,p])	Position of the character string c within the string s, starting at position p
	LENGTH(s)	Number of characters or bits in the string s
	LOW(c)	String of length c of repeated occurrences of the lowest character in the collating sequence
	MAXLENGTH(s)	Maximum length of varying string s
	REVERSE(s)	Reverse of the source character string or bit string
	SEARCH(s,c[,p])	Position of the first character in s, starting at position p, that is found in c
	SOME(s)	Boolean value indicating whether at least one bit in bit string s is '1'B
	STRING(s)	Concatenation of values in array or structure s
	SUBSTR(s,i[,j])	Part of string s beginning at i for j characters

Category	Function Reference	Value Returned
	TRANSLATE(s,c[,d])	String s with substitutions defined in c and d
	TRIM(s[,e,f])	String s with all characters in e removed from the left, and all characters in f removed from the right
	VERIFY(s,c[,p])	Position of the first character in s, starting at position p, which is not found in c
Conversion	BINARY(x[,p[,q]])	Binary value of x with precision p and scale factor q
	BIT(s[,l])	Value of s converted to a bit string of length l
	BYTE(x)	ASCII character represented by the integer x
	CHARACTER(s[,l])	Value of s converted to a character string of length l
	DECIMAL(x[,p[,q]])	Decimal value of x
	DECODE(c,r)	Fixed binary value of the character string c converted to a base r number
	ENCODE(i,r)	Character string representing the base r number that is equivalent to the fixed binary expression i
	FIXED(x,p[,q])	Fixed arithmetic value of x
	FLOAT(x,p)	Floating arithmetic value of x
	INT(x[,p[,l]])	Signed integer value of variable x, located at position p with length l
	POSINT(x[,p[,l]])	Unsigned integer value of variable x, located at position p with length l
	RANK(c)	Integer representation of the ASCII character c
	UNSPEC(x[,p[,l]])	Internal coded form of x, located at position p with length l
Condition-Handling	ONARGSLIST( )	Pointer to argument lists of exception condition

Category	Function Reference	Value Returned
	ONCHAR( )	Character that caused the CONVERSION condition to be raised
	ONCODE( )	Error code of the most recent run-time error
	ONFILE( )	Name of file constant for which the most recent ENDFILE, ENDPAGE, KEY, or UNDEFINEDFILE condition was signaled
	ONKEY( )	Value of key that caused KEY condition
	ONSOURCE( )	Field containing the ONCHAR character when the CONVERSION condition was raised
Array-Handling	DIMENSION(x[,n])	Extent of the nth dimension of x
	HBOUND(x[,n])	Higher bound of the nth dimension of x
	LBOUND(x[,n])	Lower bound of the nth dimension of x
	PROD(x)	Arithmetic product of all the elements in x
	SUM(x)	Arithmetic sum of all the elements in x
Storage	ADDR(x)	Pointer identifying the storage referenced by x
	ALLOCATION(x)	Number of existing generations for controlled variable x
	EMPTY( )	An empty area value
	NULL( )	A null pointer value
	OFFSET(p,a)	An offset into the location in area a pointed to by pointer p
	POINTER(o,a)	A pointer to the location at offset o within area a
	SIZE(x)	Number of bytes allocated to variable x
Timekeeping	DATE( )	System date in the form YYMMDD
	DATETIME( )	System date and time in the form CCYYMMDDHHMMSSXX
	TIME( )	System time of day in the form HHMMSSXX

Category	Function Reference	Value Returned
File Control	LINENO(x)	Line number of the print file identified by x
	PAGENO(x)	Page number of the print file identified by x
Preprocessor	ABS(x)	Absolute value of x
	BYTE(x)	ASCII character represented by integer x
	COPY(s,c)	c copies of specified string s
	DATE( )	Compilation date in the form YYMMDD
	ERROR( )	Count of user-generated diagnostic error messages
	INDEX(s,c[,p])	Position of the character string c within the string s, starting at position p
	INFORM( )	Count of user-generated diagnostic informational messages
	LENGTH(s)	Number of characters or bits in the string s
	LINE( )	Line number in source program that contains the end of the specified preprocessor statement
	MAX(x,y)	Larger of the values x and y
	MIN(x,y)	Smaller of the values x and y
	MOD(x,y)	Value of x modulo y
	RANK(c)	Integer representation of the ASCII character c
	REVERSE(s)	Reverse of the source character string or bit string
	SEARCH(s,c[,p])	Position of the first character in s, starting at position p, that is found in c
	SIGN(x)	-1, 0, or 1 to indicate the sign of x
	SUBSTR(s,i[,j])	Part of string s beginning at i for j characters
	TIME( )	Compilation time of the day in the form HHMMSSXX

Category	Function Reference	Value Returned
	TRANSLATE(s,c[,d])	String s with substitutions defined in c and d
	TRIM(s[,e,f])	String s with all characters in e removed from the left and all characters in f removed from the right
	VARIANT( )	String result representing the value of /VARIANT of the PLI command qualifier
	VERIFY(s,c[,p])	Position of the first character in s, starting at position p, which is not found in c
	WARN( )	Count of user-generated diagnostic warning messages
Miscellaneous	ACTUALCOUNT( )	Number of parameters the current procedure was called with
	DESCRIPTOR(x)	Forces its argument to be passed by descriptor to a non-PL/I procedure
	PRESENT(p)	Boolean value indicating whether parameter p was specified in a call
	REFERENCE(x)	Forces its argument to be passed by reference to a non-PL/I procedure
	VALID(p)	Boolean value, indicating whether the pictured variable p has a value consistent with its picture specification
	VALUE(x)	Forces its argument to be passed by value to a non-PL/I procedure

E.5 Pseudovariables

VAX PL/I has the following pseudovariables:

INT
ONSOURCE
ONCHAR
PAGENO
POSINT
STRING
SUBSTR
UNSPEC

A pseudovariable can be used, in certain assignment contexts, in place of an ordinary variable reference. For example:

```
SUBSTR(S,2,1) = 'A';
```

This assigns the character 'A' to a 1-character substring of S, beginning at the second character of S.

A pseudovariable can be used wherever the following three conditions are true:

- The syntax specifies a variable reference.
- A value is explicitly assigned to the variable.
- The context does not require the variable to be addressable.

Pseudovariables are used most often in the following locations:

- The left side of an assignment statement
- The input target of a GET statement

Note that a pseudovariable cannot be used in preprocessor statements or in an argument list. For example:

```
CALL P(SUBSTR(S,2,1));
```

Here, SUBSTR is interpreted as a built-in function reference, not as a pseudovariable. The actual argument passed to procedure P is a dummy argument containing the second character of string S.

E.6 Built-In Subroutines

The following table summarizes the file-handling built-in subroutines.

Summary of File-Handling Built-In Subroutines

Subroutine	Function
DISPLAY	Returns information about a file.
EXTEND	Allocates additional disk blocks for a file.
FLUSH	Requests the file system to write all buffers onto disk to preserve the current status of a file.
FREE	Unlocks all the locked records in a file.
NEXT_VOLUME	Begins processing the next volume in a multivolume tape set.
RELEASE	Unlocks a specified record in a file.
REWIND	Positions a file at its beginning or at a specific record.
SPACEBLOCK	Positions a file forward or backward a specified number of blocks.

VAX PL/I also has the condition-handling subroutine RESIGNAL. This subroutine allows an ON-unit to "pass" on a condition signal and causes the condition to be resignaled for handling by a different ON-unit.

INDEX

A

B

C

D

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z

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